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**FIDEP2 USER MANUAL TO
MICROMECHANICAL MODELS FOR
THERMOVISCOPLASTIC BEHAVIOR OF METAL
MATRIX COMPOSITES**



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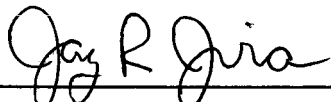
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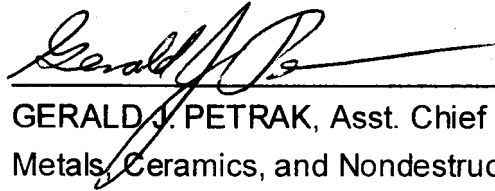
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FOREWORD

The development of this user manual was performed at the Ceramics Development and Materials Behavior Branch, Metals, Ceramics, and NDE Division, Materials and Manufacturing Directorate, Air Force Research Laboratory (AFRL/MLLN) under contract Nos. F33615-94-C-5200 and F33615-98-C-5214/ These contracts are administered under the direction of Mr. Jay R. Jira. The writing of this manual was performed by the Advanced Materials Group of the Structural Integrity Division, University of Dayton Research Institute.

SECTION 1

INTRODUCTION

FIDEP2 (**F**inite-**D**ifference code for **E**lastic-visco**P**lastic analysis) is a PC-compatible, user-friendly computer code developed in-house at the Materials Directorate, Wright Laboratory, Wright-Patterson AFB, Ohio. The program is capable of predicting micromechanical stresses in metal matrix composites under complex thermal and mechanical loading histories. FIDEP2 is a generalized version of FIDEP program [Coker and Ashbaugh, 1992] which was limited by the concentric cylindrical geometry and elastic-plastic constitutive model. The program FIDEP2 incorporates different loading histories, micromechanical models, and constitutive models in a modular form to allow for easy implementation of new requirements.

The features of the current program include:

- Micromechanical models
 - Concentric cylinder model (CCM)
 - Hybrid CCM: a CCM with a parallel [90] element
 - Uniaxial parallel bars
- Constitutive Models
 - Elastic
 - Bilinear elastic-plastic
 - Bodner-Partom with backstress
 - Bodner-Partom with directional hardening
 - Bodner-Partom with directional hardening and damage
 - New Bodner-Partom with directional hardening
- Load histories
 - Monotonic loading
 - Isothermal fatigue
 - Thermal loading
 - Thermomechanical fatigue
- Types of load control
 - Strain
 - Stress
- Predictive Capabilities
 - Effective composite stress-strain response
 - Constituent stress-strain response

1.1 Background

The behavior of a unidirectional composite material can be determined using the CCM or the uniaxial stress model. The CCM has been shown to predict the stress distributions accurately around the fiber [Coker et al., 1993a & 1993b] whereas the uniaxial stress model can be

preferred for a speedy and, in some instances, accurate determination of the overall composite behavior. The behavior of a [0/90] cross-ply laminate can be determined using the CCM with smeared [90] ply properties where the strain compatibility in the load direction is preserved between the [0] ply and [90] ply. In this instance, the properties of the [90] ply are determined using finite element analysis or from experiments. The uniaxial stress model can also be used to determine the overall behavior of [0/90] composite using isothermal properties to represent the [90] ply. Schematics of the three geometric models are shown in Figure 1.

A number of constitutive models can be used to characterize the constitutive behavior in micromechanical models. For the SCS-6 fiber in titanium matrix composites used in our investigations, the fiber has been characterized with a linear elastic model. The titanium matrix was Timetal α 21S and has been characterized using elastic-plastic model and elastic- viscoplastic models with Bodner-Partom formulations [Bodner and Partom, 1975]. The [90] ply has been characterized using the Bodner-Partom model with the addition of damage to account for fiber/matrix separation [Neu et al., 1996].

The major assumptions in all the micromechanical models implemented in the program were as follows: a) no spatial temperature gradients in the composite, b) perfect bonding between fiber and matrix in the [0] ply, c) generalized plane strain state, d) small displacements, and e) isotropic material properties.

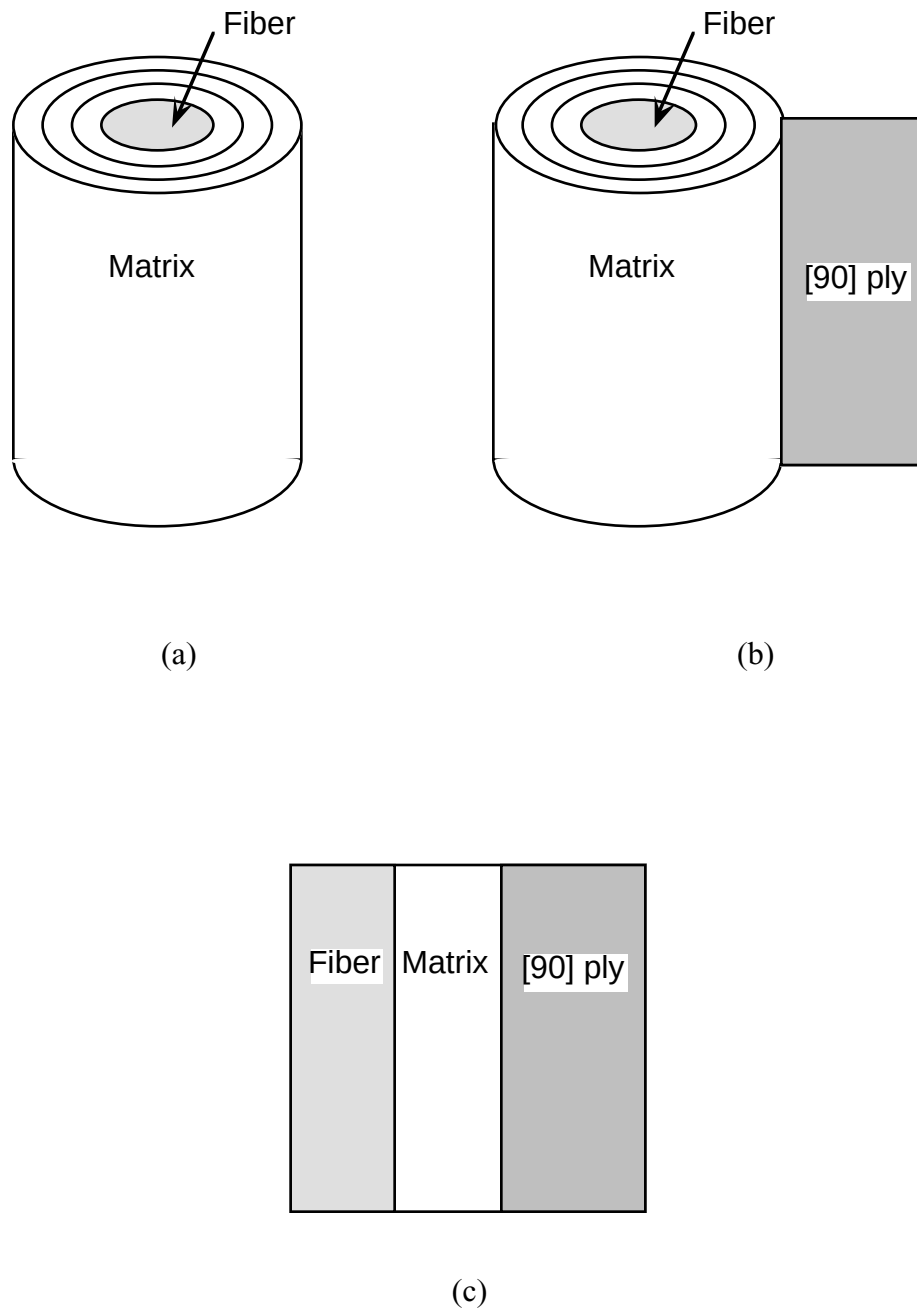


Figure 1. Micromechanical Models Implemented into FIDEP2 (a) CCM, (b) CCM with a Parallel [90] Ply, (c) Uniaxial Stress Model.

1.2 Program Overview

Operation of the FIDEP2 program is straightforward, requiring a loading history file and a material properties data file. Input data are in free format and some descriptive titles are allowed. The following sections describe the program in more detail. In Section 2 the FIDEP2 program operation is described in sufficient detail to allow the reader to begin to use the program. Demonstration problems are discussed in Section 3 to provide the user with examples of input and output information. Verification problems are presented in Section 4 to evaluate the accuracy of the numerical algorithms. In Section 5, a more detailed description of FIDEP2 is provided so that a more advanced user can make substantial modifications to the material and loading data files. Finally, the micromechanical models, the available constitutive models, and the numerical integration schemes which are implemented in the FIDEP2 code are summarized in Section 6.

SECTION 2

PROGRAM OPERATION

The FIDEP2 program can be run interactively on any machine with a FORTRAN compiler. Two input files are required to run the program: a material database file and a problem file. The material database consists of a compilation of the mechanical properties for the materials of interest. The problem file defines the materials to be used, the applied thermal and mechanical loading history, the volume fraction of each constituent in the composite, the type of analysis, and the parameters for requested output.

2.1 Input Files

Two input data files are required for this program: the material properties database file and the loading file.

2.1.1 Material Properties Database File

The temperature-dependent mechanical properties and coefficient of thermal expansion (CTE) for the materials of interest are collected in this database. The material model is defined by the variable ITYPE. The available material models and the corresponding ITYPE are listed in Table 1. The properties for each material are divided into the elastic part and the inelastic part. For each material, the elastic part is tabulated as a function of temperature. The elastic properties consist of the elastic modulus, Poisson's ratio and the secant CTE.

Table 1. Types of Material Models in FIDEP2

ITYPE	MATERIAL MODEL
1	Thermoelastic
2	Bilinear thermoelastic-plastic - Algorithm 1
3	Bilinear thermoelastic-plastic - Algorithm 2
4	Bodner-Partom with directional hardening and damage
5	Bodner-Partom with backstress
6	Bodner-Partom with directional hardening
7	New Bodner-Partom with directional hardening

The material database file format is as follows:

The top line in the file

1 line	title
--------	-------

For each material, the format for the elastic part is as follows:

1 line	separating or dummy line between materials
1 line	IMAT, material number in sequential order;
	ITYPE, type of material model

1 line	name of material
1 line	NROW, number of rows of data
1 line	header line for the properties
NROW lines	Temperature, elastic modulus (GPa); Poisson's ratio, secant CTE (10 ⁻⁶ /° C)
1 line	Reference temperature ° C for secant CTE

If the material is elastic, i.e., ITYPE=1, the properties for the next material are listed. If the material is inelastic, i. e., ITYPE>1, the elastic part is followed by tables of the inelastic properties. The specific order of listing of the properties for different constitutive models is shown in Table 2. The inelastic properties for these constitutive models should be listed in the exact sequence defined in this table. The temperature-dependent properties can be separated into different sets to accommodate the properties measured at different temperature intervals from each other. Each set is formatted as follows:

1 line	NSET, number of sets of inelastic properties
1 line	NROW, number of rows of data; N, (umber of columns of properties
1 line	header line
NROW lines	Temperature; property 1; property 2; ... ; property N (If NROW = 1, then no temperature is specified)

Table 2. Listing of the Material Properties for ITYPE = 1 Thermoelastic Material Model

TP(IM, IR, IC)	IC	IS
E(IR)	1	1 = elastic properties
_(IR)	2	
CTE(IR)	3	

Table 3. Listing of the Material Properties for ITYPE = 2, 3 Thermoelastic-Plastic Material Model

TP(IM, IR, IC)	IC	IS
E(IR)	1	1 = elastic properties
_(IR)	2	
CTE(IR)	3	
s _y (IR)	4	2 = First set of inelastic properties
E _p (IR)	5	

Table 4. Listing of the Material Properties for ITYPE = 4 Bodner-Partom with Directional Hardening And Damage

TP(IM, IR, IC)	IC	IS
E(IR)	1	1 = elastic properties
_(IR)	2	
CTE(IR)	3	
ISUB	4	2 = First set of inelastic properties
n(IR)	5	
Z ₀ (IR)	6	
Z ₃ (IR)	7	
m ₂ (IR)	8	
A ₁	9	3 = Second set of inelastic properties
m ₁	10	
Z ₁	11	
r ₁ =r ₂	12	
D ₀	13	
Sm	14	4 = Damage Properties
Sch	15	5 =Damage Properties
Scl	16	
m	17	
Theta	18	
D*	19	
Beta	20	
Dch	21	

Table 5. Listing of the Material Properties for ITYPE = 5 Bodner-Partom Material Model with Backstress

TP(IM, IR, IC)	IC	IS
E(IR)	1	1 = elastic properties
_(IR)	2	
CTE(IR)	3	
ISUB	4	2 = First set of inelastic properties
n(IR)	5	
Z ₀ (IR)	6	
f ₁ (IR)	7	
f ₃ (IR)	8	
W _{max} (IR)	9	
s ₀	10	3 = Second set of inelastic properties
D ₀	11	

Table 6. Listing of the Material Properties for ITYPE = 6 Bodner-Partom Material Model with Directional Hardening

TP(IM, IR, IC)	IC	IS
E(IR)	1	1 = elastic properties
_(IR)	2	
CTE(IR)	3	
ISUB	4	2 = First set of inelastic properties
n(IR)	5	
Z ₀ (IR)	6	
Z ₃ (IR)	7	
m ₂ (IR)	8	
A ₁	9	3 = Second set of inelastic properties
m ₁	10	
Z ₁	11	
r ₁ =r ₂	12	
D ₀	13	

Table 7. Listing of the Material Properties for ITYPE = 7 New Bodner-Partom Model with Directional Hardening

TP(IM, IR, IC)	IC	IS
E(IR)	1	1 = elastic properties
_(IR)	2	
CTE(IR)	3	
ISUB	4	2 = First set of inelastic properties
n(IR)	5	
Z ₀ (IR)	6	
Z ₃ (IR)	7	
m ₂ (IR)	8	
A ₁	9	3 = Second set of inelastic properties
m ₁	10	
Z ₁	11	
r ₁ =r ₂	12	
D ₀	13	

Notes:

IM = Material number

IR = Row number

IS = Data set number

IC = Column number

TP(IM, IR, IC) = Temperature-dependent material properties array where IM is the material number, IR is the row number of the corresponding temperature value, and IC is the column number corresponding to the mechanical property

AT(IM, IR, IS) = Temperature values for the data set of temperature-dependent properties, IS

Material properties can also be given in function form in the program by inserting -9999 for the requested property in the table and adding the appropriate function to the program. Two material data files were used in our investigations. MATERIAL.DAT, consisting of properties for SCS-6 fiber, Ti-24Al-11Nb and Timetal α 21S matrices (see Appendix A), and TIMETAL.DAT, consisting of properties for SCS-6 fiber, Timetal21S matrix, and [90] SCS-6/Timetal21S composite (see Appendix B).

For material represented by a Bodner-Partom model, and additional material properties, ISUB, is used. The ISUB initiates more subcuts in numerical computation for higher temperatures where viscoplastic response is more prevalent. The values of ISUB are defined by the user. Examples of ISUB values are shown later in Table 8. For the material information shown in Appendices A and B, ISUB values would need to be included for appropriate material model types.

2.1.2 Input Loading File

This file consists of loading conditions, type of problem, materials to be used in the analysis, and parameters for printing the output. There are two types of case files: stress loading and strain loading. These files differ only in the loading section. The format is as follows:

1 line	Title line
1 line	ICASE, type of problem, ILOAD, loading type
1 line	Material database file name
1 line	NCBlock, number of blocks in loading history
1 line	Header line for block
1 line	NLOAD, number of rows of data in the block loading history, NCYCLE, number of cycles for block execution, IPRINTSTEP, print frequency, ISTEPOUT, print start, INTOUT, out put at material number, NIOUT, crosssectional stress file
1 line	Step numbers of output of stresses at the cross section if NIOUT $\neq$ 0
1 line	Header line for the loading history table
NLOAD lines	Step number, time (s), temperature: (for stress loading) applied axial stress (MPa); radial stress (MPa); or (for strain loading) applied axial strain (mm/mm) *Repeat previous 5 items for each block
1 line	blank
1 line	NOMAT, number of materials
1 line	IMAT, material ID; VF, volume fraction; NODES, number of nodes

The loading cases and the corresponding ICASE number are shown in Table 4.

Table 8. Types of Micromechanical Models and Loading in FIDEP2

ICASE	PROBLEM TYPE
1	Multiple concentric cylinder model
2	Uniaxial stress model
3	Concentric cylinder model with parallel [90] element
ILOAD	PROBLEM TYPE
0	Stress load control
1	Strain load control

An example loading file is shown in Table 9.

Table 9. Example Loading File

Example file	Explanation
COOL-DOWN OF [0] SCS-6/TIMETAL®21S	header line
1 0	case number and stress/strain control flag
MATERIAL	material file name
1	number of blocks in history data
BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INOUT NIOUT	header line
5 1 100 9 1 3	number of rows of history data and output flags
3 720 900	detailed output at these steps
Step, t(s), T(C), Axial, Radial	header line
0 0 900 0 0	
1800 14400 621 0 0	
3600 43200 621 0 0	loading data
7200 72000 23 0 0	
9000 72090 900 0 0	
2	number of materials
14 0.35 3	material ID, volume fraction, number of nodes
16 0.65 15	

2.2 Running the Program and Output Files

The program is run interactively after compiling on any computer with a FORTRAN compiler. The user is prompted for input and output filenames and given the option to print out material properties in the output file.

The output consists of the echo of the input parameters and the computed stress and strain values. One output file is created for the uniaxial stress model. The top lines consist of the input loading data and material properties if requested, followed by output data with columns shown in Table 10.

Two output files are created for the models consisting of the CCM. The first file contains echo of the input loading parameters and, if desired, the material properties. For the CCM, the first output file consists of the stresses and strains at the interface for every n steps specified in the load history file as shown in Table 11. At the steps specified by the input file, stresses and plastic strains across the cross section as a function of radius are written to a separate output. The second data file, called the Y-file, includes the average stresses and mechanical strains in each material and the total composite strain, as shown in Table 12. All output files also contain the computational step number, time, temperature and the resultant composite stress.

Table 10. Listing of Columns in Output File for Uniaxial Stress Model

Column	Variable
1	Block
2	Cycle
3	Computational Step
4	Time (s)
5	Temperature (° C)
6	Applied Stress (MPa)
7	Stress in Laminate 1 (MPa)
8	Stress in Laminate 2 (MPa)
9	Stress in Laminate 3 (MPa)
10	Total Strain
11	Strain in Laminate 1
12	Strain in Laminate 2
13	Strain in Laminate 3

Table 11. Listing of Columns in First Output File for Options with CCM

Column	Variable
1	Block
2	Cycle
3	Computational Step
4	Time (s)
5	Temperature (° C)
6	Effective stress at the interface(MPa)
7	Radial stress at the interface (MPa)
8	Tangential stress at the interface (MPa)
9	Axial stress at the interface (MPa)
10	Radial strain at the interface
11	Tangential strain at the interface
12	Axial strain at the interface

*

Cross sectional results at the specified computational step in the input file

1	Radius
2	Effective stress (MPa)
3	Radial stress (MPa)
4	Tangential stress (MPa)
5	Axial stress (MPa)
6	Radial strain
7	Tangential strain
8	Axial strain

Table 12. Listing of Columns in Second Output File for Options with CCM

Column	Variable
1	Block
2	Cycle
3	Computational step
4	Time (s)
5	Temperature (° C)
6	Applied stress (MPa)
7	Average fiber stress (MPa)
8	Average matrix stress (MPa)
9	Average [90] ply stress (MPa)
10	Mechanical strain in the fiber
11	Mechanical strain in the matrix
12	Mechanical strain in the [90] ply
13	Total composite strain

SECTION 3

DEMONSTRATION PROBLEMS

In this section the capabilities of the FIDEP2 code are exercised and some benchmark problems are presented. The material models used for these problems are given in Table 13. Also, references are given in the table for the sources of the material properties in the unified model. The material data file for these runs is listed in Table 14. The file consists of the material properties for Timetal21S matrix, SCS-6 fiber, and material constants for the [90] SCS-6/Timetal21S damage model.

The cases that are investigated are monotonic loading of a uniaxial bar, cool-down of a concentric cylinder model, thermomechanical fatigue behavior of a concentric cylinder model, and cyclic behavior of a [90] ply composite using a damage model. The input file, a plot of the loading history and relevant output plots are presented. The complete output files are listed in Appendix C. In running problems, if a convergence is not obtained, the number of computational steps can be increased until the solution converges. For time-independent problems, the usual number of computational steps between loading peaks is 30 steps; for time-dependent constitutive models, the steps are approximately 400.

Table 13. List of Material Constitutive Models in Sample Input File

Material No.	Material Model	Material Definition
1	1	Thermoelastic response for SCS-6 fiber
2	2	Bilinear elastic-plastic response for Timetal21S
3	5	Bodner-Partom theory with backstress for Timetal21S (Sherwood and Quimby, 1995)
4	6	Bodner-Partom theory with directional hardening for Timetal21S (Neu, 1993)
5	4	Directional B-P theory with [90] ply damage model (Neu et al., 1996)

Table 14. Sample Material Data File

Sample Material Database File for FIDEP2.6

=====

1 1

Thermo-Elastic Response for SCS-6 fiber

10

T(C)	E(GPa)	NU	CTE(1E-6/C)
21.11	393	0.25	3.9907
93.33	390	0.25	4.0289
204.44	386	0.25	4.0989
315.56	382	0.25	4.1801
426.67	378	0.25	4.2655
537.78	374	0.25	4.3510
648.89	370	0.25	4.4324
760.00	365	0.25	4.5074
871.11	361	0.25	4.5718
1093.3	354	0.25	4.5723

900

2 2

Bilinear Elastic-Plastic Response for Timetal21S

7

T(C)	E(GPa)	NU	CTE(1E-6/C)
23	114	0.34	8.8700
260	114	0.34	9.8800
482	90	0.34	10.713
650	78	0.34	11.282
760	70	0.34	11.624
815	64	0.34	11.787
900	55	0.34	12.027

900

1

7 2

T(C)	SY(MPa)	EP(GPa)
23	1107.	0.459
260	1010.	1.486
482	810.	2.000
650	350.	0.000
760	120.	0.000
815	110.	0.000
900	94.0	0.000

3 5

Sherwood's Model with Backstress for Timetal21S

17

Temp	E (GPa)	NU	CTE (1E-6/C)
23.0	114.30	0.3400	9.490
260.0	108.00	0.3400	10.45
482.0	90.37	0.3400	11.24
560.0	83.02	0.3400	11.50
584.0	80.76	0.3400	11.57
600.0	79.25	0.3400	11.62
610.0	78.31	0.3400	11.66
620.0	77.37	0.3400	11.69
627.0	76.71	0.3400	11.71
634.0	76.05	0.3400	11.73
639.0	75.58	0.3400	11.75
643.0	75.20	0.3400	11.76
647.0	74.82	0.3400	11.78
650.0	74.54	0.3400	11.78
760.0	60.28	0.3400	12.11
815.1	53.22	0.3400	12.27
900.0	53.22	0.3400	12.27

Table 14. Sample Material Data File (Continued)

900.0						
2						
17	6					
Temp	ISUB	n	Zo	F1	F3	BSMAX
22.99	1.	1.9500	3.390E+02	4.499E+04	8.795E-01	7.440E+02
260.0	2.	1.8500	3.820E+02	3.700E+04	8.152E-01	5.730E+02
482.0	2.	1.5000	4.980E+02	3.559E+04	7.954E-01	5.120E+02
560.0	2.	0.8500	1.565E+03	2.858E+04	4.746E-01	3.000E+02
584.0	5.	0.6500	3.173E+03	2.643E+04	3.759E-01	2.350E+02
600.0	10.	0.5170	6.684E+03	2.499E+04	3.101E-01	1.910E+02
610.0	15.	0.4330	1.326E+04	2.409E+04	2.690E-01	1.640E+02
620.0	20.	0.3500	3.597E+04	2.319E+04	2.279E-01	1.360E+02
627.0	20.	0.2920	1.007E+05	2.257E+04	1.991E-01	1.180E+02
634.0	20.	0.2330	4.681E+05	2.194E+04	1.703E-01	9.900E+01
639.0	20.	0.1920	2.472E+06	2.149E+04	1.497E-01	8.500E+01
643.0	20.	0.1580	1.752E+07	2.113E+04	1.333E-01	7.400E+01
647.0	20.	0.1250	3.519E+08	2.077E+04	1.168E-01	6.300E+01
650.0	20.	0.1000	1.240E+10	2.050E+04	1.045E-01	5.500E+01
760.0	30.	0.1200	2.470E+08	9.900E+02	2.400E-03	3.000E+00
815.1	50.	0.1160	2.450E+08	7.600E+02	1.900E-03	1.000E+00
900.0	60.	0.0700	2.430E+08	5.000E+02	5.000E-04	5.000E-01
1	1					
D0						
1.0E4						

4	6					
Bodner-Partom Theory for Timetal21S, Neu 93						
16						
T(C)	E(GPa)	NU	CTE(1E-6/C)			
23	112.0	0.34	9.7787			
260	108.0	0.34	10.713			
315	106.1	0.34	10.915			
365	104.1	0.34	11.093			
415	101.7	0.34	11.267			
465	99.09	0.34	11.436			
482	98.11	0.34	11.492			
500	97.05	0.34	11.550			
525	95.50	0.34	11.631			
550	93.87	0.34	11.710			
575	92.17	0.34	11.788			
600	90.40	0.34	11.865			
650	86.61	0.34	12.014			
760	77.22	0.34	12.323			
815	71.96	0.34	12.467			
900	63.12	0.34	12.689			
900						
2						
16	5					
T(C)	ISUB	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)	
23	1.	4.800	1550.0	100.0	0.350	
260	1.	3.500	1300.0	300.0	0.350	
315	1.	3.054	1250.4	390.0	1.502	
365	1.	2.649	1205.4	500.0	2.549	
415	2.	2.243	1160.4	660.0	3.597	
465	2.	1.838	1115.3	960.0	4.644	
482	5.	1.700	1100.0	1100.	5.000	
500	7.	1.500	1089.3	1300.	5.763	
525	10.	1.280	1074.4	1670.	6.822	
550	10.	1.100	1059.5	2100.	7.881	
575	10.	0.970	1044.6	2600.	8.941	
600	15.	0.820	1029.8	3700.	10.00	
650	15.	0.740	1000.0	3800.	10.00	

Table 14. Sample Material Data File (Continued)

	760	20.	0.580	600.0	4000.	15.00	
	815	20.	0.550	300.0	4100.	30.00	
	900	30.	0.550	300.0	4300.	30.00	
1 5							
	A1=A2	M1	Z1	R1=R2	DO		
	-9999	0.0	1600.	3.0	10000.		

5	4						
Directional B-P Theory with [90] Ply Damage Model of Neu 94							
8							
	T(C)	E(GPa)	NU	CTE(1E-6/C)			
	23	133	0.19	9.7787			
	260	128	0.19	10.713			
	482	119	0.19	11.492			
	538	115	0.18	11.670			
	593	112	0.18	11.860			
	650	105	0.17	12.014			
	815	50	0.17	12.467			
	900	20	0.17	12.689			
900							
4							
16 5							
	T(C)	isub	N	Z0=Z2(1/S)	Z3(MPa)	M2(1/MPa)	
	23	1.	4.800	1550.0	100.0	0.350	
	260	2.	3.500	1300.0	300.0	0.350	
	315	2.	3.054	1250.4	390.0	1.502	
	365	2.	2.649	1205.4	500.0	2.549	
	415	3.	2.243	1160.4	660.0	3.597	
	465	3.	1.838	1115.3	960.0	4.644	
	482	4.	1.700	1100.0	1100.	5.000	
	500	5.	1.500	1089.3	1300.	5.763	
	525	7.	1.280	1074.4	1670.	6.822	
	550	10.	1.100	1059.5	2100.	7.881	
	575	20.	0.970	1044.6	2600.	8.941	
	600	30.	0.820	1029.8	3700.	10.00	
	650	40.	0.740	1000.0	3800.	10.00	
	760	50.	0.580	600.0	4000.	15.00	
	815	60.	0.550	300.0	4100.	30.00	
	900	70.	0.550	300.0	4300.	30.00	
1 5							
	A1=A2	M1	Z1	R1=R2	DO		
	-9999	0.0	1600.0	3.0	10000.		
7 1							
	Temp	Sm					
	23.	190 .					
	260.	130.					
	482.	70.					
	538.	50.					
	593.	36.					
	650.	17.					
	815.	.0					
1 7							
	scho	scl	m	theta	Dstar	beta	Dch
	80	0.	1.	100.	0.61	0.05	0.5

6	7						

3.1 Tensile Behavior of a Uniaxial Bar Using Bodner-Partom with Backstress (Cases 1 and 2)

Simulation of strain controlled tensile loading were conducted on uniaxial bars at 25° C and 450° C to verify the implementation of the Bodner-Partom with backstress constitutive model in the code. The loading history, consisting of a constant temperature and a constant strain rate, is shown in Figure 2. The material is ramped to a strain of 0.04 at 23° C and 450° C at a strain rate of 833E-6/s. The input files are shown in Tables 14 and 15. The resulting stress-strain behavior is shown in Figure 3.

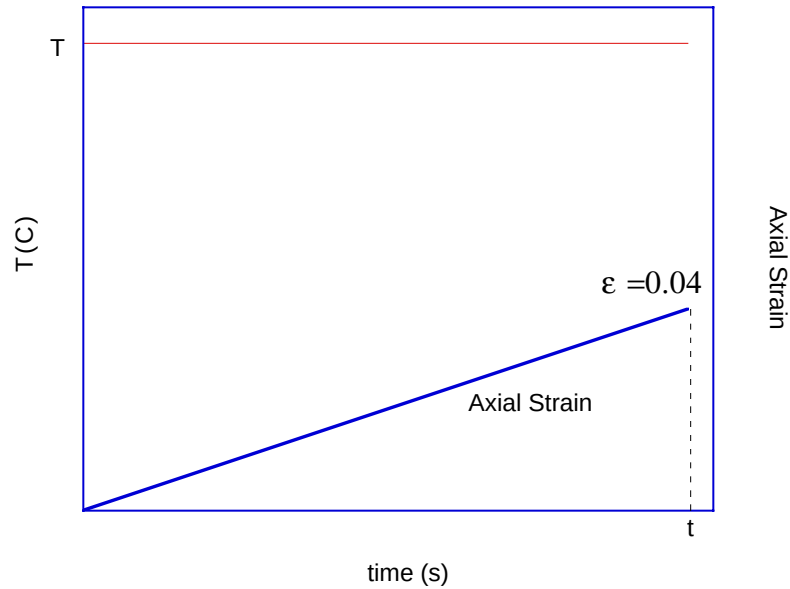


Figure 2. Loading history for Tensile Loading of a Bar in Cases 1 - 4.

Table 15. Input File for Case 1 (23° C)

Bodner-Partom with Backstress at 23C (strain rate = 833E-6/s)

2 1

sample_mat

1

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

2 1 20 0 1 0

Step	Time	Temp	Load	SR
------	------	------	------	----

0	0.0	23.0	0.0	0.
---	-----	------	-----	----

480	48.0	23.0	0.04	0.
-----	------	------	------	----

1

3 1.00 2

Table 16. Input File for Case 2 (450° C)

Bodner-Partom with Backstress at 450C (strain rate = 833E-6/s)

2 1

sample_mat

1

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

2 1 20 0 1 0

Step	Time	Temp	Load	SR
------	------	------	------	----

0	0.0	450.0	0.0	0.
---	-----	-------	-----	----

480	48.0	450.0	0.04	0.
-----	------	-------	------	----

1

3 1.00 2

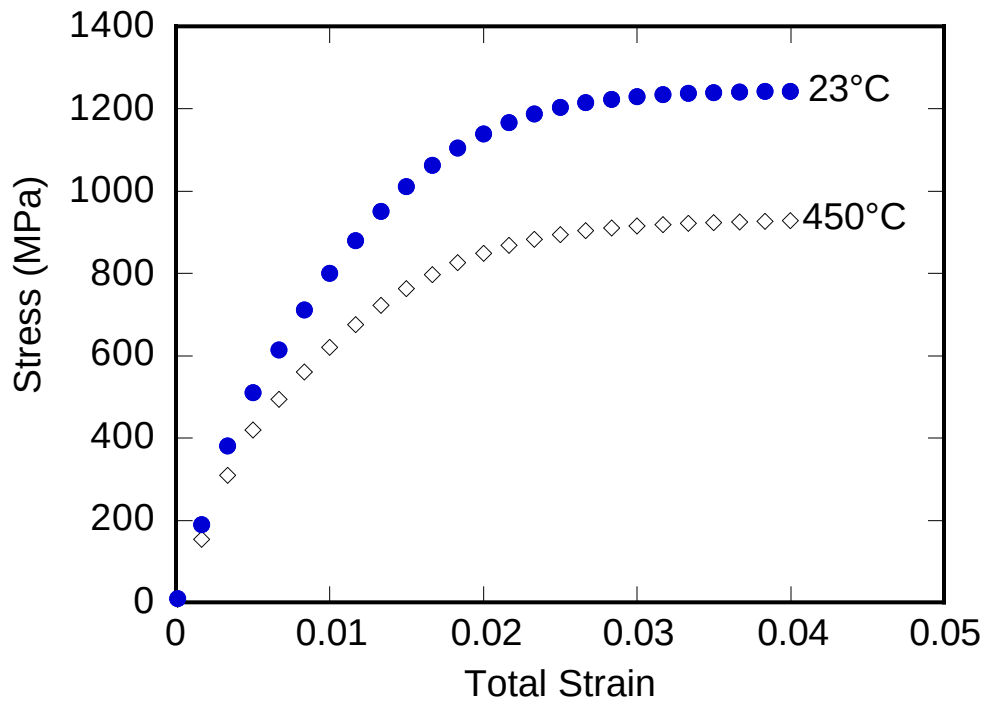


Figure 3. Stress-Strain Behavior for Cases 1 and 2.

3.2 Tensile Behavior of a Uniaxial Bar Using Bodner-Partom with Directional Hardening (Cases 3 and 4)

Simulation of strain-controlled tensile loading were conducted on uniaxial bars at 25° C and 650° C to verify the implementation of the Bodner-Partom model with directional hardening in the code. The loading history, consisting of a constant temperature and a constant strain rate, is shown in Figure 2. The material is ramped to a strain of 0.04 at 23° C and 650° C at a strain rate of 8.33E-6/s. The input files are shown in Tables 17 and 18. For case 4 at 650° C, the program did not converge for the same 480 steps used in the previous cases. The steps were increased until the program did converge, which in this case turned out to be 1,600 steps. The stress-strain behavior is shown in Figure 4.

Table 17. Input File for Case 3 (23° C)

Bodner Partom with Dir. Hardening at 23C (strain rate = 833E-6/s)

2 1

sample_mat

1

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

2 1 20 0 1 0

Step Time Temp Load SR

0 0.0 23.0 0.0 0.

480 4800.0 23.0 0.04 0.

1

4 1.00 2

Table 18. Input File for Case 4 (650° C)

Bodner Partom with Dir. Hardening at 650C (strain rate = 833E-6/s)

2 1

sample_mat

1

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

2 1 40 0 1 0

Step Time Temp Load SR

0 0.0 650.0 0.0 0.

1600 4800.0 650.0 0.04 0.

1

4 1.00 2

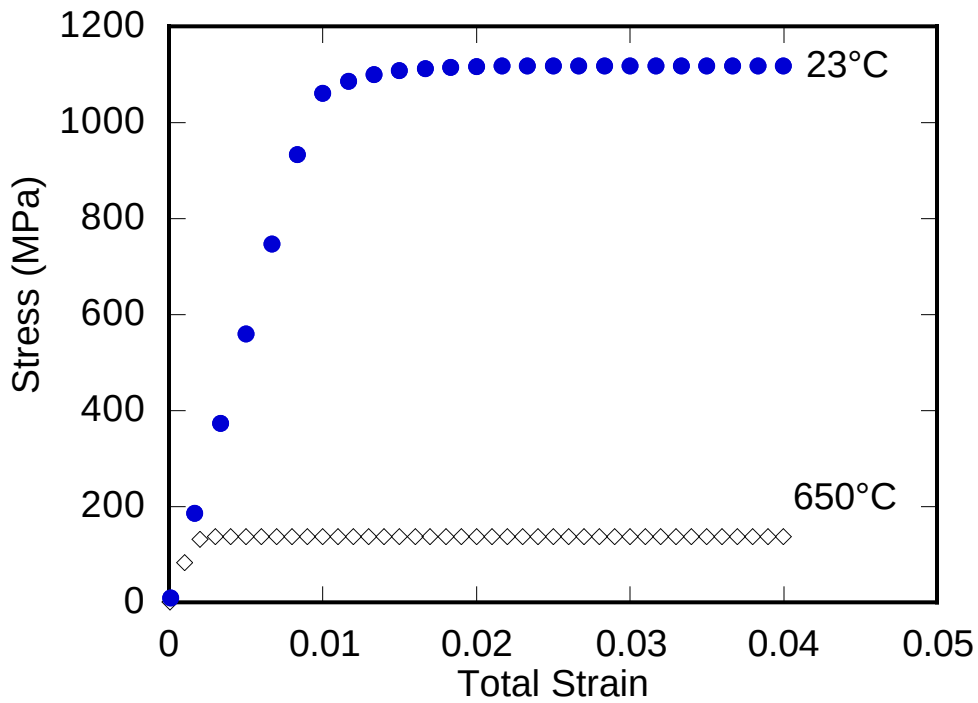


Figure 4. Stress-Strain Behavior for Cases 3 and 4.

3.3 Uniaxial Bar Under Thermal and Mechanical Loading (Case 5)

Thermomechanical strain loading was applied to a uniaxial bar with loading history as shown in Figure 5. The input file is shown in Table 19. The resultant stress-strain behavior is shown in Figure 6.

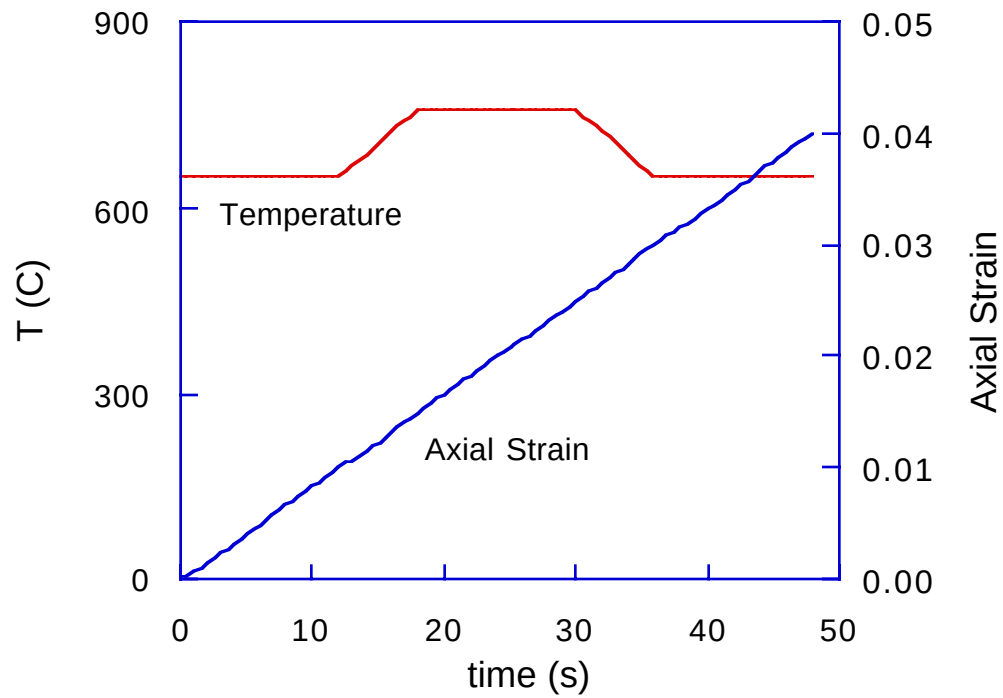


Figure 5. Loading History for Case 5.

Table 19. Input File for Case 5

Bodner Partom with Dir. Hardening from 650C to 750C

2 1

sample_mat

1

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

	6		1		40	0	1	0
Step	Time	Temp	Load	SR				
0	0.0	650.0	0.0	0.				
1200	12.0	650.0	0.01	0.				
1800	18.0	750.0	0.015	0.				
2400	30.0	750.0	0.025	0.				
3600	36.0	650.0	0.03	0.				
4800	48.0	650.0	0.04	0.				

1

4 1.00 2

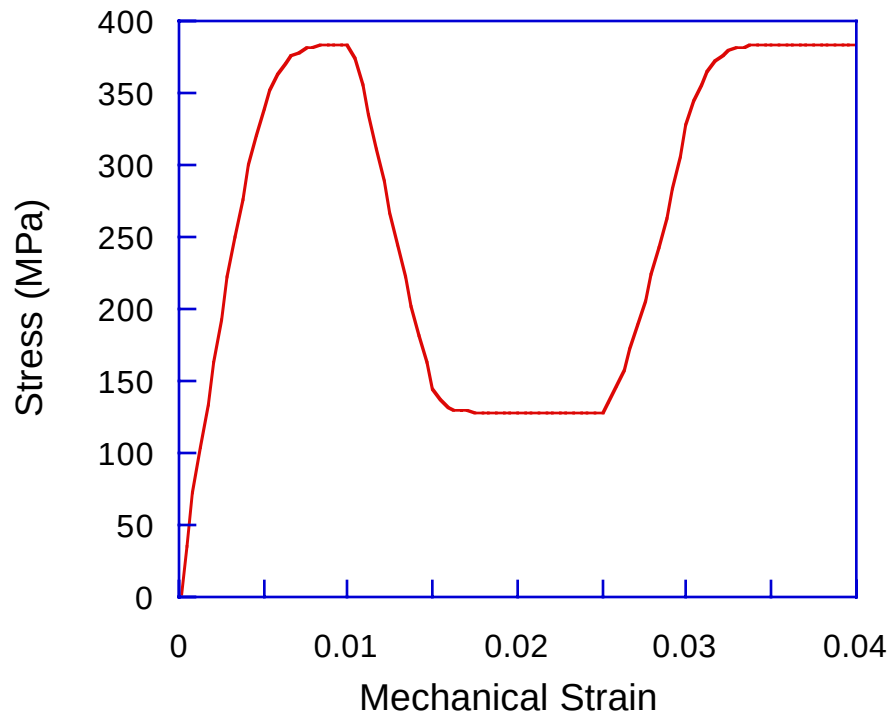


Figure 6. Stress-Strain Behavior for Case 5.

3.4 Cool-Down of a CCM with Elastic-Plastic Matrix (Case 6)

The CCM with elastic SCS-6 fiber and bilinear thermoelastic-plastic Timetal21S matrix is cooled down to room temperature from a processing temperature of 900° C. The temperatures profile is shown in Figure 7. The input file is given in Table 20. The average matrix and fiber stress obtained from the second output file is shown in Figure 8. The stress components in the matrix at the interface, which is obtained from the first output file, are shown in Figure 9. The stresses across the cross section at room temperature are shown in Figure 10, obtained from the end of the first output file.

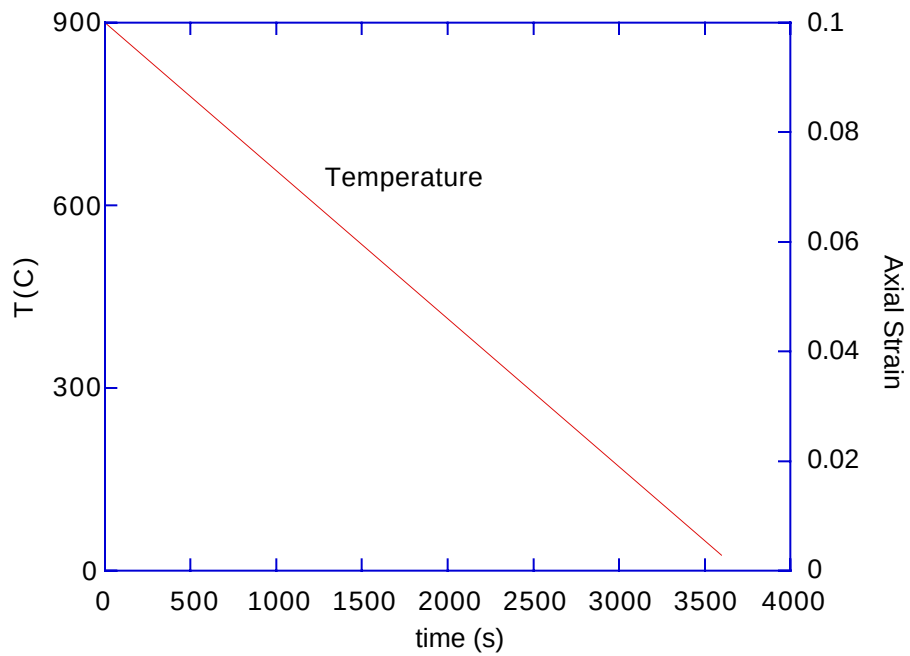


Figure 7. Loading History for Cases 6 and 7.

Table 20. Input File for Case 6

SCS-6/TIMETAL21S(EP) Concentric Cylinder cooled from 900C to 23C

1 0

sample_mat

1

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

2 1 10 0 2 1

360

Step	Time	Temp	Load	SR
------	------	------	------	----

0	0.0	900.0	0.0	0.
---	-----	-------	-----	----

360	3600.0	23.0	0.0	0.
-----	--------	------	-----	----

2

1	0.35	5
---	------	---

2	0.65	15
---	------	----

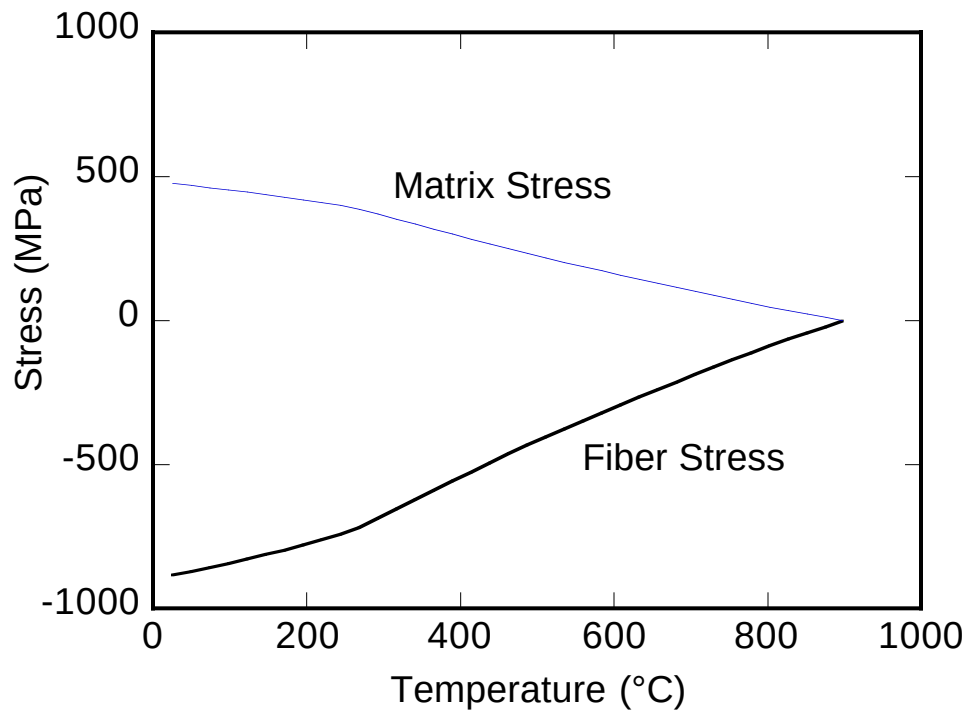


Figure 8. Average Stresses in the Matrix and Fiber During Cool-Down.

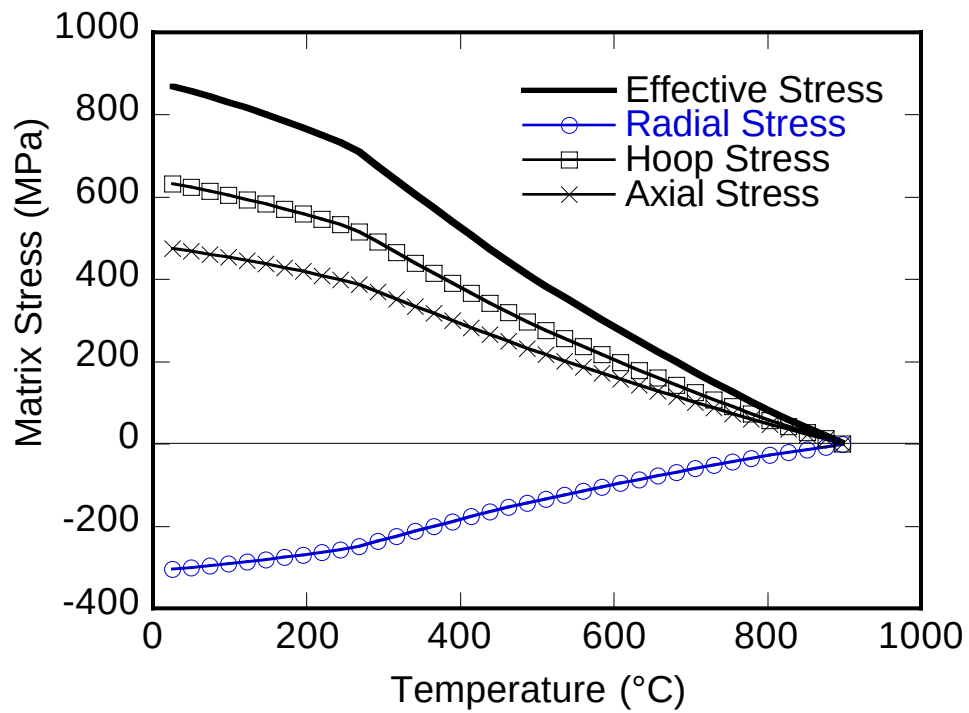


Figure 9. Stresses in the Matrix at the Fiber/Matrix Interface — Case 6.

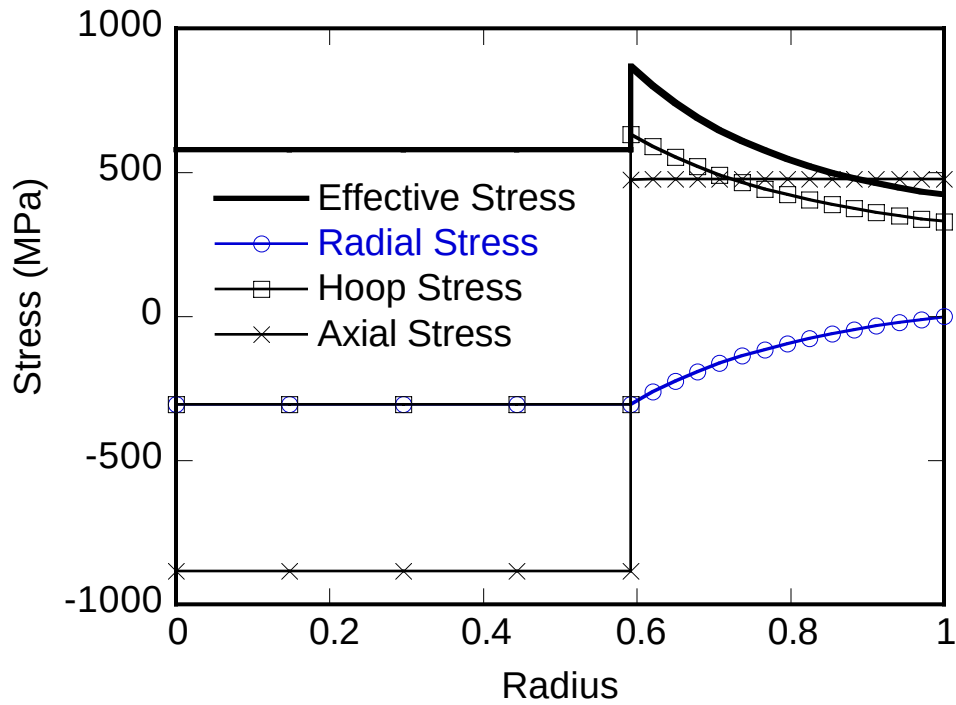


Figure 10. Stresses Across the Cross Section at Room Temperature.

3.5 Cool-Down of a CCM Using Bodner-Partom with Directional Hardening Matrix (Case 7)

The CCM with elastic SCS-6 fiber and viscoplastic Timetal21S matrix is cooled down to room temperature from a processing temperature of 900° C as is shown in Figure 5. The input file is given in Table 21. The average matrix and fiber stresses obtained from the second output file are shown in Figure 11. The stress components in the matrix at the interface are shown in Figure 12 which is obtained from the first output file. The stresses across the cross section at room temperature are shown in Figure 13, obtained from the end of the first output file. Compared to the Case 6 the stresses have relaxed due to viscoplastic behavior of the matrix.

Table 21. Input File for Case 7

SCS-6/TIMETAL21S(DBP) Concentric Cylinder cooled from 900C to 23C

1 0

sample_mat

1

BLOCK	1	NUMBER OF CYCLES	PRFREQ	PRSTART	INTOUT	NIOUT
	2	1	100	0	2	1

3600

Step	Time	Temp	Load	SR
0	0.0	900.0	0.0	0.
3600	3600.0	23.0	0.0	0.

2

1	0.35	7
2	0.65	20

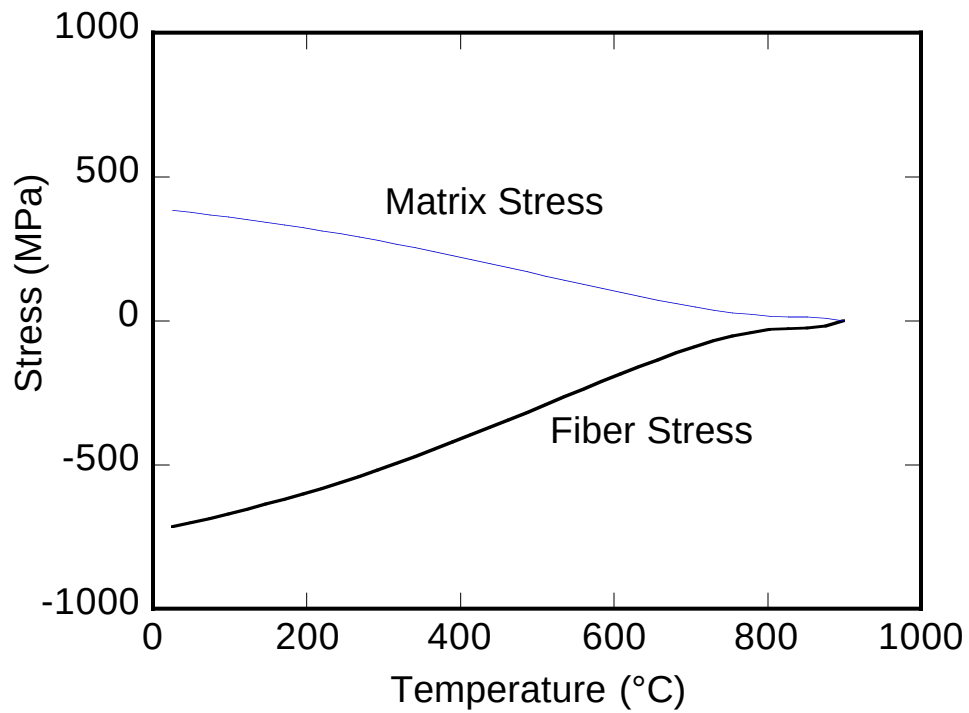


Figure 11. Average Stresses in the Matrix and Fiber During Cool-Down.

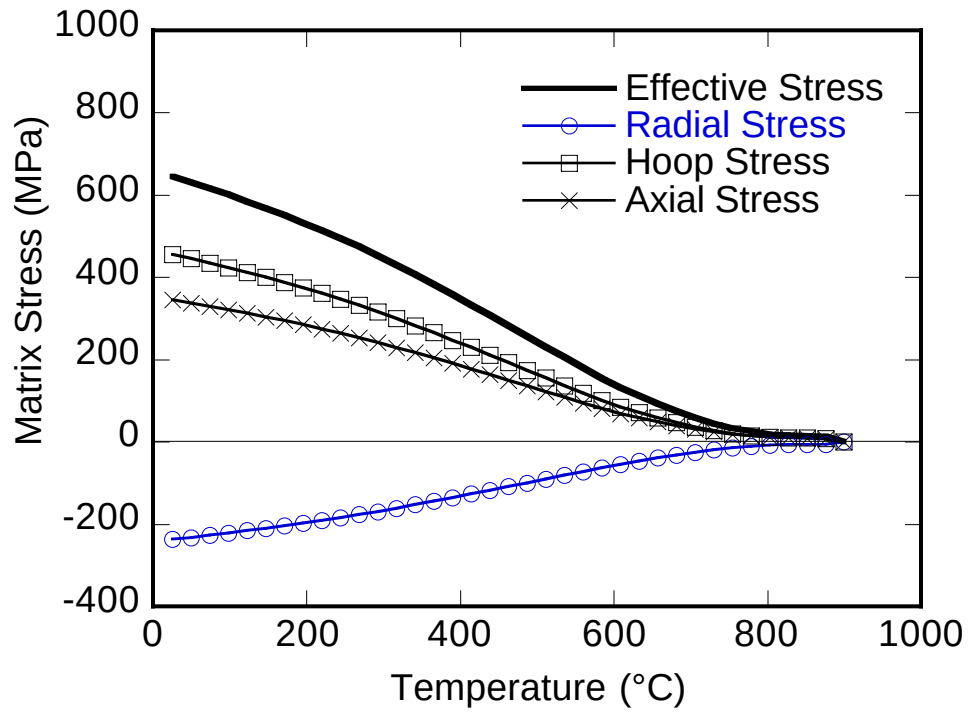


Figure 12. Stresses in the Matrix at the Fiber/Matrix Interface — Case 7.

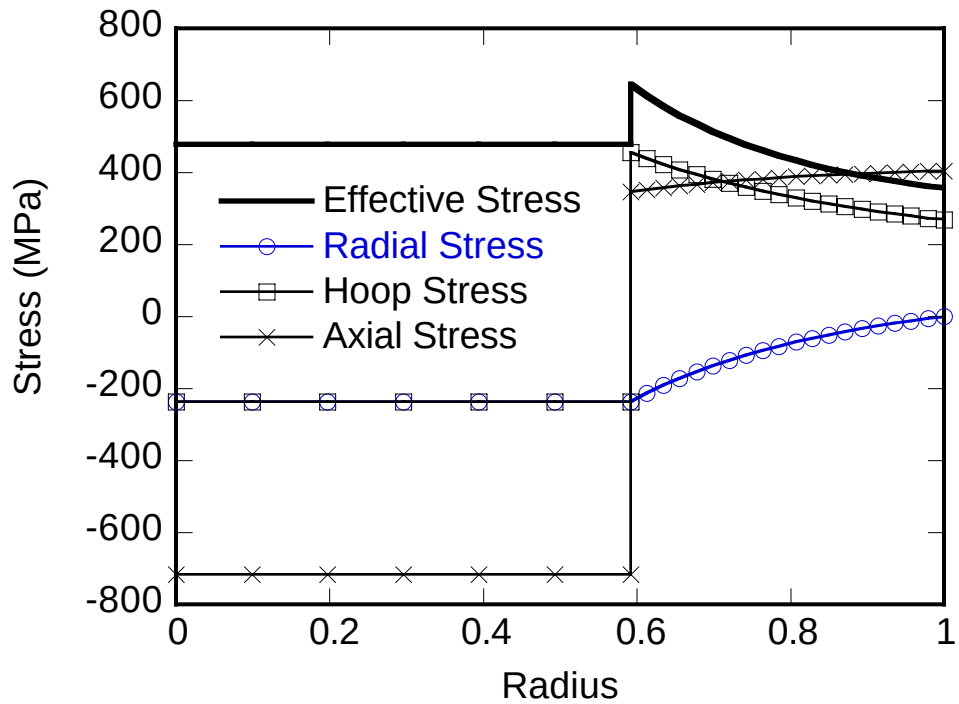


Figure 13. Stresses Across the Cross Section at Room Temperature — Case 7.

3.6 Thermomechanical Cyclic Behavior of CCM Under Mechanical Strain Loading (Case 8)

The CCM with elastic SCS-6 fiber and viscoplastic Timetal21S matrix is thermomechanically cycled after being cooled down to room temperature from a processing temperature of 900° C (Figure 14). The simulation is conducted under strain controlled loading. The input file is shown in Table 22. The average matrix and fiber stresses together with the total stress and temperature are shown in Figure 15. The stresses across the cross section at minimum temperature of the cycle, 150° C, are shown in Figure 16.

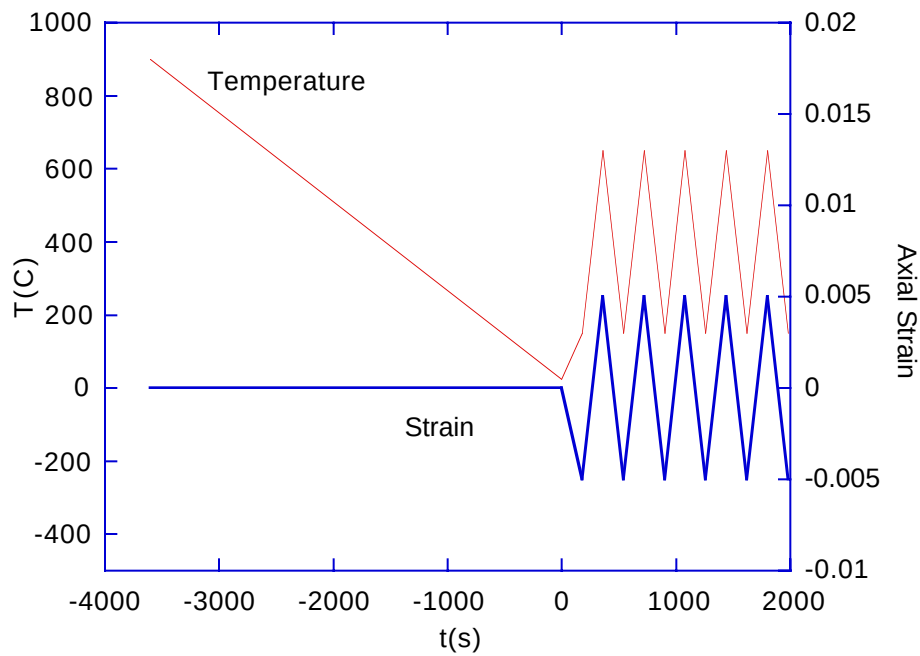


Figure 14. Loading History for Case 8.

Table 22. Input File for Case 8

SCS-6/TIMETAL21S(DBP) In-Phase TMF - strain control

1 1

sample_mat

2

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

2 1 10 0 2 0

Step Time Temp Load SR

0 0.0 900.0 0.0 0.

1000 3600.0 23.0 0.0 0.

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

11 1 10 0 2 2

0 1100

Step Time Temp Load SR

0 0.0 23.0 0.0 0.

100 180.0 150.0 -0.005 0.

200 360.0 650.0 0.005 0.

300 540.0 150.0 -0.005 0.

400 720.0 650.0 0.005 0.

500 900.0 150.0 -0.005 0.

600 1080.0 650.0 0.005 0.

700 1260.0 150.0 -0.005 0.

800 1440.0 650.0 0.005 0.

900 1620.0 150.0 -0.005 0.

1000 1800.0 650.0 0.005 0.

1100 1980.0 150.0 -0.005 0.

2

1 0.35 5

4 0.65 15

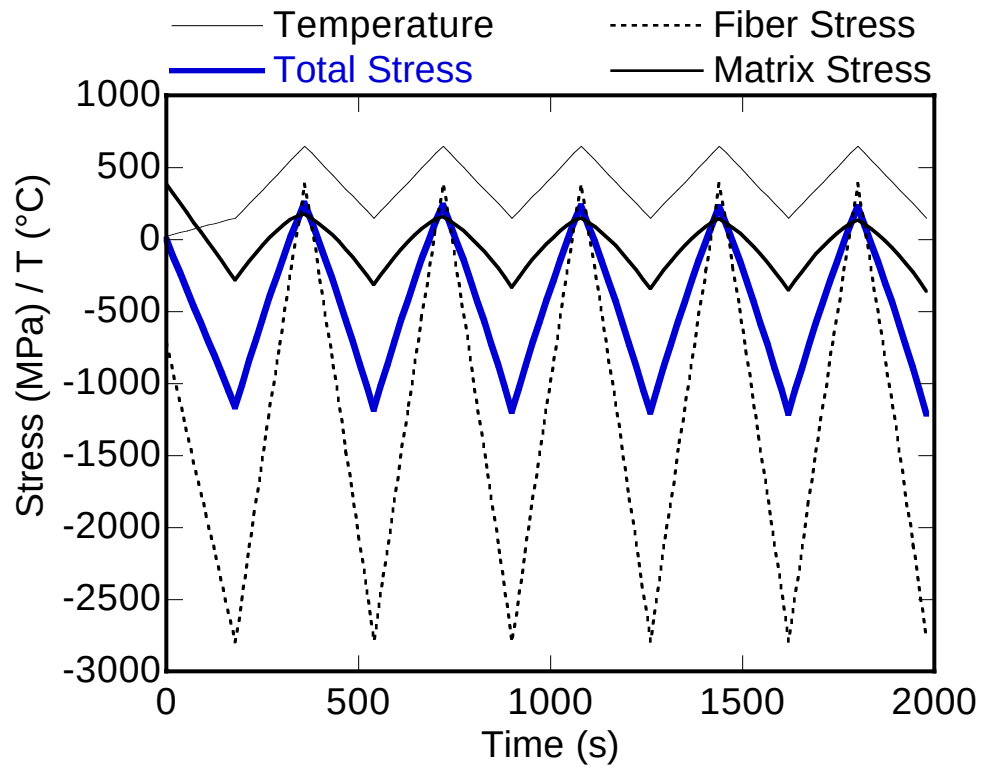


Figure 15. Average Stresses in the Matrix and Fiber.

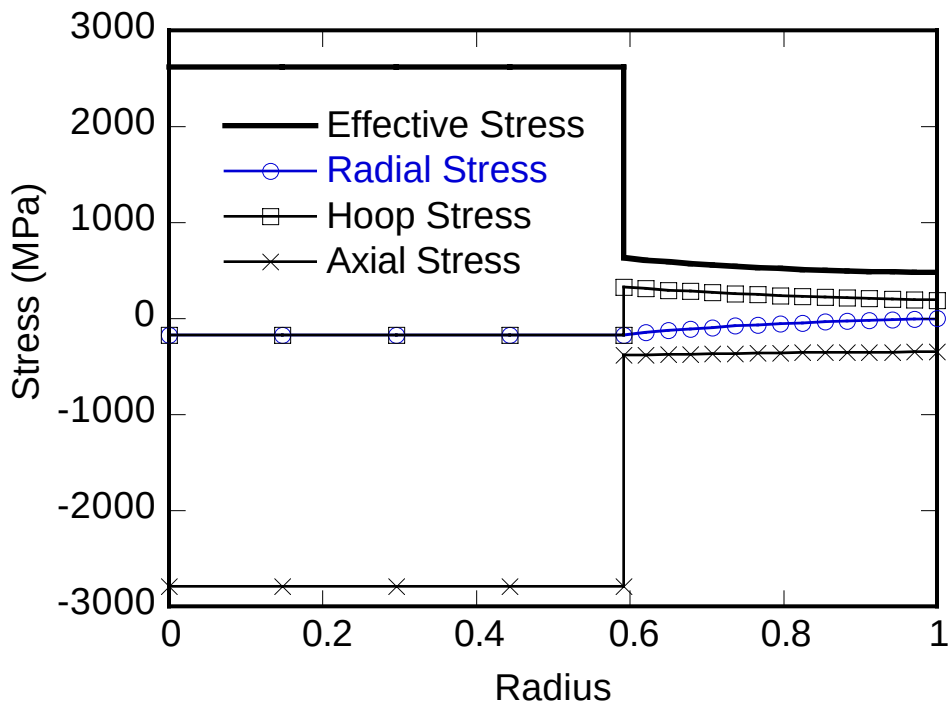


Figure 16. Stresses Across the Cross Section at 150° C.

3.7 Thermomechanical Cyclic Behavior of CCM Under Mechanical Stress Loading (Case 9)

The concentric cylinder model with elastic SCS-6 fiber and viscoplastic Timetal21S matrix is thermomechanically cycled after being cooled down to room temperature from a processing temperature of 900° C (Figure 17). The simulation is conducted under stress loading. The input file is given in Table 23. The average matrix and fiber stresses together with the total stress and temperature are shown in Figure 18. The stresses across the cross-section at minimum temperature of the cycle, 150° C, are shown in Figure 19.

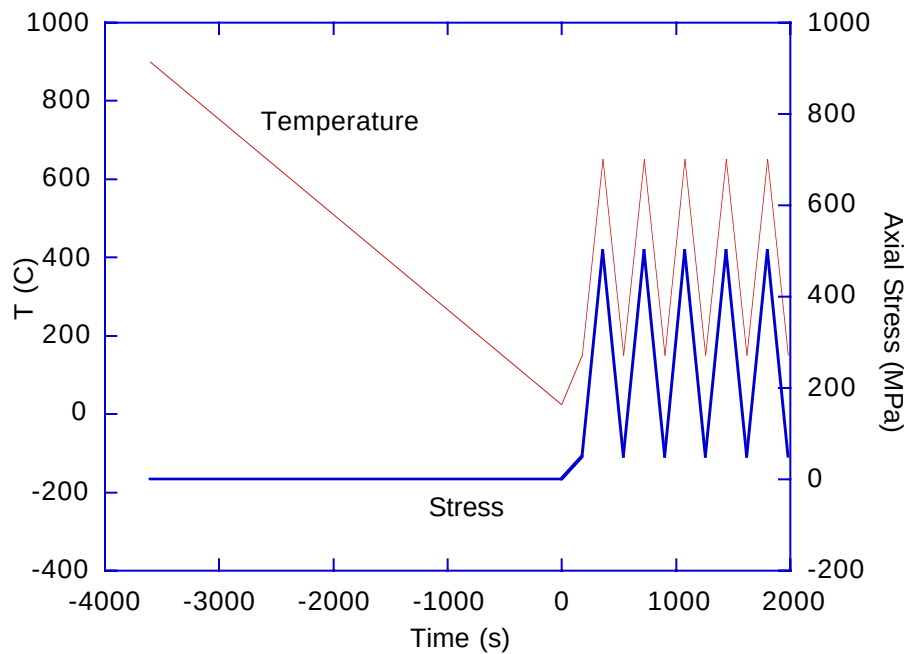


Figure 17. Loading History for Case 9.

Table 23. Input File for Case 9

SCS-6/TIMETAL21S(DBP) In-Phase TMF - stress control

1 0

sample_mat

2

BLOCK 1	NUMBER OF CYCLES	PRFREQ	PRSTART	INTOUT	NIOUT	
	2	1	10	0	2	0

Step	Time	Temp	Load	SR
0	0.0	900.0	0.0	0.
1000	3600.0	23.0	0.0	0.

BLOCK 1	NUMBER OF CYCLES	PRFREQ	PRSTART	INTOUT	NIOUT	
	11	1	10	0	2	1

3200

Step	Time	Temp	Load	SR
0	0.0	23.0	0.0	0.
200	180.0	150.0	50.0	0.
400	360.0	650.0	500.0	0.
600	540.0	150.0	50.0	0.
800	720.0	650.0	500.0	0.
1000	900.0	150.0	50.0	0.
1200	1080.0	650.0	500.0	0.
1400	1260.0	150.0	50.0	0.
1600	1440.0	650.0	500.0	0.
1800	1620.0	150.0	50.0	0.
2000	1800.0	650.0	500.0	0.
2200	1980.0	150.0	50.0	0.

2

1 0.35 5

4 0.65 15

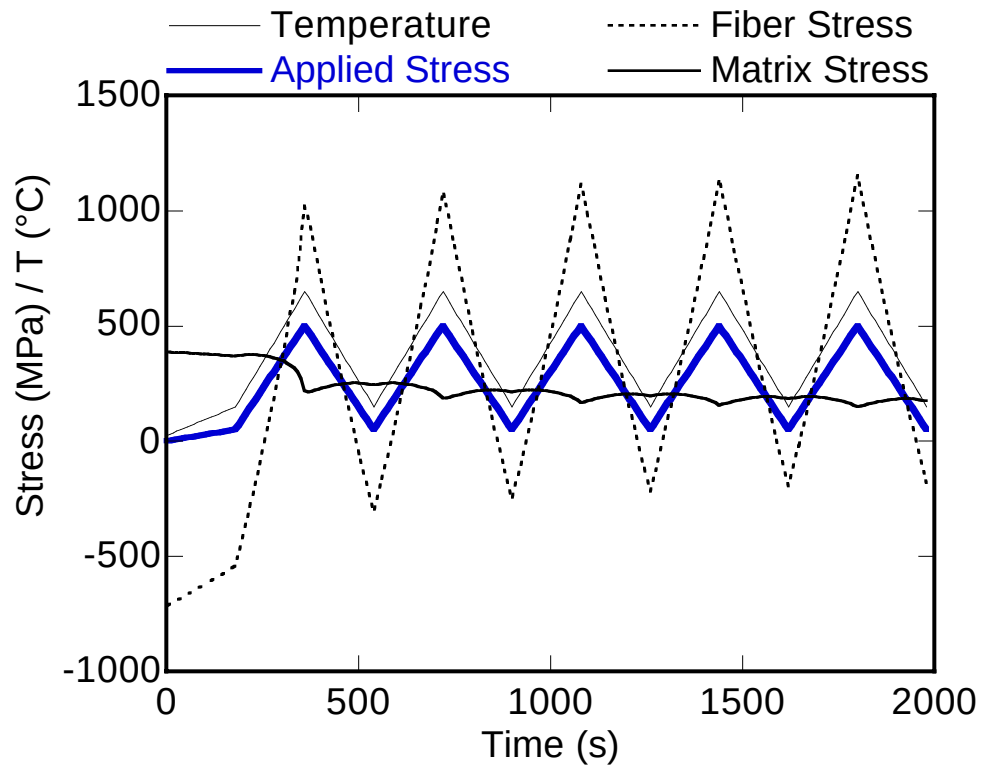


Figure 18. Average Stresses in the Matrix and Fiber.

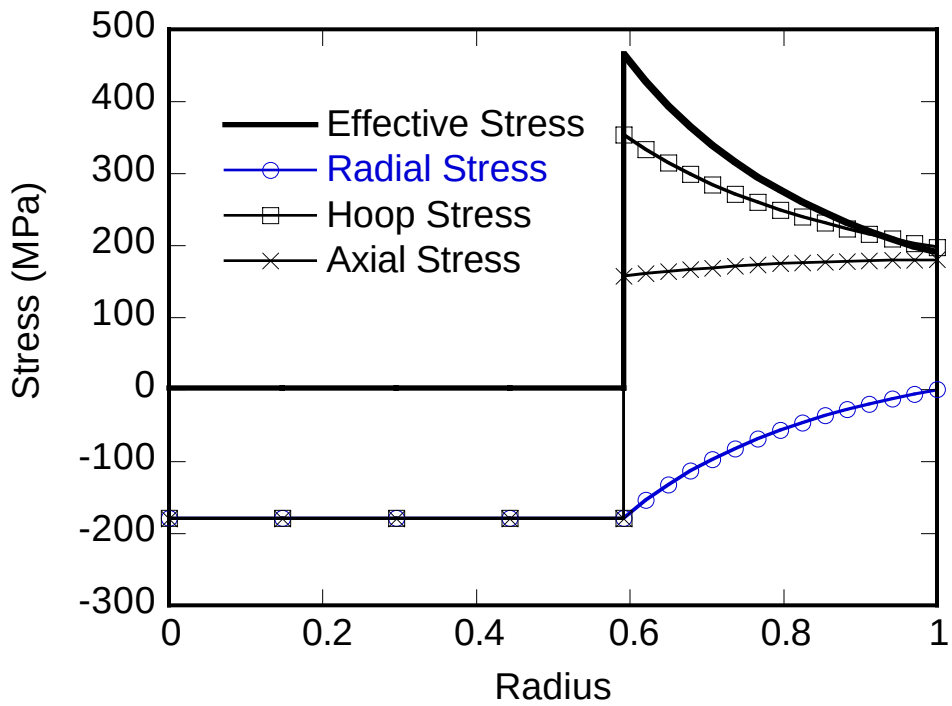


Figure 19. Stresses Across the Cross Section at 150° C.

3.8 Uniaxial Bar Using Bodner-Partom with Damage Model

This section presents three examples for the stress-strain behavior of a uniaxial bar using the Bodner-Partom with directional hardening and damage model. Loading/unloading paths are applied at 23° C and 650° C and a full reverse cyclic loading is applied to exercise the capabilities of the damage model.

3.8.1 Loading/Unloading Behavior at 23° C (Case 10)

The isothermal strain loading history at room temperature is shown in Figure 20 and the input file is shown in Table 24. The resultant stress-strain behavior is shown in Figure 21. As indicated in Figure 21, the modulus degrades with strain and regains original value during compression.

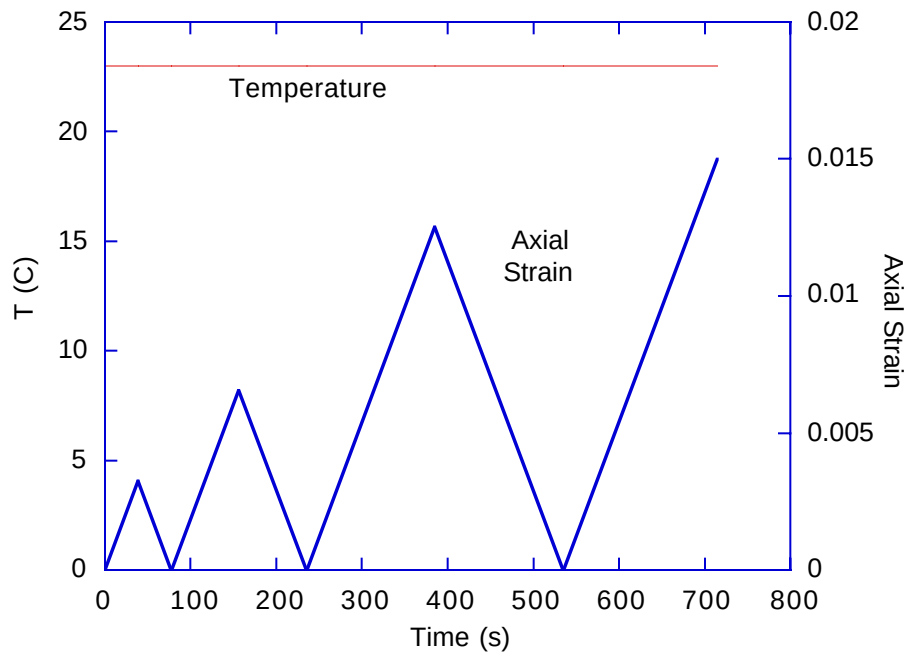


Figure 20. Loading History for Case 10.

Table 24 Input File for Case 10

Uniaxial Test of [90] Ply Damage Model

2 1

sample_mat

1

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

8 1 50 0 1 0

Step	Time	Temp	Load	SR
0	0.0	23.0	0.0	0.
1000	39.0	23.0	0.00325	0.
2000	78.0	23.0	0.0	0.
3000	156.0	23.0	0.00325	0.
4000	236.0	23.0	0.0	0.
5000	385.0	23.0	0.00325	0.
6000	535.0	23.0	0.0	0.
7000	715.0	23.0	0.00325	0.

1

5 1.00 2

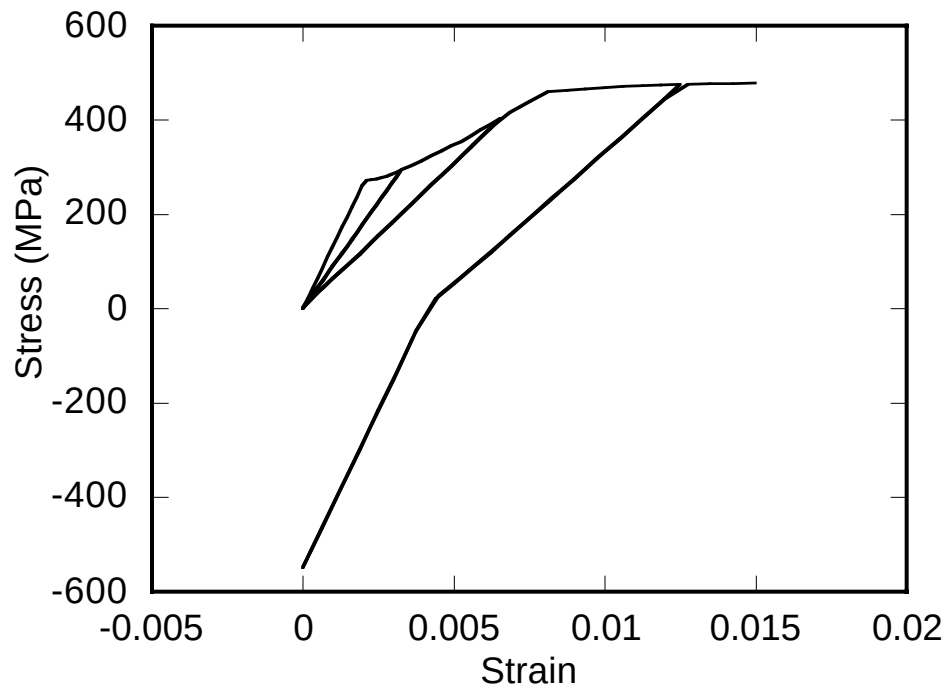


Figure 21 Stress-Strain Behavior for Case 10 (23° C).

3.8.2 Loading/Unloading Behavior at 650° C (Case 11)

The isothermal strain loading history at 650° C is shown in Figure 22 and the input file is shown in Table 25. The resultant stress-strain behavior is shown in Figure 23.

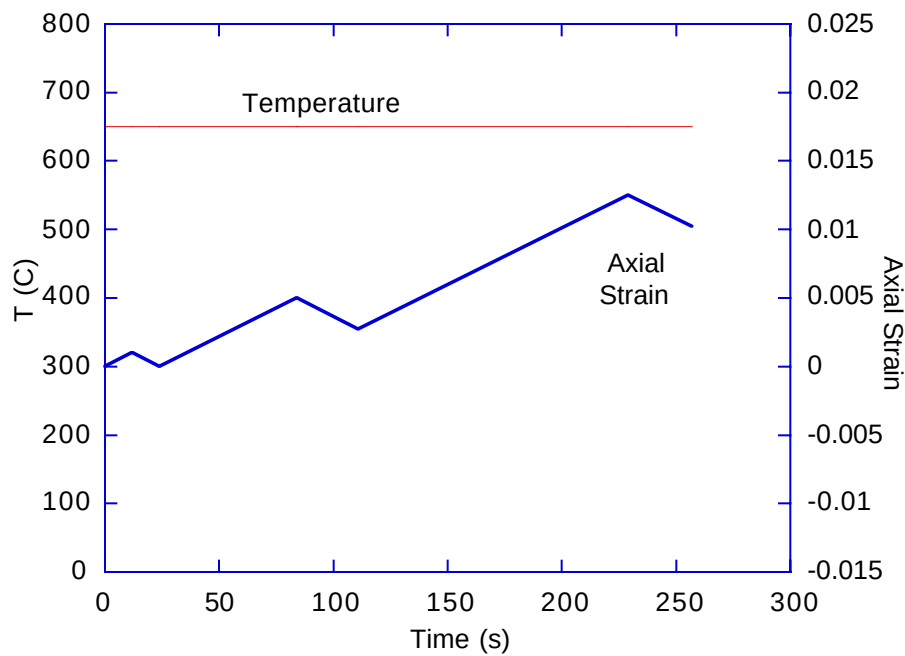


Figure 22. Loading History for Case 11.

Table 25. Input File for Case 11

Loading and Unloading Test of [90] Ply Damage Model at 650C

2 1

sample_mat

1

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

7 1 10 0 1 0

Step	Time	Temp	Load	SR
0	0.0	650.0	0.0	0.
120	12.0	650.0	0.001	0.
240	24.0	650.0	0.0	0.
840	84.0	650.0	0.005	0.
1110	111.0	650.0	0.002708	0.
2290	229.0	650.0	0.012484	0.
2570	257.0	650.0	0.010224	0.

1

5 1.00 2

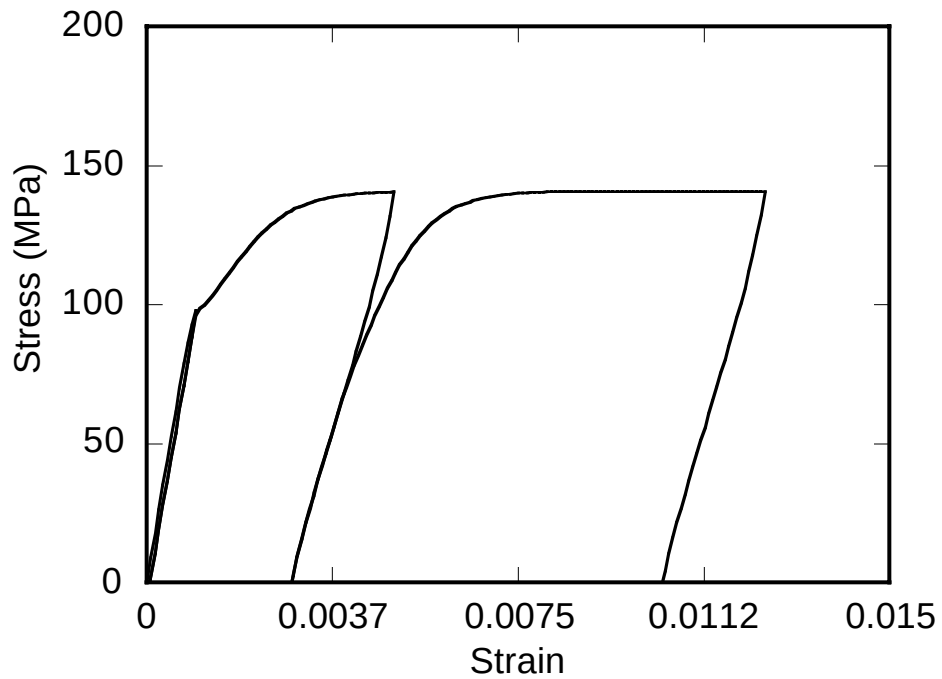


Figure 23. Stress-Strain Behavior for Case 11 (650° C).

3.8.3 Full Reverse Cyclic Behavior (Case 12)

The isothermal strain loading history at 650° C is shown in Figure 24 and the input file is shown in Table 26. The cyclic stress-strain behavior is shown in Figure 25.

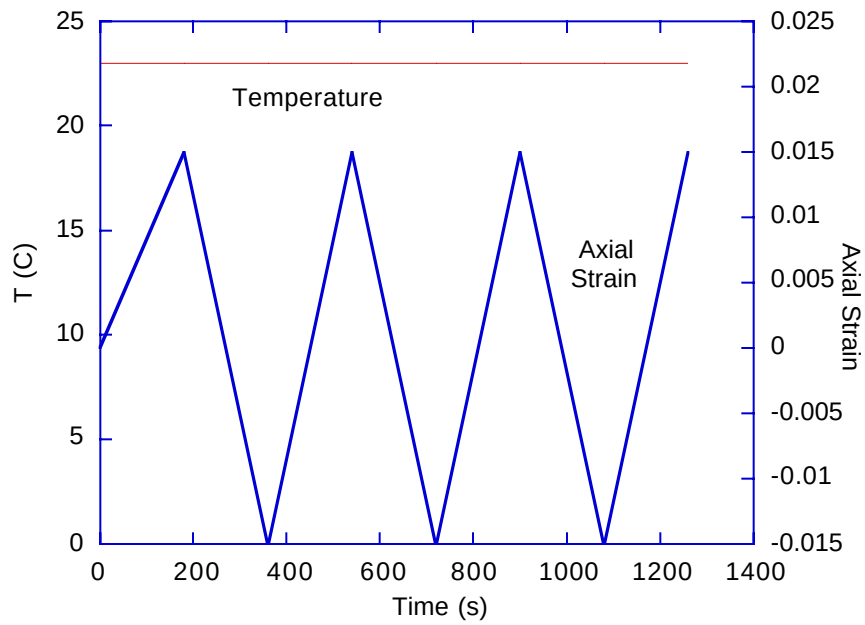


Figure 24. Loading History for Case 12.

Table 26. Input File for Case 12

Cyclic Test of [90] Ply Damage Model

2 1

sample_mat

1

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

8 1 10 0 1 0

Step	Time	Temp	Load	SR
0	0.0	23.0	0.0	0.
180	180.0	23.0	0.015	0.
360	360.0	23.0	-0.015	0.
540	540.0	23.0	0.015	0.
720	720.0	23.0	-0.015	0.
900	900.0	23.0	0.015	0.
1080	1080.0	23.0	-0.015	0.
1260	1260.0	23.0	0.015	0.

1

5 1.00 2

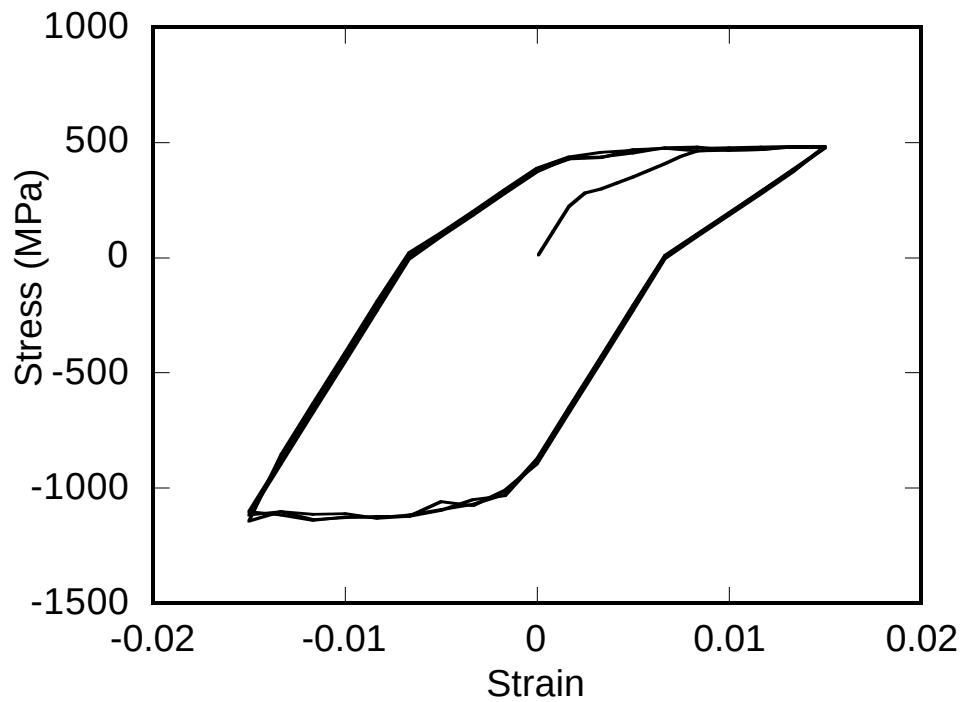


Figure 25. Stress-Strain Behavior for Case 12 (650° C).

SECTION 4

VERIFICATION OF SELECT PROBLEMS

The FIDEP2 source code has been extensively checked with solutions obtained from independent sources to provide confidence that numerical errors have been minimized. Cases from the demonstration problems from Section 3 were selected to verify that the numerical algorithms within FIDEP2 are functioning correctly, especially those cases containing highly nonlinear material response, e.g., the Bodner-Partom constitutive model.

4.1 Tensile Behavior of a Uniaxial Bar using Bodner-Partom with Backstress

The results in Section 3.1 (Case 1) for the Bodner-Partom model with backstress at 25° C have been compared against a solution in Figure 26 obtained from Mathematica. Mathematica is a differential equation solver which allows the precision of the solution to be selected by the user. For this particular case, the Mathematica solution, which was run on a SUN SPARC2 work station provided 7 or 8 digits of precision. The deviation of the FIDEP2 results from the Mathematica solution in Figure 26 indicates agreement to about 3%. The FIDEP2 solution is improved to less than 1.5% deviation when the number of solution steps is increased from 480 to 4,800.

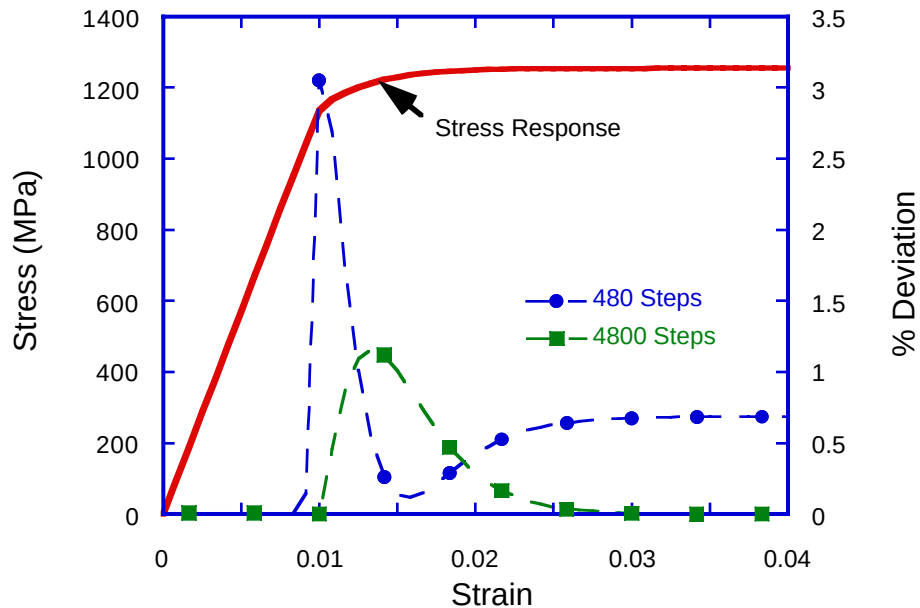


Figure 26. Tensile Behavior of the Bodner-Partom Model with Backstress at 25° C.

4.2 Uniaxial Bar under Thermal and Mechanical Loading

Results in Section 3.3 (Case 5) for the Bodner-Partom model with directional hardening have also been compared against the solution in Figure 27 obtained from Mathematica. Under the thermal and mechanical load in Figure 5, the deviation between the two solutions is well below 0.5% during isothermal loading and increases to less than 1.5% during nonisothermal conditions. Similar to the results found in Section 4.1, the error decreases with increasing number of solution steps, thus providing confidence that both viscoplastic algorithms are functioning correctly within FIDEP2.

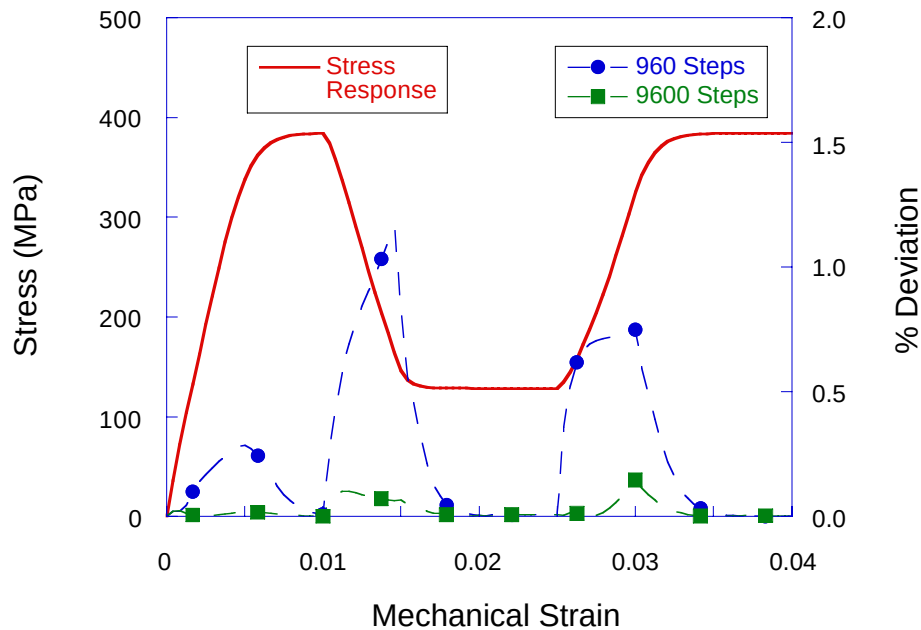


Figure 27. Comparison of FIDEP2 and Mathematica Solutions for Tensile Behavior of the Bodner-Partom Model with Directional Hardening.

4.3 Cool-Down Of A CCM - Elastic-Plastic Matrix

This verification case checks the bilinear elastic-plastic material model as well as the concentric cylinder geometry in Section 3.4 (Case 6). The loading is the same as that found in Figure 7, which is a cool-down from the processing temperature of an unidirectional metal matrix composite. The solution is compared with that obtained from a finite element method (FEM). The finite element mesh consists of forty-two 8-node axisymmetric elements that are solved with the finite element package ABAQUS. The number of elements is sufficiently high to give good accuracy (within an estimated 0.1%). The CCM within the FIDEP2 solution contained 21 nodes.

The matrix stress components at the fiber/matrix interface, illustrated in Figure 28, compare well between the FIDEP and FEM solutions (within 0.5 %). At room temperature, inspection of all of the stress components throughout the concentric cylinder (see Figure 29) also shows good

agreement between the two solutions which are also with 0.5% accuracy. The good agreement between the two solutions provides confidence that the elastic-plastic material response and the concentric cylinder model are functioning correctly within FIDEP2.

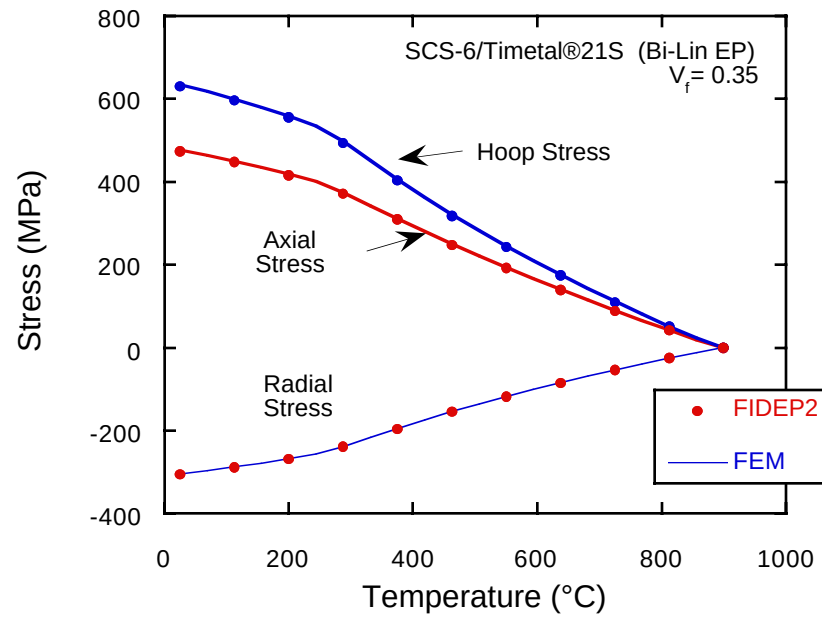


Figure 28. Matrix Stress at Fiber/Matrix Interface Comparison between FIDEP2 and the FEM with Elastic-Plastic Matrix Response.

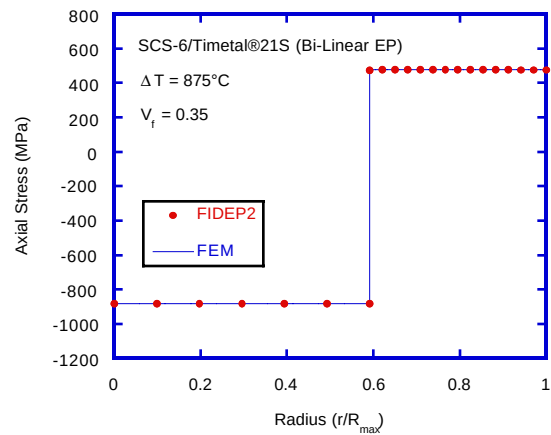
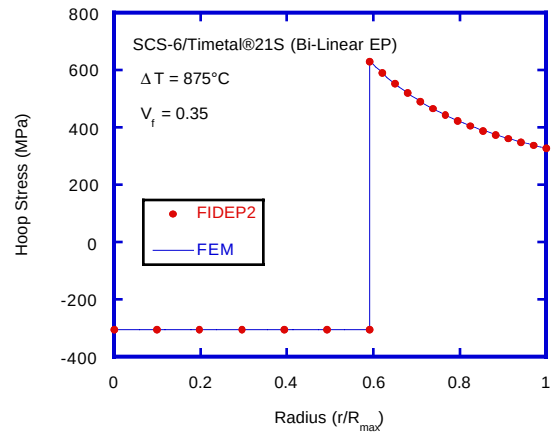
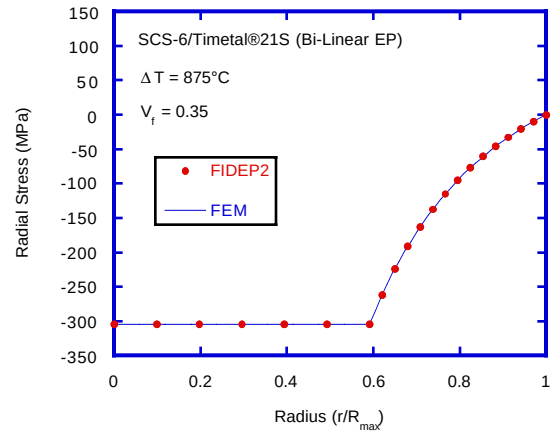


Figure 29. Comparison of Stress Components at Room Temperature from Cool-Down of a CCM with Elastic-Plastic Matrix.

4.4 Cool-Down of a CCM using Bodner-Partom with Directional Hardening Matrix

This verification problem checks the viscoplastic model of Bodner-Partom in conjunction with the concentric cylinder geometry in Section 3.5 (Case 7). The loading, given in Figure 7, is the cool-down of an unidirectional metal matrix composite from processing temperature. The only difference is the change from the previous elastic-plastic model for the matrix to a viscoplastic material response. The independent solution source for this case is also the FEM. The Bodner-Partom model is incorporated into the finite element package ABAQUS through user-subroutines [Kroupa, 1995]. The error from the finite element solution is estimated to be within 1 % for the boundary conditions prescribed.

The matrix stress at the fiber/matrix interface shown in Figure 30 also shows good agreement between FIDEP2 and FEM solutions, within 3%. Stress component throughout the concentric cylinder (see Figure 31) also shows good agreement (within 3%) between the two solutions. The accuracy of 3 % is not as good at the elastic-plastic case; however, the error is reasonable with respect to state-of-the-art viscoplastic algorithms. As noted from the previous viscoplastic cases, this error can be reduced with an increased number of solution increments.

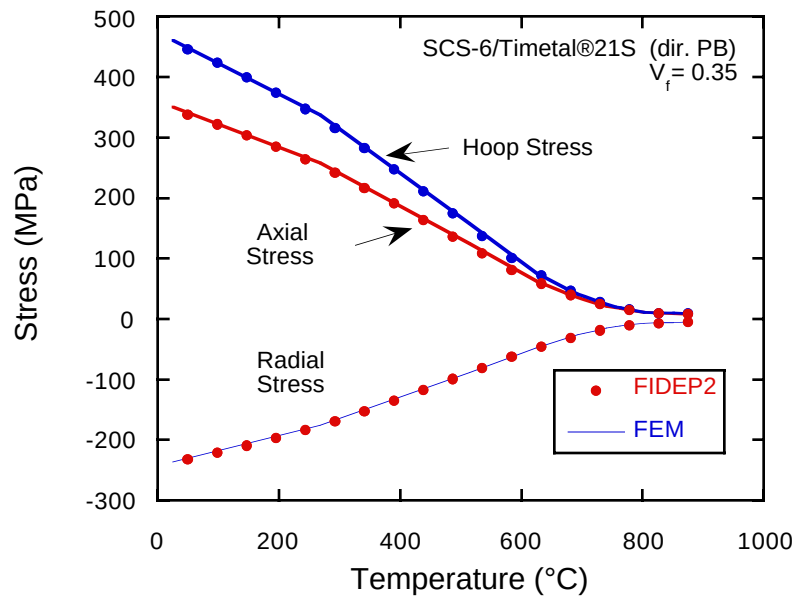


Figure 30. Matrix Stress at Fiber/Matrix Interface Comparison Between FIDEP2 and the FEM with Viscoplastic Matrix Response.

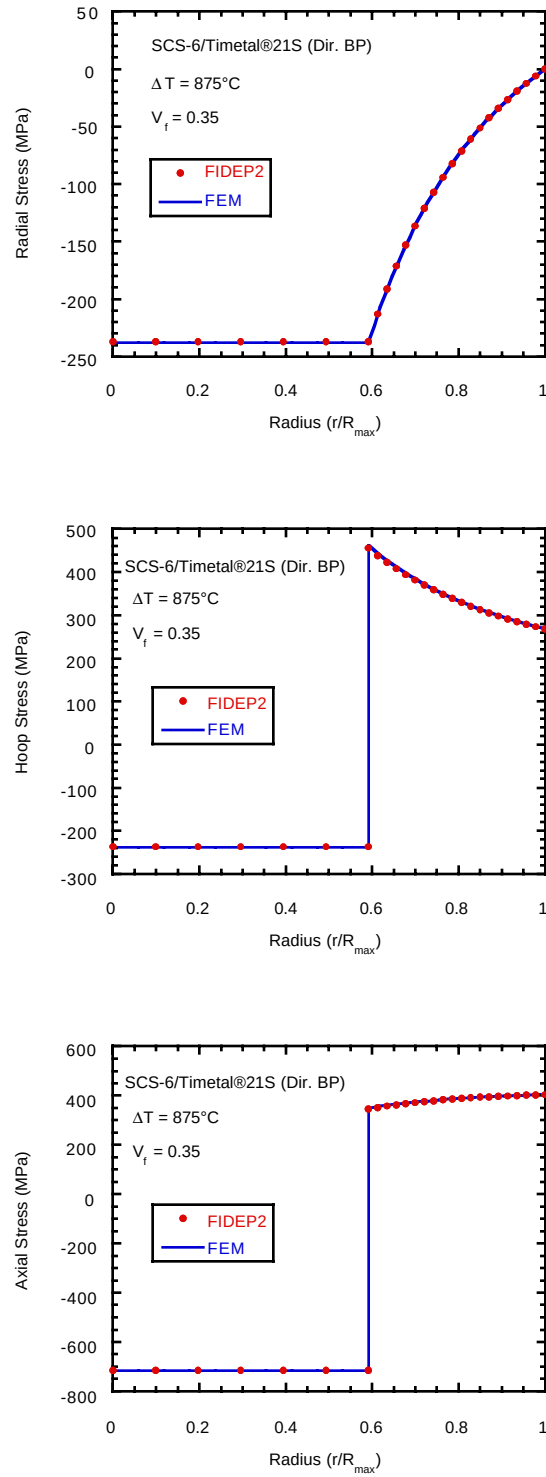


Figure 31. Comparison of Stress Components at Room Temperature from Cool-Down of a CCM with Viscoplastic Matrix.

4.5 Uniaxial Bar using Bodner-Partom with Damage Model

The last verification problem of interest is the tensile loading and unloading of a uniaxial bar. The constitutive model represents damage evolution in a transversely loaded unidirectional metal matrix composite. The independent solution source is a special purpose C-program that was designed to solve the complex set of equations. For the demonstration problem of Section 3.8.2 (Case 11), the comparison of the FIDEP2 and the C-program solutions is shown in Figure 32. The stress-strain response consists of repeated loading and unloading stages with progressively increasing strain levels (see Figure 22). This type of loading triggers the damage evolution in the material response model. Generally, the results from the two analyses are within 1.5 % of each other during loading and unloading, as illustrated in Figure 33. The accuracy of the C-program is estimated to be within 1.5 %. The good agreement between these two solutions provides confidence that the numerical algorithms used to solve this progressive damage model are functioning correctly.

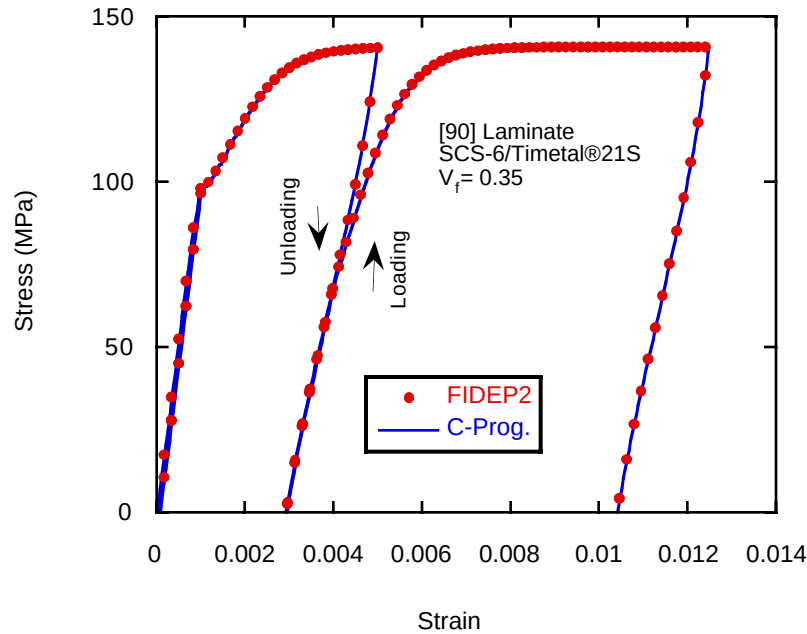


Figure 32. Stress-Strain Response of [90] Laminate Damage Model at 650° C.

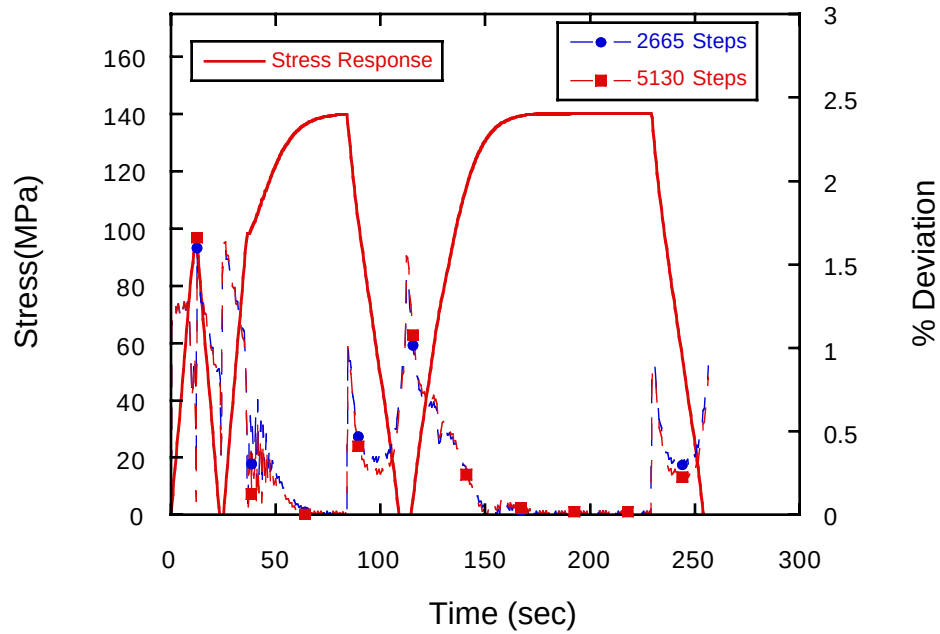


Figure 33. Solution Deviation of Stress Response from FIDEP2 and C-Program Output.

4.6 Summary of Verification Cases

The verification cases presented in this section demonstrate that all of the numerical algorithms within FIDEP2 are functioning correctly. As expected, the viscoplastic models exhibited more error than the bilinear counterpart. However, the errors occurring in these highly nonlinear cases are generally reduced by increasing the number of solution increments.

SECTION 5

PROGRAM DESCRIPTION

FIDEP2 efficiently predicts the stress and strain distributions in a composite under processing conditions and complex thermomechanical fatigue loading histories with axial and radial stress- or strain- controlled loading [Coker and Ashbaugh, 1992]. A listing of FIDEP2, Version 8, code is given in Appendix D. FIDEP2 is written in a modular form to allow for different micromechanical and nonlinear constitutive models. Other types of micromechanical models can be added to the program, provided that the total stresses are written in terms of the inelastic strain increments. Time-independent inelastic behavior of the constituents can be represented by bilinear elastic-plastic formulation, and the viscoplastic behavior of the constituents can be represented by the Bodner-Partom unified strain theory incorporating backstress [Ramaswamy, et al., 1990] or directional hardening [Chan, et al., 1988] formulations. The incremental iterative algorithm for computing stresses and inelastic strains makes use of the successive elastic solutions technique [Mendelson, 1968] and is explained further in Section 6. The same subroutine that is used for all material models is explained in section 5.2. The pseudocodes are given in section 5.3. Finally, the placement of the nodes in the CCM is explained in section 5.4.

5.1 General Outline of FIDEP2

FIDEP2 code uses a successive elastic solutions technique to determine the inelastic behavior of the material. The general outline of the program consists of the following steps:

1. Initialize variables.
2. Read Input.
 - a) Loading history, type of loading, type of micromechanical model (ICASE)
 - b) Type of constitutive model and corresponding temperature-dependent material properties for each component (ITYPE)
3. Compute new secant CTE with respect to the initial temperature in the loading file, if different from the reference temperature of CTE.
4. Define node locations for each component for the CCM case.
5. Apply the thermal and mechanical load increment.
6. Interpolate to compute the mechanical properties at the current temperature, and assign properties to each node.
7. If the CCM is used, compute L-U decomposition for the A-matrix.
8. Solve the boundary value problem for the appropriate micromechanical model, and compute estimates for the stresses assuming an elastic load increment.
9. Compute incremental inelastic strain estimates using the flow rule and the numerical integration scheme corresponding to the constitutive behavior of each component.
10. Compute new stress estimates using the new inelastic strain increments.
11. Compute internal state variable increments from the evolution equations.
12. Repeat steps 9 - 11 until convergence is obtained for the effective inelastic strains or the stresses.
13. If convergence of the stresses and strains is reached, repeat from step 5 until the end of the loading history is reached.

The constitutive model is defined by ITYPE in the input material data file. In addition to the available material models, a user-defined constitutive model can be added to the program. To

add a new constitutive model, the following three changes have to be made in the program: (a) add new common statements, (b) define new material property names in SUBROUTINE PROPNODES, and (c) add the new equations to SUBROUTINE INELASTIC.

The problem type is defined by ICASE in the input file. In addition to the available micromechanical models, other stress solutions could be added to the program. The first step is to solve for the stresses in terms of the plastic strain increments for the new problem. The new equations can then be added by creating a new SUBROUTINE STRESS4, and additional IF statements can be added in SUBROUTINE STRESS and SUBROUTINE GEOMETRY.

5.2 Subroutine for Constitutive Models

After determining the elastic estimates for the stresses, SUBROUTINE INELASTIC is called. This subroutine uses a different algorithm to compute the plastic strain increments for each component with different constitutive models. As a result, different viscoplastic models for each component of the composite can be used. The flowchart for FIDEP2 is as follow:

```

    Apply incremental load
    Determine elastic estimate for stresses
10   Do k=1, number of materials
        IF( ITYPE(k) = 1 ) THEN
            Goto next material
        IF( ITYPE(k) = 2 ) THEN
            For all nodes in material k
                Elastic-Plastic Algorithm for  $De_{ij}^p$ 
            ...
        IF( ITYPE(I) = 5 ) THEN
            For all nodes in material k
                Bodner-Partom Algorithm for  $De_{ij}^p$ 
        ENDIF
    Compute new plastic strain estimates at all nodes
ENDDO
    Determine stresses using the plastic strain estimates
    Goto 10 until convergence of the stresses and strains is obtained.
    Goto next loading increment.

```

The differences between the algorithm described in section 6.2.2 for elastic-plastic material and the straightforward Euler algorithm used for the unified strain theory algorithms is illustrated below for the Bodner-Partom with backstress model.

```

    Elastic-Plastic Algorithm
0   Compute elastic estimates for stresses
1   For each node
2       Estimate incremental plastic strain
3       Compute effective incremental plastic strain
4       Compute effective stress
5   Compute stresses with the assumed plastic strain increment
6   For each node

```

```

7           Compute new incremental plastic strain using results from
           steps 3, 4, 5
8   Repeat.
   Viscoplastic Algorithm for Bodner-Partom with Backstress
0   Compute elastic estimates for stresses
1   For each node
2       Compute effective stress
3       Compute effective incremental plastic strain, deff, from Bodner-Partom equation
4       Estimate incremental plastic strain from deff
5   Compute stresses with the assumed plastic strain increment
6   For each node
7       Compute incremental backstress
8   Goto 1.

```

5.3 Pseudocode

The pseudocode for the main program is given in Table 26. The pseudocodes for the individual subroutines called from the program are given in Table 27.

5.4 Node Assignment in the CCM

For the CCM, given the number of materials or cylinders, number of nodes in each cylinder, and the volume fraction of each material, the distribution of the nodes in each cylinder are computed using the following quadratic polynomial:

$$r_i = a_n + (a_{n+1} - a_n) \frac{(k_i^2 - 1)}{(k_{\max_n}^2 - 1)} \quad (1)$$

where $i = 1, \dots, \text{NTOT}$,

$n = 1, \dots, \text{NOMAT}$

$k_i = 1, \dots, k_{\max}$

r is the distance from the center of the nodes

a_n and a_{n+1} are the inner and outer radius of the n th cylinder

NTOT is the total number of nodes

NOMAT is the number of materials

$k_{\max_n}$ is the number of nodes in cylinder n .

The distribution of the nodes is denser near the interface, and more accurate stresses are obtained as compared to a uniform distribution because of a large stress gradient at the interface. The effect on the stresses is noticeable for a very small fiber volume fraction, which simulates a single fiber in an infinite matrix. The core cylinder is automatically divided into three nodes since there is no stress or strain variation in the core. In addition, the innermost node in each cylinder is moved away from the interface and is located halfway between the interface and the next node.

Table 27. Pseudocode for FIDEP2

MAIN PROGRAM FIDEP2_6

Initialize the material property and loading arrays

CALL INITIAL(ITYPE, EP2, XT1)

Read loading conditions, geometry and output preferences

CALL READLOAD(NLOAD)

Read input data; constitutive model and corresponding properties

CALL READMAT(ITYPE)

Compute new cte if reference temp is not the same as the first temperature in the loading file

CALL NEWCTE(BT(1))

Rewind and close input files

CALL CLOSEFILES

Write loading and material data into output file 15

CALL WRITEMAT(ITYPE)

Define physical and geometric parameters

CALL GEOMETRY

Fix zero stress state temperature as the first temp in the data file

Reset counter ICOUNT = 0

Start block loading from input file

Start incremental loading for each block in input file

Table 27. Pseudocode for FIDEP2 (Continued)

Start counter ICOUNT = ICOUNT + 1

Compute total and incremental temperature, applied stresses, applied strain, and time
CALL LOAD(IB, NSteps, IStep, BT(1))

Interpolate for material properties at temperature T
CALL PROPT(IType, T)

Assign material properties to nodes and multiply by appropriate constants to account for units such as MPa etc. in input file
CALL PROPNODES(IType, ICOUNT)

For concentric cylinder model create A-matrix and the L-U decomposition
IF(ICASE .NE. 2) CALL AMATRIX(ICOUNT)

Compute stresses assuming elastic behavior
CALL STRESS(EP2, ICOUNT)

Compute inelastic strain increments and iterate to converge to right combination of stresses and strains.
CALL INELASTIC(ICOUNT, IType, EP2)

Output results at the end of incremental loading
CALL OUTPUT1(ICOUNT, IType, EP2, BS)

Goto next step

Go to next block in input file

Stop
End

Table 28. Pseudocode for the Subroutines in FIDEP2

SUBROUTINES

SUBROUTINE INITIAL

Initialize variables

SUBROUTINE READLOAD

Read loading conditions, geometry and output preferences

Assigns ICASE, ILOAD

GEOMETRY TYPE

IF(ICASE .EQ. 1) Concentric Cylinder Model

IF(ICASE .EQ. 2) 1-D Laminate Model

IF(ICASE .EQ. 3) Concentric Cylinder Model with [90]

LOADING TYPE

IF (ILOAD .EQ. 0) Stress Control

ELSE Strain Control

Printout at every n steps: IPRINTSTEP

Start Printout at steps: ISTEPOUT

SUBROUTINE READMAT

Read constitutive model type and temperature-dependent properties for materials defined by the load file. This subroutine reads both temperature-dependent and independent elastic and inelastic material properties for any constitutive model into material, row, column array $tp(i,j,k)$.

Go through each material, until you find your material

Then for each material

Read the elastic material properties

Inelastic material properties are given in this many sets

Read the inelastic material properties

Note: If only one row of data then there is no temp variable

Goto next material if material number is not what is wanted

Store the materials that are used

Read material type ITYPE for each material

Assign ITYPE, Constitutive model:

IF(ITYPE(K) .EQ. 1) Elastic

IF(ITYPE(K) .EQ. 2) Bilinear Elastic-Plastic #1

IF(ITYPE(K) .EQ. 3) Bilinear Elastic-Plastic #2

IF(ITYPE(K) .EQ. 4) Viscoplastic with Damage

IF(ITYPE(K) .EQ. 5) Bodner-Partom with Back Stress

IF(ITYPE(K) .EQ. 6) Bodner-Partom with Directional Hardening

IDAMAGE = 0

Bodner-Partom with direct hard and damage is automatically redefined as ITYPE = 6 and

IDAMAGE = 1

If material type is found and stored, continue with next material

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

SUBROUTINE NEWCTE

Compute new cte if reference temperature is not the same as the first temperature in the loading file

FAC is used to extrapolate for the new cte at the new ref temp due to the fact that the new cte is infinity here.

For interpolations between temperatures (general case) JFAC=0

Compute new secant CTE with respect to the initial temperature that is given in the loading file, i. e. TPROC.

Replace the old CTE table with the new CTE table

Compute new CTE wrt processing temperature

If the new processing temperature is one of the data points then interpolate between the previous and the next CTE.

SUBROUTINE WRITEMAT

Write material data into output file 15

SUBROUTINE LOAD

Interpolate for applied loading, time and temperature

Compute increments in temperature, applied stress, total applied strain and time using
FUNCTION XNEW = ISTEP*(X2 - X1)/NSTEPS + X1

SUBROUTINE PROPT

Interpolate for material properties at temperature T

FUNCTION CURVE

Material properties given as an explicit function of temperature

if(id_cur .eq. -9999) CURVE = 5.8E5*EXP(-1.37E4/(T+273))

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

SUBROUTINE PROPNODES

Assign material properties to nodes and multiply by appropriate const

Elastic properties at the nodes

CALL ELAS(IM, K)

Compute composite modulus and composite CTE

Inelastic properties at the nodes, the arrays are given physical names for each node

For each material

IF(ITYPE(IM) .EQ. 1) goto next material

IF(ITYPE(IM) .EQ. 2) for each node CALL MAT2(IM, K)

IF(ITYPE(IM) .EQ. 3) for each node CALL MAT2(IM, K)

IF(ITYPE(IM) .EQ. 4) already reassigned as ITYPE=6 IDAMAGE=1

IF(ITYPE(IM) .EQ. 5) for each node CALL MAT5(IM, K, ICOUNT)

IF(ITYPE(IM) .EQ. 6) for each node CALL MAT6(IM, K, ICOUNT)

IF(ITYPE(IM) .EQ. 7) for each node CALL MAT7(IM, K, ICOUNT)

SUBROUTINE ELAS(I, K)

For damage in [90] define TEO(K) = TE(K)

SUBROUTINE MAT2(I, K)

SUBROUTINE MAT5(I, K, ICOUNT)

SUBROUTINE MAT6(I, K, ICOUNT)

IF(IDAMAGE(I) .EQ. 1) assign values to damage parameters

SUBROUTINE MAT7(I, K, ICOUNT)

SUBROUTINE AMATRIX

For concentric cylinder model case (for ICASE = 1, 3), create A-matrix and the L-U decomposition at this loading step to determine radial and hoop stresses.

Subtract 2 nodes from the total number of nodes for ICASE=3 because there is no effect of [90] ply on the radial stresses except through the axial stresses => NTOT = NTOT - 2 and NOMAT = NOMAT - 1

Define matrix dimension => NRA = 2*(NTOT - 1)

Fill in the elements for the A-matrix

Take the limits for the first terms in left submatrices

Skip the addition to the amatrix during strain loading

IF(ILOAD .EQ. 1 .AND. ICOUNT .GT. ISTRAIN)GOTO 55

Add additional terms in equations for interface nodes

If radial loading is applied, add term BMAT(NTOT-1) = SR

Compute the LU factorization of AMAT and store in AMAT

CALL LUDCMP(AMAT,NRA,LDA,IPVT,D)

Add back 2 nodes to the total number of nodes for ICASE=3

IF(ICASE .EQ. 3) NTOT = NTOT + 2 and NOMAT = NOMAT + 1

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

SUBROUTINE STRESS

Compute stresses assuming elastic behavior for the last load incr.

For damage model reduce stiffness here

```
IF( IDAMAGE(I) .EQ. 1 )for each node in material
  DO 8 J = ibeg(I), iend(i)
    TE(J) = TEO(J)*(1.0-ETA(J)*D(J))
```

Compute new composite modulus and cte, ECOM and CTECOM

```
ECOM = ECOM + TE(J)*VF(I)
CTECOM = CTECOM + TCTE(J)*TE(J)*VF(I)
CTECOM = CTECOM/ECOM
```

For each material

```
for icase 1 - concentric cylinder
  CALL STRESS1( EP, ICOUNT )
for icase 2 - Lamina model
  CALL STRESS2( EP, ICOUNT )
for icase 3 - concentric cylinder with [90]
  CALL STRESS3( EP, ICOUNT )
```

Compute total strains at all nodes from stresses calculated above

Compute effective stress and deviatoric stresses

```
SEFF(J) = CSEFF( J )
CALL DEVIATS( J )
```

SUBROUTINE STRESS1

Solves stress state for multiple concentric cylinder model

Calculate total strain:

- a) For strain controlled loading after cool down $ez^*=ez_{tot}$
IF(ILOAD .EQ.1 .and. ICOUNT .GT. ISTRAIN) THEN
EZSTAR = EZ + EZCOOL and EZTOT = EZSTAR
- b) For stress controlled loading calculate EZSTAR from integral
 $\text{sum}(2/b^2 * E/Ec * \text{integral}(ezp * rdr))$

Complete B matrix by calculating plastic term PP(I) using EZSTAR in "function plastic".

Add contribution of sr term to the last term in bmat

Using Bmat, and the L-U decomposition of Amat determine XSOL, the vector of radial and hoop stresses

```
CALL LUBKSB(AMAT,NRA,LDA,IPVT,BMAT,XSOL)
```

Compute stresses from the XSOL solution vector

Use Boundary conditions

```
S(1,NTOT2) = SR
S(2,1) = S(1,1)
```

Compute total axial strain for stress controlled cases from ez^*

Compute axial stress from the axial stress-strain equation

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

SUBROUTINE STRESS2

Solves Stress state for 1-D lamina model, multiple laminates

Calculate total strain:

- a) For strain controlled loading after cool down $ez^*=ez_{tot}$
IF(ILOAD .EQ. 1 .AND. ICOUNT .GT. ISTRAIN)
EZSTAR = EZ + EZCOOL and EZTOT = EZSTAR or
b) For stress controlled loading calculate EZTOT from equations
Compute uniaxial stress as a function of ez_{tot} and $e_{estimate}$

SUBROUTINE STRESS3

Solves stress state for CCM with [90]

Calculate total strain:

- a) For strain controlled loading after cool down $ez^*=ez_{tot}$
IF(ILOAD .EQ.1 .and. ICOUNT .GT. ISTRAIN) THEN
EZSTAR = EZ + EZCOOL and EZTOT = EZSTAR
b) For stress controlled loading calculate EZSTAR from integral
 $\text{sum}(2/b^2 * E/E_c * \text{integral}(ezp * rdr))$

For the following use NTOT2=NTOT - 2 nodes to neglect effect of [90] ply

Complete B matrix by calculating plastic term PP(I) using EZSTAR in "function plastic".

Add contribution of sr term to the last term in bmat

Using Bmat, and the L-U decomposition of Amat determine XSOL, the vector of radial and hoop stresses

CALL LUBKSB(AMAT,NRA,LDA,IPVT,BMAT,XSOL)

Compute stresses from the XSOL solution vector

Use Boundary conditions

$$S(1,NTOT2) = SR$$

$$S(2,1) = S(1,1)$$

Compute total axial strain for stress controlled cases from ez^*

Compute axial stress from the axial stress-strain equation

FUNCTION PLASTIC

Computes special plastic term in Concentric Cylinder Model

SUBROUTINE GEOMETRY

Define geometric properties NTOT, IBEG and IEND for each material

IF (ICASE .EQ. 2) only one node

Compute total number of nodes, NTOT

Compute radii limits for each material Block

Compute location of nodes

SUBROUTINE INELASTIC

Compute inelastic strain increments and iterate to converge to the right combination of stresses and strains

If all the materials are elastic, then return to main

Calculate initial yield surfaces for elastic-plastic material and check for plasticity

$$SE(J) = YSURFACE(EPEFF(J), J)$$

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

Plastic step starts here

Compute estimates for plastic strain increments except for ITYPE = 2

Compute estimates for backstress model

Compute estimates for directional Bodner Model

MAXITER = 150

RELAX = 0.8

Start Iterations for inelastic strains

Compute new estimates for the plastic strain increments

For each material ITYPE

IF ITYPE = 2, Bilinear Elastic-Plastic

at each node for J = IBEG(I), IEND(I)

Calculate modified total strains

Relationship between dep or psi and eff MTS

Calculate new PSIs using modified P-R equations

IF ITYPE = 3, Bilinear Elastic-Plastic with 2nd el-pl algorithm

Check stress state for yielding at node j

If F<0 during iterations, still iterate for conv.

For algorithm 2 start iterations with nonzero ep

Compute equivalent plastic strain

Compute the yield surface, se from epeff

IF ITYPE = 5, Bodner-Partom with backstress

IF ITYPE = 6, Bodner-Partom with directional hardening

Compute Stresses given the plastic strain estimates

CALL STRESS(EP2, ICOUNT)

Evolution equations for the internal state variables

Calculate effective stress as a combination of seff at old and new
time step

SEFF(J) = SEFF(J)*(1.0-relax)+SEFFOLD(j)*relax

Check for convergence using difference between effective stresses and/or effective
plastic strains

IF(ITER .GT. 4 .AND. ERROR .LT. TOLER) goto next loading incr.

IF(ITER .EQ. MAXITER) no convergence

ITERATION LOOP

END OF ITERATIONS

print out at selected number of steps

Update state variables

IF(ITYPE(I) .EQ. 5) at each node in material I ...

IF(ITYPE(I) .EQ. 6) at each node in material I ...

IF(IDAMAGE(I) .EQ. 1) update damage properties

Compute work rate, ssum, bsum=SQRT(bij*bij)

Compute v(i) and u(i) vectors

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

Compute directional hardening $ZD = b_{ij}u_{ij}$
Compute isotropic hardening $ZI = b_{ij}u_{ij}$
When ZD becomes negative we get nonconvergence
Compute total drag stress
IF(IDAMAGE(I) .EQ. 1) $ZTOT(J) = ZTOT(J)*(1-ETA(J)*D(J))$
IF(S(3,J) - DSM - DSCHNEW .GT. SPEAK) update Speak

SUBROUTINE OUTPUT1

Print output

SUBROUTINE INTERPOL

Called from newcte

FUNCTION INTER

Determines Temperature-dependent Properties at Temperature T

FUNCTION FUNCINTER(T1, T2, VAR1, VAR2, T)

Computes Linear Interpolation

SUBROUTINE DEVIATS

Compute Deviatoric Stress

FUNCTION CDEFF5(J)

Compute the effective stress with backstress

SUBROUTINE LUDCMP

Compute Lower Decomposition of a matrix

SUBROUTINE LUBKSB

Solves $A*X=B$

SECTION 6

THEORETICAL BACKGROUND

Thermoviscoplastic micromechanical modeling of metal matrix composites consists of two problems: a boundary value problem in terms of stresses in an idealized geometry, and an initial value problem for marching through time to determine the internal state variables after incremental changes in the thermal and mechanical loading conditions. Three micromechanical geometries are described in section 6.1. These geometries are a) the concentric cylinder geometry (CCM) that yields a three-dimensional state of stress around the fiber in a unidirectional composite, b) CCM with a parallel element representing the [90] ply, and c) a uniaxial stress model in which the fiber/matrix acts in parallel with a fiber/matrix/[90] or any other layup characterized by average axial stresses and strains in each component. In the case of the first two models that use the CCM, finite difference techniques are used to solve for the stress-strain distribution by estimating the plastic strain increments. The constitutive models used to describe the mechanical behavior of each component in the above geometries can be chosen from elastic, bilinear elastic-plastic, Bodner-Partom with backstress, Bodner-Partom with directional hardening, and Bodner-Partom with directional hardening and damage options in the program. The relevant equations for these constitutive models are summarized in section 6.2. These constitutive models are numerically integrated for each loading increment to determine the plastic strains and the internal state variables. Two versions of the forward Euler technique used in FIDEP2 code for numerical integration are summarized in section 6.3.

6.1 Micromechanical Models

The formulation of a micromechanical model results in a boundary value problem. The CCM, hybrid CCM with a [90] ply, and a uniaxial stress model subjected to thermal loading and either stress- or strain-controlled loading conditions are discussed below (Fig. 34). The formulation is in terms of total stresses and strains. This allows the use of the same formulation for temperature-dependent material properties as well as isothermal problems without making modifications to account for the change of properties with temperature. For example, in the one-dimensional elastic case, the total stress-strain relationship for both isothermal and nonisothermal cases is $\sigma = E(T) \epsilon$. In incremental form, the variation of the modulus with temperature should be taken into account for the nonisothermal case as follows:

$$d\sigma = E(T)d\epsilon + \epsilon \frac{\partial E}{\partial T} dT. \quad (2)$$

In the present formulation, only the constitutive relations for the internal state variables and the plastic strains are in incremental form, since the evolution of these variables is path dependent.

6.1.1 Concentric Cylinder Model

The methodology is presented in Coker, et al., 1993, and is repeated here for completeness sake. A representative volume element of the composite is modeled as concentric cylinders with the core cylinder representing the fiber and the outer ring representing the matrix (Fig. 34). The fiber and matrix radii are denoted as a and b , respectively. The direction of the z -axis is along the fibers, and the cylinders are infinitely long in the axial direction. Cylindrical coordinates are used in the equations.

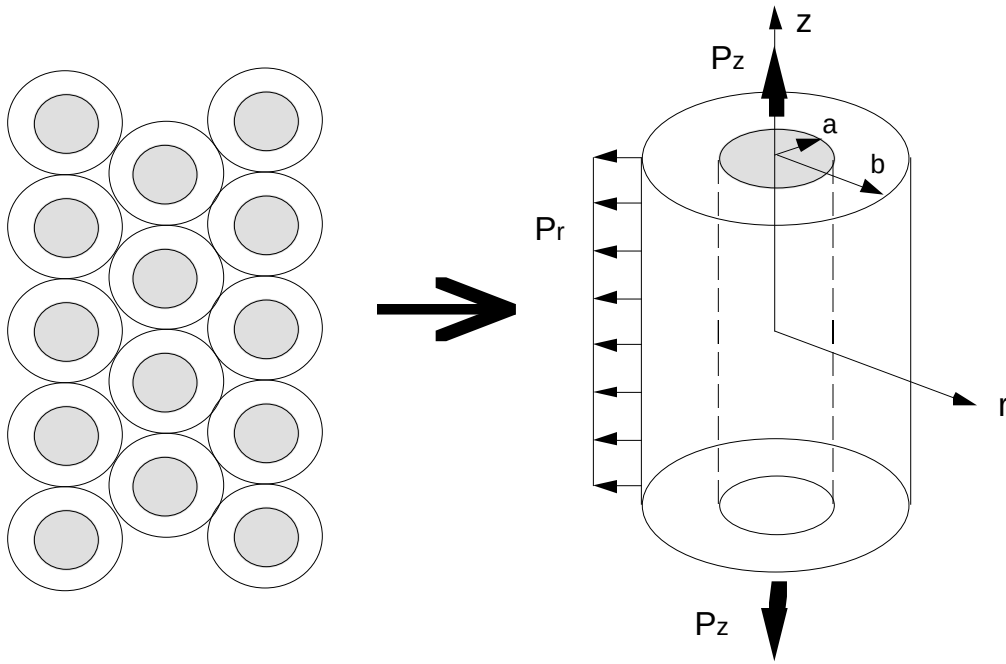


Figure 34. Representative Volume Element (RVE) of a Unidirectional Composite Modeled as Concentric Cylinders.

The following assumptions are made in the analysis: the temperature distribution is uniform and is quasi-static; a perfect bond exists between the constituents of the composite so that there is no slippage nor separation of the constituents; the concentric cylinders are in generalized plane strain and are subjected to axisymmetric loadings and displacements so that the shear stresses are zero; and the constituent properties are isotropic and the material is incompressible.

In addition, the following boundary conditions are imposed: a) radial stress is P_r at $r=b$, b) stresses are finite at $r=0$, and c) radial displacements and radial stresses are continuous at the interface.

6.1.1.1 Governing Equations

Equilibrium and compatibility equations in cylindrical coordinates for an axisymmetric generalized plane-strain case simplify to:

$$\frac{d\sigma_r}{dr} + \frac{\sigma_r - \sigma_\theta}{r} = 0, \quad (3)$$

$$\frac{d\varepsilon_\theta}{dr} - \frac{\varepsilon_r - \varepsilon_\theta}{r} = 0, \quad (4)$$

And the stress-strain equations are as follows:

$$\begin{aligned}\varepsilon_r &= \frac{1}{E}(\sigma_r - \nu(\sigma_\theta + \sigma_z)) + \alpha T + \varepsilon_r^p + d\varepsilon_r^p, \\ \varepsilon_\theta &= \frac{1}{E}(\sigma_\theta - \nu(\sigma_r + \sigma_z)) + \alpha T + \varepsilon_\theta^p + d\varepsilon_\theta^p, \\ \varepsilon_z &= \frac{1}{E}(\sigma_z - \nu(\sigma_r + \sigma_\theta)) + \alpha T + \varepsilon_z^p + d\varepsilon_z^p,\end{aligned}\tag{5}$$

where: ε_r^p , ε_θ^p , and ε_z^p are the total accumulated plastic strains up to, but not including the current increment of loading.

$d\varepsilon_r^p$, $d\varepsilon_\theta^p$, and $d\varepsilon_z^p$ are the plastic strain increments due to the current increment of loading.

ε_r , ε_θ , and ε_z are the total strains.

σ_r , σ_θ , and σ_z are the stresses.

α is the secant coefficient of thermal expansion (CTE).

ν is the Poisson's ratio.

E is the Young's modulus.

T is the change in temperature from a reference state in which the stresses and the strains are assumed to be zero.

Substitution of equation 5 into equation 4 to eliminate total radial and hoop strains yields:

$$\begin{aligned}&\frac{d}{dr}\left(\frac{\sigma_\theta}{E} - \frac{\nu}{E}(\sigma_r + \nu(\sigma_r + \sigma_\theta)) - \alpha ET + E(\varepsilon_z - \varepsilon_z^p - d\varepsilon_z^p)\right) + \alpha T + \varepsilon_\theta^p + d\varepsilon_\theta^p \\ &+ \frac{(1+\nu)}{Er}(\sigma_\theta - \sigma_r) + \frac{\varepsilon_\theta^p + d\varepsilon_\theta^p - \varepsilon_r^p - d\varepsilon_r^p}{r} = 0.\end{aligned}\tag{6}$$

The equations 3 and 6, and the boundary conditions define the boundary value problem for the two unknowns σ_r and σ_θ . The axial strain, ε_z , is a constant value across the cross section due to the imposed generalized plane-strain condition and will be determined next.

6.1.1.2 Computation of Axial Strain

To compute the axial strain, the stress-strain equation in the axial direction (eqn. 5) is multiplied by r and integrated over the cross section:

$$\varepsilon_z \int_0^b Er dr = \int_0^b \sigma_z r dr - \int_0^b \nu(\sigma_r + \sigma_\theta) r dr + \int_0^b \alpha ET r dr + \int_0^b E(\varepsilon_z^p + d\varepsilon_z^p) r dr.\tag{7}$$

For k concentric cylinders, let a_i be the outer radius of the i^{th} ring and $a_o = 0$, then the integral on the left hand side reduces to:

$$\varepsilon_z \int_0^b Er dr = \varepsilon_z \sum_{i=1}^k \frac{E_i}{2} (a_i^2 - a_{i-1}^2).\tag{8}$$

The first integral on the right side is evaluated using the global equilibrium equation in the axial direction; i. e., internal forces are equal to the external applied forces:

$$\int_0^b \sigma_z(2\pi r)dr = P_z(\pi r^2), \quad (9)$$

where P_z is the applied axial stress.

Rearranging the terms, the equilibrium equation (eqn. 3) can also be written as:

$$(\sigma_r + \sigma_\theta)r = \frac{d}{dr}(r^2\sigma_r). \quad (10)$$

Using equation 10, the second integral on the right side of equation 7 becomes:

$$\int_0^b v \frac{d}{dr}(r^2\sigma_r)dr = \sum_{i=1}^k v_i(a_i^2\sigma_r(a_i) - a_{i-1}^2\sigma_r(a_{i-1})). \quad (11)$$

Expanding and recollecting terms in equation 11:

$$\int_0^b v \frac{d}{dr}(r^2\sigma_r)dr = \sum_{i=1}^{k-1} (v_i - v_{i+1})a_i^2\sigma_r(a_i) + v_k b^2\sigma_r(b), \quad (12)$$

where $\sigma_r(b)$ is the applied radial stress at $r=b$.

The remaining terms are similarly evaluated assuming constant material properties and temperature distribution in each cylinder. The axial strain for k concentric cylinders then becomes:

$$\varepsilon_z = \frac{1}{E_c} \left(P_z - 2 \sum_{i=1}^{k-1} V_i \sigma_r(a_i)(v_i - v_{i+1}) - 2v_k \sigma_r(b) + \alpha_c E_c T + \frac{2}{b^2} \sum_{i=1}^k E_i \left(\int_0^b (\varepsilon_z^p + d\varepsilon_z^p) r dr \right) \right) \quad (13)$$

where $\sigma_r(b) = P_r$ is the applied radial stress at $r=b$

V_i is the volume fraction of the i th cylinder, $V_i = \frac{a_i^2 - a_{i-1}^2}{b^2}$

E_c is the axial composite modulus, $E_c = \sum_{i=1}^k E_i V_i$

α_c is the axial CTE of the composite, $\alpha_c = \frac{1}{E_c} \sum_{i=1}^k \alpha_i E_i V_i$.

In equation 13, the axial strain is written in terms of the radial stresses at the interfaces. The total plastic strains are known from the previous loading steps, and the new plastic strain increments are related to the stresses through a flow rule.

Note that for elastic fiber, equal Poisson's ratios for the fiber and matrix and zero applied radial stress, the second and third terms vanish leaving the total axial strain as the sum of the composite elastic strain (ε_z^{ec}), composite thermal strain (ε_z^{thc}) and composite plastic strain (ε_z^{pc}), as shown in the following equation:

$$\varepsilon_z^c = \varepsilon_z^{ec} + \varepsilon_z^{thc} + \varepsilon_z^{pc} = \frac{P_z}{E_c} + \alpha_c T + \frac{2}{b^2} \frac{E_m}{E_c} \int_a^b (\varepsilon_z^p + d\varepsilon_z^p) r dr. \quad (14)$$

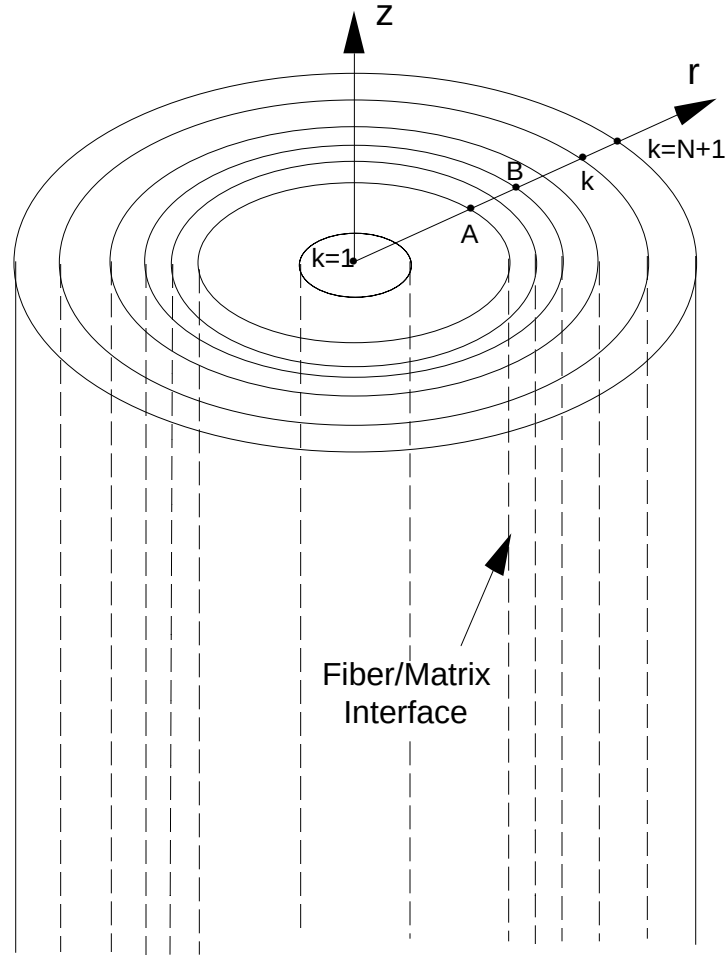
If the plastic strain is constant throughout the matrix, then we have for the total strain:

$$\varepsilon_z^c = \frac{P_z}{E_c} + \alpha_c T + \frac{E_m V_m}{E_c} \varepsilon_z^{pm}, \quad (15)$$

where ε_z^{pm} is the average matrix plastic strain. This expression is the same as that for the uniaxial stress model.

6.1.1.3 Numerical Solution

The method of finite differences is used to solve the two ordinary differential equations [Mendelson, 1968]. The disk radius is divided into N intervals as shown in Figure 35. There are thus $N+1$ stations, the first station being at the center of the disk and the last station at the outer



35. Discretization of the CCM.

radius. Equations. 3 and 6 are written in finite difference form at the midpoints of N cylinders, resulting in $2N$ equations as follows:

$$\left. \begin{aligned} \frac{1}{c_i} \sigma_{r,i-1} - \sigma_{r,i} + a_i \sigma_{\theta,i-1} + a_i \sigma_{\theta,i} &= 0 \\ G_i \sigma_{r,i-1} + D_i \sigma_{r,i} + H_i \sigma_{\theta,i-1} - F_i \sigma_{\theta,i} &= Q_i - P_i \end{aligned} \right\} \quad i = 2, \dots, N+1, \quad (16)$$

where $a_i = (r_i - r_{i-1}) / 2r_i$, $b_i = E_i / E_{i-1}$, $c_i = r_i / r_{i-1}$,

and

$$\begin{aligned} D_i &= (1 + \nu_i)(\nu_i + a_i), \\ F_i &= (1 + \nu_i)(1 - \nu_i + a_i), \\ G_i &= b_i(1 + \nu_{i-1})(\nu_{i-1} - a_i c_i), \\ H_i &= b_i(1 + \nu_{i-1})(1 - \nu_{i-1} - a_i c_i), \\ Q_i &= E_i T(\alpha_i(1 + \nu_i) - \alpha_{i-1}(1 + \nu_{i-1})), \\ P_i &= E_i(P_i^* + \varepsilon_z(\nu_i - \nu_{i-1})), \end{aligned}$$

where

$$P_i^* = \nu_i(\varepsilon_{r,i}^{p+} + \varepsilon_{\theta,i}^{p+}) - \nu_{i-1}(\varepsilon_{r,i-1}^{p+} + \varepsilon_{\theta,i-1}^{p+}) + a_i[\varepsilon_{r,i}^{p+} + c_i \varepsilon_{r,i-1}^{p+} - \varepsilon_{\theta,i}^{p+}(1/a_i + 1) + \varepsilon_{\theta,i-1}^{p+}(1/a_i - c_i)]$$

and the plastic strains, $\varepsilon_{r,i}^{p+}$, etc., are the updated plastic strains, i. e., $\varepsilon_{r,i}^{p+} = \varepsilon_{r,i}^p + d\varepsilon_{r,i}^p$, etc. The coefficients at the left side are functions of material properties at the i^{th} station. Only the P^* term on the right side involves plastic strains. The unknowns are $\sigma_{r,i}$ and $\sigma_{\theta,i}$, $i = 1, \dots, N+1$. Using the boundary conditions, $\sigma_{r,N+1} = P_r$ and $\sigma_{\theta,1} = 0$ the unknowns reduce to $2N$; $\sigma_{r,i}$, $i = 1, \dots, N$, and $\sigma_{\theta,i}$, $i = 2, \dots, N+1$. The axial stress distribution, σ_z , $i = 1, \dots, N+1$, is given by equation 5.

Moving the radial stress terms in equation 13 to the left side of equation. 16 and letting the radial stress at the j^{th} interface correspond to the radial stress at node $i = I_j$ i. e., $\sigma_r(a_j) = \sigma_{r,I_j}$, the second expression in equation 16 becomes:

$$\begin{aligned} -G_i \sigma_{r,i-1} + D_i \sigma_{r,i} + H_i \sigma_{\theta,i-1} - F_i \sigma_{\theta,i} - 2(\nu_i - \nu_{i-1}) \frac{E_i}{E_c} \sum_{j=1}^{k-1} V_j \sigma_{r,I_j} (\nu_{I_j} - \nu_{I_{j+1}}) \\ = Q_i - E_i P_i^* - E_i (\nu_i - \nu_{i-1}) \varepsilon_z^*, \end{aligned} \quad (17)$$

where

$$\varepsilon_z^* = \frac{1}{E_c} (P_z - 2\nu_k P_r + \alpha_c E_c T + 2/b^2 \sum_{j=1}^k E_j \int_0^b \varepsilon_z^{p+} r dr). \quad (18)$$

In the case of two concentric cylinders, $k=2$ and $j=1$, let INT be defined as the index of the highest numbered node in the fiber and $INT+1$ be the index of the lowest numbered node in the matrix. The fiber/matrix interface lies between these two nodes. Then, for all equations in which $i > INT+1$, i. e., equations for nodes not adjacent to the interface, $\nu_i - \nu_{i-1}$ is zero and the axial strain vanishes from these equations. For the $INT+1^{\text{st}}$ equation, equation 17 reduces to:

$$\begin{aligned}
& (2V_f E_m / E_c (v_f - v_m)^2 - G_{INT+1}) \sigma_{r,INT} + D_{INT+1} \sigma_{r,INT+1} + H_{INT+1} \sigma_{\theta,INT} + F_{INT+1} \sigma_{\theta,INT+1} \\
& = Q_{INT+1} - E_m P_{INT+1}^* - E_m (v_m - v_f) \varepsilon_z^*.
\end{aligned} \tag{19}$$

One final step before equation 16 is written in matrix form is to eliminate singular terms for $i=2$. Note that $\sigma_{r,l} = \sigma_{\theta,l}$. Replacing $\sigma_{\theta,l}$ in equation 16 by $\sigma_{r,l}$ we obtain:

$$(1/c_2 + a_2) \sigma_{r,1} - \sigma_{r,2} + a_2 \sigma_{\theta,2} = 0 \tag{20}$$

and

$$(H_2 - G_2) \sigma_{r,1} + D_2 \sigma_{r,2} - F_2 \sigma_{\theta,2} = Q_2 - P_2. \tag{21}$$

In the first equation $1/c_2 = r_1/r_2 = 0$. In the second equation, the term $H_2 - G_2$ is expanded and simplified. The final equations for $i=2$ become:

$$a_2 \sigma_{r,1} - \sigma_{r,2} + a_2 \sigma_{\theta,2} = 0 \tag{22}$$

and

$$(1 + v_1)(1 - 2v_1) b_2 \sigma_{r,1} + D_2 \sigma_{r,2} - F_2 \sigma_{\theta,2} = Q_2 - P_2 \tag{23}$$

Hence equation 16 is written in matrix form as:

$$\underline{A} \underline{x} = \underline{B}, \tag{24}$$

where $\underline{A}$ is a 2N by 2N matrix of constant coefficients, $\underline{x}$ is the radial and hoop stress vector of length 2N, and $\underline{B}$ is a vector of length 2N, as shown in Figure 36. In matrices $\underline{A}$ and $\underline{B}$, all of the constants are known except the plastic strain increments, which are presumed or computed from a flow rule.

6.1.2 Hybrid [0/90] Model

The [0/90] layup is treated by adding a parallel element with smeared [90] ply properties to the [0] ply represented by the concentric cylinder model (CCM) as shown in Figure 37 [Coker, et al., 1993b]. Stress equilibrium and strain compatibility are satisfied in the axial direction. No coupling of the transverse strains is assumed between the plies. There is no applied radial stress. The [90] lamina is characterized as a one-dimensional, homogeneous and isotropic element. The smeared mechanical and thermal properties for the [90] ply are obtained from a 3-D finite element analysis of a unit-cell or experiments.

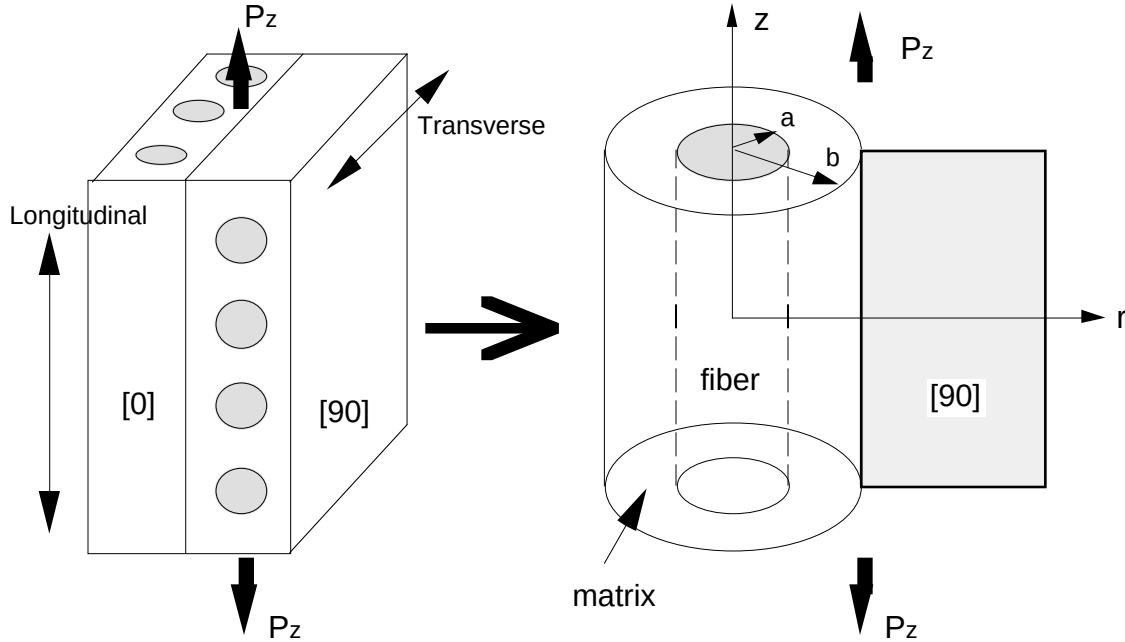


Figure 37. [0/90] Laminate and Its Representation as a CCM with a Parallel [90] Element.

The equations for the radial and hoop stresses for the CCM remain the same. The [90] element does not influence the transverse stresses in the CCM except through the effect on the axial strain and stress. Accounting for the parallel [90] element, the equation for the axial strain (eqn. 13) becomes:

$$\epsilon_z = \frac{1}{E_c} \left\{ P_z - 2 \sum_{i=1}^{k-2} V_i \sigma_r(a_i)(v_i - v_{i+1}) + \alpha_c E_c T + \frac{2}{b^2} \sum_{i=1}^{k-1} E_i \int_0^b \epsilon_z^p r dr + V_{90} E_{90} \epsilon_{z,90}^p \right\} \quad (25)$$

First, the radial and hoop stresses in the [0] ply are obtained from equation 24. The axial stresses in the [0] ply is then obtained from equation 5. Finally, the axial aggregate stress in the [90] ply is obtained from:

$$\sigma_{90} = \frac{1}{V_{90}} (P_z - \sigma_f V_f - \frac{V_m}{b^2 - a^2} \int \sigma_m r dr). \quad (26)$$

The smeared properties for the [90] ply are computed from finite element analysis of tensile loading at several temperatures. The effective transverse CTE is obtained from the aggregate strain versus temperature plot during cool-down and a database is created for the effective [90] ply properties at several temperatures and strain rates. The [90] ply is defined by a constitutive model which, in this study, is a Bodner-Partom model with directional hardening and damage, described in Section 6.2.4. The constitutive model of the [90] ply accounts for viscoplastic matrix behavior and damage in the form of fiber/matrix separation. The analysis accounts for the residual thermal stresses due to the CTE mismatch between the fiber and the matrix, as well as between the [0] ply and the [90] ply that occur during consolidation of the laminate. The [0/90] model utilizes the efficiency and simplicity of the CCM as incorporated into the computer program FIDEP2.

6.1.3 Uniaxial Stress Model

The uniaxial stress model (USM) is a rule of mixtures model consisting of multiple parallel elements that can represent constituents such as the fiber, matrix, and [90] ply constraining each other in the axial direction (Figure 1(c)). For the USM, the constituent strain is equal to the composite strain:

$$\varepsilon_i = \varepsilon_c, i=f, m, 90 \quad (27)$$

where f is the fiber, m is the matrix and c is the composite. The stress-strain relations are:

$$\sigma_i = E_i(\varepsilon_c - \varepsilon_i^{th} - \varepsilon_i^p), i = f, m, 90 \quad (28)$$

where ε_i^{th} is the thermal strain and ε_i^p is the inelastic strain. Load equilibrium in the axial direction is:

$$\sigma_{app} = \sum \sigma_i V_i, i=f, m, 90. \quad (29)$$

From these equations the expression for total strain becomes:

$$\varepsilon_c = \frac{1}{E_c}(\sigma_{app} + \alpha_c E_c \Delta T + \sum E_i V_i \varepsilon_i^p). \quad (30)$$

The stresses in the constituents are then obtained from equation 28. The CCM yields a three-dimensional stress distribution around the fiber, whereas the USM considers only the axial stresses in the constituents.

6.2 Constitutive Models

The plastic strain rates or plastic strain increments at the next incremental load is obtained by the solution of an initial value problem. The plastic strain rates and other internal state variables are given by the constitutive models and are obtained by numerical integration of the respective evolution equations. First, the general formulation that yields the relationship between the stresses and the plastic strains is described. The following sections then describe the different

constitutive models and their formulation of the evolution of plastic strain rates and the internal state variables with time. The constitutive models that have been incorporated into FIDEP2 are: elastic-plastic, Bodner-Partom with backstress, Bodner-Partom with directional hardening, and Bodner-Partom with damage.

6.2.1 General Formulation

The total strain can be divided into its elastic, plastic and thermal components:

$$\epsilon_{ij} = \epsilon_{ij}^e + \epsilon_{ij}^p + \epsilon_{ij}^{th}. \quad (31)$$

The inelastic strain, ϵ_{ij}^p , is equal to the plastic strain in the case of elastic-plastic material. In the case of viscoplastic behavior, the unified theory such as Bodner-Partom, this term represents plastic flow, creep, and stress relaxation. The elastic strain is given by Hooke's law:

$$\epsilon_{ij}^e = \frac{S_{ij}}{2G}. \quad (32)$$

The thermal strain is given by:

$$\epsilon_{ij}^{th} = \alpha \Delta T. \quad (33)$$

The plastic strain can be written as a plastic strain increment plus the plastic strain from the old time step:

$$\epsilon_{ij}^p = \epsilon_{ij,old}^p + d\epsilon_{ij}^p. \quad (34)$$

It may also be written in terms of inelastic strain rate as:

$$\epsilon_{ij}^p = \epsilon_{ij,old}^p + \dot{\epsilon}_{ij}^p \Delta \tau. \quad (35)$$

Flow rules define the relationship between the inelastic strain rates and the stresses. A common flow rule is the Prandtl-Reuss flow rule in which the plastic strain is assumed to be parallel to the deviatoric stresses:

$$\dot{\epsilon}_{ij}^p = \lambda_1 S_{ij}, \quad \dot{\epsilon}_{kk}^p = 0. \quad (36)$$

This flow rule is used by both classical plasticity and Bodner-Partom with directional hardening models. The Bodner-Partom with backstress model assumes the plastic strain rate to be parallel to deviatoric stress minus a backstress or equilibrium stress:

$$\dot{\epsilon}_{ij}^p = \lambda_1 (S_{ij} - \Omega_{ij}), \quad \dot{\epsilon}_{kk}^p = 0, \quad (37)$$

where Ω_{ij} is the backstress.

Kinetic equations are obtained by squaring both sides of the above equations:

$$\lambda = \left(\frac{D_2^p}{J_2} \right)^{1/2}, \quad (38)$$

where D_2^p is the second invariant of the plastic strain rate, $D_2^p = \frac{1}{2} \varepsilon_{ij}^p \varepsilon_{ij}^p$, and J_2 is the second invariant of the deviatoric stress, $J_2 = \frac{1}{2} S_{ij} S_{ij}$. For the Bodner-Partom with backstress model, $J_2 = \frac{1}{2} (S_{ij} - \Omega_{ij})(S_{ij} - \Omega_{ij})$. We define effective plastic strain increment and effective stress, respectively, as:

$$d\varepsilon^p = \sqrt{\frac{2}{3} d\varepsilon_{ij}^p d\varepsilon_{ij}^p} \quad \text{and} \quad \sigma_{eff} = \sqrt{\frac{3}{2} S_{ij} S_{ij}}. \quad (39)$$

Then in terms of effective quantities,

$$\lambda = \frac{3}{2} \frac{d\varepsilon^p}{\sigma_{eff}}, \quad (40)$$

and the flow rule becomes,

$$d\varepsilon_{ij}^p = \frac{3}{2} \frac{d\varepsilon^p}{\sigma_{eff}} S_{ij}. \quad (41)$$

These effective quantities are equal to the stress and plastic strain increment in the case of a uniaxial tension test.

6.2.2 Bilinear Elastic-Plastic Model

For an elastic-plastic material, equations 39 and 41 are used together with the von Mises yield criterion. Yielding begins when the effective stress reaches the yield stress determined from a uniaxial tensile test. The yield stress for a bilinear stress strain curve, with a plastic modulus E_p and elastic modulus E is given by:

$$Y = \sigma_y + \frac{mE}{1-m} \varepsilon_p^{eff}, \quad (42)$$

where m is the ratio of the plastic modulus to the elastic modulus, and ε_p^{eff} is the integral of the effective plastic strain increment.

The Prandtl-Reuss relations (eqn. 41) relate the plastic strain increments to the stresses. Another method for computing the plastic strain increments is to use equations that relate the plastic strain increments to the modified total strains. These equations are more stable with respect to the loading increment size and converge faster for most loading cases. In this approach the plastic strain increments are computed using a modified Prandtl-Reuss relations as discussed below [Mendelson, 1968].

Assume a loading path to a given state of stress and total plastic strains ϵ_{ij}^p and let the next load step be applied producing additional plastic strains $\Delta\epsilon_{ij}^p$. The total strains can be written as:

$$\epsilon_{ij} = \epsilon_{ij}^e + \epsilon_{ij}^{th} + \epsilon_{ij,old}^p + \Delta\epsilon_{ij}^p, \quad (43)$$

where ϵ_{ij}^e is the elastic component of the total strain, ϵ_{ij}^{th} is the thermal strain, ϵ_{ij}^p is the accumulated plastic strain up to (but not including) the current increment of load, and $\Delta\epsilon_{ij}^p$ is the increment of plastic strain due to the increment of load. The previous plastic strains ϵ_{ij}^p are presumed to be known, and $\Delta\epsilon_{ij}^p$ is to be calculated.

The modified total strains are defined as:

$$\epsilon'_{ij} = \epsilon_{ij} - \epsilon_{ij,old}^p = \epsilon_{ij}^e + \epsilon_{ij}^{th} + \Delta\epsilon_{ij}^p. \quad (44)$$

The deviatoric strains are obtained by subtracting the mean strain from the diagonal component of both sides:

$$\epsilon'_{ij} = \epsilon_{ij}^e + \Delta\epsilon_{ij}^p, \quad (45)$$

where ϵ_{ij}^e is the elastic strain deviator tensor and ϵ'_{ij} is the modified strain deviator tensor. From Hooke's Law and Prandtl-Reuss equation (eqn. 41):

$$\epsilon_{ij}^e = \frac{S_{ij}}{2G} = \frac{\Delta\epsilon_{ij}^p}{2G\lambda}, \quad (46)$$

where G is the shear modulus. Using this expression and equation 41, equation 45 becomes:

$$\epsilon'_{ij} = \left(1 + \frac{1}{2G\lambda}\right) d\epsilon_{ij}^p. \quad (47)$$

Multiplying both sides of the equation by two thirds itself yields:

$$\frac{2}{3} \epsilon'_{ij} \epsilon'_{ij} = \frac{2}{3} \left(1 + \frac{1}{2G\lambda}\right)^2 d\epsilon_{ij}^p d\epsilon_{ij}^p. \quad (48)$$

We define effective modified total strain in a similar fashion to the effective incremental plastic strain rate to obtain:

$$\epsilon'_{eff} = \left(1 + \frac{1}{2G\lambda}\right) d\epsilon^p. \quad (49)$$

The modified Prandtl-Reuss relations then become:

$$d\epsilon_{ij}^p = \frac{d\epsilon^p}{\epsilon'_{eff}} \epsilon'_{ij}, \quad (50)$$

where ϵ'_{ij} are the modified total deviatoric strains, ϵ'_{eff} is the equivalent or effective modified total strain defined by:

$$\epsilon'_{eff} = \sqrt{\frac{2}{3} \epsilon'_{ij} \epsilon'_{ij}}, \quad (51)$$

and $d\epsilon^p$ is the equivalent or effective plastic strain increment defined by equation 39. The modified Prandtl-Reuss equations are:

$$\begin{aligned} d\epsilon_x^p &= \frac{d\epsilon^p}{3\epsilon'_{eff}} (2\epsilon'_x - \epsilon'_y - \epsilon'_z), \\ d\epsilon_y^p &= \frac{d\epsilon^p}{3\epsilon'_{eff}} (2\epsilon'_y - \epsilon'_x - \epsilon'_z), \end{aligned} \quad (52)$$

and

$$d\epsilon_z^p = -(d\epsilon_x^p + d\epsilon_y^p).$$

Equation 50 is equivalent to the Prandtl-Reuss equation 41, but relate the incremental plastic strains to modified total strains instead of the stresses.

The relationship between the effective incremental plastic strain and effective modified total strain is obtained by substituting λ from equation 40 in equation 49:

$$\epsilon'_{eff} = d\epsilon^p + \frac{1}{3G} \sigma_{eff}. \quad (53)$$

Let the effective stress from the previous loading step be $\sigma_{eff,i-1}$. By expanding the effective stress in a Taylor series about $\sigma_{eff,i-1}$:

$$\sigma_{eff} = \sigma_{eff,i-1} + \left(\frac{d\sigma_{eff}}{d\epsilon^p} \right)_{i-1} d\epsilon^p, \quad (54)$$

the effective stress is eliminated from equation 4341 to obtain:

$$d\epsilon^p = \left(\epsilon'_{eff} - \frac{1}{3G} \sigma_{eff,i-1} \right) \frac{1}{1 + \frac{1}{3G} (d\sigma_{eff} / d\epsilon^p)_{i-1}}. \quad (55)$$

Equations 50, 51, and 55 are used simultaneously to determine plastic strain increments at each loading step for a bilinear elastic-plastic material.

6.2.3 Bodner-Partom Model with Backstress

The Bodner-Partom with backstress model is a modified version of the Bodner-Partom model [Bodner and Partom, 1975] in which backstress is included to account for both isotropic and

kinematic hardening behavior [Ramaswamy, et al., 1990]. The effective plastic strain rate is defined by:

$$\dot{\epsilon}^p = \frac{2}{\sqrt{3}} D_o \exp\left(-\frac{1}{2}\left(\frac{Z^2}{3K_2}\right)^n\right), \quad (56)$$

where $K_2 = \frac{1}{2}(S_{ij} - \Omega_{ij})(S_{ij} - \Omega_{ij})$. The backstress evolution equation is represented by:

$$\dot{\Omega}_{ij} = \frac{2}{3} f_1 \dot{\epsilon}_{ij}^I - f_1 \frac{\Omega_{ij}}{\Omega_s} \dot{\epsilon}_{eff}^I + f_2 \dot{S}_{ij}, \quad (57)$$

where Ω_s is the saturation value of the backstress during creep loading. The saturation of the backstress is given by the relation:

$$\dot{\Omega}_s = -B \left(\frac{\sqrt{3J_2}}{\sigma_o} \right) (\Omega_s - \Omega_{crp}). \quad (58)$$

The drag-stress evolution equation is given by:

$$\dot{Z} = m \dot{W}_p (Z_1 - Z) - A_1 (Z - Z_2)^p, \quad (59)$$

where $\dot{W}_p$ is the rate of inelastic work, given by, $\dot{W}_p = \sigma_{ij} \dot{\epsilon}_{ij}^p$.

6.2.4 Bodner-Partom Model with Directional Hardening

The effective plastic strain rate is defined by:

$$\dot{\epsilon}^p = \frac{2}{\sqrt{3}} D_o \exp\left(-\frac{1}{2}\left(\frac{(Z_I + Z_D)^2}{3K_2}\right)^n\right), \quad (60)$$

where Z_I and Z_D represent the isotropic and directional hardening components, respectively. [Chan, et al., 1988; Chan et al., 1990]. The isotropic hardening evolution equation is given by:

$$\dot{Z}_I = m_1 \dot{W}_p (Z_1 - Z_I) - A_1 Z_1 \left(\frac{Z_I - Z_2}{Z_1} \right)^p + \dot{T} \left[\left(\frac{Z_I - Z_2}{Z_1 - Z_2} \right) \frac{\partial Z_1}{\partial T} + \left(\frac{Z_1 - Z_I}{Z_1 - Z_2} \right) \frac{\partial Z_2}{\partial T} \right] \quad (61)$$

The directional hardening is given by:

$$Z_D = \beta_{ij} u_{ij}, \quad (62)$$

where the evolution equation for b_{ij} is given by:

$$\dot{\beta}_{ij} = m_2 \dot{W}_p (Z_3 u_{ij} - \beta_{ij}) - A_2 Z_1 \frac{\beta_{ij}}{\sqrt{\beta_{kl} \beta_{kl}}} \left(\frac{\sqrt{\beta_{kl} \beta_{kl}}}{Z_1} \right)^{r_2} + \dot{T} \frac{\beta_{ij}}{Z_3} \frac{\partial Z_3}{\partial T}, \quad (63)$$

where $u_{ij} = \frac{\sigma_{ij}}{\sqrt{\sigma_{kl} \sigma_{kl}}}$. The constants used in this model for Timetal21S are determined by trial and error using Mathematica“ from experiments [Neu, 1993].

6.2.5 Bodner-Partom Model with Directional Hardening and Damage

The model discussed in section 6.2.4 was modified to account for fiber/matrix separation by adding a damage parameter [Neu et al., 1996]. This model uses the uniaxial version of the previous equations except that the stress is replaced by an equivalent stress defined by:

$$\tilde{\sigma} = \frac{\sigma}{1 - \eta D} \quad (64)$$

This effective stress is used in the constitutive relations, which include the isotropic and directional hardening components. The elastic component becomes:

$$\tilde{\sigma} = E(\varepsilon - \varepsilon^p - \varepsilon^{th}). \quad (65)$$

This is equivalent to the modulus degradation identified by the following:

$$\tilde{E} = E(1 - \eta D). \quad (66)$$

The evolution equation for damage is given by,:

$$\frac{D}{D^*} = 1 - \exp \left[- \left(\frac{\sigma - \sigma_m - \sigma_{ch}}{\theta} \right)^m \right]. \quad (67)$$

This evolution equation is updated whenever $\sigma - \sigma_m - \sigma_{ch} > \sigma_p$, where σ_p is the peak stress reached in the [90] ply. The evolution of the internal state variables and the plastic strains are described by the same equations used in Section 6.2.4.

6.3 NUMERICAL INTEGRATION

Two iterative algorithms were considered for this investigation both of which use a forward-Euler integration scheme. The first algorithm uses the Prandtl-Reuss relations. For an increment of load, a distribution is assumed for the plastic strain increments. The boundary value problem is then solved for a first elastic approximation to the stresses and strains. At the same time, the effective plastic strain increment is calculated and the effective stress is computed. Finally, a new estimate is computed for the plastic strain increments and these steps are repeated until convergence is obtained. This algorithm is not very stable and may not converge for large load increments. For nonconvergent cases, the time increments can be taken smaller and smaller until convergence is obtained.

A second iterative method was used for the elastic-plastic material in which the modified version of the Prandtl-Reuss or the plastic strain-total strain relations are used [Mendelson, 1968]. This method is also called the elastic-predictor radial corrector method. In this algorithm, total strains are obtained from the stresses from equation 16 with assumed or previously calculated plastic strain increment estimates. Modified total strains and effective total strain are obtained from equation 49 and stress-strain curve using equation 56. The new plastic strain increments are then determined from equation 51. This process is repeated until convergence of the plastic strains is obtained. This method converges for even large loading increments and converges very rapidly.

Both of these algorithms are implemented into the program FIDEP2, Finite-Difference Code for Elastic-Viscoplastic Analysis of Composites. For the viscoplastic model, the program uses the first algorithm, whereas for an elastic-plastic material, the code uses the second algorithm.

REFERENCES

- Bodner, S. R. and Partom, Y., 1975, "Constitutive Equations for Elastic-Viscoplastic Strain Hardening Materials," ASME Journal of Applied Mechanics, Vol. 242, p. 385.
- Chan, K. S., Bodner, S. R., and Lindholm, U. S., 1988, "Phenomenological Modeling of Hardening and Thermal Recovery in Metals," ASME Journal of Engineering Materials and Technology, Vol. 110, pp. 1-8.
- Chan, K. S., Lindholm, U. S., Bodner, S. R., and Nagy, A., 1990, "High Temperature Inelastic Deformation of the B1900+Hf Alloy under Multiaxial Loading Theory and Experiment," ASME Journal of Engineering Materials and Technology, Vol. 112, January, pp. 7-14.
- Coker, D. and Ashbaugh, N. E., 1992, Elastic-Plastic Finite Difference Analysis of Unidirectional Composites Subjected to Thermomechanical Cyclic Loading, WL-TR-93-4043, Wright-Patterson AFB, Materials Directorate, Wright Laboratory.
- Coker, D., Ashbaugh, N. E., and Nicholas, T., 1993a, "Analysis of Thermomechanical Cyclic Behavior of Unidirectional Metal Matrix Composites," Thermomechanical Fatigue Behavior of Materials, ASTM STP 1186, Ed. H. Sehitoglu, American Society of Testing and Materials, Philadelphia, pp. 50-69.
- Coker, D., Ashbaugh, N. E., and Nicholas, T., 1993b, "Analysis of the Thermomechanical Behavior of [0] and [0/90] SCS-6/Timetal21S Composites," Thermomechanical Behavior of Advanced Structural Materials, AD-Vol 34/AMD-Vol. 173, Ed. W. F. Jones, The American Society of Mechanical Engineers, pp. 1-16.
- Kroupa, J.L., 1995, "Implementation of a Nonisothermal Unified Inelastic-Strain Theory for a Ti Alloy in ABAQUS5.4 - USER GUIDE, Accepted as an Air Force Technical Manual, AFRL-ML-WP-TR-1998-4143, May 1996.
- Mendelson, A., 1968, Plasticity: Theory and Application, MacMillan, New York.
- Neu, R. W., 1993, "Nonisothermal Material Properties for the Bodner-Partom Model," MD-Vol. 43/AMD-Vol. 168, L. A. Bertram, S. B. Brown, and A. D. Freed, Eds., Material Parameter Estimation for Modern Constitutive Equations, The American Society of Mechanical Engineers, New York, pp. 211-226.
- Neu, R. W., Coker, D., and Nicholas, T., 1996, "Cyclic Behavior of Unidirectional and Crossply Titanium Matrix Composites," International Journal of Plasticity, 12, pp. 361-385.
- Ramaswamy, V. G., Stouffer, D. C., and Laflen, J. H., 1990, "A Unified Constitutive Model for the Inelastic Uniaxial Response of Rene 80 at Temperatures between 538° C and 982° C," ASME Journal of Engineering Materials and Technology, Vol. 112, No. 3, pp. 280-286.
- Sherwood, J.A., and Quimby H.M., 1995, "Micromechanical Modeling of Damage Growth in Titanium Based Metal-Matrix Composites, Computers and Structures, Vol. 56, No. 2/3, pp.505-514.

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APPENDIX A

Material Database File: MATERIAL.DAT

Summary of Material Properties and Types in material data file MATERIAL.DAT

Material no.	Material Model	Material Definition
1	1	SCS-6 Fiber (1), Temperature-independent, $n = 0.3$
2	1	SCS-6 Fiber (2), Temperature-dependent, $n = 0.3$
3	1	SCS-6 Fiber (3), Temperature-dependent, $n = 0.22$
4	2	Ti-24-11 bilinear elastic-plastic, temperature-independent
5	2	Ti-24-11 bilinear elastic-plastic
6	1	Ti-24-11 elastic matrix
7	5	Ti-24-11 Bodner-Partom with backstress
8	5	Ti-24-11 Bodner-Partom with backstress, temperature-independent
9	2	TIMETAL21S bilinear elastic-plastic/UDRI/Strain controlled/ $\dot{\epsilon} = 833.3E-6$
10	2	TIMETAL21S bilinear elastic-plastic/Round Robin/Stress controlled
11	2	[0 _i] 35% SCS-6/Ti-24-11 ply bilinear elastic-plastic
12	2	[90 _j] 35% SCS-6/Ti-24-11 ply bilinear elastic-plastic
13	1	SCS-6 Fiber/Steve Johnson, NASA, LaRC, CTE/UDRI/GE $T_{ref} = 1010$
14	1	SCS-6 Fiber/R. W. Neu/ same as 13 except $T_{ref} = 900$
15	2	[90 _j] 35% SCS-6/TIMETAL21S bilinear elastic-plastic/no bonding
16	6	TIMETAL21S Bodner-Partom with Directional Hardening with A1 given as a function
17	6	TIMETAL21S Bodner-Partom with Directional Hardening with A1, CTE, and E given as a function
18	2	TIMETAL21S bilinear elastic-plastic/strain-controlled/ $\dot{\epsilon} = 8.33e-6$
19	2	[90] SCS6/TIMETAL21S weak f/m interface $\dot{\epsilon} = 833e-6$ / Ref: Kroupa Report, 1994
20	2	[90] SCS6/TIMETAL21S weak f/m interface $\dot{\epsilon} = 8.33e-6$ / Ref: Kroupa Report, 1994

MATERIAL PROPERTIES DATA FILE: MATERIAL.DAT

=====

1 1

SCS-6 FIBER (1), temp indep props, n = 0.3

1

T(C)	E(GPa)	NU	CTE(1E-6/C)
------	--------	----	-------------

20	414	0.3	4.703
----	-----	-----	-------

20

2 1

SCS-6 FIBER (2), temp dep props, n = 0.3

11

T(C)	E(GPa)	NU	CTE(1E-6/C)
------	--------	----	-------------

20	414	0.30	4.703
----	-----	------	-------

93	414	0.30	4.812
----	-----	------	-------

204	414	0.30	4.970
-----	-----	------	-------

316	414	0.30	5.119
-----	-----	------	-------

427	414	0.30	5.256
-----	-----	------	-------

538	414	0.30	5.382
-----	-----	------	-------

649	414	0.30	5.497
-----	-----	------	-------

760	414	0.30	5.602
-----	-----	------	-------

871	414	0.30	5.697
-----	-----	------	-------

982	414	0.30	5.781
-----	-----	------	-------

1010	414	0.30	5.800
------	-----	------	-------

1010

3 1

SCS-6 FIBER (3), temp dep props, n = 0.22

11

T(C)	E(GPa)	NU	CTE(1E-6/C)
------	--------	----	-------------

20	414	0.22	4.703
----	-----	------	-------

93	414	0.22	4.812
----	-----	------	-------

204	414	0.22	4.970
-----	-----	------	-------

316	414	0.22	5.119
-----	-----	------	-------

427	414	0.22	5.256
-----	-----	------	-------

538	414	0.22	5.382
649	414	0.22	5.497
760	414	0.22	5.602
871	414	0.22	5.697
982	414	0.22	5.781
1010	414	0.22	5.800
1010			

4 2

TI-24-11 bilinear elastic-plastic matrix, temp indep

1

T(C)	E(GPa)	NU	CTE(1E-6/C)
------	--------	----	-------------

20	94.0	0.3	11.310
----	------	-----	--------

20

1

1 2

SY(MPa)	EP(GPa)
---------	---------

604.0	1.300
-------	-------

5 2

Ti-24-11 bilinear elastic-plastic matrix

11

T(C)	E(GPa)	NU	CTE(1E-6/C)
------	--------	----	-------------

20	94.0	0.3	11.310
----	------	-----	--------

93	92.0	0.3	11.480
----	------	-----	--------

204	91.0	0.3	11.690
-----	------	-----	--------

316	89.0	0.3	11.880
-----	------	-----	--------

427	79.0	0.3	12.096
-----	------	-----	--------

538	70.0	0.3	12.365
-----	------	-----	--------

649	49.5	0.3	12.727
-----	------	-----	--------

760	24.5	0.3	13.217
-----	------	-----	--------

871	18.0	0.3	13.870
-----	------	-----	--------

982	15.9	0.3	14.720
-----	------	-----	--------

1010	15.0	0.3	14.972
------	------	-----	--------

1010

1

11 2

T (C)	SY (MPa)	EP (GPa)
-------	----------	----------

20	604.0	1.300
----	-------	-------

93	560.0	0.900
----	-------	-------

204	498.0	0.719
-----	-------	-------

316	447.0	0.692
-----	-------	-------

427	421.0	0.415
-----	-------	-------

538	381.0	0.110
-----	-------	-------

649	356.5	0.000
-----	-------	-------

760	252.4	2.350
-----	-------	-------

871	138.3	2.628
-----	-------	-------

982	38.04	1.180
-----	-------	-------

1010	30.00	1.000
------	-------	-------

6 1

TI-24-11 elastic matrix

11

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

20	94.0	0.3	11.310
----	------	-----	--------

93	92.0	0.3	11.480
----	------	-----	--------

204	91.0	0.3	11.690
-----	------	-----	--------

316	89.0	0.3	11.880
-----	------	-----	--------

427	79.0	0.3	12.096
-----	------	-----	--------

538	70.0	0.3	12.365
-----	------	-----	--------

649	49.5	0.3	12.727
-----	------	-----	--------

760	24.5	0.3	13.217
-----	------	-----	--------

871	18.0	0.3	13.870
-----	------	-----	--------

982	15.9	0.3	14.720
-----	------	-----	--------

1010	15.0	0.3	14.972
------	------	-----	--------

1010

7 5

TI-24-11 BODNER-PARTOM WITH BACKSTRESS

11

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

20	94.0	0.3	11.310
----	------	-----	--------

93	92.0	0.3	11.480
204	91.0	0.3	11.690
316	89.0	0.3	11.880
427	79.0	0.3	12.096
538	70.0	0.3	12.365
649	49.5	0.3	12.727
760	24.5	0.3	13.217
871	18.95	0.3	13.870
982	15.9	0.3	14.720
1010	15.0	0.3	14.972

1010

2

11 5

T (C)	n	Zo (MPa)	f1 (MPa)	f3	BSMAX (MPa)
20.0	1.300	484.	144375.	0.7926	476
93.0	1.300	484.	65317.	0.7800	435
204.0	1.250	491.	36437.	0.7665	377
316.0	1.120	517.	55000.	0.7740	341
427.0	1.000	551.	68750.	0.7680	327
538.0	0.870	970.	78375.	0.6572	280
649.0	0.700	1649.	88000.	0.5000	214
760.0	0.520	4384.	7187.	0.3500	123
871.0	0.300	49012.	7562.	0.0010	25
982.0	0.150	5000000.	4000.	0.0001	18
1010.0	0.150	5000000.	4000.	0.0001	18

1 2

S D0

1.0 1.0E4

8 5

TI-24-11 B-P WITH BACKSTRESS, TEMP INDEPENDENT

1

T (C)	E (GPa)	NU	CTE (1E-6/C)
20	93.06	0.3	11.310

20

2

```

1 5
n      Zo (MPa)    f1 (MPa)   f3   BS MAX (MPa)
1.300  484.        144375.   0.7926  476

```

```

1 2
S      D0
1.0    1.0E4

```

```

-----
9 2
B21S/UDRI/Strain control-EDOT=833.3E-6, EL-PL

```

```

7
T(C)  E(GPa)  NU      CTE(1E-6/C)
23     114    0.34     8.8700
260    114    0.34     9.8800
482     90    0.34    10.713
650     78    0.34    11.282
760     70    0.34    11.624
815     64    0.34    11.787
900    54.7   0.34    12.027

```

```

650

```

```

1

```

```

7 2
T(C)   SY (MPa)  EP (GPa)
23     1107      0.459
260    1010      1.486
482    810.      2.000
650    350.      0.000
760    120.      0.000
815    110.      0.000
900    94.0      0.000

```

```

-----
10 2
B21S/Round Robin/Stress control, EL-PL

```

```

7
T(C)  E(GPa)  NU      CTE(1E-6/C)
21     117    0.34     9.4514
316    101    0.34     9.9880

```

482	95.4	0.34	10.313
566	78.1	0.34	10.477
621	73.2	0.34	10.590
650	70.6	0.34	10.651
900	50.9	0.34	11.168

650

1

7 2

T (C)	SY (MPa)	EP (GPa)
-------	----------	----------

21	1050	3.840
----	------	-------

316	775.	5.400
-----	------	-------

482	690.	6.380
-----	------	-------

566	470.	16.96
-----	------	-------

621	289.	14.72
-----	------	-------

650	269.	0.000
-----	------	-------

900	94.0	0.000
-----	------	-------

11 2

0 degree el-pl ply properties

5

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

20	201	0.25	6.54
----	-----	------	------

315	205	0.25	7.02
-----	-----	------	------

650	176	0.25	6.73
-----	-----	------	------

815	166	0.25	6.61
-----	-----	------	------

1010	155	0.25	6.19
------	-----	------	------

1010

1

5 2

T (C)	SY (MPa)	EP (GPa)
-------	----------	----------

20	1256	171.2
----	------	-------

315	249	146.3
-----	-----	-------

650	582	148.8
-----	-----	-------

815	565	146.3
-----	-----	-------

1010	400	140.0
------	-----	-------

12 2

90 degree ply properties (SCS-6/Ti-24-11/35%)

6

T(C)	E(GPa)	NU	CTE(1E-6/C)
------	--------	----	-------------

20	115	0.25	9.42
----	-----	------	------

315	109	0.25	9.98
-----	-----	------	------

650	28.8	0.25	10.7
-----	------	------	------

760	21.3	0.25	11.1
-----	------	------	------

815	17.2	0.25	11.37
-----	------	------	-------

1010	10	0.25	12.60
------	----	------	-------

1010

1

6 2

T(C)	SY(MPa)	EP(GPa)
------	---------	---------

20	219	41.4
----	-----	------

315	197	6.2
-----	-----	-----

650	144	3.3
-----	-----	-----

760	96	2.86
-----	----	------

815	82	2.8
-----	----	-----

1010	40	2.7
------	----	-----

13 1

SCS-6 Fiber properties (Steve Johnson, NASA LaRC),cte/udri/ge

10

T(C)	E(GPa)	NU	CTE(1E-6/C)
------	--------	----	-------------

21.11	393	0.25	4.70
-------	-----	------	------

93.33	390	0.25	4.81
-------	-----	------	------

204.44	386	0.25	4.97
--------	-----	------	------

315.56	382	0.25	5.12
--------	-----	------	------

426.67	378	0.25	5.26
--------	-----	------	------

537.78	374	0.25	5.38
--------	-----	------	------

648.89	370	0.25	5.50
--------	-----	------	------

760.00	365	0.25	5.60
--------	-----	------	------

871.11	361	0.25	5.70
--------	-----	------	------

1093.3	354	0.25	5.80
--------	-----	------	------

1010

14 1

SCS-6 Fiber - R.W. Neu - same as Kroupa CTE??

10

T (C)	E (GPa)	NU	CTE (1E-6/C)
21.11	393	0.25	3.9907
93.33	390	0.25	4.0289
204.44	386	0.25	4.0989
315.56	382	0.25	4.1801
426.67	378	0.25	4.2655
537.78	374	0.25	4.3510
648.89	370	0.25	4.4324
760.00	365	0.25	4.5074
871.11	361	0.25	4.5718
1093.3	354	0.25	4.5723

900

15 2

SCS-6/TIMETAL21S NO BONDING 90 BILINEAR BEHAVIOR

7

T (C)	E (GPa)	NU	CTE (1E-6/C)
23	138.4	0.3	8.13
260	137.99	0.3	8.81
480	114.25	0.3	9.45
650	95.04	0.3	9.94
760	93.03	0.3	10.26
815	97.25	0.3	10.41
900	28.65	0.3	10.66

900

1

7 2

T (C)	SY (MPa)	EP (GPa)
23	257.4	39.11
260	226.3	37.65
480	121.1	38.95
650	71.28	28.01

760	33.49	20.82
815	21.59	25.64
900	47.75	0.997

16 6

TIMETAL 21S B-P WITH DIRECTIONAL HARDENING 4/93

16

T (C)	E (GPa)	NU	CTE (1E-6/C)
23	112.0	0.34	9.7787
260	108.0	0.34	10.713
315	106.1	0.34	10.915
365	104.1	0.34	11.093
415	101.7	0.34	11.267
465	99.09	0.34	11.436
482	98.11	0.34	11.492
500	97.05	0.34	11.550
525	95.50	0.34	11.631
550	93.87	0.34	11.710
575	92.17	0.34	11.788
600	90.40	0.34	11.865
650	86.61	0.34	12.014
760	77.22	0.34	12.323
815	71.96	0.34	12.467
900	63.12	0.34	12.689

900

2

16 4

T (C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
23	4.800	1550.0	100.0	0.350
260	3.500	1300.0	300.0	0.350
315	3.054	1250.4	390.0	1.502
365	2.649	1205.4	500.0	2.549
415	2.243	1160.4	660.0	3.597
465	1.838	1115.3	960.0	4.644
482	1.700	1100.0	1100.	5.000
500	1.500	1089.3	1300.	5.763

525	1.280	1074.4	1670.	6.822
550	1.100	1059.5	2100.	7.881
575	0.970	1044.6	2600.	8.941
600	0.820	1029.8	3700.	10.00
650	0.740	1000.0	3800.	10.00
760	0.580	600.0	4000.	15.00
815	0.550	300.0	4100.	30.00
900	0.550	300.0	4300.	30.00

1 5

A1=A2 M1 Z1 R1=R2 DO

-9999 0.0 1600. 3.0 10000.

17 6

TIMETAL 21S B-P WITH DIRECTIONAL HARDENING 4/93

1 ---- SAME AS MAT17, SIMPLIFIED ----

T(C) E(GPa) NU CTE(1E-6/C)

23 -9999 0.34 -9999

23 WARNING:PROGRAM WON'T CALCULATE CTE WRT TO TPROC

2

16 4

T(C) N Z0(1/S) Z3(MPa) M2(1/MPa)

23 4.800 1550.0 100.0 0.350

260 3.500 1300.0 300.0 0.350

315 3.054 1250.4 390.0 1.502

365 2.649 1205.4 500.0 2.549

415 2.243 1160.4 660.0 3.597

465 1.838 1115.3 960.0 4.644

482 1.700 1100.0 1100. 5.000

500 1.500 1089.3 1300. 5.763

525 1.280 1074.4 1670. 6.822

550 1.100 1059.5 2100. 7.881

575 0.970 1044.6 2600. 8.941

600 0.820 1029.8 3700. 10.00

650 0.740 1000.0 3800. 10.00

760 0.580 600.0 4000. 15.00

815 0.550 300.0 4100. 30.00

```

900    0.550    300.0    4300.    30.00
1 5
A1=A2    M1    Z1    R1=R2    DO
-9999    0.0    1600.    3.0    10000.

```

```

18 2

```

Strain control-EDOT=8.33E-6, EL-PL

```

7

```

T (C)	E (GPa)	NU	CTE (1E-6/C)
23	114	0.34	8.8700
260	106	0.34	9.8800
482	96	0.34	10.713
650	55	0.34	11.282
760	38	0.34	11.624
815	24	0.34	11.787
900	5	0.34	12.027

```

650
1

```

```

7 2

```

T (C)	SY (MPa)	EP (GPa)
23	1065	0.459
260	865	1.486
482	685	2.000
650	125	0.000
760	31	0.000
815	20	0.000
900	10	0.000

APPENDIX B

Material Properties Database File: TIMETAL.DAT

Summary of Material Properties and Types in material data file TIMETAL.DAT

Material no.	Material Model	Material Definition
1	1	SCS-6 Fiber
2	2	TIMETAL21S/UDRI/ EDOT=833.3E-6, EL-PL
3	2	TIMETAL21S EDOT=8.33E-6, EL-PL
4	6	TIMETAL 21S B-P WITH DIRECTIONAL HARDENING 4/93
5	2	[90] 35% bp timetal weak f/m int edot=833 (Kroupa)
6	2	[90] 35% bp timetal edot=8.33, bilinear fit, (Kroupa)
7	2	[90] 35% bp timetal weak f/m int edot=833,new curve fit
8	2	[90] 35% bp timetal edot=8.33, bilinear, new curve fit
9	2	[90] 35% bp timetal weak f/m int edot=833, MAT5+MAT7
10	4	90 with damage and b-p 4/93
11	6	90 without damage and with b-p 4/93
12	6	TIMETAL 21S B-P w/diff props at 650 to make zd work
13	6	TIMETAL 21S B-P w/diff props at 650 and 815 to make zd work
14	4	90 with damage and b-p 4/93 and diff prop@650
15	4	90 with damage and b-p 4/93 and diff prop@650 & 815
16	4	90 with damage and b-p=MAT10 with matrix cte from mat4

Materials for SCS-6/Timetal composite - TIMETAL.DAT

=====

1 1

SCS-6 Fiber

10

T (C)	E (GPa)	NU	CTE (1E-6/C)
21.11	393	0.25	3.9907
93.33	390	0.25	4.0289
204.44	386	0.25	4.0989
315.56	382	0.25	4.1801
426.67	378	0.25	4.2655
537.78	374	0.25	4.3510
648.89	370	0.25	4.4324
760.00	365	0.25	4.5074
871.11	361	0.25	4.5718
1093.3	354	0.25	4.5723
900			

2 2

TIMETAL21S/UDRI/ EDOT=833.3E-6, EL-PL

7

T (C)	E (GPa)	NU	CTE (1E-6/C)
23	114	0.34	8.8700
260	114	0.34	9.8800
482	90	0.34	10.713
650	78	0.34	11.282
760	70	0.34	11.624
815	64	0.34	11.787
900	54.7	0.34	12.027
650			

1

7 2

T (C)	SY (MPa)	EP (GPa)
23	1107	0.459
260	1010	1.486

482	810.	2.000
650	350.	0.000
760	120.	0.000
815	110.	0.000
900	94.0	0.000

3 2

TIMETAL21S EDOT=8.33E-6, EL-PL

7

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

23	114	0.34	8.8700
260	106	0.34	9.8800
482	96	0.34	10.713
650	55	0.34	11.282
760	38	0.34	11.624
815	24	0.34	11.787
900	5	0.34	12.027

650

1

7 2

T (C)	SY (MPa)	EP (GPa)
-------	----------	----------

23	1065	0.459
260	865	1.486
482	685	2.000
650	125	0.000
760	31	0.000
815	20	0.000
900	10	0.000

4 6

TIMETAL 21S B-P WITH DIRECTIONAL HARDENING 4/93

16

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

23	112.0	0.34	9.7787
260	108.0	0.34	10.713
315	106.1	0.34	10.915

365	104.1	0.34	11.093
415	101.7	0.34	11.267
465	99.09	0.34	11.436
482	98.11	0.34	11.492
500	97.05	0.34	11.550
525	95.50	0.34	11.631
550	93.87	0.34	11.710
575	92.17	0.34	11.788
600	90.40	0.34	11.865
650	86.61	0.34	12.014
760	77.22	0.34	12.323
815	71.96	0.34	12.467
900	63.12	0.34	12.689
900			

2

16 4

T (C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
23	4.800	1550.0	100.0	0.350
260	3.500	1300.0	300.0	0.350
315	3.054	1250.4	390.0	1.502
365	2.649	1205.4	500.0	2.549
415	2.243	1160.4	660.0	3.597
465	1.838	1115.3	960.0	4.644
482	1.700	1100.0	1100.	5.000
500	1.500	1089.3	1300.	5.763
525	1.280	1074.4	1670.	6.822
550	1.100	1059.5	2100.	7.881
575	0.970	1044.6	2600.	8.941
600	0.820	1029.8	3700.	10.00
650	0.740	1000.0	3800.	10.00
760	0.580	600.0	4000.	15.00
815	0.550	300.0	4100.	30.00
900	0.550	300.0	4300.	30.00

1 5

A1=A2	M1	Z1	R1=R2	DO
-9999	0.0	1600.	3.0	10000.

5 2

[90] 35% bp timetal weak f/m int edot=833, Ref:kroupa

8

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

23	133	0.19	5.75
----	-----	------	------

260	128	0.19	6.20
-----	-----	------	------

482	119	0.19	6.91
-----	-----	------	------

538	115	0.18	7.08
-----	-----	------	------

593	112	0.18	7.25
-----	-----	------	------

650	105	0.17	7.42
-----	-----	------	------

815	50	0.17	7.94
-----	----	------	------

900	20	0.17	8.32
-----	----	------	------

25

1

8 2

T (C)	SY (MPa)	EP (GPa)
-------	----------	----------

23	190	62
----	-----	----

260	130	56
-----	-----	----

482	70	50
-----	----	----

538	50	50
-----	----	----

593	36	50
-----	----	----

650	17	47
-----	----	----

815	10	28
-----	----	----

900	10	10
-----	----	----

6 2

[90] 35% bp timetal edot=8.33, bilinear fit, Ref:kroupa

8

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

23	133	0.19	5.75
----	-----	------	------

260	128	0.19	6.20
-----	-----	------	------

482	119	0.19	6.91
-----	-----	------	------

538	115	0.18	7.08
-----	-----	------	------

593	112	0.18	7.25
-----	-----	------	------

650	105	0.17	7.42
-----	-----	------	------

815	50	0.17	7.94
900	20	0.17	8.32

25

1

8 2

T (C)	SY (MPa)	EP (GPa)
-------	----------	----------

23	190	62
----	-----	----

260	130	56
-----	-----	----

482	70	50
-----	----	----

538	50	50
-----	----	----

593	36	50
-----	----	----

650	17	45
-----	----	----

815	10	20
-----	----	----

900	10	10
-----	----	----

7 2

[90] 35% bp timetal weak f/m int edot=833,new curvefit

8

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

23	85.2	0.19	5.75
----	------	------	------

260	66.5	0.19	6.20
-----	------	------	------

482	64.4	0.19	6.91
-----	------	------	------

538	60.9	0.18	7.08
-----	------	------	------

593	44.2	0.18	7.25
-----	------	------	------

650	40.4	0.17	7.42
-----	------	------	------

815	31.9	0.17	7.94
-----	------	------	------

900	20.0	0.17	8.32
-----	------	------	------

25

1

8 2

T (C)	SY (MPa)	EP (GPa)
-------	----------	----------

23	554	4.15
----	-----	------

260	452	5.00
-----	-----	------

482	406	1.61
-----	-----	------

538	347	1.40
-----	-----	------

593	287	1.26
-----	-----	------

650	194	1.64
815	51.0	0.136
900	10	0

8 2

[90] 35% bp timetal edot=8.33, bilinear,new curve fit

8

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

23	133	0.19	5.75
----	-----	------	------

260	128	0.19	6.20
-----	-----	------	------

482	119	0.19	6.91
-----	-----	------	------

538	115	0.18	7.08
-----	-----	------	------

593	112	0.18	7.25
-----	-----	------	------

650	105	0.17	7.42
-----	-----	------	------

815	50	0.17	7.94
-----	----	------	------

900	20	0.17	8.32
-----	----	------	------

25

1

8 2

T (C)	SY (MPa)	EP (GPa)
-------	----------	----------

23	527	4.58
----	-----	------

260	435	3.87
-----	-----	------

482	340	2.51
-----	-----	------

538	218	2.63
-----	-----	------

593	131	0.83
-----	-----	------

650	72.9	0.65
-----	------	------

815	10.5	0.08
-----	------	------

900	10	0
-----	----	---

9 2

[90] 35% bp timetal weak f/m int edot=833, MAT5+MAT7

8

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

23	133	0.19	5.75
----	-----	------	------

260	128	0.19	6.20
-----	-----	------	------

482	119	0.19	6.91
-----	-----	------	------

538	115	0.18	7.08
593	112	0.18	7.25
650	40.4	0.17	7.42
815	31.9	0.17	7.94
900	20.0	0.17	8.32

25

1

8 2

T (C)	SY (MPa)	EP (GPa)
-------	----------	----------

23	190	62
260	130	56
482	70	50
538	50	50
593	36	50
650	194	1.64
815	51.0	0.136
900	10	0

10 4

90 with damage and b-p 4/93

8

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

23	133	0.19	5.75
260	128	0.19	6.20
482	119	0.19	6.91
538	115	0.18	7.08
593	112	0.18	7.25
650	105	0.17	7.42
815	50	0.17	7.94
900	20	0.17	8.32

25

4

16 4

T (C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
-------	---	-------------	----------	------------

23	4.800	1550.0	100.0	0.350
260	3.500	1300.0	300.0	0.350

315	3.054	1250.4	390.0	1.502
365	2.649	1205.4	500.0	2.549
415	2.243	1160.4	660.0	3.597
465	1.838	1115.3	960.0	4.644
482	1.700	1100.0	1100.	5.000
500	1.500	1089.3	1300.	5.763
525	1.280	1074.4	1670.	6.822
550	1.100	1059.5	2100.	7.881
575	0.970	1044.6	2600.	8.941
600	0.820	1029.8	3700.	10.00
650	0.740	1000.0	3800.	10.00
760	0.580	600.0	4000.	15.00
815	0.550	300.0	4100.	30.00
900	0.550	300.0	4300.	30.00

1 5

A1=A2	M1	Z1	R1=R2	DO
-9999	0.0	1600.	3.0	10000.

7 1

T	sm
23	190
260	130
482	70
538	50
593	36
650	17
815	0

1 7

scho	scl	m	theta	Dstar	beta	Dch
80	0	1	100	0.61	0.05	0.5

11 6

90 without damage and with b-p 4/93

8

T(C)	E(GPa)	NU	CTE(1E-6/C)
23	133	0.19	5.75
260	128	0.19	6.20

482	119	0.19	6.91
538	115	0.18	7.08
593	112	0.18	7.25
650	105	0.17	7.42
815	50	0.17	7.94
900	20	0.17	8.32

25

2

16 4

T (C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
23	4.800	1550.0	100.0	0.350
260	3.500	1300.0	300.0	0.350
315	3.054	1250.4	390.0	1.502
365	2.649	1205.4	500.0	2.549
415	2.243	1160.4	660.0	3.597
465	1.838	1115.3	960.0	4.644
482	1.700	1100.0	1100.	5.000
500	1.500	1089.3	1300.	5.763
525	1.280	1074.4	1670.	6.822
550	1.100	1059.5	2100.	7.881
575	0.970	1044.6	2600.	8.941
600	0.820	1029.8	3700.	10.00
650	0.740	1000.0	3800.	10.00
760	0.580	600.0	4000.	15.00
815	0.550	300.0	4100.	30.00
900	0.550	300.0	4300.	30.00

1 5

A1=A2	M1	Z1	R1=R2	DO
-9999	0.0	1600.	3.0	10000.

12 6

TIMETAL 21S B-P WITH Diff props at 650 to make zd work

16

T (C)	E (GPa)	NU	CTE (1E-6/C)
23	112.0	0.34	9.7787
260	108.0	0.34	10.713

315	106.1	0.34	10.915
365	104.1	0.34	11.093
415	101.7	0.34	11.267
465	99.09	0.34	11.436
482	98.11	0.34	11.492
500	97.05	0.34	11.550
525	95.50	0.34	11.631
550	93.87	0.34	11.710
575	92.17	0.34	11.788
600	90.40	0.34	11.865
650	86.61	0.34	12.014
760	77.22	0.34	12.323
815	71.96	0.34	12.467
900	63.12	0.34	12.689

900

2

16 4

T (C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
23	4.800	1550.0	100.0	0.350
260	3.500	1300.0	300.0	0.350
315	3.054	1250.4	390.0	1.502
365	2.649	1205.4	500.0	2.549
415	2.243	1160.4	660.0	3.597
465	1.838	1115.3	960.0	4.644
482	1.700	1100.0	1100.	5.000
500	1.500	1089.3	1300.	5.763
525	1.280	1074.4	1670.	6.822
550	1.100	1059.5	2100.	7.881
575	0.970	1044.6	2600.	8.941
600	0.820	1029.8	3700.	10.00
650	0.900	1500.0	1000.	10.00
760	0.580	600.0	4000.	15.00
815	0.550	300.0	4100.	30.00
900	0.550	300.0	4300.	30.00

1 5

A1=A2	M1	Z1	R1=R2	DO
-------	----	----	-------	----

-9999 0.0 1600. 3.0 10000.

13 6

TIMETAL 21S B-P w/diff props at 650 & 815 to make zd work

16

T (C)	E (GPa)	NU	CTE (1E-6/C)
-------	---------	----	--------------

23	112.0	0.34	9.7787
----	-------	------	--------

260	108.0	0.34	10.713
-----	-------	------	--------

315	106.1	0.34	10.915
-----	-------	------	--------

365	104.1	0.34	11.093
-----	-------	------	--------

415	101.7	0.34	11.267
-----	-------	------	--------

465	99.09	0.34	11.436
-----	-------	------	--------

482	98.11	0.34	11.492
-----	-------	------	--------

500	97.05	0.34	11.550
-----	-------	------	--------

525	95.50	0.34	11.631
-----	-------	------	--------

550	93.87	0.34	11.710
-----	-------	------	--------

575	92.17	0.34	11.788
-----	-------	------	--------

600	90.40	0.34	11.865
-----	-------	------	--------

650	86.61	0.34	12.014
-----	-------	------	--------

760	77.22	0.34	12.323
-----	-------	------	--------

815	71.96	0.34	12.467
-----	-------	------	--------

900	63.12	0.34	12.689
-----	-------	------	--------

900

2

15 4

T (C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
-------	---	-------------	----------	------------

23	4.800	1550.0	100.0	0.350
----	-------	--------	-------	-------

260	3.500	1300.0	300.0	0.350
-----	-------	--------	-------	-------

315	3.054	1250.4	390.0	1.502
-----	-------	--------	-------	-------

365	2.649	1205.4	500.0	2.549
-----	-------	--------	-------	-------

415	2.243	1160.4	660.0	3.597
-----	-------	--------	-------	-------

465	1.838	1115.3	960.0	4.644
-----	-------	--------	-------	-------

482	1.700	1100.0	1100.	5.000
-----	-------	--------	-------	-------

500	1.500	1089.3	1300.	5.763
-----	-------	--------	-------	-------

525	1.280	1074.4	1670.	6.822
-----	-------	--------	-------	-------

550	1.100	1059.5	2100.	7.881
-----	-------	--------	-------	-------

575	0.970	1044.6	2600.	8.941
600	0.820	1029.8	3700.	10.00
650	0.900	1500.0	1000.	10.00
815	0.570	1000.0	950.	30.00
900	0.550	300.0	4300.	30.00

1 5

A1=A2 M1 Z1 R1=R2 DO

-9999 0.0 1600. 3.0 10000.

14 4

90 with damage and b-p 4/93 and diff prop@650

8

T(C)	E(GPa)	NU	CTE(1E-6/C)
------	--------	----	-------------

23	133	0.19	5.75
----	-----	------	------

260	128	0.19	6.20
-----	-----	------	------

482	119	0.19	6.91
-----	-----	------	------

538	115	0.18	7.08
-----	-----	------	------

593	112	0.18	7.25
-----	-----	------	------

650	105	0.17	7.42
-----	-----	------	------

815	50	0.17	7.94
-----	----	------	------

900	20	0.17	8.32
-----	----	------	------

25

4

16 4

T(C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
------	---	-------------	----------	------------

23	4.800	1550.0	100.0	0.350
----	-------	--------	-------	-------

260	3.500	1300.0	300.0	0.350
-----	-------	--------	-------	-------

315	3.054	1250.4	390.0	1.502
-----	-------	--------	-------	-------

365	2.649	1205.4	500.0	2.549
-----	-------	--------	-------	-------

415	2.243	1160.4	660.0	3.597
-----	-------	--------	-------	-------

465	1.838	1115.3	960.0	4.644
-----	-------	--------	-------	-------

482	1.700	1100.0	1100.	5.000
-----	-------	--------	-------	-------

500	1.500	1089.3	1300.	5.763
-----	-------	--------	-------	-------

525	1.280	1074.4	1670.	6.822
-----	-------	--------	-------	-------

550	1.100	1059.5	2100.	7.881
-----	-------	--------	-------	-------

575	0.970	1044.6	2600.	8.941
-----	-------	--------	-------	-------

600	0.820	1029.8	3700.	10.00
650	0.900	1500.0	1000.	10.00
760	0.580	600.0	4000.	15.00
815	0.550	300.0	4100.	30.00
900	0.550	300.0	4300.	30.00

1 5

A1=A2	M1	Z1	R1=R2	DO
-9999	0.0	1600.	3.0	10000.

7 1

T	sm
23	190
260	130
482	70
538	50
593	36
650	17
815	0

1 7

scho	scl	m	theta	Dstar	beta	Dch
80	0	1	100	0.61	0.05	0.5

15 4

90 with damage and b-p 4/93 and diff prop@650 & 815

8

T(C)	E(GPa)	NU	CTE(1E-6/C)
23	133	0.19	5.75
260	128	0.19	6.20
482	119	0.19	6.91
538	115	0.18	7.08
593	112	0.18	7.25
650	105	0.17	7.42
815	50	0.17	7.94
900	20	0.17	8.32

25

4

15 4

T (C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
23	4.800	1550.0	100.0	0.350
260	3.500	1300.0	300.0	0.350
315	3.054	1250.4	390.0	1.502
365	2.649	1205.4	500.0	2.549
415	2.243	1160.4	660.0	3.597
465	1.838	1115.3	960.0	4.644
482	1.700	1100.0	1100.	5.000
500	1.500	1089.3	1300.	5.763
525	1.280	1074.4	1670.	6.822
550	1.100	1059.5	2100.	7.881
575	0.970	1044.6	2600.	8.941
600	0.820	1029.8	3700.	10.00
650	0.900	1500.0	1000.	10.00
815	0.570	1000.0	950.	30.00
900	0.550	300.0	4300.	30.00

1 5

A1=A2	M1	Z1	R1=R2	DO
-9999	0.0	1600.	3.0	10000.

7 1

T	sm
23	190
260	130
482	70
538	50
593	36
650	17
815	0

1 7

scho	scl	m	theta	Dstar	beta	Dch
80	0	1	100	0.61	0.05	0.5

16 4

90 with damage and b-p=MAT10 with matrix cte from mat4

8

T(C)	E (GPa)	NU	CTE (1E-6/C)
------	---------	----	--------------

23	133	0.19	9.7787
260	128	0.19	10.713
482	119	0.19	11.492
538	115	0.18	11.670
593	112	0.18	11.860
650	105	0.17	12.014
815	50	0.17	12.467
900	20	0.17	12.689

900

4

16 4

T (C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
23	4.800	1550.0	100.0	0.350
260	3.500	1300.0	300.0	0.350
315	3.054	1250.4	390.0	1.502
365	2.649	1205.4	500.0	2.549
415	2.243	1160.4	660.0	3.597
465	1.838	1115.3	960.0	4.644
482	1.700	1100.0	1100.	5.000
500	1.500	1089.3	1300.	5.763
525	1.280	1074.4	1670.	6.822
550	1.100	1059.5	2100.	7.881
575	0.970	1044.6	2600.	8.941
600	0.820	1029.8	3700.	10.00
650	0.740	1000.0	3800.	10.00
760	0.580	600.0	4000.	15.00
815	0.550	300.0	4100.	30.00
900	0.550	300.0	4300.	30.00

1 5

A1=A2	M1	Z1	R1=R2	DO
-9999	0.0	1600.	3.0	10000.

7 1

T	sm
23	190
260	130
482	70

538 50

593 36

650 17

815 0

1 7

scho	scl	m	theta	Dstar	beta	Dch
------	-----	---	-------	-------	------	-----

80	0	1	100	0.61	0.05	0.5
----	---	---	-----	------	------	-----

APPENDIX C

Output Files for Demonstration Runs

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*****
*
*   F I D E P 2 - VERSION 6
*
*****

***** PROBLEM TITLE *****
Bodner Partom with Back Stress at 23C (strain rate = 833E-6/s)

***** GEOMETRY TYPE *****
1-D Laminate Model

***** LOADING TYPE *****
Strain Control

***** LOADING HISTORY *****
POINTS IN HISTORY  2

      Step      Time      Temperature  Axial Strain
      .0000E+00    .0000E+00    2.3000E+01    .0000E+00
      4.8000E+02    4.8000E+01    2.3000E+01    4.0000E-02

***** GEOMETRY INFORMATION *****
Number of Cells  1
For Cell Number : 1
      Material Number :  3
      Volume Fraction :  1.0
      Nodes in cell   :  2

***** OUTPUT INFORMATION *****
Output at Interface for Material:  1

***** MATERIAL INFORMATION *****
Material for Cell Number :  1
Sherwood's Model with Back Stress for Timetal021S
Constitutive model: Bodner-Partom with Back Stress

----- MATERIAL PROPERTIES -----

      Temp      E (GPa)      NU      CTE (1E-6/C)
      2.3000E+01    1.1430E+02    3.4000E-01    5.8314E+00
      2.6000E+02    1.0800E+02    3.4000E-01    6.8976E+00
      4.8200E+02    9.0370E+01    3.4000E-01    7.8963E+00
      5.6000E+02    8.3020E+01    3.4000E-01    8.2174E+00
      5.8400E+02    8.0760E+01    3.4000E-01    8.3184E+00
      6.0000E+02    7.9250E+01    3.4000E-01    8.3825E+00
      6.1000E+02    7.8310E+01    3.4000E-01    8.4179E+00
      6.2000E+02    7.7370E+01    3.4000E-01    8.4582E+00
      6.2700E+02    7.6710E+01    3.4000E-01    8.4866E+00
      6.3400E+02    7.6050E+01    3.4000E-01    8.5148E+00
      6.3900E+02    7.5580E+01    3.4000E-01    8.5324E+00
      6.4300E+02    7.5200E+01    3.4000E-01    8.5490E+00
      6.4700E+02    7.4820E+01    3.4000E-01    8.5615E+00
      6.5000E+02    7.4540E+01    3.4000E-01    8.5769E+00
      7.6000E+02    6.0280E+01    3.4000E-01    8.9923E+00
      8.1510E+02    5.3220E+01    3.4000E-01    9.1920E+00
      9.0000E+02    5.3220E+01    3.4000E-01    9.4900E+00

Reference Temperature =  23.0
-----

      Temp      n      Zo      F1      F3      BSMAX

```

2.2990E+01	1.9500E+00	3.3900E+02	4.4990E+04	7.0000E-01	7.4400E+02
2.6000E+02	1.8500E+00	3.8200E+02	3.7000E+04	6.5000E-01	5.7300E+02
4.8200E+02	1.5000E+00	4.9800E+02	3.5590E+04	6.0000E-01	5.1200E+02
5.6000E+02	8.5000E+00	1.5650E+03	2.8580E+04	4.7460E-01	3.0000E+02
5.8400E+02	6.5000E+00	3.1730E+03	2.6430E+04	3.7590E-01	2.3500E+02
6.0000E+02	5.1700E+00	6.6840E+03	2.4990E+04	3.1010E-01	1.9100E+02
6.1000E+02	4.3300E+00	1.3260E+04	2.4090E+04	2.6900E-01	1.6400E+02
6.2000E+02	3.5000E+00	3.5970E+04	2.3190E+04	2.2790E-01	1.3600E+02
6.2700E+02	2.9200E+00	1.0070E+05	2.2570E+04	1.9910E-01	1.1800E+02
6.3400E+02	2.3300E+00	4.6810E+05	2.1940E+04	1.7030E-01	9.9000E+01
6.3900E+02	1.9200E+00	2.4720E+06	2.1490E+04	1.4970E-01	8.5000E+01
6.4300E+02	1.5800E+00	1.7520E+07	2.1130E+04	1.3330E-01	7.4000E+01
6.4700E+02	1.2500E+00	3.5190E+08	2.0770E+04	1.1680E-01	6.3000E+01
6.5000E+02	1.0000E+00	1.2400E+10	2.0500E+04	1.0450E-01	5.5000E+01
7.6000E+02	1.2000E+00	2.4700E+08	9.9000E+02	2.4000E-03	3.0000E+00
8.1510E+02	1.1600E+00	2.4500E+08	7.6000E+02	1.9000E-03	1.0000E+00
9.0000E+02	7.0000E-01	2.4300E+08	5.0000E+02	5.0000E-04	5.0000E-01

D0
10000.0

----- OUTPUT -----

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	1.0000E-01	2.3000E+01	9.5250E+00	9.5250E+00	.0000E+00	.0000E+00	8.3333E-05
20	2.0000E+00	2.3000E+01	1.9050E+02	1.9050E+02	.0000E+00	.0000E+00	1.6667E-03
40	4.0000E+00	2.3000E+01	3.8100E+02	3.8100E+02	.0000E+00	.0000E+00	3.3333E-03
60	6.0000E+00	2.3000E+01	5.1082E+02	5.1082E+02	.0000E+00	.0000E+00	5.0000E-03
80	8.0000E+00	2.3000E+01	6.1515E+02	6.1515E+02	.0000E+00	.0000E+00	6.6667E-03
100	1.0000E+01	2.3000E+01	7.1194E+02	7.1194E+02	.0000E+00	.0000E+00	8.3333E-03
120	1.2000E+01	2.3000E+01	8.0051E+02	8.0051E+02	.0000E+00	.0000E+00	1.0000E-02
140	1.4000E+01	2.3000E+01	8.8025E+02	8.8025E+02	.0000E+00	.0000E+00	1.1667E-02
160	1.6000E+01	2.3000E+01	9.5071E+02	9.5071E+02	.0000E+00	.0000E+00	1.3333E-02
180	1.8000E+01	2.3000E+01	1.0117E+03	1.0117E+03	.0000E+00	.0000E+00	1.5000E-02
200	2.0000E+01	2.3000E+01	1.0632E+03	1.0632E+03	.0000E+00	.0000E+00	1.6667E-02
220	2.2000E+01	2.3000E+01	1.1057E+03	1.1057E+03	.0000E+00	.0000E+00	1.8333E-02
240	2.4000E+01	2.3000E+01	1.1399E+03	1.1399E+03	.0000E+00	.0000E+00	2.0000E-02
260	2.6000E+01	2.3000E+01	1.1669E+03	1.1669E+03	.0000E+00	.0000E+00	2.1667E-02
280	2.8000E+01	2.3000E+01	1.1876E+03	1.1876E+03	.0000E+00	.0000E+00	2.3333E-02
300	3.0000E+01	2.3000E+01	1.2034E+03	1.2034E+03	.0000E+00	.0000E+00	2.5000E-02
320	3.2000E+01	2.3000E+01	1.2151E+03	1.2151E+03	.0000E+00	.0000E+00	2.6667E-02
340	3.4000E+01	2.3000E+01	1.2237E+03	1.2237E+03	.0000E+00	.0000E+00	2.8333E-02
360	3.6000E+01	2.3000E+01	1.2300E+03	1.2300E+03	.0000E+00	.0000E+00	3.0000E-02
380	3.8000E+01	2.3000E+01	1.2346E+03	1.2346E+03	.0000E+00	.0000E+00	3.1667E-02
400	4.0000E+01	2.3000E+01	1.2379E+03	1.2379E+03	.0000E+00	.0000E+00	3.3333E-02
420	4.2000E+01	2.3000E+01	1.2402E+03	1.2402E+03	.0000E+00	.0000E+00	3.5000E-02
440	4.4000E+01	2.3000E+01	1.2419E+03	1.2419E+03	.0000E+00	.0000E+00	3.6667E-02
460	4.6000E+01	2.3000E+01	1.2431E+03	1.2431E+03	.0000E+00	.0000E+00	3.8333E-02
480	4.8000E+01	2.3000E+01	1.2440E+03	1.2440E+03	.0000E+00	.0000E+00	4.0000E-02

```

*****
*
*   F I D E P 2 - VERSION 6
*
*****

***** PROBLEM TITLE *****

Bodner Partom with Back Stress at 450C (strain rate = 833E-6/s)

***** GEOMETRY TYPE *****

1-D Laminate Model

***** LOADING TYPE *****

Strain Control

***** LOADING HISTORY *****

POINTS IN HISTORY  2

      Step      Time      Temperature  Axial Strain
      .0000E+00    .0000E+00    4.5000E+02    .0000E+00
      4.8000E+02    4.8000E+01    4.5000E+02    4.0000E-02

***** GEOMETRY INFORMATION *****

Number of Cells  1

      For Cell Number : 1

          Material Number :  3
          Volume Fraction :  1.0
          Nodes in cell   :  2

***** OUTPUT INFORMATION *****

Output at Interface for Material:  1

***** MATERIAL INFORMATION *****

Material for Cell Number :  1

      Sherwood's Model with Back Stress for Timetal021S
      Constitutive model: Bodner-Partom with Back Stress

----- MATERIAL PROPERTIES -----

      Temp      E (GPa)      NU      CTE (1E-6/C)
      2.3000E+01    1.1430E+02    3.4000E-01    7.7657E+00
      2.6000E+02    1.0800E+02    3.4000E-01    8.8486E+00
      4.8200E+02    9.0370E+01    3.4000E-01    9.6386E+00
      5.6000E+02    8.3020E+01    3.4000E-01    9.9705E+00
      5.8400E+02    8.0760E+01    3.4000E-01    1.0079E+01
      6.0000E+02    7.9250E+01    3.4000E-01    1.0138E+01
      6.1000E+02    7.8310E+01    3.4000E-01    1.0158E+01
      6.2000E+02    7.7370E+01    3.4000E-01    1.0197E+01
      6.2700E+02    7.6710E+01    3.4000E-01    1.0226E+01
      6.3400E+02    7.6050E+01    3.4000E-01    1.0253E+01
      6.3900E+02    7.5580E+01    3.4000E-01    1.0265E+01
      6.4300E+02    7.5200E+01    3.4000E-01    1.0282E+01
      6.4700E+02    7.4820E+01    3.4000E-01    1.0286E+01
      6.5000E+02    7.4540E+01    3.4000E-01    1.0309E+01
      7.6000E+02    6.0280E+01    3.4000E-01    1.0682E+01
      8.1510E+02    5.3220E+01    3.4000E-01    1.0860E+01
      9.0000E+02    5.3220E+01    3.4000E-01    1.1126E+01

Reference Temperature =  450.0
-----

```

Temp	n	Zo	F1	F3	BSMAX
2.2990E+01	1.9500E+00	3.3900E+02	4.4990E+04	7.0000E-01	7.4400E+02
2.6000E+02	1.8500E+00	3.8200E+02	3.7000E+04	6.5000E-01	5.7300E+02
4.8200E+02	1.5000E+00	4.9800E+02	3.5590E+04	6.0000E-01	5.1200E+02
5.6000E+02	8.5000E+00	1.5650E+03	2.8580E+04	4.7460E-01	3.0000E+02
5.8400E+02	6.5000E+00	3.1730E+03	2.6430E+04	3.7590E-01	2.3500E+02
6.0000E+02	5.1700E+00	6.6840E+03	2.4990E+04	3.1010E-01	1.9100E+02
6.1000E+02	4.3300E+00	1.3260E+04	2.4090E+04	2.6900E-01	1.6400E+02
6.2000E+02	3.5000E+00	3.5970E+04	2.3190E+04	2.2790E-01	1.3600E+02
6.2700E+02	2.9200E+00	1.0070E+05	2.2570E+04	1.9910E-01	1.1800E+02
6.3400E+02	2.3300E+00	4.6810E+05	2.1940E+04	1.7030E-01	9.9000E+01
6.3900E+02	1.9200E+00	2.4720E+06	2.1490E+04	1.4970E-01	8.5000E+01
6.4300E+02	1.5800E+00	1.7520E+07	2.1130E+04	1.3330E-01	7.4000E+01
6.4700E+02	1.2500E+00	3.5190E+08	2.0770E+04	1.1680E-01	6.3000E+01
6.5000E+02	1.0000E+00	1.2400E+10	2.0500E+04	1.0450E-01	5.5000E+01
7.6000E+02	1.2000E+00	2.4700E+08	9.9000E+02	2.4000E-03	3.0000E+00
8.1510E+02	1.1600E+00	2.4500E+08	7.6000E+02	1.9000E-03	1.0000E+00
9.0000E+02	7.0000E-01	2.4300E+08	5.0000E+02	5.0000E-04	5.0000E-01

D0
10000.0

----- OUTPUT -----

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	1.0000E-01	4.5000E+02	7.7426E+00	7.7426E+00	.0000E+00	.0000E+00	8.3333E-05
20	2.0000E+00	4.5000E+02	1.5485E+02	1.5485E+02	.0000E+00	.0000E+00	1.6667E-03
40	4.0000E+00	4.5000E+02	3.0970E+02	3.0970E+02	.0000E+00	.0000E+00	3.3333E-03
60	6.0000E+00	4.5000E+02	4.2060E+02	4.2060E+02	.0000E+00	.0000E+00	5.0000E-03
80	8.0000E+00	4.5000E+02	4.9384E+02	4.9384E+02	.0000E+00	.0000E+00	6.6667E-03
100	1.0000E+01	4.5000E+02	5.6095E+02	5.6095E+02	.0000E+00	.0000E+00	8.3333E-03
120	1.2000E+01	4.5000E+02	6.2161E+02	6.2161E+02	.0000E+00	.0000E+00	1.0000E-02
140	1.4000E+01	4.5000E+02	6.7563E+02	6.7563E+02	.0000E+00	.0000E+00	1.1667E-02
160	1.6000E+01	4.5000E+02	7.2294E+02	7.2294E+02	.0000E+00	.0000E+00	1.3333E-02
180	1.8000E+01	4.5000E+02	7.6363E+02	7.6363E+02	.0000E+00	.0000E+00	1.5000E-02
200	2.0000E+01	4.5000E+02	7.9802E+02	7.9802E+02	.0000E+00	.0000E+00	1.6667E-02
220	2.2000E+01	4.5000E+02	8.2654E+02	8.2654E+02	.0000E+00	.0000E+00	1.8333E-02
240	2.4000E+01	4.5000E+02	8.4979E+02	8.4979E+02	.0000E+00	.0000E+00	2.0000E-02
260	2.6000E+01	4.5000E+02	8.6844E+02	8.6844E+02	.0000E+00	.0000E+00	2.1667E-02
280	2.8000E+01	4.5000E+02	8.8318E+02	8.8318E+02	.0000E+00	.0000E+00	2.3333E-02
300	3.0000E+01	4.5000E+02	8.9469E+02	8.9469E+02	.0000E+00	.0000E+00	2.5000E-02
320	3.2000E+01	4.5000E+02	9.0358E+02	9.0358E+02	.0000E+00	.0000E+00	2.6667E-02
340	3.4000E+01	4.5000E+02	9.1039E+02	9.1039E+02	.0000E+00	.0000E+00	2.8333E-02
360	3.6000E+01	4.5000E+02	9.1557E+02	9.1557E+02	.0000E+00	.0000E+00	3.0000E-02
380	3.8000E+01	4.5000E+02	9.1949E+02	9.1949E+02	.0000E+00	.0000E+00	3.1667E-02
400	4.0000E+01	4.5000E+02	9.2244E+02	9.2244E+02	.0000E+00	.0000E+00	3.3333E-02
420	4.2000E+01	4.5000E+02	9.2465E+02	9.2465E+02	.0000E+00	.0000E+00	3.5000E-02
440	4.4000E+01	4.5000E+02	9.2631E+02	9.2631E+02	.0000E+00	.0000E+00	3.6667E-02
460	4.6000E+01	4.5000E+02	9.2755E+02	9.2755E+02	.0000E+00	.0000E+00	3.8333E-02
480	4.8000E+01	4.5000E+02	9.2848E+02	9.2848E+02	.0000E+00	.0000E+00	4.0000E-02

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*****
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*   F I D E P 2 - VERSION 6
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```
***** PROBLEM TITLE *****
Bodner Partom with Dir. Hardening at 23C (strain rate = 8.33E-6/s)
```

```
***** GEOMETRY TYPE *****
1-D Laminate Model
```

```
***** LOADING TYPE *****
Strain Control
```

```
***** LOADING HISTORY *****
POINTS IN HISTORY 2
```

Step	Time	Temperature	Axial Strain
.0000E+00	.0000E+00	2.3000E+01	.0000E+00
4.8000E+02	4.8000E+03	2.3000E+01	4.0000E-02

```
***** GEOMETRY INFORMATION *****
Number of Cells 1
For Cell Number : 1
Material Number : 4
Volume Fraction : 1.0
Nodes in cell : 2
```

```
***** OUTPUT INFORMATION *****
Output at Interface for Material: 1
```

```
***** MATERIAL INFORMATION *****
Material for Cell Number : 1
Bodner-Partom Theory with Directional Hardening for Timetal021S
Constitutive model: Bodner-Partom with Directional Hardening
```

----- OUTPUT -----

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	1.0000E+01	2.3000E+01	9.3333E+00	9.3333E+00	.0000E+00	.0000E+00	8.3333E-05
20	2.0000E+02	2.3000E+01	1.8667E+02	1.8667E+02	.0000E+00	.0000E+00	1.6667E-03
40	4.0000E+02	2.3000E+01	3.7333E+02	3.7333E+02	.0000E+00	.0000E+00	3.3333E-03
60	6.0000E+02	2.3000E+01	5.6000E+02	5.6000E+02	.0000E+00	.0000E+00	5.0000E-03
80	8.0000E+02	2.3000E+01	7.4667E+02	7.4667E+02	.0000E+00	.0000E+00	6.6667E-03
100	1.0000E+03	2.3000E+01	9.3333E+02	9.3333E+02	.0000E+00	.0000E+00	8.3333E-03
120	1.2000E+03	2.3000E+01	1.0609E+03	1.0609E+03	.0000E+00	.0000E+00	1.0000E-02
140	1.4000E+03	2.3000E+01	1.0851E+03	1.0851E+03	.0000E+00	.0000E+00	1.1667E-02
160	1.6000E+03	2.3000E+01	1.0997E+03	1.0997E+03	.0000E+00	.0000E+00	1.3333E-02
180	1.8000E+03	2.3000E+01	1.1080E+03	1.1080E+03	.0000E+00	.0000E+00	1.5000E-02
200	2.0000E+03	2.3000E+01	1.1126E+03	1.1126E+03	.0000E+00	.0000E+00	1.6667E-02
220	2.2000E+03	2.3000E+01	1.1150E+03	1.1150E+03	.0000E+00	.0000E+00	1.8333E-02
240	2.4000E+03	2.3000E+01	1.1162E+03	1.1162E+03	.0000E+00	.0000E+00	2.0000E-02
260	2.6000E+03	2.3000E+01	1.1169E+03	1.1169E+03	.0000E+00	.0000E+00	2.1667E-02
280	2.8000E+03	2.3000E+01	1.1172E+03	1.1172E+03	.0000E+00	.0000E+00	2.3333E-02
300	3.0000E+03	2.3000E+01	1.1174E+03	1.1174E+03	.0000E+00	.0000E+00	2.5000E-02
320	3.2000E+03	2.3000E+01	1.1175E+03	1.1175E+03	.0000E+00	.0000E+00	2.6667E-02
340	3.4000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	2.8333E-02
360	3.6000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.0000E-02
380	3.8000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.1667E-02
400	4.0000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.3333E-02

420	4.2000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.5000E-02
440	4.4000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.6667E-02
460	4.6000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.8333E-02
480	4.8000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	4.0000E-02

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*****
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*   F I D E P 2 - VERSION 6
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***** PROBLEM TITLE *****
Bodner Partom with Dir. Hardening at 650C (strain rate = 8.33E-6/s)

***** GEOMETRY TYPE *****
1-D Laminate Model

***** LOADING TYPE *****
Strain Control

***** LOADING HISTORY *****
POINTS IN HISTORY  2

      Step      Time      Temperature  Axial Strain
      .0000E+00   .0000E+00   6.5000E+02   .0000E+00
      1.6000E+03   4.8000E+03   6.5000E+02   4.0000E-02

***** GEOMETRY INFORMATION *****
Number of Cells  1

      For Cell Number : 1

      Material Number : 4
      Volume Fraction : 1.0
      Nodes in cell   : 2

***** OUTPUT INFORMATION *****
Output at Interface for Material:  1

***** MATERIAL INFORMATION *****
Material for Cell Number :  1

Bodner-Partom Theory with Directional Hardening for Timetal021S
Constitutive model: Bodner-Partom with Directional Hardening

----- MATERIAL PROPERTIES -----
      T(C)      E(GPa)      NU      CTE(1E-6/C)
      2.3000E+01   1.1200E+02   3.4000E-01   8.8874E+00
      2.6000E+02   1.0800E+02   3.4000E-01   9.8790E+00
      3.1500E+02   1.0610E+02   3.4000E-01   1.0095E+01
      3.6500E+02   1.0410E+02   3.4000E-01   1.0285E+01
      4.1500E+02   1.0170E+02   3.4000E-01   1.0472E+01
      4.6500E+02   9.9090E+01   3.4000E-01   1.0655E+01
      4.8200E+02   9.8110E+01   3.4000E-01   1.0715E+01
      5.0000E+02   9.7050E+01   3.4000E-01   1.0777E+01
      5.2500E+02   9.5500E+01   3.4000E-01   1.0865E+01
      5.5000E+02   9.3870E+01   3.4000E-01   1.0950E+01
      5.7500E+02   9.2170E+01   3.4000E-01   1.1035E+01
      6.0000E+02   9.0400E+01   3.4000E-01   1.1120E+01
      6.5000E+02   8.6610E+01   3.4000E-01   1.1276E+01
      7.6000E+02   7.7220E+01   3.4000E-01   1.1621E+01
      8.1500E+02   7.1960E+01   3.4000E-01   1.1781E+01
      9.0000E+02   6.3120E+01   3.4000E-01   1.2014E+01
Reference Temperature =  650.0
-----

      T(C)      N      Z0=Z2(1/S)      Z3(MPa)      M2(1/MPa)
      2.3000E+01   4.8000E+00   1.5500E+03   1.0000E+02   3.5000E-01
      2.6000E+02   3.5000E+00   1.3000E+03   3.0000E+02   3.5000E-01
      3.1500E+02   3.0540E+00   1.2504E+03   3.9000E+02   1.5020E+00
      3.6500E+02   2.6490E+00   1.2054E+03   5.0000E+02   2.5490E+00
      4.1500E+02   2.2430E+00   1.1604E+03   6.6000E+02   3.5970E+00
      4.6500E+02   1.8380E+00   1.1153E+03   9.6000E+02   4.6440E+00
      4.8200E+02   1.7000E+00   1.1000E+03   1.1000E+03   5.0000E+00
      5.0000E+02   1.5000E+00   1.0893E+03   1.3000E+03   5.7630E+00
      5.2500E+02   1.2800E+00   1.0744E+03   1.6700E+03   6.8220E+00
      5.5000E+02   1.1000E+00   1.0595E+03   2.1000E+03   7.8810E+00
      5.7500E+02   9.7000E-01   1.0446E+03   2.6000E+03   8.9410E+00
      6.0000E+02   8.2000E-01   1.0298E+03   3.7000E+03   1.0000E+01

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6.5000E+02	7.4000E-01	1.0000E+03	3.8000E+03	1.0000E+01
7.6000E+02	5.8000E-01	6.0000E+02	4.0000E+03	1.5000E+01
8.1500E+02	5.5000E-01	3.0000E+02	4.1000E+03	3.0000E+01
9.0000E+02	5.5000E-01	3.0000E+02	4.3000E+03	3.0000E+01

A1=A2	M1	Z1	R1=R2	DO
-9999.0	.0	1600.0	3.0	10000.0

----- OUTPUT -----

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	3.0000E+00	6.5000E+02	2.1653E+00	2.1653E+00	.0000E+00	.0000E+00	2.5000E-05
40	1.2000E+02	6.5000E+02	8.3912E+01	8.3912E+01	.0000E+00	.0000E+00	1.0000E-03
80	2.4000E+02	6.5000E+02	1.3222E+02	1.3222E+02	.0000E+00	.0000E+00	2.0000E-03
120	3.6000E+02	6.5000E+02	1.3895E+02	1.3895E+02	.0000E+00	.0000E+00	3.0000E-03
160	4.8000E+02	6.5000E+02	1.3827E+02	1.3827E+02	.0000E+00	.0000E+00	4.0000E-03
200	6.0000E+02	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	5.0000E-03
240	7.2000E+02	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	6.0000E-03
280	8.4000E+02	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	7.0000E-03
320	9.6000E+02	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	8.0000E-03
360	1.0800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	9.0000E-03
400	1.2000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.0000E-02
440	1.3200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.1000E-02
480	1.4400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.2000E-02
520	1.5600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.3000E-02
560	1.6800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.4000E-02
600	1.8000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.5000E-02
640	1.9200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.6000E-02
680	2.0400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.7000E-02
720	2.1600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.8000E-02
760	2.2800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.9000E-02
800	2.4000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.0000E-02
840	2.5200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.1000E-02
880	2.6400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.2000E-02
920	2.7600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.3000E-02
960	2.8800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.4000E-02
1000	3.0000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.5000E-02
1040	3.1200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.6000E-02
1080	3.2400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.7000E-02
1120	3.3600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.8000E-02
1160	3.4800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.9000E-02
1200	3.6000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.0000E-02
1240	3.7200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.1000E-02
1280	3.8400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.2000E-02
1320	3.9600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.3000E-02
1360	4.0800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.4000E-02
1400	4.2000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.5000E-02
1440	4.3200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.6000E-02
1480	4.4400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.7000E-02
1520	4.5600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.8000E-02
1560	4.6800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.9000E-02
1600	4.8000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	4.0000E-02

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*   F I D E P 2 - VERSION 6
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***** PROBLEM TITLE *****
Bodner Partom with Dir. Hardening from 650C to 750C

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***** GEOMETRY TYPE *****
1-D Laminate Model

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***** LOADING TYPE *****
Strain Control

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***** LOADING HISTORY *****
POINTS IN HISTORY 6

```

Step	Time	Temperature	Axial Strain
.0000E+00	.0000E+00	6.5000E+02	.0000E+00
1.2000E+03	1.2000E+01	6.5000E+02	1.0000E-02
1.8000E+03	1.8000E+01	7.6000E+02	1.5000E-02
2.4000E+03	3.0000E+01	7.6000E+02	2.5000E-02
3.6000E+03	3.6000E+01	6.5000E+02	3.0000E-02
4.8000E+03	4.8000E+01	6.5000E+02	4.0000E-02

```

***** GEOMETRY INFORMATION *****

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```

Number of Cells 1
For Cell Number : 1
Material Number : 4
Volume Fraction : 1.0
Nodes in cell : 2

```

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***** OUTPUT INFORMATION *****

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Output at Interface for Material: 1

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***** MATERIAL INFORMATION *****

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```

Material for Cell Number : 1
Bodner-Partom Theory with Directional Hardening for Timetal021S
Constitutive model: Bodner-Partom with Directional Hardening

```

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----- OUTPUT -----

```

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	1.0000E-02	6.5000E+02	7.2175E-01	7.2175E-01	.0000E+00	.0000E+00	8.3333E-06
40	4.0000E-01	6.5000E+02	2.8870E+01	2.8870E+01	.0000E+00	.0000E+00	3.3333E-04
80	8.0000E-01	6.5000E+02	5.7740E+01	5.7740E+01	.0000E+00	.0000E+00	6.6667E-04
120	1.2000E+00	6.5000E+02	8.6375E+01	8.6375E+01	.0000E+00	.0000E+00	1.0000E-03
160	1.6000E+00	6.5000E+02	1.0981E+02	1.0981E+02	.0000E+00	.0000E+00	1.3333E-03
200	2.0000E+00	6.5000E+02	1.3309E+02	1.3309E+02	.0000E+00	.0000E+00	1.6667E-03
240	2.4000E+00	6.5000E+02	1.5670E+02	1.5670E+02	.0000E+00	.0000E+00	2.0000E-03
280	2.8000E+00	6.5000E+02	1.8038E+02	1.8038E+02	.0000E+00	.0000E+00	2.3333E-03
320	3.2000E+00	6.5000E+02	2.0388E+02	2.0388E+02	.0000E+00	.0000E+00	2.6667E-03
360	3.6000E+00	6.5000E+02	2.2691E+02	2.2691E+02	.0000E+00	.0000E+00	3.0000E-03
400	4.0000E+00	6.5000E+02	2.4917E+02	2.4917E+02	.0000E+00	.0000E+00	3.3333E-03
440	4.4000E+00	6.5000E+02	2.7032E+02	2.7032E+02	.0000E+00	.0000E+00	3.6667E-03
480	4.8000E+00	6.5000E+02	2.9005E+02	2.9005E+02	.0000E+00	.0000E+00	4.0000E-03
520	5.2000E+00	6.5000E+02	3.0802E+02	3.0802E+02	.0000E+00	.0000E+00	4.3333E-03
560	5.6000E+00	6.5000E+02	3.2396E+02	3.2396E+02	.0000E+00	.0000E+00	4.6667E-03
600	6.0000E+00	6.5000E+02	3.3768E+02	3.3768E+02	.0000E+00	.0000E+00	5.0000E-03
640	6.4000E+00	6.5000E+02	3.4910E+02	3.4910E+02	.0000E+00	.0000E+00	5.3333E-03

680	6.8000E+00	6.5000E+02	3.5828E+02	3.5828E+02	.0000E+00	.0000E+00	5.6667E-03
720	7.2000E+00	6.5000E+02	3.6542E+02	3.6542E+02	.0000E+00	.0000E+00	6.0000E-03
760	7.6000E+00	6.5000E+02	3.7081E+02	3.7081E+02	.0000E+00	.0000E+00	6.3333E-03
800	8.0000E+00	6.5000E+02	3.7476E+02	3.7476E+02	.0000E+00	.0000E+00	6.6667E-03
840	8.4000E+00	6.5000E+02	3.7760E+02	3.7760E+02	.0000E+00	.0000E+00	7.0000E-03
880	8.8000E+00	6.5000E+02	3.7960E+02	3.7960E+02	.0000E+00	.0000E+00	7.3333E-03
920	9.2000E+00	6.5000E+02	3.8100E+02	3.8100E+02	.0000E+00	.0000E+00	7.6667E-03
960	9.6000E+00	6.5000E+02	3.8196E+02	3.8196E+02	.0000E+00	.0000E+00	8.0000E-03
1000	1.0000E+01	6.5000E+02	3.8262E+02	3.8262E+02	.0000E+00	.0000E+00	8.3333E-03
1040	1.0400E+01	6.5000E+02	3.8308E+02	3.8308E+02	.0000E+00	.0000E+00	8.6667E-03
1080	1.0800E+01	6.5000E+02	3.8338E+02	3.8338E+02	.0000E+00	.0000E+00	9.0000E-03
1120	1.1200E+01	6.5000E+02	3.8359E+02	3.8359E+02	.0000E+00	.0000E+00	9.3333E-03
1160	1.1600E+01	6.5000E+02	3.8373E+02	3.8373E+02	.0000E+00	.0000E+00	9.6667E-03
1200	1.2000E+01	6.5000E+02	3.8383E+02	3.8383E+02	.0000E+00	.0000E+00	1.0000E-02
1240	1.2400E+01	6.5733E+02	3.7163E+02	3.7163E+02	.0000E+00	.0000E+00	1.0333E-02
1280	1.2800E+01	6.6467E+02	3.5666E+02	3.5666E+02	.0000E+00	.0000E+00	1.0667E-02
1320	1.3200E+01	6.7200E+02	3.3994E+02	3.3994E+02	.0000E+00	.0000E+00	1.1000E-02
1360	1.3600E+01	6.7933E+02	3.2223E+02	3.2223E+02	.0000E+00	.0000E+00	1.1333E-02
1400	1.4000E+01	6.8667E+02	3.0406E+02	3.0406E+02	.0000E+00	.0000E+00	1.1667E-02
1440	1.4400E+01	6.9400E+02	2.8576E+02	2.8576E+02	.0000E+00	.0000E+00	1.2000E-02
1480	1.4800E+01	7.0133E+02	2.6758E+02	2.6758E+02	.0000E+00	.0000E+00	1.2333E-02
1520	1.5200E+01	7.0867E+02	2.4966E+02	2.4966E+02	.0000E+00	.0000E+00	1.2667E-02
1560	1.5600E+01	7.1600E+02	2.3210E+02	2.3210E+02	.0000E+00	.0000E+00	1.3000E-02
1600	1.6000E+01	7.2333E+02	2.1499E+02	2.1499E+02	.0000E+00	.0000E+00	1.3333E-02
1640	1.6400E+01	7.3067E+02	1.9839E+02	1.9839E+02	.0000E+00	.0000E+00	1.3667E-02
1680	1.6800E+01	7.3800E+02	1.8237E+02	1.8237E+02	.0000E+00	.0000E+00	1.4000E-02
1720	1.7200E+01	7.4533E+02	1.6696E+02	1.6696E+02	.0000E+00	.0000E+00	1.4333E-02
1760	1.7600E+01	7.5267E+02	1.5221E+02	1.5221E+02	.0000E+00	.0000E+00	1.4667E-02
1800	1.8000E+01	7.6000E+02	1.3817E+02	1.3817E+02	.0000E+00	.0000E+00	1.5000E-02
1840	1.8800E+01	7.6000E+02	1.3163E+02	1.3163E+02	.0000E+00	.0000E+00	1.5667E-02
1880	1.9600E+01	7.6000E+02	1.2955E+02	1.2955E+02	.0000E+00	.0000E+00	1.6333E-02
1920	2.0400E+01	7.6000E+02	1.2885E+02	1.2885E+02	.0000E+00	.0000E+00	1.7000E-02
1960	2.1200E+01	7.6000E+02	1.2861E+02	1.2861E+02	.0000E+00	.0000E+00	1.7667E-02
2000	2.2000E+01	7.6000E+02	1.2853E+02	1.2853E+02	.0000E+00	.0000E+00	1.8333E-02
2040	2.2800E+01	7.6000E+02	1.2850E+02	1.2850E+02	.0000E+00	.0000E+00	1.9000E-02
2080	2.3600E+01	7.6000E+02	1.2849E+02	1.2849E+02	.0000E+00	.0000E+00	1.9667E-02
2120	2.4400E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.0333E-02
2160	2.5200E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.1000E-02
2200	2.6000E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.1667E-02
2240	2.6800E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.2333E-02
2280	2.7600E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.3000E-02
2320	2.8400E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.3667E-02
2360	2.9200E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.4333E-02
2400	3.0000E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.5000E-02
2440	3.0200E+01	7.5633E+02	1.3269E+02	1.3269E+02	.0000E+00	.0000E+00	2.5167E-02
2480	3.0400E+01	7.5267E+02	1.3736E+02	1.3736E+02	.0000E+00	.0000E+00	2.5333E-02
2520	3.0600E+01	7.4900E+02	1.4245E+02	1.4245E+02	.0000E+00	.0000E+00	2.5500E-02
2560	3.0800E+01	7.4533E+02	1.4786E+02	1.4786E+02	.0000E+00	.0000E+00	2.5667E-02
2600	3.1000E+01	7.4167E+02	1.5357E+02	1.5357E+02	.0000E+00	.0000E+00	2.5833E-02
2640	3.1200E+01	7.3800E+02	1.5954E+02	1.5954E+02	.0000E+00	.0000E+00	2.6000E-02
2680	3.1400E+01	7.3433E+02	1.6574E+02	1.6574E+02	.0000E+00	.0000E+00	2.6167E-02
2720	3.1600E+01	7.3067E+02	1.7216E+02	1.7216E+02	.0000E+00	.0000E+00	2.6333E-02
2760	3.1800E+01	7.2700E+02	1.7878E+02	1.7878E+02	.0000E+00	.0000E+00	2.6500E-02
2800	3.2000E+01	7.2333E+02	1.8558E+02	1.8558E+02	.0000E+00	.0000E+00	2.6667E-02
2840	3.2200E+01	7.1967E+02	1.9256E+02	1.9256E+02	.0000E+00	.0000E+00	2.6833E-02
2880	3.2400E+01	7.1600E+02	1.9972E+02	1.9972E+02	.0000E+00	.0000E+00	2.7000E-02
2920	3.2600E+01	7.1233E+02	2.0704E+02	2.0704E+02	.0000E+00	.0000E+00	2.7167E-02
2960	3.2800E+01	7.0867E+02	2.1453E+02	2.1453E+02	.0000E+00	.0000E+00	2.7333E-02
3000	3.3000E+01	7.0500E+02	2.2217E+02	2.2217E+02	.0000E+00	.0000E+00	2.7500E-02
3040	3.3200E+01	7.0133E+02	2.2997E+02	2.2997E+02	.0000E+00	.0000E+00	2.7667E-02
3080	3.3400E+01	6.9767E+02	2.3791E+02	2.3791E+02	.0000E+00	.0000E+00	2.7833E-02
3120	3.3600E+01	6.9400E+02	2.4601E+02	2.4601E+02	.0000E+00	.0000E+00	2.8000E-02
3160	3.3800E+01	6.9033E+02	2.5424E+02	2.5424E+02	.0000E+00	.0000E+00	2.8167E-02
3200	3.4000E+01	6.8667E+02	2.6262E+02	2.6262E+02	.0000E+00	.0000E+00	2.8333E-02
3240	3.4200E+01	6.8300E+02	2.7114E+02	2.7114E+02	.0000E+00	.0000E+00	2.8500E-02
3280	3.4400E+01	6.7933E+02	2.7979E+02	2.7979E+02	.0000E+00	.0000E+00	2.8667E-02
3320	3.4600E+01	6.7567E+02	2.8857E+02	2.8857E+02	.0000E+00	.0000E+00	2.8833E-02
3360	3.4800E+01	6.7200E+02	2.9749E+02	2.9749E+02	.0000E+00	.0000E+00	2.9000E-02
3400	3.5000E+01	6.6833E+02	3.0653E+02	3.0653E+02	.0000E+00	.0000E+00	2.9167E-02
3440	3.5200E+01	6.6467E+02	3.1570E+02	3.1570E+02	.0000E+00	.0000E+00	2.9333E-02
3480	3.5400E+01	6.6100E+02	3.2500E+02	3.2500E+02	.0000E+00	.0000E+00	2.9500E-02
3520	3.5600E+01	6.5733E+02	3.3441E+02	3.3441E+02	.0000E+00	.0000E+00	2.9667E-02
3560	3.5800E+01	6.5367E+02	3.4393E+02	3.4393E+02	.0000E+00	.0000E+00	2.9833E-02
3600	3.6000E+01	6.5000E+02	3.5357E+02	3.5357E+02	.0000E+00	.0000E+00	3.0000E-02
3640	3.6400E+01	6.5000E+02	3.6182E+02	3.6182E+02	.0000E+00	.0000E+00	3.0333E-02
3680	3.6800E+01	6.5000E+02	3.6812E+02	3.6812E+02	.0000E+00	.0000E+00	3.0667E-02
3720	3.7200E+01	6.5000E+02	3.7281E+02	3.7281E+02	.0000E+00	.0000E+00	3.1000E-02
3760	3.7600E+01	6.5000E+02	3.7622E+02	3.7622E+02	.0000E+00	.0000E+00	3.1333E-02
3800	3.8000E+01	6.5000E+02	3.7864E+02	3.7864E+02	.0000E+00	.0000E+00	3.1667E-02
3840	3.8400E+01	6.5000E+02	3.8034E+02	3.8034E+02	.0000E+00	.0000E+00	3.2000E-02
3880	3.8800E+01	6.5000E+02	3.8153E+02	3.8153E+02	.0000E+00	.0000E+00	3.2333E-02
3920	3.9200E+01	6.5000E+02	3.8234E+02	3.8234E+02	.0000E+00	.0000E+00	3.2667E-02
3960	3.9600E+01	6.5000E+02	3.8289E+02	3.8289E+02	.0000E+00	.0000E+00	3.3000E-02
4000	4.0000E+01	6.5000E+02	3.8327E+02	3.8327E+02	.0000E+00	.0000E+00	3.3333E-02
4040	4.0400E+01	6.5000E+02	3.8353E+02	3.8353E+02	.0000E+00	.0000E+00	3.3667E-02
4080	4.0800E+01	6.5000E+02	3.8371E+02	3.8371E+02	.0000E+00	.0000E+00	3.4000E-02

4120	4.1200E+01	6.5000E+02	3.8382E+02	3.8382E+02	.0000E+00	.0000E+00	3.4333E-02
4160	4.1600E+01	6.5000E+02	3.8390E+02	3.8390E+02	.0000E+00	.0000E+00	3.4667E-02
4200	4.2000E+01	6.5000E+02	3.8396E+02	3.8396E+02	.0000E+00	.0000E+00	3.5000E-02
4240	4.2400E+01	6.5000E+02	3.8400E+02	3.8400E+02	.0000E+00	.0000E+00	3.5333E-02
4280	4.2800E+01	6.5000E+02	3.8402E+02	3.8402E+02	.0000E+00	.0000E+00	3.5667E-02
4320	4.3200E+01	6.5000E+02	3.8404E+02	3.8404E+02	.0000E+00	.0000E+00	3.6000E-02
4360	4.3600E+01	6.5000E+02	3.8405E+02	3.8405E+02	.0000E+00	.0000E+00	3.6333E-02
4400	4.4000E+01	6.5000E+02	3.8406E+02	3.8406E+02	.0000E+00	.0000E+00	3.6667E-02
4440	4.4400E+01	6.5000E+02	3.8406E+02	3.8406E+02	.0000E+00	.0000E+00	3.7000E-02
4480	4.4800E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.7333E-02
4520	4.5200E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.7667E-02
4560	4.5600E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.8000E-02
4600	4.6000E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.8333E-02
4640	4.6400E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.8667E-02
4680	4.6800E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.9000E-02
4720	4.7200E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.9333E-02
4760	4.7600E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.9667E-02
4800	4.8000E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	4.0000E-02

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*                               *
*   F I D E P 2 - VERSION 6   *
*                               *
*****

***** PROBLEM TITLE *****

SCS-6/TIMETAL21S(EP) Concentric Cylinder cooled from 900C to 23C

***** GEOMETRY TYPE *****

Concentric Cylinder Model

***** LOADING TYPE *****

Stress Control

***** LOADING HISTORY *****

POINTS IN HISTORY  2

      Step      Time      Temperature  Axial Stress  Radial Stress
      .0000E+00    .0000E+00    9.0000E+02    .0000E+00    .0000E+00
      3.6000E+02    3.6000E+03    2.5000E+01    .0000E+00    .0000E+00

***** GEOMETRY INFORMATION *****

Number of Cells  2

  For Cell Number : 1

      Material Number :  1
      Volume Fraction :  .35
      Nodes in cell   :  5

  For Cell Number : 2

      Material Number :  2
      Volume Fraction :  .65
      Nodes in cell   : 15

***** OUTPUT INFORMATION *****

Output at Interface for Material:  2

***** MATERIAL INFORMATION *****

Material for Cell Number :  1

Thermo-Elastic Response for SCS-6 fiber

Constitutive model: Elastic
----- MATERIAL PROPERTIES -----

      T(C)      E(GPa)      NU      CTE(1E-6/C)
      2.1110E+01    3.9300E+02    2.5000E-01    3.9907E+00
      9.3330E+01    3.9000E+02    2.5000E-01    4.0289E+00
      2.0444E+02    3.8600E+02    2.5000E-01    4.0989E+00

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3.1556E+02  3.8200E+02  2.5000E-01  4.1801E+00
4.2667E+02  3.7800E+02  2.5000E-01  4.2655E+00
5.3778E+02  3.7400E+02  2.5000E-01  4.3510E+00
6.4889E+02  3.7000E+02  2.5000E-01  4.4324E+00
7.6000E+02  3.6500E+02  2.5000E-01  4.5074E+00
8.7111E+02  3.6100E+02  2.5000E-01  4.5718E+00
1.0933E+03  3.5400E+02  2.5000E-01  4.5723E+00

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Reference Temperature = 900.0

Material for Cell Number : 2

Bilinear Elastic-Plastic Response for Timetal021S

Constitutive model: Bilinear Elastic-Plastic

----- MATERIAL PROPERTIES -----

T(C)	E(GPa)	NU	CTE(1E-6/C)
2.3000E+01	1.1400E+02	3.4000E-01	9.7699E+00
2.6000E+02	1.1400E+02	3.4000E-01	1.0719E+01
4.8200E+02	9.0000E+01	3.4000E-01	1.1499E+01
6.5000E+02	7.8000E+01	3.4000E-01	1.2027E+01
7.6000E+02	7.0000E+01	3.4000E-01	1.2344E+01
8.1500E+02	6.4000E+01	3.4000E-01	1.2493E+01
9.0000E+02	5.5000E+01	3.4000E-01	1.3796E+01

Reference Temperature = 900.0

T(C)	SY(MPa)	EP(GPa)
2.3000E+01	1.1070E+03	4.5900E-01
2.6000E+02	1.0100E+03	1.4860E+00
4.8200E+02	8.1000E+02	2.0000E+00
6.5000E+02	3.5000E+02	.0000E+00
7.6000E+02	1.2000E+02	.0000E+00
8.1500E+02	1.1000E+02	.0000E+00
9.0000E+02	9.4000E+01	.0000E+00

----- OUTPUT -----

STEP	TIME	TEMPERATURE	Seff	Srad	Stan	Sz	Erad	Etan	Ez
1	1.0000E+01	8.9757E+02	1.9956E+00	-6.8121E-01	1.4153E+00	1.1952E+00	-2.8391E-05	2.2451E-05	1.7113E-05
10	1.0000E+02	8.7569E+02	1.9963E+01	-6.8244E+00	1.4179E+01	1.1904E+01	-2.7257E-04	2.1627E-04	1.6334E-04
20	2.0000E+02	8.5139E+02	3.9857E+01	-1.3646E+01	2.8351E+01	2.3655E+01	-5.2085E-04	4.1479E-04	3.1015E-04
30	3.0000E+02	8.2708E+02	5.9488E+01	-2.0397E+01	4.2378E+01	3.5140E+01	-7.4542E-04	5.9574E-04	4.4111E-04
40	4.0000E+02	8.0278E+02	8.0244E+01	-2.7555E+01	5.7249E+01	4.7179E+01	-9.6521E-04	7.7413E-04	5.6760E-04
50	5.0000E+02	7.7847E+02	1.0331E+02	-3.5525E+01	7.3809E+01	6.0453E+01	-1.1940E-03	9.6101E-04	6.9776E-04
60	6.0000E+02	7.5417E+02	1.2666E+02	-4.3762E+01	9.0452E+01	7.3675E+01	-1.4225E-03	1.1452E-03	8.2424E-04
70	7.0000E+02	7.2986E+02	1.5018E+02	-5.1909E+01	1.0737E+02	8.7123E+01	-1.6437E-03	1.3266E-03	9.4914E-04
80	8.0000E+02	7.0556E+02	1.7430E+02	-6.0276E+01	1.2474E+02	1.0085E+02	-1.8607E-03	1.5053E-03	1.0707E-03
90	9.0000E+02	6.8125E+02	1.9900E+02	-6.8856E+01	1.4255E+02	1.1483E+02	-2.0736E-03	1.6813E-03	1.1889E-03
100	1.0000E+03	6.5694E+02	2.2425E+02	-7.7641E+01	1.6079E+02	1.2905E+02	-2.2823E-03	1.8545E-03	1.3040E-03
110	1.1000E+03	6.3264E+02	2.4984E+02	-8.6555E+01	1.7930E+02	1.4339E+02	-2.4856E-03	2.0241E-03	1.4151E-03
120	1.2000E+03	6.0833E+02	2.7582E+02	-9.5615E+01	1.9811E+02	1.5787E+02	-2.6842E-03	2.1904E-03	1.5228E-03
130	1.3000E+03	5.8403E+02	3.0222E+02	-1.0484E+02	2.1726E+02	1.7253E+02	-2.8785E-03	2.3537E-03	1.6272E-03
140	1.4000E+03	5.5972E+02	3.2903E+02	-1.1421E+02	2.3672E+02	1.8733E+02	-3.0684E-03	2.5140E-03	1.7285E-03
150	1.5000E+03	5.3542E+02	3.5622E+02	-1.2373E+02	2.5649E+02	2.0228E+02	-3.2542E-03	2.6714E-03	1.8268E-03
160	1.6000E+03	5.1111E+02	3.8382E+02	-1.3340E+02	2.7657E+02	2.1738E+02	-3.4362E-03	2.8262E-03	1.9222E-03
170	1.7000E+03	4.8681E+02	4.1175E+02	-1.4320E+02	2.9693E+02	2.3259E+02	-3.6140E-03	2.9781E-03	2.0148E-03

180	1.8000E+03	4.6250E+02	4.4258E+02	-1.5408E+02	3.1950E+02	2.4906E+02	-3.7802E-03	3.1234E-03	2.0968E-03
190	1.9000E+03	4.3819E+02	4.7455E+02	-1.6538E+02	3.4296E+02	2.6597E+02	-3.9398E-03	3.2644E-03	2.1736E-03
200	2.0000E+03	4.1389E+02	5.0700E+02	-1.7686E+02	3.6681E+02	2.8302E+02	-4.0945E-03	3.4020E-03	2.2470E-03
210	2.1000E+03	3.8958E+02	5.3989E+02	-1.8853E+02	3.9102E+02	3.0019E+02	-4.2445E-03	3.5361E-03	2.3171E-03
220	2.2000E+03	3.6528E+02	5.7319E+02	-2.0035E+02	4.1557E+02	3.1746E+02	-4.3897E-03	3.6668E-03	2.3840E-03
230	2.3000E+03	3.4097E+02	6.0685E+02	-2.1231E+02	4.4041E+02	3.3480E+02	-4.5304E-03	3.7941E-03	2.4477E-03
240	2.4000E+03	3.1667E+02	6.4084E+02	-2.2441E+02	4.6553E+02	3.5220E+02	-4.6664E-03	3.9180E-03	2.5085E-03
250	2.5000E+03	2.9236E+02	6.7502E+02	-2.3660E+02	4.9083E+02	3.6959E+02	-4.7973E-03	4.0379E-03	2.5659E-03
260	2.6000E+03	2.6806E+02	7.0944E+02	-2.4888E+02	5.1634E+02	3.8698E+02	-4.9236E-03	4.1543E-03	2.6204E-03
270	2.7000E+03	2.4375E+02	7.3339E+02	-2.5734E+02	5.3389E+02	3.9966E+02	-5.0504E-03	4.2640E-03	2.6845E-03
280	2.8000E+03	2.1944E+02	7.5153E+02	-2.6367E+02	5.4705E+02	4.0972E+02	-5.1752E-03	4.3684E-03	2.7524E-03
290	2.9000E+03	1.9514E+02	7.6890E+02	-2.6973E+02	5.5965E+02	4.1937E+02	-5.2947E-03	4.4682E-03	2.8175E-03
300	3.0000E+03	1.7083E+02	7.8543E+02	-2.7550E+02	5.7163E+02	4.2856E+02	-5.4084E-03	4.5630E-03	2.8796E-03
310	3.1000E+03	1.4653E+02	8.0128E+02	-2.8103E+02	5.8311E+02	4.3739E+02	-5.5175E-03	4.6539E-03	2.9393E-03
320	3.2000E+03	1.2222E+02	8.1645E+02	-2.8632E+02	5.9410E+02	4.4585E+02	-5.6219E-03	4.7408E-03	2.9965E-03
330	3.3000E+03	9.7917E+01	8.3095E+02	-2.9137E+02	6.0460E+02	4.5396E+02	-5.7217E-03	4.8238E-03	3.0514E-03
340	3.4000E+03	7.3611E+01	8.4452E+02	-2.9609E+02	6.1441E+02	4.6158E+02	-5.8151E-03	4.9012E-03	3.1031E-03
350	3.5000E+03	4.9306E+01	8.5733E+02	-3.0055E+02	6.2367E+02	4.6880E+02	-5.9033E-03	4.9742E-03	3.1521E-03
360	3.6000E+03	2.5000E+01	8.6945E+02	-3.0476E+02	6.3241E+02	4.7565E+02	-5.9868E-03	5.0430E-03	3.1986E-03

Cross-Sectional Results at Step 360
time = 3600.0000

Radius	Seff	Srad	Stan	Sz	Er	Etan	Ez
.000	5.7882E+02	-3.0476E+02	-3.0476E+02	-8.8441E+02	-1.9004E-05	-1.9004E-05	-1.8634E-03
.148	5.7882E+02	-3.0476E+02	-3.0476E+02	-8.8441E+02	-1.9004E-05	-1.9004E-05	-1.8634E-03
.296	5.7882E+02	-3.0476E+02	-3.0476E+02	-8.8441E+02	-1.9004E-05	-1.9004E-05	-1.8634E-03
.444	5.7882E+02	-3.0476E+02	-3.0476E+02	-8.8441E+02	-1.9004E-05	-1.9004E-05	-1.8634E-03
.592	5.7882E+02	-3.0476E+02	-3.0476E+02	-8.8441E+02	-1.9004E-05	-1.9004E-05	-1.8634E-03
.592	8.6945E+02	-3.0476E+02	6.3241E+02	4.7565E+02	-5.9868E-03	5.0430E-03	3.1986E-03
.621	8.0095E+02	-2.6171E+02	5.9004E+02	4.7627E+02	-5.4760E-03	4.5359E-03	3.1986E-03
.650	7.4168E+02	-2.2433E+02	5.5256E+02	4.7624E+02	-5.0361E-03	4.0957E-03	3.1986E-03
.679	6.9071E+02	-1.9166E+02	5.1982E+02	4.7622E+02	-4.6519E-03	3.7112E-03	3.1986E-03
.708	6.4670E+02	-1.6295E+02	4.9106E+02	4.7620E+02	-4.3142E-03	3.3733E-03	3.1986E-03
.737	6.0856E+02	-1.3758E+02	4.6564E+02	4.7618E+02	-4.0158E-03	3.0747E-03	3.1986E-03
.767	5.7540E+02	-1.1506E+02	4.4308E+02	4.7617E+02	-3.7509E-03	2.8097E-03	3.1986E-03
.796	5.4647E+02	-9.4968E+01	4.2296E+02	4.7616E+02	-3.5146E-03	2.5733E-03	3.1986E-03
.825	5.2118E+02	-7.6973E+01	4.0494E+02	4.7615E+02	-3.3030E-03	2.3616E-03	3.1986E-03
.854	4.9900E+02	-6.0791E+01	3.8873E+02	4.7614E+02	-3.1127E-03	2.1712E-03	3.1986E-03
.883	4.7952E+02	-4.6187E+01	3.7411E+02	4.7614E+02	-2.9410E-03	1.9994E-03	3.1986E-03
.912	4.6237E+02	-3.2963E+01	3.6087E+02	4.7613E+02	-2.7855E-03	1.8438E-03	3.1986E-03
.942	4.4723E+02	-2.0949E+01	3.4884E+02	4.7613E+02	-2.6442E-03	1.7025E-03	3.1986E-03
.971	4.3385E+02	-1.0002E+01	3.3788E+02	4.7612E+02	-2.5155E-03	1.5737E-03	3.1986E-03
1.000	4.2200E+02	.0000E+00	3.2787E+02	4.7612E+02	-2.3979E-03	1.4561E-03	3.1986E-03

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* F I D E P 2 - VERSION 6 *
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***** PROBLEM TITLE *****

SCS-6/TIMETAL21S(EP) Concentric Cylinder cooled from 900C to 23C

----- Average Stress Output -----

STEP	TIME	TEMPERATURE	SZAPP	SZF	SZM	SZ90	EME-F	EME-M	EME-90	EZC
1	1.0000E+01	8.9757E+02	.0000E+00	-2.2193E+00	1.1950E+00	.0000E+00	-5.2163E-06	1.7113E-05	.0000E+00	-1.6328E-05
10	1.0000E+02	8.7569E+02	.0000E+00	-2.2105E+01	1.1903E+01	.0000E+00	-5.1801E-05	1.6334E-04	.0000E+00	-1.6292E-04
20	2.0000E+02	8.5139E+02	.0000E+00	-4.3924E+01	2.3651E+01	.0000E+00	-1.0257E-04	3.1015E-04	.0000E+00	-3.2426E-04
30	3.0000E+02	8.2708E+02	.0000E+00	-6.5251E+01	3.5135E+01	.0000E+00	-1.5183E-04	4.4111E-04	.0000E+00	-4.8333E-04
40	4.0000E+02	8.0278E+02	.0000E+00	-8.7606E+01	4.7173E+01	.0000E+00	-2.0313E-04	5.6760E-04	.0000E+00	-6.4376E-04
50	5.0000E+02	7.7847E+02	.0000E+00	-1.1225E+02	6.0445E+01	.0000E+00	-2.5935E-04	6.9776E-04	.0000E+00	-8.0843E-04
60	6.0000E+02	7.5417E+02	.0000E+00	-1.3755E+02	7.4064E+01	.0000E+00	-3.1667E-04	8.2424E-04	.0000E+00	-9.7342E-04
70	7.0000E+02	7.2986E+02	.0000E+00	-1.6254E+02	8.7520E+01	.0000E+00	-3.7281E-04	9.4914E-04	.0000E+00	-1.1362E-03
80	8.0000E+02	7.0556E+02	.0000E+00	-1.8804E+02	1.0125E+02	.0000E+00	-4.2971E-04	1.0707E-03	.0000E+00	-1.2990E-03
90	9.0000E+02	6.8125E+02	.0000E+00	-2.1402E+02	1.1524E+02	.0000E+00	-4.8729E-04	1.1889E-03	.0000E+00	-1.4617E-03
100	1.0000E+03	6.5694E+02	.0000E+00	-2.4045E+02	1.2947E+02	.0000E+00	-5.4548E-04	1.3040E-03	.0000E+00	-1.6241E-03
110	1.1000E+03	6.3264E+02	.0000E+00	-2.6710E+02	1.4382E+02	.0000E+00	-6.0396E-04	1.4151E-03	.0000E+00	-1.7858E-03
120	1.2000E+03	6.0833E+02	.0000E+00	-2.9401E+02	1.5831E+02	.0000E+00	-6.6278E-04	1.5228E-03	.0000E+00	-1.9469E-03
130	1.3000E+03	5.8403E+02	.0000E+00	-3.2123E+02	1.7297E+02	.0000E+00	-7.2196E-04	1.6272E-03	.0000E+00	-2.1075E-03
140	1.4000E+03	5.5972E+02	.0000E+00	-3.4874E+02	1.8778E+02	.0000E+00	-7.8141E-04	1.7285E-03	.0000E+00	-2.2674E-03
150	1.5000E+03	5.3542E+02	.0000E+00	-3.7651E+02	2.0274E+02	.0000E+00	-8.4111E-04	1.8268E-03	.0000E+00	-2.4267E-03
160	1.6000E+03	5.1111E+02	.0000E+00	-4.0456E+02	2.1784E+02	.0000E+00	-9.0106E-04	1.9222E-03	.0000E+00	-2.5851E-03
170	1.7000E+03	4.8681E+02	.0000E+00	-4.3283E+02	2.3306E+02	.0000E+00	-9.6114E-04	2.0148E-03	.0000E+00	-2.7427E-03
180	1.8000E+03	4.6250E+02	.0000E+00	-4.6344E+02	2.4954E+02	.0000E+00	-1.0257E-03	2.0968E-03	.0000E+00	-2.9039E-03
190	1.9000E+03	4.3819E+02	.0000E+00	-4.9486E+02	2.6646E+02	.0000E+00	-1.0916E-03	2.1736E-03	.0000E+00	-3.0655E-03
200	2.0000E+03	4.1389E+02	.0000E+00	-5.2655E+02	2.8353E+02	.0000E+00	-1.1576E-03	2.2470E-03	.0000E+00	-3.2264E-03
210	2.1000E+03	3.8958E+02	.0000E+00	-5.5846E+02	3.0071E+02	.0000E+00	-1.2237E-03	2.3171E-03	.0000E+00	-3.3863E-03
220	2.2000E+03	3.6528E+02	.0000E+00	-5.9055E+02	3.1799E+02	.0000E+00	-1.2898E-03	2.3840E-03	.0000E+00	-3.5454E-03
230	2.3000E+03	3.4097E+02	.0000E+00	-6.2278E+02	3.3535E+02	.0000E+00	-1.3557E-03	2.4477E-03	.0000E+00	-3.7034E-03
240	2.4000E+03	3.1667E+02	.0000E+00	-6.5512E+02	3.5276E+02	.0000E+00	-1.4214E-03	2.5085E-03	.0000E+00	-3.8603E-03
250	2.5000E+03	2.9236E+02	.0000E+00	-6.8743E+02	3.7015E+02	.0000E+00	-1.4866E-03	2.5659E-03	.0000E+00	-4.0163E-03
260	2.6000E+03	2.6806E+02	.0000E+00	-7.1975E+02	3.8756E+02	.0000E+00	-1.5515E-03	2.6204E-03	.0000E+00	-4.1711E-03
270	2.7000E+03	2.4375E+02	.0000E+00	-7.4331E+02	4.0025E+02	.0000E+00	-1.5982E-03	2.6845E-03	.0000E+00	-4.3070E-03
280	2.8000E+03	2.1944E+02	.0000E+00	-7.6199E+02	4.1030E+02	.0000E+00	-1.6348E-03	2.7524E-03	.0000E+00	-4.4318E-03
290	2.9000E+03	1.9514E+02	.0000E+00	-7.7991E+02	4.1995E+02	.0000E+00	-1.6696E-03	2.8175E-03	.0000E+00	-4.5547E-03
300	3.0000E+03	1.7083E+02	.0000E+00	-7.9697E+02	4.2914E+02	.0000E+00	-1.7025E-03	2.8796E-03	.0000E+00	-4.6758E-03
310	3.1000E+03	1.4653E+02	.0000E+00	-8.1336E+02	4.3797E+02	.0000E+00	-1.7338E-03	2.9393E-03	.0000E+00	-4.7947E-03
320	3.2000E+03	1.2222E+02	.0000E+00	-8.2908E+02	4.4643E+02	.0000E+00	-1.7635E-03	2.9965E-03	.0000E+00	-4.9112E-03
330	3.3000E+03	9.7917E+01	.0000E+00	-8.4413E+02	4.5453E+02	.0000E+00	-1.7916E-03	3.0514E-03	.0000E+00	-5.0255E-03
340	3.4000E+03	7.3611E+01	.0000E+00	-8.5829E+02	4.6215E+02	.0000E+00	-1.8173E-03	3.1031E-03	.0000E+00	-5.1381E-03
350	3.5000E+03	4.9306E+01	.0000E+00	-8.7170E+02	4.6937E+02	.0000E+00	-1.8412E-03	3.1521E-03	.0000E+00	-5.2487E-03
360	3.6000E+03	2.5000E+01	.0000E+00	-8.8441E+02	4.7622E+02	.0000E+00	-1.8634E-03	3.1986E-03	.0000E+00	-5.3571E-03

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*   F I D E P 2 - VERSION 6   *
*                               *
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***** PROBLEM TITLE *****
SCS-6/TIMETAL21S(DBP) Concentric Cylinder cooled from 900C to 23C

***** GEOMETRY TYPE *****

Concentric Cylinder Model

***** LOADING TYPE *****

Stress Control

***** LOADING HISTORY *****

POINTS IN HISTORY  2

      Step      Time      Temperature  Axial Stress  Radial Stress
      .0000E+00    .0000E+00    9.0000E+02    .0000E+00    .0000E+00
      3.6000E+03    3.6000E+03    2.5000E+01    .0000E+00    .0000E+00

***** GEOMETRY INFORMATION *****

Number of Cells  2

For Cell Number : 1

Material Number : 1
Volume Fraction : .35
Nodes in cell   : 7

For Cell Number : 2

Material Number : 4
Volume Fraction : .65
Nodes in cell   : 20

***** OUTPUT INFORMATION *****

Output at Interface for Material:  2

***** MATERIAL INFORMATION *****

Material for Cell Number : 1

Thermo-Elastic Response for SCS-6 fiber

Constitutive model: Elastic

----- MATERIAL PROPERTIES -----

      T(C)      E(GPa)      NU      CTE(1E-6/C)
      2.1110E+01    3.9300E+02    2.5000E-01    3.9907E+00

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9.3330E+01	3.9000E+02	2.5000E-01	4.0289E+00
2.0444E+02	3.8600E+02	2.5000E-01	4.0989E+00
3.1556E+02	3.8200E+02	2.5000E-01	4.1801E+00
4.2667E+02	3.7800E+02	2.5000E-01	4.2655E+00
5.3778E+02	3.7400E+02	2.5000E-01	4.3510E+00
6.4889E+02	3.7000E+02	2.5000E-01	4.4324E+00
7.6000E+02	3.6500E+02	2.5000E-01	4.5074E+00
8.7111E+02	3.6100E+02	2.5000E-01	4.5718E+00
1.0933E+03	3.5400E+02	2.5000E-01	4.5723E+00

Reference Temperature = 900.0

Material for Cell Number : 2

Bodner-Partom Theory with Directional Hardening for Timetal021S

Constitutive model: Bodner-Partom with Directional Hardening

----- MATERIAL PROPERTIES -----

T (C)	E (GPa)	NU	CTE (1E-6/C)
2.3000E+01	1.1200E+02	3.4000E-01	9.7787E+00
2.6000E+02	1.0800E+02	3.4000E-01	1.0713E+01
3.1500E+02	1.0610E+02	3.4000E-01	1.0915E+01
3.6500E+02	1.0410E+02	3.4000E-01	1.1093E+01
4.1500E+02	1.0170E+02	3.4000E-01	1.1267E+01
4.6500E+02	9.9090E+01	3.4000E-01	1.1436E+01
4.8200E+02	9.8110E+01	3.4000E-01	1.1492E+01
5.0000E+02	9.7050E+01	3.4000E-01	1.1550E+01
5.2500E+02	9.5500E+01	3.4000E-01	1.1631E+01
5.5000E+02	9.3870E+01	3.4000E-01	1.1710E+01
5.7500E+02	9.2170E+01	3.4000E-01	1.1788E+01
6.0000E+02	9.0400E+01	3.4000E-01	1.1865E+01
6.5000E+02	8.6610E+01	3.4000E-01	1.2014E+01
7.6000E+02	7.7220E+01	3.4000E-01	1.2323E+01
8.1500E+02	7.1960E+01	3.4000E-01	1.2467E+01
9.0000E+02	6.3120E+01	3.4000E-01	1.2689E+01

Reference Temperature = 900.0

T (C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
2.3000E+01	4.8000E+00	1.5500E+03	1.0000E+02	3.5000E-01
2.6000E+02	3.5000E+00	1.3000E+03	3.0000E+02	3.5000E-01
3.1500E+02	3.0540E+00	1.2504E+03	3.9000E+02	1.5020E+00
3.6500E+02	2.6490E+00	1.2054E+03	5.0000E+02	2.5490E+00
4.1500E+02	2.2430E+00	1.1604E+03	6.6000E+02	3.5970E+00
4.6500E+02	1.8380E+00	1.1153E+03	9.6000E+02	4.6440E+00
4.8200E+02	1.7000E+00	1.1000E+03	1.1000E+03	5.0000E+00
5.0000E+02	1.5000E+00	1.0893E+03	1.3000E+03	5.7630E+00
5.2500E+02	1.2800E+00	1.0744E+03	1.6700E+03	6.8220E+00
5.5000E+02	1.1000E+00	1.0595E+03	2.1000E+03	7.8810E+00
5.7500E+02	9.7000E-01	1.0446E+03	2.6000E+03	8.9410E+00
6.0000E+02	8.2000E-01	1.0298E+03	3.7000E+03	1.0000E+01
6.5000E+02	7.4000E-01	1.0000E+03	3.8000E+03	1.0000E+01
7.6000E+02	5.8000E-01	6.0000E+02	4.0000E+03	1.5000E+01
8.1500E+02	5.5000E-01	3.0000E+02	4.1000E+03	3.0000E+01
9.0000E+02	5.5000E-01	3.0000E+02	4.3000E+03	3.0000E+01

A1=A2 M1 Z1 R1=R2 DO
-9999.0 .0 1600.0 3.0 10000.0

----- OUTPUT -----

STEP	TIME	TEMPERATRE	Seff	Srad	Stan	Sz	Erad	Etan	Ez
1	1.0000E+00	8.9976E+02	1.9900E-01	-6.8276E-02	1.4183E-01	1.1735E-01	-2.4768E-06	1.9819E-06	1.4624E-06
100	1.0000E+02	8.7569E+02	1.3784E+01	-5.4012E+00	8.9691E+00	7.7093E+00	-2.9383E-04	1.9751E-04	1.5130E-04
200	2.0000E+02	8.5139E+02	1.5526E+01	-6.4797E+00	9.3174E+00	8.7599E+00	-6.6740E-04	3.9274E-04	3.2909E-04
300	3.0000E+02	8.2708E+02	1.6094E+01	-6.6193E+00	9.5672E+00	9.3799E+00	-1.0447E-03	5.8437E-04	5.1613E-04
400	4.0000E+02	8.0278E+02	1.8817E+01	-7.7147E+00	1.1312E+01	1.0885E+01	-1.4050E-03	7.7340E-04	6.9497E-04
500	5.0000E+02	7.7847E+02	2.5574E+01	-1.0616E+01	1.5498E+01	1.4378E+01	-1.7355E-03	9.6065E-04	8.5648E-04
600	6.0000E+02	7.5417E+02	3.3371E+01	-1.4007E+01	2.0249E+01	1.8402E+01	-2.0554E-03	1.1457E-03	1.0113E-03
700	7.0000E+02	7.2986E+02	4.4683E+01	-1.8772E+01	2.7420E+01	2.4228E+01	-2.3501E-03	1.3280E-03	1.1539E-03
800	8.0000E+02	7.0556E+02	5.8492E+01	-2.4544E+01	3.6285E+01	3.1287E+01	-2.6271E-03	1.5078E-03	1.2875E-03
900	9.0000E+02	6.8125E+02	7.4450E+01	-3.1146E+01	4.6662E+01	3.9413E+01	-2.8893E-03	1.6849E-03	1.4138E-03
1000	1.0000E+03	6.5694E+02	9.2429E+01	-3.8476E+01	5.8524E+01	4.8574E+01	-3.1377E-03	1.8592E-03	1.5338E-03
1100	1.1000E+03	6.3264E+02	1.1142E+02	-4.6136E+01	7.1167E+01	5.8284E+01	-3.3765E-03	2.0303E-03	1.6494E-03
1200	1.2000E+03	6.0833E+02	1.3111E+02	-5.3961E+01	8.4397E+01	6.8431E+01	-3.6078E-03	2.1984E-03	1.7618E-03
1300	1.3000E+03	5.8403E+02	1.5390E+02	-6.2520E+01	1.0031E+02	8.0542E+01	-3.8178E-03	2.3629E-03	1.8686E-03
1400	1.4000E+03	5.5972E+02	1.7931E+02	-7.1607E+01	1.1857E+02	9.4382E+01	-4.0091E-03	2.5236E-03	1.9708E-03
1500	1.5000E+03	5.3542E+02	2.0496E+02	-8.0755E+01	1.3705E+02	1.0833E+02	-4.1956E-03	2.6811E-03	2.0701E-03
1600	1.6000E+03	5.1111E+02	2.3070E+02	-8.9933E+01	1.5562E+02	1.2228E+02	-4.3779E-03	2.8354E-03	2.1667E-03
1700	1.7000E+03	4.8681E+02	2.5644E+02	-9.9113E+01	1.7421E+02	1.3620E+02	-4.5561E-03	2.9865E-03	2.2607E-03
1800	1.8000E+03	4.6250E+02	2.8208E+02	-1.0825E+02	1.9275E+02	1.5002E+02	-4.7297E-03	3.1341E-03	2.3520E-03
1900	1.9000E+03	4.3819E+02	3.0733E+02	-1.1725E+02	2.1102E+02	1.6364E+02	-4.8985E-03	3.2776E-03	2.4406E-03
2000	2.0000E+03	4.1389E+02	3.3258E+02	-1.2625E+02	2.2931E+02	1.7720E+02	-5.0631E-03	3.4179E-03	2.5266E-03
2100	2.1000E+03	3.8958E+02	3.5734E+02	-1.3507E+02	2.4726E+02	1.9050E+02	-5.2226E-03	3.5539E-03	2.6099E-03
2200	2.2000E+03	3.6528E+02	3.8203E+02	-1.4387E+02	2.6516E+02	2.0371E+02	-5.3779E-03	3.6866E-03	2.6905E-03
2300	2.3000E+03	3.4097E+02	4.0582E+02	-1.5233E+02	2.8242E+02	2.1649E+02	-5.5286E-03	3.8151E-03	2.7691E-03
2400	2.4000E+03	3.1667E+02	4.2941E+02	-1.6073E+02	2.9955E+02	2.2913E+02	-5.6751E-03	3.9403E-03	2.8453E-03
2500	2.5000E+03	2.9236E+02	4.5202E+02	-1.6876E+02	3.1596E+02	2.4125E+02	-5.8155E-03	4.0601E-03	2.9185E-03
2600	2.6000E+03	2.6806E+02	4.7428E+02	-1.7667E+02	3.3212E+02	2.5317E+02	-5.9515E-03	4.1763E-03	2.9891E-03
2700	2.7000E+03	2.4375E+02	4.9463E+02	-1.8387E+02	3.4690E+02	2.6419E+02	-6.0812E-03	4.2863E-03	3.0576E-03
2800	2.8000E+03	2.1944E+02	5.1374E+02	-1.9061E+02	3.6077E+02	2.7459E+02	-6.2055E-03	4.3913E-03	3.1237E-03
2900	2.9000E+03	1.9514E+02	5.3223E+02	-1.9713E+02	3.7419E+02	2.8464E+02	-6.3244E-03	4.4918E-03	3.1869E-03
3000	3.0000E+03	1.7083E+02	5.5002E+02	-2.0341E+02	3.8710E+02	2.9431E+02	-6.4374E-03	4.5873E-03	3.2468E-03
3100	3.1000E+03	1.4653E+02	5.6727E+02	-2.0951E+02	3.9962E+02	3.0368E+02	-6.5457E-03	4.6790E-03	3.3043E-03
3200	3.2000E+03	1.2222E+02	5.8398E+02	-2.1541E+02	4.1175E+02	3.1274E+02	-6.6493E-03	4.7668E-03	3.3591E-03
3300	3.3000E+03	9.7917E+01	6.0014E+02	-2.2112E+02	4.2348E+02	3.2149E+02	-6.7483E-03	4.8506E-03	3.4115E-03
3400	3.4000E+03	7.3611E+01	6.1549E+02	-2.2654E+02	4.3461E+02	3.2982E+02	-6.8408E-03	4.9289E-03	3.4605E-03
3500	3.5000E+03	4.9306E+01	6.3019E+02	-2.3174E+02	4.4528E+02	3.3779E+02	-6.9281E-03	5.0029E-03	3.5067E-03
3600	3.6000E+03	2.5000E+01	6.4429E+02	-2.3673E+02	4.5551E+02	3.4543E+02	-7.0106E-03	5.0728E-03	3.5503E-03

Cross-Sectional Results at Step 3600
time = 3600.0000

Radius	Seff	Srad	Stan	Sz	Er	Etan	Ez
.000	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.099	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.197	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.296	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.394	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.493	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.592	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.592	6.4429E+02	-2.3673E+02	4.5551E+02	3.4543E+02	-7.0106E-03	5.0728E-03	3.5503E-03
.613	6.1224E+02	-2.1277E+02	4.3821E+02	3.5150E+02	-6.5581E-03	4.6567E-03	3.5503E-03

.635	5.8342E+02	-1.9099E+02	4.2230E+02	3.5708E+02	-6.1520E-03	4.2834E-03	3.5503E-03
.656	5.5744E+02	-1.7113E+02	4.0762E+02	3.6222E+02	-5.7864E-03	3.9472E-03	3.5503E-03
.678	5.3399E+02	-1.5299E+02	3.9402E+02	3.6695E+02	-5.4561E-03	3.6434E-03	3.5503E-03
.699	5.1278E+02	-1.3637E+02	3.8138E+02	3.7129E+02	-5.1570E-03	3.3681E-03	3.5503E-03
.721	4.9356E+02	-1.2110E+02	3.6959E+02	3.7527E+02	-4.8852E-03	3.1176E-03	3.5503E-03
.742	4.7612E+02	-1.0704E+02	3.5858E+02	3.7892E+02	-4.6377E-03	2.8893E-03	3.5503E-03
.764	4.6028E+02	-9.4082E+01	3.4827E+02	3.8224E+02	-4.4118E-03	2.6804E-03	3.5503E-03
.785	4.4588E+02	-8.2103E+01	3.3860E+02	3.8528E+02	-4.2051E-03	2.4890E-03	3.5503E-03
.807	4.3277E+02	-7.1012E+01	3.2951E+02	3.8804E+02	-4.0155E-03	2.3130E-03	3.5503E-03
.828	4.2082E+02	-6.0727E+01	3.2096E+02	3.9055E+02	-3.8412E-03	2.1509E-03	3.5503E-03
.850	4.0993E+02	-5.1171E+01	3.1291E+02	3.9283E+02	-3.6808E-03	2.0013E-03	3.5503E-03
.871	3.9999E+02	-4.2281E+01	3.0532E+02	3.9490E+02	-3.5327E-03	1.8628E-03	3.5503E-03
.893	3.9090E+02	-3.3996E+01	2.9816E+02	3.9677E+02	-3.3958E-03	1.7345E-03	3.5503E-03
.914	3.8260E+02	-2.6264E+01	2.9140E+02	3.9846E+02	-3.2690E-03	1.6153E-03	3.5503E-03
.936	3.7501E+02	-1.9039E+01	2.8501E+02	4.0000E+02	-3.1513E-03	1.5043E-03	3.5503E-03
.957	3.6805E+02	-1.2278E+01	2.7897E+02	4.0138E+02	-3.0419E-03	1.4010E-03	3.5503E-03
.979	3.6167E+02	-5.9431E+00	2.7326E+02	4.0263E+02	-2.9401E-03	1.3044E-03	3.5503E-03
1.000	3.5583E+02	.0000E+00	2.6785E+02	4.0375E+02	-2.8451E-03	1.2142E-03	3.5503E-03

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*   F I D E P 2 - VERSION 6
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***** PROBLEM TITLE *****

SCS-6/TIMETAL21S(DBP) Concentric Cylinder cooled from 900C to 23C

----- Average Stress Output -----

STE	TIME	TEMPERATURE	SZAPP	SZF	SZM	SZ90	EME-F	EME-M	EME-90	EZC
1	1.0000E+00	8.9976E+02	.0000E+00	-2.1792E-01	1.1734E-01	.0000E+00	-5.1037E-07	1.4624E-06	.0000E+00	-1.6216E-06
100	1.0000E+02	8.7569E+02	.0000E+00	-1.8742E+01	1.0092E+01	.0000E+00	-4.4454E-05	1.5130E-04	.0000E+00	-1.5557E-04
200	2.0000E+02	8.5139E+02	.0000E+00	-2.4900E+01	1.3408E+01	.0000E+00	-5.9882E-05	3.2909E-04	.0000E+00	-2.8157E-04
300	3.0000E+02	8.2708E+02	.0000E+00	-2.6413E+01	1.4223E+01	.0000E+00	-6.3719E-05	5.1613E-04	.0000E+00	-3.9522E-04
400	4.0000E+02	8.0278E+02	.0000E+00	-3.0520E+01	1.6434E+01	.0000E+00	-7.3359E-05	6.9497E-04	.0000E+00	-5.1399E-04
500	5.0000E+02	7.7847E+02	.0000E+00	-4.0981E+01	2.2067E+01	.0000E+00	-9.7912E-05	8.5648E-04	.0000E+00	-6.4699E-04
600	6.0000E+02	7.5417E+02	.0000E+00	-5.3285E+01	2.8692E+01	.0000E+00	-1.2671E-04	1.0113E-03	.0000E+00	-7.8346E-04
700	7.0000E+02	7.2986E+02	.0000E+00	-6.9793E+01	3.7581E+01	.0000E+00	-1.6489E-04	1.1539E-03	.0000E+00	-9.2831E-04
800	8.0000E+02	7.0556E+02	.0000E+00	-8.9282E+01	4.8075E+01	.0000E+00	-2.0958E-04	1.2875E-03	.0000E+00	-1.0789E-03
900	9.0000E+02	6.8125E+02	.0000E+00	-1.1106E+02	5.9802E+01	.0000E+00	-2.5909E-04	1.4138E-03	.0000E+00	-1.2335E-03
1000	1.0000E+03	6.5694E+02	.0000E+00	-1.3469E+02	7.2524E+01	.0000E+00	-3.1233E-04	1.5338E-03	.0000E+00	-1.3910E-03
1100	1.1000E+03	6.3264E+02	.0000E+00	-1.5906E+02	8.5648E+01	.0000E+00	-3.6697E-04	1.6494E-03	.0000E+00	-1.5488E-03
1200	1.2000E+03	6.0833E+02	.0000E+00	-1.8371E+02	9.8920E+01	.0000E+00	-4.2192E-04	1.7618E-03	.0000E+00	-1.7060E-03
1300	1.3000E+03	5.8403E+02	.0000E+00	-2.0973E+02	1.1293E+02	.0000E+00	-4.7933E-04	1.8686E-03	.0000E+00	-1.8648E-03
1400	1.4000E+03	5.5972E+02	.0000E+00	-2.3666E+02	1.2743E+02	.0000E+00	-5.3817E-04	1.9708E-03	.0000E+00	-2.0242E-03
1500	1.5000E+03	5.3542E+02	.0000E+00	-2.6361E+02	1.4195E+02	.0000E+00	-5.9675E-04	2.0701E-03	.0000E+00	-2.1824E-03
1600	1.6000E+03	5.1111E+02	.0000E+00	-2.9053E+02	1.5644E+02	.0000E+00	-6.5491E-04	2.1667E-03	.0000E+00	-2.3390E-03
1700	1.7000E+03	4.8681E+02	.0000E+00	-3.1735E+02	1.7088E+02	.0000E+00	-7.1252E-04	2.2607E-03	.0000E+00	-2.4941E-03
1800	1.8000E+03	4.6250E+02	.0000E+00	-3.4394E+02	1.8520E+02	.0000E+00	-7.6934E-04	2.3520E-03	.0000E+00	-2.6476E-03
1900	1.9000E+03	4.3819E+02	.0000E+00	-3.7006E+02	1.9926E+02	.0000E+00	-8.2480E-04	2.4406E-03	.0000E+00	-2.7987E-03
2000	2.0000E+03	4.1389E+02	.0000E+00	-3.9608E+02	2.1327E+02	.0000E+00	-8.7977E-04	2.5266E-03	.0000E+00	-2.9485E-03
2100	2.1000E+03	3.8958E+02	.0000E+00	-4.2154E+02	2.2698E+02	.0000E+00	-9.3323E-04	2.6099E-03	.0000E+00	-3.0959E-03
2200	2.2000E+03	3.6528E+02	.0000E+00	-4.4685E+02	2.4061E+02	.0000E+00	-9.8608E-04	2.6905E-03	.0000E+00	-3.2417E-03
2300	2.3000E+03	3.4097E+02	.0000E+00	-4.7121E+02	2.5373E+02	.0000E+00	-1.0366E-03	2.7691E-03	.0000E+00	-3.3844E-03
2400	2.4000E+03	3.1667E+02	.0000E+00	-4.9532E+02	2.6671E+02	.0000E+00	-1.0864E-03	2.8453E-03	.0000E+00	-3.5253E-03
2500	2.5000E+03	2.9236E+02	.0000E+00	-5.1840E+02	2.7914E+02	.0000E+00	-1.1337E-03	2.9185E-03	.0000E+00	-3.6634E-03
2600	2.6000E+03	2.6806E+02	.0000E+00	-5.4109E+02	2.9136E+02	.0000E+00	-1.1799E-03	2.9891E-03	.0000E+00	-3.7996E-03
2700	2.7000E+03	2.4375E+02	.0000E+00	-5.6191E+02	3.0257E+02	.0000E+00	-1.2220E-03	3.0576E-03	.0000E+00	-3.9308E-03
2800	2.8000E+03	2.1944E+02	.0000E+00	-5.8149E+02	3.1311E+02	.0000E+00	-1.2613E-03	3.1237E-03	.0000E+00	-4.0583E-03
2900	2.9000E+03	1.9514E+02	.0000E+00	-6.0043E+02	3.2331E+02	.0000E+00	-1.2990E-03	3.1869E-03	.0000E+00	-4.1841E-03
3000	3.0000E+03	1.7083E+02	.0000E+00	-6.1866E+02	3.3312E+02	.0000E+00	-1.3351E-03	3.2468E-03	.0000E+00	-4.3084E-03
3100	3.1000E+03	1.4653E+02	.0000E+00	-6.3632E+02	3.4263E+02	.0000E+00	-1.3697E-03	3.3043E-03	.0000E+00	-4.4306E-03
3200	3.2000E+03	1.2222E+02	.0000E+00	-6.5342E+02	3.5184E+02	.0000E+00	-1.4030E-03	3.3591E-03	.0000E+00	-4.5508E-03
3300	3.3000E+03	9.7917E+01	.0000E+00	-6.6994E+02	3.6074E+02	.0000E+00	-1.4349E-03	3.4115E-03	.0000E+00	-4.6688E-03
3400	3.4000E+03	7.3611E+01	.0000E+00	-6.8567E+02	3.6921E+02	.0000E+00	-1.4646E-03	3.4605E-03	.0000E+00	-4.7854E-03
3500	3.5000E+03	4.9306E+01	.0000E+00	-7.0074E+02	3.7732E+02	.0000E+00	-1.4927E-03	3.5067E-03	.0000E+00	-4.9002E-03
3600	3.6000E+03	2.5000E+01	.0000E+00	-7.1521E+02	3.8511E+02	.0000E+00	-1.5193E-03	3.5503E-03	.0000E+00	-5.0130E-03

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*   F I D E P 2 - VERSION 6
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***** PROBLEM TITLE *****

SCS-6/TIMETAL21S(DBP) In-Phase TMF - strain control

***** GEOMETRY TYPE *****

Concentric Cylinder Model

***** LOADING TYPE *****

Strain Control

***** LOADING HISTORY *****

POINTS IN HISTORY 13

Step	Time	Temperature	Axial Strain
.0000E+00	-3.6000E+03	9.0000E+02	.0000E+00
1.0000E+03	.0000E+00	2.5000E+01	.0000E+00
1.1000E+03	1.8000E+02	1.5000E+02	-5.0000E-03
1.2000E+03	3.6000E+02	6.5000E+02	5.0000E-03
1.3000E+03	5.4000E+02	1.5000E+02	-5.0000E-03
1.4000E+03	7.2000E+02	6.5000E+02	5.0000E-03
1.5000E+03	9.0000E+02	1.5000E+02	-5.0000E-03
1.6000E+03	1.0800E+03	6.5000E+02	5.0000E-03
1.7000E+03	1.2600E+03	1.5000E+02	-5.0000E-03
1.8000E+03	1.4400E+03	6.5000E+02	5.0000E-03
1.9000E+03	1.6200E+03	1.5000E+02	-5.0000E-03
2.0000E+03	1.8000E+03	6.5000E+02	5.0000E-03
2.1000E+03	1.9800E+03	1.5000E+02	-5.0000E-03

***** GEOMETRY INFORMATION *****

Number of Cells 2

For Cell Number : 1

Material Number : 1

Volume Fraction : .35

Nodes in cell : 5

For Cell Number : 2

Material Number : 4

Volume Fraction : .65

Nodes in cell : 15

***** OUTPUT INFORMATION *****

Output at Interface for Material: 2

***** MATERIAL INFORMATION *****

Material for Cell Number : 1

Thermo-Elastic Response for SCS-6 fiber

Constitutive model: Elastic

----- MATERIAL PROPERTIES -----

T (C)	E (GPa)	NU	CTE (1E-6/C)
2.1110E+01	3.9300E+02	2.5000E-01	3.9907E+00
9.3330E+01	3.9000E+02	2.5000E-01	4.0289E+00
2.0444E+02	3.8600E+02	2.5000E-01	4.0989E+00
3.1556E+02	3.8200E+02	2.5000E-01	4.1801E+00
4.2667E+02	3.7800E+02	2.5000E-01	4.2655E+00
5.3778E+02	3.7400E+02	2.5000E-01	4.3510E+00
6.4889E+02	3.7000E+02	2.5000E-01	4.4324E+00
7.6000E+02	3.6500E+02	2.5000E-01	4.5074E+00
8.7111E+02	3.6100E+02	2.5000E-01	4.5718E+00
1.0933E+03	3.5400E+02	2.5000E-01	4.5723E+00

Reference Temperature = 900.0

Material for Cell Number : 2

Bodner-Partom Theory with Directional Hardening for Timetal021S

Constitutive model: Bodner-Partom with Directional Hardening

----- MATERIAL PROPERTIES -----

T (C)	E (GPa)	NU	CTE (1E-6/C)
2.3000E+01	1.1200E+02	3.4000E-01	9.7787E+00
2.6000E+02	1.0800E+02	3.4000E-01	1.0713E+01
3.1500E+02	1.0610E+02	3.4000E-01	1.0915E+01
3.6500E+02	1.0410E+02	3.4000E-01	1.1093E+01
4.1500E+02	1.0170E+02	3.4000E-01	1.1267E+01
4.6500E+02	9.9090E+01	3.4000E-01	1.1436E+01
4.8200E+02	9.8110E+01	3.4000E-01	1.1492E+01
5.0000E+02	9.7050E+01	3.4000E-01	1.1550E+01
5.2500E+02	9.5500E+01	3.4000E-01	1.1631E+01
5.5000E+02	9.3870E+01	3.4000E-01	1.1710E+01
5.7500E+02	9.2170E+01	3.4000E-01	1.1788E+01
6.0000E+02	9.0400E+01	3.4000E-01	1.1865E+01
6.5000E+02	8.6610E+01	3.4000E-01	1.2014E+01
7.6000E+02	7.7220E+01	3.4000E-01	1.2323E+01
8.1500E+02	7.1960E+01	3.4000E-01	1.2467E+01
9.0000E+02	6.3120E+01	3.4000E-01	1.2689E+01

Reference Temperature = 900.0

T (C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
2.3000E+01	4.8000E+00	1.5500E+03	1.0000E+02	3.5000E-01
2.6000E+02	3.5000E+00	1.3000E+03	3.0000E+02	3.5000E-01
3.1500E+02	3.0540E+00	1.2504E+03	3.9000E+02	1.5020E+00
3.6500E+02	2.6490E+00	1.2054E+03	5.0000E+02	2.5490E+00
4.1500E+02	2.2430E+00	1.1604E+03	6.6000E+02	3.5970E+00
4.6500E+02	1.8380E+00	1.1153E+03	9.6000E+02	4.6440E+00
4.8200E+02	1.7000E+00	1.1000E+03	1.1000E+03	5.0000E+00
5.0000E+02	1.5000E+00	1.0893E+03	1.3000E+03	5.7630E+00
5.2500E+02	1.2800E+00	1.0744E+03	1.6700E+03	6.8220E+00
5.5000E+02	1.1000E+00	1.0595E+03	2.1000E+03	7.8810E+00
5.7500E+02	9.7000E-01	1.0446E+03	2.6000E+03	8.9410E+00
6.0000E+02	8.2000E-01	1.0298E+03	3.7000E+03	1.0000E+01
6.5000E+02	7.4000E-01	1.0000E+03	3.8000E+03	1.0000E+01
7.6000E+02	5.8000E-01	6.0000E+02	4.0000E+03	1.5000E+01
8.1500E+02	5.5000E-01	3.0000E+02	4.1000E+03	3.0000E+01
9.0000E+02	5.5000E-01	3.0000E+02	4.3000E+03	3.0000E+01

A1=A2 M1 Z1 R1=R2 DO
-9999.0 .0 1600.0 3.0 10000.0

----- OUTPUT -----

STEP	TIME	TEMPERATRE	Seff	Srad	Stan	Sz	Erad	Etan	Ez
1	-3.5964E+03	8.9913E+02	7.1692E-01	-2.4595E-01	5.1101E-01	4.2275E-01	-8.9135E-06	7.1332E-06	5.2622E-06
10	-3.5640E+03	8.9125E+02	7.2351E+00	-2.4833E+00	5.1594E+00	4.2599E+00	-8.8801E-05	7.1144E-05	5.2320E-05
20	-3.5280E+03	8.8250E+02	1.1759E+01	-4.5688E+00	7.7945E+00	6.4744E+00	-1.9987E-04	1.4231E-04	1.0536E-04
30	-3.4920E+03	8.7375E+02	1.4255E+01	-5.6047E+00	9.2258E+00	7.9933E+00	-3.2153E-04	2.1320E-04	1.6477E-04
40	-3.4560E+03	8.6500E+02	1.5162E+01	-6.2023E+00	9.4262E+00	8.4442E+00	-4.5489E-04	2.8380E-04	2.2702E-04
50	-3.4200E+03	8.5625E+02	1.5414E+01	-6.4495E+00	9.3042E+00	8.5988E+00	-5.9180E-04	3.5399E-04	2.9198E-04
60	-3.3840E+03	8.4750E+02	1.5524E+01	-6.5302E+00	9.2247E+00	8.7514E+00	-7.2896E-04	4.2363E-04	3.5874E-04
70	-3.3480E+03	8.3875E+02	1.5725E+01	-6.5691E+00	9.3114E+00	8.9948E+00	-8.6490E-04	4.9278E-04	4.2616E-04
80	-3.3120E+03	8.3000E+02	1.5937E+01	-6.6131E+00	9.4315E+00	9.2124E+00	-1.0005E-03	5.6153E-04	4.9364E-04
90	-3.2760E+03	8.2125E+02	1.6159E+01	-6.6689E+00	9.5694E+00	9.4080E+00	-1.1356E-03	6.2991E-04	5.6096E-04
100	-3.2400E+03	8.1250E+02	1.6631E+01	-6.7398E+00	9.8773E+00	9.7025E+00	-1.2687E-03	6.9798E-04	6.2716E-04
110	-3.2040E+03	8.0375E+02	1.8558E+01	-7.6243E+00	1.1134E+01	1.0726E+01	-1.3917E-03	7.6587E-04	6.8824E-04
120	-3.1680E+03	7.9500E+02	2.0887E+01	-8.5998E+00	1.2610E+01	1.1947E+01	-1.5118E-03	8.3354E-04	7.4737E-04
130	-3.1320E+03	7.8625E+02	2.3369E+01	-9.6604E+00	1.4152E+01	1.3238E+01	-1.6304E-03	9.0096E-04	8.0537E-04
140	-3.0960E+03	7.7750E+02	2.5948E+01	-1.0776E+01	1.5730E+01	1.4574E+01	-1.7479E-03	9.6811E-04	8.6252E-04
150	-3.0600E+03	7.6875E+02	2.8604E+01	-1.1933E+01	1.7343E+01	1.5946E+01	-1.8645E-03	1.0350E-03	9.1896E-04
160	-3.0240E+03	7.6000E+02	3.1324E+01	-1.3126E+01	1.8984E+01	1.7347E+01	-1.9802E-03	1.1016E-03	9.7477E-04
170	-2.9880E+03	7.5125E+02	3.4749E+01	-1.4585E+01	2.1123E+01	1.9116E+01	-2.0908E-03	1.1677E-03	1.0284E-03
180	-2.9520E+03	7.4250E+02	3.8661E+01	-1.6233E+01	2.3599E+01	2.1137E+01	-2.1980E-03	1.2335E-03	1.0803E-03
190	-2.9160E+03	7.3375E+02	4.2944E+01	-1.8032E+01	2.6324E+01	2.3344E+01	-2.3026E-03	1.2990E-03	1.1310E-03
200	-2.8800E+03	7.2500E+02	4.7547E+01	-1.9961E+01	2.9265E+01	2.5706E+01	-2.4049E-03	1.3642E-03	1.1804E-03
210	-2.8440E+03	7.1625E+02	5.2447E+01	-2.2009E+01	3.2407E+01	2.8214E+01	-2.5052E-03	1.4290E-03	1.2288E-03
220	-2.8080E+03	7.0750E+02	5.7632E+01	-2.4171E+01	3.5747E+01	3.0862E+01	-2.6035E-03	1.4935E-03	1.2762E-03
230	-2.7720E+03	6.9875E+02	6.3095E+01	-2.6441E+01	3.9281E+01	3.3647E+01	-2.6998E-03	1.5576E-03	1.3226E-03
240	-2.7360E+03	6.9000E+02	6.8831E+01	-2.8814E+01	4.3010E+01	3.6569E+01	-2.7943E-03	1.6214E-03	1.3681E-03
250	-2.7000E+03	6.8125E+02	7.4834E+01	-3.1285E+01	4.6933E+01	3.9626E+01	-2.8869E-03	1.6849E-03	1.4127E-03
260	-2.6640E+03	6.7250E+02	8.1098E+01	-3.3850E+01	5.1048E+01	4.2818E+01	-2.9778E-03	1.7480E-03	1.4566E-03
270	-2.6280E+03	6.6375E+02	8.7617E+01	-3.6504E+01	5.5354E+01	4.6142E+01	-3.0669E-03	1.8107E-03	1.4997E-03
280	-2.5920E+03	6.5500E+02	9.4385E+01	-3.9243E+01	5.9848E+01	4.9598E+01	-3.1544E-03	1.8731E-03	1.5420E-03
290	-2.5560E+03	6.4625E+02	1.0130E+02	-4.2029E+01	6.4453E+01	5.3128E+01	-3.2405E-03	1.9349E-03	1.5838E-03
300	-2.5200E+03	6.3750E+02	1.0810E+02	-4.4773E+01	6.8979E+01	5.6606E+01	-3.3263E-03	1.9964E-03	1.6253E-03
310	-2.4840E+03	6.2875E+02	1.1501E+02	-4.7539E+01	7.3601E+01	6.0158E+01	-3.4111E-03	2.0574E-03	1.6664E-03
320	-2.4480E+03	6.2000E+02	1.2205E+02	-5.0342E+01	7.8329E+01	6.3788E+01	-3.4947E-03	2.1181E-03	1.7070E-03
330	-2.4120E+03	6.1125E+02	1.2924E+02	-5.3187E+01	8.3173E+01	6.7499E+01	-3.5773E-03	2.1784E-03	1.7472E-03
340	-2.3760E+03	6.0250E+02	1.3657E+02	-5.6075E+01	8.8139E+01	7.1294E+01	-3.6586E-03	2.2384E-03	1.7869E-03
350	-2.3400E+03	5.9375E+02	1.4469E+02	-5.9138E+01	9.3789E+01	7.5597E+01	-3.7348E-03	2.2977E-03	1.8255E-03
360	-2.3040E+03	5.8500E+02	1.5359E+02	-6.2368E+01	1.0013E+02	8.0410E+01	-3.8060E-03	2.3564E-03	1.8630E-03
370	-2.2680E+03	5.7625E+02	1.6269E+02	-6.5635E+01	1.0666E+02	8.5365E+01	-3.8756E-03	2.4147E-03	1.9002E-03
380	-2.2320E+03	5.6750E+02	1.7185E+02	-6.8903E+01	1.1324E+02	9.0352E+01	-3.9444E-03	2.4725E-03	1.9370E-03
390	-2.1960E+03	5.5875E+02	1.8104E+02	-7.2185E+01	1.1986E+02	9.5363E+01	-4.0126E-03	2.5300E-03	1.9734E-03
400	-2.1600E+03	5.5000E+02	1.9029E+02	-7.5483E+01	1.2652E+02	1.0039E+02	-4.0802E-03	2.5870E-03	2.0094E-03
410	-2.1240E+03	5.4125E+02	1.9951E+02	-7.8771E+01	1.3316E+02	1.0540E+02	-4.1472E-03	2.6436E-03	2.0450E-03
420	-2.0880E+03	5.3250E+02	2.0877E+02	-8.2075E+01	1.3984E+02	1.1043E+02	-4.2137E-03	2.6998E-03	2.0804E-03
430	-2.0520E+03	5.2375E+02	2.1807E+02	-8.5389E+01	1.4655E+02	1.1457E+02	-4.2797E-03	2.7557E-03	2.1154E-03
440	-2.0160E+03	5.1500E+02	2.2731E+02	-8.8684E+01	1.5322E+02	1.2048E+02	-4.3450E-03	2.8110E-03	2.1499E-03
450	-1.9800E+03	5.0625E+02	2.3658E+02	-9.1989E+01	1.5991E+02	1.2550E+02	-4.4097E-03	2.8659E-03	2.1842E-03
460	-1.9440E+03	4.9750E+02	2.4585E+02	-9.5297E+01	1.6661E+02	1.3051E+02	-4.4740E-03	2.9204E-03	2.2181E-03
470	-1.9080E+03	4.8875E+02	2.5512E+02	-9.8599E+01	1.7330E+02	1.3552E+02	-4.5379E-03	2.9746E-03	2.2518E-03
480	-1.8720E+03	4.8000E+02	2.6439E+02	-1.0190E+02	1.8000E+02	1.4053E+02	-4.6011E-03	3.0283E-03	2.2851E-03
490	-1.8360E+03	4.7125E+02	2.7362E+02	-1.0520E+02	1.8668E+02	1.4551E+02	-4.6637E-03	3.0814E-03	2.3180E-03
500	-1.8000E+03	4.6250E+02	2.8282E+02	-1.0848E+02	1.9333E+02	1.5047E+02	-4.7256E-03	3.1341E-03	2.3505E-03
510	-1.7640E+03	4.5375E+02	2.9192E+02	-1.1171E+02	1.9991E+02	1.5538E+02	-4.7868E-03	3.1861E-03	2.3827E-03

520	-1.7280E+03	4.4500E+02	3.0101E+02	-1.1495E+02	2.0649E+02	1.6028E+02	-4.8475E-03	3.2377E-03	2.4146E-03
530	-1.6920E+03	4.3625E+02	3.1011E+02	-1.1819E+02	2.1308E+02	1.6518E+02	-4.9077E-03	3.2889E-03	2.4461E-03
540	-1.6560E+03	4.2750E+02	3.1921E+02	-1.2143E+02	2.1967E+02	1.7007E+02	-4.9673E-03	3.3397E-03	2.4773E-03
550	-1.6200E+03	4.1875E+02	3.2831E+02	-1.2468E+02	2.2626E+02	1.7496E+02	-5.0264E-03	3.3901E-03	2.5081E-03
560	-1.5840E+03	4.1000E+02	3.3731E+02	-1.2788E+02	2.3278E+02	1.7979E+02	-5.0848E-03	3.4398E-03	2.5386E-03
570	-1.5480E+03	4.0125E+02	3.4623E+02	-1.3106E+02	2.3925E+02	1.8459E+02	-5.1424E-03	3.4890E-03	2.5687E-03
580	-1.5120E+03	3.9250E+02	3.5515E+02	-1.3424E+02	2.4571E+02	1.8937E+02	-5.1995E-03	3.5377E-03	2.5985E-03
590	-1.4760E+03	3.8375E+02	3.6405E+02	-1.3741E+02	2.5217E+02	1.9414E+02	-5.2561E-03	3.5860E-03	2.6279E-03
600	-1.4400E+03	3.7500E+02	3.7294E+02	-1.4058E+02	2.5862E+02	1.9890E+02	-5.3121E-03	3.6339E-03	2.6570E-03
610	-1.4040E+03	3.6625E+02	3.8183E+02	-1.4375E+02	2.6506E+02	2.0365E+02	-5.3676E-03	3.6814E-03	2.6858E-03
620	-1.3680E+03	3.5750E+02	3.9045E+02	-1.4682E+02	2.7132E+02	2.0829E+02	-5.4224E-03	3.7281E-03	2.7144E-03
630	-1.3320E+03	3.4875E+02	3.9902E+02	-1.4986E+02	2.7753E+02	2.1289E+02	-5.4767E-03	3.7744E-03	2.7427E-03
640	-1.2960E+03	3.4000E+02	4.0756E+02	-1.5290E+02	2.8373E+02	2.1747E+02	-5.5304E-03	3.8202E-03	2.7707E-03
650	-1.2600E+03	3.3125E+02	4.1607E+02	-1.5593E+02	2.8991E+02	2.2203E+02	-5.5835E-03	3.8656E-03	2.7983E-03
660	-1.2240E+03	3.2250E+02	4.2456E+02	-1.5895E+02	2.9607E+02	2.2658E+02	-5.6361E-03	3.9105E-03	2.8257E-03
670	-1.1880E+03	3.1375E+02	4.3298E+02	-1.6194E+02	3.0219E+02	2.3109E+02	-5.6881E-03	3.9549E-03	2.8526E-03
680	-1.1520E+03	3.0500E+02	4.4112E+02	-1.6484E+02	3.0810E+02	2.3546E+02	-5.7389E-03	3.9983E-03	2.8792E-03
690	-1.1160E+03	2.9625E+02	4.4923E+02	-1.6771E+02	3.1398E+02	2.3981E+02	-5.7892E-03	4.0412E-03	2.9054E-03
700	-1.0800E+03	2.8750E+02	4.5729E+02	-1.7058E+02	3.1984E+02	2.4413E+02	-5.8389E-03	4.0836E-03	2.9312E-03
710	-1.0440E+03	2.7875E+02	4.6532E+02	-1.7343E+02	3.2567E+02	2.4843E+02	-5.8880E-03	4.1256E-03	2.9568E-03
720	-1.0080E+03	2.7000E+02	4.7331E+02	-1.7628E+02	3.3148E+02	2.5271E+02	-5.9366E-03	4.1671E-03	2.9820E-03
730	-9.7200E+02	2.6125E+02	4.8126E+02	-1.7910E+02	3.3725E+02	2.5696E+02	-5.9846E-03	4.2082E-03	3.0069E-03
740	-9.3600E+02	2.5250E+02	4.8844E+02	-1.8164E+02	3.4247E+02	2.6086E+02	-6.0312E-03	4.2476E-03	3.0316E-03
750	-9.0000E+02	2.4375E+02	4.9544E+02	-1.8411E+02	3.4755E+02	2.6467E+02	-6.0770E-03	4.2863E-03	3.0560E-03
760	-8.6400E+02	2.3500E+02	5.0238E+02	-1.8655E+02	3.5258E+02	2.6845E+02	-6.1223E-03	4.3245E-03	3.0801E-03
770	-8.2800E+02	2.2625E+02	5.0925E+02	-1.8897E+02	3.5757E+02	2.7219E+02	-6.1670E-03	4.3623E-03	3.1039E-03
780	-7.9200E+02	2.1750E+02	5.1606E+02	-1.9138E+02	3.6251E+02	2.7589E+02	-6.2110E-03	4.3995E-03	3.1273E-03
790	-7.5600E+02	2.0875E+02	5.2280E+02	-1.9375E+02	3.6740E+02	2.7956E+02	-6.2545E-03	4.4363E-03	3.1504E-03
800	-7.2000E+02	2.0000E+02	5.2942E+02	-1.9609E+02	3.7221E+02	2.8316E+02	-6.2970E-03	4.4722E-03	3.1730E-03
810	-6.8400E+02	1.9125E+02	5.3593E+02	-1.9839E+02	3.7693E+02	2.8670E+02	-6.3386E-03	4.5073E-03	3.1951E-03
820	-6.4800E+02	1.8250E+02	5.4236E+02	-2.0066E+02	3.8160E+02	2.9020E+02	-6.3795E-03	4.5420E-03	3.2168E-03
830	-6.1200E+02	1.7375E+02	5.4873E+02	-2.0290E+02	3.8622E+02	2.9366E+02	-6.4198E-03	4.5761E-03	3.2382E-03
840	-5.7600E+02	1.6500E+02	5.5503E+02	-2.0513E+02	3.9079E+02	2.9708E+02	-6.4596E-03	4.6097E-03	3.2593E-03
850	-5.4000E+02	1.5625E+02	5.6126E+02	-2.0733E+02	3.9531E+02	3.0046E+02	-6.4987E-03	4.6428E-03	3.2800E-03
860	-5.0400E+02	1.4750E+02	5.6741E+02	-2.0950E+02	3.9978E+02	3.0380E+02	-6.5372E-03	4.6754E-03	3.3004E-03
870	-4.6800E+02	1.3875E+02	5.7350E+02	-2.1165E+02	4.0420E+02	3.0710E+02	-6.5751E-03	4.7075E-03	3.3205E-03
880	-4.3200E+02	1.3000E+02	5.7952E+02	-2.1378E+02	4.0857E+02	3.1037E+02	-6.6124E-03	4.7391E-03	3.3403E-03
890	-3.9600E+02	1.2125E+02	5.8546E+02	-2.1588E+02	4.1288E+02	3.1359E+02	-6.6491E-03	4.7702E-03	3.3597E-03
900	-3.6000E+02	1.1250E+02	5.9133E+02	-2.1795E+02	4.1715E+02	3.1677E+02	-6.6852E-03	4.8008E-03	3.3788E-03
910	-3.2400E+02	1.0375E+02	5.9714E+02	-2.2000E+02	4.2136E+02	3.1992E+02	-6.7207E-03	4.8309E-03	3.3976E-03
920	-2.8800E+02	9.5000E+01	6.0287E+02	-2.2203E+02	4.2552E+02	3.2302E+02	-6.7556E-03	4.8604E-03	3.4160E-03
930	-2.5200E+02	8.6250E+01	6.0843E+02	-2.2399E+02	4.2956E+02	3.2604E+02	-6.7892E-03	4.8889E-03	3.4338E-03
940	-2.1600E+02	7.7500E+01	6.1390E+02	-2.2593E+02	4.3353E+02	3.2901E+02	-6.8221E-03	4.9168E-03	3.4512E-03
950	-1.8000E+02	6.8750E+01	6.1930E+02	-2.2783E+02	4.3744E+02	3.3194E+02	-6.8544E-03	4.9441E-03	3.4683E-03
960	-1.4400E+02	6.0000E+01	6.2462E+02	-2.2971E+02	4.4130E+02	3.3482E+02	-6.8860E-03	4.9709E-03	3.4851E-03
970	-1.0800E+02	5.1250E+01	6.2986E+02	-2.3157E+02	4.4510E+02	3.3766E+02	-6.9170E-03	4.9971E-03	3.5015E-03
980	-7.2000E+01	4.2500E+01	6.3503E+02	-2.3339E+02	4.4885E+02	3.4046E+02	-6.9474E-03	5.0229E-03	3.5176E-03
990	-3.6000E+01	3.3750E+01	6.4012E+02	-2.3519E+02	4.5254E+02	3.4322E+02	-6.9772E-03	5.0481E-03	3.5333E-03
1000	.0000E+00	2.5000E+01	6.4513E+02	-2.3697E+02	4.5618E+02	3.4593E+02	-7.0063E-03	5.0728E-03	3.5487E-03

Cross-Sectional Results at Step 1000
time = .0000

Radius	Seff	Srad	Stan	Sz	Er	Etan	Ez
.000	4.7896E+02	-2.3697E+02	-2.3697E+02	-7.1595E+02	3.2106E-06	3.2106E-06	-1.5209E-03
.148	4.7896E+02	-2.3697E+02	-2.3697E+02	-7.1595E+02	3.2106E-06	3.2106E-06	-1.5209E-03
.296	4.7896E+02	-2.3697E+02	-2.3697E+02	-7.1595E+02	3.2106E-06	3.2106E-06	-1.5209E-03
.444	4.7896E+02	-2.3697E+02	-2.3697E+02	-7.1595E+02	3.2106E-06	3.2106E-06	-1.5209E-03
.592	4.7896E+02	-2.3697E+02	-2.3697E+02	-7.1595E+02	3.2106E-06	3.2106E-06	-1.5209E-03
.592	6.4513E+02	-2.3697E+02	4.5618E+02	3.4593E+02	-7.0063E-03	5.0728E-03	3.5487E-03
.621	6.0232E+02	-2.0494E+02	4.3296E+02	3.5403E+02	-6.4036E-03	4.5184E-03	3.5487E-03

	.650	5.6523E+02	-1.7678E+02	4.1220E+02	3.6126E+02	-5.8825E-03	4.0391E-03	3.5487E-03	
	.679	5.3296E+02	-1.5188E+02	3.9351E+02	3.6772E+02	-5.4293E-03	3.6221E-03	3.5487E-03	
	.708	5.0481E+02	-1.2977E+02	3.7660E+02	3.7347E+02	-5.0329E-03	3.2570E-03	3.5487E-03	
	.737	4.8017E+02	-1.1004E+02	3.6121E+02	3.7858E+02	-4.6845E-03	2.9356E-03	3.5487E-03	
	.767	4.5855E+02	-9.2377E+01	3.4714E+02	3.8309E+02	-4.3769E-03	2.6511E-03	3.5487E-03	
	.796	4.3955E+02	-7.6503E+01	3.3424E+02	3.8708E+02	-4.1041E-03	2.3983E-03	3.5487E-03	
	.825	4.2281E+02	-6.2189E+01	3.2237E+02	3.9058E+02	-3.8612E-03	2.1724E-03	3.5487E-03	
	.854	4.0805E+02	-4.9242E+01	3.1144E+02	3.9365E+02	-3.6442E-03	1.9699E-03	3.5487E-03	
	.883	3.9501E+02	-3.7497E+01	3.0135E+02	3.9634E+02	-3.4494E-03	1.7875E-03	3.5487E-03	
	.912	3.8346E+02	-2.6814E+01	2.9202E+02	3.9869E+02	-3.2741E-03	1.6228E-03	3.5487E-03	
	.942	3.7324E+02	-1.7071E+01	2.8339E+02	4.0074E+02	-3.1157E-03	1.4734E-03	3.5487E-03	
	.971	3.6416E+02	-8.1631E+00	2.7539E+02	4.0252E+02	-2.9722E-03	1.3376E-03	3.5487E-03	
	1.000	3.5609E+02	.0000E+00	2.6796E+02	4.0406E+02	-2.8418E-03	1.2137E-03	3.5487E-03	
1010	1.8000E+01	3.7500E+01	6.1213E+02	-2.3216E+02	4.4625E+02	2.7888E+02	-6.7377E-03	5.1804E-03	2.9689E-03
1020	3.6000E+01	5.0000E+01	5.8459E+02	-2.2730E+02	4.3622E+02	2.1192E+02	-6.4675E-03	5.2871E-03	2.3878E-03
1030	5.4000E+01	6.2500E+01	5.6326E+02	-2.2239E+02	4.2609E+02	1.4505E+02	-6.1959E-03	5.3928E-03	1.8055E-03
1040	7.2000E+01	7.5000E+01	5.4885E+02	-2.1743E+02	4.1586E+02	7.8273E+01	-5.9228E-03	5.4976E-03	1.2220E-03
1050	9.0000E+01	8.7500E+01	5.4187E+02	-2.1243E+02	4.0553E+02	1.1586E+01	-5.6482E-03	5.6015E-03	6.3724E-04
1060	1.0800E+02	1.0000E+02	5.4251E+02	-2.0734E+02	3.9504E+02	-5.5019E+01	-5.3716E-03	5.7038E-03	5.1252E-05
1070	1.2600E+02	1.1250E+02	5.5072E+02	-2.0219E+02	3.8441E+02	-1.2154E+02	-5.0931E-03	5.8048E-03	-5.3597E-04
1080	1.4400E+02	1.2500E+02	5.6621E+02	-1.9700E+02	3.7368E+02	-1.8796E+02	-4.8131E-03	5.9048E-03	-1.1244E-03
1090	1.6200E+02	1.3750E+02	5.8838E+02	-1.9175E+02	3.6286E+02	-2.5429E+02	-4.5317E-03	6.0039E-03	-1.7141E-03
1100	1.8000E+02	1.5000E+02	6.1647E+02	-1.8647E+02	3.5194E+02	-3.2052E+02	-4.2488E-03	6.1022E-03	-2.3050E-03
1110	1.9800E+02	2.0000E+02	5.5104E+02	-1.7681E+02	3.3214E+02	-2.5305E+02	-4.3227E-03	5.7169E-03	-1.6810E-03
1120	2.1600E+02	2.5000E+02	4.8825E+02	-1.6612E+02	3.1021E+02	-1.8914E+02	-4.3705E-03	5.3139E-03	-1.0767E-03
1130	2.3400E+02	3.0000E+02	4.2554E+02	-1.5329E+02	2.8405E+02	-1.2862E+02	-4.3876E-03	4.8926E-03	-4.9860E-04
1140	2.5200E+02	3.5000E+02	3.6569E+02	-1.3918E+02	2.5535E+02	-7.2270E+01	-4.3780E-03	4.4550E-03	5.7233E-05
1150	2.7000E+02	4.0000E+02	3.1027E+02	-1.2410E+02	2.2477E+02	-2.0250E+01	-4.3448E-03	4.0032E-03	5.9285E-04
1160	2.8800E+02	4.5000E+02	2.6141E+02	-1.0839E+02	1.9295E+02	2.7161E+01	-4.2888E-03	3.5380E-03	1.1088E-03
1170	3.0600E+02	5.0000E+02	2.2154E+02	-9.2210E+01	1.6024E+02	6.9783E+01	-4.2102E-03	3.0591E-03	1.6055E-03
1180	3.2400E+02	5.5000E+02	1.9375E+02	-7.5740E+01	1.2705E+02	1.0749E+02	-4.1106E-03	2.5679E-03	2.0840E-03
1190	3.4200E+02	6.0000E+02	1.7286E+02	-5.6761E+01	8.9685E+01	1.3392E+02	-4.0234E-03	2.0690E-03	2.5450E-03
1200	3.6000E+02	6.5000E+02	1.6096E+02	-5.3170E+01	5.3165E+01	1.4852E+02	-3.9404E-03	1.5587E-03	2.9890E-03
1210	3.7800E+02	6.0000E+02	1.5639E+02	-5.2839E+01	8.4425E+01	1.1742E+02	-4.0931E-03	2.0756E-03	2.5450E-03
1220	3.9600E+02	5.5000E+02	1.7200E+02	-6.9063E+01	1.1716E+02	8.3849E+01	-4.2133E-03	2.5791E-03	2.0840E-03
1230	4.1400E+02	5.0000E+02	2.0424E+02	-8.5319E+01	1.5004E+02	4.5350E+01	-4.3131E-03	3.0706E-03	1.6055E-03
1240	4.3200E+02	4.5000E+02	2.4878E+02	-1.0131E+02	1.8248E+02	2.0216E+00	-4.3920E-03	3.5497E-03	1.1088E-03
1250	4.5000E+02	4.0000E+02	3.0179E+02	-1.1685E+02	2.1405E+02	-4.6027E+01	-4.4482E-03	4.0152E-03	5.9285E-04
1260	4.6800E+02	3.5000E+02	3.6075E+02	-1.3177E+02	2.4441E+02	-9.8618E+01	-4.4815E-03	4.4671E-03	5.7233E-05
1270	4.8600E+02	3.0000E+02	4.2361E+02	-1.4576E+02	2.7292E+02	-1.5545E+02	-4.4912E-03	4.9049E-03	-4.9860E-04
1280	5.0400E+02	2.5000E+02	4.8893E+02	-1.5848E+02	2.9893E+02	-2.1636E+02	-4.4742E-03	5.3263E-03	-1.0767E-03
1290	5.2200E+02	2.0000E+02	5.5403E+02	-1.6911E+02	3.2078E+02	-2.8048E+02	-4.4265E-03	5.7294E-03	-1.6810E-03
1300	5.4000E+02	1.5000E+02	6.2151E+02	-1.7872E+02	3.4050E+02	-3.4816E+02	-4.3526E-03	6.1147E-03	-2.3050E-03
1310	5.5800E+02	2.0000E+02	5.5403E+02	-1.6911E+02	3.2078E+02	-2.8048E+02	-4.4265E-03	5.7294E-03	-1.6810E-03
1320	5.7600E+02	2.5000E+02	4.8893E+02	-1.5848E+02	2.9893E+02	-2.1636E+02	-4.4742E-03	5.3263E-03	-1.0767E-03
1330	5.9400E+02	3.0000E+02	4.2361E+02	-1.4576E+02	2.7292E+02	-1.5545E+02	-4.4912E-03	4.9049E-03	-4.9860E-04
1340	6.1200E+02	3.5000E+02	3.6075E+02	-1.3177E+02	2.4441E+02	-9.8618E+01	-4.4815E-03	4.4671E-03	5.7233E-05
1350	6.3000E+02	4.0000E+02	3.0179E+02	-1.1685E+02	2.1405E+02	-4.6027E+01	-4.4482E-03	4.0152E-03	5.9285E-04
1360	6.4800E+02	4.5000E+02	2.4878E+02	-1.0131E+02	1.8248E+02	2.0216E+00	-4.3920E-03	3.5497E-03	1.1088E-03
1370	6.6600E+02	5.0000E+02	2.0424E+02	-8.5319E+01	1.5004E+02	4.5350E+01	-4.3131E-03	3.0706E-03	1.6055E-03
1380	6.8400E+02	5.5000E+02	1.7200E+02	-6.9063E+01	1.1716E+02	8.3849E+01	-4.2133E-03	2.5791E-03	2.0840E-03
1390	7.0200E+02	6.0000E+02	1.5413E+02	-5.2617E+01	8.2782E+01	1.1512E+02	-4.1066E-03	2.0760E-03	2.5450E-03
1400	7.2000E+02	6.5000E+02	1.4703E+02	-3.4268E+01	4.8200E+01	1.3548E+02	-4.0008E-03	1.5639E-03	2.9890E-03
1410	7.3800E+02	6.0000E+02	1.4438E+02	-4.9964E+01	7.9880E+01	1.0551E+02	-4.1460E-03	2.0804E-03	2.5450E-03
1420	7.5600E+02	5.5000E+02	1.6199E+02	-6.6084E+01	1.1245E+02	7.1494E+01	-4.2663E-03	2.5841E-03	2.0840E-03
1430	7.7400E+02	5.0000E+02	1.9696E+02	-8.2244E+01	1.4519E+02	3.2578E+01	-4.3662E-03	3.0757E-03	1.6055E-03
1440	7.9200E+02	4.5000E+02	2.4406E+02	-9.8154E+01	1.7749E+02	-1.1120E+02	-4.4452E-03	3.5549E-03	1.1088E-03
1450	8.1000E+02	4.0000E+02	2.9920E+02	-1.1362E+02	2.0895E+02	-5.9502E+01	-4.5014E-03	4.0205E-03	5.9285E-04
1460	8.2800E+02	3.5000E+02	3.5990E+02	-1.2847E+02	2.3920E+02	-1.1239E+02	-4.5348E-03	4.4725E-03	5.7233E-05
1470	8.4600E+02	3.0000E+02	4.2421E+02	-1.4240E+02	2.6763E+02	-1.6947E+02	-4.5446E-03	4.9104E-03	-4.9860E-04
1480	8.6400E+02	2.5000E+02	4.9077E+02	-1.5508E+02	2.9356E+02	-2.3058E+02	-4.5276E-03	5.3319E-03	-1.0767E-03

1490	8.8200E+02	2.0000E+02	5.5696E+02	-1.6568E+02	3.1537E+02	-2.9482E+02	-4.4799E-03	5.7349E-03	-1.6810E-03
1500	9.0000E+02	1.5000E+02	6.2539E+02	-1.7526E+02	3.3505E+02	-3.6261E+02	-4.4060E-03	6.1203E-03	-2.3050E-03
1510	9.1800E+02	2.0000E+02	5.5696E+02	-1.6568E+02	3.1537E+02	-2.9482E+02	-4.4799E-03	5.7349E-03	-1.6810E-03
1520	9.3600E+02	2.5000E+02	4.9077E+02	-1.5508E+02	2.9356E+02	-2.3058E+02	-4.5276E-03	5.3319E-03	-1.0767E-03
1530	9.5400E+02	3.0000E+02	4.2421E+02	-1.4240E+02	2.6763E+02	-1.6947E+02	-4.5446E-03	4.9104E-03	-4.9860E-04
1540	9.7200E+02	3.5000E+02	3.5990E+02	-1.2847E+02	2.3920E+02	-1.1239E+02	-4.5348E-03	4.4725E-03	5.7233E-05
1550	9.9000E+02	4.0000E+02	2.9920E+02	-1.1362E+02	2.0895E+02	-5.9502E+01	-4.5014E-03	4.0205E-03	5.9285E-04
1560	1.0080E+03	4.5000E+02	2.4406E+02	-9.8154E+01	1.7749E+02	-1.1120E+01	-4.4452E-03	3.5549E-03	1.1088E-03
1570	1.0260E+03	5.0000E+02	1.9696E+02	-8.2244E+01	1.4519E+02	3.2578E+01	-4.3662E-03	3.0757E-03	1.6055E-03
1580	1.0440E+03	5.5000E+02	1.6199E+02	-6.6084E+01	1.1245E+02	7.1494E+01	-4.2663E-03	2.5841E-03	2.0840E-03
1590	1.0620E+03	6.0000E+02	1.4390E+02	-4.9935E+01	7.9500E+01	1.0501E+02	-4.1490E-03	2.0805E-03	2.5450E-03
1600	1.0800E+03	6.5000E+02	1.3806E+02	-3.2301E+01	4.5155E+01	1.2710E+02	-4.0391E-03	1.5672E-03	2.9890E-03
1610	1.0980E+03	6.0000E+02	1.3621E+02	-4.8004E+01	7.6882E+01	9.7243E+01	-4.1822E-03	2.0837E-03	2.5450E-03
1620	1.1160E+03	5.5000E+02	1.5547E+02	-6.4053E+01	1.0935E+02	6.2906E+01	-4.3026E-03	2.5875E-03	2.0840E-03
1630	1.1340E+03	5.0000E+02	1.9251E+02	-8.0149E+01	1.4199E+02	2.3701E+01	-4.4026E-03	3.0792E-03	1.6055E-03
1640	1.1520E+03	4.5000E+02	2.4142E+02	-9.6001E+01	1.7421E+02	-2.0254E+01	-4.4816E-03	3.5585E-03	1.1088E-03
1650	1.1700E+03	4.0000E+02	2.9801E+02	-1.1141E+02	2.0558E+02	-6.8868E+01	-4.5380E-03	4.0242E-03	5.9285E-04
1660	1.1880E+03	3.5000E+02	3.5988E+02	-1.2622E+02	2.3577E+02	-1.2196E+02	-4.5714E-03	4.4762E-03	5.7233E-05
1670	1.2060E+03	3.0000E+02	4.2515E+02	-1.4010E+02	2.6414E+02	-1.7922E+02	-4.5812E-03	4.9141E-03	-4.9860E-04
1680	1.2240E+03	2.5000E+02	4.9253E+02	-1.5275E+02	2.9002E+02	-2.4047E+02	-4.5643E-03	5.3357E-03	-1.0767E-03
1690	1.2420E+03	2.0000E+02	5.5944E+02	-1.6334E+02	3.1180E+02	-3.0478E+02	-4.5166E-03	5.7387E-03	-1.6810E-03
1700	1.2600E+03	1.5000E+02	6.2851E+02	-1.7290E+02	3.3145E+02	-3.7265E+02	-4.4427E-03	6.1241E-03	-2.3050E-03
1710	1.2780E+03	2.0000E+02	5.5944E+02	-1.6334E+02	3.1180E+02	-3.0478E+02	-4.5166E-03	5.7387E-03	-1.6810E-03
1720	1.2960E+03	2.5000E+02	4.9253E+02	-1.5275E+02	2.9002E+02	-2.4047E+02	-4.5643E-03	5.3357E-03	-1.0767E-03
1730	1.3140E+03	3.0000E+02	4.2515E+02	-1.4010E+02	2.6414E+02	-1.7922E+02	-4.5812E-03	4.9141E-03	-4.9860E-04
1740	1.3320E+03	3.5000E+02	3.5988E+02	-1.2622E+02	2.3577E+02	-1.2196E+02	-4.5714E-03	4.4762E-03	5.7233E-05
1750	1.3500E+03	4.0000E+02	2.9801E+02	-1.1141E+02	2.0558E+02	-6.8868E+01	-4.5380E-03	4.0242E-03	5.9285E-04
1760	1.3680E+03	4.5000E+02	2.4142E+02	-9.6001E+01	1.7421E+02	-2.0254E+01	-4.4816E-03	3.5585E-03	1.1088E-03
1770	1.3860E+03	5.0000E+02	1.9251E+02	-8.0149E+01	1.4199E+02	2.3701E+01	-4.4026E-03	3.0792E-03	1.6055E-03
1780	1.4040E+03	5.5000E+02	1.5547E+02	-6.4053E+01	1.0935E+02	6.2906E+01	-4.3026E-03	2.5875E-03	2.0840E-03
1790	1.4220E+03	6.0000E+02	1.3613E+02	-4.8000E+01	7.6817E+01	9.7161E+01	-4.1827E-03	2.0837E-03	2.5450E-03
1800	1.4400E+03	6.5000E+02	1.3160E+02	-3.0911E+01	4.3077E+01	1.2103E+02	-4.0664E-03	1.5696E-03	2.9890E-03
1810	1.4580E+03	6.0000E+02	1.3029E+02	-4.6588E+01	7.4078E+01	9.1081E+01	-4.2088E-03	2.0861E-03	2.5450E-03
1820	1.4760E+03	5.5000E+02	1.5094E+02	-6.2586E+01	1.0717E+02	5.6510E+01	-4.3293E-03	2.5899E-03	2.0840E-03
1830	1.4940E+03	5.0000E+02	1.8960E+02	-7.8635E+01	1.3974E+02	1.7089E+01	-4.4294E-03	3.0817E-03	1.6055E-03
1840	1.5120E+03	4.5000E+02	2.3986E+02	-9.4445E+01	1.7190E+02	-2.7057E+01	-4.5084E-03	3.5611E-03	1.1088E-03
1850	1.5300E+03	4.0000E+02	2.9751E+02	-1.0982E+02	2.0322E+02	-7.5844E+01	-4.5648E-03	4.0268E-03	5.9285E-04
1860	1.5480E+03	3.5000E+02	3.6022E+02	-1.2459E+02	2.3336E+02	-1.2910E+02	-4.5982E-03	4.4789E-03	5.7233E-05
1870	1.5660E+03	3.0000E+02	4.2619E+02	-1.3845E+02	2.6169E+02	-1.8648E+02	-4.6081E-03	4.9168E-03	-4.9860E-04
1880	1.5840E+03	2.5000E+02	4.9416E+02	-1.5108E+02	2.8754E+02	-2.4784E+02	-4.5912E-03	5.3384E-03	-1.0767E-03
1890	1.6020E+03	2.0000E+02	5.6158E+02	-1.6165E+02	3.0930E+02	-3.1221E+02	-4.5435E-03	5.7414E-03	-1.6810E-03
1900	1.6200E+03	1.5000E+02	6.3110E+02	-1.7120E+02	3.2893E+02	-3.8013E+02	-4.4696E-03	6.1268E-03	-2.3050E-03
1910	1.6380E+03	2.0000E+02	5.6158E+02	-1.6165E+02	3.0930E+02	-3.1221E+02	-4.5435E-03	5.7414E-03	-1.6810E-03
1920	1.6560E+03	2.5000E+02	4.9416E+02	-1.5108E+02	2.8754E+02	-2.4784E+02	-4.5912E-03	5.3384E-03	-1.0767E-03
1930	1.6740E+03	3.0000E+02	4.2619E+02	-1.3845E+02	2.6169E+02	-1.8648E+02	-4.6081E-03	4.9168E-03	-4.9860E-04
1940	1.6920E+03	3.5000E+02	3.6022E+02	-1.2459E+02	2.3336E+02	-1.2910E+02	-4.5982E-03	4.4789E-03	5.7233E-05
1950	1.7100E+03	4.0000E+02	2.9751E+02	-1.0982E+02	2.0322E+02	-7.5844E+01	-4.5648E-03	4.0268E-03	5.9285E-04
1960	1.7280E+03	4.5000E+02	2.3986E+02	-9.4445E+01	1.7190E+02	-2.7057E+01	-4.5084E-03	3.5611E-03	1.1088E-03
1970	1.7460E+03	5.0000E+02	1.8960E+02	-7.8635E+01	1.3974E+02	1.7089E+01	-4.4294E-03	3.0817E-03	1.6055E-03
1980	1.7640E+03	5.5000E+02	1.5094E+02	-6.2586E+01	1.0717E+02	5.6510E+01	-4.3293E-03	2.5899E-03	2.0840E-03
1990	1.7820E+03	6.0000E+02	1.3027E+02	-4.6588E+01	7.4765E+01	9.1063E+01	-4.2090E-03	2.0861E-03	2.5450E-03
2000	1.8000E+03	6.5000E+02	1.2667E+02	-2.9871E+01	4.1575E+01	1.1638E+02	-4.0870E-03	1.5713E-03	2.9890E-03
2010	1.8180E+03	6.0000E+02	1.2581E+02	-4.5523E+01	7.3243E+01	8.6315E+01	-4.2292E-03	2.0879E-03	2.5450E-03
2020	1.8360E+03	5.5000E+02	1.4766E+02	-6.1482E+01	1.0558E+02	5.1562E+01	-4.3496E-03	2.5918E-03	2.0840E-03
2030	1.8540E+03	5.0000E+02	1.8761E+02	-7.7495E+01	1.3810E+02	1.1974E+01	-4.4498E-03	3.0836E-03	1.6055E-03
2040	1.8720E+03	4.5000E+02	2.3892E+02	-9.3274E+01	1.7022E+02	-3.2321E+01	-4.5289E-03	3.5630E-03	1.1088E-03
2050	1.8900E+03	4.0000E+02	2.9738E+02	-1.0862E+02	2.0150E+02	-8.1241E+01	-4.5853E-03	4.0288E-03	5.9285E-04
2060	1.9080E+03	3.5000E+02	3.6072E+02	-1.2337E+02	2.3160E+02	-1.3461E+02	-4.6188E-03	4.4809E-03	5.7233E-05
2070	1.9260E+03	3.0000E+02	4.2720E+02	-1.3720E+02	2.5990E+02	-1.9210E+02	-4.6286E-03	4.9189E-03	-4.9860E-04
2080	1.9440E+03	2.5000E+02	4.9561E+02	-1.4981E+02	2.8573E+02	-2.5354E+02	-4.6117E-03	5.3404E-03	-1.0767E-03
2090	1.9620E+03	2.0000E+02	5.6341E+02	-1.6038E+02	3.0748E+02	-3.1795E+02	-4.5640E-03	5.7435E-03	-1.6810E-03

2100 1.9800E+03 1.5000E+02 6.3327E+02 -1.6992E+02 3.2709E+02 -3.8592E+02 -4.4901E-03 6.1289E-03 -2.3050E-03

Cross-Sectional Results at Step 2100
time = 1980.0000

Radius	Seff	Srad	Stan	Sz	Er	Etan	Ez
.000	2.6175E+03	-1.6992E+02	-1.6992E+02	-2.7875E+03	1.4678E-03	1.4678E-03	-6.9661E-03
.148	2.6175E+03	-1.6992E+02	-1.6992E+02	-2.7875E+03	1.4678E-03	1.4678E-03	-6.9661E-03
.296	2.6175E+03	-1.6992E+02	-1.6992E+02	-2.7875E+03	1.4678E-03	1.4678E-03	-6.9661E-03
.444	2.6175E+03	-1.6992E+02	-1.6992E+02	-2.7875E+03	1.4678E-03	1.4678E-03	-6.9661E-03
.592	2.6175E+03	-1.6992E+02	-1.6992E+02	-2.7875E+03	1.4678E-03	1.4678E-03	-6.9661E-03
.592	6.3327E+02	-1.6992E+02	3.2709E+02	-3.8592E+02	-4.4901E-03	6.1289E-03	-2.3050E-03
.621	6.0895E+02	-1.4695E+02	3.1048E+02	-3.8073E+02	-3.9689E-03	5.6413E-03	-2.3050E-03
.650	5.8810E+02	-1.2675E+02	2.9560E+02	-3.7609E+02	-3.5180E-03	5.2194E-03	-2.3050E-03
.679	5.7014E+02	-1.0890E+02	2.8219E+02	-3.7199E+02	-3.1258E-03	4.8520E-03	-2.3050E-03
.708	5.5458E+02	-9.3043E+01	2.7010E+02	-3.6826E+02	-2.7820E-03	4.5301E-03	-2.3050E-03
.737	5.4112E+02	-7.8898E+01	2.5904E+02	-3.6509E+02	-2.4802E-03	4.2465E-03	-2.3050E-03
.767	5.2940E+02	-6.6231E+01	2.4892E+02	-3.6227E+02	-2.2134E-03	3.9953E-03	-2.3050E-03
.796	5.1918E+02	-5.4849E+01	2.3965E+02	-3.5982E+02	-1.9766E-03	3.7718E-03	-2.3050E-03
.825	5.1027E+02	-4.4586E+01	2.3113E+02	-3.5768E+02	-1.7656E-03	3.5721E-03	-2.3050E-03
.854	5.0250E+02	-3.5304E+01	2.2329E+02	-3.5584E+02	-1.5768E-03	3.3929E-03	-2.3050E-03
.883	4.9569E+02	-2.6883E+01	2.1605E+02	-3.5425E+02	-1.4072E-03	3.2314E-03	-2.3050E-03
.912	4.8972E+02	-1.9224E+01	2.0936E+02	-3.5286E+02	-1.2544E-03	3.0854E-03	-2.3050E-03
.942	4.8440E+02	-1.2239E+01	2.0317E+02	-3.5157E+02	-1.1160E-03	2.9531E-03	-2.3050E-03
.971	4.7966E+02	-5.8524E+00	1.9744E+02	-3.5039E+02	-9.9015E-04	2.8326E-03	-2.3050E-03
1.000	4.7560E+02	.0000E+00	1.9211E+02	-3.4949E+02	-8.7609E-04	2.7227E-03	-2.3050E-03

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* F I D E P 2 - VERSION 6 *
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***** PROBLEM TITLE *****

SCS-6/TIMETAL21S(DBP) In-Phase TMF - strain control

----- Average Stress Output -----

142

STEP	TIME	TEMPERATURE	SZAPP	SZF	SZM	SZ90	EME-F	EME-M	EME-90	EZC
1	-3.5964E+03	8.9913E+02	-3.5580E-05	-7.8499E-01	4.2263E-01	.0000E+00	-1.8383E-06	5.2622E-06	.0000E+00	-5.8387E-06
10	-3.5640E+03	8.9125E+02	-3.5924E-04	-7.9102E+00	4.2588E+00	.0000E+00	-1.8505E-05	5.2320E-05	.0000E+00	-5.8509E-05
20	-3.5280E+03	8.8250E+02	-1.2840E-03	-1.5228E+01	8.1975E+00	.0000E+00	-3.5889E-05	1.0536E-04	.0000E+00	-1.1590E-04
30	-3.4920E+03	8.7375E+02	-1.9511E-03	-1.9586E+01	1.0543E+01	.0000E+00	-4.6503E-05	1.6477E-04	.0000E+00	-1.6651E-04
40	-3.4560E+03	8.6500E+02	-2.5137E-03	-2.2608E+01	1.2170E+01	.0000E+00	-5.4003E-05	2.2702E-04	.0000E+00	-2.1389E-04
50	-3.4200E+03	8.5625E+02	-2.9690E-03	-2.4385E+01	1.3126E+01	.0000E+00	-5.8528E-05	2.9198E-04	.0000E+00	-2.5817E-04
60	-3.3840E+03	8.4750E+02	-3.1772E-03	-2.5315E+01	1.3626E+01	.0000E+00	-6.0935E-05	3.5874E-04	.0000E+00	-3.0024E-04
70	-3.3480E+03	8.3875E+02	-3.2346E-03	-2.5871E+01	1.3926E+01	.0000E+00	-6.2366E-05	4.2616E-04	.0000E+00	-3.4124E-04
80	-3.3120E+03	8.3000E+02	-3.2568E-03	-2.6299E+01	1.4156E+01	.0000E+00	-6.3431E-05	4.9364E-04	.0000E+00	-3.8179E-04
90	-3.2760E+03	8.2125E+02	-3.2743E-03	-2.6681E+01	1.4362E+01	.0000E+00	-6.4352E-05	5.6096E-04	.0000E+00	-4.2211E-04
100	-3.2400E+03	8.1250E+02	-3.3570E-03	-2.7412E+01	1.4755E+01	.0000E+00	-6.6073E-05	6.2716E-04	.0000E+00	-4.6313E-04
110	-3.2040E+03	8.0375E+02	-3.7095E-03	-3.0194E+01	1.6253E+01	.0000E+00	-7.2593E-05	6.8824E-04	.0000E+00	-5.0887E-04
120	-3.1680E+03	7.9500E+02	-4.1631E-03	-3.3675E+01	1.8127E+01	.0000E+00	-8.0760E-05	7.4737E-04	.0000E+00	-5.5617E-04
130	-3.1320E+03	7.8625E+02	-4.6799E-03	-3.7502E+01	2.0186E+01	.0000E+00	-8.9745E-05	8.0537E-04	.0000E+00	-6.0419E-04
140	-3.0960E+03	7.7750E+02	-5.2399E-03	-4.1555E+01	2.2368E+01	.0000E+00	-9.9261E-05	8.6252E-04	.0000E+00	-6.5266E-04
150	-3.0600E+03	7.6875E+02	-5.8320E-03	-4.5781E+01	2.4642E+01	.0000E+00	-1.0918E-04	9.1896E-04	.0000E+00	-7.0144E-04
160	-3.0240E+03	7.6000E+02	-6.4514E-03	-5.0148E+01	2.6997E+01	.0000E+00	-1.1941E-04	9.7477E-04	.0000E+00	-7.5045E-04
170	-2.9880E+03	7.5125E+02	-7.1367E-03	-5.5315E+01	2.9774E+01	.0000E+00	-1.3143E-04	1.0284E-03	.0000E+00	-8.0103E-04
180	-2.9520E+03	7.4250E+02	-7.8747E-03	-6.1058E+01	3.2865E+01	.0000E+00	-1.4473E-04	1.0803E-03	.0000E+00	-8.5279E-04
190	-2.9160E+03	7.3375E+02	-8.6573E-03	-6.7255E+01	3.6201E+01	.0000E+00	-1.5904E-04	1.1310E-03	.0000E+00	-9.0545E-04
200	-2.8800E+03	7.2500E+02	-9.4789E-03	-7.3843E+01	3.9747E+01	.0000E+00	-1.7421E-04	1.1804E-03	.0000E+00	-9.5887E-04
210	-2.8440E+03	7.1625E+02	-1.0333E-02	-8.0781E+01	4.3481E+01	.0000E+00	-1.9014E-04	1.2288E-03	.0000E+00	-1.0129E-03
220	-2.8080E+03	7.0750E+02	-1.1214E-02	-8.8040E+01	4.7389E+01	.0000E+00	-2.0676E-04	1.2762E-03	.0000E+00	-1.0676E-03
230	-2.7720E+03	6.9875E+02	-1.2115E-02	-9.5598E+01	5.1457E+01	.0000E+00	-2.2400E-04	1.3226E-03	.0000E+00	-1.1228E-03
240	-2.7360E+03	6.9000E+02	-1.3031E-02	-1.0343E+02	5.5674E+01	.0000E+00	-2.4182E-04	1.3681E-03	.0000E+00	-1.1784E-03
250	-2.7000E+03	6.8125E+02	-1.3955E-02	-1.1152E+02	6.0030E+01	.0000E+00	-2.6016E-04	1.4127E-03	.0000E+00	-1.2345E-03
260	-2.6640E+03	6.7250E+02	-1.4884E-02	-1.1985E+02	6.4513E+01	.0000E+00	-2.7898E-04	1.4566E-03	.0000E+00	-1.2910E-03
270	-2.6280E+03	6.6375E+02	-1.5811E-02	-1.2840E+02	6.9114E+01	.0000E+00	-2.9824E-04	1.4997E-03	.0000E+00	-1.3478E-03
280	-2.5920E+03	6.5500E+02	-1.6733E-02	-1.3715E+02	7.3824E+01	.0000E+00	-3.1788E-04	1.5420E-03	.0000E+00	-1.4048E-03
290	-2.5560E+03	6.4625E+02	-1.7645E-02	-1.4600E+02	7.8588E+01	.0000E+00	-3.3771E-04	1.5838E-03	.0000E+00	-1.4619E-03
300	-2.5200E+03	6.3750E+02	-1.8563E-02	-1.5474E+02	8.3294E+01	.0000E+00	-3.5732E-04	1.6253E-03	.0000E+00	-1.5186E-03
310	-2.4840E+03	6.2875E+02	-1.9466E-02	-1.6352E+02	8.8018E+01	.0000E+00	-3.7696E-04	1.6664E-03	.0000E+00	-1.5752E-03
320	-2.4480E+03	6.2000E+02	-2.0355E-02	-1.7237E+02	9.2781E+01	.0000E+00	-3.9671E-04	1.7070E-03	.0000E+00	-1.6319E-03
330	-2.4120E+03	6.1125E+02	-2.1231E-02	-1.8130E+02	9.7590E+01	.0000E+00	-4.1660E-04	1.7472E-03	.0000E+00	-1.6885E-03
340	-2.3760E+03	6.0250E+02	-2.2095E-02	-1.9032E+02	1.0245E+02	.0000E+00	-4.3663E-04	1.7869E-03	.0000E+00	-1.7452E-03
350	-2.3400E+03	5.9375E+02	-2.2832E-02	-1.9966E+02	1.0747E+02	.0000E+00	-4.5725E-04	1.8255E-03	.0000E+00	-1.8023E-03
360	-2.3040E+03	5.8500E+02	-2.3445E-02	-2.0930E+02	1.1266E+02	.0000E+00	-4.7841E-04	1.8630E-03	.0000E+00	-1.8599E-03
370	-2.2680E+03	5.7625E+02	-2.4030E-02	-2.1900E+02	1.1788E+02	.0000E+00	-4.9966E-04	1.9002E-03	.0000E+00	-1.9174E-03
380	-2.2320E+03	5.6750E+02	-2.4601E-02	-2.2868E+02	1.2310E+02	.0000E+00	-5.2082E-04	1.9370E-03	.0000E+00	-1.9748E-03
390	-2.1960E+03	5.5875E+02	-2.5171E-02	-2.3838E+02	1.2832E+02	.0000E+00	-5.4198E-04	1.9734E-03	.0000E+00	-2.0320E-03
400	-2.1600E+03	5.5000E+02	-2.5742E-02	-2.4811E+02	1.3356E+02	.0000E+00	-5.6315E-04	2.0094E-03	.0000E+00	-2.0891E-03
410	-2.1240E+03	5.4125E+02	-2.6308E-02	-2.5780E+02	1.3877E+02	.0000E+00	-5.8419E-04	2.0450E-03	.0000E+00	-2.1460E-03
420	-2.0880E+03	5.3250E+02	-2.6876E-02	-2.6751E+02	1.4400E+02	.0000E+00	-6.0524E-04	2.0804E-03	.0000E+00	-2.2027E-03
430	-2.0520E+03	5.2375E+02	-2.7445E-02	-2.7724E+02	1.4924E+02	.0000E+00	-6.2628E-04	2.1154E-03	.0000E+00	-2.2593E-03
440	-2.0160E+03	5.1500E+02	-2.8007E-02	-2.8690E+02	1.5444E+02	.0000E+00	-6.4713E-04	2.1499E-03	.0000E+00	-2.3155E-03
450	-1.9800E+03	5.0625E+02	-2.8571E-02	-2.9657E+02	1.5965E+02	.0000E+00	-6.6796E-04	2.1842E-03	.0000E+00	-2.3716E-03
460	-1.9440E+03	4.9750E+02	-2.9134E-02	-3.0624E+02	1.6485E+02	.0000E+00	-6.8874E-04	2.2181E-03	.0000E+00	-2.4275E-03

470	-1.9080E+03	4.8875E+02	-2.9693E-02	-3.1588E+02	1.7004E+02	.0000E+00	-7.0942E-04	2.2518E-03	.0000E+00	-2.4833E-03
480	-1.8720E+03	4.8000E+02	-3.0252E-02	-3.2550E+02	1.7523E+02	.0000E+00	-7.3004E-04	2.2851E-03	.0000E+00	-2.5388E-03
490	-1.8360E+03	4.7125E+02	-3.0808E-02	-3.3509E+02	1.8038E+02	.0000E+00	-7.5051E-04	2.3180E-03	.0000E+00	-2.5941E-03
500	-1.8000E+03	4.6250E+02	-3.1360E-02	-3.4462E+02	1.8552E+02	.0000E+00	-7.7084E-04	2.3505E-03	.0000E+00	-2.6491E-03
510	-1.7640E+03	4.5375E+02	-3.1900E-02	-3.5403E+02	1.9058E+02	.0000E+00	-7.9087E-04	2.3827E-03	.0000E+00	-2.7036E-03
520	-1.7280E+03	4.4500E+02	-3.2441E-02	-3.6343E+02	1.9565E+02	.0000E+00	-8.1083E-04	2.4146E-03	.0000E+00	-2.7581E-03
530	-1.6920E+03	4.3625E+02	-3.2982E-02	-3.7283E+02	2.0070E+02	.0000E+00	-8.3074E-04	2.4461E-03	.0000E+00	-2.8123E-03
540	-1.6560E+03	4.2750E+02	-3.3523E-02	-3.8221E+02	2.0576E+02	.0000E+00	-8.5059E-04	2.4773E-03	.0000E+00	-2.8663E-03
550	-1.6200E+03	4.1875E+02	-3.4064E-02	-3.9159E+02	2.1080E+02	.0000E+00	-8.7038E-04	2.5081E-03	.0000E+00	-2.9202E-03
560	-1.5840E+03	4.1000E+02	-3.4597E-02	-4.0086E+02	2.1579E+02	.0000E+00	-8.8989E-04	2.5386E-03	.0000E+00	-2.9737E-03
570	-1.5480E+03	4.0125E+02	-3.5123E-02	-4.1003E+02	2.2073E+02	.0000E+00	-9.0918E-04	2.5687E-03	.0000E+00	-3.0269E-03
580	-1.5120E+03	3.9250E+02	-3.5649E-02	-4.1919E+02	2.2566E+02	.0000E+00	-9.2838E-04	2.5985E-03	.0000E+00	-3.0798E-03
590	-1.4760E+03	3.8375E+02	-3.6174E-02	-4.2833E+02	2.3058E+02	.0000E+00	-9.4751E-04	2.6279E-03	.0000E+00	-3.1325E-03
600	-1.4400E+03	3.7500E+02	-3.6699E-02	-4.3745E+02	2.3549E+02	.0000E+00	-9.6656E-04	2.6570E-03	.0000E+00	-3.1851E-03
610	-1.4040E+03	3.6625E+02	-3.7223E-02	-4.4654E+02	2.4039E+02	.0000E+00	-9.8552E-04	2.6858E-03	.0000E+00	-3.2374E-03
620	-1.3680E+03	3.5750E+02	-3.7724E-02	-4.5538E+02	2.4515E+02	.0000E+00	-1.0039E-03	2.7144E-03	.0000E+00	-3.2891E-03
630	-1.3320E+03	3.4875E+02	-3.8220E-02	-4.6415E+02	2.4987E+02	.0000E+00	-1.0221E-03	2.7427E-03	.0000E+00	-3.3404E-03
640	-1.2960E+03	3.4000E+02	-3.8714E-02	-4.7289E+02	2.5457E+02	.0000E+00	-1.0402E-03	2.7707E-03	.0000E+00	-3.3916E-03
650	-1.2600E+03	3.3125E+02	-3.9208E-02	-4.8160E+02	2.5926E+02	.0000E+00	-1.0582E-03	2.7983E-03	.0000E+00	-3.4425E-03
660	-1.2240E+03	3.2250E+02	-3.9700E-02	-4.9027E+02	2.6393E+02	.0000E+00	-1.0761E-03	2.8257E-03	.0000E+00	-3.4932E-03
670	-1.1880E+03	3.1375E+02	-4.0188E-02	-4.9886E+02	2.6856E+02	.0000E+00	-1.0938E-03	2.8526E-03	.0000E+00	-3.5436E-03
680	-1.1520E+03	3.0500E+02	-4.0654E-02	-5.0718E+02	2.7303E+02	.0000E+00	-1.1108E-03	2.8792E-03	.0000E+00	-3.5934E-03
690	-1.1160E+03	2.9625E+02	-4.1118E-02	-5.1545E+02	2.7749E+02	.0000E+00	-1.1278E-03	2.9054E-03	.0000E+00	-3.6430E-03
700	-1.0800E+03	2.8750E+02	-4.1581E-02	-5.2368E+02	2.8192E+02	.0000E+00	-1.1446E-03	2.9312E-03	.0000E+00	-3.6923E-03
710	-1.0440E+03	2.7875E+02	-4.2041E-02	-5.3187E+02	2.8632E+02	.0000E+00	-1.1613E-03	2.9568E-03	.0000E+00	-3.7415E-03
720	-1.0080E+03	2.7000E+02	-4.2500E-02	-5.4001E+02	2.9071E+02	.0000E+00	-1.1778E-03	2.9820E-03	.0000E+00	-3.7903E-03
730	-9.7200E+02	2.6125E+02	-4.2956E-02	-5.4810E+02	2.9506E+02	.0000E+00	-1.1943E-03	3.0069E-03	.0000E+00	-3.8390E-03
740	-9.3600E+02	2.5250E+02	-4.3350E-02	-5.5546E+02	2.9903E+02	.0000E+00	-1.2091E-03	3.0316E-03	.0000E+00	-3.8859E-03
750	-9.0000E+02	2.4375E+02	-4.3730E-02	-5.6263E+02	3.0289E+02	.0000E+00	-1.2236E-03	3.0560E-03	.0000E+00	-3.9324E-03
760	-8.6400E+02	2.3500E+02	-4.4108E-02	-5.6974E+02	3.0672E+02	.0000E+00	-1.2379E-03	3.0801E-03	.0000E+00	-3.9785E-03
770	-8.2800E+02	2.2625E+02	-4.4481E-02	-5.7678E+02	3.1051E+02	.0000E+00	-1.2520E-03	3.1039E-03	.0000E+00	-4.0244E-03
780	-7.9200E+02	2.1750E+02	-4.4852E-02	-5.8376E+02	3.1426E+02	.0000E+00	-1.2660E-03	3.1273E-03	.0000E+00	-4.0700E-03
790	-7.5600E+02	2.0875E+02	-4.5219E-02	-5.9066E+02	3.1798E+02	.0000E+00	-1.2798E-03	3.1504E-03	.0000E+00	-4.1153E-03
800	-7.2000E+02	2.0000E+02	-4.5581E-02	-5.9745E+02	3.2163E+02	.0000E+00	-1.2933E-03	3.1730E-03	.0000E+00	-4.1605E-03
810	-6.8400E+02	1.9125E+02	-4.5936E-02	-6.0411E+02	3.2522E+02	.0000E+00	-1.3065E-03	3.1951E-03	.0000E+00	-4.2057E-03
820	-6.4800E+02	1.8250E+02	-4.6288E-02	-6.1070E+02	3.2877E+02	.0000E+00	-1.3195E-03	3.2168E-03	.0000E+00	-4.2506E-03
830	-6.1200E+02	1.7375E+02	-4.6636E-02	-6.1723E+02	3.3228E+02	.0000E+00	-1.3324E-03	3.2382E-03	.0000E+00	-4.2952E-03
840	-5.7600E+02	1.6500E+02	-4.6981E-02	-6.2367E+02	3.3575E+02	.0000E+00	-1.3451E-03	3.2593E-03	.0000E+00	-4.3395E-03
850	-5.4000E+02	1.5625E+02	-4.7323E-02	-6.3005E+02	3.3918E+02	.0000E+00	-1.3576E-03	3.2800E-03	.0000E+00	-4.3836E-03
860	-5.0400E+02	1.4750E+02	-4.7660E-02	-6.3635E+02	3.4258E+02	.0000E+00	-1.3699E-03	3.3004E-03	.0000E+00	-4.4274E-03
870	-4.6800E+02	1.3875E+02	-4.7995E-02	-6.4258E+02	3.4593E+02	.0000E+00	-1.3821E-03	3.3205E-03	.0000E+00	-4.4709E-03
880	-4.3200E+02	1.3000E+02	-4.8325E-02	-6.4874E+02	3.4925E+02	.0000E+00	-1.3941E-03	3.3403E-03	.0000E+00	-4.5141E-03
890	-3.9600E+02	1.2125E+02	-4.8653E-02	-6.5482E+02	3.5252E+02	.0000E+00	-1.4059E-03	3.3597E-03	.0000E+00	-4.5571E-03
900	-3.6000E+02	1.1250E+02	-4.8976E-02	-6.6083E+02	3.5576E+02	.0000E+00	-1.4175E-03	3.3788E-03	.0000E+00	-4.5998E-03
910	-3.2400E+02	1.0375E+02	-4.9296E-02	-6.6676E+02	3.5895E+02	.0000E+00	-1.4290E-03	3.3976E-03	.0000E+00	-4.6422E-03
920	-2.8800E+02	9.5000E+01	-4.9612E-02	-6.7262E+02	3.6211E+02	.0000E+00	-1.4402E-03	3.4160E-03	.0000E+00	-4.6844E-03
930	-2.5200E+02	8.6250E+01	-4.9920E-02	-6.7833E+02	3.6518E+02	.0000E+00	-1.4510E-03	3.4338E-03	.0000E+00	-4.7265E-03
940	-2.1600E+02	7.7500E+01	-5.0223E-02	-6.8394E+02	3.6820E+02	.0000E+00	-1.4616E-03	3.4512E-03	.0000E+00	-4.7685E-03
950	-1.8000E+02	6.8750E+01	-5.0522E-02	-6.8947E+02	3.7118E+02	.0000E+00	-1.4719E-03	3.4683E-03	.0000E+00	-4.8101E-03
960	-1.4400E+02	6.0000E+01	-5.0818E-02	-6.9492E+02	3.7411E+02	.0000E+00	-1.4821E-03	3.4851E-03	.0000E+00	-4.8516E-03
970	-1.0800E+02	5.1250E+01	-5.1109E-02	-7.0030E+02	3.7700E+02	.0000E+00	-1.4921E-03	3.5015E-03	.0000E+00	-4.8927E-03
980	-7.2000E+01	4.2500E+01	-5.1397E-02	-7.0559E+02	3.7986E+02	.0000E+00	-1.5019E-03	3.5176E-03	.0000E+00	-4.9336E-03
990	-3.6000E+01	3.3750E+01	-5.1680E-02	-7.1081E+02	3.8266E+02	.0000E+00	-1.5115E-03	3.5333E-03	.0000E+00	-4.9742E-03
1000	.0000E+00	2.5000E+01	-5.1960E-02	-7.1595E+02	3.8543E+02	.0000E+00	-1.5209E-03	3.5487E-03	.0000E+00	-5.0145E-03
1010	1.8000E+01	3.7500E+01	-1.1729E+02	-9.2625E+02	3.1831E+02	.0000E+00	-2.0651E-03	2.9689E-03	.0000E+00	-5.5145E-03
1020	3.6000E+01	5.0000E+01	-2.3428E+02	-1.1360E+03	2.5127E+02	.0000E+00	-2.6095E-03	2.3878E-03	.0000E+00	-6.0145E-03
1030	5.4000E+01	6.2500E+01	-3.5104E+02	-1.3453E+03	1.8433E+02	.0000E+00	-3.1540E-03	1.8055E-03	.0000E+00	-6.5145E-03
1040	7.2000E+01	7.5000E+01	-4.6755E+02	-1.5540E+03	1.1748E+02	.0000E+00	-3.6987E-03	1.2220E-03	.0000E+00	-7.0145E-03
1050	9.0000E+01	8.7500E+01	-5.8381E+02	-1.7622E+03	5.0719E+01	.0000E+00	-4.2436E-03	6.3724E-04	.0000E+00	-7.5145E-03
1060	1.0800E+02	1.0000E+02	-6.9983E+02	-1.9699E+03	-1.5958E+01	.0000E+00	-4.7881E-03	5.1252E-05	.0000E+00	-8.0145E-03
1070	1.2600E+02	1.1250E+02	-8.1561E+02	-2.1770E+03	-8.2550E+01	.0000E+00	-5.3323E-03	-5.3597E-04	.0000E+00	-8.5145E-03

1080	1.4400E+02	1.2500E+02	-9.3118E+02	-2.3837E+03	-1.4905E+02	.0000E+00	-5.8767E-03	-1.1244E-03	.0000E+00	-9.0145E-03
1090	1.6200E+02	1.3750E+02	-1.0465E+03	-2.5900E+03	-2.1545E+02	.0000E+00	-6.4213E-03	-1.7141E-03	.0000E+00	-9.5145E-03
1100	1.8000E+02	1.5000E+02	-1.1617E+03	-2.7958E+03	-2.8175E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02
1110	1.9800E+02	2.0000E+02	-1.0013E+03	-2.4622E+03	-2.1457E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1120	2.1600E+02	2.5000E+02	-8.4403E+02	-2.1312E+03	-1.5096E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1130	2.3400E+02	3.0000E+02	-6.9027E+02	-1.8033E+03	-9.0978E+01	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1140	2.5200E+02	3.5000E+02	-5.4051E+02	-1.4788E+03	-3.5300E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1150	2.7000E+02	4.0000E+02	-3.9496E+02	-1.1580E+03	1.5921E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1160	2.8800E+02	4.5000E+02	-2.5388E+02	-8.4133E+02	6.2438E+01	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1170	3.0600E+02	5.0000E+02	-1.1741E+02	-5.2873E+02	1.0407E+02	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1180	3.2400E+02	5.5000E+02	1.4293E+01	-2.2038E+02	1.4065E+02	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1190	3.4200E+02	6.0000E+02	1.3669E+02	8.4794E+01	1.6464E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1200	3.6000E+02	6.5000E+02	2.4791E+02	3.8597E+02	1.7357E+02	.0000E+00	1.0937E-03	2.9890E-03	.0000E+00	-1.4547E-05
1210	3.7800E+02	6.0000E+02	1.2387E+02	8.6754E+01	1.4385E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1220	3.9600E+02	5.5000E+02	-3.6230E+00	-2.11704E+02	1.1129E+02	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1230	4.1400E+02	5.0000E+02	-1.3593E+02	-5.2529E+02	7.3718E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1240	4.3200E+02	4.5000E+02	-2.7294E+02	-8.3779E+02	3.1208E+01	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1250	4.5000E+02	4.0000E+02	-4.1451E+02	-1.1544E+03	-1.6102E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1260	4.6800E+02	3.5000E+02	-5.6049E+02	-1.4751E+03	-6.8032E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1270	4.8600E+02	3.0000E+02	-7.1062E+02	-1.7995E+03	-1.2431E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1280	5.0400E+02	2.5000E+02	-8.6467E+02	-2.1274E+03	-1.8477E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1290	5.2200E+02	2.0000E+02	-1.0221E+03	-2.4584E+03	-2.4865E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1300	5.4000E+02	1.5000E+02	-1.1826E+03	-2.7919E+03	-3.1609E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02
1310	5.5800E+02	2.0000E+02	-1.0221E+03	-2.4584E+03	-2.4865E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1320	5.7600E+02	2.5000E+02	-8.6467E+02	-2.1274E+03	-1.8477E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1330	5.9400E+02	3.0000E+02	-7.1062E+02	-1.7995E+03	-1.2431E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1340	6.1200E+02	3.5000E+02	-5.6049E+02	-1.4751E+03	-6.8032E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1350	6.3000E+02	4.0000E+02	-4.1451E+02	-1.1544E+03	-1.6102E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1360	6.4800E+02	4.5000E+02	-2.7294E+02	-8.3779E+02	3.1208E+01	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1370	6.6600E+02	5.0000E+02	-1.3593E+02	-5.2529E+02	7.3718E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1380	6.8400E+02	5.5000E+02	-3.6230E+00	-2.1704E+02	1.1129E+02	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1390	7.0200E+02	6.0000E+02	1.2367E+02	8.6866E+01	1.4349E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1400	7.2000E+02	6.5000E+02	2.3884E+02	3.8750E+02	1.5880E+02	.0000E+00	1.0937E-03	2.9890E-03	.0000E+00	-1.4547E-05
1410	7.3800E+02	6.0000E+02	1.1526E+02	8.8192E+01	1.2983E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1420	7.5600E+02	5.5000E+02	-1.2562E+01	-2.1555E+02	9.6739E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1430	7.7400E+02	5.0000E+02	-1.4518E+02	-5.2375E+02	5.8672E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1440	7.9200E+02	4.5000E+02	-2.8245E+02	-8.3621E+02	1.5726E+01	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1450	8.1000E+02	4.0000E+02	-4.2426E+02	-1.1528E+03	-3.1977E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1460	8.2800E+02	3.5000E+02	-5.7046E+02	-1.4734E+03	-8.4259E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1470	8.4600E+02	3.0000E+02	-7.2077E+02	-1.7978E+03	-1.4083E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1480	8.6400E+02	2.5000E+02	-8.7497E+02	-2.1256E+03	-2.0153E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1490	8.8200E+02	2.0000E+02	-1.0324E+03	-2.4567E+03	-2.6554E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1500	9.0000E+02	1.5000E+02	-1.1931E+03	-2.7902E+03	-3.3311E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02
1510	9.1800E+02	2.0000E+02	-1.0324E+03	-2.4567E+03	-2.6554E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1520	9.3600E+02	2.5000E+02	-8.7497E+02	-2.1256E+03	-2.0153E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1530	9.5400E+02	3.0000E+02	-7.2077E+02	-1.7978E+03	-1.4083E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1540	9.7200E+02	3.5000E+02	-5.7046E+02	-1.4734E+03	-8.4259E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1550	9.9000E+02	4.0000E+02	-4.2426E+02	-1.1528E+03	-3.1977E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1560	1.0080E+03	4.5000E+02	-2.8245E+02	-8.3621E+02	1.5726E+01	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1570	1.0260E+03	5.0000E+02	-1.4518E+02	-5.2375E+02	5.8672E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1580	1.0440E+03	5.5000E+02	-1.2562E+01	-2.1555E+02	9.6739E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1590	1.0620E+03	6.0000E+02	1.1524E+02	8.8206E+01	1.2979E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1600	1.0800E+03	6.5000E+02	2.3277E+02	3.8848E+02	1.4892E+02	.0000E+00	1.0937E-03	2.9890E-03	.0000E+00	-1.4547E-05
1610	1.0980E+03	6.0000E+02	1.0919E+02	8.9172E+01	1.1996E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1620	1.1160E+03	5.5000E+02	-1.8867E+01	-2.1453E+02	8.6493E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1630	1.1340E+03	5.0000E+02	-1.5169E+02	-5.2270E+02	4.8080E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1640	1.1520E+03	4.5000E+02	-2.8916E+02	-8.3513E+02	4.8278E+00	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1650	1.1700E+03	4.0000E+02	-4.3114E+02	-1.1517E+03	-4.3153E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1660	1.1880E+03	3.5000E+02	-5.7749E+02	-1.4723E+03	-9.5682E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1670	1.2060E+03	3.0000E+02	-7.2793E+02	-1.7967E+03	-1.5246E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1680	1.2240E+03	2.5000E+02	-8.8223E+02	-2.1245E+03	-2.1333E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03

1690	1.2420E+03	2.0000E+02	-1.0398E+03	-2.4555E+03	-2.7743E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1700	1.2600E+03	1.5000E+02	-1.2005E+03	-2.7890E+03	-3.4510E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02
1710	1.2780E+03	2.0000E+02	-1.0398E+03	-2.4555E+03	-2.7743E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1720	1.2960E+03	2.5000E+02	-8.8223E+02	-2.1245E+03	-2.1333E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1730	1.3140E+03	3.0000E+02	-7.2793E+02	-1.7967E+03	-1.5246E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1740	1.3320E+03	3.5000E+02	-5.7749E+02	-1.4723E+03	-9.5682E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1750	1.3500E+03	4.0000E+02	-4.3114E+02	-1.1517E+03	-4.3153E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1760	1.3680E+03	4.5000E+02	-2.8916E+02	-8.3513E+02	4.8278E+00	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1770	1.3860E+03	5.0000E+02	-1.5169E+02	-5.2270E+02	4.8080E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1780	1.4040E+03	5.5000E+02	-1.8867E+01	-2.1453E+02	8.6493E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1790	1.4220E+03	6.0000E+02	1.0918E+02	8.9174E+01	1.1996E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1800	1.4400E+03	6.5000E+02	2.2833E+02	3.8917E+02	1.4172E+02	.0000E+00	1.0937E-03	2.9890E-03	.0000E+00	-1.4547E-05
1810	1.4580E+03	6.0000E+02	1.0465E+02	8.9880E+01	1.1260E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1820	1.4760E+03	5.5000E+02	-2.3578E+01	-2.1380E+02	7.8850E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1830	1.4940E+03	5.0000E+02	-1.5656E+02	-5.2195E+02	4.0180E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1840	1.5120E+03	4.5000E+02	-2.9417E+02	-8.3435E+02	-3.3016E+00	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1850	1.5300E+03	4.0000E+02	-4.3628E+02	-1.1509E+03	-5.1489E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1860	1.5480E+03	3.5000E+02	-5.8274E+02	-1.4715E+03	-1.0420E+02	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1870	1.5660E+03	3.0000E+02	-7.3328E+02	-1.7958E+03	-1.6114E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1880	1.5840E+03	2.5000E+02	-8.8766E+02	-2.1236E+03	-2.2213E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1890	1.6020E+03	2.0000E+02	-1.0452E+03	-2.4547E+03	-2.8630E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1900	1.6200E+03	1.5000E+02	-1.2060E+03	-2.7882E+03	-3.5404E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02
1910	1.6380E+03	2.0000E+02	-1.0452E+03	-2.4547E+03	-2.8630E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1920	1.6560E+03	2.5000E+02	-8.8766E+02	-2.1236E+03	-2.2213E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1930	1.6740E+03	3.0000E+02	-7.3328E+02	-1.7958E+03	-1.6114E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1940	1.6920E+03	3.5000E+02	-5.8274E+02	-1.4715E+03	-1.0420E+02	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1950	1.7100E+03	4.0000E+02	-4.3628E+02	-1.1509E+03	-5.1489E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1960	1.7280E+03	4.5000E+02	-2.9417E+02	-8.3435E+02	-3.3016E+00	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1970	1.7460E+03	5.0000E+02	-1.5656E+02	-5.2195E+02	4.0180E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1980	1.7640E+03	5.5000E+02	-2.3578E+01	-2.1380E+02	7.8850E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1990	1.7820E+03	6.0000E+02	1.0465E+02	8.9880E+01	1.1260E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
2000	1.8000E+03	6.5000E+02	2.2488E+02	3.8969E+02	1.3614E+02	.0000E+00	1.0937E-03	2.9890E-03	.0000E+00	-1.4547E-05
2010	1.8180E+03	6.0000E+02	1.0111E+02	9.0413E+01	1.0688E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
2020	1.8360E+03	5.5000E+02	-2.7249E+01	-2.1325E+02	7.2905E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
2030	1.8540E+03	5.0000E+02	-1.6036E+02	-5.2138E+02	3.4034E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
2040	1.8720E+03	4.5000E+02	-2.9808E+02	-8.3377E+02	-9.6252E+00	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
2050	1.8900E+03	4.0000E+02	-4.4028E+02	-1.1503E+03	-5.7973E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
2060	1.9080E+03	3.5000E+02	-5.8684E+02	-1.4709E+03	-1.1083E+02	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
2070	1.9260E+03	3.0000E+02	-7.3745E+02	-1.7952E+03	-1.6789E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
2080	1.9440E+03	2.5000E+02	-8.9189E+02	-2.1230E+03	-2.2898E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
2090	1.9620E+03	2.0000E+02	-1.0495E+03	-2.4540E+03	-2.9320E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
2100	1.9800E+03	1.5000E+02	-1.2103E+03	-2.7875E+03	-3.6099E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02

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*   F I D E P 2 - VERSION 6   *
*                               *
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***** PROBLEM TITLE *****
SCS-6/TIMETAL21S(DBP) Inphase TMF - stress control

***** GEOMETRY TYPE *****
Concentric Cylinder Model

***** LOADING TYPE *****
Stress Control

***** LOADING HISTORY *****
POINTS IN HISTORY  13

      Step      Time      Temperature  Axial Stress  Radial Stress
.0000E+00  -3.6000E+03  9.0000E+02   .0000E+00   .0000E+00
1.0000E+03   .0000E+00  2.5000E+01   .0000E+00   .0000E+00
1.2000E+03  1.8000E+02  1.5000E+02   5.0000E+01   .0000E+00
1.4000E+03  3.6000E+02  6.5000E+02   5.0000E+02   .0000E+00
1.6000E+03  5.4000E+02  1.5000E+02   5.0000E+01   .0000E+00
1.8000E+03  7.2000E+02  6.5000E+02   5.0000E+02   .0000E+00
2.0000E+03  9.0000E+02  1.5000E+02   5.0000E+01   .0000E+00
2.2000E+03  1.0800E+03  6.5000E+02   5.0000E+02   .0000E+00
2.4000E+03  1.2600E+03  1.5000E+02   5.0000E+01   .0000E+00
2.6000E+03  1.4400E+03  6.5000E+02   5.0000E+02   .0000E+00
2.8000E+03  1.6200E+03  1.5000E+02   5.0000E+01   .0000E+00
3.0000E+03  1.8000E+03  6.5000E+02   5.0000E+02   .0000E+00
3.2000E+03  1.9800E+03  1.5000E+02   5.0000E+01   .0000E+00

***** GEOMETRY INFORMATION *****
Number of Cells  2
  For Cell Number : 1
    Material Number : 1
    Volume Fraction : .35
    Nodes in cell   : 5
  For Cell Number : 2
    Material Number : 4
    Volume Fraction : .65
    Nodes in cell   : 15

***** OUTPUT INFORMATION *****
Output at Interface for Material:  2

***** MATERIAL INFORMATION *****
Material for Cell Number :  1

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Thermo-Elastic Response for SCS-6 fiber

Constitutive model: Elastic

----- MATERIAL PROPERTIES -----

T(C)	E(GPa)	NU	CTE(1E-6/C)
2.1110E+01	3.9300E+02	2.5000E-01	3.9907E+00
9.3330E+01	3.9000E+02	2.5000E-01	4.0289E+00
2.0444E+02	3.8600E+02	2.5000E-01	4.0989E+00
3.1556E+02	3.8200E+02	2.5000E-01	4.1801E+00
4.2667E+02	3.7800E+02	2.5000E-01	4.2655E+00
5.3778E+02	3.7400E+02	2.5000E-01	4.3510E+00
6.4889E+02	3.7000E+02	2.5000E-01	4.4324E+00
7.6000E+02	3.6500E+02	2.5000E-01	4.5074E+00
8.7111E+02	3.6100E+02	2.5000E-01	4.5718E+00
1.0933E+03	3.5400E+02	2.5000E-01	4.5723E+00

Reference Temperature = 900.0

Material for Cell Number : 2

Bodner-Partom Theory with Directional Hardening for Timetal021S

Constitutive model: Bodner-Partom with Directional Hardening

----- MATERIAL PROPERTIES -----

T(C)	E(GPa)	NU	CTE(1E-6/C)
2.3000E+01	1.1200E+02	3.4000E-01	9.7787E+00
2.6000E+02	1.0800E+02	3.4000E-01	1.0713E+01
3.1500E+02	1.0610E+02	3.4000E-01	1.0915E+01
3.6500E+02	1.0410E+02	3.4000E-01	1.1093E+01
4.1500E+02	1.0170E+02	3.4000E-01	1.1267E+01
4.6500E+02	9.9090E+01	3.4000E-01	1.1436E+01
4.8200E+02	9.8110E+01	3.4000E-01	1.1492E+01
5.0000E+02	9.7050E+01	3.4000E-01	1.1550E+01
5.2500E+02	9.5500E+01	3.4000E-01	1.1631E+01
5.5000E+02	9.3870E+01	3.4000E-01	1.1710E+01
5.7500E+02	9.2170E+01	3.4000E-01	1.1788E+01
6.0000E+02	9.0400E+01	3.4000E-01	1.1865E+01
6.5000E+02	8.6610E+01	3.4000E-01	1.2014E+01
7.6000E+02	7.7220E+01	3.4000E-01	1.2323E+01
8.1500E+02	7.1960E+01	3.4000E-01	1.2467E+01
9.0000E+02	6.3120E+01	3.4000E-01	1.2689E+01

Reference Temperature = 900.0

T(C)	N	Z0=Z2 (1/S)	Z3 (MPa)	M2 (1/MPa)
2.3000E+01	4.8000E+00	1.5500E+03	1.0000E+02	3.5000E-01
2.6000E+02	3.5000E+00	1.3000E+03	3.0000E+02	3.5000E-01
3.1500E+02	3.0540E+00	1.2504E+03	3.9000E+02	1.5020E+00
3.6500E+02	2.6490E+00	1.2054E+03	5.0000E+02	2.5490E+00
4.1500E+02	2.2430E+00	1.1604E+03	6.6000E+02	3.5970E+00
4.6500E+02	1.8380E+00	1.1153E+03	9.6000E+02	4.6440E+00
4.8200E+02	1.7000E+00	1.1000E+03	1.1000E+03	5.0000E+00
5.0000E+02	1.5000E+00	1.0893E+03	1.3000E+03	5.7630E+00
5.2500E+02	1.2800E+00	1.0744E+03	1.6700E+03	6.8220E+00
5.5000E+02	1.1000E+00	1.0595E+03	2.1000E+03	7.8810E+00
5.7500E+02	9.7000E-01	1.0446E+03	2.6000E+03	8.9410E+00
6.0000E+02	8.2000E-01	1.0298E+03	3.7000E+03	1.0000E+01

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6.5000E+02  7.4000E-01  1.0000E+03  3.8000E+03  1.0000E+01
7.6000E+02  5.8000E-01  6.0000E+02  4.0000E+03  1.5000E+01
8.1500E+02  5.5000E-01  3.0000E+02  4.1000E+03  3.0000E+01
9.0000E+02  5.5000E-01  3.0000E+02  4.3000E+03  3.0000E+01
-----

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```

A1=A2      M1      Z1      R1=R2      DO
-9999.0 .0 1600.0 3.0 10000.0
-----

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----- OUTPUT -----
STEP      TIME      TEMPERATRE      Seff      Srad      Stan      Sz      Erad      Etan      Ez
1      -3.5964E+03  8.9913E+02  7.1692E-01  -2.4595E-01  5.1101E-01  4.2275E-01  -8.9135E-06  7.1332E-06  5.2622E-06
10     -3.5640E+03  8.9125E+02  7.2351E+00  -2.4833E+00  5.1594E+00  4.2599E+00  -8.8801E-05  7.1144E-05  5.2320E-05
20     -3.5280E+03  8.8250E+02  1.1759E+01  -4.5688E+00  7.7945E+00  6.4744E+00  -1.9987E-04  1.4231E-04  1.0536E-04
30     -3.4920E+03  8.7375E+02  1.4255E+01  -5.6047E+00  9.2258E+00  7.9933E+00  -3.2153E-04  2.1320E-04  1.6477E-04
40     -3.4560E+03  8.6500E+02  1.5162E+01  -6.2023E+00  9.4262E+00  8.4442E+00  -4.5489E-04  2.8380E-04  2.2702E-04
50     -3.4200E+03  8.5625E+02  1.5414E+01  -6.4495E+00  9.3042E+00  8.5988E+00  -5.9180E-04  3.5399E-04  2.9198E-04
60     -3.3840E+03  8.4750E+02  1.5524E+01  -6.5302E+00  9.2247E+00  8.7514E+00  -7.2896E-04  4.2363E-04  3.5874E-04
70     -3.3480E+03  8.3875E+02  1.5725E+01  -6.5691E+00  9.3114E+00  8.9948E+00  -8.6490E-04  4.9278E-04  4.2616E-04
80     -3.3120E+03  8.3000E+02  1.5937E+01  -6.6131E+00  9.4315E+00  9.2124E+00  -1.0005E-03  5.6153E-04  4.9364E-04
90     -3.2760E+03  8.2125E+02  1.6159E+01  -6.6689E+00  9.5694E+00  9.4080E+00  -1.1356E-03  6.2991E-04  5.6096E-04
100    -3.2400E+03  8.1250E+02  1.6631E+01  -6.8398E+00  9.8773E+00  9.7025E+00  -1.2687E-03  6.9798E-04  6.2716E-04
110    -3.2040E+03  8.0375E+02  1.8558E+01  -7.6243E+00  9.1134E+01  1.0726E+01  -1.3917E-03  7.6587E-04  6.8824E-04
120    -3.1680E+03  7.9500E+02  2.0887E+01  -8.5998E+00  1.2610E+01  1.1947E+01  -1.5118E-03  8.3354E-04  7.4737E-04
130    -3.1320E+03  7.8625E+02  2.3369E+01  -9.6604E+00  1.4152E+01  1.3238E+01  -1.6304E-03  9.0096E-04  8.0537E-04
140    -3.0960E+03  7.7750E+02  2.5948E+01  -1.0776E+01  1.5734E+01  1.4574E+01  -1.7479E-03  9.6811E-04  8.6252E-04
150    -3.0600E+03  7.6875E+02  2.8604E+01  -1.1933E+01  1.7343E+01  1.5946E+01  -1.8645E-03  1.0350E-03  9.1896E-04
160    -3.0240E+03  7.6000E+02  3.1324E+01  -1.3126E+01  1.8984E+01  1.7347E+01  -1.9802E-03  1.1016E-03  9.7477E-04
170    -2.9880E+03  7.5125E+02  3.4749E+01  -1.4585E+01  2.1123E+01  1.9116E+01  -2.0908E-03  1.1677E-03  1.0284E-03
180    -2.9520E+03  7.4250E+02  3.8661E+01  -1.6233E+01  2.3599E+01  2.1137E+01  -2.1980E-03  1.2335E-03  1.0803E-03
190    -2.9160E+03  7.3375E+02  4.2944E+01  -1.8032E+01  2.6324E+01  2.3344E+01  -2.3026E-03  1.2990E-03  1.1310E-03
200    -2.8800E+03  7.2500E+02  4.7547E+01  -1.9961E+01  2.9265E+01  2.5706E+01  -2.4049E-03  1.3642E-03  1.1804E-03
210    -2.8440E+03  7.1625E+02  5.2447E+01  -2.2009E+01  3.2407E+01  2.8214E+01  -2.5052E-03  1.4290E-03  1.2288E-03
220    -2.8080E+03  7.0750E+02  5.7632E+01  -2.4171E+01  3.5747E+01  3.0862E+01  -2.6035E-03  1.4935E-03  1.2762E-03
230    -2.7720E+03  6.9875E+02  6.3095E+01  -2.6441E+01  3.9281E+01  3.3647E+01  -2.6998E-03  1.5576E-03  1.3226E-03
240    -2.7360E+03  6.9000E+02  6.8831E+01  -2.8814E+01  4.3010E+01  3.6569E+01  -2.7943E-03  1.6214E-03  1.3681E-03
250    -2.7000E+03  6.8125E+02  7.4834E+01  -3.1285E+01  4.6933E+01  3.9626E+01  -2.8869E-03  1.6849E-03  1.4127E-03
260    -2.6640E+03  6.7250E+02  8.1098E+01  -3.3850E+01  5.1048E+01  4.2818E+01  -2.9778E-03  1.7480E-03  1.4566E-03
270    -2.6280E+03  6.6375E+02  8.7617E+01  -3.6504E+01  5.5354E+01  4.6142E+01  -3.0669E-03  1.8107E-03  1.4997E-03
280    -2.5920E+03  6.5500E+02  9.4385E+01  -3.9243E+01  5.9848E+01  4.9598E+01  -3.1544E-03  1.8731E-03  1.5420E-03
290    -2.5560E+03  6.4625E+02  1.0130E+02  -4.2029E+01  6.4453E+01  5.3128E+01  -3.2405E-03  1.9349E-03  1.5838E-03
300    -2.5200E+03  6.3750E+02  1.0810E+02  -4.4773E+01  6.8979E+01  5.6606E+01  -3.3263E-03  1.9964E-03  1.6253E-03
310    -2.4840E+03  6.2875E+02  1.1501E+02  -4.7539E+01  7.3601E+01  6.0158E+01  -3.4111E-03  2.0574E-03  1.6664E-03
320    -2.4480E+03  6.2000E+02  1.2205E+02  -5.0342E+01  7.8329E+01  6.3788E+01  -3.4947E-03  2.1181E-03  1.7070E-03
330    -2.4120E+03  6.1125E+02  1.2924E+02  -5.3187E+01  8.3173E+01  6.7499E+01  -3.5773E-03  2.1784E-03  1.7472E-03
340    -2.3760E+03  6.0250E+02  1.3657E+02  -5.6075E+01  8.8139E+01  7.1294E+01  -3.6586E-03  2.2384E-03  1.7869E-03
350    -2.3400E+03  5.9375E+02  1.4469E+02  -5.9138E+01  9.3789E+01  7.5597E+01  -3.7348E-03  2.2977E-03  1.8255E-03
360    -2.3040E+03  5.8500E+02  1.5359E+02  -6.2368E+01  1.0013E+02  8.0410E+01  -3.8060E-03  2.3564E-03  1.8630E-03
370    -2.2680E+03  5.7625E+02  1.6269E+02  -6.5635E+01  1.0666E+02  8.5365E+01  -3.8756E-03  2.4147E-03  1.9002E-03
380    -2.2320E+03  5.6750E+02  1.7185E+02  -6.8903E+01  1.1324E+02  9.0352E+01  -3.9444E-03  2.4725E-03  1.9370E-03
390    -2.1960E+03  5.5875E+02  1.8104E+02  -7.2185E+01  1.1986E+02  9.5363E+01  -4.0126E-03  2.5300E-03  1.9734E-03
400    -2.1600E+03  5.5000E+02  1.9029E+02  -7.5483E+01  1.2652E+02  1.0039E+02  -4.0802E-03  2.5870E-03  2.0094E-03
410    -2.1240E+03  5.4125E+02  1.9951E+02  -7.8771E+01  1.3316E+02  1.0540E+02  -4.1472E-03  2.6436E-03  2.0450E-03
420    -2.0880E+03  5.3250E+02  2.0877E+02  -8.2075E+01  1.3984E+02  1.1043E+02  -4.2137E-03  2.6998E-03  2.0804E-03
430    -2.0520E+03  5.2375E+02  2.1807E+02  -8.5389E+01  1.4655E+02  1.1547E+02  -4.2797E-03  2.7557E-03  2.1154E-03
440    -2.0160E+03  5.1500E+02  2.2731E+02  -8.8684E+01  1.5322E+02  1.2048E+02  -4.3450E-03  2.8110E-03  2.1499E-03
450    -1.9800E+03  5.0625E+02  2.3658E+02  -9.1989E+01  1.5991E+02  1.2550E+02  -4.4097E-03  2.8659E-03  2.1842E-03
460    -1.9440E+03  4.9750E+02  2.4585E+02  -9.5297E+01  1.6661E+02  1.3051E+02  -4.4740E-03  2.9204E-03  2.2181E-03
470    -1.9080E+03  4.8875E+02  2.5512E+02  -9.8599E+01  1.7330E+02  1.3552E+02  -4.5379E-03  2.9746E-03  2.2518E-03
480    -1.8720E+03  4.8000E+02  2.6439E+02  -1.0190E+02  1.8000E+02  1.4053E+02  -4.6011E-03  3.0283E-03  2.2851E-03

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490	-1.8360E+03	4.7125E+02	2.7362E+02	-1.0520E+02	1.8668E+02	1.4551E+02	-4.6637E-03	3.0814E-03	2.3180E-03
500	-1.8000E+03	4.6250E+02	2.8282E+02	-1.0848E+02	1.9333E+02	1.5047E+02	-4.7256E-03	3.1341E-03	2.3505E-03
510	-1.7640E+03	4.5375E+02	2.9192E+02	-1.1171E+02	1.9991E+02	1.5538E+02	-4.7868E-03	3.1861E-03	2.3827E-03
520	-1.7280E+03	4.4500E+02	3.0101E+02	-1.1495E+02	2.0649E+02	1.6028E+02	-4.8475E-03	3.2377E-03	2.4146E-03
530	-1.6920E+03	4.3625E+02	3.1011E+02	-1.1819E+02	2.1308E+02	1.6518E+02	-4.9077E-03	3.2889E-03	2.4461E-03
540	-1.6560E+03	4.2750E+02	3.1921E+02	-1.2143E+02	2.1967E+02	1.7007E+02	-4.9673E-03	3.3397E-03	2.4773E-03
550	-1.6200E+03	4.1875E+02	3.2831E+02	-1.2468E+02	2.2626E+02	1.7496E+02	-5.0264E-03	3.3901E-03	2.5081E-03
560	-1.5840E+03	4.1000E+02	3.3731E+02	-1.2788E+02	2.3278E+02	1.7979E+02	-5.0848E-03	3.4398E-03	2.5386E-03
570	-1.5480E+03	4.0125E+02	3.4623E+02	-1.3106E+02	2.3925E+02	1.8459E+02	-5.1424E-03	3.4890E-03	2.5687E-03
580	-1.5120E+03	3.9250E+02	3.5515E+02	-1.3424E+02	2.4571E+02	1.8937E+02	-5.1995E-03	3.5377E-03	2.5985E-03
590	-1.4760E+03	3.8375E+02	3.6405E+02	-1.3741E+02	2.5217E+02	1.9414E+02	-5.2561E-03	3.5860E-03	2.6279E-03
600	-1.4400E+03	3.7500E+02	3.7294E+02	-1.4058E+02	2.5862E+02	1.9890E+02	-5.3121E-03	3.6339E-03	2.6570E-03
610	-1.4040E+03	3.6625E+02	3.8183E+02	-1.4375E+02	2.6506E+02	2.0365E+02	-5.3676E-03	3.6814E-03	2.6858E-03
620	-1.3680E+03	3.5750E+02	3.9045E+02	-1.4682E+02	2.7132E+02	2.0829E+02	-5.4224E-03	3.7281E-03	2.7144E-03
630	-1.3320E+03	3.4875E+02	3.9902E+02	-1.4986E+02	2.7753E+02	2.1289E+02	-5.4767E-03	3.7744E-03	2.7427E-03
640	-1.2960E+03	3.4000E+02	4.0756E+02	-1.5290E+02	2.8373E+02	2.1747E+02	-5.5304E-03	3.8202E-03	2.7707E-03
650	-1.2600E+03	3.3125E+02	4.1607E+02	-1.5593E+02	2.8991E+02	2.2203E+02	-5.5835E-03	3.8656E-03	2.7983E-03
660	-1.2240E+03	3.2250E+02	4.2456E+02	-1.5895E+02	2.9607E+02	2.2658E+02	-5.6361E-03	3.9105E-03	2.8257E-03
670	-1.1880E+03	3.1375E+02	4.3298E+02	-1.6194E+02	3.0219E+02	2.3109E+02	-5.6881E-03	3.9549E-03	2.8526E-03
680	-1.1520E+03	3.0500E+02	4.4112E+02	-1.6484E+02	3.0810E+02	2.3546E+02	-5.7389E-03	3.9983E-03	2.8792E-03
690	-1.1160E+03	2.9625E+02	4.4923E+02	-1.6771E+02	3.1398E+02	2.3981E+02	-5.7892E-03	4.0412E-03	2.9054E-03
700	-1.0800E+03	2.8750E+02	4.5729E+02	-1.7058E+02	3.1984E+02	2.4413E+02	-5.8389E-03	4.0836E-03	2.9312E-03
710	-1.0440E+03	2.7875E+02	4.6532E+02	-1.7343E+02	3.2567E+02	2.4843E+02	-5.8880E-03	4.1256E-03	2.9568E-03
720	-1.0080E+03	2.7000E+02	4.7331E+02	-1.7628E+02	3.3148E+02	2.5271E+02	-5.9366E-03	4.1671E-03	2.9820E-03
730	-9.7200E+02	2.6125E+02	4.8126E+02	-1.7910E+02	3.3725E+02	2.5696E+02	-5.9846E-03	4.2082E-03	3.0069E-03
740	-9.3600E+02	2.5250E+02	4.8844E+02	-1.8164E+02	3.4247E+02	2.6086E+02	-6.0312E-03	4.2476E-03	3.0316E-03
750	-9.0000E+02	2.4375E+02	4.9544E+02	-1.8411E+02	3.4755E+02	2.6467E+02	-6.0770E-03	4.2863E-03	3.0560E-03
760	-8.6400E+02	2.3500E+02	5.0238E+02	-1.8655E+02	3.5258E+02	2.6845E+02	-6.1223E-03	4.3245E-03	3.0801E-03
770	-8.2800E+02	2.2625E+02	5.0925E+02	-1.8897E+02	3.5757E+02	2.7219E+02	-6.1670E-03	4.3623E-03	3.1039E-03
780	-7.9200E+02	2.1750E+02	5.1606E+02	-1.9138E+02	3.6251E+02	2.7589E+02	-6.2110E-03	4.3995E-03	3.1273E-03
790	-7.5600E+02	2.0875E+02	5.2280E+02	-1.9375E+02	3.6740E+02	2.7956E+02	-6.2545E-03	4.4363E-03	3.1504E-03
800	-7.2000E+02	2.0000E+02	5.2942E+02	-1.9609E+02	3.7221E+02	2.8316E+02	-6.2970E-03	4.4722E-03	3.1730E-03
810	-6.8400E+02	1.9125E+02	5.3593E+02	-1.9839E+02	3.7693E+02	2.8670E+02	-6.3386E-03	4.5073E-03	3.1951E-03
820	-6.4800E+02	1.8250E+02	5.4236E+02	-2.0066E+02	3.8160E+02	2.9020E+02	-6.3795E-03	4.5420E-03	3.2168E-03
830	-6.1200E+02	1.7375E+02	5.4873E+02	-2.0290E+02	3.8622E+02	2.9366E+02	-6.4198E-03	4.5761E-03	3.2382E-03
840	-5.7600E+02	1.6500E+02	5.5503E+02	-2.0513E+02	3.9079E+02	2.9708E+02	-6.4596E-03	4.6097E-03	3.2593E-03
850	-5.4000E+02	1.5625E+02	5.6126E+02	-2.0733E+02	3.9531E+02	3.0046E+02	-6.4987E-03	4.6428E-03	3.2800E-03
860	-5.0400E+02	1.4750E+02	5.6741E+02	-2.0950E+02	3.9978E+02	3.0380E+02	-6.5372E-03	4.6754E-03	3.3004E-03
870	-4.6800E+02	1.3875E+02	5.7350E+02	-2.1165E+02	4.0420E+02	3.0710E+02	-6.5751E-03	4.7075E-03	3.3205E-03
880	-4.3200E+02	1.3000E+02	5.7952E+02	-2.1378E+02	4.0857E+02	3.1037E+02	-6.6124E-03	4.7391E-03	3.3403E-03
890	-3.9600E+02	1.2125E+02	5.8546E+02	-2.1588E+02	4.1288E+02	3.1359E+02	-6.6491E-03	4.7702E-03	3.3597E-03
900	-3.6000E+02	1.1250E+02	5.9133E+02	-2.1795E+02	4.1715E+02	3.1677E+02	-6.6852E-03	4.8008E-03	3.3788E-03
910	-3.2400E+02	1.0375E+02	5.9714E+02	-2.2000E+02	4.2136E+02	3.1992E+02	-6.7207E-03	4.8309E-03	3.3976E-03
920	-2.8800E+02	9.5000E+01	6.0287E+02	-2.2203E+02	4.2552E+02	3.2302E+02	-6.7556E-03	4.8604E-03	3.4160E-03
930	-2.5200E+02	8.6250E+01	6.0843E+02	-2.2399E+02	4.2956E+02	3.2604E+02	-6.7892E-03	4.8889E-03	3.4338E-03
940	-2.1600E+02	7.7500E+01	6.1390E+02	-2.2593E+02	4.3353E+02	3.2901E+02	-6.8221E-03	4.9168E-03	3.4512E-03
950	-1.8000E+02	6.8750E+01	6.1930E+02	-2.2783E+02	4.3744E+02	3.3194E+02	-6.8544E-03	4.9441E-03	3.4683E-03
960	-1.4400E+02	6.0000E+01	6.2462E+02	-2.2971E+02	4.4130E+02	3.3482E+02	-6.8860E-03	4.9709E-03	3.4851E-03
970	-1.0800E+02	5.1250E+01	6.2986E+02	-2.3157E+02	4.4510E+02	3.3766E+02	-6.9170E-03	4.9971E-03	3.5015E-03
980	-7.2000E+01	4.2500E+01	6.3503E+02	-2.3339E+02	4.4885E+02	3.4046E+02	-6.9474E-03	5.0229E-03	3.5176E-03
990	-3.6000E+01	3.3750E+01	6.4012E+02	-2.3519E+02	4.5254E+02	3.4322E+02	-6.9772E-03	5.0481E-03	3.5333E-03
1000	.0000E+00	2.5000E+01	6.4513E+02	-2.3697E+02	4.5618E+02	3.4593E+02	-7.0063E-03	5.0728E-03	3.5487E-03
1010	9.0000E+00	3.1250E+01	6.4216E+02	-2.3575E+02	4.5369E+02	3.4535E+02	-6.9904E-03	5.0522E-03	3.5496E-03
1020	1.8000E+01	3.7500E+01	6.3916E+02	-2.3452E+02	4.5117E+02	3.4474E+02	-6.9742E-03	5.0313E-03	3.5504E-03
1030	2.7000E+01	4.3750E+01	6.3612E+02	-2.3328E+02	4.4862E+02	3.4411E+02	-6.9576E-03	5.0101E-03	3.5510E-03
1040	3.6000E+01	5.0000E+01	6.3304E+02	-2.3202E+02	4.4605E+02	3.4345E+02	-6.9408E-03	4.9886E-03	3.5515E-03
1050	4.5000E+01	5.6250E+01	6.2992E+02	-2.3075E+02	4.4344E+02	3.4278E+02	-6.9236E-03	4.9669E-03	3.5518E-03
1060	5.4000E+01	6.2500E+01	6.2677E+02	-2.2947E+02	4.4081E+02	3.4208E+02	-6.9061E-03	4.9449E-03	3.5519E-03
1070	6.3000E+01	6.8750E+01	6.2358E+02	-2.2817E+02	4.3815E+02	3.4136E+02	-6.8884E-03	4.9226E-03	3.5519E-03
1080	7.2000E+01	7.5000E+01	6.2036E+02	-2.2686E+02	4.3546E+02	3.4061E+02	-6.8703E-03	4.9001E-03	3.5517E-03
1090	8.1000E+01	8.1250E+01	6.1709E+02	-2.2554E+02	4.3274E+02	3.3985E+02	-6.8519E-03	4.8773E-03	3.5514E-03

1100	9.0000E+01	8.7500E+01	6.1380E+02	-2.2420E+02	4.2999E+02	3.3906E+02	-6.8332E-03	4.8542E-03	3.5510E-03
1110	9.9000E+01	9.3750E+01	6.1046E+02	-2.2284E+02	4.2721E+02	3.3825E+02	-6.8141E-03	4.8308E-03	3.5503E-03
1120	1.0800E+02	1.0000E+02	6.0701E+02	-2.2145E+02	4.2435E+02	3.3738E+02	-6.7942E-03	4.8067E-03	3.5493E-03
1130	1.1700E+02	1.0625E+02	6.0353E+02	-2.2005E+02	4.2147E+02	3.3649E+02	-6.7740E-03	4.7823E-03	3.5481E-03
1140	1.2600E+02	1.1250E+02	6.0001E+02	-2.1863E+02	4.1855E+02	3.3558E+02	-6.7535E-03	4.7577E-03	3.5468E-03
1150	1.3500E+02	1.1875E+02	5.9646E+02	-2.1720E+02	4.1561E+02	3.3465E+02	-6.7328E-03	4.7328E-03	3.5453E-03
1160	1.4400E+02	1.2500E+02	5.9288E+02	-2.1575E+02	4.1265E+02	3.3370E+02	-6.7117E-03	4.7076E-03	3.5437E-03
1170	1.5300E+02	1.3125E+02	5.8926E+02	-2.1429E+02	4.0965E+02	3.3273E+02	-6.6903E-03	4.6822E-03	3.5419E-03
1180	1.6200E+02	1.3750E+02	5.8561E+02	-2.1282E+02	4.0663E+02	3.3173E+02	-6.6686E-03	4.6565E-03	3.5400E-03
1190	1.7100E+02	1.4375E+02	5.8193E+02	-2.1134E+02	4.0359E+02	3.3072E+02	-6.6466E-03	4.6306E-03	3.5379E-03
1200	1.8000E+02	1.5000E+02	5.7821E+02	-2.0985E+02	4.0051E+02	3.2968E+02	-6.6243E-03	4.6044E-03	3.5357E-03
1210	1.8900E+02	1.7500E+02	5.6635E+02	-2.0398E+02	3.8847E+02	3.3203E+02	-6.5567E-03	4.4814E-03	3.5857E-03
1220	1.9800E+02	2.0000E+02	5.5414E+02	-1.9792E+02	3.7601E+02	3.3404E+02	-6.4843E-03	4.3541E-03	3.6336E-03
1230	2.0700E+02	2.2500E+02	5.4138E+02	-1.9158E+02	3.6297E+02	3.3559E+02	-6.4056E-03	4.2211E-03	3.6785E-03
1240	2.1600E+02	2.5000E+02	5.2830E+02	-1.8504E+02	3.4952E+02	3.3678E+02	-6.3220E-03	4.0837E-03	3.7213E-03
1250	2.2500E+02	2.7500E+02	5.1354E+02	-1.7777E+02	3.3464E+02	3.3689E+02	-6.2324E-03	3.9395E-03	3.7629E-03
1260	2.3400E+02	3.0000E+02	4.9775E+02	-1.7002E+02	3.1881E+02	3.3619E+02	-6.1376E-03	3.7897E-03	3.8035E-03
1270	2.4300E+02	3.2500E+02	4.8164E+02	-1.6204E+02	3.0253E+02	3.3502E+02	-6.0380E-03	3.6351E-03	3.8424E-03
1280	2.5200E+02	3.5000E+02	4.6512E+02	-1.5379E+02	2.8571E+02	3.3330E+02	-5.9332E-03	3.4753E-03	3.8797E-03
1290	2.6100E+02	3.7500E+02	4.4845E+02	-1.4535E+02	2.6852E+02	3.3112E+02	-5.8244E-03	3.3113E-03	3.9161E-03
1300	2.7000E+02	4.0000E+02	4.3157E+02	-1.3668E+02	2.5090E+02	3.2838E+02	-5.7117E-03	3.1428E-03	3.9518E-03
1310	2.7900E+02	4.2500E+02	4.1485E+02	-1.2791E+02	2.3309E+02	3.2528E+02	-5.5948E-03	2.9700E-03	3.9862E-03
1320	2.8800E+02	4.5000E+02	3.9831E+02	-1.1903E+02	2.1506E+02	3.2176E+02	-5.4736E-03	2.7927E-03	4.0195E-03
1330	2.9700E+02	4.7500E+02	3.8213E+02	-1.1009E+02	1.9692E+02	3.1787E+02	-5.3485E-03	2.6113E-03	4.0518E-03
1340	3.0600E+02	5.0000E+02	3.6337E+02	-1.0074E+02	1.7689E+02	3.1052E+02	-5.2354E-03	2.4249E-03	4.0854E-03
1350	3.1500E+02	5.2500E+02	3.4423E+02	-9.0282E+01	1.5668E+02	3.0292E+02	-5.1326E-03	2.2319E-03	4.1383E-03
1360	3.2400E+02	5.5000E+02	3.2590E+02	-8.0031E+01	1.3671E+02	2.9475E+02	-5.0262E-03	2.0343E-03	4.1900E-03
1370	3.3300E+02	5.7500E+02	3.0820E+02	-6.9981E+01	1.1696E+02	2.8575E+02	-4.9186E-03	1.8325E-03	4.2413E-03
1380	3.4200E+02	6.0000E+02	2.8583E+02	-5.9053E+01	9.5861E+01	2.7079E+02	-4.8524E-03	1.6214E-03	4.3198E-03
1390	3.5100E+02	6.2500E+02	2.5264E+02	-4.6414E+01	7.2809E+01	2.4377E+02	-4.8819E-03	1.3916E-03	4.4671E-03
1400	3.6000E+02	6.5000E+02	2.1140E+02	-3.2327E+01	5.0879E+01	2.0801E+02	-5.0190E-03	1.1338E-03	4.7223E-03
1410	3.6900E+02	6.2500E+02	2.0797E+02	-3.9462E+01	6.5506E+01	2.0007E+02	-5.2615E-03	1.3338E-03	4.7452E-03
1420	3.7800E+02	6.0000E+02	2.1435E+02	-4.7393E+01	8.1521E+01	2.0004E+02	-5.4461E-03	1.5363E-03	4.7387E-03
1430	3.8700E+02	5.7500E+02	2.2678E+02	-5.6040E+01	9.9081E+01	2.0423E+02	-5.5947E-03	1.7372E-03	4.7160E-03
1440	3.9600E+02	5.5000E+02	2.4098E+02	-6.4803E+01	1.1696E+02	2.0854E+02	-5.7373E-03	1.9343E-03	4.6917E-03
1450	4.0500E+02	5.2500E+02	2.5637E+02	-7.3622E+01	1.3498E+02	2.1259E+02	-5.8763E-03	2.1276E-03	4.6667E-03
1460	4.1400E+02	5.0000E+02	2.7267E+02	-8.2443E+01	1.5301E+02	2.1630E+02	-6.0113E-03	2.3166E-03	4.6406E-03
1470	4.2300E+02	4.7500E+02	2.8973E+02	-9.1261E+01	1.7106E+02	2.1971E+02	-6.1430E-03	2.5020E-03	4.6139E-03
1480	4.3200E+02	4.5000E+02	3.0716E+02	-9.9974E+01	1.8890E+02	2.2268E+02	-6.2701E-03	2.6827E-03	4.5889E-03
1490	4.4100E+02	4.2500E+02	3.2502E+02	-1.0863E+02	2.0665E+02	2.2532E+02	-6.3932E-03	2.8592E-03	4.5566E-03
1500	4.5000E+02	4.0000E+02	3.4309E+02	-1.1719E+02	2.2419E+02	2.2759E+02	-6.5119E-03	3.0314E-03	4.5259E-03
1510	4.5900E+02	3.7500E+02	3.6134E+02	-1.2565E+02	2.4155E+02	2.2952E+02	-6.6263E-03	3.1993E-03	4.4938E-03
1520	4.6800E+02	3.5000E+02	3.7940E+02	-1.3391E+02	2.5851E+02	2.3097E+02	-6.7365E-03	3.3628E-03	4.4605E-03
1530	4.7700E+02	3.2500E+02	3.9731E+02	-1.4199E+02	2.7511E+02	2.3202E+02	-6.8426E-03	3.5221E-03	4.4259E-03
1540	4.8600E+02	3.0000E+02	4.1482E+02	-1.4982E+02	2.9119E+02	2.3256E+02	-6.9434E-03	3.6763E-03	4.3894E-03
1550	4.9500E+02	2.7500E+02	4.3197E+02	-1.5742E+02	3.0683E+02	2.3266E+02	-7.0392E-03	3.8257E-03	4.3510E-03
1560	5.0400E+02	2.5000E+02	4.4813E+02	-1.6457E+02	3.2156E+02	2.3206E+02	-7.1295E-03	3.9695E-03	4.3109E-03
1570	5.1300E+02	2.2500E+02	4.6268E+02	-1.7104E+02	3.3491E+02	2.3052E+02	-7.2134E-03	4.1069E-03	4.2688E-03
1580	5.2200E+02	2.0000E+02	4.7686E+02	-1.7730E+02	3.4785E+02	2.2863E+02	-7.2924E-03	4.2397E-03	4.2244E-03
1590	5.3100E+02	1.7500E+02	4.9045E+02	-1.8329E+02	3.6021E+02	2.2628E+02	-7.3650E-03	4.3669E-03	4.1771E-03
1600	5.4000E+02	1.5000E+02	5.0367E+02	-1.8908E+02	3.7216E+02	2.2359E+02	-7.4329E-03	4.4898E-03	4.1277E-03
1610	5.4900E+02	1.2500E+02	4.9045E+02	-1.8329E+02	3.6021E+02	2.2628E+02	-7.3650E-03	4.3669E-03	4.1771E-03
1620	5.5800E+02	2.0000E+02	4.7686E+02	-1.7730E+02	3.4785E+02	2.2863E+02	-7.2924E-03	4.2397E-03	4.2244E-03
1630	5.6700E+02	2.2500E+02	4.6268E+02	-1.7104E+02	3.3491E+02	2.3052E+02	-7.2134E-03	4.1069E-03	4.2688E-03
1640	5.7600E+02	2.5000E+02	4.4813E+02	-1.6457E+02	3.2156E+02	2.3206E+02	-7.1295E-03	3.9695E-03	4.3109E-03
1650	5.8500E+02	2.7500E+02	4.3197E+02	-1.5742E+02	3.0683E+02	2.3266E+02	-7.0392E-03	3.8257E-03	4.3510E-03
1660	5.9400E+02	3.0000E+02	4.1482E+02	-1.4982E+02	2.9119E+02	2.3256E+02	-6.9434E-03	3.6763E-03	4.3894E-03
1670	6.0300E+02	3.2500E+02	3.9731E+02	-1.4199E+02	2.7511E+02	2.3202E+02	-6.8426E-03	3.5221E-03	4.4259E-03
1680	6.1200E+02	3.5000E+02	3.7940E+02	-1.3391E+02	2.5851E+02	2.3097E+02	-6.7365E-03	3.3628E-03	4.4605E-03
1690	6.2100E+02	3.7500E+02	3.6134E+02	-1.2565E+02	2.4155E+02	2.2952E+02	-6.6263E-03	3.1993E-03	4.4938E-03
1700	6.3000E+02	4.0000E+02	3.4309E+02	-1.1719E+02	2.2419E+02	2.2759E+02	-6.5119E-03	3.0314E-03	4.5259E-03

1710	6.3900E+02	4.2500E+02	3.2502E+02	-1.0863E+02	2.0665E+02	2.2532E+02	-6.3932E-03	2.8592E-03	4.5566E-03
1720	6.4800E+02	4.5000E+02	3.0716E+02	-9.9974E+01	1.8890E+02	2.2268E+02	-6.2701E-03	2.6827E-03	4.5859E-03
1730	6.5700E+02	4.7500E+02	2.8973E+02	-9.1261E+01	1.7106E+02	2.1971E+02	-6.1430E-03	2.5020E-03	4.6139E-03
1740	6.6600E+02	5.0000E+02	2.7267E+02	-8.2443E+01	1.5301E+02	2.1630E+02	-6.0113E-03	2.3166E-03	4.6406E-03
1750	6.7500E+02	5.2500E+02	2.5637E+02	-7.3622E+01	1.3498E+02	2.1259E+02	-5.8763E-03	2.1276E-03	4.6667E-03
1760	6.8400E+02	5.5000E+02	2.4098E+02	-6.4803E+01	1.1696E+02	2.0854E+02	-5.7373E-03	1.9343E-03	4.6917E-03
1770	6.9300E+02	5.7500E+02	2.2601E+02	-5.5997E+01	9.8682E+01	2.0337E+02	-5.5992E-03	1.7372E-03	4.7163E-03
1780	7.0200E+02	6.0000E+02	2.0892E+02	-4.6390E+01	7.9283E+01	1.9477E+02	-5.4850E-03	1.5333E-03	4.7576E-03
1790	7.1100E+02	6.2500E+02	1.9266E+02	-3.6878E+01	6.0287E+01	1.8501E+02	-5.3739E-03	1.3234E-03	4.8041E-03
1800	7.2000E+02	6.5000E+02	1.7425E+02	-2.7236E+01	4.1501E+01	1.7090E+02	-5.2938E-03	1.1047E-03	4.8733E-03
1810	7.2900E+02	6.2500E+02	1.7822E+02	-3.4960E+01	5.7540E+01	1.7049E+02	-5.4865E-03	1.3087E-03	4.8758E-03
1820	7.3800E+02	6.0000E+02	1.8734E+02	-4.3210E+01	7.4241E+01	1.7283E+02	-5.6521E-03	1.5128E-03	4.8610E-03
1830	7.4700E+02	5.7500E+02	2.0024E+02	-5.1815E+01	9.1791E+01	1.7693E+02	-5.7996E-03	1.7135E-03	4.8392E-03
1840	7.5600E+02	5.5000E+02	2.1480E+02	-6.0509E+01	1.0956E+02	1.8088E+02	-5.9428E-03	1.9103E-03	4.8162E-03
1850	7.6500E+02	5.2500E+02	2.3064E+02	-6.9263E+01	1.2747E+02	1.8457E+02	-6.0824E-03	2.1034E-03	4.7925E-03
1860	7.7400E+02	5.0000E+02	2.4745E+02	-7.8021E+01	1.4540E+02	1.8794E+02	-6.2179E-03	2.2922E-03	4.7676E-03
1870	7.8300E+02	4.7500E+02	2.6505E+02	-8.6780E+01	1.6334E+02	1.9103E+02	-6.3501E-03	2.4774E-03	4.7419E-03
1880	7.9200E+02	4.5000E+02	2.8305E+02	-9.5438E+01	1.8110E+02	1.9370E+02	-6.4777E-03	2.6579E-03	4.7149E-03
1890	8.0100E+02	4.2500E+02	3.0146E+02	-1.0404E+02	1.9875E+02	1.9606E+02	-6.6012E-03	2.8343E-03	4.6865E-03
1900	8.1000E+02	4.0000E+02	3.2007E+02	-1.1255E+02	2.1621E+02	1.9806E+02	-6.7203E-03	3.0063E-03	4.6567E-03
1910	8.1900E+02	3.7500E+02	3.3884E+02	-1.2097E+02	2.3349E+02	1.9973E+02	-6.8351E-03	3.1741E-03	4.6253E-03
1920	8.2800E+02	3.5000E+02	3.5742E+02	-1.2918E+02	2.5038E+02	2.0095E+02	-6.9456E-03	3.3375E-03	4.5928E-03
1930	8.3700E+02	3.2500E+02	3.7582E+02	-1.3722E+02	2.6691E+02	2.0177E+02	-7.0520E-03	3.4967E-03	4.5588E-03
1940	8.4600E+02	3.0000E+02	3.9380E+02	-1.4501E+02	2.8293E+02	2.0211E+02	-7.1531E-03	3.6508E-03	4.5229E-03
1950	8.5500E+02	2.7500E+02	4.1142E+02	-1.5258E+02	2.9851E+02	2.0202E+02	-7.2491E-03	3.8001E-03	4.4850E-03
1960	8.6400E+02	2.5000E+02	4.2805E+02	-1.5970E+02	3.1319E+02	2.0126E+02	-7.3396E-03	3.9439E-03	4.4452E-03
1970	8.7300E+02	2.2500E+02	4.4307E+02	-1.6615E+02	3.2652E+02	1.9962E+02	-7.4236E-03	4.0812E-03	4.4032E-03
1980	8.8200E+02	2.0000E+02	4.5770E+02	-1.7240E+02	3.3942E+02	1.9763E+02	-7.5026E-03	4.2140E-03	4.3590E-03
1990	8.9100E+02	1.7500E+02	4.7174E+02	-1.7837E+02	3.5175E+02	1.9517E+02	-7.5753E-03	4.3412E-03	4.3118E-03
2000	9.0000E+02	1.5000E+02	4.8539E+02	-1.8414E+02	3.6367E+02	1.9238E+02	-7.6433E-03	4.4640E-03	4.2626E-03
2010	9.0900E+02	1.2500E+02	4.7174E+02	-1.7837E+02	3.5175E+02	1.9517E+02	-7.5753E-03	4.3412E-03	4.3118E-03
2020	9.1800E+02	2.0000E+02	4.5770E+02	-1.7240E+02	3.3942E+02	1.9763E+02	-7.5026E-03	4.2140E-03	4.3590E-03
2030	9.2700E+02	2.2500E+02	4.4307E+02	-1.6615E+02	3.2652E+02	1.9962E+02	-7.4236E-03	4.0812E-03	4.4032E-03
2040	9.3600E+02	2.5000E+02	4.2805E+02	-1.5970E+02	3.1319E+02	2.0126E+02	-7.3396E-03	3.9439E-03	4.4452E-03
2050	9.4500E+02	2.7500E+02	4.1142E+02	-1.5258E+02	2.9851E+02	2.0202E+02	-7.2491E-03	3.8001E-03	4.4850E-03
2060	9.5400E+02	3.0000E+02	3.9380E+02	-1.4501E+02	2.8293E+02	2.0211E+02	-7.1531E-03	3.6508E-03	4.5229E-03
2070	9.6300E+02	3.2500E+02	3.7582E+02	-1.3722E+02	2.6691E+02	2.0177E+02	-7.0520E-03	3.4967E-03	4.5588E-03
2080	9.7200E+02	3.5000E+02	3.5742E+02	-1.2918E+02	2.5038E+02	2.0095E+02	-6.9456E-03	3.3375E-03	4.5928E-03
2090	9.8100E+02	3.7500E+02	3.3884E+02	-1.2097E+02	2.3349E+02	1.9973E+02	-6.8351E-03	3.1741E-03	4.6253E-03
2100	9.9000E+02	4.0000E+02	3.2007E+02	-1.1255E+02	2.1621E+02	1.9806E+02	-6.7203E-03	3.0063E-03	4.6567E-03
2110	9.9900E+02	4.2500E+02	3.0146E+02	-1.0404E+02	1.9875E+02	1.9606E+02	-6.6012E-03	2.8343E-03	4.6865E-03
2120	1.0080E+03	4.5000E+02	2.8305E+02	-9.5438E+01	1.8110E+02	1.9370E+02	-6.4777E-03	2.6579E-03	4.7149E-03
2130	1.0170E+03	4.7500E+02	2.6505E+02	-8.6780E+01	1.6334E+02	1.9103E+02	-6.3501E-03	2.4774E-03	4.7419E-03
2140	1.0260E+03	5.0000E+02	2.4745E+02	-7.8021E+01	1.4540E+02	1.8794E+02	-6.2179E-03	2.2922E-03	4.7676E-03
2150	1.0350E+03	5.2500E+02	2.3064E+02	-6.9263E+01	1.2747E+02	1.8457E+02	-6.0824E-03	2.1034E-03	4.7925E-03
2160	1.0440E+03	5.5000E+02	2.1480E+02	-6.0509E+01	1.0956E+02	1.8088E+02	-5.9428E-03	1.9103E-03	4.8162E-03
2170	1.0530E+03	5.7500E+02	2.0021E+02	-5.1814E+01	9.1773E+01	1.7689E+02	-5.7998E-03	1.7135E-03	4.8392E-03
2180	1.0620E+03	6.0000E+02	1.8432E+02	-4.2662E+01	7.2951E+01	1.6990E+02	-5.6733E-03	1.5113E-03	4.8707E-03
2190	1.0710E+03	6.2500E+02	1.7037E+02	-3.3533E+01	5.4698E+01	1.6285E+02	-5.5450E-03	1.3033E-03	4.9070E-03
2200	1.0800E+03	6.5000E+02	1.5618E+02	-2.4414E+01	3.6728E+01	1.5308E+02	-5.4346E-03	1.0885E-03	4.9572E-03
2210	1.0890E+03	6.2500E+02	1.6237E+02	-3.2392E+01	5.3169E+01	1.5486E+02	-5.6094E-03	1.2945E-03	4.9500E-03
2220	1.0980E+03	6.0000E+02	1.7248E+02	-4.0746E+01	7.0108E+01	1.5797E+02	-5.7685E-03	1.4990E-03	4.9326E-03
2230	1.1070E+03	5.7500E+02	1.8559E+02	-4.9315E+01	8.7613E+01	1.6191E+02	-5.9160E-03	1.6996E-03	4.9115E-03
2240	1.1160E+03	5.5000E+02	2.0039E+02	-5.7969E+01	1.0532E+02	1.6566E+02	-6.0595E-03	1.8963E-03	4.8893E-03
2250	1.1250E+03	5.2500E+02	2.1654E+02	-6.6683E+01	1.2316E+02	1.6916E+02	-6.1995E-03	2.0892E-03	4.8663E-03
2260	1.1340E+03	5.0000E+02	2.3368E+02	-7.5404E+01	1.4103E+02	1.7235E+02	-6.3354E-03	2.2780E-03	4.8421E-03
2270	1.1430E+03	4.7500E+02	2.5162E+02	-8.4128E+01	1.5892E+02	1.7527E+02	-6.4679E-03	2.4631E-03	4.8171E-03
2280	1.1520E+03	4.5000E+02	2.6996E+02	-9.2753E+01	1.7662E+02	1.7778E+02	-6.5957E-03	2.6434E-03	4.7906E-03
2290	1.1610E+03	4.2500E+02	2.8870E+02	-1.0133E+02	1.9423E+02	1.7999E+02	-6.7195E-03	2.8198E-03	4.7628E-03
2300	1.1700E+03	4.0000E+02	3.0763E+02	-1.0980E+02	2.1164E+02	1.8184E+02	-6.8388E-03	2.9917E-03	4.7335E-03
2310	1.1790E+03	3.7500E+02	3.2670E+02	-1.1819E+02	2.2887E+02	1.8337E+02	-6.9538E-03	3.1593E-03	4.7026E-03

2320	1.1880E+03	3.5000E+02	3.4557E+02	-1.2638E+02	2.4572E+02	1.8447E+02	-7.0646E-03	3.3227E-03	4.6704E-03
2330	1.1970E+03	3.2500E+02	3.6425E+02	-1.3440E+02	2.6221E+02	1.8517E+02	-7.1711E-03	3.4818E-03	4.6368E-03
2340	1.2060E+03	3.0000E+02	3.8250E+02	-1.4217E+02	2.7820E+02	1.8540E+02	-7.2723E-03	3.6358E-03	4.6012E-03
2350	1.2150E+03	2.7500E+02	4.0038E+02	-1.4972E+02	2.9374E+02	1.8521E+02	-7.3685E-03	3.7851E-03	4.5636E-03
2360	1.2240E+03	2.5000E+02	4.1726E+02	-1.5682E+02	3.0839E+02	1.8437E+02	-7.4591E-03	3.9289E-03	4.5241E-03
2370	1.2330E+03	2.2500E+02	4.3254E+02	-1.6326E+02	3.2170E+02	1.8267E+02	-7.5431E-03	4.0662E-03	4.4822E-03
2380	1.2420E+03	2.0000E+02	4.4743E+02	-1.6949E+02	3.3459E+02	1.8062E+02	-7.6222E-03	4.1990E-03	4.4380E-03
2390	1.2510E+03	1.7500E+02	4.6171E+02	-1.7545E+02	3.4690E+02	1.7811E+02	-7.6949E-03	4.3261E-03	4.3909E-03
2400	1.2600E+03	1.5000E+02	4.7559E+02	-1.8121E+02	3.5880E+02	1.7525E+02	-7.7629E-03	4.4490E-03	4.3417E-03
2410	1.2690E+03	1.2500E+02	4.8999E+02	-1.8697E+02	3.7069E+02	1.7234E+02	-7.8317E-03	4.5776E-03	4.2946E-03
2420	1.2780E+03	1.0000E+02	5.0449E+02	-1.9273E+02	3.8258E+02	1.6942E+02	-7.9005E-03	4.7064E-03	4.2474E-03
2430	1.2870E+03	7.5000E+01	5.1899E+02	-1.9849E+02	3.9447E+02	1.6650E+02	-7.9693E-03	4.8352E-03	4.1999E-03
2440	1.2960E+03	5.0000E+01	5.3349E+02	-2.0425E+02	4.0636E+02	1.6358E+02	-8.0381E-03	4.9640E-03	4.1527E-03
2450	1.3050E+03	2.5000E+01	5.4799E+02	-2.1001E+02	4.1825E+02	1.6066E+02	-8.1069E-03	5.0928E-03	4.1055E-03
2460	1.3140E+03	0.0000E+00	5.6249E+02	-2.1577E+02	4.3014E+02	1.5774E+02	-8.1757E-03	5.2216E-03	4.0583E-03
2470	1.3230E+03	3.5000E+02	3.6425E+02	-1.3440E+02	2.6221E+02	1.8517E+02	-7.1711E-03	3.4818E-03	4.6368E-03
2480	1.3320E+03	3.5000E+02	3.4557E+02	-1.2638E+02	2.4572E+02	1.8447E+02	-7.0646E-03	3.3227E-03	4.6704E-03
2490	1.3410E+03	3.7500E+02	3.2670E+02	-1.1819E+02	2.2887E+02	1.8337E+02	-6.9538E-03	3.1593E-03	4.7026E-03
2500	1.3500E+03	4.0000E+02	3.0763E+02	-1.0980E+02	2.1164E+02	1.8184E+02	-6.8388E-03	2.9917E-03	4.7335E-03
2510	1.3590E+03	4.2500E+02	2.8870E+02	-1.0133E+02	1.9423E+02	1.7999E+02	-6.7195E-03	2.8198E-03	4.7628E-03
2520	1.3680E+03	4.5000E+02	2.6996E+02	-9.2753E+01	1.7662E+02	1.7778E+02	-6.5957E-03	2.6434E-03	4.7906E-03
2530	1.3770E+03	4.7500E+02	2.5162E+02	-8.4128E+01	1.5892E+02	1.7527E+02	-6.4679E-03	2.4631E-03	4.8171E-03
2540	1.3860E+03	5.0000E+02	2.3368E+02	-7.5404E+01	1.4103E+02	1.7235E+02	-6.3354E-03	2.2780E-03	4.8421E-03
2550	1.3950E+03	5.2500E+02	2.1654E+02	-6.6683E+01	1.2316E+02	1.6916E+02	-6.1995E-03	2.0892E-03	4.8663E-03
2560	1.4040E+03	5.5000E+02	2.0039E+02	-5.7969E+01	1.0532E+02	1.6566E+02	-6.0595E-03	1.8963E-03	4.8893E-03
2570	1.4130E+03	5.7500E+02	1.8559E+02	-4.9315E+01	8.7612E+01	1.6191E+02	-5.9160E-03	1.6996E-03	4.9115E-03
2580	1.4220E+03	6.0000E+02	1.7049E+02	-4.0438E+01	6.9234E+01	1.5597E+02	-5.7817E-03	1.4983E-03	4.9374E-03
2590	1.4310E+03	6.2500E+02	1.5739E+02	-3.1479E+01	5.1303E+01	1.5003E+02	-5.6465E-03	1.2912E-03	4.9694E-03
2600	1.4400E+03	6.5000E+02	1.4507E+02	-2.2610E+01	3.3711E+01	1.4218E+02	-5.5226E-03	1.0781E-03	5.0108E-03
2610	1.4490E+03	6.2500E+02	1.5218E+02	-3.0693E+01	5.0316E+01	1.4486E+02	-5.6897E-03	1.2850E-03	4.9994E-03
2620	1.4580E+03	6.0000E+02	1.6278E+02	-3.9086E+01	6.7364E+01	1.4830E+02	-5.8457E-03	1.4897E-03	4.9811E-03
2630	1.4670E+03	5.7500E+02	1.7604E+02	-4.7628E+01	8.4833E+01	1.5213E+02	-5.9934E-03	1.6902E-03	4.9605E-03
2640	1.4760E+03	5.5000E+02	1.9103E+02	-5.6254E+01	1.0249E+02	1.5575E+02	-6.1372E-03	1.8868E-03	4.9389E-03
2650	1.4850E+03	5.2500E+02	2.0740E+02	-6.4942E+01	1.2030E+02	1.5912E+02	-6.2773E-03	2.0796E-03	4.9164E-03
2660	1.4940E+03	5.0000E+02	2.2477E+02	-7.3638E+01	1.3813E+02	1.6220E+02	-6.4134E-03	2.2683E-03	4.8926E-03
2670	1.5030E+03	4.7500E+02	2.4296E+02	-8.2338E+01	1.5598E+02	1.6501E+02	-6.5462E-03	2.4533E-03	4.8681E-03
2680	1.5120E+03	4.5000E+02	2.6153E+02	-9.0942E+01	1.7364E+02	1.6742E+02	-6.6742E-03	2.6336E-03	4.8420E-03
2690	1.5210E+03	4.2500E+02	2.8050E+02	-9.9495E+01	1.9122E+02	1.6953E+02	-6.7981E-03	2.8098E-03	4.8146E-03
2700	1.5300E+03	4.0000E+02	2.9964E+02	-1.0795E+02	2.0860E+02	1.7129E+02	-6.9176E-03	2.9817E-03	4.7856E-03
2710	1.5390E+03	3.7500E+02	3.1892E+02	-1.1632E+02	2.2580E+02	1.7273E+02	-7.0328E-03	3.1493E-03	4.7550E-03
2720	1.5480E+03	3.5000E+02	3.3798E+02	-1.2449E+02	2.4261E+02	1.7374E+02	-7.1436E-03	3.3126E-03	4.7231E-03
2730	1.5570E+03	3.2500E+02	3.5684E+02	-1.3249E+02	2.5908E+02	1.7437E+02	-7.2503E-03	3.4717E-03	4.6898E-03
2740	1.5660E+03	3.0000E+02	3.7527E+02	-1.4025E+02	2.7505E+02	1.7453E+02	-7.3516E-03	3.6257E-03	4.6544E-03
2750	1.5750E+03	2.7500E+02	3.9332E+02	-1.4778E+02	2.9057E+02	1.7428E+02	-7.4479E-03	3.7749E-03	4.6170E-03
2760	1.5840E+03	2.5000E+02	4.1036E+02	-1.5487E+02	3.0520E+02	1.7338E+02	-7.5386E-03	3.9186E-03	4.5776E-03
2770	1.5930E+03	2.2500E+02	4.2581E+02	-1.6131E+02	3.1850E+02	1.7164E+02	-7.6226E-03	4.0559E-03	4.5357E-03
2780	1.6020E+03	2.0000E+02	4.4087E+02	-1.6753E+02	3.3138E+02	1.6956E+02	-7.7017E-03	4.1888E-03	4.4916E-03
2790	1.6110E+03	1.7500E+02	4.5530E+02	-1.7349E+02	3.4368E+02	1.6701E+02	-7.7745E-03	4.3159E-03	4.4446E-03
2800	1.6200E+03	1.5000E+02	4.6934E+02	-1.7924E+02	3.5557E+02	1.6412E+02	-7.8425E-03	4.4387E-03	4.3954E-03
2810	1.6290E+03	1.2500E+02	4.8338E+02	-1.8500E+02	3.6787E+02	1.6117E+02	-7.9103E-03	4.5618E-03	4.3482E-03
2820	1.6380E+03	1.0000E+02	4.9742E+02	-1.9076E+02	3.8017E+02	1.5822E+02	-7.9781E-03	4.6848E-03	4.3010E-03
2830	1.6470E+03	7.5000E+01	5.1146E+02	-1.9652E+02	3.9247E+02	1.5527E+02	-8.0459E-03	4.8078E-03	4.2538E-03
2840	1.6560E+03	5.0000E+01	5.2550E+02	-2.0228E+02	4.0477E+02	1.5232E+02	-8.1137E-03	4.9308E-03	4.2066E-03
2850	1.6650E+03	2.5000E+01	5.3954E+02	-2.0804E+02	4.1707E+02	1.4937E+02	-8.1815E-03	5.0538E-03	4.1594E-03
2860	1.6740E+03	0.0000E+00	5.5358E+02	-2.1380E+02	4.2937E+02	1.4642E+02	-8.2493E-03	5.1768E-03	4.1122E-03
2870	1.6830E+03	3.5000E+02	3.5684E+02	-1.3249E+02	2.5908E+02	1.7437E+02	-7.2503E-03	3.4717E-03	4.6898E-03
2880	1.6920E+03	3.2500E+02	3.7998E+02	-1.2449E+02	2.4261E+02	1.7374E+02	-7.1436E-03	3.3126E-03	4.7231E-03
2890	1.7010E+03	3.0000E+02	4.0302E+02	-1.1649E+02	2.2580E+02	1.7273E+02	-7.0328E-03	3.1493E-03	4.7550E-03
2900	1.7100E+03	2.7500E+02	4.2606E+02	-1.0849E+02	2.0860E+02	1.7129E+02	-6.9176E-03	2.9817E-03	4.7856E-03
2910	1.7190E+03	2.5000E+02	4.4910E+02	-1.0049E+02	1.9122E+02	1.6953E+02	-6.7981E-03	2.8098E-03	4.8146E-03
2920	1.7280E+03	2.2500E+02	4.7214E+02	-9.2495E+01	1.7364E+02	1.6742E+02	-6.6742E-03	2.6336E-03	4.8420E-03

2930	1.7370E+03	4.7500E+02	2.4296E+02	-8.2338E+01	1.5598E+02	1.6501E+02	-6.5462E-03	2.4533E-03	4.8681E-03
2940	1.7460E+03	5.0000E+02	2.2477E+02	-7.3638E+01	1.3813E+02	1.6220E+02	-6.4134E-03	2.2683E-03	4.8926E-03
2950	1.7550E+03	5.2500E+02	2.0740E+02	-6.4942E+01	1.2030E+02	1.5912E+02	-6.2773E-03	2.0796E-03	4.9164E-03
2960	1.7640E+03	5.5000E+02	1.9103E+02	-5.6254E+01	1.0249E+02	1.5575E+02	-6.1372E-03	1.8868E-03	4.9389E-03
2970	1.7730E+03	5.7500E+02	1.7604E+02	-4.7628E+01	8.4833E+01	1.5213E+02	-5.9934E-03	1.6902E-03	4.9605E-03
2980	1.7820E+03	6.0000E+02	1.6141E+02	-3.8927E+01	6.6746E+01	1.4687E+02	-5.8542E-03	1.4894E-03	4.9831E-03
2990	1.7910E+03	6.2500E+02	1.4870E+02	-3.0072E+01	4.8977E+01	1.4146E+02	-5.7153E-03	1.2828E-03	5.0123E-03
3000	1.8000E+03	6.5000E+02	1.3742E+02	-2.1348E+01	3.1602E+01	1.3466E+02	-5.5840E-03	1.0708E-03	5.0486E-03
3010	1.8090E+03	6.2500E+02	1.4496E+02	-2.9477E+01	4.8281E+01	1.3778E+02	-5.7472E-03	1.2781E-03	5.0353E-03
3020	1.8180E+03	6.0000E+02	1.5585E+02	-3.7881E+01	6.5387E+01	1.4138E+02	-5.9017E-03	1.4828E-03	5.0168E-03
3030	1.8270E+03	5.7500E+02	1.6921E+02	-4.6403E+01	8.2827E+01	1.4513E+02	-6.0496E-03	1.6832E-03	4.9967E-03
3040	1.8360E+03	5.5000E+02	1.8435E+02	-5.5009E+01	1.0046E+02	1.4866E+02	-6.1935E-03	1.8797E-03	4.9755E-03
3050	1.8450E+03	5.2500E+02	2.0090E+02	-6.3678E+01	1.1823E+02	1.5195E+02	-6.3339E-03	2.0725E-03	4.9533E-03
3060	1.8540E+03	5.0000E+02	2.1846E+02	-7.2357E+01	1.3603E+02	1.5494E+02	-6.4701E-03	2.2611E-03	4.9299E-03
3070	1.8630E+03	4.7500E+02	2.3683E+02	-8.1040E+01	1.5385E+02	1.5767E+02	-6.6030E-03	2.4461E-03	4.9056E-03
3080	1.8720E+03	4.5000E+02	2.5557E+02	-8.9627E+01	1.7150E+02	1.6001E+02	-6.7312E-03	2.6263E-03	4.8798E-03
3090	1.8810E+03	4.2500E+02	2.7471E+02	-9.8166E+01	1.8904E+02	1.6205E+02	-6.8552E-03	2.8025E-03	4.8527E-03
3100	1.8900E+03	4.0000E+02	2.9401E+02	-1.0661E+02	2.0640E+02	1.6375E+02	-6.9749E-03	2.9743E-03	4.8239E-03
3110	1.8990E+03	3.7500E+02	3.1343E+02	-1.1496E+02	2.2358E+02	1.6512E+02	-7.0901E-03	3.1419E-03	4.7936E-03
3120	1.9080E+03	3.5000E+02	3.3263E+02	-1.2312E+02	2.4038E+02	1.6608E+02	-7.2011E-03	3.3051E-03	4.7619E-03
3130	1.9170E+03	3.2500E+02	3.5163E+02	-1.3111E+02	2.5683E+02	1.6666E+02	-7.3078E-03	3.4642E-03	4.7288E-03
3140	1.9260E+03	3.0000E+02	3.7019E+02	-1.3885E+02	2.7277E+02	1.6677E+02	-7.4092E-03	3.6182E-03	4.6935E-03
3150	1.9350E+03	2.7500E+02	3.8835E+02	-1.4638E+02	2.8828E+02	1.6646E+02	-7.5056E-03	3.7674E-03	4.6563E-03
3160	1.9440E+03	2.5000E+02	4.0552E+02	-1.5346E+02	3.0290E+02	1.6553E+02	-7.5963E-03	3.9111E-03	4.6170E-03
3170	1.9530E+03	2.2500E+02	4.2109E+02	-1.5989E+02	3.1619E+02	1.6376E+02	-7.6803E-03	4.0484E-03	4.5751E-03
3180	1.9620E+03	2.0000E+02	4.3626E+02	-1.6611E+02	3.2906E+02	1.6165E+02	-7.7595E-03	4.1812E-03	4.5311E-03
3190	1.9710E+03	1.7500E+02	4.5081E+02	-1.7206E+02	3.4135E+02	1.5908E+02	-7.8322E-03	4.3083E-03	4.4841E-03
3200	1.9800E+03	1.5000E+02	4.6496E+02	-1.7781E+02	3.5323E+02	1.5616E+02	-7.9003E-03	4.4311E-03	4.4350E-03

Cross-Sectional Results at Step 3200
time = 1980.0000

Radius	Seff	Srad	Stan	Sz	Er	Etan	Ez
.000	1.2030E+00	-1.7781E+02	-1.7781E+02	-1.7660E+02	-2.2993E-04	-2.2993E-04	-2.2606E-04
.148	1.2030E+00	-1.7781E+02	-1.7781E+02	-1.7660E+02	-2.2993E-04	-2.2993E-04	-2.2606E-04
.296	1.2030E+00	-1.7781E+02	-1.7781E+02	-1.7660E+02	-2.2993E-04	-2.2993E-04	-2.2606E-04
.444	1.2030E+00	-1.7781E+02	-1.7781E+02	-1.7660E+02	-2.2993E-04	-2.2993E-04	-2.2606E-04
.592	1.2030E+00	-1.7781E+02	-1.7781E+02	-1.7660E+02	-2.2993E-04	-2.2993E-04	-2.2606E-04
.592	4.6496E+02	-1.7781E+02	3.5323E+02	1.5616E+02	-7.9003E-03	4.4311E-03	4.4350E-03
.621	4.2671E+02	-1.5334E+02	3.3270E+02	1.5973E+02	-7.3118E-03	3.8645E-03	4.4350E-03
.650	3.9323E+02	-1.3193E+02	3.1458E+02	1.6273E+02	-6.8025E-03	3.3736E-03	4.4350E-03
.679	3.6373E+02	-1.1309E+02	2.9848E+02	1.6518E+02	-6.3592E-03	2.9454E-03	4.4350E-03
.708	3.3764E+02	-9.6440E+01	2.8410E+02	1.6729E+02	-5.9708E-03	2.5697E-03	4.4350E-03
.737	3.1446E+02	-8.1643E+01	2.7118E+02	1.6908E+02	-5.6286E-03	2.2382E-03	4.4350E-03
.767	2.9377E+02	-6.8439E+01	2.5952E+02	1.7060E+02	-5.3258E-03	1.9443E-03	4.4350E-03
.796	2.7530E+02	-5.6611E+01	2.4899E+02	1.7200E+02	-5.0561E-03	1.6825E-03	4.4350E-03
.825	2.5883E+02	-4.5973E+01	2.3947E+02	1.7346E+02	-4.8144E-03	1.4483E-03	4.4350E-03
.854	2.4412E+02	-3.6372E+01	2.3084E+02	1.7496E+02	-4.5968E-03	1.2379E-03	4.4350E-03
.883	2.3089E+02	-2.7678E+01	2.2297E+02	1.7633E+02	-4.4008E-03	1.0483E-03	4.4350E-03
.912	2.1893E+02	-1.9780E+01	2.1577E+02	1.7749E+02	-4.2239E-03	8.7679E-04	4.4350E-03
.942	2.0807E+02	-1.2586E+01	2.0914E+02	1.7840E+02	-4.0640E-03	7.2114E-04	4.4350E-03
.971	1.9817E+02	-6.0156E+00	2.0303E+02	1.7912E+02	-3.9188E-03	5.7945E-04	4.4350E-03
1.000	1.8913E+02	.0000E+00	1.9738E+02	1.7963E+02	-3.7869E-03	4.5007E-04	4.4350E-03

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* F I D E P 2 - VERSION 6 *
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***** PROBLEM TITLE *****

SCS-6/TIMETAL21S(DBP) Inphase TMF - stress control

----- Average Stress Output -----

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STEP	TIME	TEMPERATURE	SZAPP	SZF	SZM	SZ90	EME-F	EME-M	EME-90	EZC	
1	-3.5964E+03	8.9913E+02	.0000E+00	-7.8499E-01	4.2268E-01	.0000E+00	-1.8383E-06	5.2622E-06	.0000E+00	-5.8387E-06	
10	-3.5640E+03	8.9125E+02	.0000E+00	-7.9102E+00	4.2593E+00	.0000E+00	-1.8505E-05	5.2320E-05	.0000E+00	-5.8509E-05	
20	-3.5280E+03	8.8250E+02	.0000E+00	-1.5228E+01	8.1994E+00	.0000E+00	-3.5889E-05	1.0536E-04	.0000E+00	-1.1590E-04	
30	-3.4920E+03	8.7375E+02	.0000E+00	-1.9586E+01	1.0546E+01	.0000E+00	-4.6503E-05	1.6477E-04	.0000E+00	-1.6651E-04	
40	-3.4560E+03	8.6500E+02	.0000E+00	-2.2608E+01	1.2174E+01	.0000E+00	-5.4003E-05	2.2702E-04	.0000E+00	-2.1389E-04	
50	-3.4200E+03	8.5625E+02	.0000E+00	-2.4385E+01	1.3130E+01	.0000E+00	-5.8528E-05	2.9198E-04	.0000E+00	-2.5817E-04	
60	-3.3840E+03	8.4750E+02	.0000E+00	-2.5315E+01	1.3631E+01	.0000E+00	-6.0935E-05	3.5874E-04	.0000E+00	-3.0024E-04	
70	-3.3480E+03	8.3875E+02	.0000E+00	-2.5871E+01	1.3931E+01	.0000E+00	-6.2366E-05	4.2616E-04	.0000E+00	-3.4124E-04	
80	-3.3120E+03	8.3000E+02	.0000E+00	-2.6299E+01	1.4161E+01	.0000E+00	-6.3431E-05	4.9364E-04	.0000E+00	-3.8179E-04	
90	-3.2760E+03	8.2125E+02	.0000E+00	-2.6681E+01	1.4367E+01	.0000E+00	-6.4352E-05	5.6096E-04	.0000E+00	-4.2211E-04	
100	-3.2400E+03	8.1250E+02	.0000E+00	-2.7412E+01	1.4760E+01	.0000E+00	-6.6073E-05	6.2716E-04	.0000E+00	-4.6313E-04	
110	-3.2040E+03	8.0375E+02	.0000E+00	-3.0194E+01	1.6259E+01	.0000E+00	-7.2593E-05	6.8824E-04	.0000E+00	-5.0887E-04	
120	-3.1680E+03	7.9500E+02	.0000E+00	-3.3675E+01	1.8133E+01	.0000E+00	-8.0760E-05	7.4737E-04	.0000E+00	-5.5617E-04	
130	-3.1320E+03	7.8625E+02	.0000E+00	-3.7502E+01	2.0193E+01	.0000E+00	-8.9745E-05	8.0537E-04	.0000E+00	-6.0419E-04	
140	-3.0960E+03	7.7750E+02	.0000E+00	-4.1555E+01	2.2376E+01	.0000E+00	-9.9261E-05	8.6252E-04	.0000E+00	-6.5266E-04	
150	-3.0600E+03	7.6875E+02	.0000E+00	-4.5781E+01	2.4651E+01	.0000E+00	-1.0918E-04	9.1896E-04	.0000E+00	-7.0144E-04	
	160	-3.0240E+03	7.6000E+02	.0000E+00	-5.0148E+01	2.7003E+01	.0000E+00	-1.1941E-04	9.7477E-04	.0000E+00	-7.5045E-04
170	-2.9880E+03	7.5125E+02	.0000E+00	-5.5315E+01	2.9785E+01	.0000E+00	-1.3143E-04	1.0284E-03	.0000E+00	-8.0103E-04	
180	-2.9520E+03	7.4250E+02	.0000E+00	-6.1058E+01	3.2877E+01	.0000E+00	-1.4473E-04	1.0803E-03	.0000E+00	-8.5279E-04	
190	-2.9160E+03	7.3375E+02	.0000E+00	-6.7255E+01	3.6214E+01	.0000E+00	-1.5904E-04	1.1310E-03	.0000E+00	-9.0545E-04	
200	-2.8800E+03	7.2500E+02	.0000E+00	-7.3843E+01	3.9761E+01	.0000E+00	-1.7421E-04	1.1804E-03	.0000E+00	-9.5887E-04	
210	-2.8440E+03	7.1625E+02	.0000E+00	-8.0781E+01	4.3497E+01	.0000E+00	-1.9014E-04	1.2288E-03	.0000E+00	-1.0129E-03	
220	-2.8080E+03	7.0750E+02	.0000E+00	-8.8040E+01	4.7406E+01	.0000E+00	-2.0676E-04	1.2762E-03	.0000E+00	-1.0676E-03	
230	-2.7720E+03	6.9875E+02	.0000E+00	-9.5598E+01	5.1476E+01	.0000E+00	-2.2400E-04	1.3226E-03	.0000E+00	-1.1228E-03	
240	-2.7360E+03	6.9000E+02	.0000E+00	-1.0343E+02	5.5694E+01	.0000E+00	-2.4182E-04	1.3681E-03	.0000E+00	-1.1784E-03	
250	-2.7000E+03	6.8125E+02	.0000E+00	-1.1152E+02	6.0051E+01	.0000E+00	-2.6016E-04	1.4127E-03	.0000E+00	-1.2345E-03	
260	-2.6640E+03	6.7250E+02	.0000E+00	-1.1985E+02	6.4536E+01	.0000E+00	-2.7898E-04	1.4566E-03	.0000E+00	-1.2910E-03	
	270	-2.6280E+03	6.6375E+02	.0000E+00	-1.2840E+02	6.9139E+01	.0000E+00	-2.9824E-04	1.4997E-03	.0000E+00	-1.3478E-03
280	-2.5920E+03	6.5500E+02	.0000E+00	-1.3715E+02	7.3850E+01	.0000E+00	-3.1788E-04	1.5420E-03	.0000E+00	-1.4048E-03	
290	-2.5560E+03	6.4625E+02	.0000E+00	-1.4600E+02	7.8615E+01	.0000E+00	-3.3771E-04	1.5838E-03	.0000E+00	-1.4619E-03	
300	-2.5200E+03	6.3750E+02	.0000E+00	-1.5474E+02	8.3322E+01	.0000E+00	-3.5732E-04	1.6253E-03	.0000E+00	-1.5186E-03	
310	-2.4840E+03	6.2875E+02	.0000E+00	-1.6352E+02	8.8048E+01	.0000E+00	-3.7696E-04	1.6664E-03	.0000E+00	-1.5752E-03	
320	-2.4480E+03	6.2000E+02	.0000E+00	-1.7237E+02	9.2813E+01	.0000E+00	-3.9671E-04	1.7070E-03	.0000E+00	-1.6319E-03	
330	-2.4120E+03	6.1125E+02	.0000E+00	-1.8130E+02	9.7622E+01	.0000E+00	-4.1660E-04	1.7472E-03	.0000E+00	-1.6885E-03	
340	-2.3760E+03	6.0250E+02	.0000E+00	-1.9032E+02	1.0248E+02	.0000E+00	-4.3663E-04	1.7869E-03	.0000E+00	-1.7452E-03	
350	-2.3400E+03	5.9375E+02	.0000E+00	-1.9966E+02	1.0751E+02	.0000E+00	-4.5725E-04	1.8255E-03	.0000E+00	-1.8023E-03	
360	-2.3040E+03	5.8500E+02	.0000E+00	-2.0930E+02	1.1270E+02	.0000E+00	-4.7841E-04	1.8630E-03	.0000E+00	-1.8599E-03	
370	-2.2680E+03	5.7625E+02	.0000E+00	-2.1900E+02	1.1792E+02	.0000E+00	-4.9966E-04	1.9002E-03	.0000E+00	-1.9174E-03	
	380	-2.2320E+03	5.6750E+02	.0000E+00	-2.2868E+02	1.2314E+02	.0000E+00	-5.2082E-04	1.9370E-03	.0000E+00	-1.9748E-03
390	-2.1960E+03	5.5875E+02	.0000E+00	-2.3838E+02	1.2836E+02	.0000E+00	-5.4198E-04	1.9734E-03	.0000E+00	-2.0320E-03	
400	-2.1600E+03	5.5000E+02	.0000E+00	-2.4811E+02	1.3360E+02	.0000E+00	-5.6315E-04	2.0094E-03	.0000E+00	-2.0891E-03	
	410	-2.1240E+03	5.4125E+02	.0000E+00	-2.5780E+02	1.3881E+02	.0000E+00	-5.8419E-04	2.0450E-03	.0000E+00	-2.1460E-03
420	-2.0880E+03	5.3250E+02	.0000E+00	-2.6751E+02	1.4405E+02	.0000E+00	-6.0524E-04	2.0804E-03	.0000E+00	-2.2027E-03	
	430	-2.0520E+03	5.2375E+02	.0000E+00	-2.7724E+02	1.4928E+02	.0000E+00	-6.2628E-04	2.1154E-03	.0000E+00	-2.2593E-03
440	-2.0160E+03	5.1500E+02	.0000E+00	-2.8690E+02	1.5448E+02	.0000E+00	-6.4713E-04	2.1499E-03	.0000E+00	-2.3155E-03	

450	-1.9800E+03	5.0625E+02	.0000E+00	-2.9657E+02	1.5969E+02	.0000E+00	-6.6796E-04	2.1842E-03	.0000E+00	-2.3716E-03
460	-1.9440E+03	4.9750E+02	.0000E+00	-3.0624E+02	1.6490E+02	.0000E+00	-6.8874E-04	2.2181E-03	.0000E+00	-2.4275E-03
470	-1.9080E+03	4.8875E+02	.0000E+00	-3.1588E+02	1.7009E+02	.0000E+00	-7.0942E-04	2.2518E-03	.0000E+00	-2.4833E-03
480	-1.8720E+03	4.8000E+02	.0000E+00	-3.2550E+02	1.7527E+02	.0000E+00	-7.3004E-04	2.2851E-03	.0000E+00	-2.5388E-03
490	-1.8360E+03	4.7125E+02	.0000E+00	-3.3509E+02	1.8043E+02	.0000E+00	-7.5051E-04	2.3180E-03	.0000E+00	-2.5941E-03
500	-1.8000E+03	4.6250E+02	.0000E+00	-3.4462E+02	1.8557E+02	.0000E+00	-7.7084E-04	2.3505E-03	.0000E+00	-2.6491E-03
510	-1.7640E+03	4.5375E+02	.0000E+00	-3.5403E+02	1.9063E+02	.0000E+00	-7.9087E-04	2.3827E-03	.0000E+00	-2.7036E-03
520	-1.7280E+03	4.4500E+02	.0000E+00	-3.6343E+02	1.9570E+02	.0000E+00	-8.1083E-04	2.4146E-03	.0000E+00	-2.7581E-03
530	-1.6920E+03	4.3625E+02	.0000E+00	-3.7283E+02	2.0075E+02	.0000E+00	-8.3074E-04	2.4461E-03	.0000E+00	-2.8123E-03
540	-1.6560E+03	4.2750E+02	.0000E+00	-3.8221E+02	2.0581E+02	.0000E+00	-8.5059E-04	2.4773E-03	.0000E+00	-2.8663E-03
550	-1.6200E+03	4.1875E+02	.0000E+00	-3.9159E+02	2.1086E+02	.0000E+00	-8.7038E-04	2.5081E-03	.0000E+00	-2.9202E-03
560	-1.5840E+03	4.1000E+02	.0000E+00	-4.0086E+02	2.1585E+02	.0000E+00	-8.8989E-04	2.5386E-03	.0000E+00	-2.9737E-03
570	-1.5480E+03	4.0125E+02	.0000E+00	-4.1003E+02	2.2079E+02	.0000E+00	-9.0918E-04	2.5687E-03	.0000E+00	-3.0269E-03
580	-1.5120E+03	3.9250E+02	.0000E+00	-4.1919E+02	2.2572E+02	.0000E+00	-9.2838E-04	2.5985E-03	.0000E+00	-3.0798E-03
590	-1.4760E+03	3.8375E+02	.0000E+00	-4.2833E+02	2.3064E+02	.0000E+00	-9.4751E-04	2.6279E-03	.0000E+00	-3.1325E-03
600	-1.4400E+03	3.7500E+02	.0000E+00	-4.3745E+02	2.3555E+02	.0000E+00	-9.6656E-04	2.6570E-03	.0000E+00	-3.1851E-03
610	-1.4040E+03	3.6625E+02	.0000E+00	-4.4654E+02	2.4045E+02	.0000E+00	-9.8552E-04	2.6858E-03	.0000E+00	-3.2374E-03
620	-1.3680E+03	3.5750E+02	.0000E+00	-4.5538E+02	2.4521E+02	.0000E+00	-1.0039E-03	2.7144E-03	.0000E+00	-3.2891E-03
630	-1.3320E+03	3.4875E+02	.0000E+00	-4.6415E+02	2.4993E+02	.0000E+00	-1.0221E-03	2.7427E-03	.0000E+00	-3.3404E-03
640	-1.2960E+03	3.4000E+02	.0000E+00	-4.7289E+02	2.5463E+02	.0000E+00	-1.0402E-03	2.7707E-03	.0000E+00	-3.3916E-03
650	-1.2600E+03	3.3125E+02	.0000E+00	-4.8160E+02	2.5932E+02	.0000E+00	-1.0582E-03	2.7983E-03	.0000E+00	-3.4425E-03
660	-1.2240E+03	3.2250E+02	.0000E+00	-4.9027E+02	2.6399E+02	.0000E+00	-1.0761E-03	2.8257E-03	.0000E+00	-3.4932E-03
670	-1.1880E+03	3.1375E+02	.0000E+00	-4.9886E+02	2.6862E+02	.0000E+00	-1.0938E-03	2.8526E-03	.0000E+00	-3.5436E-03
680	-1.1520E+03	3.0500E+02	.0000E+00	-5.0718E+02	2.7310E+02	.0000E+00	-1.1108E-03	2.8792E-03	.0000E+00	-3.5934E-03
690	-1.1160E+03	2.9625E+02	.0000E+00	-5.1545E+02	2.7755E+02	.0000E+00	-1.1278E-03	2.9054E-03	.0000E+00	-3.6430E-03
700	-1.0800E+03	2.8750E+02	.0000E+00	-5.2368E+02	2.8198E+02	.0000E+00	-1.1446E-03	2.9312E-03	.0000E+00	-3.6923E-03
710	-1.0440E+03	2.7875E+02	.0000E+00	-5.3187E+02	2.8639E+02	.0000E+00	-1.1613E-03	2.9568E-03	.0000E+00	-3.7415E-03
720	-1.0080E+03	2.7000E+02	.0000E+00	-5.4001E+02	2.9077E+02	.0000E+00	-1.1778E-03	2.9820E-03	.0000E+00	-3.7903E-03
730	-9.7200E+02	2.6125E+02	.0000E+00	-5.4810E+02	2.9513E+02	.0000E+00	-1.1943E-03	3.0069E-03	.0000E+00	-3.8390E-03
740	-9.3600E+02	2.5250E+02	.0000E+00	-5.5546E+02	2.9909E+02	.0000E+00	-1.2091E-03	3.0316E-03	.0000E+00	-3.8859E-03
750	-9.0000E+02	2.4375E+02	.0000E+00	-5.6263E+02	3.0296E+02	.0000E+00	-1.2236E-03	3.0560E-03	.0000E+00	-3.9324E-03
760	-8.6400E+02	2.3500E+02	.0000E+00	-5.6974E+02	3.0678E+02	.0000E+00	-1.2379E-03	3.0801E-03	.0000E+00	-3.9785E-03
770	-8.2800E+02	2.2625E+02	.0000E+00	-5.7678E+02	3.1058E+02	.0000E+00	-1.2520E-03	3.1039E-03	.0000E+00	-4.0244E-03
780	-7.9200E+02	2.1750E+02	.0000E+00	-5.8376E+02	3.1433E+02	.0000E+00	-1.2660E-03	3.1273E-03	.0000E+00	-4.0700E-03
790	-7.5600E+02	2.0875E+02	.0000E+00	-5.9066E+02	3.1805E+02	.0000E+00	-1.2798E-03	3.1504E-03	.0000E+00	-4.1153E-03
800	-7.2000E+02	2.0000E+02	.0000E+00	-5.9745E+02	3.2170E+02	.0000E+00	-1.2933E-03	3.1730E-03	.0000E+00	-4.1605E-03
810	-6.8400E+02	1.9125E+02	.0000E+00	-6.0411E+02	3.2529E+02	.0000E+00	-1.3065E-03	3.1951E-03	.0000E+00	-4.2057E-03
820	-6.4800E+02	1.8250E+02	.0000E+00	-6.1070E+02	3.2884E+02	.0000E+00	-1.3195E-03	3.2168E-03	.0000E+00	-4.2506E-03
830	-6.1200E+02	1.7375E+02	.0000E+00	-6.1723E+02	3.3235E+02	.0000E+00	-1.3324E-03	3.2382E-03	.0000E+00	-4.2952E-03
840	-5.7600E+02	1.6500E+02	.0000E+00	-6.2367E+02	3.3582E+02	.0000E+00	-1.3451E-03	3.2593E-03	.0000E+00	-4.3395E-03
850	-5.4000E+02	1.5625E+02	.0000E+00	-6.3005E+02	3.3926E+02	.0000E+00	-1.3576E-03	3.2800E-03	.0000E+00	-4.3836E-03
860	-5.0400E+02	1.4750E+02	.0000E+00	-6.3635E+02	3.4265E+02	.0000E+00	-1.3699E-03	3.3004E-03	.0000E+00	-4.4274E-03
870	-4.6800E+02	1.3875E+02	.0000E+00	-6.4258E+02	3.4601E+02	.0000E+00	-1.3821E-03	3.3205E-03	.0000E+00	-4.4709E-03
880	-4.3200E+02	1.3000E+02	.0000E+00	-6.4874E+02	3.4932E+02	.0000E+00	-1.3941E-03	3.3403E-03	.0000E+00	-4.5141E-03
890	-3.9600E+02	1.2125E+02	.0000E+00	-6.5482E+02	3.5260E+02	.0000E+00	-1.4059E-03	3.3597E-03	.0000E+00	-4.5571E-03
900	-3.6000E+02	1.1250E+02	.0000E+00	-6.6083E+02	3.5583E+02	.0000E+00	-1.4175E-03	3.3788E-03	.0000E+00	-4.5998E-03
910	-3.2400E+02	1.0375E+02	.0000E+00	-6.6676E+02	3.5903E+02	.0000E+00	-1.4290E-03	3.3976E-03	.0000E+00	-4.6422E-03
920	-2.8800E+02	9.5000E+01	.0000E+00	-6.7262E+02	3.6218E+02	.0000E+00	-1.4402E-03	3.4160E-03	.0000E+00	-4.6844E-03
930	-2.5200E+02	8.6250E+01	.0000E+00	-6.7833E+02	3.6525E+02	.0000E+00	-1.4510E-03	3.4338E-03	.0000E+00	-4.7265E-03
940	-2.1600E+02	7.7500E+01	.0000E+00	-6.8394E+02	3.6827E+02	.0000E+00	-1.4616E-03	3.4512E-03	.0000E+00	-4.7685E-03
950	-1.8000E+02	6.8750E+01	.0000E+00	-6.8947E+02	3.7125E+02	.0000E+00	-1.4719E-03	3.4683E-03	.0000E+00	-4.8101E-03
960	-1.4400E+02	6.0000E+01	.0000E+00	-6.9492E+02	3.7419E+02	.0000E+00	-1.4821E-03	3.4851E-03	.0000E+00	-4.8516E-03
970	-1.0800E+02	5.1250E+01	.0000E+00	-7.0030E+02	3.7708E+02	.0000E+00	-1.4921E-03	3.5015E-03	.0000E+00	-4.8927E-03
980	-7.2000E+01	4.2500E+01	.0000E+00	-7.0559E+02	3.7993E+02	.0000E+00	-1.5019E-03	3.5176E-03	.0000E+00	-4.9336E-03
990	-3.6000E+01	3.3750E+01	.0000E+00	-7.1081E+02	3.8274E+02	.0000E+00	-1.5115E-03	3.5333E-03	.0000E+00	-4.9742E-03
1000	.0000E+00	2.5000E+01	.0000E+00	-7.1595E+02	3.8551E+02	.0000E+00	-1.5209E-03	3.5487E-03	.0000E+00	-5.0145E-03
1010	9.0000E+00	3.1250E+01	2.5000E+00	-7.0764E+02	3.8488E+02	.0000E+00	-1.5023E-03	3.5496E-03	.0000E+00	-4.9739E-03
1020	1.8000E+01	3.7500E+01	5.0000E+00	-6.9930E+02	3.8424E+02	.0000E+00	-1.4836E-03	3.5504E-03	.0000E+00	-4.9330E-03
1030	2.7000E+01	4.3750E+01	7.5000E+00	-6.9092E+02	3.8357E+02	.0000E+00	-1.4648E-03	3.5510E-03	.0000E+00	-4.8921E-03
1040	3.6000E+01	5.0000E+01	1.0000E+01	-6.8249E+02	3.8288E+02	.0000E+00	-1.4458E-03	3.5515E-03	.0000E+00	-4.8509E-03
1050	4.5000E+01	5.6250E+01	1.2500E+01	-6.7402E+02	3.8217E+02	.0000E+00	-1.4268E-03	3.5518E-03	.0000E+00	-4.8096E-03

1060	5.4000E+01	6.2500E+01	1.5000E+01	-6.6551E+02	3.8143E+02	.0000E+00	-1.4076E-03	3.5519E-03	.0000E+00	-4.7682E-03
1070	6.3000E+01	6.8750E+01	1.7500E+01	-6.5696E+02	3.8067E+02	.0000E+00	-1.3884E-03	3.5519E-03	.0000E+00	-4.7266E-03
1080	7.2000E+01	7.5000E+01	2.0000E+01	-6.4837E+02	3.7989E+02	.0000E+00	-1.3690E-03	3.5517E-03	.0000E+00	-4.6848E-03
1090	8.1000E+01	8.1250E+01	2.2500E+01	-6.3974E+02	3.7909E+02	.0000E+00	-1.3495E-03	3.5514E-03	.0000E+00	-4.6429E-03
1100	9.0000E+01	8.7500E+01	2.5000E+01	-6.3107E+02	3.7827E+02	.0000E+00	-1.3299E-03	3.5510E-03	.0000E+00	-4.6008E-03
1110	9.9000E+01	9.3750E+01	2.7500E+01	-6.2235E+02	3.7742E+02	.0000E+00	-1.3101E-03	3.5503E-03	.0000E+00	-4.5586E-03
1120	1.0800E+02	1.0000E+02	3.0000E+01	-6.1353E+02	3.7651E+02	.0000E+00	-1.2900E-03	3.5493E-03	.0000E+00	-4.5165E-03
1130	1.1700E+02	1.0625E+02	3.2500E+01	-6.0466E+02	3.7559E+02	.0000E+00	-1.2698E-03	3.5481E-03	.0000E+00	-4.4742E-03
1140	1.2600E+02	1.1250E+02	3.5000E+01	-5.9576E+02	3.7464E+02	.0000E+00	-1.2495E-03	3.5468E-03	.0000E+00	-4.4318E-03
1150	1.3500E+02	1.1875E+02	3.7500E+01	-5.8682E+02	3.7367E+02	.0000E+00	-1.2291E-03	3.5453E-03	.0000E+00	-4.3892E-03
1160	1.4400E+02	1.2500E+02	4.0000E+01	-5.7784E+02	3.7268E+02	.0000E+00	-1.2086E-03	3.5437E-03	.0000E+00	-4.3464E-03
1170	1.5300E+02	1.3125E+02	4.2500E+01	-5.6882E+02	3.7167E+02	.0000E+00	-1.1879E-03	3.5419E-03	.0000E+00	-4.3035E-03
1180	1.6200E+02	1.3750E+02	4.5000E+01	-5.5976E+02	3.7064E+02	.0000E+00	-1.1672E-03	3.5400E-03	.0000E+00	-4.2605E-03
1190	1.7100E+02	1.4375E+02	4.7500E+01	-5.5067E+02	3.6959E+02	.0000E+00	-1.1464E-03	3.5379E-03	.0000E+00	-4.2172E-03
1200	1.8000E+02	1.5000E+02	5.0000E+01	-5.4153E+02	3.6852E+02	.0000E+00	-1.1254E-03	3.5357E-03	.0000E+00	-4.1738E-03
1210	1.8900E+02	1.7500E+02	7.2500E+01	-4.8134E+02	3.7072E+02	.0000E+00	-9.8007E-04	3.5857E-03	.0000E+00	-3.9383E-03
1220	1.9800E+02	2.0000E+02	9.5000E+01	-4.2051E+02	3.7258E+02	.0000E+00	-8.3268E-04	3.6336E-03	.0000E+00	-3.7000E-03
1230	2.0700E+02	2.2500E+02	1.1750E+02	-3.5882E+02	3.7398E+02	.0000E+00	-6.8273E-04	3.6785E-03	.0000E+00	-3.4596E-03
1240	2.1600E+02	2.5000E+02	1.4000E+02	-2.9648E+02	3.7503E+02	.0000E+00	-5.3064E-04	3.7213E-03	.0000E+00	-3.2166E-03
1250	2.2500E+02	2.7500E+02	1.6250E+02	-2.3195E+02	3.7489E+02	.0000E+00	-3.7308E-04	3.7629E-03	.0000E+00	-2.9671E-03
1260	2.3400E+02	3.0000E+02	1.8500E+02	-1.6580E+02	3.7389E+02	.0000E+00	-2.1119E-04	3.8035E-03	.0000E+00	-2.7124E-03
1270	2.4300E+02	3.2500E+02	2.0750E+02	-9.8742E+01	3.7240E+02	.0000E+00	-4.6437E-05	3.8424E-03	.0000E+00	-2.4542E-03
1280	2.5200E+02	3.5000E+02	2.3000E+02	-3.0602E+01	3.7032E+02	.0000E+00	1.2158E-04	3.8797E-03	.0000E+00	-2.1920E-03
1290	2.6100E+02	3.7500E+02	2.5250E+02	3.8446E+01	3.6776E+02	.0000E+00	2.9253E-04	3.9161E-03	.0000E+00	-1.9260E-03
1300	2.7000E+02	4.0000E+02	2.7500E+02	1.0860E+02	3.6460E+02	.0000E+00	4.6690E-04	3.9518E-03	.0000E+00	-1.6556E-03
1310	2.7900E+02	4.2500E+02	2.9750E+02	1.7946E+02	3.6106E+02	.0000E+00	6.4385E-04	3.9862E-03	.0000E+00	-1.3816E-03
1320	2.8800E+02	4.5000E+02	3.2000E+02	2.5114E+02	3.5708E+02	.0000E+00	8.2367E-04	4.0195E-03	.0000E+00	-1.1039E-03
1330	2.9700E+02	4.7500E+02	3.4250E+02	3.2352E+02	3.5272E+02	.0000E+00	1.0061E-03	4.0518E-03	.0000E+00	-8.2251E-04
1340	3.0600E+02	5.0000E+02	3.6500E+02	3.9789E+02	3.4729E+02	.0000E+00	1.1942E-03	4.0854E-03	.0000E+00	-5.3457E-04
1350	3.1500E+02	5.2500E+02	3.8750E+02	4.8082E+02	3.3725E+02	.0000E+00	1.4046E-03	4.1383E-03	.0000E+00	-2.2335E-04
1360	3.2400E+02	5.5000E+02	4.1000E+02	5.6419E+02	3.2697E+02	.0000E+00	1.6174E-03	4.1900E-03	.0000E+00	9.1454E-05
1370	3.3300E+02	5.7500E+02	4.3250E+02	6.4814E+02	3.1638E+02	.0000E+00	1.8331E-03	4.2413E-03	.0000E+00	4.1019E-04
1380	3.4200E+02	6.0000E+02	4.5500E+02	7.4348E+02	2.9966E+02	.0000E+00	2.0793E-03	4.3198E-03	.0000E+00	7.6035E-04
1390	3.5100E+02	6.2500E+02	4.7750E+02	8.6605E+02	2.6828E+02	.0000E+00	2.3978E-03	4.4671E-03	.0000E+00	1.1837E-03
1400	3.6000E+02	6.5000E+02	5.0000E+02	1.0297E+03	2.1476E+02	.0000E+00	2.8271E-03	4.7223E-03	.0000E+00	1.7188E-03
1410	3.6900E+02	6.2500E+02	4.7750E+02	9.7267E+02	2.1087E+02	.0000E+00	2.6759E-03	4.7452E-03	.0000E+00	1.4618E-03
1420	3.7800E+02	6.0000E+02	4.5500E+02	9.0504E+02	2.1267E+02	.0000E+00	2.4982E-03	4.7387E-03	.0000E+00	1.1792E-03
1430	3.8700E+02	5.7500E+02	4.3250E+02	8.3201E+02	2.1738E+02	.0000E+00	2.3078E-03	4.7160E-03	.0000E+00	8.8487E-04
1440	3.9600E+02	5.5000E+02	4.1000E+02	7.5925E+02	2.2194E+02	.0000E+00	2.1192E-03	4.6917E-03	.0000E+00	5.9322E-04
1450	4.0500E+02	5.2500E+02	3.8750E+02	6.8701E+02	2.2622E+02	.0000E+00	1.9330E-03	4.6667E-03	.0000E+00	3.0505E-04
1460	4.1400E+02	5.0000E+02	3.6500E+02	6.1542E+02	2.3016E+02	.0000E+00	1.7494E-03	4.6406E-03	.0000E+00	2.0602E-05
1470	4.2300E+02	4.7500E+02	3.4250E+02	5.4443E+02	2.3377E+02	.0000E+00	1.5682E-03	4.6139E-03	.0000E+00	-2.6042E-04
1480	4.3200E+02	4.5000E+02	3.2000E+02	4.7428E+02	2.3693E+02	.0000E+00	1.3900E-03	4.5859E-03	.0000E+00	-5.3751E-04
1490	4.4100E+02	4.2500E+02	2.9750E+02	4.0474E+02	2.3975E+02	.0000E+00	1.2142E-03	4.5566E-03	.0000E+00	-8.1126E-04
1500	4.5000E+02	4.0000E+02	2.7500E+02	3.3592E+02	2.4220E+02	.0000E+00	1.0410E-03	4.5259E-03	.0000E+00	-1.0815E-03
1510	4.5900E+02	3.7500E+02	2.5250E+02	2.6773E+02	2.4430E+02	.0000E+00	8.7020E-04	4.4938E-03	.0000E+00	-1.3483E-03
1520	4.6800E+02	3.5000E+02	2.3000E+02	2.0046E+02	2.4591E+02	.0000E+00	7.0232E-04	4.4605E-03	.0000E+00	-1.6113E-03
1530	4.7700E+02	3.2500E+02	2.0750E+02	1.3397E+02	2.4709E+02	.0000E+00	5.3705E-04	4.4259E-03	.0000E+00	-1.8707E-03
1540	4.8600E+02	3.0000E+02	1.8500E+02	6.8443E+01	2.4776E+02	.0000E+00	3.7472E-04	4.3894E-03	.0000E+00	-2.1265E-03
1550	4.9500E+02	2.7500E+02	1.6250E+02	3.7437E+00	2.4798E+02	.0000E+00	2.1503E-04	4.3510E-03	.0000E+00	-2.3790E-03
1560	5.0400E+02	2.5000E+02	1.4000E+02	-5.9601E+01	2.4748E+02	.0000E+00	5.9021E-05	4.3109E-03	.0000E+00	-2.6269E-03
1570	5.1300E+02	2.2500E+02	1.1750E+02	-1.2114E+02	2.4600E+02	.0000E+00	-9.2463E-05	4.2688E-03	.0000E+00	-2.8694E-03
1580	5.2200E+02	2.0000E+02	9.5000E+01	-1.8203E+02	2.4417E+02	.0000E+00	-2.4182E-04	4.2244E-03	.0000E+00	-3.1091E-03
1590	5.3100E+02	1.7500E+02	7.2500E+01	-2.4206E+02	2.4188E+02	.0000E+00	-3.8861E-04	4.1771E-03	.0000E+00	-3.3469E-03
1600	5.4000E+02	1.5000E+02	5.0000E+01	-3.0146E+02	2.3925E+02	.0000E+00	-5.3335E-04	4.1277E-03	.0000E+00	-3.5818E-03
1610	5.4900E+02	1.7500E+02	7.2500E+01	-2.4206E+02	2.4188E+02	.0000E+00	-3.8861E-04	4.1771E-03	.0000E+00	-3.3469E-03
1620	5.5800E+02	2.0000E+02	9.5000E+01	-1.8203E+02	2.4417E+02	.0000E+00	-2.4182E-04	4.2244E-03	.0000E+00	-3.1091E-03
1630	5.6700E+02	2.2500E+02	1.1750E+02	-1.2114E+02	2.4600E+02	.0000E+00	-9.2463E-05	4.2688E-03	.0000E+00	-2.8694E-03
1640	5.7600E+02	2.5000E+02	1.4000E+02	-5.9601E+01	2.4748E+02	.0000E+00	5.9021E-05	4.3109E-03	.0000E+00	-2.6269E-03
1650	5.8500E+02	2.7500E+02	1.6250E+02	3.7437E+00	2.4798E+02	.0000E+00	2.1503E-04	4.3510E-03	.0000E+00	-2.3790E-03
1660	5.9400E+02	3.0000E+02	1.8500E+02	6.8443E+01	2.4776E+02	.0000E+00	3.7472E-04	4.3894E-03	.0000E+00	-2.1265E-03

1670	6.0300E+02	3.2500E+02	2.0750E+02	1.3397E+02	2.4709E+02	.0000E+00	5.3705E-04	4.4259E-03	.0000E+00	-1.8707E-03	
1680	6.1200E+02	3.5000E+02	2.3000E+02	2.0046E+02	2.4591E+02	.0000E+00	7.0232E-04	4.4605E-03	.0000E+00	-1.6113E-03	
1690	6.2100E+02	3.7500E+02	2.5250E+02	2.6773E+02	2.4430E+02	.0000E+00	8.7020E-04	4.4938E-03	.0000E+00	-1.3483E-03	
1700	6.3000E+02	4.0000E+02	2.7500E+02	3.3592E+02	2.4220E+02	.0000E+00	1.0410E-03	4.5259E-03	.0000E+00	-1.0815E-03	
1710	6.3900E+02	4.2500E+02	2.9750E+02	4.0474E+02	2.3975E+02	.0000E+00	1.2142E-03	4.5566E-03	.0000E+00	-8.1126E-04	
1720	6.4800E+02	4.5000E+02	3.2000E+02	4.7428E+02	2.3693E+02	.0000E+00	1.3900E-03	4.5859E-03	.0000E+00	-5.3751E-04	
1730	6.5700E+02	4.7500E+02	3.4250E+02	5.4443E+02	2.3377E+02	.0000E+00	1.5682E-03	4.6139E-03	.0000E+00	-2.6042E-04	
1740	6.6600E+02	5.0000E+02	3.6500E+02	6.1542E+02	2.3016E+02	.0000E+00	1.7494E-03	4.6406E-03	.0000E+00	2.0602E-05	
1750	6.7500E+02	5.2500E+02	3.8750E+02	6.8701E+02	2.2622E+02	.0000E+00	1.9330E-03	4.6667E-03	.0000E+00	3.0505E-04	
1760	6.8400E+02	5.5000E+02	4.1000E+02	7.5925E+02	2.2194E+02	.0000E+00	2.1192E-03	4.6917E-03	.0000E+00	5.9322E-04	
1770	6.9300E+02	5.7500E+02	4.3250E+02	8.3215E+02	2.1730E+02	.0000E+00	2.3081E-03	4.7163E-03	.0000E+00	8.8519E-04	
1780	7.0200E+02	6.0000E+02	4.5500E+02	9.1256E+02	2.0862E+02	.0000E+00	2.5171E-03	4.7576E-03	.0000E+00	1.1981E-03	
1790	7.1100E+02	6.2500E+02	4.7750E+02	9.9579E+02	1.9842E+02	.0000E+00	2.7348E-03	4.8041E-03	.0000E+00	1.5207E-03	
1800	7.2000E+02	6.5000E+02	5.0000E+02	1.0881E+03	1.8332E+02	.0000E+00	2.9781E-03	4.8733E-03	.0000E+00	1.8698E-03	
1810	7.2900E+02	6.2500E+02	4.7750E+02	1.0234E+03	1.8357E+02	.0000E+00	2.8066E-03	4.8758E-03	.0000E+00	1.5925E-03	
1820	7.3800E+02	6.0000E+02	4.5500E+02	9.5258E+02	1.8707E+02	.0000E+00	2.6205E-03	4.8610E-03	.0000E+00	1.3015E-03	
1830	7.4700E+02	5.7500E+02	4.3250E+02	8.8003E+02	1.9152E+02	.0000E+00	2.4310E-03	4.8392E-03	.0000E+00	1.0081E-03	
1840	7.5600E+02	5.5000E+02	4.1000E+02	8.0791E+02	1.9574E+02	.0000E+00	2.2437E-03	4.8162E-03	.0000E+00	7.1774E-04	
1850	7.6500E+02	5.2500E+02	3.8750E+02	7.3630E+02	1.9969E+02	.0000E+00	2.0588E-03	4.7925E-03	.0000E+00	4.3083E-04	
1860	7.7400E+02	5.0000E+02	3.6500E+02	6.6529E+02	2.0331E+02	.0000E+00	1.8763E-03	4.7676E-03	.0000E+00	1.4756E-04	
1870	7.8300E+02	4.7500E+02	3.4250E+02	5.9484E+02	2.0662E+02	.0000E+00	1.6963E-03	4.7419E-03	.0000E+00	-1.3239E-04	
1880	7.9200E+02	4.5000E+02	3.2000E+02	5.2520E+02	2.0951E+02	.0000E+00	1.5190E-03	4.7149E-03	.0000E+00	-4.0851E-04	
1890	8.0100E+02	4.2500E+02	2.9750E+02	4.5615E+02	2.1207E+02	.0000E+00	1.3442E-03	4.6865E-03	.0000E+00	-6.8134E-04	
1900	8.1000E+02	4.0000E+02	2.7500E+02	3.8779E+02	2.1427E+02	.0000E+00	1.1718E-03	4.6567E-03	.0000E+00	-9.5069E-04	
1910	8.1900E+02	3.7500E+02	2.5250E+02	3.2005E+02	2.1612E+02	.0000E+00	1.0018E-03	4.6253E-03	.0000E+00	-1.2168E-03	
1920	8.2800E+02	3.5000E+02	2.3000E+02	2.5319E+02	2.1751E+02	.0000E+00	8.3460E-04	4.5928E-03	.0000E+00	-1.4790E-03	
	1930	8.3700E+02	3.2500E+02	2.0750E+02	1.8708E+02	2.1849E+02	.0000E+00	6.6995E-04	4.5588E-03	.0000E+00	-1.7378E-03
1940	8.4600E+02	3.0000E+02	1.8500E+02	1.2190E+02	2.1898E+02	.0000E+00	5.0817E-04	4.5229E-03	.0000E+00	-1.9931E-03	
1950	8.5500E+02	2.7500E+02	1.6250E+02	5.7533E+01	2.1902E+02	.0000E+00	3.4899E-04	4.4850E-03	.0000E+00	-2.2450E-03	
1960	8.6400E+02	2.5000E+02	1.4000E+02	-5.5415E+00	2.1837E+02	.0000E+00	1.9333E-04	4.4452E-03	.0000E+00	-2.4926E-03	
1970	8.7300E+02	2.2500E+02	1.1750E+02	-6.6900E+01	2.1679E+02	.0000E+00	4.1986E-05	4.4032E-03	.0000E+00	-2.7349E-03	
1980	8.8200E+02	2.0000E+02	9.5000E+01	-1.2761E+02	2.1487E+02	.0000E+00	-1.0724E-04	4.3590E-03	.0000E+00	-2.9745E-03	
1990	8.9100E+02	1.7500E+02	7.2500E+01	-1.8746E+02	2.1248E+02	.0000E+00	-2.5389E-04	4.3118E-03	.0000E+00	-3.2121E-03	
2000	9.0000E+02	1.5000E+02	5.0000E+01	-2.4667E+02	2.0974E+02	.0000E+00	-3.9849E-04	4.2626E-03	.0000E+00	-3.4469E-03	
2010	9.0900E+02	1.7500E+02	7.2500E+01	-1.8746E+02	2.1248E+02	.0000E+00	-2.5389E-04	4.3118E-03	.0000E+00	-3.2121E-03	
2020	9.1800E+02	2.0000E+02	9.5000E+01	-1.2761E+02	2.1487E+02	.0000E+00	-1.0724E-04	4.3590E-03	.0000E+00	-2.9745E-03	
2030	9.2700E+02	2.2500E+02	1.1750E+02	-6.6900E+01	2.1679E+02	.0000E+00	4.1986E-05	4.4032E-03	.0000E+00	-2.7349E-03	
2040	9.3600E+02	2.5000E+02	1.4000E+02	-5.5415E+00	2.1837E+02	.0000E+00	1.9333E-04	4.4452E-03	.0000E+00	-2.4926E-03	
2050	9.4500E+02	2.7500E+02	1.6250E+02	5.7533E+01	2.1902E+02	.0000E+00	3.4899E-04	4.4850E-03	.0000E+00	-2.2450E-03	
2060	9.5400E+02	3.0000E+02	1.8500E+02	1.2190E+02	2.1898E+02	.0000E+00	5.0817E-04	4.5229E-03	.0000E+00	-1.9931E-03	
2070	9.6300E+02	3.2500E+02	2.0750E+02	1.8708E+02	2.1849E+02	.0000E+00	6.6995E-04	4.5588E-03	.0000E+00	-1.7378E-03	
2080	9.7200E+02	3.5000E+02	2.3000E+02	2.5319E+02	2.1751E+02	.0000E+00	8.3460E-04	4.5928E-03	.0000E+00	-1.4790E-03	
2090	9.8100E+02	3.7500E+02	2.5250E+02	3.2005E+02	2.1612E+02	.0000E+00	1.0018E-03	4.6253E-03	.0000E+00	-1.2168E-03	
2100	9.9000E+02	4.0000E+02	2.7500E+02	3.8779E+02	2.1427E+02	.0000E+00	1.1718E-03	4.6567E-03	.0000E+00	-9.5069E-04	
2110	9.9900E+02	4.2500E+02	2.9750E+02	4.5615E+02	2.1207E+02	.0000E+00	1.3442E-03	4.6865E-03	.0000E+00	-6.8134E-04	
2120	1.0080E+03	4.5000E+02	3.2000E+02	5.2520E+02	2.0951E+02	.0000E+00	1.5190E-03	4.7149E-03	.0000E+00	-4.0851E-04	
2130	1.0170E+03	4.7500E+02	3.4250E+02	5.9484E+02	2.0662E+02	.0000E+00	1.6963E-03	4.7419E-03	.0000E+00	-1.3239E-04	
2140	1.0260E+03	5.0000E+02	3.6500E+02	6.6529E+02	2.0331E+02	.0000E+00	1.8763E-03	4.7676E-03	.0000E+00	1.4756E-04	
	2150	1.0350E+03	5.2500E+02	3.8750E+02	7.3630E+02	1.9969E+02	.0000E+00	2.0588E-03	4.7925E-03	.0000E+00	4.3083E-04
2160	1.0440E+03	5.5000E+02	4.1000E+02	8.0791E+02	1.9574E+02	.0000E+00	2.2437E-03	4.8162E-03	.0000E+00	7.1774E-04	
2170	1.0530E+03	5.7500E+02	4.3250E+02	8.8003E+02	1.9152E+02	.0000E+00	2.4310E-03	4.8392E-03	.0000E+00	1.0081E-03	
2180	1.0620E+03	6.0000E+02	4.5500E+02	9.5646E+02	1.8498E+02	.0000E+00	2.6302E-03	4.8707E-03	.0000E+00	1.3112E-03	
2190	1.0710E+03	6.2500E+02	4.7750E+02	1.0356E+03	1.7696E+02	.0000E+00	2.8378E-03	4.9070E-03	.0000E+00	1.6237E-03	
	2200	1.0800E+03	6.5000E+02	5.0000E+02	1.1206E+03	1.6584E+02	.0000E+00	3.0620E-03	4.9572E-03	.0000E+00	1.9537E-03
2210	1.0890E+03	6.2500E+02	4.7750E+02	1.0521E+03	1.6807E+02	.0000E+00	2.8807E-03	4.9500E-03	.0000E+00	1.6666E-03	
2220	1.0980E+03	6.0000E+02	4.5500E+02	9.8042E+02	1.7208E+02	.0000E+00	2.6920E-03	4.9326E-03	.0000E+00	1.3731E-03	
2230	1.1070E+03	5.7500E+02	4.3250E+02	9.0823E+02	1.7634E+02	.0000E+00	2.5033E-03	4.9115E-03	.0000E+00	1.0804E-03	
2240	1.1160E+03	5.5000E+02	4.1000E+02	8.3649E+02	1.8035E+02	.0000E+00	2.3168E-03	4.8893E-03	.0000E+00	7.9085E-04	
2250	1.1250E+03	5.2500E+02	3.8750E+02	7.6524E+02	1.8410E+02	.0000E+00	2.1326E-03	4.8663E-03	.0000E+00	5.0467E-04	
2260	1.1340E+03	5.0000E+02	3.6500E+02	6.9457E+02	1.8754E+02	.0000E+00	1.9509E-03	4.8421E-03	.0000E+00	2.2208E-04	

2270	1.1430E+03	4.7500E+02	3.4250E+02	6.2445E+02	1.9068E+02	.0000E+00	1.7714E-03	4.8171E-03	.0000E+00	-5.7225E-05
2280	1.1520E+03	4.5000E+02	3.2000E+02	5.5511E+02	1.9340E+02	.0000E+00	1.5948E-03	4.7906E-03	.0000E+00	-3.3277E-04
2290	1.1610E+03	4.2500E+02	2.9750E+02	4.8635E+02	1.9581E+02	.0000E+00	1.4204E-03	4.7628E-03	.0000E+00	-6.0506E-04
2300	1.1700E+03	4.0000E+02	2.7500E+02	4.1826E+02	1.9786E+02	.0000E+00	1.2486E-03	4.7335E-03	.0000E+00	-8.7392E-04
2310	1.1790E+03	3.7500E+02	2.5250E+02	3.5078E+02	1.9958E+02	.0000E+00	1.0790E-03	4.7026E-03	.0000E+00	-1.1395E-03
2320	1.1880E+03	3.5000E+02	2.3000E+02	2.8416E+02	2.0084E+02	.0000E+00	9.1225E-04	4.6704E-03	.0000E+00	-1.4014E-03
2330	1.1970E+03	3.2500E+02	2.0750E+02	2.1827E+02	2.0170E+02	.0000E+00	7.4797E-04	4.6368E-03	.0000E+00	-1.6598E-03
2340	1.2060E+03	3.0000E+02	1.8500E+02	1.5330E+02	2.0207E+02	.0000E+00	5.8652E-04	4.6012E-03	.0000E+00	-1.9147E-03
2350	1.2150E+03	2.7500E+02	1.6250E+02	8.9122E+01	2.0201E+02	.0000E+00	4.2763E-04	4.5636E-03	.0000E+00	-2.1664E-03
2360	1.2240E+03	2.5000E+02	1.4000E+02	2.6206E+01	2.0127E+02	.0000E+00	2.7218E-04	4.5241E-03	.0000E+00	-2.4137E-03
2370	1.2330E+03	2.2500E+02	1.1750E+02	-3.5045E+01	1.9964E+02	.0000E+00	1.2092E-04	4.4822E-03	.0000E+00	-2.6560E-03
2380	1.2420E+03	2.0000E+02	9.5000E+01	-9.5647E+01	1.9766E+02	.0000E+00	-2.8226E-05	4.4380E-03	.0000E+00	-2.8955E-03
2390	1.2510E+03	1.7500E+02	7.2500E+01	-1.5539E+02	1.9521E+02	.0000E+00	-1.7480E-04	4.3909E-03	.0000E+00	-3.1331E-03
2400	1.2600E+03	1.5000E+02	5.0000E+01	-2.1449E+02	1.9242E+02	.0000E+00	-3.1933E-04	4.3417E-03	.0000E+00	-3.3678E-03
2410	1.2690E+03	1.7500E+02	7.2500E+01	-1.5539E+02	1.9521E+02	.0000E+00	-1.7480E-04	4.3909E-03	.0000E+00	-3.1331E-03
2420	1.2780E+03	2.0000E+02	9.5000E+01	-9.5647E+01	1.9766E+02	.0000E+00	-2.8226E-05	4.4380E-03	.0000E+00	-2.8955E-03
2430	1.2870E+03	2.2500E+02	1.1750E+02	-3.5045E+01	1.9964E+02	.0000E+00	1.2092E-04	4.4822E-03	.0000E+00	-2.6560E-03
2440	1.2960E+03	2.5000E+02	1.4000E+02	2.6206E+01	2.0127E+02	.0000E+00	2.7218E-04	4.5241E-03	.0000E+00	-2.4137E-03
2450	1.3050E+03	2.7500E+02	1.6250E+02	8.9122E+01	2.0201E+02	.0000E+00	4.2763E-04	4.5636E-03	.0000E+00	-2.1664E-03
2460	1.3140E+03	3.0000E+02	1.8500E+02	1.5330E+02	2.0207E+02	.0000E+00	5.8652E-04	4.6012E-03	.0000E+00	-1.9147E-03
2470	1.3230E+03	3.2500E+02	2.0750E+02	2.1827E+02	2.0170E+02	.0000E+00	7.4797E-04	4.6368E-03	.0000E+00	-1.6598E-03
2480	1.3320E+03	3.5000E+02	2.3000E+02	2.8416E+02	2.0084E+02	.0000E+00	9.1225E-04	4.6704E-03	.0000E+00	-1.4014E-03
2490	1.3410E+03	3.7500E+02	2.5250E+02	3.5078E+02	1.9958E+02	.0000E+00	1.0790E-03	4.7026E-03	.0000E+00	-1.1395E-03
2500	1.3500E+03	4.0000E+02	2.7500E+02	4.1826E+02	1.9786E+02	.0000E+00	1.2486E-03	4.7335E-03	.0000E+00	-8.7392E-04
2510	1.3590E+03	4.2500E+02	2.9750E+02	4.8635E+02	1.9581E+02	.0000E+00	1.4204E-03	4.7628E-03	.0000E+00	-6.0506E-04
2520	1.3680E+03	4.5000E+02	3.2000E+02	5.5511E+02	1.9340E+02	.0000E+00	1.5948E-03	4.7906E-03	.0000E+00	-3.3277E-04
2530	1.3770E+03	4.7500E+02	3.4250E+02	6.2445E+02	1.9068E+02	.0000E+00	1.7714E-03	4.8171E-03	.0000E+00	-5.7225E-05
2540	1.3860E+03	5.0000E+02	3.6500E+02	6.9457E+02	1.8754E+02	.0000E+00	1.9509E-03	4.8421E-03	.0000E+00	2.2208E-04
2550	1.3950E+03	5.2500E+02	3.8750E+02	7.6524E+02	1.8410E+02	.0000E+00	2.1326E-03	4.8663E-03	.0000E+00	5.0467E-04
2560	1.4040E+03	5.5000E+02	4.1000E+02	8.3649E+02	1.8035E+02	.0000E+00	2.3168E-03	4.8893E-03	.0000E+00	7.9085E-04
2570	1.4130E+03	5.7500E+02	4.3250E+02	9.0823E+02	1.7634E+02	.0000E+00	2.5033E-03	4.9115E-03	.0000E+00	1.0804E-03
2580	1.4220E+03	6.0000E+02	4.5500E+02	9.8237E+02	1.7103E+02	.0000E+00	2.6969E-03	4.9374E-03	.0000E+00	1.3779E-03
2590	1.4310E+03	6.2500E+02	4.7750E+02	1.0598E+03	1.6394E+02	.0000E+00	2.9002E-03	4.9694E-03	.0000E+00	1.6861E-03
2600	1.4400E+03	6.5000E+02	5.0000E+02	1.1413E+03	1.5469E+02	.0000E+00	3.1155E-03	5.0108E-03	.0000E+00	2.0073E-03
2610	1.4490E+03	6.2500E+02	4.7750E+02	1.0713E+03	1.5776E+02	.0000E+00	2.9301E-03	4.9994E-03	.0000E+00	1.7160E-03
2620	1.4580E+03	6.0000E+02	4.5500E+02	9.9929E+02	1.6192E+02	.0000E+00	2.7406E-03	4.9811E-03	.0000E+00	1.4216E-03
2630	1.4670E+03	5.7500E+02	4.3250E+02	9.2735E+02	1.6604E+02	.0000E+00	2.5524E-03	4.9605E-03	.0000E+00	1.1294E-03
2640	1.4760E+03	5.5000E+02	4.1000E+02	8.5587E+02	1.6991E+02	.0000E+00	2.3664E-03	4.9389E-03	.0000E+00	8.4044E-04
2650	1.4850E+03	5.2500E+02	3.8750E+02	7.8486E+02	1.7353E+02	.0000E+00	2.1827E-03	4.9164E-03	.0000E+00	5.5477E-04
2660	1.4940E+03	5.0000E+02	3.6500E+02	7.1443E+02	1.7684E+02	.0000E+00	2.0014E-03	4.8926E-03	.0000E+00	2.7264E-04
2670	1.5030E+03	4.7500E+02	3.4250E+02	6.4453E+02	1.7987E+02	.0000E+00	1.8224E-03	4.8681E-03	.0000E+00	-6.2381E-06
2680	1.5120E+03	4.5000E+02	3.2000E+02	5.7539E+02	1.8248E+02	.0000E+00	1.6462E-03	4.8420E-03	.0000E+00	-2.8140E-04
2690	1.5210E+03	4.2500E+02	2.9750E+02	5.0682E+02	1.8479E+02	.0000E+00	1.4722E-03	4.8146E-03	.0000E+00	-5.5332E-04
2700	1.5300E+03	4.0000E+02	2.7500E+02	4.3892E+02	1.8673E+02	.0000E+00	1.3007E-03	4.7856E-03	.0000E+00	-8.2184E-04
2710	1.5390E+03	3.7500E+02	2.5250E+02	3.7162E+02	1.8836E+02	.0000E+00	1.1314E-03	4.7550E-03	.0000E+00	-1.0871E-03
2720	1.5480E+03	3.5000E+02	2.3000E+02	3.0516E+02	1.8953E+02	.0000E+00	9.6493E-04	4.7231E-03	.0000E+00	-1.3487E-03
2730	1.5570E+03	3.2500E+02	2.0750E+02	2.3943E+02	1.9031E+02	.0000E+00	8.0090E-04	4.6898E-03	.0000E+00	-1.6068E-03
2740	1.5660E+03	3.0000E+02	1.8500E+02	1.7459E+02	1.9061E+02	.0000E+00	6.3967E-04	4.6544E-03	.0000E+00	-1.8616E-03
2750	1.5750E+03	2.7500E+02	1.6250E+02	1.1055E+02	1.9048E+02	.0000E+00	4.8098E-04	4.6170E-03	.0000E+00	-2.1131E-03
2760	1.5840E+03	2.5000E+02	1.4000E+02	4.7738E+01	1.8968E+02	.0000E+00	3.2567E-04	4.5776E-03	.0000E+00	-2.3603E-03
2770	1.5930E+03	2.2500E+02	1.1750E+02	-1.3441E+01	1.8801E+02	.0000E+00	1.7446E-04	4.5357E-03	.0000E+00	-2.6024E-03
2780	1.6020E+03	2.0000E+02	9.5000E+01	-7.3970E+01	1.8598E+02	.0000E+00	2.5370E-05	4.4916E-03	.0000E+00	-2.8419E-03
2790	1.6110E+03	1.7500E+02	7.2500E+01	-1.3364E+02	1.8350E+02	.0000E+00	-1.2115E-04	4.4446E-03	.0000E+00	-3.0794E-03
2800	1.6200E+03	1.5000E+02	5.0000E+01	-1.9267E+02	1.8067E+02	.0000E+00	-2.6562E-04	4.3954E-03	.0000E+00	-3.3141E-03
2810	1.6290E+03	1.7500E+02	7.2500E+01	-1.3364E+02	1.8350E+02	.0000E+00	-1.2115E-04	4.4446E-03	.0000E+00	-3.0794E-03
2820	1.6380E+03	2.0000E+02	9.5000E+01	-7.3970E+01	1.8598E+02	.0000E+00	2.5370E-05	4.4916E-03	.0000E+00	-2.8419E-03
2830	1.6470E+03	2.2500E+02	1.1750E+02	-1.3441E+01	1.8801E+02	.0000E+00	1.7446E-04	4.5357E-03	.0000E+00	-2.6024E-03
2840	1.6560E+03	2.5000E+02	1.4000E+02	4.7738E+01	1.8968E+02	.0000E+00	3.2567E-04	4.5776E-03	.0000E+00	-2.3603E-03
2850	1.6650E+03	2.7500E+02	1.6250E+02	1.1055E+02	1.9048E+02	.0000E+00	4.8098E-04	4.6170E-03	.0000E+00	-2.1131E-03
2860	1.6740E+03	3.0000E+02	1.8500E+02	1.7459E+02	1.9061E+02	.0000E+00	6.3967E-04	4.6544E-03	.0000E+00	-1.8616E-03
2870	1.6830E+03	3.2500E+02	2.0750E+02	2.3943E+02	1.9031E+02	.0000E+00	8.0090E-04	4.6898E-03	.0000E+00	-1.6068E-03

2880	1.6920E+03	3.5000E+02	2.3000E+02	3.0516E+02	1.8953E+02	.0000E+00	9.6493E-04	4.7231E-03	.0000E+00	-1.3487E-03
2890	1.7010E+03	3.7500E+02	2.5250E+02	3.7162E+02	1.8836E+02	.0000E+00	1.1314E-03	4.7550E-03	.0000E+00	-1.0871E-03
2900	1.7100E+03	4.0000E+02	2.7500E+02	4.3892E+02	1.8673E+02	.0000E+00	1.3007E-03	4.7856E-03	.0000E+00	-8.2184E-04
2910	1.7190E+03	4.2500E+02	2.9750E+02	5.0682E+02	1.8479E+02	.0000E+00	1.4722E-03	4.8146E-03	.0000E+00	-5.5332E-04
2920	1.7280E+03	4.5000E+02	3.2000E+02	5.7539E+02	1.8248E+02	.0000E+00	1.6462E-03	4.8420E-03	.0000E+00	-2.8140E-04
2930	1.7370E+03	4.7500E+02	3.4250E+02	6.4453E+02	1.7987E+02	.0000E+00	1.8224E-03	4.8681E-03	.0000E+00	-6.2381E-06
2940	1.7460E+03	5.0000E+02	3.6500E+02	7.1443E+02	1.7684E+02	.0000E+00	2.0014E-03	4.8926E-03	.0000E+00	2.7264E-04
2950	1.7550E+03	5.2500E+02	3.8750E+02	7.8486E+02	1.7353E+02	.0000E+00	2.1827E-03	4.9164E-03	.0000E+00	5.5477E-04
2960	1.7640E+03	5.5000E+02	4.1000E+02	8.5587E+02	1.6991E+02	.0000E+00	2.3664E-03	4.9389E-03	.0000E+00	8.4044E-04
2970	1.7730E+03	5.7500E+02	4.3250E+02	9.2735E+02	1.6604E+02	.0000E+00	2.5524E-03	4.9605E-03	.0000E+00	1.1294E-03
2980	1.7820E+03	6.0000E+02	4.5500E+02	1.0001E+03	1.6148E+02	.0000E+00	2.7426E-03	4.9831E-03	.0000E+00	1.4236E-03
2990	1.7910E+03	6.2500E+02	4.7750E+02	1.0764E+03	1.5500E+02	.0000E+00	2.9430E-03	5.0123E-03	.0000E+00	1.7289E-03
3000	1.8000E+03	6.5000E+02	5.0000E+02	1.1559E+03	1.4681E+02	.0000E+00	3.1534E-03	5.0486E-03	.0000E+00	2.0451E-03
3010	1.8090E+03	6.2500E+02	4.7750E+02	1.0852E+03	1.5025E+02	.0000E+00	2.9660E-03	5.0353E-03	.0000E+00	1.7519E-03
3020	1.8180E+03	6.0000E+02	4.5500E+02	1.0132E+03	1.5445E+02	.0000E+00	2.7763E-03	5.0168E-03	.0000E+00	1.4573E-03
3030	1.8270E+03	5.7500E+02	4.3250E+02	9.4143E+02	1.5846E+02	.0000E+00	2.5885E-03	4.9967E-03	.0000E+00	1.1656E-03
3040	1.8360E+03	5.5000E+02	4.1000E+02	8.7014E+02	1.6223E+02	.0000E+00	2.4030E-03	4.9755E-03	.0000E+00	8.7698E-041
3050	1.8450E+03	5.2500E+02	3.8750E+02	7.9932E+02	1.6575E+02	.0000E+00	2.2196E-03	4.9533E-03	.0000E+00	5.9167E-04
3060	1.8540E+03	5.0000E+02	3.6500E+02	7.2905E+02	1.6897E+02	.0000E+00	2.0387E-03	4.9299E-03	.0000E+00	3.0989E-04
3070	1.8630E+03	4.7500E+02	3.4250E+02	6.5931E+02	1.7191E+02	.0000E+00	1.8600E-03	4.9056E-03	.0000E+00	3.1327E-05
3080	1.8720E+03	4.5000E+02	3.2000E+02	5.9033E+02	1.7444E+02	.0000E+00	1.6840E-03	4.8798E-03	.0000E+00	-2.4355E-04
3090	1.8810E+03	4.2500E+02	2.9750E+02	5.2190E+02	1.7667E+02	.0000E+00	1.5103E-03	4.8527E-03	.0000E+00	-5.1520E-04
3100	1.8900E+03	4.0000E+02	2.7500E+02	4.5413E+02	1.7854E+02	.0000E+00	1.3390E-03	4.8239E-03	.0000E+00	-7.8347E-04
3110	1.8990E+03	3.7500E+02	2.5250E+02	3.8697E+02	1.8009E+02	.0000E+00	1.1700E-03	4.7936E-03	.0000E+00	-1.0485E-03
3120	1.9080E+03	3.5000E+02	2.3000E+02	3.2062E+02	1.8120E+02	.0000E+00	1.0037E-03	4.7619E-03	.0000E+00	-1.3099E-03
3130	1.9170E+03	3.2500E+02	2.0750E+02	2.5500E+02	1.8192E+02	.0000E+00	8.3990E-04	4.7288E-03	.0000E+00	-1.5678E-03
3140	1.9260E+03	3.0000E+02	1.8500E+02	1.9026E+02	1.8217E+02	.0000E+00	6.7882E-04	4.6935E-03	.0000E+00	-1.8224E-03
3150	1.9350E+03	2.7500E+02	1.6250E+02	1.2632E+02	1.8198E+02	.0000E+00	5.2028E-04	4.6563E-03	.0000E+00	-2.0738E-03
3160	1.9440E+03	2.5000E+02	1.4000E+02	6.3590E+01	1.8114E+02	.0000E+00	3.6508E-04	4.6170E-03	.0000E+00	-2.3208E-03
3170	1.9530E+03	2.2500E+02	1.1750E+02	2.4649E+00	1.7944E+02	.0000E+00	2.1391E-04	4.5751E-03	.0000E+00	-2.5630E-03
3180	1.9620E+03	2.0000E+02	9.5000E+01	-5.8010E+01	1.7739E+02	.0000E+00	6.4858E-05	4.5311E-03	.0000E+00	-2.8024E-03
3190	1.9710E+03	1.7500E+02	7.2500E+01	-1.1762E+02	1.7487E+02	.0000E+00	-8.1627E-05	4.4841E-03	.0000E+00	-3.0399E-03
3200	1.9800E+03	1.5000E+02	5.0000E+01	-1.7660E+02	1.7202E+02	.0000E+00	-2.2606E-04	4.4350E-03	.0000E+00	-3.2745E-03

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*   F I D E P 2 - VERSION 6
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***** PROBLEM TITLE *****
Uniaxial Test of [90] Ply Damage Model

***** GEOMETRY TYPE *****
1-D Laminate Model

***** LOADING TYPE *****
Strain Control

***** LOADING HISTORY *****
POINTS IN HISTORY 8

      Step      Time      Temperature  Axial Strain
    .0000E+00    .0000E+00    2.3000E+01    .0000E+00
    1.0000E+03    3.9000E+01    2.3000E+01    3.2500E-03
    2.0000E+03    7.8000E+01    2.3000E+01    .0000E+00
    3.0000E+03    1.5660E+02    2.3000E+01    6.5500E-03
    4.0000E+03    2.3630E+02    2.3000E+01    .0000E+00
    5.0000E+03    3.8530E+02    2.3000E+01    1.2500E-02
    6.0000E+03    5.3530E+02    2.3000E+01    .0000E+00
    7.0000E+03    7.1530E+02    2.3000E+01    1.5000E-02

***** GEOMETRY INFORMATION *****
Number of Cells 1
      For Cell Number : 1
          Material Number : 5
          Volume Fraction : 1.0
          Nodes in cell   : 2

***** OUTPUT INFORMATION *****
Output at Interface for Material: 1

***** MATERIAL INFORMATION *****
Material for Cell Number : 1
Directional B-P Theory with [90] Ply Damage Model of Neu
Constitutive model: Bodner-Partom with Directional Hardening

----- MATERIAL PROPERTIES -----
      T(C)      E(GPa)      NU      CTE(1E-6/C)
    2.3000E+01    1.3300E+02    1.9000E-01    6.2279E+00
    2.6000E+02    1.2800E+02    1.9000E-01    7.2557E+00
    4.8200E+02    1.1900E+02    1.9000E-01    8.2184E+00
    5.3800E+02    1.1500E+02    1.8000E-01    8.4493E+00
    5.9300E+02    1.1200E+02    1.8000E-01    8.6577E+00
    6.5000E+02    1.0500E+02    1.7000E-01    8.8874E+00
    8.1500E+02    5.0000E+01    1.7000E-01    9.4902E+00
    9.0000E+02    2.0000E+01    1.7000E-01    9.7787E+00

Reference Temperature = 23.0
-----

      T(C)      N      Z0=Z2(1/S)      Z3(MPa)      M2(1/MPa)
    2.3000E+01    4.8000E+00    1.5500E+03    1.0000E+02    3.5000E-01
    2.6000E+02    3.5000E+00    1.3000E+03    3.0000E+02    3.5000E-01
    3.1500E+02    3.0540E+00    1.2504E+03    3.9000E+02    1.5020E+00
    3.6500E+02    2.6490E+00    1.2054E+03    5.0000E+02    2.5490E+00
    4.1500E+02    2.2430E+00    1.1604E+03    6.6000E+02    3.5970E+00
    4.6500E+02    1.8380E+00    1.1153E+03    9.6000E+02    4.6440E+00
    4.8200E+02    1.7000E+00    1.1000E+03    1.1000E+03    5.0000E+00
    5.0000E+02    1.5000E+00    1.0893E+03    1.3000E+03    5.7630E+00
    5.2500E+02    1.2800E+00    1.0744E+03    1.6700E+03    6.8220E+00
    5.5000E+02    1.1000E+00    1.0595E+03    2.1000E+03    7.8810E+00
    5.7500E+02    9.7000E-01    1.0446E+03    2.6000E+03    8.9410E+00
    6.0000E+02    8.2000E-01    1.0298E+03    3.7000E+03    1.0000E+01

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6.5000E+02	7.4000E-01	1.0000E+03	3.8000E+03	1.0000E+01
7.6000E+02	5.8000E-01	6.0000E+02	4.0000E+03	1.5000E+01
8.1500E+02	5.5000E-01	3.0000E+02	4.1000E+03	3.0000E+01
9.0000E+02	5.5000E-01	3.0000E+02	4.3000E+03	3.0000E+01

A1=A2	M1	Z1	R1=R2	DO
-9999.0	.0	1600.0	3.0	10000.0

Temp	Sm
2.3000E+01	1.9000E+02
2.6000E+02	1.3000E+02
4.8200E+02	7.0000E+01
5.3800E+02	5.0000E+01
5.9300E+02	3.6000E+01
6.5000E+02	1.7000E+01
8.1500E+02	.0000E+00

scho	scl	m	theta	Dstar	beta	Dch
80.0	.0	1.0	100.0	.61	5.0000000000000000E-02	.5

----- OUTPUT -----

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	3.9000E-02	2.3000E+01	4.3225E-01	4.3225E-01	.0000E+00	.0000E+00	3.2500E-06
50	1.9500E+00	2.3000E+01	2.1613E+01	2.1613E+01	.0000E+00	.0000E+00	1.6250E-04
100	3.9000E+00	2.3000E+01	4.3225E+01	4.3225E+01	.0000E+00	.0000E+00	3.2500E-04
150	5.8500E+00	2.3000E+01	6.4837E+01	6.4837E+01	.0000E+00	.0000E+00	4.8750E-04
200	7.8000E+00	2.3000E+01	8.6450E+01	8.6450E+01	.0000E+00	.0000E+00	6.5000E-04
250	9.7500E+00	2.3000E+01	1.0806E+02	1.0806E+02	.0000E+00	.0000E+00	8.1250E-04
300	1.1700E+01	2.3000E+01	1.2967E+02	1.2967E+02	.0000E+00	.0000E+00	9.7500E-04
350	1.3650E+01	2.3000E+01	1.5129E+02	1.5129E+02	.0000E+00	.0000E+00	1.1375E-03
400	1.5600E+01	2.3000E+01	1.7290E+02	1.7290E+02	.0000E+00	.0000E+00	1.3000E-03
450	1.7550E+01	2.3000E+01	1.9451E+02	1.9451E+02	.0000E+00	.0000E+00	1.4625E-03
500	1.9500E+01	2.3000E+01	2.1613E+02	2.1613E+02	.0000E+00	.0000E+00	1.6250E-03
550	2.1450E+01	2.3000E+01	2.3774E+02	2.3774E+02	.0000E+00	.0000E+00	1.7875E-03
600	2.3400E+01	2.3000E+01	2.5935E+02	2.5935E+02	.0000E+00	.0000E+00	1.9500E-03
650	2.5350E+01	2.3000E+01	2.7058E+02	2.7058E+02	.0000E+00	.0000E+00	2.1125E-03
700	2.7300E+01	2.3000E+01	2.7215E+02	2.7215E+02	.0000E+00	.0000E+00	2.2750E-03
750	2.9250E+01	2.3000E+01	2.7460E+02	2.7460E+02	.0000E+00	.0000E+00	2.4375E-03
800	3.1200E+01	2.3000E+01	2.7768E+02	2.7768E+02	.0000E+00	.0000E+00	2.6000E-03
850	3.3150E+01	2.3000E+01	2.8120E+02	2.8120E+02	.0000E+00	.0000E+00	2.7625E-03
900	3.5100E+01	2.3000E+01	2.8506E+02	2.8506E+02	.0000E+00	.0000E+00	2.9250E-03
950	3.7050E+01	2.3000E+01	2.8918E+02	2.8918E+02	.0000E+00	.0000E+00	3.0875E-03
1000	3.9000E+01	2.3000E+01	2.9350E+02	2.9350E+02	.0000E+00	.0000E+00	3.2500E-03
1050	4.0950E+01	2.3000E+01	2.7863E+02	2.7863E+02	.0000E+00	.0000E+00	3.0875E-03
1100	4.2900E+01	2.3000E+01	2.6397E+02	2.6397E+02	.0000E+00	.0000E+00	2.9250E-03
1150	4.4850E+01	2.3000E+01	2.4931E+02	2.4931E+02	.0000E+00	.0000E+00	2.7625E-03
1200	4.6800E+01	2.3000E+01	2.3464E+02	2.3464E+02	.0000E+00	.0000E+00	2.6000E-03
1250	4.8750E+01	2.3000E+01	2.1998E+02	2.1998E+02	.0000E+00	.0000E+00	2.4375E-03
1300	5.0700E+01	2.3000E+01	2.0531E+02	2.0531E+02	.0000E+00	.0000E+00	2.2750E-03
1350	5.2650E+01	2.3000E+01	1.9065E+02	1.9065E+02	.0000E+00	.0000E+00	2.1125E-03
1400	5.4600E+01	2.3000E+01	1.7599E+02	1.7599E+02	.0000E+00	.0000E+00	1.9500E-03
1450	5.6550E+01	2.3000E+01	1.6134E+02	1.6134E+02	.0000E+00	.0000E+00	1.7875E-03
1500	5.8500E+01	2.3000E+01	1.4669E+02	1.4669E+02	.0000E+00	.0000E+00	1.6250E-03
1550	6.0450E+01	2.3000E+01	1.3207E+02	1.3207E+02	.0000E+00	.0000E+00	1.4625E-03
1600	6.2400E+01	2.3000E+01	1.1747E+02	1.1747E+02	.0000E+00	.0000E+00	1.3000E-03
1650	6.4350E+01	2.3000E+01	1.0293E+02	1.0293E+02	.0000E+00	.0000E+00	1.1375E-03
1700	6.6300E+01	2.3000E+01	8.8477E+01	8.8477E+01	.0000E+00	.0000E+00	9.7500E-04
1750	6.8250E+01	2.3000E+01	7.4146E+01	7.4146E+01	.0000E+00	.0000E+00	8.1250E-04
1800	7.0200E+01	2.3000E+01	5.9963E+01	5.9963E+01	.0000E+00	.0000E+00	6.5000E-04
1850	7.2150E+01	2.3000E+01	4.5880E+01	4.5880E+01	.0000E+00	.0000E+00	4.8750E-04
1900	7.4100E+01	2.3000E+01	3.1668E+01	3.1668E+01	.0000E+00	.0000E+00	3.2500E-04
1950	7.6050E+01	2.3000E+01	1.6741E+01	1.6741E+01	.0000E+00	.0000E+00	1.6250E-04
2000	7.8000E+01	2.3000E+01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
2050	8.1930E+01	2.3000E+01	3.1968E+01	3.1968E+01	.0000E+00	.0000E+00	3.2750E-04
2100	8.5860E+01	2.3000E+01	6.0447E+01	6.0447E+01	.0000E+00	.0000E+00	6.5500E-04
2150	8.9790E+01	2.3000E+01	8.9162E+01	8.9162E+01	.0000E+00	.0000E+00	9.8250E-04
2200	9.3720E+01	2.3000E+01	1.1838E+02	1.1838E+02	.0000E+00	.0000E+00	1.3100E-03
2250	9.7650E+01	2.3000E+01	1.4782E+02	1.4782E+02	.0000E+00	.0000E+00	1.6375E-03
2300	1.0158E+02	2.3000E+01	1.7735E+02	1.7735E+02	.0000E+00	.0000E+00	1.9650E-03
2350	1.0551E+02	2.3000E+01	2.0689E+02	2.0689E+02	.0000E+00	.0000E+00	2.2925E-03
2400	1.0944E+02	2.3000E+01	2.3645E+02	2.3645E+02	.0000E+00	.0000E+00	2.6200E-03
2450	1.1337E+02	2.3000E+01	2.6600E+02	2.6600E+02	.0000E+00	.0000E+00	2.9475E-03
2500	1.1730E+02	2.3000E+01	2.9429E+02	2.9429E+02	.0000E+00	.0000E+00	3.2750E-03
2550	1.2123E+02	2.3000E+01	3.0351E+02	3.0351E+02	.0000E+00	.0000E+00	3.6025E-03
2600	1.2516E+02	2.3000E+01	3.1319E+02	3.1319E+02	.0000E+00	.0000E+00	3.9300E-03
2650	1.2909E+02	2.3000E+01	3.2322E+02	3.2322E+02	.0000E+00	.0000E+00	4.2575E-03
2700	1.3302E+02	2.3000E+01	3.3354E+02	3.3354E+02	.0000E+00	.0000E+00	4.5850E-03
2750	1.3695E+02	2.3000E+01	3.4412E+02	3.4412E+02	.0000E+00	.0000E+00	4.9125E-03
2800	1.4088E+02	2.3000E+01	3.5494E+02	3.5494E+02	.0000E+00	.0000E+00	5.2400E-03
2850	1.4481E+02	2.3000E+01	3.6639E+02	3.6639E+02	.0000E+00	.0000E+00	5.5675E-03
2900	1.4874E+02	2.3000E+01	3.7854E+02	3.7854E+02	.0000E+00	.0000E+00	5.8950E-03

2950	1.5267E+02	2.3000E+01	3.9074E+02	3.9074E+02	.0000E+00	.0000E+00	6.2225E-03
3000	1.5660E+02	2.3000E+01	4.0303E+02	4.0303E+02	.0000E+00	.0000E+00	6.5500E-03
3050	1.6059E+02	2.3000E+01	3.8273E+02	3.8273E+02	.0000E+00	.0000E+00	6.2225E-03
3100	1.6457E+02	2.3000E+01	3.6259E+02	3.6259E+02	.0000E+00	.0000E+00	5.8950E-03
3150	1.6856E+02	2.3000E+01	3.4245E+02	3.4245E+02	.0000E+00	.0000E+00	5.5675E-03
3200	1.7254E+02	2.3000E+01	3.2230E+02	3.2230E+02	.0000E+00	.0000E+00	5.2400E-03
3250	1.7653E+02	2.3000E+01	3.0216E+02	3.0216E+02	.0000E+00	.0000E+00	4.9125E-03
3300	1.8051E+02	2.3000E+01	2.8201E+02	2.8201E+02	.0000E+00	.0000E+00	4.5850E-03
3350	1.8450E+02	2.3000E+01	2.6187E+02	2.6187E+02	.0000E+00	.0000E+00	4.2575E-03
3400	1.8848E+02	2.3000E+01	2.4173E+02	2.4173E+02	.0000E+00	.0000E+00	3.9300E-03
3450	1.9247E+02	2.3000E+01	2.2159E+02	2.2159E+02	.0000E+00	.0000E+00	3.6025E-03
3500	1.9645E+02	2.3000E+01	2.0145E+02	2.0145E+02	.0000E+00	.0000E+00	3.2750E-03
3550	2.0044E+02	2.3000E+01	1.8132E+02	1.8132E+02	.0000E+00	.0000E+00	2.9475E-03
3600	2.0442E+02	2.3000E+01	1.6121E+02	1.6121E+02	.0000E+00	.0000E+00	2.6200E-03
3650	2.0841E+02	2.3000E+01	1.4115E+02	1.4115E+02	.0000E+00	.0000E+00	2.2925E-03
3700	2.1239E+02	2.3000E+01	1.2118E+02	1.2118E+02	.0000E+00	.0000E+00	1.9650E-03
3750	2.1638E+02	2.3000E+01	1.0143E+02	1.0143E+02	.0000E+00	.0000E+00	1.6375E-03
3800	2.2036E+02	2.3000E+01	8.2069E+01	8.2069E+01	.0000E+00	.0000E+00	1.3100E-03
3850	2.2435E+02	2.3000E+01	6.3235E+01	6.3235E+01	.0000E+00	.0000E+00	9.8250E-04
3900	2.2833E+02	2.3000E+01	4.4732E+01	4.4732E+01	.0000E+00	.0000E+00	6.5500E-04
3950	2.3232E+02	2.3000E+01	2.5228E+01	2.5228E+01	.0000E+00	.0000E+00	3.2750E-04
4000	2.3630E+02	2.3000E+01	-8.3866E-14	-8.3866E-14	.0000E+00	.0000E+00	-8.6750E-19
4050	2.4375E+02	2.3000E+01	4.3210E+01	4.3210E+01	.0000E+00	.0000E+00	6.2500E-04
4100	2.5120E+02	2.3000E+01	7.8663E+01	7.8663E+01	.0000E+00	.0000E+00	1.2500E-03
4150	2.5865E+02	2.3000E+01	1.1575E+02	1.1575E+02	.0000E+00	.0000E+00	1.8750E-03
4200	2.6610E+02	2.3000E+01	1.5385E+02	1.5385E+02	.0000E+00	.0000E+00	2.5000E-03
4250	2.7355E+02	2.3000E+01	1.9223E+02	1.9223E+02	.0000E+00	.0000E+00	3.1250E-03
4300	2.8100E+02	2.3000E+01	2.3066E+02	2.3066E+02	.0000E+00	.0000E+00	3.7500E-03
4350	2.8845E+02	2.3000E+01	2.6910E+02	2.6910E+02	.0000E+00	.0000E+00	4.3750E-03
4400	2.9590E+02	2.3000E+01	3.0754E+02	3.0754E+02	.0000E+00	.0000E+00	5.0000E-03
4450	3.0335E+02	2.3000E+01	3.4598E+02	3.4598E+02	.0000E+00	.0000E+00	5.6250E-03
4500	3.1080E+02	2.3000E+01	3.8443E+02	3.8443E+02	.0000E+00	.0000E+00	6.2500E-03
4550	3.1825E+02	2.3000E+01	4.1542E+02	4.1542E+02	.0000E+00	.0000E+00	6.8750E-03
4600	3.2570E+02	2.3000E+01	4.3948E+02	4.3948E+02	.0000E+00	.0000E+00	7.5000E-03
4650	3.3315E+02	2.3000E+01	4.5917E+02	4.5917E+02	.0000E+00	.0000E+00	8.1250E-03
4700	3.4060E+02	2.3000E+01	4.6283E+02	4.6283E+02	.0000E+00	.0000E+00	8.7500E-03
4750	3.4805E+02	2.3000E+01	4.6591E+02	4.6591E+02	.0000E+00	.0000E+00	9.3750E-03
4800	3.5550E+02	2.3000E+01	4.6849E+02	4.6849E+02	.0000E+00	.0000E+00	1.0000E-02
4850	3.6295E+02	2.3000E+01	4.7063E+02	4.7063E+02	.0000E+00	.0000E+00	1.0625E-02
4900	3.7040E+02	2.3000E+01	4.7239E+02	4.7239E+02	.0000E+00	.0000E+00	1.1250E-02
4950	3.7785E+02	2.3000E+01	4.7382E+02	4.7382E+02	.0000E+00	.0000E+00	1.1875E-02
5000	3.8530E+02	2.3000E+01	4.7497E+02	4.7497E+02	.0000E+00	.0000E+00	1.2500E-02
5050	3.9280E+02	2.3000E+01	4.3770E+02	4.3770E+02	.0000E+00	.0000E+00	1.1875E-02
5100	4.0030E+02	2.3000E+01	4.0235E+02	4.0235E+02	.0000E+00	.0000E+00	1.1250E-02
5150	4.0780E+02	2.3000E+01	3.6700E+02	3.6700E+02	.0000E+00	.0000E+00	1.0625E-02
5200	4.1530E+02	2.3000E+01	3.3164E+02	3.3164E+02	.0000E+00	.0000E+00	1.0000E-02
5250	4.2280E+02	2.3000E+01	2.9629E+02	2.9629E+02	.0000E+00	.0000E+00	9.3750E-03
5300	4.3030E+02	2.3000E+01	2.6094E+02	2.6094E+02	.0000E+00	.0000E+00	8.7500E-03
5350	4.3780E+02	2.3000E+01	2.2559E+02	2.2559E+02	.0000E+00	.0000E+00	8.1250E-03
5400	4.4530E+02	2.3000E+01	1.9025E+02	1.9025E+02	.0000E+00	.0000E+00	7.5000E-03
5450	4.5280E+02	2.3000E+01	1.5497E+02	1.5497E+02	.0000E+00	.0000E+00	6.8750E-03
5500	4.6030E+02	2.3000E+01	1.1992E+02	1.1992E+02	.0000E+00	.0000E+00	6.2500E-03
5550	4.6780E+02	2.3000E+01	8.5673E+01	8.5673E+01	.0000E+00	.0000E+00	5.6250E-03
5600	4.7530E+02	2.3000E+01	5.3040E+01	5.3040E+01	.0000E+00	.0000E+00	5.0000E-03
5650	4.8280E+02	2.3000E+01	1.8491E+01	1.8491E+01	.0000E+00	.0000E+00	4.3750E-03
5700	4.9030E+02	2.3000E+01	-4.8889E+01	-4.8889E+01	.0000E+00	.0000E+00	3.7500E-03
5750	4.9780E+02	2.3000E+01	-1.3448E+02	-1.3448E+02	.0000E+00	.0000E+00	3.1250E-03
5800	5.0530E+02	2.3000E+01	-2.1770E+02	-2.1770E+02	.0000E+00	.0000E+00	2.5000E-03
5850	5.1280E+02	2.3000E+01	-3.0083E+02	-3.0083E+02	.0000E+00	.0000E+00	1.8750E-03
5900	5.2030E+02	2.3000E+01	-3.8395E+02	-3.8395E+02	.0000E+00	.0000E+00	1.2500E-03
5950	5.2780E+02	2.3000E+01	-4.6708E+02	-4.6708E+02	.0000E+00	.0000E+00	6.2500E-04
6000	5.3530E+02	2.3000E+01	-5.5020E+02	-5.5020E+02	.0000E+00	.0000E+00	.0000E+00
6050	5.4430E+02	2.3000E+01	-4.5045E+02	-4.5045E+02	.0000E+00	.0000E+00	7.5000E-04
6100	5.5330E+02	2.3000E+01	-3.5070E+02	-3.5070E+02	.0000E+00	.0000E+00	1.5000E-03
6150	5.6230E+02	2.3000E+01	-2.5095E+02	-2.5095E+02	.0000E+00	.0000E+00	2.2500E-03
6200	5.7130E+02	2.3000E+01	-1.5116E+02	-1.5116E+02	.0000E+00	.0000E+00	3.0000E-03
6250	5.8030E+02	2.3000E+01	-4.9357E+01	-4.9357E+01	.0000E+00	.0000E+00	3.7500E-03
6300	5.8930E+02	2.3000E+01	2.6563E+01	2.6563E+01	.0000E+00	.0000E+00	4.5000E-03
6350	5.9830E+02	2.3000E+01	6.6092E+01	6.6092E+01	.0000E+00	.0000E+00	5.2500E-03
6400	6.0730E+02	2.3000E+01	1.0612E+02	1.0612E+02	.0000E+00	.0000E+00	6.0000E-03
6450	6.1630E+02	2.3000E+01	1.4794E+02	1.4794E+02	.0000E+00	.0000E+00	6.7500E-03
6500	6.2530E+02	2.3000E+01	1.9025E+02	1.9025E+02	.0000E+00	.0000E+00	7.5000E-03
6550	6.3430E+02	2.3000E+01	2.3266E+02	2.3266E+02	.0000E+00	.0000E+00	8.2500E-03
6600	6.4330E+02	2.3000E+01	2.7508E+02	2.7508E+02	.0000E+00	.0000E+00	9.0000E-03
6650	6.5230E+02	2.3000E+01	3.1750E+02	3.1750E+02	.0000E+00	.0000E+00	9.7500E-03
6700	6.6130E+02	2.3000E+01	3.5993E+02	3.5993E+02	.0000E+00	.0000E+00	1.0500E-02
6750	6.7030E+02	2.3000E+01	4.0235E+02	4.0235E+02	.0000E+00	.0000E+00	1.1250E-02
6800	6.7930E+02	2.3000E+01	4.4477E+02	4.4477E+02	.0000E+00	.0000E+00	1.2000E-02
6850	6.8830E+02	2.3000E+01	4.7534E+02	4.7534E+02	.0000E+00	.0000E+00	1.2750E-02
6900	6.9730E+02	2.3000E+01	4.7635E+02	4.7635E+02	.0000E+00	.0000E+00	1.3500E-02
6950	7.0630E+02	2.3000E+01	4.7710E+02	4.7710E+02	.0000E+00	.0000E+00	1.4250E-02
7000	7.1530E+02	2.3000E+01	4.7767E+02	4.7767E+02	.0000E+00	.0000E+00	1.5000E-02

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*   F I D E P 2 - VERSION 6
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***** PROBLEM TITLE *****
Cyclic Test of [90] Ply Damage Model

***** GEOMETRY TYPE *****

1-D Laminate Model

***** LOADING TYPE *****

Strain Control

***** LOADING HISTORY *****

POINTS IN HISTORY  8

      Step      Time      Temperature  Axial Strain
    .0000E+00    .0000E+00    2.3000E+01    .0000E+00
    1.8000E+02    1.8000E+02    2.3000E+01    1.5000E-02
    3.6000E+02    3.6000E+02    2.3000E+01   -1.5000E-02
    5.4000E+02    5.4000E+02    2.3000E+01    1.5000E-02
    7.2000E+02    7.2000E+02    2.3000E+01   -1.5000E-02
    9.0000E+02    9.0000E+02    2.3000E+01    1.5000E-02
    1.0800E+03    1.0800E+03    2.3000E+01   -1.5000E-02
    1.2600E+03    1.2600E+03    2.3000E+01    1.5000E-02

***** GEOMETRY INFORMATION *****

Number of Cells  1

      For Cell Number : 1

          Material Number :  5
          Volume Fraction :  1.0
          Nodes in cell   :  2

***** OUTPUT INFORMATION *****

Output at Interface for Material:  1

***** MATERIAL INFORMATION *****

Material for Cell Number :  1

Directional B-P Theory with [90] Ply Damage Model of Neu
Constitutive model: Bodner-Partom with Directional Hardening

----- MATERIAL PROPERTIES -----

      T(C)      E(GPa)      NU      CTE(1E-6/C)
    2.3000E+01    1.3300E+02    1.9000E-01    6.2279E+00
    2.6000E+02    1.2800E+02    1.9000E-01    7.2557E+00
    4.8200E+02    1.1900E+02    1.9000E-01    8.2184E+00
    5.3800E+02    1.1500E+02    1.8000E-01    8.4493E+00
    5.9300E+02    1.1200E+02    1.8000E-01    8.6577E+00
    6.5000E+02    1.0500E+02    1.7000E-01    8.8874E+00
    8.1500E+02    5.0000E+01    1.7000E-01    9.4902E+00
    9.0000E+02    2.0000E+01    1.7000E-01    9.7787E+00

Reference Temperature =  23.0
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      T(C)      N      Z0=Z2(1/S)      Z3(MPa)      M2(1/MPa)
    2.3000E+01    4.8000E+00    1.5500E+03    1.0000E+02    3.5000E-01
    2.6000E+02    3.5000E+00    1.3000E+03    3.0000E+02    3.5000E-01
    3.1500E+02    3.0540E+00    1.2504E+03    3.9000E+02    1.5020E+00
    3.6500E+02    2.6490E+00    1.2054E+03    5.0000E+02    2.5490E+00
    4.1500E+02    2.2430E+00    1.1604E+03    6.6000E+02    3.5970E+00
    4.6500E+02    1.8380E+00    1.1153E+03    9.6000E+02    4.6440E+00
    4.8200E+02    1.7000E+00    1.1000E+03    1.1000E+03    5.0000E+00
    5.0000E+02    1.5000E+00    1.0893E+03    1.3000E+03    5.7630E+00
    5.2500E+02    1.2800E+00    1.0744E+03    1.6700E+03    6.8220E+00
    5.5000E+02    1.1000E+00    1.0595E+03    2.1000E+03    7.8810E+00
    5.7500E+02    9.7000E-01    1.0446E+03    2.6000E+03    8.9410E+00
    6.0000E+02    8.2000E-01    1.0298E+03    3.7000E+03    1.0000E+01
    6.5000E+02    7.4000E-01    1.0000E+03    3.8000E+03    1.0000E+01
    7.6000E+02    5.8000E-01    6.0000E+02    4.0000E+03    1.5000E+01

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      8.1500E+02   5.5000E-01   3.0000E+02   4.1000E+03   3.0000E+01
      9.0000E+02   5.5000E-01   3.0000E+02   4.3000E+03   3.0000E+01
-----
      A1=A2      M1      Z1      R1=R2      DO
-9999.0 .0 1600.0 3.0 10000.0
-----
      Temp      Sm
      2.3000E+01   1.9000E+02
      2.6000E+02   1.3000E+02
      4.8200E+02   7.0000E+01
      5.3800E+02   5.0000E+01
      5.9300E+02   3.6000E+01
      6.5000E+02   1.7000E+01
      8.1500E+02   .0000E+00
-----
      scho      scl      m      theta      Dstar      beta      Dch
80.0 .0 1.0 100.0 .61 5.000000000000000E-02 .5
-----

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----- OUTPUT -----

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	1.0000E+00	2.3000E+01	1.1083E+01	1.1083E+01	.0000E+00	.0000E+00	8.3333E-05
10	1.0000E+01	2.3000E+01	1.1083E+02	1.1083E+02	.0000E+00	.0000E+00	8.3333E-04
20	2.0000E+01	2.3000E+01	2.2167E+02	2.2167E+02	.0000E+00	.0000E+00	1.6667E-03
30	3.0000E+01	2.3000E+01	2.7983E+02	2.7983E+02	.0000E+00	.0000E+00	2.5000E-03
40	4.0000E+01	2.3000E+01	2.9853E+02	2.9853E+02	.0000E+00	.0000E+00	3.3333E-03
50	5.0000E+01	2.3000E+01	3.2244E+02	3.2244E+02	.0000E+00	.0000E+00	4.1667E-03
60	6.0000E+01	2.3000E+01	3.4868E+02	3.4868E+02	.0000E+00	.0000E+00	5.0000E-03
70	7.0000E+01	2.3000E+01	3.7749E+02	3.7749E+02	.0000E+00	.0000E+00	5.8333E-03
80	8.0000E+01	2.3000E+01	4.0855E+02	4.0855E+02	.0000E+00	.0000E+00	6.6667E-03
90	9.0000E+01	2.3000E+01	4.4040E+02	4.4040E+02	.0000E+00	.0000E+00	7.5000E-03
100	1.0000E+02	2.3000E+01	4.6095E+02	4.6095E+02	.0000E+00	.0000E+00	8.3333E-03
110	1.1000E+02	2.3000E+01	4.6563E+02	4.6563E+02	.0000E+00	.0000E+00	9.1667E-03
120	1.2000E+02	2.3000E+01	4.6913E+02	4.6913E+02	.0000E+00	.0000E+00	1.0000E-02
130	1.3000E+02	2.3000E+01	4.7183E+02	4.7183E+02	.0000E+00	.0000E+00	1.0833E-02
140	1.4000E+02	2.3000E+01	4.7386E+02	4.7386E+02	.0000E+00	.0000E+00	1.1667E-02
150	1.5000E+02	2.3000E+01	4.7537E+02	4.7537E+02	.0000E+00	.0000E+00	1.2500E-02
160	1.6000E+02	2.3000E+01	4.7647E+02	4.7647E+02	.0000E+00	.0000E+00	1.3333E-02
170	1.7000E+02	2.3000E+01	4.7728E+02	4.7728E+02	.0000E+00	.0000E+00	1.4167E-02
180	1.8000E+02	2.3000E+01	4.7786E+02	4.7786E+02	.0000E+00	.0000E+00	1.5000E-02
190	1.9000E+02	2.3000E+01	3.7880E+02	3.7880E+02	.0000E+00	.0000E+00	1.3333E-02
200	2.0000E+02	2.3000E+01	2.8475E+02	2.8475E+02	.0000E+00	.0000E+00	1.1667E-02
210	2.1000E+02	2.3000E+01	1.9071E+02	1.9071E+02	.0000E+00	.0000E+00	1.0000E-02
220	2.2000E+02	2.3000E+01	9.7280E+01	9.7280E+01	.0000E+00	.0000E+00	8.3333E-03
230	2.3000E+02	2.3000E+01	3.7023E+00	3.7023E+00	.0000E+00	.0000E+00	6.6667E-03
240	2.4000E+02	2.3000E+01	-2.1555E+02	-2.1555E+02	.0000E+00	.0000E+00	5.0000E-03
250	2.5000E+02	2.3000E+01	-4.3722E+02	-4.3722E+02	.0000E+00	.0000E+00	3.3333E-03
260	2.6000E+02	2.3000E+01	-6.5889E+02	-6.5889E+02	.0000E+00	.0000E+00	1.6667E-03
270	2.7000E+02	2.3000E+01	-8.8055E+02	-8.8055E+02	.0000E+00	.0000E+00	1.7347E-18
280	2.8000E+02	2.3000E+01	-1.0284E+03	-1.0284E+03	.0000E+00	.0000E+00	-1.6667E-03
290	2.9000E+02	2.3000E+01	-1.0692E+03	-1.0692E+03	.0000E+00	.0000E+00	-3.3333E-03
300	3.0000E+02	2.3000E+01	-1.1062E+03	-1.1062E+03	.0000E+00	.0000E+00	-5.0000E-03
310	3.1000E+02	2.3000E+01	-1.1172E+03	-1.1172E+03	.0000E+00	.0000E+00	-6.6667E-03
320	3.2000E+02	2.3000E+01	-1.1221E+03	-1.1221E+03	.0000E+00	.0000E+00	-8.3333E-03
330	3.3000E+02	2.3000E+01	-1.0892E+03	-1.0892E+03	.0000E+00	.0000E+00	-1.0000E-02
340	3.4000E+02	2.3000E+01	-1.1354E+03	-1.1354E+03	.0000E+00	.0000E+00	-1.1667E-02
350	3.5000E+02	2.3000E+01	-1.1368E+03	-1.1368E+03	.0000E+00	.0000E+00	-1.3333E-02
360	3.6000E+02	2.3000E+01	-1.1374E+03	-1.1374E+03	.0000E+00	.0000E+00	-1.5000E-02
370	3.7000E+02	2.3000E+01	-8.8378E+02	-8.8378E+02	.0000E+00	.0000E+00	-1.3333E-02
380	3.8000E+02	2.3000E+01	-6.6211E+02	-6.6211E+02	.0000E+00	.0000E+00	-1.1667E-02
390	3.9000E+02	2.3000E+01	-4.4045E+02	-4.4045E+02	.0000E+00	.0000E+00	-1.0000E-02
400	4.0000E+02	2.3000E+01	-2.1878E+02	-2.1878E+02	.0000E+00	.0000E+00	-8.3333E-03
410	4.1000E+02	2.3000E+01	2.4065E+00	2.4065E+00	.0000E+00	.0000E+00	-6.6667E-03
420	4.2000E+02	2.3000E+01	9.6841E+01	9.6841E+01	.0000E+00	.0000E+00	-5.0000E-03
430	4.3000E+02	2.3000E+01	1.8936E+02	1.8936E+02	.0000E+00	.0000E+00	-3.3333E-03
440	4.4000E+02	2.3000E+01	2.8338E+02	2.8338E+02	.0000E+00	.0000E+00	-1.6667E-03
450	4.5000E+02	2.3000E+01	3.7743E+02	3.7743E+02	.0000E+00	.0000E+00	-2.6021E-18
460	4.6000E+02	2.3000E+01	4.3350E+02	4.3350E+02	.0000E+00	.0000E+00	1.6667E-03
470	4.7000E+02	2.3000E+01	4.3762E+02	4.3762E+02	.0000E+00	.0000E+00	3.3333E-03
480	4.8000E+02	2.3000E+01	4.6164E+02	4.6164E+02	.0000E+00	.0000E+00	5.0000E-03
490	4.9000E+02	2.3000E+01	4.7459E+02	4.7459E+02	.0000E+00	.0000E+00	6.6667E-03
500	5.0000E+02	2.3000E+01	4.5761E+02	4.5761E+02	.0000E+00	.0000E+00	8.3333E-03
510	5.1000E+02	2.3000E+01	4.7276E+02	4.7276E+02	.0000E+00	.0000E+00	1.0000E-02
520	5.2000E+02	2.3000E+01	4.8246E+02	4.8246E+02	.0000E+00	.0000E+00	1.1667E-02
530	5.3000E+02	2.3000E+01	4.7425E+02	4.7425E+02	.0000E+00	.0000E+00	1.3333E-02
540	5.4000E+02	2.3000E+01	4.7869E+02	4.7869E+02	.0000E+00	.0000E+00	1.5000E-02
550	5.5000E+02	2.3000E+01	3.7840E+02	3.7840E+02	.0000E+00	.0000E+00	1.3333E-02
560	5.6000E+02	2.3000E+01	2.8472E+02	2.8472E+02	.0000E+00	.0000E+00	1.1667E-02
570	5.7000E+02	2.3000E+01	1.9106E+02	1.9106E+02	.0000E+00	.0000E+00	1.0000E-02
580	5.8000E+02	2.3000E+01	9.7997E+01	9.7997E+01	.0000E+00	.0000E+00	8.3333E-03
590	5.9000E+02	2.3000E+01	5.2237E+00	5.2237E+00	.0000E+00	.0000E+00	6.6667E-03

600	6.0000E+02	2.3000E+01	-2.1291E+02	-2.1291E+02	.0000E+00	.0000E+00	5.0000E-03
610	6.1000E+02	2.3000E+01	-4.3458E+02	-4.3458E+02	.0000E+00	.0000E+00	3.3333E-03
620	6.2000E+02	2.3000E+01	-6.5625E+02	-6.5625E+02	.0000E+00	.0000E+00	1.6667E-03
630	6.3000E+02	2.3000E+01	-8.7791E+02	-8.7791E+02	.0000E+00	.0000E+00	1.7347E-18
640	6.4000E+02	2.3000E+01	-1.0205E+03	-1.0205E+03	.0000E+00	.0000E+00	-1.6667E-03
650	6.5000E+02	2.3000E+01	-1.0259E+03	-1.0259E+03	.0000E+00	.0000E+00	-3.3333E-03
660	6.6000E+02	2.3000E+01	-1.0618E+03	-1.0618E+03	.0000E+00	.0000E+00	-5.0000E-03
670	6.7000E+02	2.3000E+01	-1.1151E+03	-1.1151E+03	.0000E+00	.0000E+00	-6.6667E-03
680	6.8000E+02	2.3000E+01	-1.1310E+03	-1.1310E+03	.0000E+00	.0000E+00	-8.3333E-03
690	6.9000E+02	2.3000E+01	-1.1377E+03	-1.1377E+03	.0000E+00	.0000E+00	-1.0000E-02
700	7.0000E+02	2.3000E+01	-1.1403E+03	-1.1403E+03	.0000E+00	.0000E+00	-1.1667E-02
710	7.1000E+02	2.3000E+01	-1.1161E+03	-1.1161E+03	.0000E+00	.0000E+00	-1.3333E-02
720	7.2000E+02	2.3000E+01	-1.1160E+03	-1.1160E+03	.0000E+00	.0000E+00	-1.5000E-02
730	7.3000E+02	2.3000E+01	-8.9338E+02	-8.9338E+02	.0000E+00	.0000E+00	-1.3333E-02
740	7.4000E+02	2.3000E+01	-6.7171E+02	-6.7171E+02	.0000E+00	.0000E+00	-1.1667E-02
750	7.5000E+02	2.3000E+01	-4.5004E+02	-4.5004E+02	.0000E+00	.0000E+00	-1.0000E-02
760	7.6000E+02	2.3000E+01	-2.2838E+02	-2.2838E+02	.0000E+00	.0000E+00	-8.3333E-03
770	7.7000E+02	2.3000E+01	-5.9326E+00	-5.9326E+00	.0000E+00	.0000E+00	-6.6667E-03
780	7.8000E+02	2.3000E+01	9.2675E+01	9.2675E+01	.0000E+00	.0000E+00	-5.0000E-03
790	7.9000E+02	2.3000E+01	1.8455E+02	1.8455E+02	.0000E+00	.0000E+00	-3.3333E-03
800	8.0000E+02	2.3000E+01	2.7819E+02	2.7819E+02	.0000E+00	.0000E+00	-1.6667E-03
810	8.1000E+02	2.3000E+01	3.7186E+02	3.7186E+02	.0000E+00	.0000E+00	-1.7347E-18
820	8.2000E+02	2.3000E+01	4.3288E+02	4.3288E+02	.0000E+00	.0000E+00	1.6667E-03
830	8.3000E+02	2.3000E+01	4.3895E+02	4.3895E+02	.0000E+00	.0000E+00	3.3333E-03
840	8.4000E+02	2.3000E+01	4.5397E+02	4.5397E+02	.0000E+00	.0000E+00	5.0000E-03
850	8.5000E+02	2.3000E+01	4.7424E+02	4.7424E+02	.0000E+00	.0000E+00	6.6667E-03
860	8.6000E+02	2.3000E+01	4.6924E+02	4.6924E+02	.0000E+00	.0000E+00	8.3333E-03
870	8.7000E+02	2.3000E+01	4.8029E+02	4.8029E+02	.0000E+00	.0000E+00	1.0000E-02
880	8.8000E+02	2.3000E+01	4.7491E+02	4.7491E+02	.0000E+00	.0000E+00	1.1667E-02
890	8.9000E+02	2.3000E+01	4.7678E+02	4.7678E+02	.0000E+00	.0000E+00	1.3333E-02
900	9.0000E+02	2.3000E+01	4.7329E+02	4.7329E+02	.0000E+00	.0000E+00	1.5000E-02
910	9.1000E+02	2.3000E+01	3.7882E+02	3.7882E+02	.0000E+00	.0000E+00	1.3333E-02
920	9.2000E+02	2.3000E+01	2.8514E+02	2.8514E+02	.0000E+00	.0000E+00	1.1667E-02
930	9.3000E+02	2.3000E+01	1.9148E+02	1.9148E+02	.0000E+00	.0000E+00	1.0000E-02
940	9.4000E+02	2.3000E+01	9.8404E+01	9.8404E+01	.0000E+00	.0000E+00	8.3333E-03
950	9.5000E+02	2.3000E+01	5.7854E+00	5.7854E+00	.0000E+00	.0000E+00	6.6667E-03
960	9.6000E+02	2.3000E+01	-2.1192E+02	-2.1192E+02	.0000E+00	.0000E+00	5.0000E-03
970	9.7000E+02	2.3000E+01	-4.3359E+02	-4.3359E+02	.0000E+00	.0000E+00	3.3333E-03
980	9.8000E+02	2.3000E+01	-6.5526E+02	-6.5526E+02	.0000E+00	.0000E+00	1.6667E-03
990	9.9000E+02	2.3000E+01	-8.7693E+02	-8.7693E+02	.0000E+00	.0000E+00	1.7347E-18
1000	1.0000E+03	2.3000E+01	-1.0215E+03	-1.0215E+03	.0000E+00	.0000E+00	-1.6667E-03
1010	1.0100E+03	2.3000E+01	-1.0342E+03	-1.0342E+03	.0000E+00	.0000E+00	-3.3333E-03
1020	1.0200E+03	2.3000E+01	-1.1047E+03	-1.1047E+03	.0000E+00	.0000E+00	-5.0000E-03
1030	1.0300E+03	2.3000E+01	-1.0977E+03	-1.0977E+03	.0000E+00	.0000E+00	-6.6667E-03
1040	1.0400E+03	2.3000E+01	-1.1289E+03	-1.1289E+03	.0000E+00	.0000E+00	-8.3333E-03
1050	1.0500E+03	2.3000E+01	-1.1373E+03	-1.1373E+03	.0000E+00	.0000E+00	-1.0000E-02
1060	1.0600E+03	2.3000E+01	-1.1093E+03	-1.1093E+03	.0000E+00	.0000E+00	-1.1667E-02
1070	1.0700E+03	2.3000E+01	-1.1421E+03	-1.1421E+03	.0000E+00	.0000E+00	-1.3333E-02
1080	1.0800E+03	2.3000E+01	-1.1415E+03	-1.1415E+03	.0000E+00	.0000E+00	-1.5000E-02
1090	1.0900E+03	2.3000E+01	-8.6105E+02	-8.6105E+02	.0000E+00	.0000E+00	-1.3333E-02
1100	1.1000E+03	2.3000E+01	-6.3939E+02	-6.3939E+02	.0000E+00	.0000E+00	-1.1667E-02
1110	1.1100E+03	2.3000E+01	-4.1772E+02	-4.1772E+02	.0000E+00	.0000E+00	-1.0000E-02
1120	1.1200E+03	2.3000E+01	-1.9605E+02	-1.9605E+02	.0000E+00	.0000E+00	-8.3333E-03
1130	1.1300E+03	2.3000E+01	1.7691E+01	1.7691E+01	.0000E+00	.0000E+00	-6.6667E-03
1140	1.1400E+03	2.3000E+01	1.0562E+02	1.0562E+02	.0000E+00	.0000E+00	-5.0000E-03
1150	1.1500E+03	2.3000E+01	1.9820E+02	1.9820E+02	.0000E+00	.0000E+00	-3.3333E-03
1160	1.1600E+03	2.3000E+01	2.9185E+02	2.9185E+02	.0000E+00	.0000E+00	-1.6667E-03
1170	1.1700E+03	2.3000E+01	3.8552E+02	3.8552E+02	.0000E+00	.0000E+00	-1.7347E-18
1180	1.1800E+03	2.3000E+01	4.1541E+02	4.1541E+02	.0000E+00	.0000E+00	1.6667E-03
1190	1.1900E+03	2.3000E+01	4.4281E+02	4.4281E+02	.0000E+00	.0000E+00	3.3333E-03
1200	1.2000E+03	2.3000E+01	4.6735E+02	4.6735E+02	.0000E+00	.0000E+00	5.0000E-03
1210	1.2100E+03	2.3000E+01	4.7515E+02	4.7515E+02	.0000E+00	.0000E+00	6.6667E-03
1220	1.2200E+03	2.3000E+01	4.7886E+02	4.7886E+02	.0000E+00	.0000E+00	8.3333E-03
1230	1.2300E+03	2.3000E+01	4.6549E+02	4.6549E+02	.0000E+00	.0000E+00	1.0000E-02
1240	1.2400E+03	2.3000E+01	4.8146E+02	4.8146E+02	.0000E+00	.0000E+00	1.1667E-02
1250	1.2500E+03	2.3000E+01	4.7365E+02	4.7365E+02	.0000E+00	.0000E+00	1.3333E-02
1260	1.2600E+03	2.3000E+01	4.8108E+02	4.8108E+02	.0000E+00	.0000E+00	1.5000E-02

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*****
*                               *
*   F I D E P 2 - VERSION 6   *
*                               *
*****

***** PROBLEM TITLE *****
Loading and Unloading Test of [90] Ply Damage Model at 650C

***** GEOMETRY TYPE *****
1-D Laminate Model

***** LOADING TYPE *****
Strain Control

***** LOADING HISTORY *****
POINTS IN HISTORY 7

      Step      Time      Temperature      Axial Strain
      .0000E+00      .0000E+00      6.5000E+02      .0000E+00
      1.2000E+02      1.2000E+01      6.5000E+02      1.0000E-03
      2.4000E+02      2.4000E+01      6.5000E+02      .0000E+00
      8.4000E+02      8.4000E+01      6.5000E+02      5.0000E-03
      1.1100E+03      1.1100E+02      6.5000E+02      2.7080E-03
      2.2900E+03      2.2900E+02      6.5000E+02      1.2484E-02
      2.5700E+03      2.5700E+02      6.5000E+02      1.0224E-02

***** GEOMETRY INFORMATION *****
Number of Cells 1
For Cell Number : 1
      Material Number : 5
      Volume Fraction : 1.0
      Nodes in cell : 2

***** OUTPUT INFORMATION *****
Output at Interface for Material: 1

***** MATERIAL INFORMATION *****
Material for Cell Number : 1
Directional B-P Theory with [90] Ply Damage Model of Neu
Constitutive model: Bodner-Partom with Directional Hardening

----- MATERIAL PROPERTIES -----
      T(C)      E(GPa)      NU      CTE(1E-6/C)
      2.3000E+01      1.3300E+02      1.9000E-01      8.8874E+00
      2.6000E+02      1.2800E+02      1.9000E-01      9.8790E+00
      4.8200E+02      1.1900E+02      1.9000E-01      1.0715E+01
      5.3800E+02      1.1500E+02      1.8000E-01      1.0902E+01
      5.9300E+02      1.1200E+02      1.8000E-01      1.1185E+01
      6.5000E+02      1.0500E+02      1.7000E-01      1.1338E+01
      8.1500E+02      5.0000E+01      1.7000E-01      1.1781E+01
      9.0000E+02      2.0000E+01      1.7000E-01      1.2014E+01

Reference Temperature = 650.0
-----
      T(C)      N      Z0=Z2(1/S)      Z3(MPa)      M2(1/MPa)
      2.3000E+01      4.8000E+00      1.5500E+03      1.0000E+02      3.5000E-01
      2.6000E+02      3.5000E+00      1.3000E+03      3.0000E+02      3.5000E-01
      3.1500E+02      3.0540E+00      1.2504E+03      3.9000E+02      1.5020E+00
      3.6500E+02      2.6490E+00      1.2054E+03      5.0000E+02      2.5490E+00
      4.1500E+02      2.2430E+00      1.1604E+03      6.6000E+02      3.5970E+00
      4.6500E+02      1.8380E+00      1.1153E+03      9.6000E+02      4.6440E+00
      4.8200E+02      1.7000E+00      1.1000E+03      1.1000E+03      5.0000E+00
      5.0000E+02      1.5000E+00      1.0893E+03      1.3000E+03      5.7630E+00
      5.2500E+02      1.2800E+00      1.0744E+03      1.6700E+03      6.8220E+00
      5.5000E+02      1.1000E+00      1.0595E+03      2.1000E+03      7.8810E+00
      5.7500E+02      9.7000E-01      1.0446E+03      2.6000E+03      8.9410E+00
      6.0000E+02      8.2000E-01      1.0298E+03      3.7000E+03      1.0000E+01
      6.5000E+02      7.4000E-01      1.0000E+03      3.8000E+03      1.0000E+01
      7.6000E+02      5.8000E-01      6.0000E+02      4.0000E+03      1.5000E+01
      8.1500E+02      5.5000E-01      3.0000E+02      4.1000E+03      3.0000E+01
      9.0000E+02      5.5000E-01      3.0000E+02      4.3000E+03      3.0000E+01
-----
      A1=A2      M1      Z1      R1=R2      DO
-9999.0 .0 1600.0 3.0 10000.0

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-----
      Temp      Sm
2.3000E+01    1.9000E+02
2.6000E+02    1.3000E+02
4.8200E+02    7.0000E+01
5.3800E+02    5.0000E+01
5.9300E+02    3.6000E+01
6.5000E+02    1.7000E+01
8.1500E+02    .0000E+00
-----

      scho      scl      m      theta      Dstar      beta      Dch
80.0 .0 1.0 100.0 .61 5.000000000000000E-02 .5
-----

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----- OUTPUT -----
STEP      TIME      TEMPERATURE      SZ-APP      SZ-LAM1      SZ-LAM2      SZ-LAM3      ETOT
1          1.0000E-01    6.5000E+02    8.7500E-01    8.7500E-01    .0000E+00    .0000E+00    8.3333E-06
10         1.0000E+00    6.5000E+02    8.7500E+00    8.7500E+00    .0000E+00    .0000E+00    8.3333E-05
20         2.0000E+00    6.5000E+02    1.7500E+01    1.7500E+01    .0000E+00    .0000E+00    1.6667E-04
30         3.0000E+00    6.5000E+02    2.6250E+01    2.6250E+01    .0000E+00    .0000E+00    2.5000E-04
40         4.0000E+00    6.5000E+02    3.5000E+01    3.5000E+01    .0000E+00    .0000E+00    3.3333E-04
50         5.0000E+00    6.5000E+02    4.3750E+01    4.3750E+01    .0000E+00    .0000E+00    4.1667E-04
60         6.0000E+00    6.5000E+02    5.2500E+01    5.2500E+01    .0000E+00    .0000E+00    5.0000E-04
70         7.0000E+00    6.5000E+02    6.1250E+01    6.1250E+01    .0000E+00    .0000E+00    5.8333E-04
80         8.0000E+00    6.5000E+02    6.9999E+01    6.9999E+01    .0000E+00    .0000E+00    6.6667E-04
90         9.0000E+00    6.5000E+02    7.8637E+01    7.8637E+01    .0000E+00    .0000E+00    7.5000E-04
100        1.0000E+01    6.5000E+02    8.6030E+01    8.6030E+01    .0000E+00    .0000E+00    8.3333E-04
110        1.1000E+01    6.5000E+02    9.2416E+01    9.2416E+01    .0000E+00    .0000E+00    9.1667E-04
120        1.2000E+01    6.5000E+02    9.7957E+01    9.7957E+01    .0000E+00    .0000E+00    1.0000E-03
130        1.3000E+01    6.5000E+02    8.8163E+01    8.8163E+01    .0000E+00    .0000E+00    9.1667E-04
140        1.4000E+01    6.5000E+02    7.9522E+01    7.9522E+01    .0000E+00    .0000E+00    8.3333E-04
150        1.5000E+01    6.5000E+02    7.0898E+01    7.0898E+01    .0000E+00    .0000E+00    7.5000E-04
160        1.6000E+01    6.5000E+02    6.2275E+01    6.2275E+01    .0000E+00    .0000E+00    6.6667E-04
170        1.7000E+01    6.5000E+02    5.3654E+01    5.3654E+01    .0000E+00    .0000E+00    5.8333E-04
180        1.8000E+01    6.5000E+02    4.5035E+01    4.5035E+01    .0000E+00    .0000E+00    5.0000E-04
190        1.9000E+01    6.5000E+02    3.6414E+01    3.6414E+01    .0000E+00    .0000E+00    4.1667E-04
200        2.0000E+01    6.5000E+02    2.7789E+01    2.7789E+01    .0000E+00    .0000E+00    3.3333E-04
210        2.1000E+01    6.5000E+02    1.9155E+01    1.9155E+01    .0000E+00    .0000E+00    2.5000E-04
220        2.2000E+01    6.5000E+02    1.0505E+01    1.0505E+01    .0000E+00    .0000E+00    1.6667E-04
230        2.3000E+01    6.5000E+02    1.8336E+00    1.8336E+00    .0000E+00    .0000E+00    8.3333E-05
240        2.4000E+01    6.5000E+02    -6.8631E+00    -6.8631E+00    .0000E+00    .0000E+00    .0000E+00
250        2.5000E+01    6.5000E+02    1.8342E+00    1.8342E+00    .0000E+00    .0000E+00    8.3333E-05
260        2.6000E+01    6.5000E+02    1.0508E+01    1.0508E+01    .0000E+00    .0000E+00    1.6667E-04
270        2.7000E+01    6.5000E+02    1.9159E+01    1.9159E+01    .0000E+00    .0000E+00    2.5000E-04
280        2.8000E+01    6.5000E+02    2.7794E+01    2.7794E+01    .0000E+00    .0000E+00    3.3333E-04
290        2.9000E+01    6.5000E+02    3.6419E+01    3.6419E+01    .0000E+00    .0000E+00    4.1667E-04
300        3.0000E+01    6.5000E+02    4.5039E+01    4.5039E+01    .0000E+00    .0000E+00    5.0000E-04
310        3.1000E+01    6.5000E+02    5.3658E+01    5.3658E+01    .0000E+00    .0000E+00    5.8333E-04
320        3.2000E+01    6.5000E+02    6.2278E+01    6.2278E+01    .0000E+00    .0000E+00    6.6667E-04
330        3.3000E+01    6.5000E+02    7.0900E+01    7.0900E+01    .0000E+00    .0000E+00    7.5000E-04
340        3.4000E+01    6.5000E+02    7.9523E+01    7.9523E+01    .0000E+00    .0000E+00    8.3333E-04
350        3.5000E+01    6.5000E+02    8.8131E+01    8.8131E+01    .0000E+00    .0000E+00    9.1667E-04
360        3.6000E+01    6.5000E+02    9.6383E+01    9.6383E+01    .0000E+00    .0000E+00    1.0000E-03
370        3.7000E+01    6.5000E+02    9.8621E+01    9.8621E+01    .0000E+00    .0000E+00    1.0833E-03
380        3.8000E+01    6.5000E+02    9.9799E+01    9.9799E+01    .0000E+00    .0000E+00    1.1667E-03
390        3.9000E+01    6.5000E+02    1.0136E+02    1.0136E+02    .0000E+00    .0000E+00    1.2500E-03
400        4.0000E+01    6.5000E+02    1.0314E+02    1.0314E+02    .0000E+00    .0000E+00    1.3333E-03
410        4.1000E+01    6.5000E+02    1.0507E+02    1.0507E+02    .0000E+00    .0000E+00    1.4167E-03
420        4.2000E+01    6.5000E+02    1.0707E+02    1.0707E+02    .0000E+00    .0000E+00    1.5000E-03
430        4.3000E+01    6.5000E+02    1.0911E+02    1.0911E+02    .0000E+00    .0000E+00    1.5833E-03
440        4.4000E+01    6.5000E+02    1.1116E+02    1.1116E+02    .0000E+00    .0000E+00    1.6667E-03
450        4.5000E+01    6.5000E+02    1.1319E+02    1.1319E+02    .0000E+00    .0000E+00    1.7500E-03
460        4.6000E+01    6.5000E+02    1.1517E+02    1.1517E+02    .0000E+00    .0000E+00    1.8333E-03
470        4.7000E+01    6.5000E+02    1.1710E+02    1.1710E+02    .0000E+00    .0000E+00    1.9167E-03
480        4.8000E+01    6.5000E+02    1.1896E+02    1.1896E+02    .0000E+00    .0000E+00    2.0000E-03
490        4.9000E+01    6.5000E+02    1.20774E+02    1.2074E+02    .0000E+00    .0000E+00    2.0833E-03
500        5.0000E+01    6.5000E+02    1.2244E+02    1.2244E+02    .0000E+00    .0000E+00    2.1667E-03
510        5.1000E+01    6.5000E+02    1.2403E+02    1.2403E+02    .0000E+00    .0000E+00    2.2500E-03
520        5.2000E+01    6.5000E+02    1.2554E+02    1.2554E+02    .0000E+00    .0000E+00    2.3333E-03
530        5.3000E+01    6.5000E+02    1.2694E+02    1.2694E+02    .0000E+00    .0000E+00    2.4167E-03
540        5.4000E+01    6.5000E+02    1.2824E+02    1.2824E+02    .0000E+00    .0000E+00    2.5000E-03
550        5.5000E+01    6.5000E+02    1.2944E+02    1.2944E+02    .0000E+00    .0000E+00    2.5833E-03
560        5.6000E+01    6.5000E+02    1.3055E+02    1.3055E+02    .0000E+00    .0000E+00    2.6667E-03
570        5.7000E+01    6.5000E+02    1.3156E+02    1.3156E+02    .0000E+00    .0000E+00    2.7500E-03
580        5.8000E+01    6.5000E+02    1.3249E+02    1.3249E+02    .0000E+00    .0000E+00    2.8333E-03
590        5.9000E+01    6.5000E+02    1.3333E+02    1.3333E+02    .0000E+00    .0000E+00    2.9167E-03
600        6.0000E+01    6.5000E+02    1.3409E+02    1.3409E+02    .0000E+00    .0000E+00    3.0000E-03
610        6.1000E+01    6.5000E+02    1.3477E+02    1.3477E+02    .0000E+00    .0000E+00    3.0833E-03
620        6.2000E+01    6.5000E+02    1.3539E+02    1.3539E+02    .0000E+00    .0000E+00    3.1667E-03
630        6.3000E+01    6.5000E+02    1.3594E+02    1.3594E+02    .0000E+00    .0000E+00    3.2500E-03
640        6.4000E+01    6.5000E+02    1.3644E+02    1.3644E+02    .0000E+00    .0000E+00    3.3333E-03
650        6.5000E+01    6.5000E+02    1.3688E+02    1.3688E+02    .0000E+00    .0000E+00    3.4167E-03
660        6.6000E+01    6.5000E+02    1.3728E+02    1.3728E+02    .0000E+00    .0000E+00    3.5000E-03

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670	6.7000E+01	6.5000E+02	1.3763E+02	1.3763E+02	.0000E+00	.0000E+00	3.5833E-03
680	6.8000E+01	6.5000E+02	1.3794E+02	1.3794E+02	.0000E+00	.0000E+00	3.6667E-03
690	6.9000E+01	6.5000E+02	1.3822E+02	1.3822E+02	.0000E+00	.0000E+00	3.7500E-03
700	7.0000E+01	6.5000E+02	1.3846E+02	1.3846E+02	.0000E+00	.0000E+00	3.8333E-03
710	7.1000E+01	6.5000E+02	1.3868E+02	1.3868E+02	.0000E+00	.0000E+00	3.9167E-03
720	7.2000E+01	6.5000E+02	1.3887E+02	1.3887E+02	.0000E+00	.0000E+00	4.0000E-03
730	7.3000E+01	6.5000E+02	1.3904E+02	1.3904E+02	.0000E+00	.0000E+00	4.0833E-03
740	7.4000E+01	6.5000E+02	1.3919E+02	1.3919E+02	.0000E+00	.0000E+00	4.1667E-03
750	7.5000E+01	6.5000E+02	1.3932E+02	1.3932E+02	.0000E+00	.0000E+00	4.2500E-03
760	7.6000E+01	6.5000E+02	1.3943E+02	1.3943E+02	.0000E+00	.0000E+00	4.3333E-03
770	7.7000E+01	6.5000E+02	1.3953E+02	1.3953E+02	.0000E+00	.0000E+00	4.4167E-03
780	7.8000E+01	6.5000E+02	1.3962E+02	1.3962E+02	.0000E+00	.0000E+00	4.5000E-03
790	7.9000E+01	6.5000E+02	1.3970E+02	1.3970E+02	.0000E+00	.0000E+00	4.5833E-03
800	8.0000E+01	6.5000E+02	1.3977E+02	1.3977E+02	.0000E+00	.0000E+00	4.6667E-03
810	8.1000E+01	6.5000E+02	1.3983E+02	1.3983E+02	.0000E+00	.0000E+00	4.7500E-03
820	8.2000E+01	6.5000E+02	1.3988E+02	1.3988E+02	.0000E+00	.0000E+00	4.8333E-03
830	8.3000E+01	6.5000E+02	1.3993E+02	1.3993E+02	.0000E+00	.0000E+00	4.9167E-03
840	8.4000E+01	6.5000E+02	1.3997E+02	1.3997E+02	.0000E+00	.0000E+00	5.0000E-03
850	8.5000E+01	6.5000E+02	1.3121E+02	1.3121E+02	.0000E+00	.0000E+00	4.9151E-03
860	8.6000E+01	6.5000E+02	1.2363E+02	1.2363E+02	.0000E+00	.0000E+00	4.8302E-03
870	8.7000E+01	6.5000E+02	1.1673E+02	1.1673E+02	.0000E+00	.0000E+00	4.7453E-03
880	8.8000E+01	6.5000E+02	1.1034E+02	1.1034E+02	.0000E+00	.0000E+00	4.6604E-03
890	8.9000E+01	6.5000E+02	1.0434E+02	1.0434E+02	.0000E+00	.0000E+00	4.5756E-03
900	9.0000E+01	6.5000E+02	9.8644E+01	9.8644E+01	.0000E+00	.0000E+00	4.4907E-03
910	9.1000E+01	6.5000E+02	9.3169E+01	9.3169E+01	.0000E+00	.0000E+00	4.4058E-03
920	9.2000E+01	6.5000E+02	8.7843E+01	8.7843E+01	.0000E+00	.0000E+00	4.3209E-03
930	9.3000E+01	6.5000E+02	8.2610E+01	8.2610E+01	.0000E+00	.0000E+00	4.2360E-03
940	9.4000E+01	6.5000E+02	7.7433E+01	7.7433E+01	.0000E+00	.0000E+00	4.1511E-03
950	9.5000E+01	6.5000E+02	7.2291E+01	7.2291E+01	.0000E+00	.0000E+00	4.0662E-03
960	9.6000E+01	6.5000E+02	6.7179E+01	6.7179E+01	.0000E+00	.0000E+00	3.9813E-03
970	9.7000E+01	6.5000E+02	6.2091E+01	6.2091E+01	.0000E+00	.0000E+00	3.8964E-03
980	9.8000E+01	6.5000E+02	5.7024E+01	5.7024E+01	.0000E+00	.0000E+00	3.8116E-03
990	9.9000E+01	6.5000E+02	5.1971E+01	5.1971E+01	.0000E+00	.0000E+00	3.7267E-03
1000	1.0000E+02	6.5000E+02	4.6919E+01	4.6919E+01	.0000E+00	.0000E+00	3.6418E-03
1010	1.0100E+02	6.5000E+02	4.1849E+01	4.1849E+01	.0000E+00	.0000E+00	3.5569E-03
1020	1.0200E+02	6.5000E+02	3.6737E+01	3.6737E+01	.0000E+00	.0000E+00	3.4720E-03
1030	1.0300E+02	6.5000E+02	3.1547E+01	3.1547E+01	.0000E+00	.0000E+00	3.3871E-03
1040	1.0400E+02	6.5000E+02	2.6230E+01	2.6230E+01	.0000E+00	.0000E+00	3.3022E-03
1050	1.0500E+02	6.5000E+02	2.0726E+01	2.0726E+01	.0000E+00	.0000E+00	3.2173E-03
1060	1.0600E+02	6.5000E+02	1.4954E+01	1.4954E+01	.0000E+00	.0000E+00	3.1324E-03
1070	1.0700E+02	6.5000E+02	8.8139E+00	8.8139E+00	.0000E+00	.0000E+00	3.0476E-03
1080	1.0800E+02	6.5000E+02	2.1921E+00	2.1921E+00	.0000E+00	.0000E+00	2.9627E-03
1090	1.0900E+02	6.5000E+02	-5.0243E+00	-5.0243E+00	.0000E+00	.0000E+00	2.8778E-03
1100	1.1000E+02	6.5000E+02	-1.2904E+01	-1.2904E+01	.0000E+00	.0000E+00	2.7929E-03
1110	1.1100E+02	6.5000E+02	-2.1415E+01	-2.1415E+01	.0000E+00	.0000E+00	2.7080E-03
1120	1.1200E+02	6.5000E+02	-1.3222E+01	-1.3222E+01	.0000E+00	.0000E+00	2.7908E-03
1130	1.1300E+02	6.5000E+02	-5.4379E+00	-5.4379E+00	.0000E+00	.0000E+00	2.8737E-03
1140	1.1400E+02	6.5000E+02	1.7072E+00	1.7072E+00	.0000E+00	.0000E+00	2.9565E-03
1150	1.1500E+02	6.5000E+02	8.2628E+00	8.2628E+00	.0000E+00	.0000E+00	3.0394E-03
1160	1.1600E+02	6.5000E+02	1.4331E+01	1.4331E+01	.0000E+00	.0000E+00	3.1222E-03
1170	1.1700E+02	6.5000E+02	2.0024E+01	2.0024E+01	.0000E+00	.0000E+00	3.2051E-03
1180	1.1800E+02	6.5000E+02	2.5440E+01	2.5440E+01	.0000E+00	.0000E+00	3.2879E-03
1190	1.1900E+02	6.5000E+02	3.0658E+01	3.0658E+01	.0000E+00	.0000E+00	3.3708E-03
1200	1.2000E+02	6.5000E+02	3.5742E+01	3.5742E+01	.0000E+00	.0000E+00	3.4536E-03
1210	1.2100E+02	6.5000E+02	4.0740E+01	4.0740E+01	.0000E+00	.0000E+00	3.5365E-03
1220	1.2200E+02	6.5000E+02	4.5688E+01	4.5688E+01	.0000E+00	.0000E+00	3.6193E-03
1230	1.2300E+02	6.5000E+02	5.0613E+01	5.0613E+01	.0000E+00	.0000E+00	3.7022E-03
1240	1.2400E+02	6.5000E+02	5.5533E+01	5.5533E+01	.0000E+00	.0000E+00	3.7850E-03
1250	1.2500E+02	6.5000E+02	6.0462E+01	6.0462E+01	.0000E+00	.0000E+00	3.8679E-03
1260	1.2600E+02	6.5000E+02	6.5371E+01	6.5371E+01	.0000E+00	.0000E+00	3.9507E-03
1270	1.2700E+02	6.5000E+02	6.9938E+01	6.9938E+01	.0000E+00	.0000E+00	4.0336E-03
1280	1.2800E+02	6.5000E+02	7.3855E+01	7.3855E+01	.0000E+00	.0000E+00	4.1164E-03
1290	1.2900E+02	6.5000E+02	7.7588E+01	7.7588E+01	.0000E+00	.0000E+00	4.1993E-03
1300	1.3000E+02	6.5000E+02	8.1293E+01	8.1293E+01	.0000E+00	.0000E+00	4.2821E-03
1310	1.3100E+02	6.5000E+02	8.4964E+01	8.4964E+01	.0000E+00	.0000E+00	4.3649E-03
1320	1.3200E+02	6.5000E+02	8.8586E+01	8.8586E+01	.0000E+00	.0000E+00	4.4478E-03
1330	1.3300E+02	6.5000E+02	9.2138E+01	9.2138E+01	.0000E+00	.0000E+00	4.5306E-03
1340	1.3400E+02	6.5000E+02	9.5603E+01	9.5603E+01	.0000E+00	.0000E+00	4.6135E-03
1350	1.3500E+02	6.5000E+02	9.8963E+01	9.8963E+01	.0000E+00	.0000E+00	4.6963E-03
1360	1.3600E+02	6.5000E+02	1.0220E+02	1.0220E+02	.0000E+00	.0000E+00	4.7792E-03
1370	1.3700E+02	6.5000E+02	1.0531E+02	1.0531E+02	.0000E+00	.0000E+00	4.8620E-03
1380	1.3800E+02	6.5000E+02	1.0826E+02	1.0826E+02	.0000E+00	.0000E+00	4.9449E-03
1390	1.3900E+02	6.5000E+02	1.1107E+02	1.1107E+02	.0000E+00	.0000E+00	5.0277E-03
1400	1.4000E+02	6.5000E+02	1.1371E+02	1.1371E+02	.0000E+00	.0000E+00	5.1106E-03
1410	1.4100E+02	6.5000E+02	1.1618E+02	1.1618E+02	.0000E+00	.0000E+00	5.1934E-03
1420	1.4200E+02	6.5000E+02	1.1849E+02	1.1849E+02	.0000E+00	.0000E+00	5.2763E-03
1430	1.4300E+02	6.5000E+02	1.2063E+02	1.2063E+02	.0000E+00	.0000E+00	5.3591E-03
1440	1.4400E+02	6.5000E+02	1.2261E+02	1.2261E+02	.0000E+00	.0000E+00	5.4420E-03
1450	1.4500E+02	6.5000E+02	1.2442E+02	1.2442E+02	.0000E+00	.0000E+00	5.5248E-03
1460	1.4600E+02	6.5000E+02	1.2608E+02	1.2608E+02	.0000E+00	.0000E+00	5.6077E-03
1470	1.4700E+02	6.5000E+02	1.2760E+02	1.2760E+02	.0000E+00	.0000E+00	5.6905E-03
1480	1.4800E+02	6.5000E+02	1.2897E+02	1.2897E+02	.0000E+00	.0000E+00	5.7734E-03
1490	1.4900E+02	6.5000E+02	1.3021E+02	1.3021E+02	.0000E+00	.0000E+00	5.8562E-03
1500	1.5000E+02	6.5000E+02	1.3134E+02	1.3134E+02	.0000E+00	.0000E+00	5.9391E-03
1510	1.5100E+02	6.5000E+02	1.3234E+02	1.3234E+02	.0000E+00	.0000E+00	6.0219E-03

1520	1.5200E+02	6.5000E+02	1.3325E+02	1.3325E+02	.0000E+00	.0000E+00	6.1047E-03
1530	1.5300E+02	6.5000E+02	1.3406E+02	1.3406E+02	.0000E+00	.0000E+00	6.1876E-03
1540	1.5400E+02	6.5000E+02	1.3478E+02	1.3478E+02	.0000E+00	.0000E+00	6.2704E-03
1550	1.5500E+02	6.5000E+02	1.3542E+02	1.3542E+02	.0000E+00	.0000E+00	6.3533E-03
1560	1.5600E+02	6.5000E+02	1.3599E+02	1.3599E+02	.0000E+00	.0000E+00	6.4361E-03
1570	1.5700E+02	6.5000E+02	1.3650E+02	1.3650E+02	.0000E+00	.0000E+00	6.5190E-03
1580	1.5800E+02	6.5000E+02	1.3695E+02	1.3695E+02	.0000E+00	.0000E+00	6.6018E-03
1590	1.5900E+02	6.5000E+02	1.3735E+02	1.3735E+02	.0000E+00	.0000E+00	6.6847E-03
1600	1.6000E+02	6.5000E+02	1.3770E+02	1.3770E+02	.0000E+00	.0000E+00	6.7675E-03
1610	1.6100E+02	6.5000E+02	1.3801E+02	1.3801E+02	.0000E+00	.0000E+00	6.8504E-03
1620	1.6200E+02	6.5000E+02	1.3829E+02	1.3829E+02	.0000E+00	.0000E+00	6.9332E-03
1630	1.6300E+02	6.5000E+02	1.3853E+02	1.3853E+02	.0000E+00	.0000E+00	7.0161E-03
1640	1.6400E+02	6.5000E+02	1.3874E+02	1.3874E+02	.0000E+00	.0000E+00	7.0989E-03
1650	1.6500E+02	6.5000E+02	1.3893E+02	1.3893E+02	.0000E+00	.0000E+00	7.1818E-03
1660	1.6600E+02	6.5000E+02	1.3909E+02	1.3909E+02	.0000E+00	.0000E+00	7.2646E-03
1670	1.6700E+02	6.5000E+02	1.3924E+02	1.3924E+02	.0000E+00	.0000E+00	7.3475E-03
1680	1.6800E+02	6.5000E+02	1.3937E+02	1.3937E+02	.0000E+00	.0000E+00	7.4303E-03
1690	1.6900E+02	6.5000E+02	1.3948E+02	1.3948E+02	.0000E+00	.0000E+00	7.5132E-03
1700	1.7000E+02	6.5000E+02	1.3958E+02	1.3958E+02	.0000E+00	.0000E+00	7.5960E-03
1710	1.7100E+02	6.5000E+02	1.3967E+02	1.3967E+02	.0000E+00	.0000E+00	7.6788E-03
1720	1.7200E+02	6.5000E+02	1.3974E+02	1.3974E+02	.0000E+00	.0000E+00	7.7617E-03
1730	1.7300E+02	6.5000E+02	1.3981E+02	1.3981E+02	.0000E+00	.0000E+00	7.8445E-03
1740	1.7400E+02	6.5000E+02	1.3987E+02	1.3987E+02	.0000E+00	.0000E+00	7.9274E-03
1750	1.7500E+02	6.5000E+02	1.3992E+02	1.3992E+02	.0000E+00	.0000E+00	8.0102E-03
1760	1.7600E+02	6.5000E+02	1.3996E+02	1.3996E+02	.0000E+00	.0000E+00	8.0931E-03
1770	1.7700E+02	6.5000E+02	1.3999E+02	1.3999E+02	.0000E+00	.0000E+00	8.1759E-03
1780	1.7800E+02	6.5000E+02	1.4001E+02	1.4001E+02	.0000E+00	.0000E+00	8.2588E-03
1790	1.7900E+02	6.5000E+02	1.4003E+02	1.4003E+02	.0000E+00	.0000E+00	8.3416E-03
1800	1.8000E+02	6.5000E+02	1.4004E+02	1.4004E+02	.0000E+00	.0000E+00	8.4245E-03
1810	1.8100E+02	6.5000E+02	1.4006E+02	1.4006E+02	.0000E+00	.0000E+00	8.5073E-03
1820	1.8200E+02	6.5000E+02	1.4007E+02	1.4007E+02	.0000E+00	.0000E+00	8.5902E-03
1830	1.8300E+02	6.5000E+02	1.4008E+02	1.4008E+02	.0000E+00	.0000E+00	8.6730E-03
1840	1.8400E+02	6.5000E+02	1.4009E+02	1.4009E+02	.0000E+00	.0000E+00	8.7559E-03
1850	1.8500E+02	6.5000E+02	1.4010E+02	1.4010E+02	.0000E+00	.0000E+00	8.8387E-03
1860	1.8600E+02	6.5000E+02	1.4010E+02	1.4010E+02	.0000E+00	.0000E+00	8.9216E-03
1870	1.8700E+02	6.5000E+02	1.4011E+02	1.4011E+02	.0000E+00	.0000E+00	9.0044E-03
1880	1.8800E+02	6.5000E+02	1.4011E+02	1.4011E+02	.0000E+00	.0000E+00	9.0873E-03
1890	1.8900E+02	6.5000E+02	1.4012E+02	1.4012E+02	.0000E+00	.0000E+00	9.1701E-03
1900	1.9000E+02	6.5000E+02	1.4012E+02	1.4012E+02	.0000E+00	.0000E+00	9.2529E-03
1910	1.9100E+02	6.5000E+02	1.4013E+02	1.4013E+02	.0000E+00	.0000E+00	9.3358E-03
1920	1.9200E+02	6.5000E+02	1.4013E+02	1.4013E+02	.0000E+00	.0000E+00	9.4186E-03
1930	1.9300E+02	6.5000E+02	1.4013E+02	1.4013E+02	.0000E+00	.0000E+00	9.5015E-03
1940	1.9400E+02	6.5000E+02	1.4013E+02	1.4013E+02	.0000E+00	.0000E+00	9.5843E-03
1950	1.9500E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	9.6672E-03
1960	1.9600E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	9.7500E-03
1970	1.9700E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	9.8329E-03
1980	1.9800E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	9.9157E-03
1990	1.9900E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	9.9986E-03
2000	2.0000E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	1.0081E-02
2010	2.0100E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	1.0164E-02
2020	2.0200E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0247E-02
2030	2.0300E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0330E-02
2040	2.0400E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0413E-02
2050	2.0500E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0496E-02
2060	2.0600E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0579E-02
2070	2.0700E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0661E-02
2080	2.0800E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0744E-02
2090	2.0900E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0827E-02
2100	2.1000E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0910E-02
2110	2.1100E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0993E-02
2120	2.1200E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1076E-02
2130	2.1300E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1158E-02
2140	2.1400E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1241E-02
2150	2.1500E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1324E-02
2160	2.1600E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1407E-02
2170	2.1700E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1490E-02
2180	2.1800E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1573E-02
2190	2.1900E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1656E-02
2200	2.2000E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1738E-02
2210	2.2100E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1821E-02
2220	2.2200E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1904E-02
2230	2.2300E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1987E-02
2240	2.2400E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2070E-02
2250	2.2500E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2153E-02
2260	2.2600E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2235E-02
2270	2.2700E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2318E-02
2280	2.2800E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2401E-02
2290	2.2900E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2484E-02
2300	2.3000E+02	6.5000E+02	1.3159E+02	1.3159E+02	.0000E+00	.0000E+00	1.2403E-02
2310	2.3100E+02	6.5000E+02	1.2419E+02	1.2419E+02	.0000E+00	.0000E+00	1.2323E-02
2320	2.3200E+02	6.5000E+02	1.1746E+02	1.1746E+02	.0000E+00	.0000E+00	1.2242E-02
2330	2.3300E+02	6.5000E+02	1.1124E+02	1.1124E+02	.0000E+00	.0000E+00	1.2161E-02
2340	2.3400E+02	6.5000E+02	1.0542E+02	1.0542E+02	.0000E+00	.0000E+00	1.2080E-02
2350	2.3500E+02	6.5000E+02	9.9903E+01	9.9903E+01	.0000E+00	.0000E+00	1.2000E-02
2360	2.3600E+02	6.5000E+02	9.4622E+01	9.4622E+01	.0000E+00	.0000E+00	1.1919E-02
2370	2.3700E+02	6.5000E+02	8.9508E+01	8.9508E+01	.0000E+00	.0000E+00	1.1838E-02

2380	2.3800E+02	6.5000E+02	8.4502E+01	8.4502E+01	.0000E+00	.0000E+00	1.1758E-02
2390	2.3900E+02	6.5000E+02	7.9563E+01	7.9563E+01	.0000E+00	.0000E+00	1.1677E-02
2400	2.4000E+02	6.5000E+02	7.4665E+01	7.4665E+01	.0000E+00	.0000E+00	1.1596E-02
2410	2.4100E+02	6.5000E+02	6.9796E+01	6.9796E+01	.0000E+00	.0000E+00	1.1515E-02
2420	2.4200E+02	6.5000E+02	6.4951E+01	6.4951E+01	.0000E+00	.0000E+00	1.1435E-02
2430	2.4300E+02	6.5000E+02	6.0128E+01	6.0128E+01	.0000E+00	.0000E+00	1.1354E-02
2440	2.4400E+02	6.5000E+02	5.5322E+01	5.5322E+01	.0000E+00	.0000E+00	1.1273E-02
2450	2.4500E+02	6.5000E+02	5.0524E+01	5.0524E+01	.0000E+00	.0000E+00	1.1193E-02
2460	2.4600E+02	6.5000E+02	4.5723E+01	4.5723E+01	.0000E+00	.0000E+00	1.1112E-02
2470	2.4700E+02	6.5000E+02	4.0902E+01	4.0902E+01	.0000E+00	.0000E+00	1.1031E-02
2480	2.4800E+02	6.5000E+02	3.6037E+01	3.6037E+01	.0000E+00	.0000E+00	1.0950E-02
2490	2.4900E+02	6.5000E+02	3.1096E+01	3.1096E+01	.0000E+00	.0000E+00	1.0870E-02
2500	2.5000E+02	6.5000E+02	2.6037E+01	2.6037E+01	.0000E+00	.0000E+00	1.0789E-02
2510	2.5100E+02	6.5000E+02	2.0805E+01	2.0805E+01	.0000E+00	.0000E+00	1.0708E-02
2520	2.5200E+02	6.5000E+02	1.5332E+01	1.5332E+01	.0000E+00	.0000E+00	1.0628E-02
2530	2.5300E+02	6.5000E+02	9.5333E+00	9.5333E+00	.0000E+00	.0000E+00	1.0547E-02
2540	2.5400E+02	6.5000E+02	3.3096E+00	3.3096E+00	.0000E+00	.0000E+00	1.0466E-02
2550	2.5500E+02	6.5000E+02	-3.4375E+00	-3.4375E+00	.0000E+00	.0000E+00	1.0385E-02
2560	2.5600E+02	6.5000E+02	-1.0778E+01	-1.0778E+01	.0000E+00	.0000E+00	1.0305E-02
2570	2.5700E+02	6.5000E+02	-1.8711E+01	-1.8711E+01	.0000E+00	.0000E+00	1.0224E-02

APPENDIX D

Listing of FIDEP2 Source Code

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Source Code for FIDEP2 (version 8)

PROGRAM FIDEP2_8

C

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C LAST DATE OF CHANGE: June 1996

C

C PROGRAMMERS: DEMIRKAN COKER

C JOSEPH L. KROUPA

C

C SUPERVISOR: NOEL E. ASHBAUGH

C

C UNIVERSITY OF DAYTON RESEARCH INSTITUTE

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C          300 COLLEGE PARK
C          DAYTON, OHIO 45469-0128
C          (513) 255-1362
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C =====
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C   Material models available:
C
C   A) Thermo-elastic
C   B) Thermo-elastic plastic
C   C) Bodner Partom with back stress
C   D) Bodner Partom with directional hardening
C   E) Bodner Partom with directional hardening
C       and damage [90] model
C   F) Bodner Partom with directional hardening (new formulation)
C
C   Composite geometries available:
C
C   A) Concentric cylinder
C   B) Laminate from 1 to 10 plys
C   C) Concentric cylinder with parallel [90] ply
C
C C =====
C
C       IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
C       PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
C       PARAMETER( NN = 50)
C *** loading input paramaters
C       COMMON /LOAD1/  BT(ML), BSAPP(ML), BTAU(ML),
C       $              BEZ(ML), BSRAPP(ML), NBLOCK(ML),
C       $              NCYCLE(ML), NCSTART(ML), NCEND(ML), NCBLOCK
C *** loading parameters
C       COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
C       $              NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
C *** output variables
C       COMMON /LOAD0/  INTOUT(ML), IOUT(ML,20),
C       $              IPRINTSTEP(ML), ISTEPOUT(ML)
C *** variables for strain controlled loading of ccm
C *** applied total and incremental loads at step i
C       COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
C       $              TINCR, SZINCR, EZINCR, SRINCR, DTAU,
C       $              TIME, ICYCLE, IBLOCK
C *** material input parameters
C       COMMON /READM/  NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),

```

```

$                AT(MM,MR,7), TREF(MM), NSET(MM)
C *** material input header lines and names
COMMON /NAME1/  NAME(MM), HEADER(MM,7)
C *** properties at temperature at step i
COMMON /PROP /  P(MM,MC)
C *** elastic properties and composite properties at step i
COMMON /ELASX/  TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
C *** plastic properties at step i
COMMON /MAT2A /  TSY(NN), TEP(NN)
C *** bodner-partom with backstress properties at step i
COMMON /MAT5A /  TN(NN), TZ0(NN), TF1(NN), TF3(NN),
$                TBSMAX(NN), TD0(NN)
COMMON /MAT5B/  F3OLD(NN), BS(6,NN), SDEVOLD(6,NN)
C *** bodner-partom with directional hardening props at step i
COMMON /MAT6A /  TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
$                TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
$                TR2(NN), TD0D(NN), TZ2(NN),
$                DTZ1(NN), DTZ2(NN), DTZ3(NN)
COMMON /MAT7A /  TA1A(NN),TA1B(NN),TA1C(NN),
$                TM1A(NN),TM1B(NN),TM1C(NN),
$                TA2(NN)
COMMON /MAT6B/  BETA(6,NN),ZD(NN),ZI(NN),ZTOT(NN)
C *** concentric cylinder model parameters for geometry
COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
C *** setting up of the ax=b system and the coefficients
COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
$                IPVT(LDA)
COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
$                FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
C *** stresses and strains for use in output and inelasticity routine
COMMON /STRES/  S(6,NN), SDEV(6,NN),
$                SEFF(NN), SE(NN), SEFFOLD(NN)
COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
$                DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
C *** stiffness reduction variables for the [90] ply
COMMON /STIF /  IDAMAGE(10), D(NN), ETA(NN), SPEAK,
$                DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
C =====
COMMON /CONTROL/ TOLER1, TOLER2, RELAX, FAST, ICOUNT,
$                ISUBTOT, IZMAX, MAXITER
C
CHARACTER*80     NAME, HEADER
REAL*8          EP2(6,NN)
INTEGER         ITYPE(MM)
C

```

[illegible]

```

$          ISTRAIN2(IFLIP) .EQ. IBLOCK) THEN
          EZCOOL = ETOT(3,1)
          WRITE(*,*) 'Converting to Strain Control '
          IFLIP = IFLIP + 1
          ILOAD = 1
        ENDIF
$          IF(-ISTRAIN(IFLIP) .EQ. ICOUNT .AND.
          -ISTRAIN2(IFLIP) .EQ. IBLOCK) THEN
          BSAPP(IB) = SZ
          BSAPP(IB+1) = BEZ(IB+1)
          WRITE(*,*) 'Converting to Stress Control '
          IFLIP = IFLIP + 1
          ILOAD = 0
        ENDIF
      CALL SUBCUT(ITYPE, IB, NSTEPS, ISTEP)
C      For concentric cylinder model create a-matrix and the l-u decom
      DO 600 ISUB = 1, ISUBTOT
        SUB = ISUB
        SUBTOT = ISUBTOT
        RSTEP = ISTEP - 1
        STEP = RSTEP + SUB/SUBTOT
C      Compute total and incremental temperature, app stresses
C      applied strain, and time.
        CALL LOAD( IB, NSTEPS, STEP, BT(1) )
C      Interpolate for material properties at temperature t
        CALL PROPT( ITYPE, T )
C      Assign material properties to nodes
        CALL PROPNODES( ITYPE, ICOUNT )
C      Stiffness reduction at the beginning of each step using old ep
C      Call damage( ep2, icount )
C      Compute stresses assuming elastic behavior
        CALL STRESS( EP2, ICOUNT )
C      Compute inelastic strain increments and iterate to converge to
C      Right combination of stresses and strains.
        CALL INELASTIC(ITYPE, EP2 )
600    CONTINUE
C
      FAST = FAST0*0.95 + FAST*0.05
      ITEMP = ICOUNT - ISTEPOUT(IBLOCK)
      if(itemp .ge. 0) then
$      IF(MOD(ITEMP,IPRINTSTEP(IBLOCK)) .EQ. 0 .OR.
          IPRINTSTEP(IBLOCK) .EQ. 1) THEN
          CALL OUTPUT1( ICOUNT, ITYPE, EP2, BS )
        ENDIF
      endif

```

```

C          Fract = 0.007
C          If(eme(3,1) .gt. fract) then
C              Call output1( icount, itype, ep2, bs )
C              Stop
C          Endif
C          Write something at sometime intervals
C          IF(MOD(ICOUNT,100) .EQ. 0)
C              $          WRITE(6,*) ' BLOCK ',IBLOCK, '      COUNT ',
C              $          ICOUNT, ' WITH FAST = ' , FAST
C              ICOUNT = ICOUNT + 1
500          CONTINUE
400          CONTINUE
300          CONTINUE
200          CONTINUE
C          Print out runtime of the code.
C          CALL PRINTTIME( XT1, ICOUNT, NTOT )
C          STOP
C          END

C
C =====
C Printtime
C Reports cpu time of the problem (see local fortran manual for
C Machine dependent time functions)
C =====
C
C          SUBROUTINE PRINTTIME( XT1, ICOUNT, NTOT )
C
C          IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
C          REAL*4  XAT(2), DELTA
C
C          XAT(1) = 0.0
C          XAT(2) = 0.0
C          DELTA  = 0.0
CJoe delta = dtime(xat)
CJoe write(6,100) xat(1), ntot, icount
C          WRITE(6,200)
100  FORMAT( 1X,'RUNTIME IS ',F12.6,' SECONDS FOR ',I5,' NODES AND ',
C          $          I7, ' COMPUTATIONAL STEPS')
200  FORMAT(//,' ***** ANALYSIS COMPLETED ***** ',/////)
C          RETURN
C          END

C
C =====
C Initial

```

```

C Initialize variables
C =====
C
      SUBROUTINE INITIAL( ITYPE, EP, XT1 )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOAD1/  BT(ML) , BSAPP(ML) , BTAU(ML) ,
$                   BEZ(ML) , BSRAPP(ML) , NBLOCK(ML) ,
$                   NCYCLE(ML) , NCSTART(ML) , NCEND(ML) , NCBLOCK
      COMMON /LOAD2/  VF(MM) , EZCOOL , IMAT(MM) ,NODES(MM) ,
$                   NOMAT , ICASE , ILOAD ,ISTRAIN(MM) ,ISTRAIN2(MM)
      COMMON /LOADT/  T , SZ , EZ , SR , TAU , DT ,
$                   TINCR , SZINCR , EZINCR , SRINCR , DTAU ,
$                   TIME , ICYCLE , IBLOCK
      COMMON /READM/  NROW(MM,7) , NCOL(MM,7) , TP(MM,MR,MC) ,
$                   AT(MM,MR,7) , TREF(MM) , NSET(MM)
      COMMON /PROP/   P(MM,MC)
      COMMON /STRES/  S(6,NN) , SDEV(6,NN) ,
$                   SEFF(NN) , SE(NN) , SEFFOLD(NN)
      COMMON /STRAI/  ETOT(6,NN) , DEP(6,NN) , EME(6,NN) , ETH(NN) ,
$                   DEFF(NN) , EPEFF(NN) , DEPOLD(6,NN)
      COMMON /STIF /  IDAMAGE(10) , D(NN) , ETA(NN) , SPEAK ,
$                   DSM , DSCH , DSCL , DM , DTHETA , DDSTAR , DBETA , DDCH
      COMMON /MAT2A /  TSY(NN) , TEP(NN)
      COMMON /MAT5A /  TN(NN) , TZ0(NN) , TF1(NN) , TF3(NN) ,
$                   TBSMAX(NN) , TD0(NN)
      COMMON /MAT5B/  F3OLD(NN) , BS(6,NN) , SDEVOLD(6,NN)
      COMMON /MAT6A /  TND(NN) , TZ0D(NN) , TZ3(NN) , TM2(NN) ,
$                   TA1(NN) , TM1(NN) , TZ1(NN) , TR1(NN) ,
$                   TR2(NN) , TD0D(NN) , TZ2(NN) ,
$                   DTZ1(NN) , DTZ2(NN) , DTZ3(NN)
      COMMON /MAT6B/  BETA(6,NN) , ZD(NN) , ZI(NN) , ZTOT(NN)
      COMMON /MAT7A /  TA1A(NN) ,TA1B(NN) ,TA1C(NN) ,
$                   TM1A(NN) ,TM1B(NN) ,TM1C(NN) ,
$                   TA2(NN)
      COMMON /CONTROL/ TOLER1 , TOLER2 , RELAX , FAST , ICOUNT ,
$                   ISUBTOT , IZMAX , MAXITER
C
      REAL*8          EP(6,NN)
      INTEGER          ITYPE(MM)
CJoe  real*4          xat(2)
C

```

```

      XT1 = 0.0
CJoe  xtl = dtime(xat)
      TIME = 0.0
      ISUBTOT = 1
      FAST = 1
      SZ = 0
      EZ = 0
      SR = 0
      TAU = 0
      DT = 0
      TINCR = 0
      SZINCR = 0
      EZINCR = 0
      SRINCR = 0
      DTA = 0
      EZCOOL = 0
      SPEAK = 0
      DSM = 0
      DSCH = 0
      DSCL = 0
      DM = 0
      DTHETA = 0
      DDSTAR = 0
      DBETA = 0
      DDC = 0
      STEP = 0.0
      DO 3 I = 1,ML
          BT(I) = 0.0
          BSAPP(I) = 0.0
          BTAU(I) = 0.0
          BEZ(I) = 0.0
          BSRAPP(I) = 0.0
          NBLOCK(I) = 0.0
3      CONTINUE
      DO 4 I = 1, MM
          VF(I) = 0.0
          TREF(I) = 0.0
          NSET(I) = 0.0
          IMAT(I) = 0.0
          ISTRAIN(I) = 0
          ISTRAIN2(I) = 0
4      CONTINUE
      DO 5 I=1,6
          DO 5 J=1,NN
              EP(I,J) = 0.0

```

```

S(I,J) = 0
SDEV(I,J)      = 0.0
ETOT(I,J)      = 0.0
DEP(I,J)       = 0.0
EME(I,J)       = 0.0
ETH(J)         = 0.0
DEFF(J)        = 0.0
EPEFF(J)       = 0.0
DEPOLD(I,J)    = 0.0
SEFF(J)        = 0.0
SE(J)          = 0.0
SEFFOLD(J)     = 0.0
D(J)           = 0.0
ETA(J)         = 0.0
TSY(J)         = 0.0
TEP(J)         = 0.0
TN(J)          = 0.0
TZ0(J)         = 0.0
TF1(J)         = 0.0
TF3(J)         = 0.0
TBSMAX(J)      = 0.0
TD0(J)         = 0.0
F3OLD(J)       = 0.0
BS(I,J)        = 0.0
TND(J)         = 0.0
TZ0D(J)        = 0.0
TZ3(J)         = 0.0
TM2(J)         = 0.0
TA1(J)         = 0.0
TM1(J)         = 0.0
TZ1(J)         = 0.0
TR1(J)         = 0.0
TR2(J)         = 0.0
TD0D(J)        = 0.0
TZ2(J)         = 0.0
DTZ1(J)        = 0.0
DTZ2(J)        = 0.0
DTZ3(J)        = 0.0
BETA(I,J)      = 0.0
ZD(J)          = 0.0
ZI(J)          = 0.0
ZTOT(J)        = 0.0

```

```
5  CONTINUE
```

```
DO 10 IM = 1, MM
```

```
DO 11 IS = 1,7
```

```

        NROW(IM,IS) = 0
        NCOL(IM,IS) = 0
        DO 11 IR=1,MR
            AT(IM,IR,IS) = 0.0
11      CONTINUE
        DO 12 IC = 1, MC
            P(IM,IC) = 0.0
            DO 12 IR = 1, MR
                TP(IM,IR,IC) = 0.0
12      CONTINUE
10      CONTINUE
        RETURN
        END

C
C =====
C Readload
C Read loading conditions, geometry and output preferences
C =====
C
        SUBROUTINE READLOAD
C
        IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
        PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
        PARAMETER( NN=50)
        COMMON /LOADO/  INTOUT(ML), IOUT(ML,20),
$                      IPRINTSTEP(ML), ISTEPOUT(ML)
        COMMON /LOAD1/  BT(ML), BSAPP(ML), BTAU(ML), BEZ(ML),
$                      BSRAPP(ML), NBLOCK(ML),
$                      NCYCLE(ML), NCSTART(ML), NCEND(ML), NCBLOCK
        COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM), NODES(MM),
$                      NOMAT, ICASE, ILOAD, ISTRAIN(MM), ISTRAIN2(MM)
        COMMON /STIF /  IDAMAGE(10), D(NN), ETA(NN), SPEAK,
$                      DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
        CHARACTER*80    TITLE, HEADER
        CHARACTER*30    MATDAT, LOADDAT, OUT1, OUT2
C
        ICS_FLAG = 0
C      Open input and output files
        WRITE(6,10)
100    WRITE(6,*)
        WRITE(6,*) '    ENTER INPUT LOADING DATA FILE '
        WRITE(6,*)
        READ(5,755) LOADDAT
        WRITE(6,*)

```

```

OPEN( UNIT = 11, ERR=109, FILE = LOADDAT, STATUS = 'OLD' )
GOTO 110
109 WRITE(6,*)
WRITE(6,*) '      ERROR OPENING FILE - TRY AGAIN  '
WRITE(6,*)
WRITE(6,*)
GOTO 100
110 WRITE(6,*) '      ENTER NAME OF YOUR INTERFACE OUTPUT FILE '
WRITE(6,*)
READ(5,755) OUT1
WRITE(6,*)
OPEN( UNIT = 15, ERR=111, FILE = OUT1, STATUS = 'NEW' )
GOTO 107
111 WRITE(6,*)
WRITE(6,*) '      ERROR OPENING FILE - TRY AGAIN  '
WRITE(6,*)
WRITE(6,*)
GOTO 110
107 CONTINUE
C      Rewriting of input data
WRITE(15,10)
10  FORMAT(/,10X,' ***** ',/,
$      10X,' * * * * * ',/,
$      10X,' * F I D E P 2 - VERSION 8 * ',/,
$      10X,' * * * * * ',/,
$      10X,' ***** ',/)
CJoe write(15,756) loaddat
WRITE(15,*)
WRITE(15,*)
WRITE(15,*) ' ***** PROBLEM TITLE ***** '
WRITE(15,*)
READ(11,750) TITLE
WRITE(15,750) TITLE
READ(11,*) ICASE, ILOAD
WRITE(15,*)
WRITE(15,*)
WRITE(15,*) ' ***** GEOMETRY TYPE ***** '
WRITE(15,*)
IF( ICASE .EQ. 1) THEN
WRITE(15,*) '      CONCENTRIC CYLINDER MODEL '
ELSEIF( ICASE .EQ. 2) THEN
WRITE(15,*) '      1-D LAMINATE MODEL '
ELSEIF( ICASE .EQ. 3) THEN
WRITE(15,*) '      CONCENTRIC CYLINDER MODEL WITH [90] '
ENDIF

```

```

WRITE(15,*)
WRITE(15,*)
WRITE(15,*) ' ***** LOADING TYPE ***** '
WRITE(15,*)
IF (ILOAD .EQ. 0) THEN
    WRITE(15,*) '      STRESS CONTROL '
ELSE
    WRITE(15,*) '      STRAIN CONTROL '
ENDIF
C    Additional prompt commands
IF(ICASE .NE. 2) THEN
    WRITE(6,*)
120  WRITE(6,*) '    ENTER NAME OF AVERAGE STRESS OUTPUT FILE '
    WRITE(6,*)
    READ(5,755) OUT2
    WRITE(6,*)
    OPEN( UNIT = 16, ERR=121, FILE = OUT2, STATUS = 'NEW' )
    WRITE(16,10)
    WRITE(16,*)
    WRITE(16,*)
    WRITE(16,*) ' ***** PROBLEM TITLE ***** '
    WRITE(16,*)
    WRITE(16,750) TITLE
    WRITE(16,*)
    WRITE(16,*)
    WRITE(16,*)
    WRITE(16,*) ' ----- AVERAGE STRESS OUTPUT ----- '
    WRITE(16,*)
    GOTO 122
121  WRITE(6,*)
    WRITE(6,*) '    ERROR OPENING FILE - TRY AGAIN '
    WRITE(6,*)
    WRITE(6,*)
    GOTO 120
122  CONTINUE
ENDIF
C    Continue reading loading file
READ(11,755) MATDAT
CJoe write(15,757) matdat
OPEN( UNIT = 10,ERR=141, FILE = MATDAT, STATUS = 'OLD' )
GOTO 140
141 WRITE(6,*)
    WRITE(6,*) ' MATERIAL DATA-BASE NOT FOUND '
    WRITE(6,*)
    STOP

```

```

140 READ(11,*)      NCBLOCK
      WRITE(15,*)
      WRITE(15,*)
      WRITE(15,*)  ' ***** LOADING HISTORY ***** '
      WRITE(15,*)
      WRITE(15,*)  '  NUMBER OF CYCLE BLOCKS ' , NCBLOCK
      WRITE(15,*)
      WRITE(15,*)
      INDEX  = 0
      IFLIP = 1
      IFLAG = 0
      DO 150  I2 = 1, NCBLOCK
        READ(11,750)  HEADER
        READ(11,*)  NLOAD, NCYCLE(I2) , IPRINTSTEP(I2), ISTEPOUT(I2),
$          INTOUT(I2), NIOUT
C      Open output file for cross-sectional stresses
      IF (NIOUT .GT. 0) THEN
        READ(11,*)  (IOUT(I2,J1), J1 = 1, NIOUT)
        IF(ICS_FLAG .EQ. 0) THEN
          WRITE(6,*)
130      WRITE(6,*)
$      '  ENTER NAME OF CROSS-SECTIONAL STRESS OUTPUT FILE '
          WRITE(6,*)
          READ(5,755) OUT2
          WRITE(6,*)
          OPEN( UNIT = 17, ERR=131, FILE = OUT2, STATUS = 'NEW' )
          WRITE(17,10)
          WRITE(17,*)
          WRITE(17,*)
          WRITE(17,*)  ' ***** PROBLEM TITLE ***** '
          WRITE(17,*)
          WRITE(17,750) TITLE
          WRITE(17,*)
          WRITE(17,*)
          WRITE(17,*)
          WRITE(17,*)
$      '  ----- CROSS-SECTIONAL STRESS OUTPUT ----- '
          WRITE(17,*)
          ICS_FLAG = 1
        ENDIF
        GOTO 132
131      WRITE(6,*)
          WRITE(6,*)  '  ERROR OPENING FILE - TRY AGAIN '
          WRITE(6,*)
          WRITE(6,*)

```

```

        GOTO 130
132      CONTINUE
      ENDIF
      WRITE(15,*)
      WRITE(15,*) ' ***** BLOCK HISTORY DATA ***** '
      WRITE(15,*)
      WRITE(15,*) '   FOR CYCLE BLOCK           ', I2
      WRITE(15,*) '   NUMBER OF LOAD POINTS ', NLOAD
      WRITE(15,*) '   NUMBER OF CYCLES           ', NCYCLE(I2)
      WRITE(15,*)
      READ(11,750)  HEADER
      WRITE(15,*)
      IF( ILOAD .EQ. 0 ) THEN
        WRITE(15,103)
        DO 165 I3 = 1, NLOAD
          INDEX = INDEX + 1
          I = INDEX
          IF(I3 .EQ. 1)      NCSTART(I2)=I
          IF(I3 .EQ. NLOAD)  NCEND(I2)=I-1
          READ(11,*)  NBLOCK(I), BTAU(I), BT(I), BSAPP(I), BSRAPP(I)
          WRITE(15,754) NBLOCK(I),BTAU(I),BT(I), BSAPP(I), BSRAPP(I)
165      CONTINUE
        ELSE
          WRITE(15,104)
          DO 166 I3 = 1 , NLOAD
            INDEX = INDEX + 1
            I = INDEX
            IF(I3 .EQ. 1)      NCSTART(I2)=I
            IF(I3 .EQ. NLOAD)  NCEND(I2)=I
            READ(11,*)  NBLOCK(I), BTAU(I), BT(I), BEZ(I)
            WRITE(15,754) NBLOCK(I), BTAU(I), BT(I), BEZ(I)
C          Find first nonzero strain step
            IF(NBLOCK(I) .LT. 0) THEN
              NBLOCK(I)      = - NBLOCK(I)
              ISTRAIN(IFLIP) = - NBLOCK(I-1)
              ISTRAIN2(IFLIP) = - I2
              IF(ISTRAIN(IFLIP) .EQ. 0) ISTRAIN(IFLIP) = -1
              IFLIP = IFLIP + 1
              IFLAG = 0
            ENDIF
            IF(I .gt. 1) then
              IF( ABS(BEZ(I)) .GT. 1.E-8 .AND.
$              ABS(BEZ(I-1)) .LT. 1.E-8 .AND.
$              IFLAG .EQ. 0 ) THEN
              ISTRAIN(IFLIP) = NBLOCK(I-1)

```

```

        ISTRAIN2(IFLIP) = I2
        IF(ISTRAIN(IFLIP) .EQ. 0) ISTRAIN(IFLIP) = 1
        IFLIP = IFLIP + 1
        IFLAG = 1
    ENDIF
ENDIF
166    CONTINUE
ENDIF
IF (INDEX .GT. ML) THEN
    WRITE(6,*)
    WRITE(6,*)
    WRITE(6,*) ' ***** '
    WRITE(6,*)
    WRITE(6,*) ' WARNING ARRAY SIZE ML EXCEEDED '
    WRITE(6,*)
    WRITE(6,*) ' ***** '
    WRITE(6,*)
    WRITE(6,*)
    STOP
ENDIF
WRITE(15,*)
WRITE(15,*) ' ***** OUTPUT INFORMATION *****'
WRITE(15,*)
WRITE(15,*) ' OUTPUT AT INTERFACE FOR MATERIAL: ' ,INTOUT(I2)
WRITE(15,*)
WRITE(15,*) ' CROSS-SECTIONAL OUTPUT AT STEPS: '
WRITE(15,*)
WRITE(15,*) ( IOUT(I2, J), J = 1, NIOUT)
WRITE(15,*)
150 CONTINUE
103 FORMAT( 2X, ' STEP ', 2X, ' TIME ', 2X, 'TEMPERATURE',
$          2X, 'AXIAL STRESS', 2X, 'RADIAL STRESS')
104 FORMAT( 2X, ' STEP ', 2X, ' TIME ', 2X, 'TEMPERATURE',
$          2X, 'AXIAL STRAIN', 2X)
WRITE(15,*)
WRITE(15,*)
WRITE(15,*) ' ***** GEOMETRY INFORMATION *****'
WRITE(15,*)
READ(11,*) NOMAT
WRITE(15,*) ' NUMBER OF CELLS ', NOMAT
WRITE(15,*)
DO 7 I=1,NOMAT
    READ(11,*) IMAT(I), VF(I), NODES(I)
    WRITE(15,*) ' FOR CELL NUMBER :', I
    WRITE(15,*)

```

```

        WRITE(15,*) '          MATERIAL NUMBER : ', IMAT(I)
        WRITE(15,*) '          VOLUME FRACTION : ', VF(I)
        WRITE(15,*) '          NODES IN CELL : ', NODES(I)
        WRITE(15,*)
7      CONTINUE
401    CONTINUE
        WRITE(6,*)
        WRITE(6,*)
        WRITE(6,*) ' PROCEEDING WITH PROBLEM NAMED '
        WRITE(6,*)
        WRITE(6,*)
        WRITE(6,750) TITLE
        WRITE(6,*)
        WRITE(6,*)
C *****
757    FORMAT(1X,/, ' MATERIAL DATA BASE : ', A20,/)
750    FORMAT( A80 )          ! FOR TITLES
755    FORMAT( A30 )          ! FOR FILE NAMES
756    FORMAT(1X,/, ' LOADING DATA FILE : ', A20)
754    FORMAT(1X, I5, 10(1X,1PE12.4))
781    FORMAT(1X, I4, 10(1X,I8))
        RETURN
        END
C
C =====
C Readmat
C Read constitutive model type and temperature dependent properties
C For materials defined by the load file.
C This subroutine reads both temperature dependent and independent
C Elastic and inelastic material properties for any constitutive
C Model into material, row, column array tp(i,j,k).
C =====
C
        SUBROUTINE READMAT( ITYPE )
C
        IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
        PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
        PARAMETER( NN=50)
        COMMON /READM/ NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
$                AT(MM,MR,7), TREF(MM), NSET(MM)
        COMMON /LOAD2/ VF(MM), EZCOOL, IMAT(MM), NODES(MM),
$                NOMAT, ICASE, ILOAD, ISTRAIN(MM), ISTRAIN2(MM)
        COMMON /NAME1/ NAME(MM), HEADER(MM,7)
        COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,

```

```

$          DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
INTEGER      ITYPE(MM)
CHARACTER*80  TITLE, NAME, HEADER
INTEGER      INROW(7), INCOL(7), INSET, IITYPE
REAL*8       ZTP(MR,MC), ZAT(MR,7), ZTREF
CHARACTER*80  ZSTUFF,  ZNAME, ZHEADER(7)

C
C   Go though each material, until you found your data
DO 410 I = 1, NOMAT
    IMCHECK = IMAT(I)
    REWIND(10)
    READ(10,755) TITLE
    DO 400 IM = 1, 40
        READ(10,755,END=999) ZSTUFF
        READ(10,*,END=999) K, IITYPE
        READ(10,755) ZNAME
C       Read elastic material properties
        READ(10,*) INROW(1)
        INCOL(1) = 3
        READ(10,755) ZHEADER(1)
        DO 5 IR = 1, INROW(1)
            READ(10,*) ZAT(IR,1), (ZTP(IR,IC), IC=1, INCOL(1))
5       CONTINUE
        READ(10,*) ZTREF
        IF( IITYPE .NE. 1 ) THEN
C           The inelastic material properties are given in this many sets
            READ(10,*) INSET
            N1 = 1
C           Read the inelastic material properties
            DO 300 IS = 2, INSET + 1
                READ(10,*) INROW(IS), INCOL(IS)
                READ(10,755) ZHEADER(IS)
                N1 = N1 + INCOL(IS-1)
                N2 = N1 + INCOL(IS) - 1
C           If only one row of data then there is no temp variable,
                IF( INROW(IS) .EQ. 1 ) THEN
                    READ(10,*) (ZTP(1,IC), IC=N1,N2)
                ELSE
C           If properties are temperature dependent,
                    DO 7 IR=1, INROW(IS)
                        READ(10,*) ZAT(IR, IS),
$                          ( ZTP(IR,IC), IC=N1,N2 )
7                   CONTINUE
                    ENDIF
300        CONTINUE

```

```

ENDIF
C      Find new material if material of interest is
C      Not found
      IF(K .EQ. IMCHECK) THEN
C      Store the materials that are used
      ITYPE(I) = IITYPE
      IDAMAGE(I) = 0
C ***** damage in 90 *****
      IF( ITYPE(I) .EQ. 4 ) THEN
          IDAMAGE(I) = 1
          ITYPE(I) = 6
      ENDIF
C *****
      NAME(I) = ZNAME
      NROW(I,1) = INROW(1)
      NCOL(I,1) = INCOL(1)
      HEADER(I,1) = ZHEADER(1)
      DO 9 IR = 1, NROW(I,1)
          AT(I,IR,1) = ZAT(IR,1)
          DO 9 IC = 1, 3
              TP(I,IR,IC) = ZTP(IR,IC)
9      CONTINUE
      TREF(I) = ZTREF
      IF( ITYPE(I) .NE. 1 ) THEN
C      The inelastic material properties are given in this many sets
      NSET(I) = INSET
      N1 = 1
      DO 310 IS = 2, NSET(I) + 1
          NROW(I,IS) = INROW(IS)
          NCOL(I,IS) = INCOL(IS)
          HEADER(I,IS) = ZHEADER(IS)
          N1 = N1 + NCOL(I,IS-1)
          N2 = N1 + NCOL(I,IS) - 1
C      If only one row of data then there is no temp variable,
      IF( NROW(I,IS) .EQ. 1 ) THEN
          DO 11 IC = N1, N2
              TP(I,1,IC) = ZTP(1,IC)
11      CONTINUE
          ELSE
C      If properties are temperature dependent,
          DO 13 IR=1,NROW(I,IS)
              AT(I,IR,IS) = ZAT(IR,IS)
              DO 13 IC = N1, N2
                  TP(I,IR,IC) = ZTP(IR,IC)
13      CONTINUE

```

```

                ENDIF
310             CONTINUE
                ENDIF
C             If material type is found and stored, continue
C             With next material
                GOTO 410
                ENDIF
400     CONTINUE
410     CONTINUE
        RETURN
C
999     CONTINUE
        WRITE(6,*)
        WRITE(6,*) ' ***** ERROR ***** '
        WRITE(6,*)
        WRITE(6,*) '   MATERIAL DATA NOT FOUND '
        WRITE(6,*) '   FOR MATERIAL NUMBER   ', IMCHECK
        WRITE(6,*)
        WRITE(6,*) ' ***** ERROR ***** '
        WRITE(6,*)
        WRITE(6,*)
        STOP
C
755     FORMAT(A80)
        END
C
C=====
C Newcte
C Compute new cte if reference temperature is not the same as the
C First temperature in the loading file
C=====
C
        SUBROUTINE NEWCTE( TPROC )
C
        IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
        PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
        PARAMETER( NN = 50)
        COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
$                      NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
        COMMON /READM/  NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
$                      AT(MM,MR,7), TREF(MM), NSET(MM)
        REAL*8      CTE(MR), T(MR)

        DO 500 K = 1, NOMAT

```

```

      IF( ABS(TREF(K)-TPROC) .LE. 1.E-6 )GOTO 500
      DO 5 J = 1, NROW(K,1)
        CTE(J) = TP(K,J,3)
        T(J) = AT(K,J,1)
5      CONTINUE
C      Jfac is used to extrapolate for the new cte at the new ref
C      Due to the fact that the new cte is infinity here.
C      For interpolations between temperatures (general case) jfac=0
C      For cte interpolated a new ref temp from the new cte table =1
      JFAC = 0
C      Compute new secant cte with respect to the initial temperature
C      In the loading file, i. e. tproc.
      J = 1
      TT = TPROC
      DOWHILE(TT.GT.T(J))
        J = J + 1
      ENDDO
C      Determine old cte at processing temperature
      CALL INTERPOL( J, CTE, T, TT, NROW(K,1), CTEPROC, JFAC )
C      Replace the old cte table with the new cte table
      DO 405 J = 1, NROW(K,1)
        XT = T(J)
        XCTE = CTE(J)
        IF(ABS(XT-TT) .LT. 1.E-5 )THEN
          JSTAR = J
          TSTAR = T(J)
          GOTO 405
        ENDIF
C      Compute new cte wrt processing temperature
      TOP = XCTE*(XT-TREF(K)) - CTEPROC*(TPROC - TREF(K))
      CTE(J) = TOP / ( XT - TPROC )
405    CONTINUE
C      If the new processing temperature is one of the data points
C      Then interpolate between the previous and the next cte.
      IF( ABS(TSTAR-TPROC) .LT. 1.E-5 )THEN
        JFAC = 1
        CALL INTERPOL( JSTAR, CTE, T, TSTAR, NROW, CTE( JSTAR ), JFAC )
      ENDIF
      DO 6 J = 1, NROW(K,1)
        TP(K,J,3) = CTE(J)
6      CONTINUE
      TREF(K) = TPROC
500    CONTINUE

755    FORMAT(A80)

```

```

410 RETURN
      END

C
C =====
C Closefiles
C Close input files
C =====
C
      SUBROUTINE CLOSEFILES
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      REWIND 10
      REWIND 11
      CLOSE(10)
      CLOSE(11)
      RETURN
      END

C
C =====
C Writemat
C Write material data into output file 15
C =====
C
      SUBROUTINE WRITEMAT( ITYPE )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /READM/  NROW(MM,7) , NCOL(MM,7) , TP(MM,MR,MC) ,
$                  AT(MM,MR,7) , TREF(MM) , NSET(MM)
      COMMON /NAME1/  NAME(MM) , HEADER(MM,7)
      COMMON /LOAD1/  BT(ML) , BSAPP(ML) , BTAU(ML) ,
$                  BEZ(ML) , BSRAPP(ML) , NBLOCK(ML) ,
$                  NCYCLE(ML) , NCSTART(ML) , NCEND(ML) , NCBLOCK
      COMMON /LOAD2/  VF(MM) , EZCOOL , IMAT(MM) , NODES(MM) ,
$                  NOMAT , ICASE , ILOAD , ISTRAIN(MM) , ISTRAIN2(MM)
      COMMON /STIF /  IDAMAGE(10) , D(NN) , ETA(NN) , SPEAK ,
$                  DSM , DSCH , DSCL , DM , DTHETA , DDSTAR , DBETA , DDCH
      INTEGER          ITYPE(MM)
      CHARACTER*80      NAME , HEADER
C
      WRITE(6,*)
      WRITE(6,*) ' ENTER: (1) FOR MATERIAL PROPERTY OUTPUT '

```

```

WRITE(6,*) '          (2) FOR NO MATERIAL PROPERTY OUTPUT '
WRITE(6,*)
READ(5,*) IMATOUT
WRITE(6,*)
WRITE(6,*)
WRITE(6,*) ' *****'
WRITE(6,*)
WRITE(6,*) ' PROCEEDING WITH PROBLEM - PLEASE STAND BY '
WRITE(6,*)
WRITE(6,*) ' *****'
WRITE(6,*)
WRITE(6,*)
WRITE(15,*)
WRITE(15,*)
WRITE(15,*) ' ***** MATERIAL INFORMATION *****'
WRITE(15,*)
DO 400 K = 1, NOMAT
  WRITE(15,*)
  WRITE(15,*) ' MATERIAL FOR CELL NUMBER : ', K
  WRITE(15,*)
  WRITE(15,755) NAME(K)
  WRITE(15,*)
  IF( ITYPE(K) .EQ. 1 )THEN
    WRITE(15,*) ' CONSTITUTIVE MODEL: ELASTIC '
  ELSEIF( ITYPE(K) .EQ. 2 )THEN
    WRITE(15,*) ' CONSTITUTIVE MODEL: BILINEAR ELASTIC-PLASTIC '
  ELSEIF( ITYPE(K) .EQ. 3 )THEN
    WRITE(15,*)
$    ' CONSTITUTIVE MODEL: ELASTIC-PLASTIC WITH DAMAGE '
  ELSEIF( ITYPE(K) .EQ. 4 )THEN
    WRITE(15,*) ' CONSTITUTIVE MODEL: VISCO-PLASTIC WITH DAMAGE '
  ELSEIF( ITYPE(K) .EQ. 5 )THEN
    WRITE(15,*)
$    ' CONSTITUTIVE MODEL: BODNER-PARTOM WITH BACK STRESS '
  ELSEIF( ITYPE(K) .EQ. 6 )THEN
    WRITE(15,*)
$    ' CONSTITUTIVE MODEL: BODNER-PARTOM WITH DIRECTIONAL HARDENING'
  ENDIF
  IF( IMATOUT .NE. 1 ) GOTO 400
  WRITE(15,*)
  WRITE(15,*)
  WRITE(15,*) ' ----- MATERIAL PROPERTIES ----- '
  WRITE(15,*)
  NCOL(K,1) = 3
  DO 300 IS = 1, NSET(K)+1

```

```

        WRITE(15,*)
        WRITE(15,755) HEADER(K,IS)
        IF( IS. EQ. 1 ) THEN
            N1 = 0
        ELSE
            N1 = N1+NCOL(K,IS-1)
        ENDIF
        N2 = NCOL(K,IS)
        IF( NROW(K,IS). EQ. 1 .AND. IS .NE. 1 ) THEN
            WRITE(15,*) ( TP(K,1,L) , L=N1+1,N1+N2 )
        ELSE
            DO 5 J = 1,NROW(K,IS)
                WRITE(15,754) AT(K,J,IS) , (TP(K,J,L) , L=N1+1,N1+N2)
5            CONTINUE
        ENDIF
        IF( IS .EQ. 1 ) THEN
            WRITE(15,*)
            WRITE(15,*) ' REFERENCE TEMPERATURE = ', TREF(K)
C            If(itype(k) .ne. 1) write(15,*) 'set no: ',nset(k)
        ENDIF
        WRITE(15,*) ' ----- '
        IF( ITYPE(K) .EQ. 1 ) GOTO 400
300    CONTINUE
400    CONTINUE
        WRITE(15,*)
754    FORMAT(10(1X,1PE12.4))
755    FORMAT(A80)
        RETURN
        END
C
C =====
C Load
C Interpolate for applied loading, time and temperature
C Compute increments in temperature, applied stress, total applied
C Strain and time
C =====
C
        SUBROUTINE LOAD( IB, NSTEPS, STEP, TPROC )
C
        IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
        PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
        PARAMETER( NN = 50)
        COMMON /LOAD1/ BT(ML) , BSAPP(ML) , BTAU(ML) ,
$                BEZ(ML) , BSRAPP(ML) , NBLOCK(ML) ,

```

```

$          NCYCLE(ML) , NCSTART(ML) , NCEND(ML) , NCBLOCK
COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
$          TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$          TIME, ICYCLE, IBLOCK
COMMON /ELASX/  TEO(NN) , TE(NN) , TNU(NN) , TCTE(NN) , ECOM, CTECOM
COMMON /CCM1 /  RAD(LDA) , IBEG(MM) , IEND(MM) , NTOT
COMMON /MATRIX/ AMAT(LDA,LDA) , BMAT(LDA) , NRA,
$          IPVT(LDA)
COMMON /MATRIX2/ AA(NN) , BB(NN) , CC(NN) , DD(NN) ,
$          FF(NN) , GG(NN) , HH(NN) , QQ(NN) , PP(NN)
C
      T    = T    + TINCR
      DT   = T    - TPROC
      SZ   = SZ   + SZINCR
      SR   = SR   + SRINCR
      EZ   = EZ   + EZINCR
      TAU  = TAU  + DTAU
      TIME = TIME + DTAU
C
C
      DO 100 I = 2, NTOT
          QQ(I) = TE(I)*DT*(TCTE(I)*(1 + TNU(I))
$           - TCTE(I-1)*(1 + TNU(I-1))
100  CONTINUE
      DO 20 I = 1, NRA
          BMAT(I) = 0.0
20   CONTINUE
C   If radial loading is applied, add term in b(ntot-1)
      BMAT(NTOT-1) = SR
      RETURN
      END
C =====
      FUNCTION XNEW( STEP, NSTEPS, X1, X2 )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      xsteps = nsteps
      XNEW = STEP*( X2 - X1 )/xsteps + X1
      RETURN
      END
C
C =====
C Subcut
C =====
C

```

```

SUBROUTINE SUBCUT( ITYPE, IB, NSTEPS, ISTEP)

C
IMPLICIT DOUBLE PRECISION ( A-H,O-Z )

C
PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
PARAMETER( NN = 50)
COMMON /LOAD1/ BT(ML), BSAPP(ML), BTAU(ML),
$              BEZ(ML), BSRAPP(ML), NBLOCK(ML),
$              NCYCLE(ML), NCSTART(ML), NCEND(ML), NCBLOCK
COMMON /LOAD2/ VF(MM), EZCOOL, IMAT(MM), NODES(MM),
$              NOMAT, ICASE, ILOAD, ISTRAIN(MM), ISTRAIN2(MM)
COMMON /CCM1 / RAD(LDA), IBEG(MM), IEND(MM), NTOT
COMMON /ELASX/ TEO(NN), TE(NN), TNU(NN), TCTE(NN), ECOM, CTECOM
COMMON /LOADT/ T, SZ, EZ, SR, TAU, DT,
$              TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$              TIME, ICYCLE, IBLOCK
COMMON /PROP/ P(MM,MC)
COMMON /CONTROL/ TOLER1, TOLER2, RELAX, FAST, ICOUNT,
$              ISUBTOT, IZMAX, MAXITER
INTEGER          ITYPE(MM)

C
C Set control variables
C
IF (ICASE .NE. 2) THEN
    TOLER1 = 0.01
    TOLER2 = 0.01
ELSE
    TOLER1 = 0.0001
    TOLER2 = 0.0001
END IF
RELAX = 0.5
IZMAX = 30
MAXITER = 30

C
STEP = ISTEP
TNEW = XNEW( STEP, NSTEPS, BT(IB), BT(IB+1) )
SZNEW = XNEW( STEP, NSTEPS, BSAPP(IB), BSAPP(IB+1) )
EZNEW = XNEW( STEP, NSTEPS, BEZ(IB), BEZ(IB+1) )
SRNEW = XNEW( STEP, NSTEPS, BSRAPP(IB), BSRAPP(IB+1) )
TAUNEW = XNEW( STEP, NSTEPS, BTAU(IB), BTAU(IB+1) )
CALL PROPT( ITYPE, TNEW )
ECOM = 0.0
CTECOM = 0.0

C Elastic properties at the nodes
DO 100 IM = 1, NOMAT

```

```

        DO 200 K = IBEG(IM), IEND(IM)
        IF(ITYPE(IM) .GE. 5) ISUBTOT = 1 + FAST* P(IM,4)
200    CALL ELAS( IM, K )
C      Compute composite modulus and composite cte
        K = IBEG(IM)
        ECOM = ECOM + TE(K)*VF(IM)
        CTECOM = CTECOM + TCTE(K)*TE(K)*VF(IM)
100    CONTINUE
C
        TINCR = (TNEW - T)/FLOAT(ISUBTOT)
        SZINCR = (SZNEW - SZ)/FLOAT(ISUBTOT)
        SRINCR = (SRNEW - SR)/FLOAT(ISUBTOT)
        EZINCR = (EZNEW - EZ)/FLOAT(ISUBTOT)
        DTAU = (TAUNEW - TAU)/FLOAT(ISUBTOT)
C
        IF(ICOUNT .GT. 1 .AND. TINCR .LE. 1.E-6) RETURN
        IF(ICASE .NE. 2) THEN
        CALL AMATRIX( ICOUNT )
        ENDIF
        RETURN
        END
C
C =====
C Propt
C Interpolate for material properties at temperature t
C =====
C
        SUBROUTINE PROPT( ITYPE, T )
C
        IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
        PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
        PARAMETER( NN = 50)
        COMMON /LOAD2/ VF(MM), EZCOOL, IMAT(MM),NODES(MM),
$              NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
        COMMON /READM/ NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
$              AT(MM,MR,7), TREF(MM), NSET(MM)
        COMMON /PROP/ P(MM,MC)
        INTEGER ITYPE(MM)
C
        DO 400 I = 1, NOMAT
            N1 = 0
            DO 400 L = 1, NSET(I)+1
                N1 = N1 + NCOL(I,L-1)
                N2 = NCOL(I,L)

```

```

      IF( NROW(I,L) .EQ. 1 )THEN
        DO 200 K = 1+N1, N1+N2
          IF( TP(I,1,K) .LE. -9990)THEN
            ID_CUR = IFIX( TP(I,1,K) )
            P(I,K) = CURVE(T,ID_CUR)
            GOTO 200
          ENDIF
          P(I,K) = TP(I,1,K)
200    CONTINUE
        ELSE
          DO 5 J = 1, NROW(I,L)
            IF( T .LE. AT(I,J,L) ) GOTO 20
          5    CONTINUE
          J = J - 1
20    DO 205 K = 1+N1, N1+N2
          IF( TP(I,1,K) .LE. -9990 )THEN
            ID_CUR = IFIX( TP(I,1,K) )
            P(I,K) = CURVE(T,ID_CUR)
            GOTO 205
          ENDIF
          CALL INTER( I, J, K, L, T )
CXx    write(15,*) i, k, p(i,k)
205    CONTINUE
        ENDIF
400  CONTINUE
      RETURN
      END

C =====
C Functional properties
C Material properties given as an explicit function of temperature
C =====

      FUNCTION CURVE(T,ID_CUR)
C
C      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
C      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
C      PARAMETER( NN = 50)
C
C      This is specifically for fuctionally defined properties
      CURVE = 0
      IF(ID_CUR .EQ. -9999) THEN
        CURVE = 5.8E5*EXP( -1.37E4/(T+273) )
      ENDIF
      RETURN
      END

```

```

C
C =====
C Propnodes
C Assign material properties to nodes and multiply by appropriate const
C =====
C
      SUBROUTINE PROPNODES( ITYPE, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER(NN=50)
      COMMON /PROP / P(MM,MC)
      COMMON /CCM1 / RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /LOAD2/ VF(MM), EZCOOL, IMAT(MM),NODES(MM),
$          NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /MAT2A/ TSY(NN),TEP(NN)
      COMMON /MAT5A/ TN(NN),TZ0(NN),TF1(NN),TF3(NN),
$          TBSMAX(NN),TD0(NN)
      COMMON /MAT6A/ TND(NN),TZ0D(NN),TZ3(NN),TM2(NN),
$          TA1(NN),TM1(NN),TZ1(NN),TR1(NN),
$          TR2(NN),TD0D(NN),TZ2(NN),
$          DTZ1(NN),DTZ2(NN),DTZ3(NN)
      COMMON /STIF / IDAMAGE(10),D(NN),ETA(NN),SPEAK,
$          DSM,DSCH,DSCL,DM,DTHETA,DDSTAR,DBETA,DDCH
      INTEGER          ITYPE(MM)
C
      ECOM = 0.0
      CTECOM = 0.0
C      Elastic properties at the nodes
      DO 100 IM = 1, NOMAT
          DO 200 K = IBEG(IM), IEND(IM)
200          CALL ELAS( IM, K )
C      Compute composite modulus and composite cte
          K = IBEG(IM)
          ECOM = ECOM + TE(K)*VF(IM)
          CTECOM = CTECOM + TCTE(K)*TE(K)*VF(IM)
100  CONTINUE
      IF(ECOM .EQ. 0) THEN
          WRITE(6,*) ' COMPOSITE MODULUS ERROR '
          WRITE(6,*) ' DOUBLE CHECK YOUR INPUT FILE '
          STOP
      ENDIF
      CTECOM = CTECOM/ECOM

```

```

C      Inelastic properties at the nodes
DO 300 IM = 1, NOMAT
  IF( ITYPE(IM) .EQ. 1 ) THEN
    GOTO 300
  ELSEIF( ITYPE(IM) .EQ. 2 ) THEN
    DO 10 K = IBEG(IM), IEND(IM)
      CALL MAT2( IM, K )
10    CONTINUE
  ELSEIF( ITYPE(IM) .EQ. 3 ) THEN
    DO 15 K = IBEG(IM), IEND(IM)
      CALL MAT2( IM, K )
15    CONTINUE
  ELSEIF( ITYPE(IM) .EQ. 4 ) THEN
C      Bodner-partom with direct hard with damage
C      Is automatically redefined as itype=6 and
C      Idamage(im) = 1
  ELSEIF( ITYPE(IM) .EQ. 5 ) THEN
    DO 20 K = IBEG(IM), IEND(IM)
      CALL MAT5( IM, K, ICOUNT )
20    CONTINUE
  ELSEIF( ITYPE(IM) .EQ. 6 ) THEN
    DO 25 K = IBEG(IM), IEND(IM)
      CALL MAT6( IM, K, ICOUNT )
25    CONTINUE
  ELSEIF( ITYPE(IM) .EQ. 7 ) THEN
    DO 30 K = IBEG(IM), IEND(IM)
      CALL MAT7( IM, K, ICOUNT )
30    CONTINUE
  ENDIF
300 CONTINUE
  RETURN
END

C
C =====
C Amatrix
C For concentric cylinder model case, create a-matrix and the l-u
C Decomposition at this loading step
C =====
C
  SUBROUTINE AMATRIX( ICOUNT )
C
  IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
  PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
  PARAMETER( NN = 50)

```

```

COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
$              TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$              TIME, ICYCLE, IBLOCK
COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
$              NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
COMMON /ELASX/  TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
$              IPVTLDA)
COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
$              FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)

IF( ICASE .EQ. 3) THEN
  NTOT = NTOT - 2
  NOMAT = NOMAT - 1
ENDIF
NRA = 2*( NTOT - 1 )
CFcb changed nn to ntot
DO 10 I = 1, NTOT
  AA(I) = 0.0
  BB(I) = 0.0
  CC(I) = 0.0
  DD(I) = 0.0
  FF(I) = 0.0
  GG(I) = 0.0
  HH(I) = 0.0
10  CONTINUE
DO 20 I = 1, NRA
  DO 20 J = 1, NRA
    AMAT(I,J) = 0.0
20  CONTINUE
DO 30 I = 2, NTOT
CJoe  aa(i) = ( rad(i) - rad(i-1) )/(rad(i) + rad(i-1))
      AA(I) = 0.5*( RAD(I) - RAD(I-1) )/RAD(I)
      BB(I) = TE(I) / TE(I-1)
      CC(I) = RAD(I) / RAD(I-1)
      DD(I) = ( 1 + TNU(I) )*( TNU(I) + AA(I) )
      FF(I) = ( 1 + TNU(I) )*( 1 - TNU(I) + AA(I) )
      GG(I) = ( 1 + TNU(I-1) )*( TNU(I-1) - AA(I)*CC(I) )*BB(I)
      HH(I) = ( 1 + TNU(I-1) )*( 1 - TNU(I-1) - AA(I)*CC(I) )
$      *BB(I)
30  CONTINUE

C      The limits are taken for the first terms in left submatrices
      AMAT(1,1) = AA(2)

```

```

      AMAT(NTOT,1) = (1 + TNU(1))*(1 - 2*TNU(1))*BB(2)
      DO 50 I = 2, NTOT - 1
C       Upper left submatrix (without the first term)
      AMAT(I-1,I) = -1.0
      AMAT(I,I) = 1/CC(I+1)
C       Lower left submatrix (without the first term)
      AMAT(NTOT+I-2,I) = DD(I)
      AMAT(NTOT+I-1,I) = -GG(I+1)
C       Lower diagonal terms in the upper right submatrix
      AMAT(I,NTOT+I-2) = AA(I+1)
C       Lower diagonal terms in the lower right submatrix
      AMAT(NTOT+I-1,NTOT+I-2) = HH(I+1)
50    CONTINUE
C       Skip the addition to the amatrix during strain loading
      IF( ILOAD .EQ. 1 )GOTO 55
CC - -add additional terms at equations for interface nodes
      DO 11 I = 2,NOMAT
      J = IEND(I-1)
      AMAT(NTOT-1+J,J) = - GG(J+1) + 2*TE(J+1)/ECOM*VF(I-1)
      $      *( TNU(J) - TNU(J+1) )**2
11    CONTINUE
55    DO 60 I=1,NTOT-1
C       Upper right submatrix diagonal
      AMAT(I,NTOT+I-1) = AA(I+1)
C       Lower right submatrix diagonal
      AMAT(NTOT+I-1,NTOT+I-1) = -FF(I+1)    ! LOWER RIGHT
60    CONTINUE
C       Compute the lu factorization of amat and store in amat
      CALL LUDCMP(AMAT,NRA,LDA,IPVT,D)
      IF( ICASE .EQ. 3 ) THEN
      NTOT = NTOT + 2
      NOMAT = NOMAT + 1
      ENDIF
      RETURN
      END
C
C =====
C Stress
C Compute stresses assuming elastic behavior for the last load incr.
C =====
C
      SUBROUTINE STRESS( EP, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C

```

```

PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
PARAMETER( NN = 50)
COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
$              TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$              TIME, ICYCLE, IBLOCK
COMMON /STIF /  IDAMAGE(10), D(NN), ETA(NN), SPEAK,
$              DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM), NODES(MM),
$              NOMAT, ICASE, ILOAD, ISTRAIN(MM), ISTRAIN2(MM)
COMMON /ELASX/  TEO(NN), TE(NN), TNU(NN), TCTE(NN), ECOM, CTECOM
COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
$              IPVT(LDA)
COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
$              FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
COMMON /STRES/  S(6,NN), SDEV(6,NN),
$              SEFF(NN), SE(NN), SEFFOLD(NN)
COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
$              DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
REAL*8          EP(6,NN)
C
C ***** damage for 90, stiffness reduction *****
DO 9 I=1,NOMAT
  IF( IDAMAGE(I) .EQ. 1 )THEN
    DO 8 J = IBEG(I), IEND(I)
      8      TE(J) = TEO(J)*(1.0-ETA(J)*D(J))
    ENDIF
  9  CONTINUE
C  Compute new composite modulus and cte
  ECOM = 0.0
  CTECOM = 0.0
  DO I=1,NOMAT
    J = IBEG(I)
    ECOM = ECOM + TE(J)*VF(I)
    CTECOM = CTECOM + TCTE(J)*TE(J)*VF(I)
  ENDDO
  CTECOM = CTECOM/ECOM
C *****
  GOTO(10,20,30), ICASE
C  For icase 1 - concentric cylinder
  10  CALL STRESS1( EP, ICOUNT )
  GO TO 99
C  For icase 2 - lamina model
  20  CALL STRESS2( EP, ICOUNT )
  GO TO 99

```

```

C      For icase 3 - concentric cylinder with [90]
30     CALL STRESS3( EP, ICOUNT )
99     CONTINUE
      DO 3 J = 1, NTOT
C      Compute total strains
      ETOT(1,J) = ( S(1,J) - TNU(J)*( S(2,J) + S(3,J) ) ) / TE(J)
$      + TCTE(J)*DT + EP(1,J)
      ETOT(2,J) = ( S(2,J) - TNU(J)*( S(1,J) + S(3,J) ) ) / TE(J)
$      + TCTE(J)*DT + EP(2,J)
      ETOT(3,J) = ( S(3,J) - TNU(J)*( S(1,J) + S(2,J) ) ) / TE(J)
$      + TCTE(J)*DT + EP(3,J)
      ETH(J) = TCTE(J)*DT
      DO 1 I = 1, 3
      EME(I,J) = ETOT(I,J) - ETH(J)
1      CONTINUE
      CALL DEVIATS( J )
      SEFF(J) = CSEFF( J )
3      CONTINUE
      RETURN
      END

C
C =====
C Output1, called from inelastic
C Print output
C =====
C
      SUBROUTINE OUTPUT1( ICOUNT, ITYPE, EP, BS )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50 )
      COMMON /LOADO/ INTOUT(ML), IOUT(ML,20),
$                  IPRINTSTEP(ML), ISTEPOUT(ML)
      COMMON /STRES/ S(6,NN), SDEV(6,NN),
$                  SEFF(NN), SE(NN), SEFFOLD(NN)
      COMMON /STRAI/ ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
$                  DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
      COMMON /ELASX/ TEO(NN), TE(NN), TNU(NN), TCTE(NN), ECOM, CTECOM
      COMMON /MAT2A/ TSY(NN), TEP(NN)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
$                  DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /CCM1 / RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /LOAD2/ VF(MM), EZCOOL, IMAT(MM), NODES(MM),
$                  NOMAT, ICASE, ILOAD, ISTRAIN(MM), ISTRAIN2(MM)

```

```

COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
$              TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$              TIME, ICYCLE, IBLOCK
COMMON /MAT6B/  BETA(6,NN), ZD(NN), ZI(NN), ZTOT(NN)
REAL*8         BS(6,NN), EP(6,NN), DUM1(10), OUTVAR(30)
INTEGER        ITYPE(MM)
CHARACTER*10   REAL10

C
C Compute effective stress which is not computed for elastic runs
      IF( ICOUNT .EQ. 0 ) THEN
        WRITE(15,699)
699    FORMAT(/,2X,
$      '----- OUTPUT -----',/)
        IF( ICASE .EQ. 1 ) WRITE(15,110)
        IF( ICASE .EQ. 2 ) WRITE(15,210)
        IF( ICASE .EQ. 3 ) WRITE(15,310)
        IF( ICASE .NE. 2 ) WRITE(16,410)
      ENDIF

C=====
110  FORMAT(' BLOCK  CYCLE  ', ' TIME  ',3X,'TEMPERATRE ',
$          3X,' SEFF  ',3X,' SRAD  ',3X,' STAN  ',
$          3X,' SZ    ',3X,' EPRAD ',3X,' EPTAN  ',
$          3X,' EPZ   ',3X,' ZI    ',3X,' ZD    ')

C=====
210  FORMAT(' BLOCK  CYCLE  STEP  ', ' TIME  ',3X,'TEMPERATRE ',
$          3X,' SZ-APP  ',3X,' SZ-LAM1 ',3X,' SZ-LAM2  ',
$          3X,' SZ-LAM3 ',3X,' ETOT   ',3X,' EME-LAM1  ')
C  $          3X,' eme-lam2 ',3X,' eme-lam3  ')

C=====
310  FORMAT(' BLOCK  CYCLE  STEP  ', ' TIME  ',3X,'TEMPERATRE ',
$          3X,' SEFF  ',3X,' SRAD  ',3X,' STAN  ',
$          3X,' SZ    ',3X,' ERAD  ',3X,' ETAN  ',
$          3X,' EZ     ')

C=====
410  FORMAT(' BLOCK  CYCLE  STEP  ', ' TIME  ',3X,'TEMPERATRE ',
$          3X,' SZAPP  ',3X,' SZF   ',3X,' SZM    ',
$          3X,' SZ90   ',3X,' EME-F  ',3X,' EME-M  ',
$          3X,' EME-90 ',3X,' EZC    ')

C=====
C      This is for summing loads for the [0/90] model
      IF( ILOAD .EQ. 1 ) THEN
        IF( ICASE .EQ. 1 ) THEN
          SZ = 0.0
          DO 6  I = 2, NTOT
            SZ = SZ + (RAD(I)**2-RAD(I-1)**2)*0.5*(S(3,I)+S(3,I-1))

```

```

6      CONTINUE
      ELSEIF(ICASE .EQ. 2) THEN
        SZ = 0.0
        DO 7 I = 1, NOMAT
          SZ = SZ + VF(I) * S(3,I)
7      CONTINUE
      ELSEIF(ICASE .EQ. 3) THEN
        SZ = 0.0
        DO 8 I = 1, NOMAT-2
          SZ = SZ + (RAD(I)**2-RAD(I-1)**2)*0.5*(S(3,I)+S(3,I-1))
8      CONTINUE
        SZ = SZ + VF(NOMAT) * S(3,NOMAT)
      ENDIF
    ENDIF

C=====
C
C File 15          t h e   x - f i l e
C
C=====
C
C   Concentric cylinder model
    IF(ICASE .EQ. 1) THEN
      IO = IBEG(INTOUT(IBLOCK))
      OUTVAR(1) = TIME
      OUTVAR(2) = T
      OUTVAR(3) = SEFF(IO)
      OUTVAR(4) = S(1,IO)
      OUTVAR(5) = S(2,IO)
      OUTVAR(6) = S(3,IO)
      OUTVAR(7) = EP(1,IO)
      OUTVAR(8) = EP(2,IO)
      OUTVAR(9) = EP(3,IO)
      OUTVAR(10) = ZI(IO)
      OUTVAR(11) = ZD(IO)
c      WRITE(15,213) IBLOCK, ICYCLE, ( OUTVAR(J), J=1,11 )
      write(15,212) iblock, icycle, (real10(outvar(j)), j=1,11)
212    FORMAT(2(1X,I5), 11(1X, A10 ))
213    FORMAT(2(1X,I5), 11(1X, 1PE15.8 ))
    ENDIF

C=====
C
C   Lamina model
C
C=====
      IF(ICASE .EQ. 2 ) THEN

```

```

        OUTVAR(1) = TIME                ! TIME
        OUTVAR(2) = T                  ! TEMPERAUTE
        OUTVAR(3) = SZ                 ! APPLIED STRESS
        OUTVAR(4) = S(3,1)
        OUTVAR(5) = S(3,2)
        OUTVAR(6) = S(3,3)
        OUTVAR(7) = ETOT(3,1)          ! TOTAL Z-STRAIN
        OUTVAR(8) = EME(3,1)
        OUTVAR(9) = EME(3,2)
        OUTVAR(10) = EME(3,3)
        OUTVAR(11) = ZD( IBEG( INTOUT( IBLOCK) ) )
        OUTVAR(12) = ZI( IBEG( INTOUT( IBLOCK) ) )
C      Outvar(6) = ep(3,1)
        WRITE(15,211) IBLOCK, ICYCLE, ICOUNT, ( OUTVAR(J), J=1,12 )
211    FORMAT(2(1X,I5), 1X,I8, 12(1X,1PE15.8) )
        ENDIF

C=====
C
C      Concentric cyclinder with parallel [90] ply
C
C=====

        IF(ICASE .EQ. 3) THEN
            IO = IBEG( INTOUT( IBLOCK) )
            OUTVAR(1) = TIME
            OUTVAR(2) = T
            OUTVAR(3) = SEFF(IO)
            OUTVAR(4) = S(1,IO)
            OUTVAR(5) = S(2,IO)
            OUTVAR(6) = S(3,IO)
            OUTVAR(7) = EME(1,IO)
            OUTVAR(8) = EME(2,IO)
            OUTVAR(9) = EME(3,IO)
            OUTVAR(10) = EP(1,IO)
            OUTVAR(12) = EP(2,IO)
            OUTVAR(11) = EP(3,IO)
            WRITE(15,211) IBLOCK, ICYCLE, ICOUNT, ( OUTVAR(J), J=1,9 )
        ENDIF

C=====
C
C File 16          t h e   y - f i l e
C
C=====
C

        IF( ICASE .NE. 2 ) THEN
            OUTVAR(1) = TIME                ! TIME

```

```

        OUTVAR(2) = T                      ! TEMPERATURE
        OUTVAR(3) = SZ                     ! APPLIED STRESS
        OUTVAR(4) = S(3,IEND(1))          ! FIBER Z-STRESS
        OUTVAR(6) = S(3,IEND(3))          ! [90] Z-STRESS
        D5 = OUTVAR(3) - OUTVAR(4)*VF(1)
$      - OUTVAR(6)*VF(3) ! AVE MATRIX Z-STRESS
        OUTVAR(5) = D5/VF(2)              ! FOR F/M/90
        OUTVAR(7) = EME(3,IEND(1))        ! EZMECH IN FIBER
        OUTVAR(8) = EME(3,IEND(2))        ! EZMECH IN MATR
        OUTVAR(9) = EME(3,IEND(3))        ! EZMECH IN [90]
        OUTVAR(10) = ETOT(3,1)            ! TOTAL Z-STRAIN
        OUTVAR(11) = ETOT(3,1)-CTECOM*DT ! COMPOSITE EZMECH
        OUTVAR(12) = EP(3,IEND(2)+1)      ! EZP @ MATRIX INT
        OUTVAR(13) = EP(3,IEND(3)+1)      ! EZP IN [90]
        OUTVAR(14) = S(3,IEND(2))         ! Z-STRESS@MATR/INT
        WRITE(16,211) IBLOCK, ICYCLE, ICOUNT,(OUTVAR(K), K = 1, 10)
    ENDIF

C=====
C
C File 17          t h e   z - f i l e
C
C=====
C Print stresses and plastic strains at the x-section for step iout
C
    IF(ICASE .NE. 2) THEN
        DO 4 KOUT = 1, 10
            IF( ICOUNT .EQ. IOUT(IBLOCK,KOUT) .AND.
$          ICOUNT .GT. 0 )THEN
                WRITE(17,509) ICYCLE, IBLOCK, ICOUNT, TIME
                WRITE(17,510)
                DO 45 I = 1, NTOT
                    DO 3 K = 1, 3
                        DUM1(K) = S(K,I)
                        DUM1(K+3) = EME(K,I)
3                  CONTINUE
                    SDUM = SEFF(I)
                    WRITE(17,511) RAD(I), SDUM, ( DUM1(K), K = 1, 6 )
45                CONTINUE
            ENDIF
4          CONTINUE
        ENDIF
    ENDIF

C          Formats -----
509  FORMAT(/, 2X, ' CROSS-SECTIONAL RESULTS AT CYCLE ', I5, /,
$      2X, '                      BLOCK ', I5, /,
$      2X, '                      STEP  ', I5, /,

```

```

$          2X,'    TIME = ', F15.4,/)
510  FORMAT( 3X,'    RADIUS  ',2X,'    SEFF    ',3X,'    SRAD    ',
$          3X,'    STAN    ',3X,'    SZ    ',3X,'    ER    ',
$          3X,'    ETAN    ',3X,'    EZ    ')
511  FORMAT(2X, F12.3, 10(2X,1PE12.4) )
C
    RETURN
    END
C
C =====
C Stress2
C Solves stress state for 1-d lamina model
C =====
C
    SUBROUTINE STRESS2( EP, ICOUNT )
C
    IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
    PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
    PARAMETER( NN = 50)
    COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
$              TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$              TIME, ICYCLE, IBLOCK
    COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
$              NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
    COMMON /STIF /  IDAMAGE(10), D(NN), ETA(NN), SPEAK,
$              DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
    COMMON /STRES/  S(6,NN), SDEV(6,NN),
$              SEFF(NN), SE(NN), SEFFOLD(NN)
    COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
$              DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
    COMMON /ELASX/  TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
    REAL*8          EP(6,NN)
C
C      Multiple laminates -----
C      For strain controlled loading after cooldown ez*=eztot
    IF( ILOAD .EQ. 1 ) THEN
        EZSTAR = EZ + EZCOOL
        EZTOT = EZSTAR
        GOTO 10
    ENDIF
    SUM = 0.0
    DO 5 I = 1, NOMAT
        SUM = SUM + TE(I)*VF(I)*EP(3,I)
5    CONTINUE

```

```

      EZTOT = SZ/ECOM + CTECOM*DT + SUM/ECOM
10  DO 15 I = 1, NOMAT
      S(1,I) = 0.0
      S(2,I) = 0.0
      S(3,I) = TE(I)*( EZTOT - TCTE(I)*DT - EP(3,I) )
15  CONTINUE
      RETURN
      END

C
C=====
C Plastic
C Computes special plastic term in concentric cylinder model
C=====
C
      FUNCTION PLASTIC( I, EP )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
$                IPVT(LDA)
      COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
$                FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
      REAL*8                EP(6,NN)
C
      PLASTIC = TE(I)*(
$  AA(I)*( EP(1,I) + CC(I)*EP(1,I-1) )
$  - EP(2,I)*( 1 + AA(I) )
$  + EP(2,I-1)*( 1 - AA(I)*CC(I) )
$  + TNU(I)*( EP(1,I) + EP(2,I) )
$  - TNU(I-1)*( EP(1,I-1) + EP(2,I-1) )
$  )
      RETURN
      END

C
C =====
C Called from subroutine stress
C Ccm with loading case 5: parallel [90] element
C =====
      SUBROUTINE STRESS3( EP, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C

```

```

PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
PARAMETER( NN = 50)
COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
$          DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
COMMON /LOAD2/ VF(MM), EZCOOL, IMAT(MM),NODES(MM),
$          NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
COMMON /LOADT/ T, SZ, EZ, SR, TAU, DT,
$          TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$          TIME, ICYCLE, IBLOCK
COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
COMMON /CCM1 / RAD(LDA), IBEG(MM), IEND(MM), NTOT
COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
$          IPVT(LDA)
COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
$          FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
COMMON /STRES/ S(6,NN), SDEV(6,NN),
$          SEFF(NN), SE(NN), SEFFOLD(NN)
COMMON /STRAI/ ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
$          DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
REAL*8          EP(6,NN), XSOL(LDA)
C
      B = 1.0
C      For strain controlled loading after cooldown ez*=eztot
      IF(ILOAD.EQ.1) THEN
        EZSTAR = EZ + EZCOOL
        EZTOT = EZSTAR
        GOTO 101
      ENDIF
      NTOT2 = NTOT-2
C      Compute sum( 2/b^2*e/ec* integral(ezp*rdr) )
      SUMTEGRAL = 0.0
      DO 5 I = 2, NTOT2
        TEGRAL = (RAD(I)-RAD(I-1))*
$      (EP(3,I)*RAD(I)+EP(3,I-1)*RAD(I-1))
        SUMTEGRAL = SUMTEGRAL + TEGRAL*TE(I)/(B**2*ECOM)
5      CONTINUE
      TEGRAL = (RAD(NTOT)**2-RAD(NTOT-1)**2)*EP(3,NTOT)
      SUMTEGRAL = SUMTEGRAL + TEGRAL*TE(NTOT)/(B**2*ECOM)
      EZSTAR = SZ/ECOM + CTECOM*DT + SUMTEGRAL
$      - 2.0*TNU(NTOT2)*SR/ECOM
101 DO 15 I = 2, NTOT2
      PP(I) = PLASTIC(I,EP) + TE(I)*EZSTAR*( TNU(I) - TNU(I-1) )
15 CONTINUE
C      Complete b matrix
      DO 60 I = 1, NTOT2-1

```

```

        BMAT(NTOT2-1+I) = QQ(I+1) - PP(I+1)
60    CONTINUE
C      Add contribution of sr term to the last term in bmat
        ILAST = 2*(NTOT2-1)
        BMAT(ILAST) = QQ(NTOT2) - PP(NTOT2) - DD(NTOT2)*SR
C      Using bmat, and the l-u decomposition of amat determine xsol
        CALL LUBKSB(AMAT,NRA,LDA,IPVT,BMAT,XSOL)
C      Compute stresses from the xsol solution vector
        DO 80 I = 1, NTOT2-1
            S(1,I) = XSOL(I)
            S(2,I+1) = XSOL(NTOT2-1+I)
80    CONTINUE
C      Boundary conditions
        S(1,NTOT2) = SR
        S(2,1) = S(1,1)
        IF( ILOAD .EQ.1) GOTO 102
C      Compute total axial strain for stress controlled cases
C      From ez*
        SUM = 0.0
        DO 90 I = 2,NOMAT
            J = IBEG(I)
            SUM = SUM + S(1,J)*VF(I-1)*( TNU(J-1) - TNU(J) )
90    CONTINUE
        EZTOT = EZSTAR - 2.0*SUM/ECOM
C      Compute axial stress from the axial stress-strain equation
102   DO 95 I = 1, NTOT
        S(3,I) = TE(I)*( EZTOT - EP(3,I) - TCTE(I)*DT )
        $      + TNU(I)*( S(1,I) + S(2,I) )
95    CONTINUE
        RETURN
        END

C
C =====
C Called from subroutine stress
C
C      Concentric cylinder model
C
C =====
        SUBROUTINE STRESS1( EP, ICOUNT )
C
        IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
        PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
        PARAMETER( NN = 50)
        COMMON /LOAD2/ VF(MM), EZCOOL, IMAT(MM),NODES(MM),

```

```

$          NOMAT, ICASE, ILOAD, ISTRAIN(MM), ISTRAIN2(MM)
COMMON /LOADT/ T, SZ, EZ, SR, TAU, DT,
$          TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$          TIME, ICYCLE, IBLOCK
COMMON /ELASX/ TEO(NN), TE(NN), TNU(NN), TCTE(NN), ECOM, CTECOM
COMMON /CCM1 / RAD(LDA), IBEG(MM), IEND(MM), NTOT
COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
$          IPVT(LDA)
COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
$          FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
COMMON /STRES/ S(6,NN), SDEV(6,NN),
$          SEFF(NN), SE(NN), SEFFOLD(NN)
COMMON /STRAI/ ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
$          DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
REAL*8          EP(6,NN), XSOL(LDA)

C
    B = 1.0
C    For strain controlled loading after cooldown ez*=eztot
    IF( ILOAD .EQ. 1 ) THEN
        EZSTAR = EZ + EZCOOL
        EZTOT = EZSTAR
        GOTO 101
    ENDIF
C    Stress control
    SUMTEGRAL = 0.0
    DO 5 I = 2, NTOT
        TEGRAL = (RAD(I)-RAD(I-1))*
$      (EP(3,I)*RAD(I) + EP(3,I-1)*RAD(I-1))
        SUMTEGRAL = SUMTEGRAL + TEGRAL*TE(I)/(B**2*ECOM)
5    CONTINUE
    EZSTAR = SZ/ECOM + CTECOM*DT + SUMTEGRAL
$    - 2.0*TNU(NTOT)*SR/ECOM
C    Strain control
101 DO 15 I = 2, NTOT
    PP(I) = PLASTIC(I,EP) + TE(I)*EZSTAR*( TNU(I) - TNU(I-1) )
15 CONTINUE
C    Complete b matrix
    DO 60 I = 1, NTOT-1
        BMAT(NTOT-1+I) = QQ(I+1) - PP(I+1)
60 CONTINUE
C    Add contribution of sr term to the last term in bmat
    ILAST = 2*(NTOT-1)
    BMAT(ILAST) = QQ(NTOT) - PP(NTOT) - DD(NTOT)*SR
C    Using bmat, and the l-u decomposition of amat determine xsol
    CALL LUBKSB(AMAT,NRA,LDA,IPVT,BMAT,XSOL)

```

```

C      Compute stresses from the xsol solution vector
      DO 80 I = 1, NTOT-1
          S(1,I) = XSOL(I)
          S(2,I+1) = XSOL(NTOT-1+I)
80     CONTINUE
C      Boundary conditions
      S(1,NTOT) = SR
      S(2,1) = S(1,1)
      IF( ILOAD .EQ. 1 ) GOTO 102
C      Compute total axial strain for stress controlled cases
C      From ez*
      SUM = 0.0
      DO 90 I = 2,NOMAT
          J = IBEG(I)
          SUM = SUM + S(1,J)*VF(I-1)*( TNU(J-1) - TNU(J) )
90     CONTINUE
      EZTOT = EZSTAR - 2.0*SUM/ECOM
C      Compute axial stress from the axial stress-strain equation
102    DO 95 I = 1, NTOT
          S(3,I) = TE(I)*( EZTOT - EP(3,I) - TCTE(I)*DT )
          $      + TNU(I)*( S(1,I) + S(2,I) )
95     CONTINUE
      RETURN
      END

C
C =====
C Called from protnodes
C =====
      SUBROUTINE ELAS( I, K )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /PROP / P(MM, MC)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
          $          DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
C
      TNU(K) = P(I,2)
      TCTE(K) = P(I,3)*1.0E-6
      TE(K) = P(I,1)*1.0E3
C***** for damage in 90 *****
      TEO(K) = TE(K)
      RETURN

```

```

      END
C =====
      SUBROUTINE MAT2 ( I, K )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /MAT2A/ TSY(NN), TEP(NN)
      COMMON /PROP/ P(MM, MC)
C
      TSY(K) = P(I,4)
      TEP(K) = P(I,5)*1.0E3
      RETURN
      END
C =====
      SUBROUTINE MAT5 ( I, K, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /MAT5A/ TN(NN), TZ0(NN), TF1(NN), TF3(NN),
$          TBSMAX(NN), TD0(NN)
      COMMON /MAT5B/ F3OLD(NN), BS(6,NN), SDEVOLD(6,NN)
      COMMON /PROP/ P(MM, MC)
      COMMON /MAT7A / TA1A(NN), TA1B(NN), TA1C(NN),
$          TM1A(NN), TM1B(NN), TM1C(NN),
$          TA2(NN)
C
      TN(K)      = P(I,5)
      TZ0(K)     = P(I,6)
      TF1(K)     = P(I,7)
      TF3(K)     = P(I,8)
      IF(ICOUNT .EQ. 0) F3OLD(K) = TF3(K)
      TBSMAX(K)  = P(I,9)
      TD0(K)     = P(I,10)
      RETURN
      END
C =====
      SUBROUTINE MAT6 ( I, K, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )

```

```

PARAMETER( NN = 50)
COMMON /MAT6A /  TND(NN) , TZ0D(NN) , TZ3(NN) , TM2(NN) ,
$              TA1(NN) , TM1(NN) , TZ1(NN) , TR1(NN) ,
$              TR2(NN) , TD0D(NN) , TZ2(NN) ,
$              DTZ1(NN) , DTZ2(NN) , DTZ3(NN)
COMMON /MAT6B/  BETA(6,NN) , ZD(NN) , ZI(NN) , ZTOT(NN)
COMMON /PROP/   P(MM, MC)
COMMON /STIF /  IDAMAGE(10) , D(NN) , ETA(NN) , SPEAK,
$              DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
C
TND(K) = P(I,5)
IF( ICOUNT .EQ. 0 ) THEN
    TZ0DOLD = P(I,6)
    ZI(K)    = P(I,6)
    ZTOT(K)  = P(I,6)
ENDIF
TZ0DOLD = TZ0D(K)
TZ0D(K) = P(I,6)
TZ2(K)  = TZ0D(K)
DTZ2(K) = TZ0D(K) - TZ0DOLD
TZ3OLD = TZ3(K)
TZ3(K) = P(I,7)
IF( ICOUNT .EQ. 0 ) TZ3OLD = P(I,7)
DTZ3(K) = TZ3(K) - TZ3OLD
TM2(K) = P(I,8)
TA1(K) = P(I,9)
TM1(K) = P(I,10)
TZ1OLD = TZ1(K)
TZ1(K) = P(I,11)
IF( ICOUNT .EQ. 0 ) TZ1OLD = TZ1(K)
DTZ1(K) = TZ1(K) - TZ1OLD
TR1(K) = P(I,12)
TR2(K) = TR1(K)
TD0D(K) = P(I,13)
C ***** damage in 90 *****
IF( IDAMAGE(I) .EQ. 1 ) THEN
    DSM = P(I,14)
    DSCH = P(I,15)
    DSCL = P(I,16)
    DM = P(I,17)
    DTHETA = P(I,18)
    DDSTAR = P(I,19)
    DBETA = P(I,20)
    DDCH = P(I,21)
ENDIF

```

```

      RETURN
      END
C =====
      SUBROUTINE MAT7( I, K, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /MAT6A /  TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
$                    TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
$                    TR2(NN), TD0D(NN), TZ2(NN),
$                    DTZ1(NN), DTZ2(NN), DTZ3(NN)
      COMMON /MAT7A /  TA1A(NN),TA1B(NN),TA1C(NN),
$                    TM1A(NN),TM1B(NN),TM1C(NN),
$                    TA2(NN)
      COMMON /MAT6B/  BETA(6,NN), ZD(NN), ZI(NN), ZTOT(NN)
      COMMON /PROP/   P(MM, MC)
      COMMON /STIF /  IDAMAGE(10), D(NN), ETA(NN), SPEAK,
$                    DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
C
      TND(K)  = P(I,5)
      IF( ICOUNT .EQ. 0 ) THEN
         TZ0DOLD  = P(I,6)
         ZI(K)    = P(I,6)
         ZTOT(K)  = P(I,6)
      ENDIF
      TZ0DOLD = TZ0D(K)
      TZ0D(K) = P(I,6)
      TZ2(K)  = TZ0D(K)
      DTZ2(K) = TZ0D(K) - TZ0DOLD
      TZ3OLD  = TZ3(K)
      TZ3(K)  = P(I,7)
      IF( ICOUNT .EQ. 0 ) TZ3OLD = P(I,7)
      DTZ3(K) = TZ3(K) - TZ3OLD
      TM1A(K) = P(I,8)
      TM1B(K) = P(I,9)
      TM1C(K) = P(I,10)
      TM2(K)  = P(I,11)
      TA1A(K) = P(I,12)
      TA1B(K) = P(I,13)
      TA1C(K) = P(I,14)
      TA2(K)  = P(I,15)
      TZ1OLD  = TZ1(K)
      TZ1(K)  = P(I,16)

```

```

      IF( ICOUNT .EQ. 0 )TZ1OLD = TZ1(K)
      DTZ1(K) = TZ1(K) - TZ1OLD
      TR1(K) = P(I,17)
      TR2(K) = TR1(K)
      TD0D(K) = P(I,19)
      RETURN
      END

C =====
C Geometry: called from main program
C Define geometric properties
C =====

      SUBROUTINE GEOMETRY

C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )

C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
$                   NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)

C
      REAL*8          A(10)
      IF (ICASE .EQ. 2) THEN
        DO 3 I = 1, NOMAT
          IBEG(I) = I
          IEND(I) = I
3        CONTINUE
        NTOT = NOMAT
        RETURN
      ENDIF
      NTOT = 1
      B = 1

C      Compute total number of nodes
      DO 5 I = 1, NOMAT
        IBEG(I) = NTOT
        IEND(I) = IBEG(I) + NODES(I) - 1
        NTOT = IEND(I) + 1
5      CONTINUE
      NTOT = IEND(NOMAT)

C      Continue with concentric cylinder model
C      Compute radii limits for each material block
      VFSUM = 0
      DO 10 I = 1, NOMAT
        VFSUM = VFSUM + VF(I)
        A(I+1) = B*SQRT(VFSUM)

```

```

10  CONTINUE
    A(1)      = 0
    RAD(1)    = 1.E-22
C   Compute location of nodes
    POWER = 1
    DO 200 I = 1, NOMAT
        RSTEP = (A(I+1) - A(I)) / (NODES(I) - 1)
        KSUM  = 0
        DO 195 J = IBEG(I), IEND(I)
            RAD(J) = A(I) + FLOAT(KSUM) * RSTEP
            IF(J .EQ. IBEG(I)) THEN
                RAD(J) = RAD(J) + 1.E-12
            ENDIF
            KSUM = KSUM + 1
195  CONTINUE
200  CONTINUE
    RETURN
    END

C =====
C Called from newcte
C =====

    SUBROUTINE INTERPOL( J, XIN, TE, T, NLAST, OUTMAT, JFAC )
C
    IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
    PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
    PARAMETER( NN = 50)
    REAL*8    XIN(MR), TE(MR), OUTMAT
C
    IF( NLAST .EQ. 1 )THEN
        OUTMAT = XIN(1)
        RETURN
    ENDIF
    IF( J.EQ.NLAST )THEN
        J1 = J - 1 - JFAC
        J2 = J - JFAC
    ELSEIF( J.EQ.1 )THEN
        J1 = J + JFAC
        J2 = J + 1 + JFAC
    ELSE
        J1 = J - 1
        J2 = J + JFAC
    END IF
    T1 = TE(J1)
    T2 = TE(J2)

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```

      VAR1 = XIN(J1)
      VAR2 = XIN(J2)
      OUTMAT = (T-T1)/(T2-T1)*(VAR2-VAR1) + VAR1
      RETURN
      END

C
C =====
C Inter
C Determines temperature dependent properties at temperature t
C =====
C
      SUBROUTINE INTER( I, J, K, L, T )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      I = material, j = row, k = column, l = set numbers
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /READM/ NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
$              AT(MM,MR,7), TREF(MM), NSET(MM)
      COMMON /PROP/ P(MM,MC)
C
      NLAST = NROW(I,L)
      IF( J.EQ.NLAST )THEN
        J1 = J - 1
        J2 = J
      ELSEIF( J.EQ.1 )THEN
        J1 = J
        J2 = J + 1
      ELSE
        J1 = J - 1
        J2 = J
      END IF
      P(I,K) = FUNCINTER( AT(I,J1,L), AT(I,J2,L), TP(I,J1,K),
$ TP(I,J2,K), T )
      RETURN
      END

C
C =====
C Funcinter
C Computes linear interpolation
C =====
C
      FUNCTION FUNCINTER( T1, T2, VAR1, VAR2, T )
C

```

```

      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )

C
      IF( T1 .EQ. T2 )THEN
        FUNCINTER = ( VAR1 + VAR2 )/2.0
        RETURN
      ENDIF
      FUNCINTER = (T-T1)/(T2-T1)*(VAR2-VAR1) + VAR1
      RETURN
    END

C
C =====
C Inelastic
C Compute inelastic strain increments and iterate to converge to the
C Right combination of stresses and strains
C =====
C
      SUBROUTINE INELASTIC(ITYPE, EP )

C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )

C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
$                   TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$                   TIME, ICYCLE, IBLOCK
      COMMON /LOADO/  INTOUT(ML), IOUT(ML,20),
$                   IPRINTSTEP(ML), ISTEPOUT(ML)
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM), NODES(MM),
$                   NOMAT, ICASE, ILOAD, ISTRAIN(MM), ISTRAIN2(MM)
      COMMON /ELASX/  TEO(NN), TE(NN), TNU(NN), TCTE(NN), ECOM, CTECOM
      COMMON /MAT2A /  TSY(NN), TEP(NN)
      COMMON /MAT5A /  TN(NN), TZ0(NN), TF1(NN), TF3(NN),
$                   TBSMAX(NN), TD0(NN)
      COMMON /MAT6A /  TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
$                   TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
$                   TR2(NN), TD0D(NN), TZ2(NN),
$                   DTZ1(NN), DTZ2(NN), DTZ3(NN)
      COMMON /MAT7A /  TA1A(NN), TA1B(NN), TA1C(NN),
$                   TM1A(NN), TM1B(NN), TM1C(NN),
$                   TA2(NN)
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
$                   IPV1(LDA)
      COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
$                   FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)

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COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
$           DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
COMMON /STRES/ S(6,NN), SDEV(6,NN),
$           SEFF(NN), SE(NN), SEFFOLD(NN)
COMMON /STRAI/ ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
$           DEFF(NN), EPEFF(NN), DEFPOLD(6,NN)
COMMON /MAT5B/ F3OLD(NN), BS(6,NN), SDEVOLD(6,NN)
COMMON /MAT6B/ BETA(6,NN), ZD(NN), ZI(NN), ZTOT(NN)
COMMON /CONTROL/ TOLER1, TOLER2, RELAX, FAST, ICOUNT,
$           ISUBTOT, IZMAX, MAXITER

C
REAL*8      EP(6,NN), EP2(6,NN), EMTS(6), EPEST
REAL*8      SEFFEST(NN), DEFFOLD(NN), V(3), U(3)
REAL*8 BSOLD(6,NN), BSEST(6,NN), ZTEST(NN), BOLD(6,NN), ZIOLD(NN)
INTEGER      ITYPE(MM), IYLDPLG(NN), K, IDUMMY(NN)

C
C   If all the materials are elastic, then return to main
IPLAS = 0
DO 10 I = 1, NOMAT
    GOTO(10,20,20,10,30,30) ITYPE(I)
20    DO 21 J = IBEG(I), IEND(I)
        SE(J) = YSURFACE( EPEFF(J), J )
        SEFF(J) = CSEFF( J )
        IF( SEFF(J) .GT. SE(J) ) IPLAS = 1
21    CONTINUE
    GOTO 10
30    IPLAS = 1
10    CONTINUE
    IF(IPLAS .EQ. 0) GOTO 777

C   Plastic step starts here
C   Set state variables for iterations
DO 5 N = 1, NTOT
    ZTEST(N) = ZTOT(N)
    ZIOLD(N) = ZI(N)
    SEFFEST(N) = SEFF(N)
DO 5 K = 1, 3
    BSOLD(K,N) = BS(K,N)
    BSEST(K,N) = BS(K,N)
    BOLD(K,N) = BETA(K,N)
5    CONTINUE
    IC = 1
800 CONTINUE
DO 40 I = 1, NOMAT
    GOTO(40,45,50,40,60,70,70) ITYPE(I)
C   Plasticity model

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```

45      DO 46 J = IBEG(I), IEND(I)
          DEFF(J) = 0.0
          DO 46 K = 1,3
              DEP(K,J) = 0.0
46      CONTINUE
          GOTO 40
C      Compute for incremental strain model
50      DO 51 J = IBEG(I), IEND(I)
          DO 51 K = 1, 3
              DEP(K,J) = DEPOLD(K,J)
51      CONTINUE
          GOTO 40
C      Compute for backstress model
60      DO 61 J = IBEG(I), IEND(I)
          SEFF(J) = CK2( J )
          DEFFOLD(J) = CDEFF5( J )      !=CALCDEFF(DEP,J)
61      CONTINUE
          GOTO 40
C      Directional bodner model
70      DO 71 J = IBEG(I), IEND(I)
          SEFF(J) = SEFFEST( J )
          DEFFOLD(J) = CDEFF6( J, ZTEST )
71      CONTINUE
40      CONTINUE
C      Iterations for inelastic strains start here -----
      DO 700 ITER = 1, MAXITER
C      Compute new estimates for the plastic strain increments
      DO 100 I = 1, NOMAT
          GOTO(100,120,130,100,150,160,160) ITYPE(I)
C      Elastic-plastic
120      DO 121 J = IBEG(I), IEND(I)
          SEFFOLD(J) = SEFF( J )
          SEFF(J) = CSEFF( J )
          SE(J) = YSURFACE( EPEFF(J), J )
          F = SEFF(J) - SE(J)
          IF( F .GT. 0 )GOTO 122
          IYLDFLG(J) = 0
          DEFF(J) = 0.0
          GOTO 121
122      IYLDFLG(J) = 2
C      Calculate modified total strains
      DO 124 K = 1, 3
          EMTS(K) = ETOT(K,J) - EP(K,J)      ! EP IS W/O DEP
124      CONTINUE
C      Calculate equivalent (effective) modified total strain

```

```

SS1 = EMTS(1) - EMTS(2)
SS2 = EMTS(3) - EMTS(2)
SS3 = EMTS(1) - EMTS(3)
EET = SQRT( SS1*SS1 + SS2*SS2 + SS3*SS3 ) * SQRT(2.)/3.
C Relationship between dep or psi and eff mts
XM = TEP(J) / TE(J)
DSDE = XM*TE(J)/( 1. - XM )
DENOMDEP = 1. + 2./3.*( 1 + TNU(J) )/TE(J)*DSDE
DEFF(J) = EET - 2./3.*(1+TNU(J))/TE(J)*SE(J)
DEFF(J) = DEFF(J)/DENOMDEP
C Calculate new psis using modified p-r equations
COEFF = DEFF(J)/3./EET
DEP(1,J) = COEFF*( 2*EMTS(1)-EMTS(2)-EMTS(3) )
DEP(2,J) = COEFF*( 2*EMTS(2)-EMTS(1)-EMTS(3) )
DEP(3,J) = COEFF*( 2*EMTS(3)-EMTS(1)-EMTS(2) )
121 CONTINUE
GOTO 100
C Bilinear elastic-plastic-damage with 2nd el-pl algorithm
130 DO 131 J = IBEG(I), IEND(I)
SEFFOLD(J) = SEFF(J)
SEFF(J) = CSEFF( J )
SE(J) = YSURFACE( EPEFF(J), J )
C Check stress state for yielding at node j
F = SEFF(J) - SE(J)
IF( F .GT. 0 ) GOTO 134
C If f<0 during iterations, still iterate for conv.
IF( IYLDFLG(J) .GT. 1 ) GOTO 134
IYLDFLG(J) = 0
GOTO 131
134 IYLDFLG(J) = 2
C For algorithm 2 start iterations with nonzero ep
IDUMMY(J) = IDUMMY(J) + 1
IF( IDUMMY(J) .EQ. 1 ) THEN
DEFFX = ( SEFF(J) - SE(J) )/TE(J)
DEP(1,J) = -DEFFX/2.0
DEP(2,J) = -DEFFX/2.0
DEP(3,J) = DEFFX
PRINT *, '1ST GUESS AT DEP:', J, DEP(3,J)
ENDIF
C Compute equivalent plastic strain
TERM12 = ( DEP(1,J) - DEP(2,J) )**2
TERM13 = ( DEP(1,J) - DEP(3,J) )**2
TERM23 = ( DEP(3,J) - DEP(2,J) )**2
DEFF(J) = SQRT(2.*(TERM12+TERM13+TERM23))/3.0
C Compute the yield surface, se from epeff

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```

      EPEST = EPEFF(J) + DEFF(J)
      SE(J) = YSURFACE( EPEST, J )
131    CONTINUE
      GOTO 100
C      Bodner-partom with backstress
150    DO 151 J = IBEG(I), IEND(I)
      C      = SEFF( J )
      IF( SEFF(J) .LT. 1.E-12 ) C = 1.0E-12
      DO 151 K = 1, 3
        DEP(K,J) = DEFFOLD(J)*(SDEV(K,J)-BSEST(K,J))/C
151    CONTINUE
      GOTO 100
C      Bodner-partom with directional hardening
160    DO 161 J = IBEG(I), IEND(I)
      C = SEFF(J)
      IF( SEFF(J) .LT. 1.E-12 ) C = 1.0E-12
      DO 161 K = 1, 3
        DEP(K,J) = SQRT(3.)* DEFFOLD(J)*SDEV(K,J)/C
161    CONTINUE
100    CONTINUE
      DO 105 J = 1, NTOT
        SEFFOLD(J) = SEFF(J)
        DO 105 K = 1, 3
          EP2(K,J) = EP(K,J) + DEP(K,J)
105    CONTINUE
C      Compute stresses given the plastic strain estimates
      CALL STRESS( EP2, ICOUNT )
C      Evolution equations for the internal state variables
      ERROR1 = 0.0
      DO 95 I = 1, NOMAT
        ID = IBEG(I)
        DIFF = ABS (SEFF(ID)-SEFFOLD(ID))
        IF(SEFF(ID) .GT. 1.E-12) DIFF = DIFF/SEFF(ID)
        ERROR1 = ERROR1 + DIFF
95    CONTINUE
      DO 200 I = 1, NOMAT
        GOTO(200,200,230,200,250,200,270) ITYPE(I)
C      B-p with elastic-plastic algorithm #2
230    DO 231 J = IBEG(I), IEND(I)
      FACTOR = DEFF(J)/2./SE(J)
      DEP(1,J) = FACTOR*( 2*S(1,J)-S(2,J)-S(3,J) )
      DEP(2,J) = FACTOR*( 2*S(2,J)-S(1,J)-S(3,J) )
      DEP(3,J) = FACTOR*( 2*S(3,J)-S(1,J)-S(2,J) )
      DEP(3,J) = - DEP(1,J) - DEP(2,J)
231    CONTINUE

```

```

250      DO 251 J = IBEG(I), IEND(I)
          SEFF(J) = CK2( J )
251      CONTINUE
          GOTO 200
270      DO 271 J = IBEG(I), IEND(I)
          SEFF(J) = SEFFOLD(J)*(1.0-RELAX)+SEFF(J)*RELAX
          DEFFOLD(J) = CDEFF6( J, ZTEST )
271      CONTINUE
200      CONTINUE
      IF( ITER .EQ. MAXITER )THEN
          WRITE(6,*)
          WRITE(6,*) ' STRESS DISTRIBUTION REFUSES TO CONVERGE '
          WRITE(6,*) ' ON CYCLE ', ICOUNT
          WRITE(6,*)
          STOP
      ENDIF
      IF(ITER .GT. 2 .AND. ERROR1 .LT. TOLER1 ) THEN
          GOTO 701
      ENDIF
700      CONTINUE      ! ITERATION LOOP
701      CONTINUE      ! END OF ITERATIONS
          FAST1 = FLOAT(ITER-3) / FLOAT(MAXITER)
C      Update state variables
      ZERR      = 0
      BSERR      = 0
      BSMEAN      = 0
      SERR      = 0
      SMEAN      = 0
      DO 80 I = 1, NOMAT
          IF( ITYPE(I) .EQ. 5 ) THEN
              DO 81 J = IBEG(I), IEND(I)
                  DF3          = TF3(J) - F3OLD(J)
                  F3OLD(J) = TF3(J)
                  DEFF(J) = CDEFF(DEP, J )
                  SERR = SERR + ABS(SEFFEST(J) - SEFF(J))
                  SEFFEST(J) = SEFFEST(J)*(1.0-RELAX)+SEFF(J)*RELAX
                  SMEAN = SMEAN + ABS(SEFF(J))
81          CONTINUE
              DO 82 J = IBEG(I), IEND(I)
                  DO 82 K = 1, 3
                      DSDEV      = SDEV(K,J) - SDEVOLD(K,J)
                      DBS = TF3(J) * DSDEV
$                      + DF3 * SDEV(K,J)
$                      + TF1(J) * DEP(K,J)
$                      - 2.0* TF1(J)*BS(K,J)*DEFFOLD(J)/(3.*TBSMAX(J))

```

```

      BS(K,J) = BSOLD(K,J) + DBS
      BSERR = BSERR + ABS(BS(K,J)-BSEST(K,J))
      BSEST(K,J) = BS(K,J)
      BSMEAN = BSMEAN + ABS(BS(K,J))
      SDEVOLD(K,J) = SDEV(K,J)
82      CONTINUE
      IF(ABS(BSMEAN) .GT. 1.E-6) BSERR = BSERR / BSMEAN
      ENDIF
C      B-p with directional hardening
      IF( ITYPE(I) .EQ. 6 ) THEN
        DO 84 J = IBEG(I), IEND(I)
C ***** damage for 90 *****
          IF(IDAMAGE(I) .EQ. 1 ) THEN
            IF( D(J) .LT. DDCH ) THEN
              DSCHNEW = DSCH*( 1. - D(J)/DDCH )
            ELSE
              DSCHNEW = 0.0
            ENDIF
C      Warning - - - - -
C      Eta(j) = 1.
            ETA(J) = 1./(1.+EXP(-DBETA*S(3,J)))
            IF( S(3,J) - DSM - DSCHNEW .GE. SPEAK ) THEN
              TERM = ((S(3,J)-DSM-DSCHNEW)/DTHETA)**DM
              D(J) = DDSTAR*(1.0-EXP(-TERM))
            ENDIF
          ENDIF
C *****
C      Compute work rate, ssum, bsum=sqrt(bij*bij)
          DWORK = 0.0
          SSUM = 0.0
          BSUM = 0.0
          DO 262 K = 1, 3
            DWORK = DWORK + S(K,J)*DEP(K,J)/(1-ETA(J)*D(J))
            SSUM = SSUM + S(K,J)*S(K,J)
            BSUM = BSUM + BETA(K,J)**2
262      CONTINUE
          SSUM = SQRT(SSUM)
          BSUM = SQRT(BSUM)
C      Compute v(i) and u(i) vectors
          DO 263 K = 1, 3
            V(K) = BETA(K,J)
            IF(BSUM.GT.1.E-15) V(K)=BETA(K,J)/BSUM
            U(K) = S(K,J)
            IF(SSUM.GT.1.E-15) U(K)=S(K,J)/SSUM
263      CONTINUE

```

```

ZD(J) = 0.0
DO 264 K = 1, 3
    TERMH = (TZ3(J)*U(K)-BETA(K,J) )*DWORK
    TERMR = TZ1(J)*V(K)*( (BSUM/TZ1(J) )**TR2(J) )
    TERMT = 0.0
    IF(TZ3(J) .GT. 0)  TERMT = BETA(K,J)*DTZ3(J)/TZ3(J)
    BETA(K,J)      = BOLD(K,J)
$      + TERMH*TM2(J)
$      - TERMR*TA1(J)*DTAU
$      + TERMT
C      Compute directional hardening zd = bijuij
      ZD(J) = ZD(J) + BETA(K,J)*U(K)
264    CONTINUE
C      Compute isotropic hardening
      TERMH = TM1(J)*(TZ1(J)-ZI(J))*DWORK
      TERMR = TA1(J)*TZ1(J)*( (ZI(J)-TZ2(J) )/TZ1(J) )**TR1(J)
      COEFF1 = (ZI(J)-TZ2(J) )/(TZ1(J)-TZ2(J) )
      COEFF2 = (TZ1(J)-ZI(J) )/(TZ1(J)-TZ2(J) )
C      For this case
C      Coeff1 = 1.0
C      Coeff2 = 1.0
      TERMT = COEFF2*DTZ2(J)
      DZI = TERMH - TERMR*DTAU + TERMT
      ZI(J) = ZIOLD(J) + DZI
C      Compute total drag stress
      ZTOT(J) = ZD(J) + ZI(J)
      ZERR = ZERR + ABS(ZTOT(J) - ZTEST(J) )/ZTOT(J)
      ZTEST(J) = ZTEST(J)*(1.-RELAX)+ZTOT(J)*RELAX
C      ZTEST(J) = ZTOT(J)
      SERR = SERR + ABS(SEFFEST(J) - SEFF(J) )
      SEFFEST(J) = SEFFEST(J)*(1.0-RELAX)+SEFF(J)*RELAX
      SMEAN = SMEAN + ABS(SEFF(J) )
C ***** damage in 90 *****
      IF( IDAMAGE(I) .EQ. 1 ) THEN
          ZTOT(J) = ZTOT(J)*(1-ETA(J)*D(J) )
          IF( S(3,J) - DSM - DSCHNEW .GT. SPEAK ) THEN
              SPEAK = S(3,J) - DSM - DSCHNEW
          ENDIF
      ENDIF
C *****
      DEFF(J) = CDEFF6(J,ZTOT)
84    CONTINUE
      ENDIF
C      B-p star with directional hardening
C      Modified via. neu and bodner september, 1995

```

```

IF( ITYPE(I) .EQ. 7 ) THEN
  DO 85 J = IBEG(I), IEND(I)
C      Compute work rate, ssum, bsum=sqrt(bij*bij)
      DWORK = 0.0
      SSUM = 0.0
      BSUM = 0.0
      DO 272 K = 1, 3
          DWORK = DWORK + S(K,J)*DEP(K,J)
          SSUM = SSUM + S(K,J)*S(K,J)
          BSUM = BSUM + BETA(K,J)**2
272  CONTINUE
      SSUM = SQRT(SSUM)
      BSUM = SQRT(BSUM)
C      Compute v(i) and u(i) vectors
      DO 273 K = 1, 3
          V(K) = BETA(K,J)
          IF(BSUM.GT.1.E-15) V(K)=BETA(K,J)/BSUM
          U(K) = S(K,J)
          IF(SSUM.GT.1.E-15) U(K)=S(K,J)/SSUM
273  CONTINUE
      ZD(J) = 0.0
      DO 274 K = 1, 3
          TERMH = (TZ3(J)*U(K)-BETA(K,J))*DWORK
          TERMR = TZ1(J)*V(K)*((BSUM/TZ1(J))**TR2(J))
          TERMT = 0.
          IF(TZ3(J).GT.0) TERMT = BETA(K,J)*DTZ3(J)/TZ3(J)
          BETA(K,J) = BOLD(K,J)
$          + TERMH*TM2(J)
$          - TERMR*TA2(J)*DTAU
$          + TERMT
C      Compute directional hardening zd = bijuij
      ZD(J) = ZD(J) + BETA(K,J)*U(K)
274  CONTINUE
C      Compute isotropic hardening
      XM1 = TM1B(J) + (TM1A(J)-TM1B(J))
$      * DEXP(-1.*TM1C(J)*(ZI(J)-TZ0D(J)))
      XA1 = TA1B(J) + (TA1A(J)-TA1B(J))
$      * DEXP(-1.*TA1C(J)*(ZI(J)-TZ2(J)))
      TERMH = XM1*(TZ1(J)-ZI(J))*DWORK
      TERMR = XA1*TZ1(J)*(ABS((ZI(J)-TZ2(J))/TZ1(J))**TR1(J)
      COEFF1 = (ZI(J)-TZ2(J))/(TZ1(J)-TZ2(J))
      COEFF2 = (TZ1(J)-ZI(J))/(TZ1(J)-TZ2(J))
      TERMT = COEFF2*DTZ2(J)
      DZI = TERMH - TERMR*DTAU + TERMT
      ZI(J) = ZIOLD(J) + DZI

```

```

        IF(ZI(J) .LT. TZ2(J)) ZI(J) = TZ2(J)
C      Compute total drag stress
        ZTOT(J) = ZD(J) + ZI(J)
        ZERR = ZERR + ABS(ZTOT(J) - ZTEST(J))/ZTOT(J)
        ZTEST(J) = ZTEST(J) * (1.0-RELAX) + ZTOT(J) * RELAX
        SERR = SERR + ABS(SEFFEST(J) - SEFF(J))
        SEFFEST(J) = SEFFEST(J) * (1.0-RELAX) + SEFF(J) * RELAX
        SMEAN = SMEAN + ABS(SEFF(J))
85      CONTINUE
        IF (SMEAN .GT. 1.E-10) SERR = SERR / SMEAN
        ENDIF
80      CONTINUE
        ERROR2 = ZERR + BSERR + SERR
        IF(ERROR2 .GT. TOLER2) THEN
            IC = IC + 1
            IF(IC .GT. IZMAX) THEN
                WRITE(6,*)
                WRITE(6,*) ' ENTIRE SOLUTION REFUSES TO CONVERGE '
                WRITE(6,*)
                STOP
            ENDIF
            GOTO 800
        ENDIF
        FAST2 = FLOAT(IC-1) / FLOAT(IZMAX)
        DO 90 N = 1, NTOT
            EPEFF(N) = EPEFF(N) + DEFF(N)
            DO 90 K = 1, 3
                DEPOLD(K,N) = DEP(K,N)
                DEP(K,N) = 0.0
                EP(K,N) = EP2(K,N)
90      CONTINUE
777     CONTINUE
        FAST = 5.0*(FAST1 + FAST2)
        RETURN
        END
C
C =====
C Deviates
C Compute deviatoric stress
C =====
C
        SUBROUTINE DEVIATS( J )
C
        IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C

```

```

        PARAMETER (NN=50)
        COMMON /STRES/  S(6,NN),  SDEV(6,NN),
$           SEFF(NN), SE(NN), SEFFOLD(NN)
C
        SAVE = ( S(1,J) + S(2,J) + S(3,J) ) / 3.0
        DO 5 K = 1, 3
            SDEV(K,J) = S(K,J) - SAVE
5        CONTINUE
        RETURN
        END
C =====
        FUNCTION CSEFF( J )
C
        IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
        PARAMETER (NN=50)
        COMMON /STRES/  S(6,NN), SDEV(6,NN),
$           SEFF(NN), SE(NN), SEFFOLD(NN)
C
        CSEFF = SQRT( 1.5*( SDEV(1,J)*SDEV(1,J) + SDEV(2,J)*SDEV(2,J)
$   + SDEV(3,J)*SDEV(3,J) ) )
        RETURN
        END
C =====
C      Compute the effective stress with backstress
        FUNCTION CK2( J )
C
        IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
        PARAMETER (NN=50)
        COMMON /MAT5B/  F3OLD(NN), BS(6,NN), SDEVOLD(6,NN)
        COMMON /STRES/  S(6,NN), SDEV(6,NN),
$           SEFF(NN), SE(NN), SEFFOLD(NN)
C
        SUM = 0
        DO 5 K = 1, 3
            TERM = SDEV(K,J) - BS(K,J)
            SUM = SUM + TERM*TERM
5        CONTINUE
        CK2 = SQRT(1.5*SUM)
        RETURN
        END
C =====
        FUNCTION CDEFF5( J )
C

```

```

      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )

C
      PARAMETER (NN=50)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
$                   TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$                   TIME, ICYCLE, IBLOCK
      COMMON /MAT5A /  TN(NN), TZ0(NN), TF1(NN), TF3(NN),
$                   TBSMAX(NN), TD0(NN)
      COMMON /STRES/  S(6,NN), SDEV(6,NN),
$                   SEFF(NN), SE(NN), SEFFOLD(NN)

C
      IF( SEFF(J) .LT. 1.E-22 )THEN
        CDEFF5 =0.0
      ELSE
        CDEFF5= TD0(J)*DEXP(-0.5*
$      ( TZ0(J)/SEFF(J) )**(2*TN(J)) )*DTAU
      ENDIF
      RETURN
      END

C =====
      FUNCTION CDEFF6( J, ZTOT )

C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )

C
      PARAMETER (NN=50)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
$                   TINCR, SZINCR, EZINCR, SRINCR, DTAU,
$                   TIME, ICYCLE, IBLOCK
      COMMON /MAT6A /  TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
$                   TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
$                   TR2(NN), TD0D(NN), TZ2(NN),
$                   DTZ1(NN), DTZ2(NN), DTZ3(NN)
      COMMON /STRES/  S(6,NN), SDEV(6,NN),
$                   SEFF(NN), SE(NN), SEFFOLD(NN)
      REAL*8          ZTOT(NN)

C
      IF( SEFF(J) .LE. 1.E-15 )THEN
        CDEFF6 = 0.0
      ELSE
        XTERM1 = (ZTOT(J) /SEFF(J))**2
        CDEFF6 = DEXP(-0.5*(XTERM1**TND(J)))
        CDEFF6 = TD0D(J)*CDEFF6*DTAU
      ENDIF
      RETURN
      END

```

```

C =====
      FUNCTION CDEFF( DEP, J )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( NN = 50)
      REAL*8          DEP(6,NN)
C
      SUM = 0.0
      DO 5 I = 1, 3
          SUM = SUM + DEP(I,J)*DEP(I,J)
5      CONTINUE
      CDEFF = SQRT( 2.0 * SUM /3.0)
      RETURN
      END
C =====
      FUNCTION YSURFACE( EPEST, J )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER(NN=50)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
$          DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /MAT2A / TSY(NN), TEP(NN)
C
      XM = TEP(J)/TE(J)
      XMO = TEP(J)/TEO(J)
      DSDE = XM*TE(J)/(1.0-XM)
      YSURFACE = DSDE*EPEST + TSY(J)*(1.0-XMO)/(1.0-XM)
      RETURN
      END
C =====
      FUNCTION YSURFACE2( J )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER(NN=50)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
$          DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /MAT2A / TSY(NN), TEP(NN)
      COMMON /STRAI/ ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
$          DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
      COMMON /STRES/ S(6,NN), SDEV(6,NN),

```

```

$          SEFF(NN), SE(NN), SEFFOLD(NN)
      REAL*8          EMAX(NN)

C
CX      xm = tep(j)/te(j)
C      This is for 1-d case only. replace eme by the associated eeff.
      IF( EME(3,J) .GE. EMAX(J) ) EMAX(J) = EME(3,J)
      XMO = TEP(J)/TEO(J)
      YSURFACE2 = EMAX(J)*TEP(J) + TSY(J)*(1.0-XMO)
      RETURN
      END

C =====
C *****
C *  equation solver routines      *
C *****
C
C      For lower decomposition
C
C      Call ludcmp(a,n,n,indx,d)
C
C      For back substitution
C
C      Call lubksb(a,n,n,indx,b,x)
C      Note: solve for new x with b as old x
C
C =====
C      Ludcmp
C      Compute lower decomposition of a matrix
C =====
C
C      SUBROUTINE LUDCMP(A,N,NP,INDX,D)
C
C      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
C      This subroutine provides du decomposition of its self
C      PARAMETER (NMAX=150, TINY=1.0E-20)
C      DIMENSION A(NP,NP),INDX(NP),VV(NMAX)
C
C      D = 1.
C      DO 12 I = 1,N
C          AAMAX = 0
C          DO 11 J=1,N
C              IF (ABS(A(I,J)) .GT. AAMAX) AAMAX = ABS(A(I,J))
11      CONTINUE
C          IF(AAMAX .EQ. 0) PAUSE 'SINGULAR MATRIX '
C          VV(I) = 1./ AAMAX

```

```

12  CONTINUE
    DO 19 J = 1,N
        DO 14 I=1,J-1
            SUM=A(I,J)
            DO 13 K = 1,I-1
                SUM=SUM-A(I,K)*A(K,J)
13      CONTINUE
            A(I,J) = SUM
14  CONTINUE
        AAMAX = 0.
        DO 16 I = J,N
            SUM=A(I,J)
            DO 15 K=1,J-1
                SUM = SUM-A(I,K)*A(K,J)
15      CONTINUE
            A(I,J)=SUM
            DUM=VV(I)*ABS(SUM)
            IF(DUM .GE. AAMAX) THEN
                IMAX = I
                AAMAX =DUM
            ENDIF
16  CONTINUE
            IF (J .NE.IMAX) THEN
                DO 17 K=1,N
                    DUM=A(IMAX,K)
                    A(IMAX,K)=A(J,K)
                    A(J,K) = DUM
17      CONTINUE
                D = -D
                VV(IMAX) = VV(J)
            ENDIF
            INDX(J)=IMAX
            IF(A(J,J) .EQ. 0. ) A(J,J) = TINY
            IF(J.NE.N) THEN
                DUM= 1./A(J,J)
                DO 18 I = J+1,N
                    A(I,J)= A(I,J) *DUM
18      CONTINUE
            ENDIF
19  CONTINUE
        RETURN
    END
C
C =====
C  Lubksb

```

```

C Compute solves a*x=b
C =====
C
      SUBROUTINE LUBKSB (A,N,NP,INDX, B, X)
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      This subroutine solves a set of n linear equations a*x = b
      DIMENSION A(NP,NP),INDX(NP), B(NP), X(NP)
C
      DO 3 IJ = 1, N
3        X(IJ) = B(IJ)
      II = 0
      DO 12 I = 1,N
        LL = INDX(I)
        SUM= X(LL)
        X(LL) = X(I)
        IF (II .NE. 0) THEN
          DO 11 J = II,I-1
            SUM = SUM - A(I,J)*X(J)
11          CONTINUE
          ELSEIF (SUM .NE. 0) THEN
            II = I
          ENDIF
          X(I) = SUM
12        CONTINUE
        DO 14 I=N,1,-1
          SUM = X(I)
          IF (I.LT.N) THEN
            DO 13 J=I+1,N
              SUM = SUM-A(I,J)*X(J)
13            CONTINUE
          ENDIF
          X(I) = SUM/A(I,I)
14        CONTINUE
      RETURN
      END
C
C =====
      CHARACTER*10 FUNCTION REAL10 ( VALUE )
C
      IMPLICIT REAL*8 (A-H,O-Z)
C
      Write a floating-point value to a 10-character string
C
      CHARACTER*13 TEMP

```

```

C
C      First write value to temporary string temp in the form -x.xxxxxxe-nn
WRITE (TEMP,'(1PE13.6)') VALUE
REAL10 = '      '
C      Eliminate exponent field if possible
IF ( TEMP(12:13) .EQ. '00' ) THEN
    REAL10(2:10) = TEMP(1:9)
    RETURN
ENDIF
C      Write mantissa
REAL10(1:8) = TEMP(1:8)
C      Write exponent sign (drop the 'e') and one- or two-digit exponent
IF ( TEMP(12:12) .EQ. '0' ) THEN
    REAL10(9:9) = TEMP(11:11)
    REAL10(10:10) = TEMP(13:13)
    REAL10(8:8) = 'E'
ELSE
    REAL10(8:10) = TEMP(11:13)
    REAL10(7:7) = 'E'
ENDIF
RETURN
END

C
C =====
C |
C |
C |
C |
C |
C |
C | %%%%%%%%% %%%%%%%%% %%%%%%%%% %%%%%%%%% %%%%%%%%% %%%%%%%%%
C | %%%%%%%%% %%%%%%%%% %%%%%%%%% %%%%%%%%% %%%%%%%%% %%%%%%%%%
C | %%%          %%%      %%% %%% %%%          %%% %%% %%% %%%
C | %%%%%%%%% %%%      %%% %%% %%%%%%%%% %%% %%% %%%          %%%
C | %%%%%%%%% %%%      %%% %%% %%%%%%%%% %%%%%%%%% %%%          %%%
C | %%%          %%%      %%% %%% %%%          %%%%%%%%% %%%
C | %%%          %%%      %%% %%% %%%          %%%%%%%%% %%%
C | %%%          %%%%%%%%% %%%%%%%%% %%%%%%%%% %%%          %%%%%%%%%
C | %%%          %%%%%%%%% %%%%%%%%% %%%%%%%%% %%%          %%%%%%%%%
C |
C |
C |
C |
C |
C =====
C End of File

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