

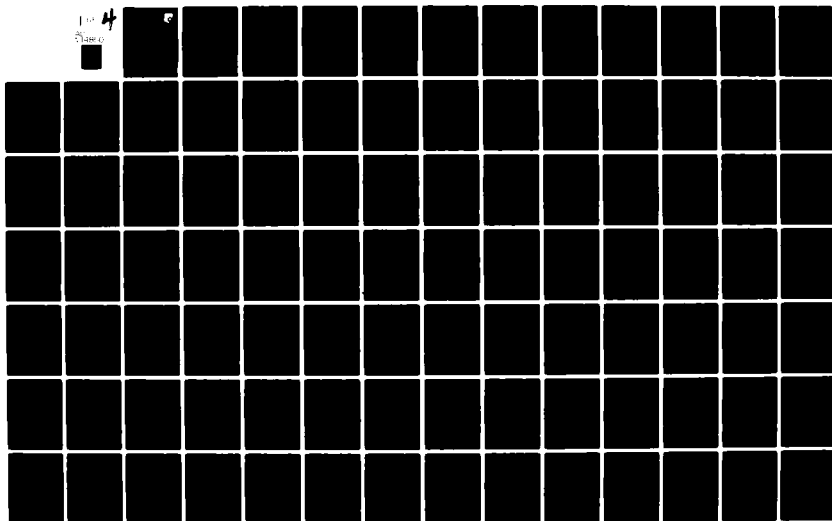
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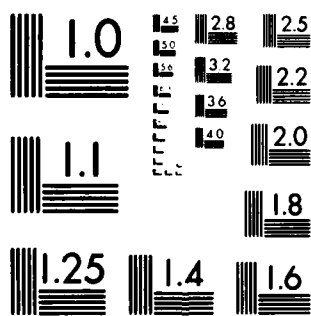
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EFFECT OF WATER ON AXIAL FLOW COMPRESSORS

PART I ANALYSIS AND PREDICTIONS

T. Tsuchiya
S.N.B. Murthy

Purdue University
School of Mechanical Engineering
West Lafayette, Indiana 47907

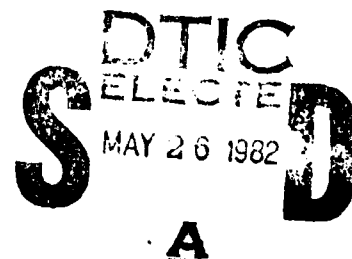
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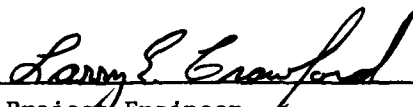
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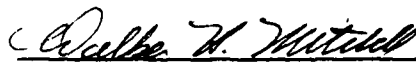
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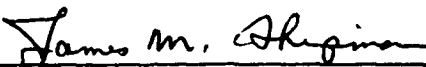


Project Engineer
LARRY E. CRAWFORD
Compressor Research Group



WALKER H. MITCHELL
Chief, Technology Branch

FOR THE COMMANDER



JAMES M. SHIPMAN, MAJOR, USAF
Deputy Directory
Turbine Engine Division
Aero Propulsion Laboratory

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out on a small test compressor with mixtures of gases (containing methane gas to simulate steam) and with air-water droplet mixtures. The experimental results have been compared with predictions. It is concluded that the basic effects of water ingestion into compressors arise through (2) blockage, (b) distortion and (c) heat and mass transfer processes, the changes in blade aerodynamic performance being relatively small. In the case of a compressor of small mass flow and pressure ratio and high operating speed, increased quantities of water ingestion give rise to large quantities of water in the tip region. (When the pressure ratio and air mass flow are large and the operating speed is correspondingly small, there arises a possibility of water evaporation, especially towards the hub, which gives rise to changes in gas phase mass flow and temperature.) The changes in compressor performance are large at high speeds and high flow rates; there also arises a change in the surge characteristics. In light of the nature of changes produced by water ingestion, a preliminary analysis has been carried out on the possible changes in engine performance.

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FOREWARD

This final report presents the results of research undertaken at Purdue University under Air Force Contract No. F33615-78-C-2401. The effort was sponsored by the Air Force Aero Propulsion Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, under Project 3066, Task 306604 and Work Unit 30660454, with Mr. Larry E. Crawford, AFAPL/TBC, as Project Engineer.

Two earlier publications of direct relevance to the project are as follows:

- i) "Water Ingestion into Axial Flow Compressor", Report No. AFAPL-TR-76-77, August, 1976; and
- ii) "Analysis of Water Ingestion Effects in Axial Flow Compressors", Report No. AFAPL-TR-78-35, June, 1978.

The research reported in the current report pertains to a further development of a prediction code for the performance of an axial compressor with water ingestion, experimental studies on a small engine-driven axial compressor with water ingestion and an analysis of the results.

The final report consists of three parts, Part I entitled Analysis and Predictions, Part II entitled Computational Program and Part III entitled Experimental Results and Discussion. Each part is presented in a separate volume.

Dr. Bruce A. Reese, currently Chief Scientist at the Arnold Engineering Development Center, Arnold Air Force Base, who was Professor and Head, School of Aeronautics and Astronautics, Purdue University, up to June 30, 1979, participated in the conduct of research from January, 1978 until June 30, 1979.

The Drive Engine and the Test Compressor provided by the Air Force for the experimental studies under this project were manufactured by the Detroit Diesel Allison of Indianapolis. They refurbished the units during this program under a subcontract. In that work and in a variety of ways the DDA and several of their personnel have been most helpful and have given their time and advice generously to the investigators.

TABLE OF CONTENTS

	Page
LIST OF FIGURES.....	vii
LIST OF TABLES.....	viii
NOMENCLATURE	ix
SUMMARY.....	xix
CHAPTER I: INTRODUCTION	1
1.1 Objectives and Scope of the Investigation..	7
1.2 Effects of Water Ingestion	13
1.3 Implications of Models.....	16
1.4 Organization of Report	17
CHAPTER II: OVERALL PROGRAM DESCRIPTION	19
2.1 Description of PURDU-WICSTK Program	19
2.2 Main Program.....	21
2.3 Off-Design Performance	25
2.4 Bleeding and Injection	26
2.5 Stator Blade Setting	27
2.6 Calculation of Stage Losses	27
2.7 Overall Program Structure	28
CHAPTER III: SUBROUTINES AND EXTERNAL FUNCTIONS	31

TABLE OF CONTENTS (Continued)

	Page
CHAPTER IV: INPUT DATA.....	35
CHAPTER V: OUTPUT	43
5.1 Output of Inputed Data	43
5.2 Output of Design Point Performance.....	43
5.3 Output of Stage Performance.....	45
5.4 Output of Overall Performance.....	47
5.5 Diagnostic Printout	48
CHAPTER VI: TEST CASE	49
FIGURES	61
APPENDIX 1: DETAIL OF TEST COMPRESSOR AND DRIVE ENGINE	69
APPENDIX 2: STAGE PERFORMANCE CALCULATION	85
APPENDIX 3: DETAILED DESCRIPTION OF SUBROUTINES AND EXTERNAL FUNCTIONS	115
APPENDIX 4: PROGRAM SOURCE LIST	185
APPENDIX 5: PRINTOUT OF TEST CASE	249
LIST OF REFERENCES	323

LIST OF FIGURES

Figure		Page
1.1	Atmospheric Particle Size Ranges	62
2.1	Flow Chart of Overall Program Structure	63
4.1	Geometry of Compressor Stage	65
4.2	Angles Associated with a Typical Rotor Blade Element ..	66
5.1	Station Number in Compressor Stage	67
A.1.1	Stage Performance Characteristics of Test Compressor (1st Stage)	74
A.1.2	Stage Performance Characteristics of Test Compressor (2nd Stage)	75
A.1.3	Stage Performance Characteristics of Test Compressor (3rd Stage)	76
A.1.4	Stage Performance Characteristics of Test Compressor (4th Stage)	77
A.1.5	Stage Performance Characteristics of Test Compressor (5th Stage)	78
A.1.6	Stage Performance Characteristics of Test Compressor (6th Stage)	79
A.1.7	Overall Performance of Test Compressor	81
A.1.8	Flow Area vs. Throttle Setting	83
A.2.1	Typical Velocity Diagram for a Compressor Stage	87
A.3.1	Prediction Procedure for Total Pressure Loss Coefficient and Outlet Angle	128
A.3.2	Model for Drag Calculation	136
A.3.3	Control Volume across a Stage	139

LIST OF TABLES

Table		Page
1.1	Comparison of Properties for Steam and Methane	11
4.1	Index for Unit Selection	36
A.1.1	Test Compressor Design Velocity Diagram Values	71
A.1.2	Symbols for Test Compressor Design	72
	Velocity Diagram Values	
A.1.3	Test Compressor Design Data (Rotor)	73
A.1.4	Test Compressor Design Data (Stator)	73

NOMENCLATURE

A	compressor flow area
A_p	droplet project area
a	acoustic speed
C_D	drag coefficient
C_{Df}	drag coefficient corresponding to loss due to water film formed on blade surface
C_{Dr}	drag coefficient corresponding to loss due to rough film surface of water on blade surface
C_w	water vapor concentration
C_{wb}	water vapor concentration at droplet surface
c	blade chord length
c_p	specific heat at constant pressure
c_w	specific heat of water
c_s	humid heat for air-water mixture
D	droplet diameter
D_d	droplet diameter

D_v	diffusivity
D_{eq}	equivalent diffusion ratio
D_{eq}^*	equivalent diffusion ratio at minimum loss point
d_{max}	largest stable droplet diameter
g_c	Newton constant relating force and mass
h_h	heat transfer coefficient
h_m	mass transfer coefficient
i	incidence angle
i^*	incidence angle at minimum loss point
J	constant relating heat and work
K_a	thermal conductivity of air
K_d	thermal conductivity of gaseous film surrounding an evaporating droplet
K_v	thermal conductivity of water vapor
k	thermal conductivity
k_g	thermal conductivity of gaseous phase
M	absolute Mach number
M_a	assumed value of Mach number

M_r relative Mach number
 M_c calculated value of Mach number
 $\dot{m}$ mass flow rate
 $\dot{m}_{film}$ mass flow rate of water film formed on blade surface
 mw molecular weight
 N rotor rotational speed
 N_d number of droplet
 Nu Nusselt number
 P_{01} total pressure at rotor inlet
 P_{02} total pressure at rotor outlet
 P_{03} total pressure at stator outlet
 $P_{01,r}$ relative total pressure at rotor inlet
 $P_{02,r}$ relative total pressure at rotor outlet
 $P_{02,ri}$ ideal relative total pressure at rotor outlet
 PR pressure ratio
 Pr Prandtl number
 P_{ref} reference pressure
 p_1 static pressure at rotor inlet
 p_2 static pressure at rotor outlet

p_3	static pressure at stator outlet
R	gas constant
Re	Reynolds number
r	radius
s	pitch
Sc	Schmidt number
Sh	Sherwood number
SN	stability number
T	static temperature
T_o	total temperature
T_{ref}	reference temperature
$T_{o1,r}$	relative total temperature at rotor inlet
$T_{o2,r}$	relative total temperature at rotor outlet
TR	temperature ratio
U_{tip}	blade tip speed
U	blade speed
V_z	axial velocity

V	absolute velocity
V_{θ}	tangential component of absolute velocity
V_{film}	velocity of film formed on blade surface
W	relative velocity
W_{θ}	tangential component of relative velocity
We	Weber number
x_g	mass fraction of gas phase
x_w	mass fraction of liquid phase

Greek Letters

α	absolute flow angle
β	relative flow angle
γ	specific heat ratio
η	adiabatic efficiency
ΔH_v	latent heat of vaporization
ΔH_0	rise in total enthalpy
$(\Delta H_0)_1$	work input to gaseous phase
$(\Delta H_0)_2$	work input absorbed by water droplets which do not impinge upon blade surface

$(\Delta H_0)_3$ work input absorbed by water droplets which impinge upon blade surface, adhere to form a film and are re-entrained from the trailing edge

$(\Delta H_0)_4$ work input absorbed by droplets which impinge upon blade surface and rebound

ΔT_0 rise in total temperature

ΔT_g rise in overall temperature of gaseous phase

$(\Delta T_g)_{ht}$ drop in temperature of gaseous phase due to heat transfer

$(\Delta T_g)_{wk}$ rise in temperature of gaseous phase due to work done

ΔT_w rise in overall temperature of droplet

$(\Delta T_w)_{ht}$ rise in temperature of droplet due to heat transfer

$(\Delta T_w)_{wk}$ rise in temperature of droplet due to work done

δ deviation angle

δ boundary layer displacement thickness

δ corrected pressure ($\delta=p/p_{ref}$)

θ boundary layer momentum thickness

θ corrected temperature ($\theta=T/T_{ref}$)

μ viscosity

ρ density

σ	surface tension of droplet
σ	solidity
σ_v	particulate liquid volume fraction
τ	equivalent temperature ratio
ϕ	flow coefficient
ψ	equivalent pressure ratio
ω	rotor angular velocity
$\bar{\omega}$	total pressure loss coefficient
$\bar{\omega}_{g,R}$	total pressure loss coefficient across rotor due to gas phase
$\bar{\omega}_{g,S}$	total pressure loss coefficient across stator due to gas phase
$\bar{\omega}_{\theta,R}$	total pressure loss coefficient due to the increase of momentum thickness because of the existence of small droplets in the boundary layer over a rotor blade surface
$\bar{\omega}_{\theta,S}$	total pressure loss coefficient due to the increase of momentum thickness because of the existence of small droplets in the boundary layer over a stator blade surface
$\bar{\omega}_{f,R}$	total pressure loss coefficient due to the momentum gained by thick water film moving over a rotor blade surface
$\bar{\omega}_{f,S}$	total pressure loss coefficient due to the momentum gained by thick water film moving over a stator blade surface
$\bar{\omega}_{r,R}$	total pressure loss coefficient due to turbulent flow of mixture over the rough film surface of rotor blade

- $\bar{\omega}_{r,S}$ total pressure loss coefficient due to turbulent flow of mixture over the rough film surface of stator blade
- $\bar{\omega}_{s,R}$ total pressure loss coefficient due to the Stokesian drag of droplets in rotor passage
- $\bar{\omega}_{s,S}$ total pressure loss coefficient due to the Stokesian drag of droplets in stator passage

Subscript

- a pertaining to assumed value
- c pertaining to calculated value
- D pertaining to design point
- g pertaining to gas phase
- i pertaining to ideal process
- l pertaining to liquid phase
- m pertaining to mixture
- r pertaining to relative value with respect to rotor
- ref pertaining to reference value
- R pertaining to rotor
- S pertaining to stator

- w pertaining to water droplet
- 0 pertaining to stagnation value
- 1 pertaining to rotor inlet
- 2 pertaining to rotor outlet
- 3 pertaining to stator outlet

Superscript

- * pertaining to minimum loss point
- pertaining to average value

SUMMARY

The PURDU-WICSTK program developed for predicting the performance of an axial flow compressor operating with mixtures of gases and water droplets has been described in detail. The utilization of the program has been illustrated with a test case.

CHAPTER I

INTRODUCTION

Water ingestion into an aircraft gas turbine arises due to two circumstantial reasons:

- (1) wheel-generated spray clouds entering the engine inlet during take-off and landing from a rough runway with puddles of water; and
- (2) rain, occasionally mixed with hail, entering the engine inlet during various parts of a flight in a rain storm.

A number of studies (Refs. 1-6) have shown that adverse effects can arise in engine performance due to such ingestion of water at engine inlet, when the engine has been designed for operation with air flow. In particular the engine may surge and may suffer blow-out or unsteadiness in the main burner or the after-burner. Simple corrective steps, such as resetting the throttle, have generally been ineffective in overcoming the problems of loss of power and nonsteady behaviour of the engine. In the case of wheel-spray ingestion, it has again become clear that basic changes in engine installation may be necessary in relation to inlets and landing wheels.

In the current investigation, there is no particular emphasis on the precise cause for the presence of water at the engine inlet. Water is assumed to enter the compressor along with air in droplet form. The droplet (nominal) diameters may be in the range of 20 to 1,300 microns. The water content by weight may be in the range of 2.5 to 15.0 per cent. In case of rain through which an aircraft may have to fly (Refs. 7-9) the droplet sizes may be of the order of 100 to 1,500 microns, although 3,000 micron size droplets have also been reported (Fig. 1.1). On the

other hand, 15.0 per cent of water by weight is probably to be considered as a large amount of ingestion into the inlet, corresponding to flight through storm conditions. Under such extreme conditions there may also be hail and snow ingestion into the engine. However, only water ingestion effects are examined here.

A comprehensive investigation of the problem of water ingestion into engines during flight should take into account details of the engine, its installation and the engine and aircraft controls. In the current investigation attention is focussed on the engine and its control.

Furthermore, it is felt that the response of the compressor in the engine to water ingestion plays a determining and crucial role in the response of the engine as a whole in view of two considerations.

- (1) The compressor receives the ingested water directly and, as a rotating machine, is most strongly affected by the ingested water, and also changes the "state of water" before the fluid enters the burner.
- (2) The compressor performance most directly affects the operating point of the engine under steady and transient state conditions.*

However, the compressor performance is affected by the presence of an inlet through the changes in the flow field introduced by it, especially the distortion of the compressor inlet flow field. While noting such strong interaction between the inlet and the compressor flow fields, the

* It may be pointed out that the operating point of an engine is determined by the matching between all of the components of the engine. Thus, the swallowing capacity of the turbine and nozzle, for example in a simple jet engine, at a given engine speed and turbine entry temperature, determine the engine operating point on the compressor map. However, any changes in the compressor outlet conditions affect the engine operating point most directly with a given turbine and nozzle. In particular, during water ingestion, the compressor map becomes completely changed, causing at least a change in the surge margin for a possible operating point and, in extreme cases, a total mismatch between the components. Even with a turbine and nozzle that have variable-area capability, it may become necessary to regulate the compressor outlet conditions independently.

most important aspect of the problem of water ingestion into an engine is still considered to be that pertaining to changes in the compressor performance itself.

In the case of turbofan engines, the air-water mixture upon entering the inlet becomes divided between the fan and the compressor. In particular cases, the compressor stream may have a different water content and droplet size distribution from that of the compressor stream in the absence of a fan. The effects of water ingestion are important both in the fan and the core engine compressor, although, perhaps, more so in the latter. When there is an after-burner in the fan stream or when a "mixing" Nozzle is employed, water ingestion into the fan stream may, however, become critically important.

From practical operational and design points of view, the effects of water ingestion in a compressor are as follows:

- (1) changes in temperature ratio, pressure ratio and efficiency of the compressor;
- (2) changes in surge line and operating line, and therefore the surge margin under given operating conditions;
- (3) blade deformation and erosion due to impact of droplets;
- (4) blade and casing deformation due to differential thermal expansion under transient conditions;
- (5) oscillation of pressure ratio and flow; and
- (6) changes in dynamic loading including aero-elastic effects.

For given entry conditions, the response of the compressor is determined by the following:

- (1) compressor geometry;
- (2) blade loading;
- (3) machine rotational speed; and
- (4) parameters of the engine of which the compressor is a part.

The latter pertain to engine matching and should include not only the steady state performance parameters but also the mechanical, aerodynamic and thermal inertia of the various components of the engine

under transient conditions. It should be noted that in particular cases, the engine components may include a fan, an after-burner or a second nozzle as part of the engine.

In establishing the response of a compressor to water ingestion, it seems therefore useful to divide the total problem into two parts.

- (1) The compressor as a machine itself; and
- (2) The compressor as a part of the engine system.

In that fashion, one can separate the problems associated with engine matching (steady or transient) from those dependent upon the design of the compressor itself. Once the latter have been understood in detail, the engine as a whole may be studied from a system point of view. This is the approach adopted in the current investigation, since it is also especially convenient in conducting experimental studies.

A number of parameters pertaining to the air-water mixture entering a compressor during water ingestion are the following:

- (1) amount of water approaching and actually entering a blade row as a fraction of the total mass flow of fluid entering compressor;
- (2) form in which water is present, film and droplets;
- (3) temperature and pressure of air, temperature of water and temperature of machine;
- (4) vapor content;
- (5) turbulence; and
- (6) distortion, radial and circumferential.

Water vapor is always present in air-water mixtures ingested into an engine. The water vapor content changes in the compressor because of changes in pressure and temperature and because of transfer processes between the two phases. In particular, in a multi-stage compressor of large pressure ratio, there is a possibility of some of the water reaching local saturation temperature and undergoing a phase change due to boiling causing addition of large quantities of vapor to the gas phase.

It will be observed that each of the afore-mentioned six parameters changes after each blade row and the cumulative changes are therefore especially significant in a multi-stage machine. Furthermore, both time-dependent changes during sudden and sporadic ingestion, as well as steady state changes, as, for example, may arise in a laboratory experiment, need consideration. Thus, a detailed study of this problem should result in the determination and verification of methods for establishing (a) the changes in the performance of a compressor with water ingestion and (b) the changes in the state of fluid between the inlet and the outlet of the compressor. Such a study requires investigations both on a single row of blades (stationary and rotating) as well as on a unit with several rows of blades, under steady, transient, and distorted flow conditions. The latter is a means of establishing the response of a blade row to the flow generated by a preceding row. Furthermore, in order to examine the occurrence and effects of phase change in a blade row, the entry conditions to the blade row have to be selected such that they are suitable for such phase change. In a multi-stage compressor of large pressure ratio, there is, of course, a considerable change in air temperature at design conditions.

However, at this stage there are still considerable problems in conducting detailed measurements of two-phase flows in rotating machinery. It has therefore been felt in this investigation that one should aim at establishing overall performance changes and fluid flow changes in a compressor for given entry conditions of state of the two-phase fluid. Once such overall changes are established and related to verifiable models for performance prediction, it is felt one can proceed to more detailed measurements and modeling.

For a given compressor, the variables of interest during water ingestion are the following:

- (1) speed of the machine;
- (2) throttle setting;
- (3) stagnation pressure
- (4) temperature of air and water;

- (5) amount of water as a fraction of total mixture flow;
- (6) droplet size and number density distribution, and
- (7) vapor content.

The variables (3) to (7) have a spanwise and circumferential distribution at compressor inlet, which may or may not be uniform.

The overall performance parameters of a compressor with two-phase flow are the following:

- (1) pressure ratio temperature ratio and efficiency;
- (2) changes in total water content and droplet size across the compressor; and
- (3) changes in vapor content across the compressor.

Each of these varies along the span of a compressor blade. Both the measurements and prediction of these is beset with considerable difficulties at this time. In particular the determination of water and vapor content and of droplet size distribution requires further advances in instrumentation, data acquisition and data processing.

On establishing and demonstrating predictive methods for the estimation of such overall performance parameters for a compressor, an analysis can be carried out for an engine operating with water ingestion. Under steady conditions, the equilibrium running of a simple engine depends upon the following parameters:

- (1) engine speed;
- (2) mass flow;
- (3) compressor performance with air-water mixture;
- (4) ratio of turbine entry temperature to inlet temperature;
- (5) turbine operational point (choked or unchoked); and
- (6) thrust nozzle geometry.

Regarding the latter, a fixed geometry thrust nozzle with a constant area turbine restricts the number of variables for equilibrium running of a simple engine to a single parameter, namely engine speed or mass flow. In a variable geometry engine which permits changes in area of the turbine and the thrust nozzle, one can select, at least in principle, three variables independently for equilibrium running; engine speed, mass flow and turbine entry temperature.

An analysis of steady state equilibrium running of an engine with water ingestion can be expected to reveal the following:

- (1) whether equilibrium running is feasible under a given set of operating conditions,
- (2) changes in surge margin, and
- (3) effect of fuel scheduling and bleed of working fluid.

The latter, along with other aspects of engine operation, is dependent upon the type of engine control incorporated in the system.

Even when attention is focussed on the performance of a compressor by itself, several aspects of the performance may come to light only when it is operated as a part of an engine. However, if engine matching and its effect on compressor performance are not included, one can test a compressor as a separate unit by driving it, for example, with an aerodynamically-independent drive engine. This has been the basis for experimental studies in the current investigation.

1.1 Objectives and Scope of the Investigation

The principal objectives of the present investigation are as follows:

- (1) Establishment and demonstration of a predictive method for the calculation of the performance of an isolated compressor driven by an external drive unit and operating with air-water mixture flow; and
- (2) Obtaining and correlating experimental data on a multistage compressor with air-water mixture flow.

In both of the above, the vapor content of the mixture is taken into account, both initial humidity and changes in vapor content due to phase change of water droplets.

The other objectives of the present investigation are as follows:

- (1) Determination of the manner in which engine performance becomes affected by water droplet ingestion into the engine compressors; and

- (2) Providing a review of instrumentation suitable in compressor.

1.1.1 Analytical-Predictive Investigations

The analytical-predictive investigations are divided into two parts; (1) investigation on the performance of a compressor with water ingestion, and (2) analysis of a simple gas turbine engine with water ingestion.

Part I: Performance of Compressor with Water Ingestion

The analytical-predictive investigations on performance of compressor with water ingestion are divided into three parts:

- (1) Setting up the general aero-thermodynamic equations for compressor with air-water mixture flow and deduction of a one-dimensional model.
- (2) Establishing one-dimensional models for the estimation of performance of a compressor in four limiting cases as follows:
 - (i) Ingestion of mixtures of gases directly into a compressor at inlet, without water droplets.
 - (ii) Ingestion of small droplets that can be assumed to follow gas motion and hence absorb angular momentum.
 - (iii) Ingestion of large droplets that can be assumed to move with equal probability in all directions and that cause a loss of compressor performance due to drag forces acting on them; and
 - (iv) Injection of water with sudden phase change into steam at an appropriate stage in the compressor.
- (3) Adapting and exercising a three-dimensional streamline computer code, the UD-0300 computer code (Ref.10), for the case of direct ingestion of mixtures of gases into a compressor.

Part II: Analysis of Gas Turbine Engine with Water Ingestion

The objectives of Part II are as follows:

- (1) Establishing a model for steady state engine matching with water ingestion; and
- (2) Establishing a model for calculation of flight performance with water ingestion.

1.1.2. Experimental Investigation

The experimental investigations have been conducted on a specially built Test Compressor. The experimental investigations may be divided into the following three parts:

- (1) Tests with air as the working fluid;
- (2) Tests with air-methane mixture as the working fluid; and
- (3) Tests with air-water droplet mixture as the working fluid.

The Air Force System Command has provided the Test Compressor and a T-63 Drive Engine for the experimental investigations. The predictive methods developed for estimating compressor performance with two phase flow have also been employed to calculate the performance of the Test Compressor.

Details regarding the Test Compressor and Drive Engine are provided in Appendix I to this Report.

The Test Compressor, it will be observed, has several limitations:

- (1) the annulus and the blade heights are small and only overall performance parameters at one or at most two radial locations at the exit plane can be measured.
- (2) the overall pressure and temperature ratios, even at design point, are too small to cause evaporation of more than 2.5 per cent of water (by weight) although the inlet temperature is raised to as high a value as 185°F (85°C).
- (3) the compressor assembly permits little flexibility in locating instrumentation, especially at the compressor exit.

Since the Test Compressor casing has a plastic coating that does not

withstand high temperatures, the Test Compressor has been tested at low inlet temperatures in the range of 70°F to 100°F (about 20°C to 40°C). Such inlet temperatures do not cause water evaporation within the Test Compressor. The test program has therefore been conducted in two parts:

- (1) With a mixture of gases to simulate air-steam mixture flow corresponding to (a) high humidity in the air and (b) operation of different stages with air-steam mixture following complete evaporation of water, and
- (2) With air-water droplet mixture flow.

In examining the effects of presence of water vapor on a compressor performance, it is clear that another gas, such as methane, can be substituted for water vapor so long as the desired similarity laws with respect to Reynolds and Mach numbers, are satisfied. A comparison of properties for steam and methane is presented in Table 1.1. In view of the similar properties, experimental studies have been undertaken in this investigation utilizing air-methane mixtures.

The tests with air-water droplet mixtures have been conducted utilizing the following variables: mixture temperature, mixture composition and droplet size.

1.1.3 Measurements and Predictions

The results of the experimental investigation have been compared with prediction from models from the point of view of examining selected assumptions introduced in the models. It is clear that in view of limitations on the feasibility of measurements and the nature of assumptions introduced in modeling, comparison of analytical predictions with experimental results is restricted to certain overall performance parameters, in particular, the effects of mechanical-aero-thermodynamic interactions are established indirectly from overall compressor performance parameters and changes in water and vapor content.

TABLE 1.1
COMPARISON OF PROPERTIES FOR STEAM AND METHANE

	Steam	Methane
Chemical Formula	H ₂ O	CH ₄
Molecular Weight	18.016	16.043
Specific Heat at Constant Pressure (Btu/lbm-°F)	0.445**	0.531*
(kJ/kg-°C)	1.863**	2.223*
Ratio of Specific Heats*	1.329**	1.304*
Enthalpy Increase (Btu/lbm)	62.70 ⁺	69.96 ⁺
(kJ/kg)	145.84 ⁺	162.73 ⁺

* pressure = 1 atm; temperature = 78°F (26°C)

** pressure = 1 atm; temperature = 212°F (100°C)

⁺ pressure ratio, $P_{02}/P_{01} = 2.6$; $T_{01} = 68°F (20°C)$

1.1.4 Measurement Techniques

A brief review of instrumentation suitable for use in axial flow compressors and cascades operating with two phase fluid flow has been undertaken.

Two important overall performance parameters in compressors are the stagnation pressure ratio and the stagnation temperature ratio. A probe for the measurement of stagnation pressure in two phase flow has been developed. Its possible use in a compressor flow field has been examined. The development of a similar probe for the measurement of stagnation temperatures has been considered.

1.1.5 Engine Performance

The engines considered are those that have been designed for air flow through the inlet. Engines in which there may be injection of water at gas flow part locations beyond the compressor or in other stream such as fan ducts or after-burners are not under consideration. Specifically water ingestion effects have been examined in the case of simple turbo-jet and turbo-fan engines that have originally been designed for air flow operation only. Thus (a) the adverse flow effects due to water ingestion and (b) possible methods of mitigating such effects are of interest.

The response of an engine to water ingestion depends upon the following:

- (a) component geometrical constraints;
- (b) component performance characteristics; and
- (c) nature of control incorporated into the engine.

The performance characteristics that are of major interest are the following:

- (a) Changes in component performance characteristics due to water injection, in particular the compressor;
- (b) Changes in operating characteristics of engine under conditions of equilibrium running;

- (c) Changes in surge margin; and
- (d) Limiting conditions of operation.

The foregoing have been analyzed in order to establish general performance trends without reference to specific engine configurations.

It may be noted that, because of the aero-thermo-mechanical processes arising on account of water ingestion, one may also expect, at least in extreme cases, aero-elastic processes becoming significant. However, the manner in which flutter, for example may be altered during two phase flow in compressors is not included for study in the current investigation.

1.2 Effects of Water Ingestion

The two critical factors during water ingestion may be said to be the following: (a) the aero-thermo-mechanical processes associated with two phase flow and (b) the centrifugal action on droplets in the compressor. The first of these includes droplet disintegration and evaporation processes. The latter gives rise to a change in gas phase mass flow as well as reduction in gas phase temperature. The centrifugal action introduces a radial distortion in the flow and fluid properties, and the distortion changes in every stage of a multistage compressor. In particular, the spanwise distribution of the composition and properties of the fluid, in terms of air, water vapor and water droplets (both content and size distribution), undergoes changes continuously along the compressor flow path. The effects (a) and (b) should be examined in a compressor in relation to the following:

- (i) Formation of a water film in the tip region, that may flow into the diffuser;
- (ii) Possibility of choking hub sections and stalling tip sections with redistributed gas and liquid phase mass flow; and
- (iii) Nonuniform distribution of water vapor in the radial direction.

The foregoing will in turn affect engine performance depending

upon engine-matching and the type of control in the engine.

In order to reduce the effects of water ingestion, one can consider the following in order of increasing complexity.

- (i) Bleeding of gas or liquid phase flow at appropriate locations in the compressor;
- (ii) Resetting stator blades;
- (iii) Modifying engine control; and
- (iv) Introduction of variable geometry nozzle and also turbine.

The results of some preliminary studies on bleeding and also gas injection have been reported in Ref. 11.

1.2.1. Relation to Other Two-Phase Flow Problems in Turbo-Machinery

The current investigation deals with air-water droplet mixture ingestion into engines. On the other hand there has also been considerable interest in the problem of dust particle ingestion into engines (Refs. 12-13). In the latter case the principal interest is in erosion of blades and nozzles, although there is some loss in aerodynamic performance.

It is generally considered that the solid particulates may agglomerate but not disintegrate during dust ingestion. Furthermore the heat and mass transfer processes between the two phases are considered negligible.

Solid particulates are also of interest in certain rocket motor nozzle and plume flows (Refs. 14-16). In this case, in addition to erosion and particulate drag effects it is generally necessary to take into account heat and mass transfer processes, as well as condensation, solidification and other phase change processes. However, in this case there is not strong centrifugal action, although there may be some swirl in the flow.

The low pressure stages of a steam turbine (Refs. 17-19) may

operate, as is well known, with steam-water droplet mixture, the droplets arising through condensation. However, in this case, while erosion, loss of aerodynamic performance, and consequences of strong centrifugal action are important, one does not have the problems of stalling and surging. A compressor is prone to surging and the surge margin with respect to operating line when it is part of an engine is an extremely important parameter in engine operation. Hence the problem of water ingestion into an engine compressor attains a level of complexity and significance much larger than the two phase flow problem in steam turbines. One should also note that a turbine is basically a nozzle, while a compressor flow (both past a blade and through a blade passage) involves diffusion and complicated blade wake interactions.

The current investigation does not take into account geometrical changes in a compressor because of, say, differential contraction of rotor and casing upon water ingestion. In general one can expect a change in clearance between rotor and stator. If a compressor has been designed with optimum clearance, one has to examine both aerodynamic and mechanical effects caused by changes in clearance. This aspect of water ingestion should be examined in relation to the general problems of gas flow path integrity (Ref. 20).

While nonsteady state operation is not considered in the current investigation, one of the most important aspects of water ingestion into compressors and engines is transient state operation. The aero-thermo-mechanical interactions including differential contraction of casing and rotor under transient conditions are significant in evolving various means of reducing the effects of water ingestion.

Finally, it is recognized that the entry conditions into a compressor are not uniform radially and circumferentially. The effects of distortion with respect to pressure, temperature, velocity and turbulence continue to be a subject of concern even with air flowing alone (Ref. 21). During water ingestion, one can expect, in general, distortion both at entry and to the compressor and at entry to each stage. The sensitivity

of an engine to water ingestion should include consideration of inlet distortion with regard to water content and water droplet size distribution. This problem has been entirely neglected in the current investigation. It may be pointed out that even under uniform inlet flow conditions, radial distortion, of course, arises within the compressor due to centrifuging and heat and mass transfer processes.

1.3 Implications of Models

The models derived in the current investigation may be divided into four groups:

- (i) Model for the calculation of stage performance with air flow.
- (ii) Model for droplet motion across a blade row.
- (iii) Model for centrifuging of water, and
- (iv) Model for heat and mass transfer processes, including droplet disintegration.

Experimental investigations have been conducted in order to determine overall compressor performance changes for given initial and operating conditions. A comparison between predictions and measurements therefore yields no detailed verification of the models. It is in any case doubtful if detailed verification of all aspects of the models can be obtained even if one attempted additional measurements.

The performance of a compressor stage with two phase flow depends upon the following parameters:

- (i) geometrical design of blade and blade passage,
- (ii) spacing between blade rows,
- (iii) leading and trailing edge geometry,
- (iv) casing geometry,
- (v) rotor and stator blade junctions,
- (vi) incoming flow conditions, and
- (vii) operating speed and throttle setting

The foregoing determine (a) the stage work input, (b) the states

of gas and liquid phases, (c) the efficiency of compressor, (d) the redistribution of water and vapor and (e) limiting condition of steady state operation of compressor. When the compressor is part of an engine, the operating characteristics of all other components of the engine and of the engine as a whole are also determined by the compressor design and initial conditions. It is clear that while the models developed can be employed to determine the performance of any compressor under a set of reasonable operating conditions, there is need to establish relations that can be employed to scale the performance of a compressor with respect to design, initial and operating conditions. Such scaling laws have to be based on characteristic lengths, characteristic times, and blade, blade passage and blade row characteristics of the compressor and, when the compressor is part of an engine, the characteristics of other components such as diffuser, burner, turbine and nozzle. Under certain assumptions an attempt has been made to establish scaling laws for both a compressor and a simple jet engine.

1.4 Organization of Report

The final report is being issued in three parts:

- Part I: Analysis and Predictions
- Part II: Computational Programs; and
- Part III: Experimental Results and Discussion

This report constitutes Part II of the Final Report. Chapter I is the introduction. Chapter II is devoted to a discussion of overall program structure, and Chapter III presents a detailed description of the subroutines and external functions. The description of input data is given in Chapter IV while a description of the output is presented in Chapter V. Finally, a test case is discussed in Chapter VI.

CHAPTER II

OVERALL PROGRAM DESCRIPTION

The numerical-computational work undertaken in the current investigation may be divided into two parts as follows.

- (1) Modification of UD-0300 computer program for use with mixtures of gases; and
- (2) Development and use of PURDU-WICSTK program for the calculation of performance of axial compressors operating with air-water droplet mixture, based on one-dimensional flow analysis.

The modification of UD-0300 program for use with mixtures of gases is described in detail in Ref. 22. Typical performance results for the Test Compressor employed in this investigation, based on the UD-0300 program, are also presented in Ref. 22.

The PURDU-WICSTK program is described in the following.

2.1 Description of PURDU-WICSTK Program

The one-dimensional flow equations for two phase flow in axial compressors have been derived in detail and presented in Ref. 22. Those equations are suitable for the calculation of performance of any chosen section along the span of an axial compressor blade row. The PURDU-WICSTK is based on those equations. For given initial conditions at the entry to a stage, the outlet conditons can be calculated using those equations.

The PURDU-WICSTK deals with a fluid that may consist of (a) a mixture of three different gases and (b) a mixture of two types of water droplets, distinguished by size. The mixture of gases may consist of air, water vapor or steam, and methane. The water droplets may be "small" and

"large" diameter droplets. Small droplets are defined as those that follow the gas flow path and hence, absorb work input into the compressor along with the gaseous phase. Large droplets are assumed to move largely independently of the gas phase, with equal probability of motion in all directions and without absorbing work input but introducing drag losses. In the general two-phase mixture that is considered as the working fluid in the compressor, the proportion of the five constituents (namely, three gases and two types of droplets) may be chosen as desired in the initial conditions assumed for a calculation. Thus, to consider humid air carrying large droplets, the content of methane and of small droplets are set equal to zero while water vapor content is related to humidity.

The performance of a stage of a compressor is based in the PURDU-WICSTK Code on five physical models as follows.

- (1) Model for the calculation of stage performance with respect to the gaseous phase and water droplets.
- (2) Model for droplet motion across a blade row from a chosen upstream location to a designated downstream location.
- (3) Model for centrifuging of water droplets.
- (4) Model for heat and mass transfer processes between the two phases; and
- (5) Model for droplet break-up and equilibration with respect to size.

The foregoing five models have been described in detail in Ref. 22. However, a further description is included in Appendix 2 of this report regarding the model for the calculation of stage performance with respect to gaseous phase and water droplets.

The general procedure for calculation is the same as described in Ref. 22. The performance of a stage is calculated for given initial and operating conditions with respect to the gaseous phase and the water droplets. Regarding small droplets, any fraction of their total number may be taken into account depending upon assumptions relating to droplet impingement and rebound processes. Details are provided in Ref. 22. Then, at the exit of a blade row, the three major processes, namely

(1) centrifugal action on droplets, (2) heat and mass transfer processes between the two phases and (3) droplet size adjustment, are taken into account. When the stage performance parameters are corrected for the afore-mentioned three processes then one obtains the outlet conditions from a stage.

The outlet conditions from a stage are modified, to account for geometry of compressor, in order to obtain the initial conditions for the next stage, where such exists.

Calculations are repeated for subsequent stages based on the well-known concept of stage-stacking.

The Code can be used to predict the design point performance as well as off-design performance of a multi-stage compressor. Regarding off-design performance calculation, further details are provided in Appendix 2 of this report.

The Code is also suitable for the calculation of compressor performance with (a) bleeding of working fluid at different stages in the compressor and (b) resetting stator blades. It may be recalled that two of the recommended methods for mitigating the effects of water ingestion in compressors consist in (a) bleeding of working fluid and (b) resetting of stator blades.

The program is written for calculation of performance both in British and metric units.

2.2 Main Program

The program consists of a main program, twenty seven subroutines and thirteen external functions.

The main computer code routine is entitled MAIN. It calls all of the major subroutines in the code.

MAIN first reads all of the input data and prints them out. Then MAIN calls the subroutine WICSPD to calculate the design point performance.

At the compressor inlet the overall mixture mass flow rate is determined from the inputted initial overall flow coefficient and selected compressor operating speed. In order to calculate the stage performance, it is necessary to establish the stage axial velocity and stage flow coefficient at the entry to the stage. The axial velocity and therefore the stage flow coefficient are determined by the composition of the mixture. The influence of mixture composition arises through (a) the density of the mixture and (b) the proportion of large droplets in the mixture, the large droplets, it may be recalled, having random motion with respect to the gas phase and the small droplets. Details regarding stage flow coefficient are provided in Ref. 22 and Appendix 2 of this report.

2.2.1 Work Done in Stage

The stage performance calculation may be carried out in one of three ways by setting the input parameter IPERFM equal to 1,2, or 3: (1) WICSPA is called to utilize inputted stage characteristics; (2) WICSPB is called to utilize the analytical/correlation method(Appendix 2) for small droplets; and (3) WICSPC is called to utilize method described in Appendix 2 for large (or general) droplets. The program is written such that if more than 20 per cent of droplets belong to the class of large droplets, WICSPC is always used.

The foregoing stage performance calculation refers only to the determination of work done by the stage on the fluid that is assumed to absorb work input into the stage. The state of the fluid at the exit of the stage is then obtained by accounting for (1) the centrifugal action on droplets leading to a redistribution of liquid phase, (2) heat and mass transfer processes leading to a redetermination of mass flow and temperature of both gas phase and liquid phase.

2.2.2 Droplet Impingement Processes

In order to perform calculations pertaining to impingement of droplets on rotor blades and rebound of droplets, MAIN calls subroutine WICIRS and WICIRL for small and large droplets, respectively. The small and large droplet trajectories are different by assumption and their impingement on blades, therefore, has to be calculated in different ways. For stator blade, the subroutines WICISS and WICISL are called for small and large droplets, respectively.

The rebound of droplets is treated parametrically as a fraction of the droplets that impact a blade. The unrebound droplets are assumed to move over the blade surface and to be reingested into the blade wake at the blade trailing edge. Details regarding these processes may be found in Ref. 22.

2.2.3 Droplet Drag

The stage performance calculation described earlier yields a value of gas phase pressure at the stage exit. This to be corrected for droplet drag in the case of large droplets. The droplet drag due to large droplets is accounted for by calling the subroutine WICDRG. The pressure loss due to drag depends upon (a) the chosen drag coefficient, and (b) the number of droplets taken into consideration. The latter in turn depends upon the droplet impingement and rebound processes. Further details may be found in Ref. 22.

2.2.4 Droplet Size Adjustment

At the trailing edge of a blade, it is necessary to establish (a) the size of droplets that re-entrained into a blade surface and (b) the nominal size of all of the droplets. In both cases, the droplet size is assumed to be determined by the critical value of Weber number. The subroutine WICWAK yields the size of droplets that are re-entrained. Regarding the nominal size of all of the droplets in the blade wake region, the WICSIZ is called to determine it. It may be observed that the droplets attain an equilibrium size in the blade wake region only after traversing a distance since the droplets undergo an accelerating motion starting from the blade trailing edge till they attain momentum equilibrium with respect to the gas phase.

2.2.5 Centrifugal Action

The spanwise redistribution of droplets due to centrifugal action is based on the theory developed in Ref.22. The centrifugal action arises due to (a) the whirl component of velocity of droplets and (b) the rota-

tional motion of blades in a rotor. In the case of small droplets, centrifugal action thus applies to (i) droplets in blade passages with respect to the whirl component of velocity and (ii) droplets on blade surfaces with respect to the blade rotational velocity. In the case of large droplets, on the other hand, centrifugal action arises only for droplets that impact the blade and are not rebound; in other words, for droplets that impinge on a blade and remain on it.

The centrifugal action arises both in a stator and a rotor for small droplets, while it arises only in a rotor for large droplets. This is again based on the earlier postulated difference between small and large droplet motion.

The centrifugal action is determined utilizing the subroutine WICCEN.

It may be pointed out that the spanwise redistribution of droplets due to centrifugal action is a time-dependent process. In other words, the total effect of centrifugal force is proportional to the length of time over which the force acts. It is assumed in the model adopted here that the time over which centrifugal force action arises on a droplet during its passage through a blade row is the mean length of time required for transit through the blade row. Thus, the particles at the trailing edge of a blade row, as they come out of a blade row, are assumed to be centrifuged at that location over a period of time equal to the time of passage through the blade row under consideration. A similar assumption applies if a complete stage is being considered. Further details are available in Ref. 22.

2.2.6. Heat and Mass Transfer Processes

The heat and mass transfer processes between the two phases are also time-dependent processes. The mean duration of time for heat and mass transfer processes across a blade row or a stage is again calculated on the basis of mean transit time through a blade row or a stage. The heat transfer is from the gas phase to the liquid phase. The mass transfer arises due to two reasons as follows.

- (i) The change of pressure and temperature in a stage and the resulting change in thermodynamic equilibrium conditions and,
- (ii) the evaporation of water when conditions are appropriate.

The details of models for heat and mass transfer calculations are presented in Ref. 22.

The heat and mass transfer calculations are carried out by calling the subroutines WICHET and WICMAS, respectively, at the exit of a stage.

The stage exit conditions are thus fully established and are printed out.

2.2.7. Multi-Stage Compressor Performance

When there is a stage following the stage for which exit conditions have been determined, the inlet conditions to the following stage are determined taking into account changes in the geometry of the interstage spacing. Utilizing those conditions as the input conditions, the performance of the following stage is established in terms of final exit conditions from that stage. The procedure is the same as that described for the first stage.

This procedure is continued for all of the stages in the case of a multi-stage compressor and the exit conditions from the last stage are printed out as the output conditions of the compressor for given initial conditions into the first stage of the compressor at the chosen operating speed.

2.3 Off-Design Performance

In order to calculate the performance of a stage at an off-design point, with respect to speed and/or mass flow, one utilizes the subroutine WICSPA, WICSPB, or WICSPC by setting the input parameter IPERFM = 1, 2, or 3. The utilization of the three subroutines is the same as at the design point.

It may be pointed out that the profile loss calculation procedure set out in the subroutine WICGSL is considered especially suitable for the case of the Test Compressor employed in the current investigation. In another case, appropriate modifications or even a replacement of this procedure may become necessary.

2.3.1. Corrections at Stage Exit

In Section 2.2, the methods of applying corrections to the basic stage performance with respect to the following have been discussed.

- (1) droplet impingement processes,
- (2) droplet drag loss,
- (3) droplet size adjustment,
- (4) centrifugal action, and
- (5) heat and mass transfer process.

It may be recalled that the corrections are related to (a) the assumed distinctions between small and large droplets, and (b) the parametrization of droplet impingement, rebound and reingestion.

In performing off-design performance calculations, the procedure is the same as described in Section 2.2. The distinctions between small and large droplets remain the same. One can, of course, introduce desired values for droplet impingement, rebound and reingestion at each calculation point.

2.4 Bleeding and Injection

At the exit of any stage of a compressor, the output yields the composition of the mixture of gases and liquid droplets. In establishing inlet conditions into the following stage, in addition to taking into account changes due to the geometry of inter-stage spacing, one can take into account bleeding or injection of any component of the mixture by adjusting the mass flow and the mixture ratios.

2.5 Stator Blade Setting

The program includes a provision for blade setting as feature of off-design performance calculations. Further details are provided in Appendix 2.

2.6 Calculation of Stage Losses

The calculation of stage losses is fully described in Appendix 2. A summary is provided here.

The stage loss calculation consists of the following five subroutines:

- (1) Subroutine WICGSL
single-phase (gas) flow profile loss calculated using the analytical/correlation method;
- (2) Subroutine WICS DL
loss for small droplets on account of the change in momentum thickness of boundary layer due to the presence of such droplets;
- (3) Subroutine WICSTL
loss due to Stokesian drag of droplets in the free stream of blade passage;
- (4) Subroutine WICFML
loss due to film formed on blades when large droplets are present either by themselves or along with small droplets; and
- (5) Subroutine WICRSL
loss due to the mixture boundary layer formed over the rough film surface referred to in (4).

The calculation schemes for various types of working fluids are as follows.

(a) In dealing with the flow of gas phase along, two options exist as follows.

- (1) Using inputted stage characteristics by utilizing subroutine WICSPA; or
- (2) Using analytical/correlation method by utilizing the relevant part of subroutine WICSPB and WICGSL.

(b) In dealing with the flow of a mixture of gas and small droplets, again two options exist as follows.

- (1) Using inputted stage characteristics through the use of WICSPA and correct for the pressure of droplets by using the subroutine WICSDL; or
- (2) Using analytical/computational method according to subroutines WICSPB, WICGSL, and WICSDL.

(c) Finally, in dealing with the flow of a mixture of gas and large or large and small droplets, one proceeds by using the subroutines WICSPC, WICGSL, WICSTL, WICFML, and WICRSL.

2.7 Overall Program Structure

The overall program structure is presented in Fig. 2.1 and also described below step by step.

Step 1: Read input data.

Step 2: Printout inputted data.

Step 3: Calculate the design point performance by calling WICSPD.

Step 4: Read initial flow coefficient.

Step 5: Calculate mass flow rate of gas phase and liquid phase from the inputted initial flow coefficient. The subroutine WICPRP and WICMAS are called.

Step 6: Calculate stage performance in one of the following five cases:

- (i) If there is no liquid phase, and the inputted stage characteristic curves are to be used, WICSPA is called.
- (ii) If there is no liquid phase, and analytical/correlation method is to be used, WICSPB is called.
- (iii) If more than 80 per cent of droplets belongs to "small" droplet, and the inputted stage characteristic curves are to be used, WICSPA is called.
- (iv) If more than 80 per cent of droplets belongs to "small" droplet and the analytical/correlation method is to be used, WICSPB is called.

- (v) If more than 20 per cent of droplet belongs to "large" droplet, WICSPC is called.

Step 7: Calculation of droplet impingement on rotor blade:

For small droplets, WICIRS is called.

For large droplets, WICIRL is called.

Step 8: Droplet size adjustment at rotor outlet: WICWAK and WICSIZ are called.

Step 9: Calculation of centrifugal action and spanwise redistribution of droplets:

For small droplet, WICCEN and WICDMS are called.

For large droplet, WICCEN and WICDML are called.

Step 10: Calculation of droplet impingement on stator blade:

For small droplet, WICISS is called.

For large droplet, WICISL is called.

Step 11: Droplet size adjustment at stator outlet: WICWAK AND WICSIZ are called.

Step 12: Calculation of heat transfer:

WICHET is called.

Step 13: Calculation of mass transfer:

WICMAS is called.

Step 14: Printout stage performance.

Step 15: Repeat steps (6) ~ (14) until the complete stage performance is obtained.

Step 16: Calculate the overall performance and print them out.

Step 17: Repeat steps (4) ~ (16) for a new value of initial flow coefficient.

CHAPTER III

SUBROUTINES AND EXTERNAL FUNCTIONS

There are 27 subroutines and 13 external functions in this program. The following is the list of subroutines and external functions. Only brief descriptions of these subprograms are given here. A more detailed description of each subprogram is presented in Appendix 3.

Subroutine WICSPA: calculation of stage performance based on the imputed stage characteristic curves.

Subroutine WICSPB: calculation of stage performance based on the analytical/correlation method for small droplet.

Subroutine WICSPC: calculation of stage performance based on the analytical/correlation method for large droplet.

Subroutine WICSPD: calculation of design point performance.

Subroutine WICSCC: calculation of the equivalent pressure ratio, equivalent pressure ratio, equivalent temperature rise ratio, and stage adiabatic efficiency for a particular stage based on the imputed stage characteristic curves.

Subroutine WICGSL: calculation of single-phase (gas) flow loss.

Subroutine WICSDL: calculation of loss for small droplets on account of the change in momentum thickness of boundary layer due to the presence of such droplets.

Subroutine WICSTL: calculation of loss due to Stokesian drag of droplets in the free stream of blade passage.

Subroutine WICFML: calculation of loss due to film formed on blade surface when large droplets are present either by themselves or along with small droplets.

Subroutine WICRSL: calculation of loss due to the rough surface when large droplets are present either by themselves or along with

Subroutine WICVT: calculation of components of velocity triangle and angles.

Subroutine WICCEN: calculation of swanwise replacement of droplets due to centrifugal action.

Subroutine WICDMS: calculation of amount of small droplets which is centrifuged.

Subroutine WICDML: calculation of amount of large droplets which is centrifuged.

Subroutine WICDRG: calculation of drag force on droplet.

Subroutine WICMAC: calculation of Mach number.

Function WICASD: calculation of acoustics speed in two phase flow.

Subroutine WICBOA: calculation of blade outlet angle.

Subroutine WICEDD: calculation of equivalent diffusion at design point.

Function WICED: calculation of equivalent diffusion.

Function WICMTK: calculation of dimensionless momentum thickness.

Function WICLOS: calculation of total pressure loss coefficient.

Subroutine WICIRS: calculation of droplet impingement and rebound in rotor for small droplet.

Subroutine WICIRL: calculation of droplet impingement and rebound in rotor for large droplet.

Subroutine WICISS: calculation of droplet impingement and rebound in stator for small droplet.

Subroutine WICISL: calculation of droplet impingement and rebound in stator for large droplet.

Subroutine WICWAK: Calculation of water reingestion into wake.

Subroutine WICHET: calculation of heat transfer between gaseous phase and droplets.

Subroutine WICMAS: calculation of mass transfer between gaseous phase and droplets.

Function WICMTR: calculation of mass transfer rate.

Function WICPWB: calculation of vapor pressure.

Function WICNEW: calculation of new trial value in the iterative procedure.

Function WICTAN: calculation of the value of tangent function.

Function WICBPT: calculation of boiling point.

Function WICSH: calculation of specific humidity.
Subroutine WICSIZ: calculation of nominal droplet size.
Subroutine WICPRP: calculation of flow properties for gaseous phase.
Function WICCPA: calculation of specific heat at constant pressure
for air.
Function WICCPH: calculation of specific heat at constant pressure
for vapor.
Function WICCPG: calculation of specific heat at constant pressure
for methane.

CHAPTER IV

INPUT DATA

All input data that are needed to use PURDU-WICSTK computer code are described in this section. The input data are presented in the same sequence as they are used in the program. The units for the input data can be selected as either all Metric or all English by choosing the value of IUNIT as shown in Table 4.1.

The following is a list of the input data as they are read in MAIN. Figures 4.1 and 4.2 show the geometry of compressor stage and angles associated with a typical rotor blade element.

<u>Card</u> <u>No.</u>	<u>Input</u> <u>Data</u>	<u>Comment</u>	<u>Format</u>
1	NS	number of stage	I1
2	RRHUB(I)	hub radius at Ith stage rotor inlet. I = 1 ~ NS Unit: inch or cm	F5.3
3	RC(I)	chord length of Ith stage rotor I = 1 ~ NS Unit: inch or cm	F 5.3
4	RBLADE(I)	number of blade for Ith stage rotor. I = 1 ~ NS	F 5.2
5	STAGER(I)	stager angle for Ith stage rotor I = 1 ~ NS Unit: degree	F 5.2
6	SRHUB(I)	hub radius at Ith stage stator inlet. I = 1 ~ NS, I = NS+1 for IG Unit: inch or cm	F 5.3
7	SC(I)	chord length of Ith stage stator I = 1 ~ NS, I = NS+1 for IG Unit: inch or cm	F 5.3

TABLE 4.1 INDEX FOR UNIT SELECTION

IUNIT	Unit of Input data	Unit of Output Variables
1	English	English
2	Metric	Metric
3	English	Metric
4	Metric	English

<u>Card No.</u>	<u>Input Data</u>	<u>Comment</u>	<u>Format</u>
8	SBLADE(I)	number of blade for Ith stage stator. I=1~NS, I=NS+1 for IGW	F 5.2
9	SIGUMR(I)	solidity of Ith stage rotor I = 1~NS	F 5.3
10	SIGUMS(I)	solidity of Ith stage stator I=1~NS, I=NS+1 for IGW	F 5.3
11	FNF	fraction of design corrected rotor speed for a particular speed	F 8.2
12	XDIN	initial water content (mass fraction) of small droplet	F 5.3
12	ICENT	index for centrifugal calculation of small droplet ICENT = 1 when XDIN = 0.0 otherwise ICENT = 2	I1
12	XDDIN	initial water content (mass fraction) of large droplet	F 5.3
12	IICENT	index for centrifugal calculation of large droplet IICENT=1 when XDDIN=0.0 otherwise IICENT = 2	I1
13	TOG	total temperature of gas phase at compressor inlet Unit: Rankin or Kelvin	F 7.2
13	TOW	temperature of droplet at compressor inlet Unit: Rankin or Kelvin	F 7.2
13	PO	total pressure at compressor inlet Unit: lbf/ft ² or N/m ²	F 7.2
14	DIN	initial diameter of small droplet Unit: μm	F 6.1
14	DDIN	initial diameter of large droplet Unit: μm	F 6.1

<u>Card No.</u>	<u>Input Data</u>	<u>Comment</u>	<u>Format</u>
15	FND	rotor corrected speed at design point Unit: RPM	F 7.1
15	T01D	compressor inlet temperature at design point Unit: Rankin or Kelvin	F 7.2
15	P01D	compressor inlet pressure at design point Unit: lbf/ft ² or N/m ²	F 7.2
16	XCH4	initial methane content (mass fraction)	F 5.3
16	RHUMID	initial relative humidity Unit: per cent	F 10.5
17	FMWA	molecular weight of air	F 7.3
17	FMWV	molecular weight of steam	F 7.3
17	FMWC	molecular weight of methane	F 7.3
18	PREB	percent of water droplet that rebound after impingement on blade surface	F 5.1
18	DLIMIT	maximum diameter for small droplet Unit: μm	F 7.1
19	STAGES(I)	stager angle for Ith stage stator I=1~NS, I=NS+1 for IGW Unit: degree	F 5.2
20	GAPR(I)	gap between Ith stage rotor and (I-1)th stage stator I = 1 ~ NS Unit: inch or cm	F 7.5
21	GAPS(I)	gap between rotor blade and stator blade for Ith stage I = 1 ~ NS Unit: inch or cm	F 7.5

<u>Card No.</u>	<u>Input Data</u>	<u>Comment</u>	<u>Format</u>
22	RRTIP(I)	blade tip radius at Ith stage rotor inlet I = 1 ~NS Unit: inch or cm	F 6.3
23	SRTIP(I)	blade tip radius at Ith stage stator inlet I = 1 ~NS Unit: inch or cm	F 6.3
24	IPERFM	index for stage performance calculation IPERFM=1: subroutine WICSPA is used IPERFM=2: subroutine WICSPA is used IPERFM=3: subroutine WICSPA is used	I1
24	IUNIT	index for unit IUNIT=1:Input=English,Output=English IUNIT=2:Input=Metric, Output=Metric IUNIT=3:Input=English,Output=Metric IUNIT=4:Input=Metric, Output=English	I1
25	IRAD	index for radius at which calculation is carried out IRAD = 1: performance at tip IRAD = 2: performance at mean IRAD = 3: performance at hub	I1
26	RT(I)	rotor inlet radius at which tip performance calculation is carried out I = 1 ~NS Unit: inch or cm	F 5.3
27	RM(I)	rotor inlet radius at which mean line performance calculation is carried out I = 1 ~NS Unit: inch or cm	F 5.3
28	RH(I)	rotor inlet radius at which hub performance calculation is carried out I = 1 ~NS Unit: inch or cm	F 5.3
29	ST(I)	stator inlet radius at which tip performance calculation is carried out I = 1 ~NS Unit: inch or cm	F 5.3

<u>Card No.</u>	<u>Input Data</u>	<u>Comment</u>	<u>Format</u>
30	SM(I)	stator inlet radius at which mean line performance is carried out I=1 ~ NS Unit: inch or cm	F 5.3
31	SH(I)	stator inlet radius at which hub performance calculation is carried out I = 1 ~ NS Unit: inch or cm	F 5.3
32	BLOCK(I)	blockage factor for Ith stage rotor $0 < \text{BLOCK}(I) < 1$	F 5.3
33	BLOCKS(I)	blockage factor for Ith stage stator $0 < \text{BLOCKS}(I) < 1$	F 5.3
34	BET1MR(I)	blade metal angle at Ith stage rotor inlet Unit: degree	F 5.2
35	BET2MR(I)	blade metal angle at Ith stage rotor outlet Unit: degree	F 5.2
36	BET1MS(I)	blade metal angle at Ith stage stator inlet Unit: degree	F 5.2
37	BET2MS(I)	blade metal angle at Ith stage stator outlet Unit: degree	F 5.2
38	DMASS	mass flow rate at design point Unit: lb_m/s or kg/s	F 10.6
39	PR12D(I)	total pressure ratio for the Ith stage rotor at design point; I=1~NS	F 5.3
40	PR13D(I)	total pressure ratio for Ith stage at design point; I = 1~NS	F 5.3

<u>Card No.</u>	<u>Input Data</u>	<u>Comment</u>	<u>Format</u>
41	ETARD(I)	adiabatic efficiency for Ith stage rotor	F 5.3
42	SAREA(I)	stream tube area Ith stage rotor inlet Unit: ft ² or m ²	F 10.7
43	SAREAS(I)	stream tube area for Ith stage stator inlet Unit: ft ² or m ²	F 10.7
44	DELB1R(I)	change of blade metal angle for Ith stage rotor resetting I= 1~ NS Unit: degree	F 5.2
45	DELB1S(I)	change of blade metal angle for Ith stage stator resetting I=1~NS, I=NS+1 for IGV	F 5.2
46	XG1BLD(I)	amount of bleed or injection of air at Ith stage outlet I = 1~ NS XG1BLD(I) < 0 for bleed XG1BLD(I) = 0 for no bleed or injection XG1BLD(I) > 0 for injection	F 5.3
47	XG2BLD(I)	amount of bleed or injection of steam at Ith stage outlet I= 1 ~ NS XG2BLD(I) < 0 for bleed XG2BLD(I) = 0 for no bleed or injection XG2BLD(I) > 0 for injection	F 5.3
48	XG3BLD(I)	amount of bleed or injection of methane at Ith stage outlet I = 1 ~ NS XG3BLD(I) < 0 for bleed XG3BLD(I) = 0 for no bleed or injection XG3BLD(I) > 0 for injection	F 5.3

<u>Card No.</u>	<u>Input Data</u>	<u>Comment</u>	<u>Format</u>
49	XWBLD(I)	amount of bleed or injection of small droplet at Ith stage outlet I = 1 ~ NS XWBLD(I) < 0 for bleed XWBLD(I) = 0 for no bleed or injection XWBLD(I) > 0 for injection	F 5.3
50	XWWBLD(I)	amount of bleed or injection of large droplet at Ith stage outlet I = 1 ~ NS XWWBLD(I) < 0 for bleed XWWBLD(I) = 0 for no bleed or injection XWWBLD(I) > 0 for injection	F 5.3
51	BET2SS(I)	absolute flow angle at Ith stage stator outlet I = 1 ~ NS, I=NS1 for IGv	F 5.2
52	FAI	initial flow coefficient. The user can input FAI as many as one wants. However, one card must contain only one FAI and the last card must be 9.99999	F 7.5

CHAPTER V

OUTPUT

The user can select the units for output variables by choosing the value of the input variable IUNIT as shown in Table 4.1.

There are two kinds of output in this program code--regular output and diagnostic output. The regular output consists of four parts as follows:

- (1) output of the inputted data;
- (2) output of design point performance;
- (3) output of stage performance; and
- (4) output of overall performance.

5.1 Output of Inputted Data

All of the data inputted can be printed out at the beginning of output.

5.2 Output of Design Point Performance

5.2.1 Compressor Inlet (Design Point Performance)

At the compressor inlet, the following properties can be printed out for the design point performance:

- (1) total temperature at compressor inlet: (R) or (K)
- (2) total pressure at compressor inlet: (lbf/ft²) or (N/m²)
- (3) static temperature at compressor inlet: (R) or (K)
- (4) static pressure at compressor inlet: (lbf/ft²) or (N/m²)
- (5) static density at compressor inlet: (lbm/ft³) or (kg/m³)
- (6) acoustic speed at compressor inlet: (ft/s) or (m/s)
- (7) axial velocity at compressor inlet: (ft/s) or (m/s)
- (8) Mach number at compressor inlet
- (9) stream tube area at compressor inlet: (ft²) or (m²)
- (10) flow coefficient at compressor inlet

5.2.2 Stage Performance (Design Point Performance)

At the end of each stage, the following properties can be printed out for the design point performance:

- (1) total temperature: (R) or (K)
- (2) total pressure: (lbf/ft²) or (N/m²)
- (3) static temperature: (R) or (K)
- (4) static pressure: (lbf/ft²) or (N/m²)
- (5) static density: (lbm/ft³) or (kg/m³)
- (6) axial velocity: (ft/s) or (m/s)
- (7) absolute velocity: (ft/s) or (m/s)
- (8) relative velocity: (ft/s) or (m/s)
- (9) tangential component of absolute velocity: (ft/s) or (m/s)
- (10) tangential component of relative velocity: (ft/s) or (m/s)
- (11) rotor wheel speed: (ft/s) or (m/s)
- (12) absolute Mach number
- (13) relative Mach number
- (14) total temperature based on relative Mach number: (R) or (K)
- (15) total pressure based on relative Mach number: (lbf/ft²) or (N/m²)
- (16) absolute flow angle: (degree)
- (17) relative flow angle: (degree)
- (18) stream tube area: (ft²) or (m²)
- (19) radius at which calculation is carried out : (ft) or (m)
- (20) flow coefficient
- (21) stage total pressure ratio
- (22) stage adiabatic efficiency
- (23) rotor total pressure ratio
- (24) rotor adiabatic efficiency
- (25) stage total temperature ratio

5.2.3 Overall Performance (Design Point Performance)

After all of stage performance is printed out, the following properties can be printed out.

- (1) compressor inlet total temperature: (R) or (K)

- (2) compressor inlet total pressure: (lbf/ft²) or (N/m²)
- (3) corrected mass flow rate: (lbm/s) or (kg/s)
- (4) overall total pressure ratio
- (5) overall total temperature ratio
- (6) overall adiabatic efficiency
- (7) overall temperature rise: (F) or (C)
- (8) relative flow angle at rotor inlet: BET1SR(I) (degree)
- (9) relative flow angle at rotor outlet: BET2SR(I) (degree)
- (10) incidence for rotor: AINCSR(I) (degree)
- (11) deviation for rotor: ADEVSR (degree)
- (12) absolute flow angle for stator inlet: BET1SS(I) (degree)
- (13) absolute flow angle for stator outlet: BET2SS(I) (degree)
- (14) incidence for stator : AINCSS(I) (degree)
- (15) deviation for stator: ADEVSS(I) (degree)
- (16) stage inlet temperature: TD(I) (R) or (K)
- (17) total pressure loss coefficient for stator: OMEGS(I)
- (18) total pressure loss coefficient for rotor : OMEGR(I)

5.3 Output of Stage Performance

The performance of a stage is calculated for given initial and operating conditions with respect to the gaseous phase and the water droplets. At the exit of a blade row, the four major processes associated with two phase flow, namely (a) droplet impingement process; (b) centrifugal action on droplets; (c) heat and mass transfer processes between the two phases; and (d) droplet size adjustment; are taken into account. When the stage performance parameters are corrected for the afore-mentioned four processes, then one obtains the outlet conditions from a stage. The output of stage performance consist of two parts. First the following properties can be printed out before the afore-mentioned four processes are taken into account.

- (1) stage total pressure ratio
- (2) stage total temperature ratio
- (3) stage adiabatic efficiency
- (4) stage flow coefficient
- (5) axial velocity: (ft/sec) or (m/sec)
- (6) rotor speed: (ft/sec) or (m/sec)

- (7) total pressure: (lbf/ft²) or (N/m²)
- (8) static pressure: (lbf/ft²) or (N/m²)
- (9) total temperature of gas phase: (R) or (K)
- (10) static temperature of gas phase: (R) or (K)
- (11) static density of gas phase: (lbm/ft³) or (kg/m³)
- (12) static density of mixture: (lbm/ft³) or (kg/m³)
- (13) axial velocity: (ft/s) or (m/s)
- (14) absolute velocity: (ft/s) or (m/s)
- (15) relative velocity: (ft/s) or (m/s)
- (16) blade wheel speed: (ft/s) or (m/s)
- (17) tangential component of absolute velocity: (ft/s) or (m/s)
- (18) tangential component of relative velocity: (ft/s) or (m/s)
- (19) acoustic speed: (ft/sec) or (m/s)
- (20) absolute Mach number
- (21) relative Mach number
- (22) flow coefficient
- (23) stream tube area (ft²) or (m²)
- (24) absolute flow angle: (degree)
- (25) relative flow angle: (degree)
- (26) incidence: (degree)
- (27) deviation: (degree)

After the stage parameters are corrected for the afore-mentioned four processes, the following second parts of output of stage performance can be printed out.

- (1) stage total pressure ratio
- (2) stage total temperature ratio
- (3) stage adiabatic efficiency
- (4) water vapor content: XV
- (5) water content of small droplet: XW
- (6) water content of large droplet: XWW
- (7) total water content: XWT
- (8) mass fraction of dry air: XAIR
- (9) mass fraction of methane: XMETAN
- (10) mass fraction of gaseous phase: XGAS

- (11) mass flow rate of small droplet: WMASS (lbm/s) or (Kg/S)
- (12) mass flow rate of large droplet: WWMASS (lbm/s) or (Kg/S)
- (13) total mass flow rate of droplet: WTMASS (lbm/s) or (Kg/S)
- (14) mass flow rate of dry air: AMASS (lbm/s) or (Kg/S)
- (15) mass flow rate of methane: CHMASS (lbm/s) or (Kg/S)
- (16) mass flow rate of water vapor: VMASS (lbm/s) or (Kg/S)
- (17) mass flow rate of gaseous phase: GMASS (lbm/s) or (kg/S)
- (18) mass flow rate of mixture: TMASS (lbm/s) or (Kg/S)
- (19) specific humidity: WS
- (20) density of air: RHOA (lbm/ft³) or (Kg/m³)
- (21) density of mixture: RHOM (lbm/ft³) or (Kg/m³)
- (22) density of gaseous phase: RHOG (lbm/ft³) or (Kg/m³)
- (23) temperature of gaseous phase: TG (R) or (K)
- (24) temperature of small droplet: TW (R) or (K)
- (25) temperature of large droplet: TWW (R) or (K)
- (26) pressure: P (lbf/ft²) or (N/m²)
- (27) boiling point: TB (R) or (K)
- (28) dew point: TDEW (R) or (K)

5.4 Output of Overall Performance

At the end of compressor, the overall performance can be printed out.
The properties to be printed out are as follows:

- (1) initial flow coefficient
- (2) corrected speed of compressor and fraction of design corrected speed
- (3) initial water content of small droplet
- (4) initial water content of large droplet
- (5) initial total water content
- (6) initial relative humidity
- (7) initial methane content
- (8) compressor inlet total temperature: (R) or (K)
- (9) compressor inlet total pressure: (lbf/ft²) or (N/m²)

- *(10) corrected mass flow rate of mixture: (lbm/s) or (Kg/S)
- *(11) corrected mass flow rate of gaseous phase: (lbm/s) or (Kg/S)
- (12) overall total pressure ratio
- (13) overall total temperature ratio
- (14) overall adiabatic efficiency
- (15) overall temperature rise of gaseous phase: (F) or (C)

5.5 Diagnostic Printout

At the inlet of each stage, the flow coefficient is calculated. If the flow coefficient gives the value of equivalent pressure ratio which is less than 1.0 or the value of stage adiabatic efficiency which is less than 0.0, the following message will appear. "FAI IS TOO BIG OR TOO SMALL AT STAGE=." If this message appears, the computation for the particular initial flow coefficient will be terminated and the next initial flow coefficient will be read.

The iterative procedure is used to determine the Mach number. If the desired accuracy can not be obtained after 50 times of iteration, the following message will appear. "M DOES NOT CONVERGE AT STAGE=." If this message appears, the final value of Mach number will be used and computation will be continued.

When the axial velocity become either higher than local acoustic speed or negative, the following message will appear: "VZ IS TOO HIGH OR TOO LOW." If this message appears, the computation for the particular initial flow coefficient will be terminated and the next initial flow coefficient will be read.

* The mass flow rate corresponds to stream tube area specified in input data. The mass flow rate which corresponds to compressor total flow area is also printed out in the brackets.

CHAPTER VI

A TEST CASE

The application of the PURDU-WICSTK program is illustrated with a test case pertaining to the Test Compressor described in Appendix 1. The Test Compressor consists of the six axial stages of the ALLISON T63-A-5 engine compressor. The design point overall pressure ratio (mass averaged) is 2.9 with 3.0 lbm/sec of mass flow rate, and the design rotor speed is 51120 RPM.

The test case consists of the following predictions for the Test Compressor.

- (i) Part I: Operation with air flow at a selected speed and throttle setting.
- (ii) Part II: Operation with air-small droplet mixture flow at a selected speed and throttle setting; and
- (iii) Part III: Operation with air-large droplet mixture flow at a selected speed and throttle setting.

The test case has been reproduced in Appendix 5.

6.1 Test Case Part I

The Test Case Part I demonstrates the use of the code for predicting the performance of a compressor which operates with air flow (only) at a selected speed and throttle setting. The performance prediction has been presented at the mean line of the Test Compressor.

6.1.1 Input Data

The input data for Test Case Part I are listed below as they are read in program MAIN.

Card 1: NS = 6

Card 2: RRHUB(1) = 0.770 inch
RRHUB(2) = 1.035 inch
RRHUB(3) = 1.232 inch
RRHUB(4) = 1.378 inch
RRHUB(5) = 1.489 inch
RRHUB(6) = 1.572 inch

Card 3: RC(1) = 0.605 inch
RC(2) = 0.554 inch
RC(3) = 0.534 inch
RC(4) = 0.510 inch
RC(5) = 0.483 inch
RC(6) = 0.456 inch

Card 4: RBLADE(1) = 16.00
RBLADE(2) = 20.00
RBLADE(3) = 20.00
RBLADE(4) = 25.00
RBLADE(5) = 28.00
RBLADE(6) = 32.00

Card 5: STAGER(1) = 34.25 degree
STAGER(2) = 29.96 degree
STAGER(3) = 27.37 degree
STAGER(4) = 28.30 degree
STAGER(5) = 29.17 degree
STAGER(6) = 29.75 degree

Card 6: SRHUB(1) = 0.923 inch
SRHUB(2) = 1.145 inch
SRHUB(3) = 1.311 inch
SRHUB(4) = 1.445 inch
SRHUB(5) = 1.538 inch
SRHUB(6) = 1.580 inch
SRHUB(7) = 0.774 inch

Card 7: SC(1) = 0.442 inch
SC(2) = 0.412 inch
SC(3) = 0.412 inch
SC(4) = 0.412 inch
SC(5) = 0.412 inch
SC(6) = 0.412 inch
SC(7) = 1.100 inch

Card 8: SBLADE(1) = 14.00
SBLADE(2) = 26.00
SBLADE(3) = 28.00
SBLADE(4) = 32.00
SBLADE(5) = 36.00
SBLADE(6) = 30.00
SBLADE(7) = 7.00

Card 9: SIGUMR(1) = 1.052
SIGUMR(2) = 1.120
SIGUMR(3) = 1.037
SIGUMR(4) = 1.182
SIGUMR(5) = 1.211
SIGUMR(6) = 1.283

Card 10: SIGUMS(1) = 0.640
SIGUMS(2) = 1.061
SIGUMS(3) = 1.093
SIGUMS(4) = 1.199
SIGUMS(5) = 1.311
SIGUMS(6) = 1.087
SIGUMS(7) = 0.858

Card 11: FNF = 1.00

Card 12: XDIN = 0.000
 ICENT = 1
 XDDIN = 0.000
 IICENT = 1

Card 13: TOG = 518.70 R
 TOW = 513.70 R
 PO = 2116.80 lb_f/ft²

Card 14: DIN = 20.0 μm
 DDIN = 600.0 μm

Card 15: FND = 51120.0 RPM
 TOLD = 518.70 R
 POLD = 2116.80 lb_f/ft²

Card 16: XCH4 = 0.000
 RHUMID = 0.00001 per cent

Card 17: FMWA = 28.964
 FMWV = 18.016
 FMWX = 16.043

Card 18: PREB = 50.00 per cent
 DLIMIT = 100.0 μm

Card 19: STAGES(1) = 23.67 degree
 STAGES(2) = 25.62 degree
 STAGES(3) = 26.94 degree
 STAGES(4) = 28.41 degree
 STAGES(5) = 29.82 degree
 STAGES(6) = 38.99 degree
 STAGES(7) = 10.99 degree

Card 20: GAPR(1) = 0.125 inch
GAPR(2) = 0.125 inch
GAPR(3) = 0.125 inch
GAPR(4) = 0.125 inch
GAPR(5) = 0.125 inch
GAPR(6) = 0.125 inch

Card 21: GAPS(1) = 0.125 inch
GAPS(2) = 0.125 inch
GAPS(3) = 0.125 inch
GAPS(4) = 0.125 inch
GAPS(5) = 0.125 inch
GAPS(6) = 0.125 inch

Card 22: RRTIP(1) = 2.16 inch
RRTIP(2) = 2.16 inch
RRTIP(3) = 2.16 inch
RRTIP(4) = 2.16 inch
RRTIP(5) = 2.16 inch
RRTIP(6) = 2.16 inch

Card 23: SRTIP(1) = 2.16 inch
SRTIP(2) = 2.16 inch
SRTIP(3) = 2.16 inch
SRTIP(4) = 2.16 inch
SRTIP(5) = 2.16 inch
SRTIP(6) = 2.16 inch

Card 24: IPERFM = 2
IUNIT = 1

Card 25: IRAD = 2

Card 26: RT(1) = 2.149 inch
RT(2) = 2.151 inch
RT(3) = 2.148 inch
RT(4) = 2.149 inch
RT(5) = 2.149 inch
RT(6) = 2.147 inch

Card 27: RM(1) = 1.426 inch
RM(2) = 1.575 inch
RM(3) = 1.642 inch
RM(4) = 1.722 inch
RM(5) = 1.789 inch
RM(6) = 1.836 inch

Card 28: RH(1) = 0.781 inch
RH(2) = 1.056 inch
RH(3) = 1.252 inch
RH(4) = 1.411 inch
RH(5) = 1.533 inch
RH(6) = 1.621 inch

Card 29: ST(1) = 0.934 inch
ST(2) = 1.152 inch
ST(3) = 1.318 inch
ST(4) = 1.453 inch
ST(5) = 1.548 inch
ST(6) = 1.592 inch

Card 30: SM(1) = 1.502 inch
SM(2) = 1.573 inch
SM(3) = 1.637 inch
SM(4) = 1.712 inch
SM(5) = 1.766 inch
SM(6) = 1.784 inch

Card 31: SH(1) = 2.147 inch
SH(2) = 2.138 inch
SH(3) = 2.127 inch
SH(4) = 2.123 inch
SH(5) = 2.118 inch
SH(6) = 2.100 inch

Card 32: BLOCK(1) = 0.983
BLOCK(2) = 0.976
BLOCK(3) = 0.967
BLOCK(4) = 0.949
BLOCK(5) = 0.923
BLOCK(6) = 0.902

Card 33: BLOCKS(1) = 0.978
BLOCKS(2) = 0.966
BLOCKS(3) = 0.945
BLOCKS(4) = 0.928
BLOCKS(5) = 0.908
BLOCKS(6) = 0.863

Card 34: BET1MR(1) = 42.72 degree
BET1MR(2) = 42.74 degree
BET1MR(3) = 41.62 degree
BET1MR(4) = 42.85 degree
BET1MR(5) = 44.00 degree
BET1MR(6) = 45.07 degree

Card 35: BET2MR(1) = 25.79 degree
BET2MR(2) = 17.17 degree
BET2MR(3) = 13.12 degree
BET2MR(4) = 13.76 degree
BET2MR(5) = 14.33 degree
BET2MR(6) = 14.43 degree

Card 36: BET1MS(1) = 35.15 degree
BET1MS(2) = 40.11 degree
BET1MS(3) = 43.36 degree
BET1MS(4) = 45.00 degree
BET1MS(5) = 46.31 degree
BET1MS(6) = 48.71 degree
BET1MS(7) = 0.00 degree

Card 37: BET2MS(1) = 12.19 degree
BET2MS(2) = 11.13 degree
BET2MS(3) = 10.51 degree
BET2MS(4) = 11.81 degree
BET2MS(5) = 13.32 degree
BET2MS(6) = 29.28 degree
BET2MS(7) = 21.99 degree

Card 38: DMASS = 0.375538 1bm/sec

Card 39: PR12D(1) = 1.154
PR12D(2) = 1.165
PR12D(3) = 1.221
PR12D(4) = 1.237
PR12D(5) = 1.230
PR12D(6) = 1.215

Card 40: PR13D(1) = 1.152
PR13D(2) = 1.159
PR13D(3) = 1.213
PR13D(4) = 1.228
PR13D(5) = 1.221
PR13D(6) = 1.208

Card 41: ETARD(1) = 0.966
ETARD(2) = 0.966
ETARD(3) = 0.968
ETARD(4) = 0.965
ETARD(5) = 0.962
ETARD(6) = 0.954

Card 42: SAREA(1) = 0.0103647 ft²
SAREA(2) = 0.0092977 ft²
SAREA(3) = 0.0080300 ft²
SAREA(4) = 0.0069214 ft²
SAREA(5) = 0.0059094 ft²
SAREA(6) = 0.0051110 ft²

Card 43: SAREAS(1) = 0.0098704 ft²
SAREAS(2) = 0.0084051 ft²
SAREAS(3) = 0.0070775 ft²
SAREAS(4) = 0.0060735 ft²
SAREAS(5) = 0.0052626 ft²
SAREAS(6) = 0.0046691 ft²
SAREAS(7) = 0.0105669 ft²

Card 44: DELB1R(1) = 0.00
DELB1R(2) = 0.00
DELB1R(3) = 0.00
DELB1R(4) = 0.00
DELB1R(5) = 0.00
DELB1R(6) = 0.00

Card 45: DELB1S(1) = 0.00
DELB1S(2) = 0.00
DELB1S(3) = 0.00
DELB1S(4) = 0.00
DELB1S(5) = 0.00
DELB1S(6) = 0.00

Card 46: XG1BLD(1) = 0.000
XG1BLD(2) = 0.000
XG1BLD(3) = 0.000
XG1BLD(4) = 0.000
XG1BLD(5) = 0.000
XG1BLD(6) = 0.000

Card 47: XG2BLD(1) = 0.000
XG2BLD(2) = 0.000
XG2BLD(3) = 0.000
XG2BLD(4) = 0.000
XG2BLD(5) = 0.000
XG2BLD(6) = 0.000

Card 48: XG3BLD(1) = 0.000
XG3BLD(2) = 0.000
XG3BLD(3) = 0.000
XG3BLD(4) = 0.000
XG3BLD(5) = 0.000
XG3BLD(6) = 0.000

Card 49: XWBLD(1) = 0.000
XWBLD(2) = 0.000
XWBLD(3) = 0.000
XWBLD(4) = 0.000
XWBLD(5) = 0.000
XWBLD(6) = 0.000

Card 50: XWWBLD(1) = 0.000
XWWBLD(2) = 0.000
XWWBLD(3) = 0.000
XWWBLD(4) = 0.000
XWWBLD(5) = 0.000
XWWBLD(6) = 0.000

Card 51: BET2SS(1) = 21.89 degree
BET2SS(2) = 19.09 degree
BET2SS(3) = 19.33 degree
BET2SS(4) = 20.18 degree
BET2SS(5) = 21.15 degree
BET2SS(6) = 34.86 degree
BET2SS(7) = 15.61 degree

Card 52: FAI = 0.5000

Card 53: FAI = 9.99999

6.1.2 Output

The output for Test Case Part I is presented in Appendix 5. The details of the output obtained are described in Chapter V.

6.2 Test Case Part II

The Test Case Part II demonstrates the use of the code for predicting the performance of a compressor which operates with air-small droplet mixture flow at a selected speed and throttle setting. The water content of small droplet has been specified as four per cent by weight. The performance prediction has been presented at the mean line of the Test Compressor.

6.2.1 Input Data

The input data for Test Case Part II are the same as those for Test Case Part I except in regard to the following.

Card 12: XDIN = 0.040
ICENT = 2
XDDIN = 0.000
IICENT = 1

6.2.2 Output

The output for Test Case Part II is presented in Appendix 5. The details of the output obtained are described in Chapter V.

6.3 Test Case Part III

The Test Case Part III demonstrates the use of the code for predicting the performance of a compressor which operates with air-large droplet mixture flow at a selected speed and throttle setting. The water content of large droplet has been specified as four per cent by weight. The performance prediction has been presented at the mean line of the Test Compressor.

6.3.1 Input Data

The input data for Test Case Part III are the same as those for Test Case Part I except in regard to the following.

```
Card 12: XDIN  = 0.000
          ICENT = 1
          XDDIN = 0.040
          IICENT = 2
```

6.3.2 Output

The output for Test Case Part III is presented in Appendix 5. The details of the output properties are described in Chapter V.

FIGURES

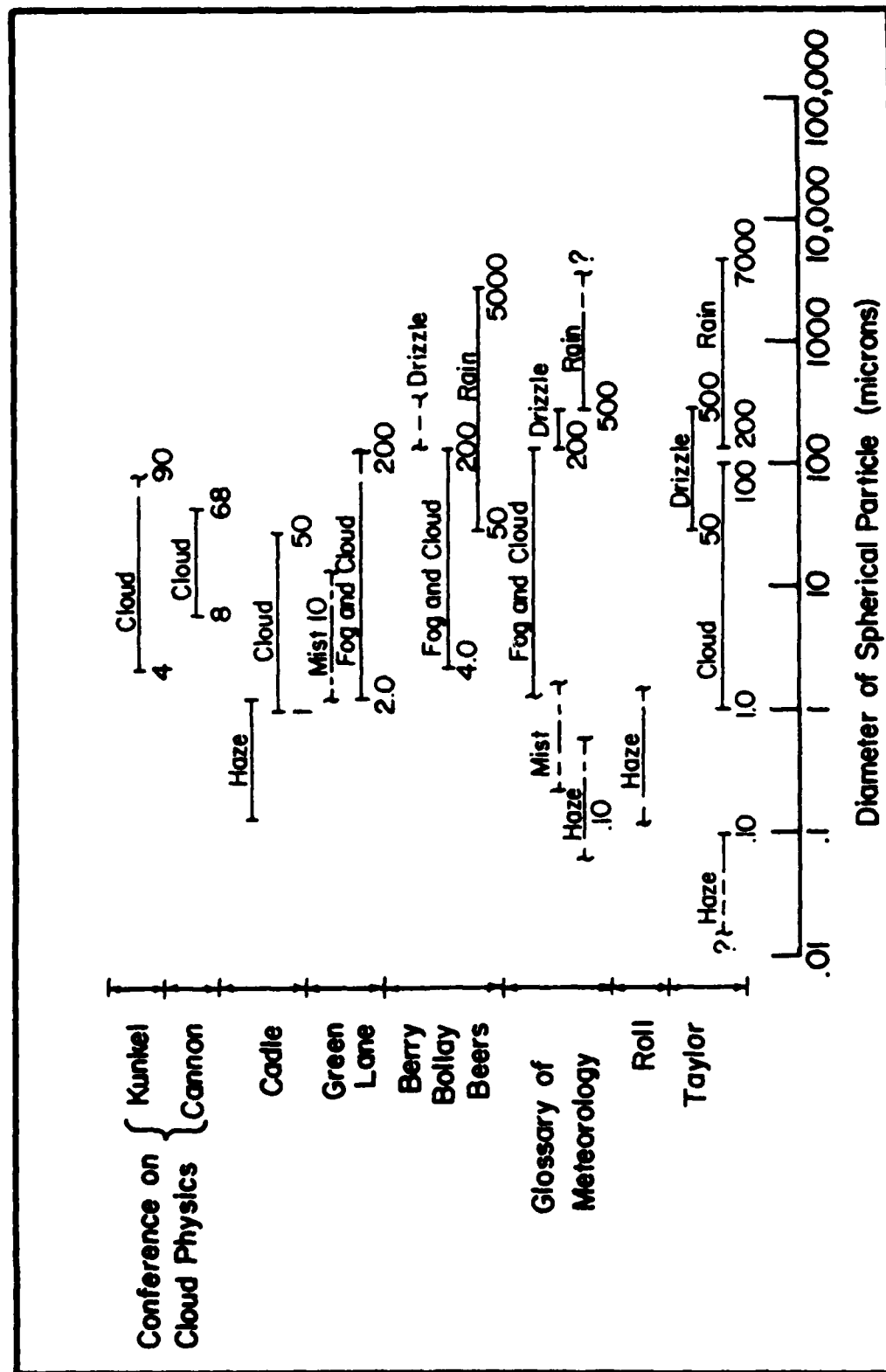


Fig. 1.1 Atmospheric Particle Size Ranges

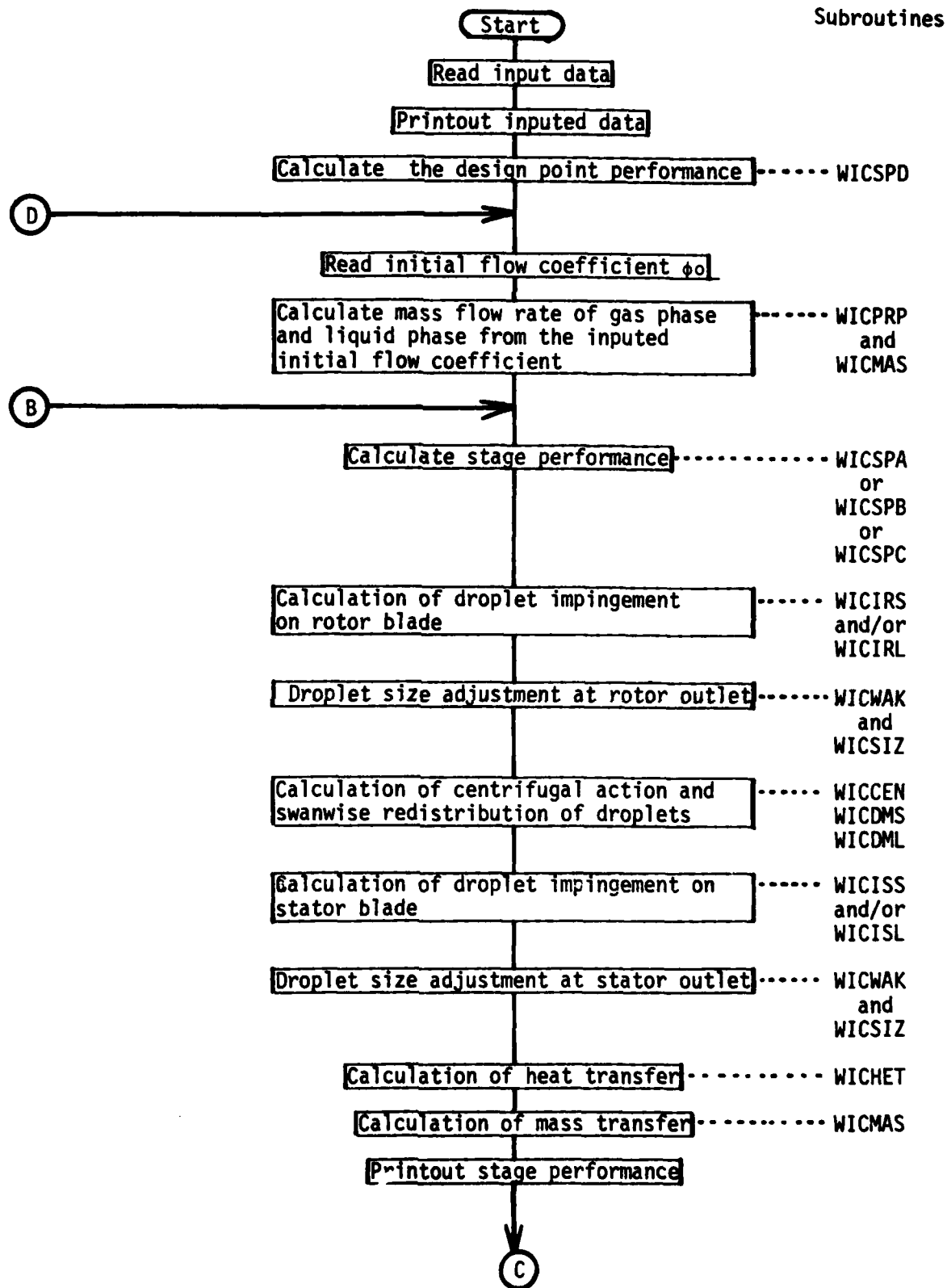


Figure 2.1 Flow Chart of Overall Program Structure

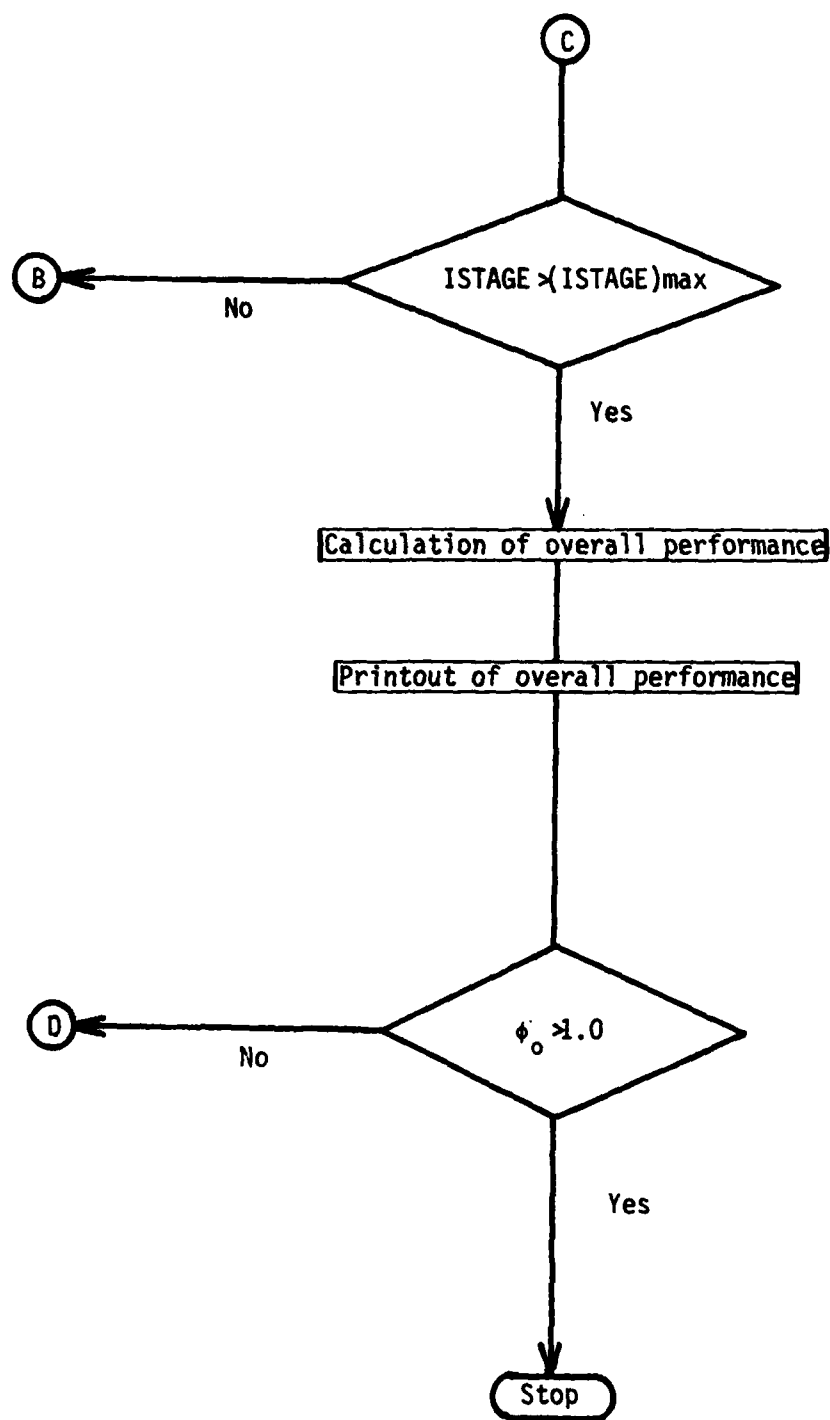


Figure 2.1 Flow Chart of Overall Program Structure (Continued)

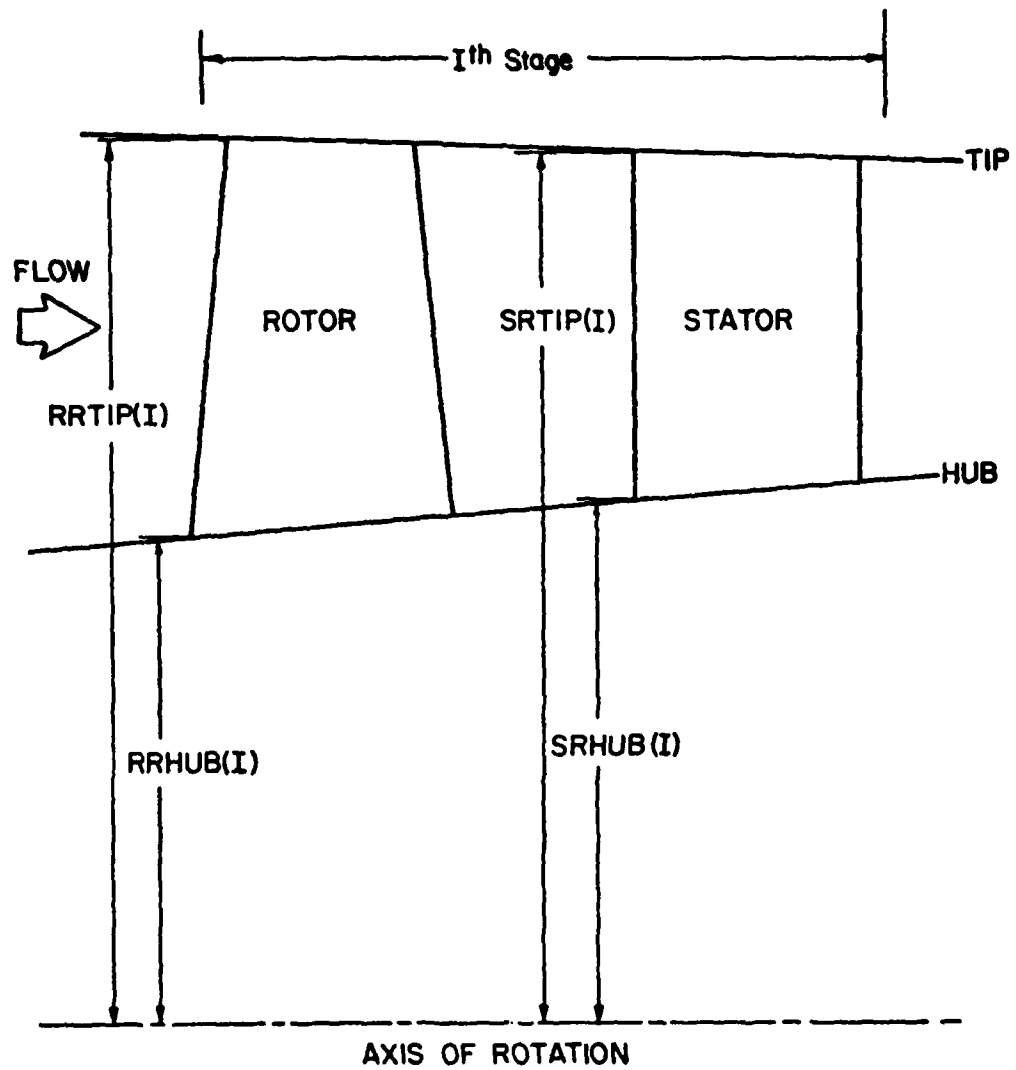


Fig. 4.1 Geometry of Compressor Stage

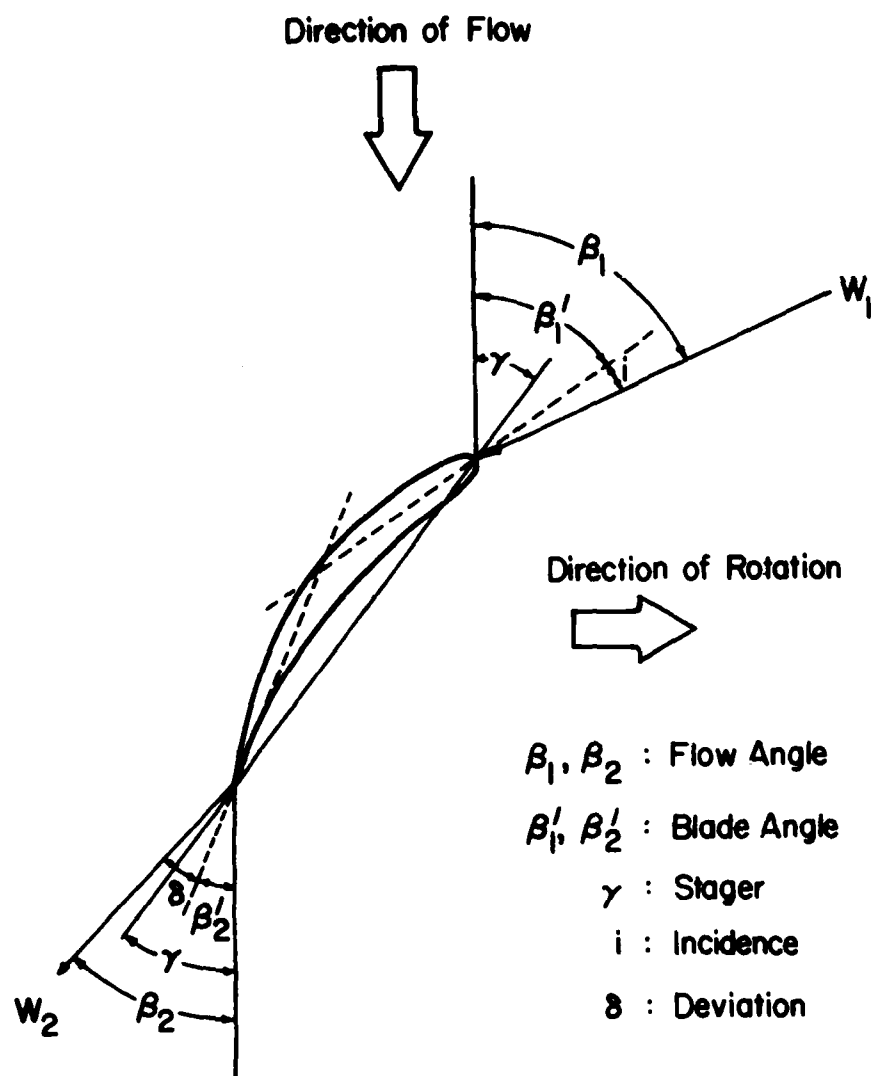


Fig. 4.2 Angles Associated With a Typical Rotor Blade Element

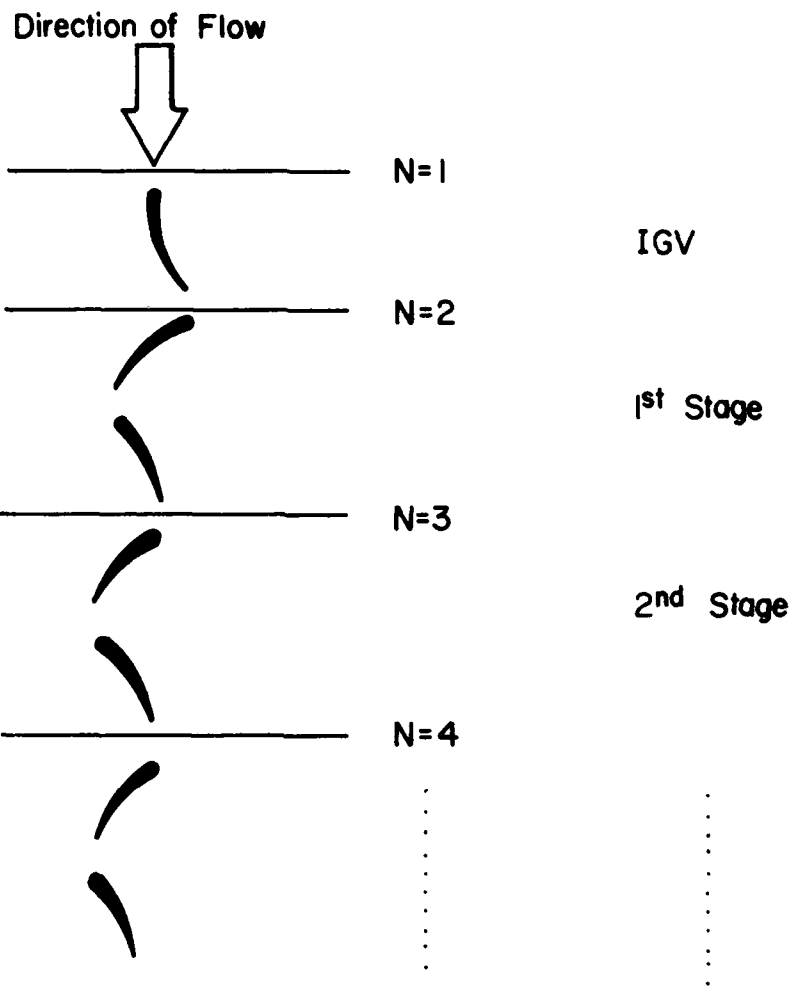


Fig. 5.1 Station Number in Compressor Stages

APPENDIX 1

DETAIL OF TEST COMPRESSOR AND DRIVE ENGINE

1. Drive Engine

A T63-A-5 engine is used to drive the Test Compressor. The specifications, limits, and performance ratings for the Drive Engine are as follows:

Design power output: 250 shp
Ram power rating: 275 shp

Design speeds:

Gas producer	51120 rpm (100%)
Power turbine	35000 rpm (100%)
Power output shaft	6000 rpm

Fuel Specification : MIL-J-5624E(JP-4)

The Drive Engine power turbine drives the Test Compressor through mechanical gearing. The power turbine speed has been increased to an output of 9,643 rpm at 100 per cent speed from the normal rating of 6,000 rpm. The Test Compressor is operated at 110 per cent (56,251.7 rpm) while the engine operates at 100 per cent or 51,120 rpm. One power turbine tachometer is used to monitor the Test Compressor speed. The ratio of the tachometer speed to the Test Compressor speed is 0.119676.

2. Test Compressor

The Test Compressor consists of the six axial stages of the ALLISON T63-A-5 engine compressor. The Test Compressor has been designed and built such that various stages of the compressor can be

assembled and tested. Thus the first two, the intermediate two or the last two stages can be tested if desired, as well as the unit with all of the six stages. Only the 6-stage unit has been used in the current tests.

The first stage of the Test Compressor is preceded by an inlet guide vane row which imparts swirl to the inlet air. The relative Mach number of the incoming air at the rotor inlet is thereby reduced as far as permissible without causing inlet blockage. The axial component features unshrouded rotors, cantilever stators, and double circular arc blading in all stages. The values of T-63 compressor design velocity diagram are presented in Table A.1.1. Table A.1.3 and A.1.4 present the hardware geometry and aerodynamic design data for rotor and stator, respectively.

Figure A.1.1. to Figure A.1.6 show the stage performance characteristics of Test Compressor supplied by the manufacturer. In each of the figures, the equivalent pressure ratio, ψ , equivalent temperature ratio, τ , and stage adiabatic efficiency, η , are presented in terms of flow coefficient, ϕ . The definitions of these parameters are as follows:

(i) flow coefficient: ϕ

$$\phi = V_z / U_{tip}$$

(ii) equivalent pressure ratio: ψ

$$\psi = \left\{ \left(\frac{U_{tip}^2}{T_{01}} \right)_D \cdot \left(\frac{T_{01}}{U_{tip}^2} \right) \left[\left(\frac{P_{02}}{P_{01}} \right)^{(\gamma-1)/\gamma} - 1 \right] + 1 \right\}^{\gamma/(\gamma-1)}$$

(iii) equivalent temperature ratio: τ

$$\tau = \left(\frac{U_{tip}}{T_{01}} \right)_D^2 \cdot \left(\frac{\Delta T_0}{U_{tip}^2} \right)$$

TABLE A.1.1
Test Compressor Design Velocity Diagram Values

Stage	1	2	3	4	5	6	
R	2.161	2.161	2.161	2.161	2.161	2.161	
U	963.5	963.5	963.5	963.5	963.5	963.5	
V_{z1}	508.4	544.1	547.0	554.9	554.1	543.7	↑
$V_{\theta 1}$	236.5	310.0	365.1	349.3	338.8	338.8	
$W_{\theta 1}$	727.0	653.5	598.4	614.2	624.7	629.9	Rotor Inlet
α_1	25.0	29.7	33.7	32.2	31.6	31.5	
β_1	54.9	50.3	47.6	47.9	48.5	49.3	
M_{1abs}	0.513	0.567	0.578	0.560	0.538	0.512	
M_{1rel}	0.812	0.765	0.713	0.707	0.692	0.658	↓
V_{z2}	507.0	554.9	551.0	554.5	548.9	544.6	↑
$V_{\theta 2}$	405.2	501.3	598.8	614.6	625.1	630.3	
$W_{\theta 2}$	558.3	462.2	364.7	348.9	338.4	333.2	Rotor Outlet
α_2	38.6	42.1	47.4	47.9	48.7	49.2	
β_2	47.8	39.8	33.6	32.2	31.7	31.5	
M_{2abs}	0.588	0.665	0.706	0.698	0.680	0.660	
M_{2rel}	0.683	0.643	0.574	0.552	0.528	0.506	↓

Note: Symbols for Table A.1.1 are provided in Table A.1.2.

TABLE A.1.2

Symbols for Test Compressor Design Velocity Diagram Values

R	Radius, inches
U	Rotor speed at R , ft/sec.
V_z	Air axial velocity, ft/sec.
V_θ	Air absolute tangential velocity, ft/sec.
W_θ	Air relative tangential velocity, ft/sec.
α	Air absolute flow angle, degrees
β	Air relative flow angle, degrees
M	Mach number

Subscript

1	rotor inlet
2	rotor outlet
abs	absolute
rel	relative

TABLE A.1.3
Test Compressor Design Data (Rotor)

Stage		1	2	3	4	5	6
Radius	R	2.161	2.161	2.161	2.161	2.161	2.161
Camber Angle	θ	22.6	15.9	18.0	19.7	20.9	22.0
Stagger	γ	46.1	42.3	36.5	36.1	36.0	36.3
Incidence	i	0.0	2.0	2.0	2.0	2.0	2.0
Deviation	δ	7.3	5.4	6.0	6.0	6.1	6.2
Chord	c	0.605	0.554	0.534	0.510	0.483	0.456
Solidity	α	0.713	0.815	0.787	0.941	0.997	1.075
Max. Thickness	t	0.036	0.039	0.037	0.036	0.034	0.032
Thickness-Chord Ratio	t/c	0.060	0.070	0.070	0.070	0.070	0.070
No. of Blades	n	16	20	20	25	28	32

Note: R, c, t in [inches] and θ , γ , δ , i in [degrees]

TABLE A.1.4
Test Compressor Design Data (Stator)

Stage	IGV	1	2	3	4	5	6
Radius	R	2.161	2.161	2.161	2.161	2.161	2.161
Camber Angle	θ	31.7	22.4	25.6	26.2	24.4	24.7
Stagger	γ	-15.9	31.3	36.3	36.6	36.8	37.4
Incidence	i	0.0	-2.0	-2.0	-2.0	-2.0	-2.0
Deviation	δ	6.7	9.6	5.2	8.0	7.9	7.5
Chord	c	1.395	0.442	0.412	0.412	0.412	0.412
Solidity	α	0.719	0.456	0.789	0.850	0.972	1.093
Max. Thickness	t	0.170	0.040	0.025	0.025	0.025	0.025
Thickness-Chord Ratio	t/c	0.122	0.09	0.06	0.06	0.06	0.06
No. of Blades	n	7	14	26	28	32	36

Note: R, c, t in [inches] and θ , γ , δ , i in [degrees]

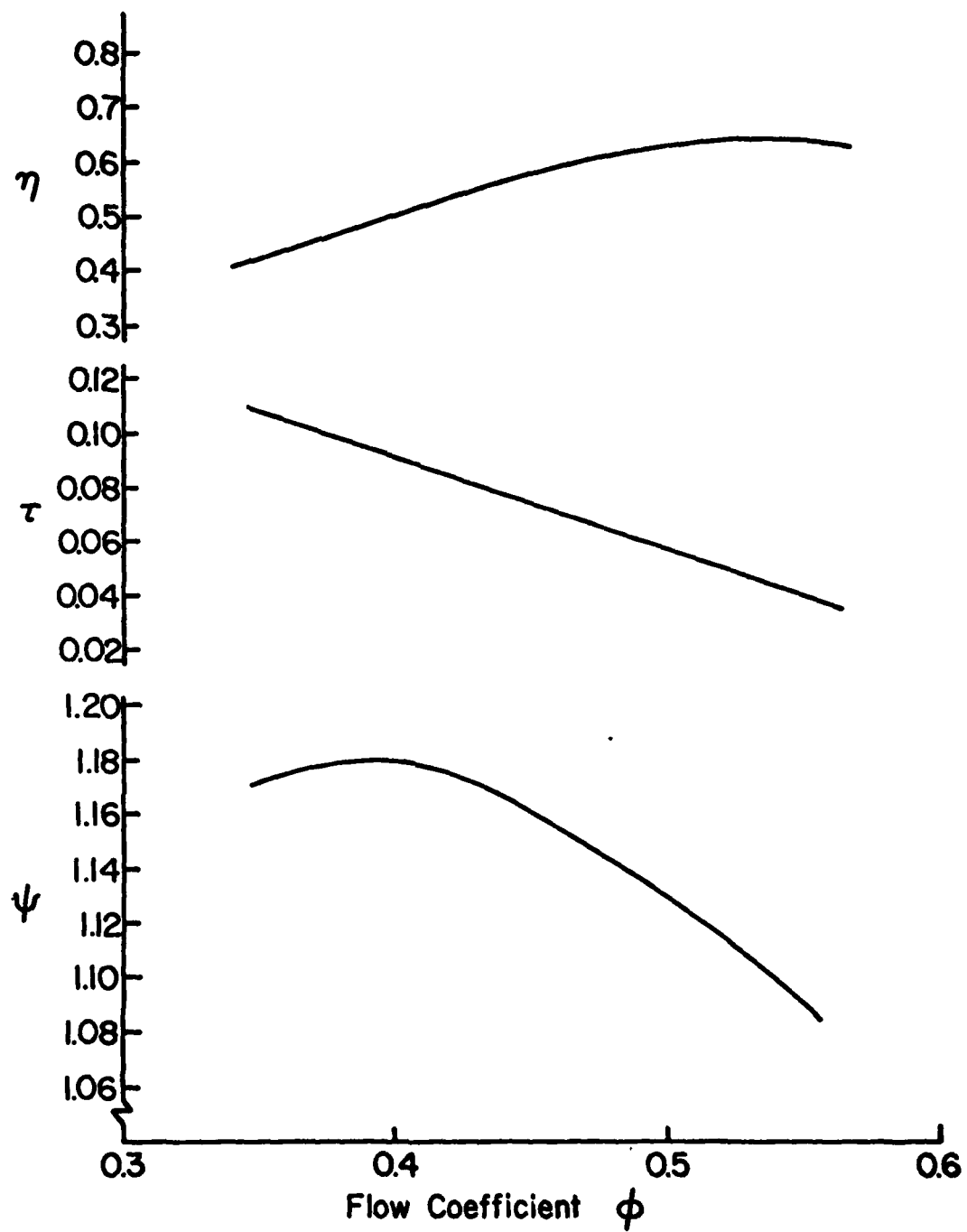


Fig. A.1.1 Performance Characteristics of Test Compressor (1st Stage)

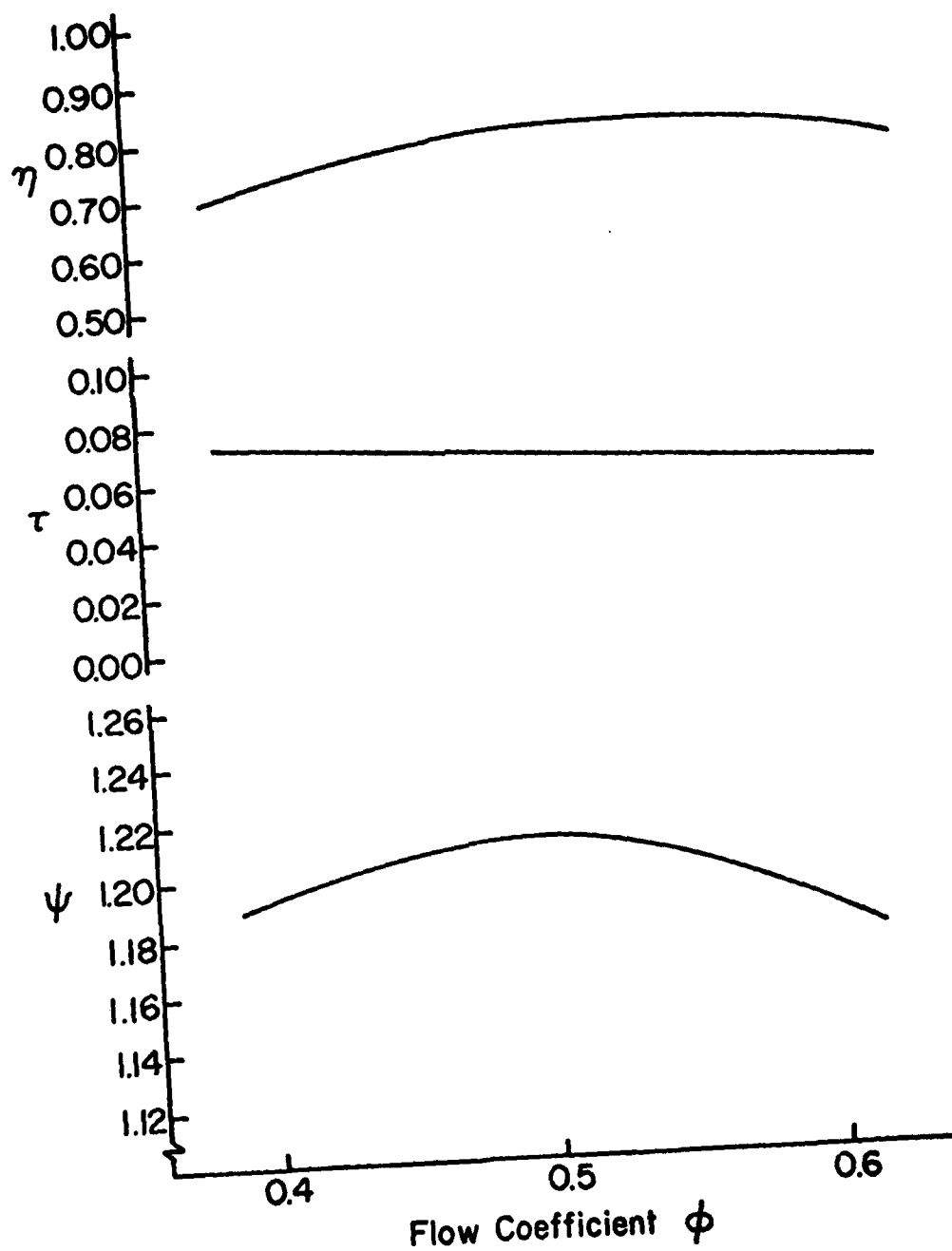


Fig. A.1.2 Performance Characteristics of Test Compressor
(2nd Stage)

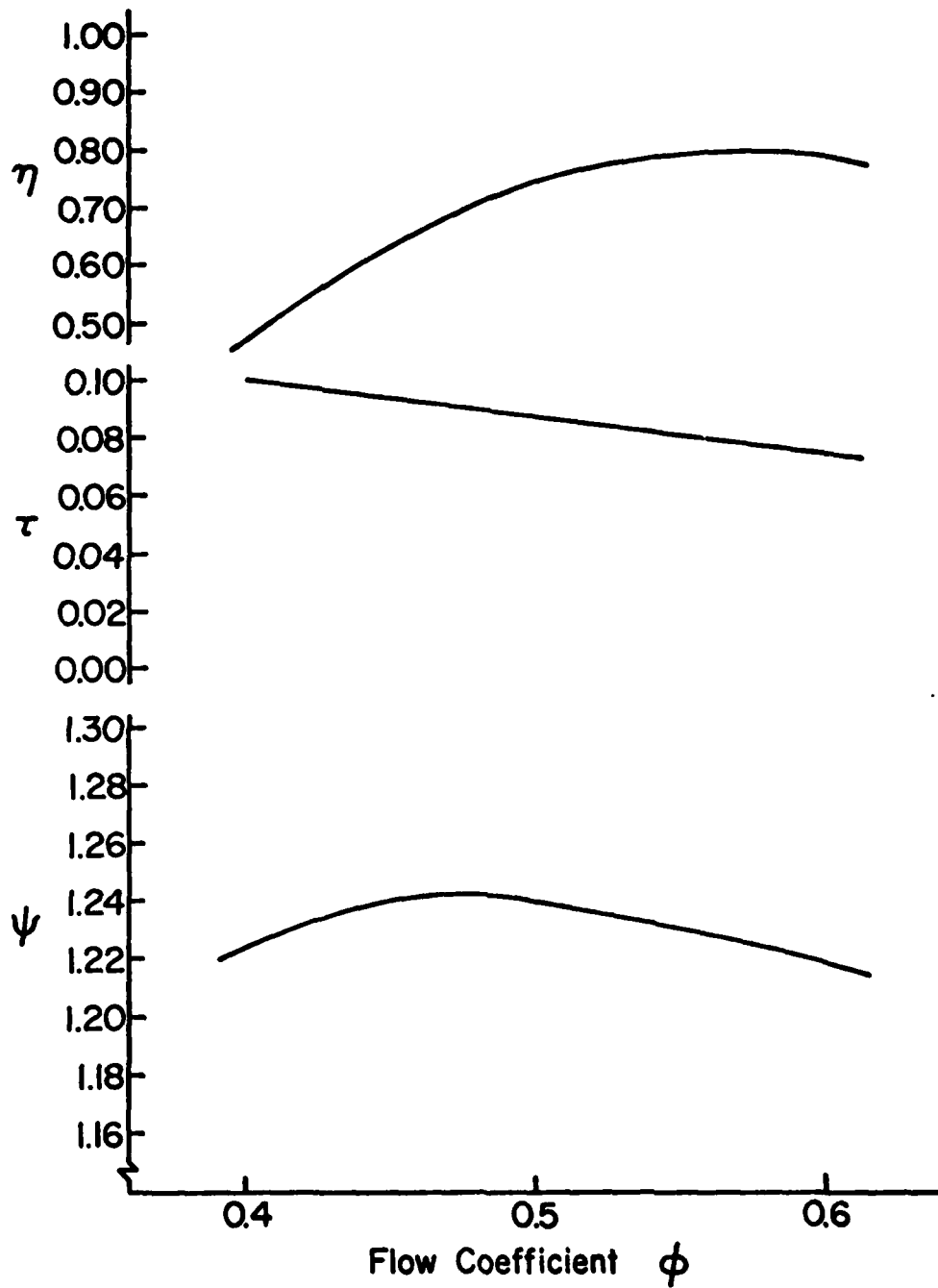


Fig. A.1.3 Performance Characteristics of Test Compressor
(3rd Stage)

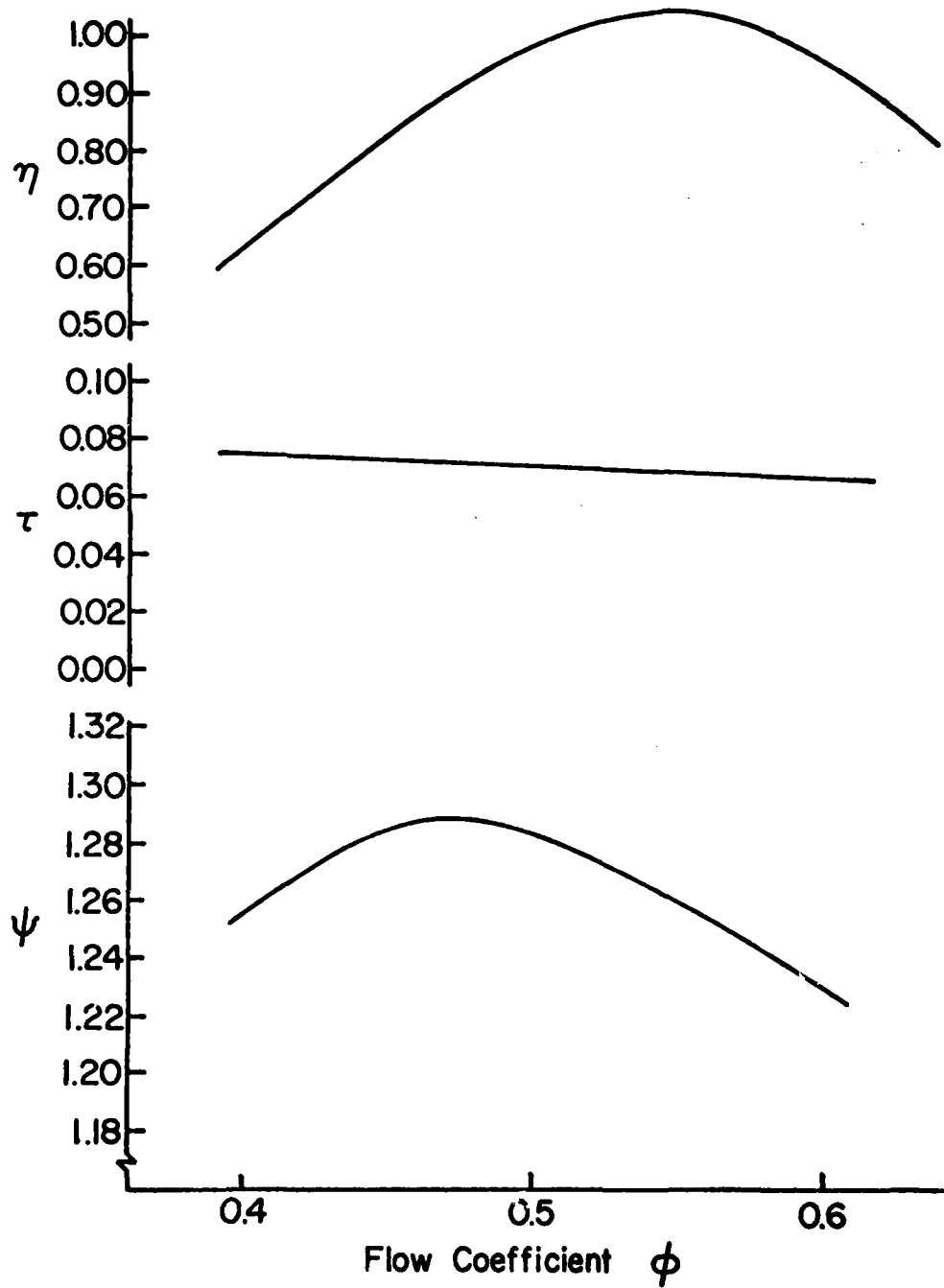


Fig. A.1.4 Performance Characteristics of Test Compressor (4th Stage)

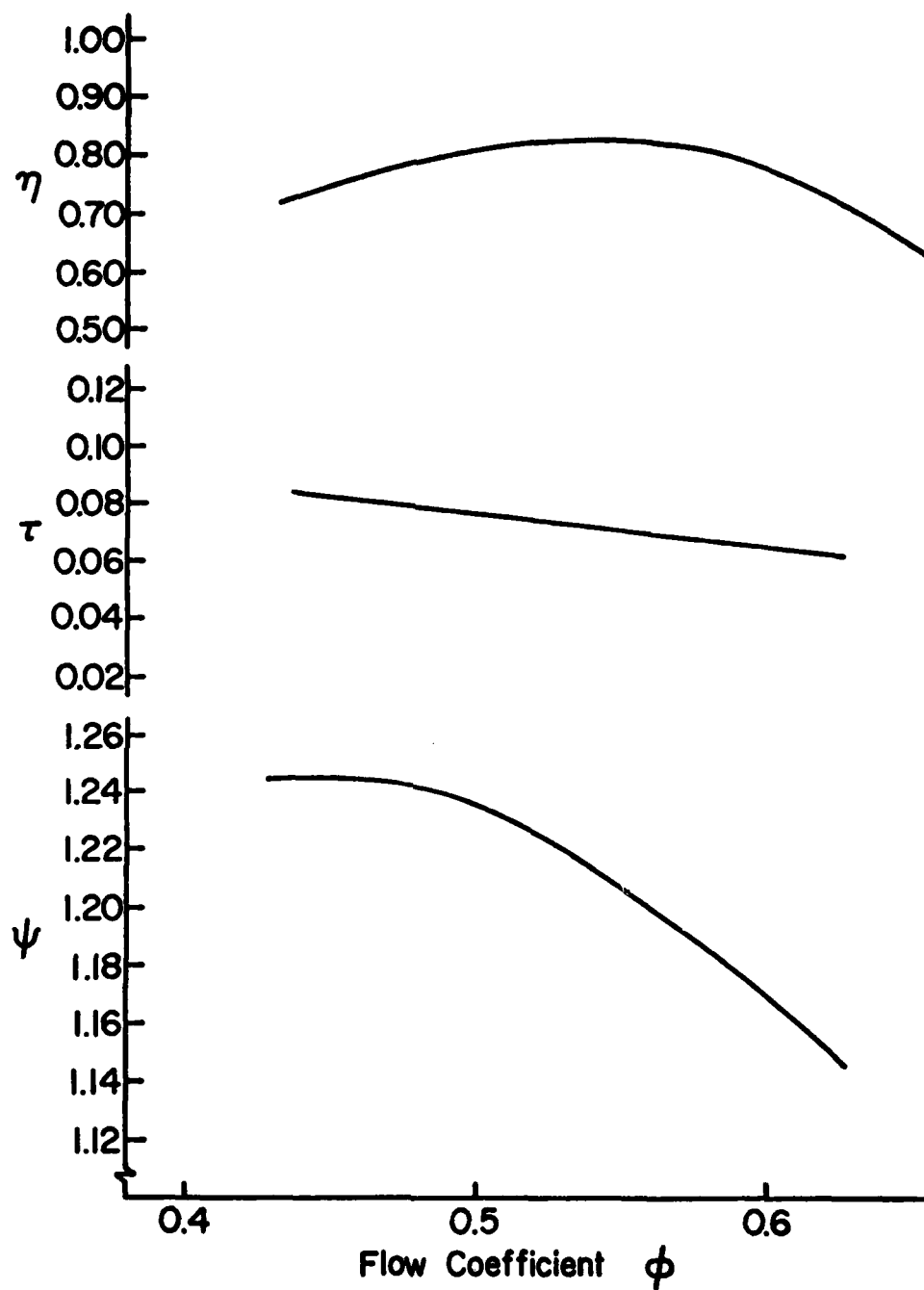


Fig. A.1.5 Performance Characteristics of Test Compressor (5th Stage)

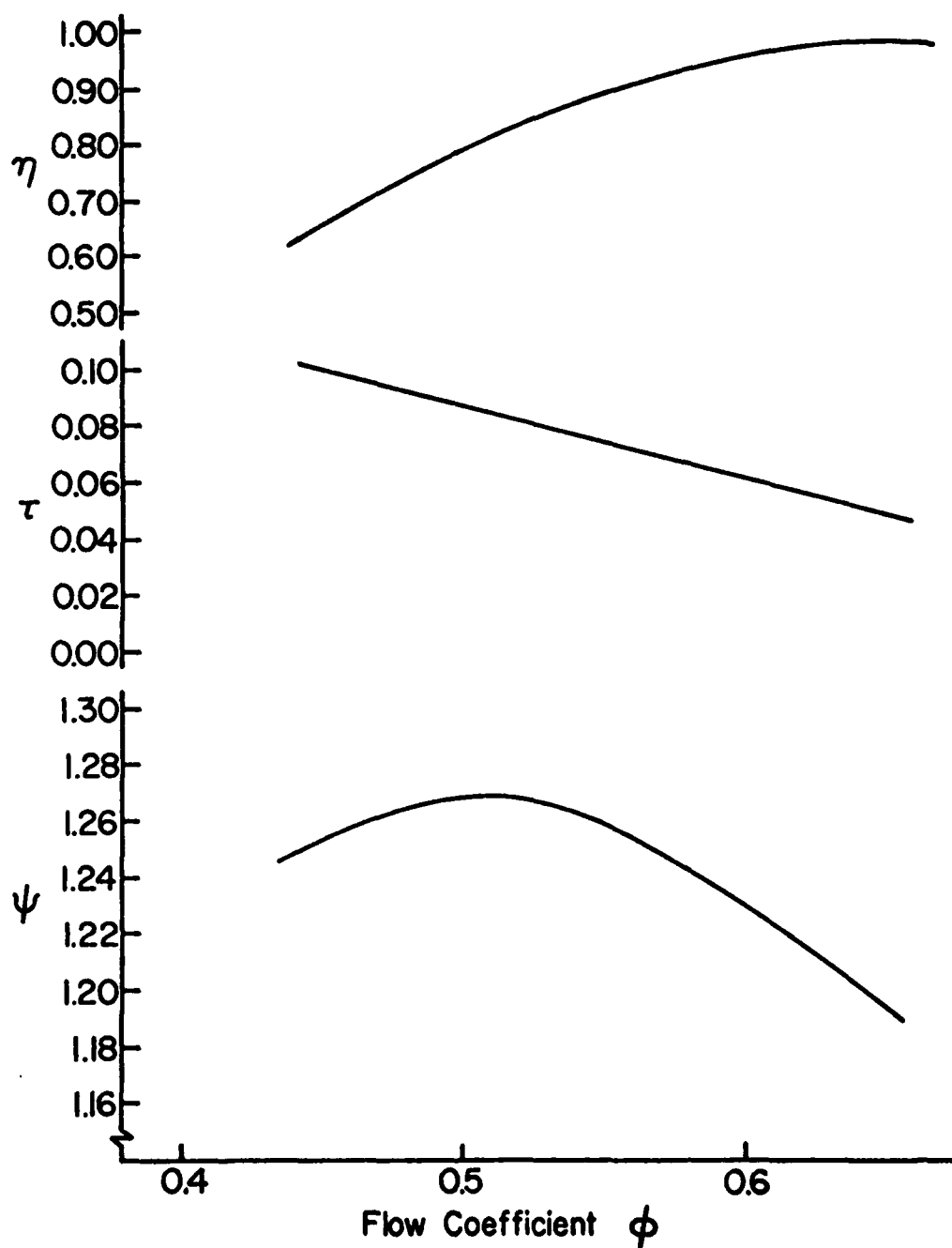


Fig. A.1.6 Performance Characteristics of Test Compressor
(6th Stage)

(iv) stage adiabatic efficiency: η

$$\eta = T_{01} \left[\left(\frac{P_{02}}{P_{01}} \right)^{\frac{\gamma-1}{\gamma}} - 1 \right] \frac{1}{\Delta T_0} = (\psi \frac{\gamma-1}{\gamma} - 1)/\tau$$

where ΔT_0 is stage total temperature rise, P_0 total pressure, T_0 total temperature, V_z axial velocity, U_{tip} blade tip wheel speed, γ specific heat ratio. The subscripts 1 and 2 mean inlet and outlet, respectively, and D design value.

Figure A.1.7 shows overall performance characteristics of Test Compressor supplied by the manufacturer. The performance parameters are the following:

$$(1) \text{ Corrected mass flow rate} = \frac{\dot{m}\sqrt{\theta}}{\delta}$$

where $\dot{m}$ = mass flow rate

T_{01} = compressor inlet pressure

P_{01} = compressor inlet temperature

θ = T_{01}/T_{ref}

δ = P_{01}/P_{ref}

T_{ref} = 58.7°F (15.2°C)

P_{ref} = 14.7 psi ($1.0132 \times 10^5 \text{ N/m}^2$)

$$(2) \text{ Corrected speed} = \frac{N}{\sqrt{\theta}}$$

where N = rotor speed (RPM)

$$(3) \text{ Overall total pressure ratio} = P_{02}/P_{01}$$

where P_{01} = compressor inlet total pressure

P_{02} = compressor outlet total pressure

$$(4) \text{ Overall adiabatic efficiency} = \eta = \frac{T_{01}}{\Delta T_0} \left[\left(\frac{P_{02}}{P_{01}} \right)^{\frac{\gamma-1}{\gamma}} - 1 \right]$$

where T_{01} = compressor inlet total temperature

ΔT_0 = compressor total temperature rise

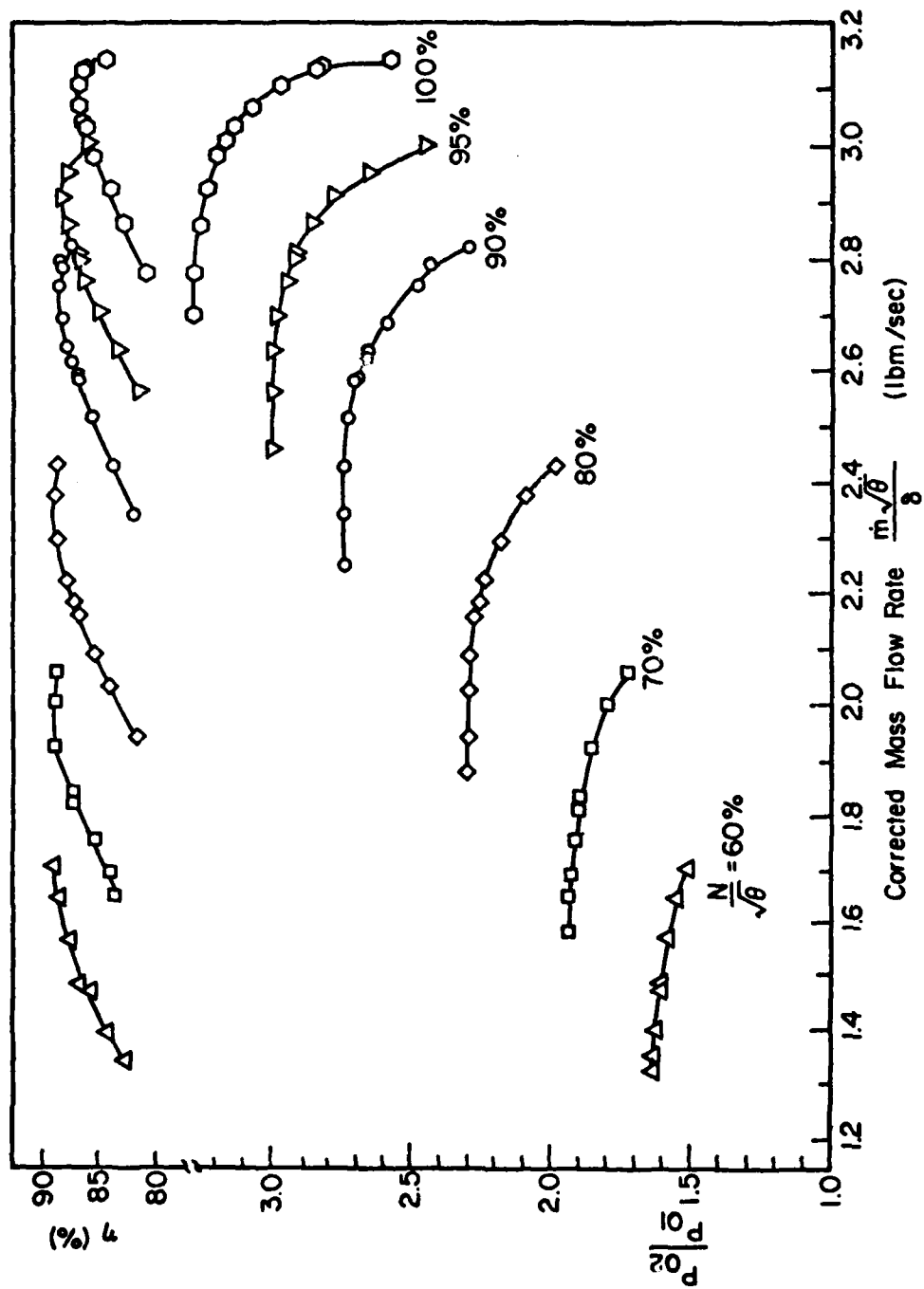


Fig. A.1.7 Overall Performance of Test Compressor

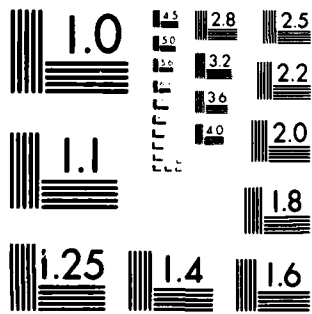
PURDUE UNIV LAFAYETTE IN SCHOOL OF MECHANICAL ENGINEERING F/O 21/5
EFFECT OF WATER ON AXIAL FLOW COMPRESSORS. PART 1. ANALYSIS AND--ETC(U)
JUN 81 T TSUCHIYA, S N MURTHY F33615-78-C-2401

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P_{02}/P_{01} = overall total pressure ratio

γ = ratio of specific heats

3. Limitations

The Test Compressor is driven, through a mechanical gear train, by the power turbine of the Drive Engine. The 6-stage Test Compressor has been utilized in the past for up to 30 hours. The available life-time for further use of that Test Compressor has been uncertain.

The Test Compressor has a plastic coating on the casing that supports the stator blade rings. The mechanical and thermal strength of the coating has been uncertain since the casing was built over ten years ago and may have aged. At design point, the Test Compressor temperature rise is about 192°F, (106°C) when the inlet-air temperature is 58.7°F, (15.2°C). A casing has been replaced by a second casing during preliminary testing.

The throttle regulating the Test Compressor mass flow at any given speed of operation consists of a conical center piece that can be set at any desired location concentrically in a diverging section which is then opened to atmospheric conditions following a straight duct. The center piece can be moved utilizing an electric motor. The throttle (annulus) area that is available during center piece motion is shown in Fig. A.1.8. It is possible to set the throttle to within a tenth of an inch (about 2.0 mm) during horizontal traverse of the throttle centerpiece. At a given Test Compressor speed, a chosen throttle setting may yield one of two types of performance: (i) when it is unchoked, the pressure ratio across the throttle (the downstream pressure being related to the atmospheric pressure) determines the mass flow throughout the Test Compressor; and (ii) when the throttle area is too large for passing the mass flow through the Test Compressor with a particular set of inlet conditions, the Compressor will operate under free-wheeling conditions.

The Test Compressor assembly with the gear box connecting it to the Drive Engine is such that there is no simple access to its outlet section for locating adequate instrumentation or adjusting probes to establish compressor outlet conditions. The gear box disassembly and removal of the compressor outlet ducting are required each time any access is desired to the compressor outlet section.

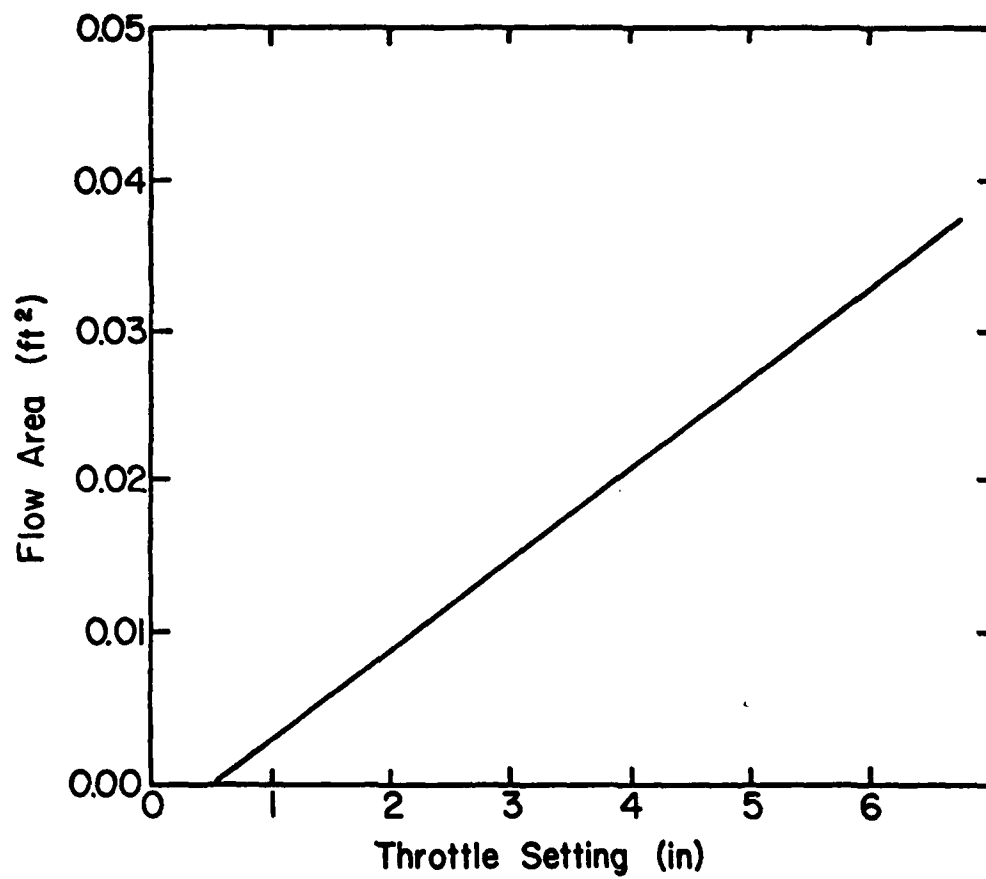


Fig. A.1.8 Flow Area vs. Throttle Setting

3.1 Refurbishment

The Drive Engine and the Test Compressor have been refurbished in the following respects by the Detroit Diesel Allison of Indianapolis, who are the original manufacturers of both the units.

- (1) Engine fuel flow control;
- (2) Drive shaft interconnecting the Drive Engine and the Test Compressor;
- (3) Test Compressor gear box;
- (4) Test Compressor bearings; and
- (5) The 6-stage assembly of Test Compressor, including balancing.

Following this refurbishment and additional work undertaken at Purdue University, proof-runs undertaken on the Drive Engine - Test Compressors installation showed feasibility of satisfactory operation of the test unit.

APPENDIX 2

STAGE PERFORMANCE CALCULATION

There are two options in the PURDU-WICSTK Code for the calculation of stage performance:

- (1) based on given stage characteristics, and
- (2) through the estimation of work done and losses in a stage, based on an analytical model.

In both cases, several approximations are required. It may also be recalled that the stage performance calculation being discussed here pertains only to establishing the stage work done, and the consequent temperature and pressure rise, and the stage losses as they occur between the leading and trailing edges of a blade. As stated in Chapter II, and also in Reference 22, the final exit conditions from a stage are established after correcting the stage outlet conditions for various two phase flow effects.

In calculating the stage performance, it is necessary to take into account the presence of droplets in the fluid, and their motion, particularly their impact on the blades. Such impaction leads to the formation of a film on the blade surface, composed of water from unrebound droplets, and a change in the boundary layer and separation characteristics. Thus, the stage characteristics become different for a droplet-laden gas flow from those for a single phase gas. The change in stage characteristics arises through modification of (a) momentum thickness of boundary layer, (b) diffusion factor and (c) deviation angle.

It may be stated at the outset that no correlations of compressor, cascade or even single airfoil performance data are available for two phase flow. It is therefore necessary to model compressor flow based on a number of approximations, in turn related to physical process models.

In order to account for various drop sizes that may arise in a spray, it has been suggested, in Reference 22 and again in Chapter 11, that two classes of droplets be identified, one referred to as "small" and the other as "large." In adjusting droplet sizes for any reason, it is assumed that small droplets may only remain small, while large droplets may become small enough to belong to the small droplet class. From the point of view of blade passage flow, the principal distinction between small and large droplets is, as has been mentioned earlier, that small droplets are sufficiently small and follow the gas phase streamlines; but large droplets, which are in order of about 100 μm in diameter, are assumed to have equal probability of motion in all directions in the forward sector. In addition, it is assumed that only small droplets may absorb part of the work input. Other distinctions between the two classes of droplets arise from the foregoing and are taken into account in developing compressor flow models for the two classes of droplets.

In order to simplify calculations of stage losses, three procedures have been developed as follows:

- (1) procedure when the compressor operate with a single (gas) phase;
- (2) procedure when only small droplets are present; and
- (3) procedure when large droplets are present either by themselves or along with small droplets.

Typical velocity diagram for an axial compressor stage is presented in Fig.A.2.1.

A.2.1. Procedure of Gas Phase Operation

One can use either (1) available stage characteristics or (2) an analytical/correlation method for obtaining stage characteristics. For the Test Compressor employed in this investigation, the analytical/correlation method recommended is based on References 23 and 24.

A.2.1.1. Use of Available Stage Characteristics

The stage performance calculation for gas phase operation, with use of available stage characteristics, are carried out as follows:

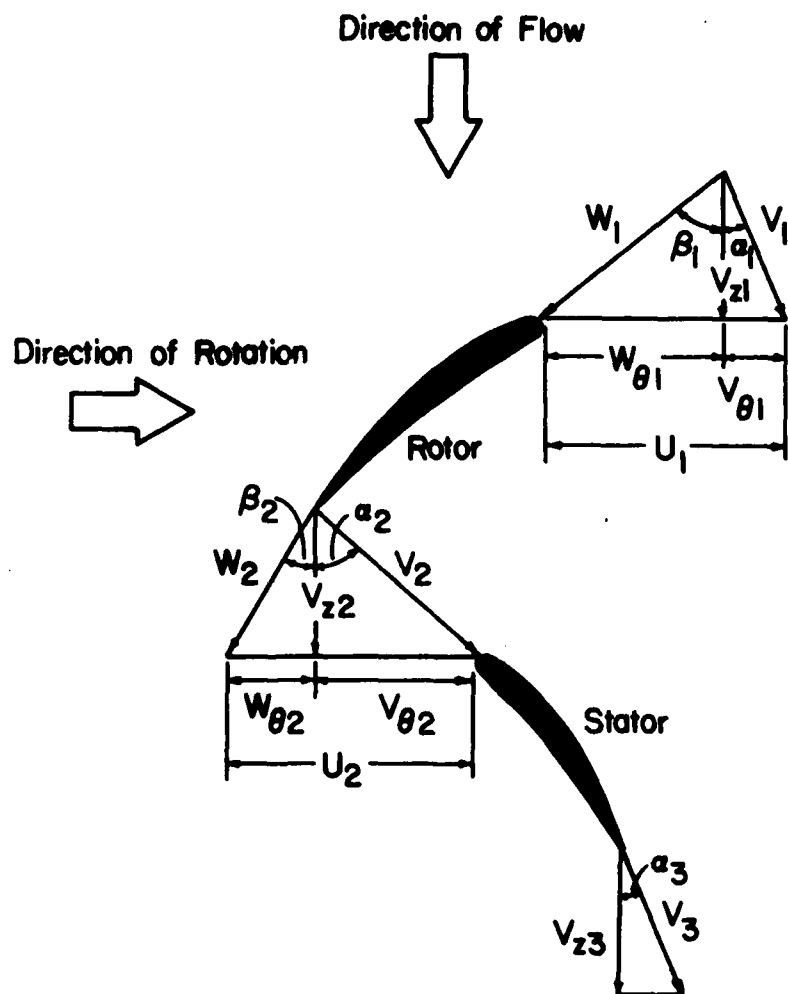


Fig. A.2.1 Typical Velocity Diagram for a Compressor Stage

- (1) From given inlet conditions or the previous stage outlet conditions, the total temperature, T_{01} , and the total pressure, P_{01} , are known.
- (2) Calculate the density based on T_{01} and P_{01}

$$\rho_{01} = P_{01} / R_m T_{01}$$

- (3) Assume Mach number M_a .
- (4) Calculate static temperature, T , and density, ρ .

$$\rho = \left\{ 1 + (\gamma - 1) M_a^2 / 2 \right\}^{-1/(\gamma - 1)} \cdot \rho_{01}$$

$$T = \left\{ 1 + (\gamma - 1) M_a^2 / 2 \right\}^{-1} \cdot T_{01}$$

- (5) Calculate acoustic speed

$$a = (\gamma R_m T g_c)^{1/2}$$

- (6) Calculate the axial velocity

$$V_z = \dot{m}_m / \rho A$$

- (7) Calculate the absolute velocity at rotor inlet, V_1 .

$$V_1 = V_z / \cos \alpha_1$$

- (8) Calculate Mach number

$$M = V_1 / a = M_c$$

- (9) Compare the assumed Mach number, M_a , with the calculated one, M_c . If M_c agrees within prescribed limits with M_a , proceed to the next step. Otherwise, steps 3 to 9 should be repeated until a satisfactory accuracy is obtained.
- (10) Calculate the flow coefficient, ϕ , at the entrance to the stage under consideration.

$$\phi = V_z / U_{tip}$$

- (11) Enter the stage characteristics curve at the value of ϕ and obtain the equivalent pressure ratio, ψ , equivalent temperature ratio, τ , and stage adiabatic efficiency, η .

The definitions of ψ , τ , and η are as follows:

- (i) flow coefficient: ϕ

$$\phi = V_z / U_{tip}$$

- (ii) equivalent pressure ratio:

$$\psi = \left\{ \left(\frac{U_{tip}^2}{T_{01}} \right)_D \left(\frac{T_{01}}{U_{tip}^2} \right) \left[\left(\frac{P_{02}}{P_{01}} \right)^{(\gamma-1)/\gamma} - 1 \right] + 1 \right\}^{\gamma/(\gamma-1)}$$

- (iii) equivalent temperature ratio: τ

$$\tau = \left(\frac{U_{tip}^2}{T_{01}} \right)_D \cdot \left(\frac{\Delta T_0}{U_{tip}^2} \right)$$

- (iv) stage adiabatic efficiency:

$$\eta = T_{01} \left[\left(\frac{P_{02}}{P_{01}} \right)^{(\gamma-1)/\gamma} - 1 \right] \frac{1}{\Delta T_0} = (\psi^{(\gamma-1)/\gamma} - 1) / \tau$$

where ΔT_0 is stage total temperature rise, P_0 total pressure, T_0 total temperature, V_z axial velocity, U_{tip} blade tip wheel speed, γ specific heat ratio. The subscripts 1 and 2 mean inlet and outlet, respectively, and D design value.

The equivalent pressure ratio, ψ , equivalent temperature ratio, τ , and stage adiabatic efficiency, η , may be expressed in terms of flow coefficient as follows:

$$\psi = A_1 + B_1\phi + C_1\phi^2 + D_1\phi^3 + E_1\phi^4 + F_1\phi^5 + G_1\phi^6$$

$$\eta = A_2 + B_2\phi + C_2\phi^2 + D_2\phi^3 + E_2\phi^4 + F_2\phi^5 + G_2\phi^6$$

$$\tau = A_3\phi + B_3$$

- (12) Once the values of ψ , τ , and η corresponding to ϕ are obtained, the stage outlet properties can be calculated from their definitions. Actually two of them are enough to determine the stage outlet properties. In the present calculation scheme, the equivalent temperature rise ratio, τ , and the stage adiabatic efficiency, η , are used. The stage total temperature rise, ΔT_0 , stage and total temperature ratio, T_{02}/T_{01} , and stage total pressure ratio, P_{02}/P_{01} , are given by the following:

$$\Delta T_0 = \tau U_{tip}^2 / (U_{tip} / T_{01})_D$$

$$T_{02}/T_{01} = 1 + \Delta T_0 / T_{01}$$

$$P_{02}/P_{01} = (1 + \eta \Delta T_0 / T_{01})^{\gamma/(\gamma-1)}$$

A.2.1.2. Use of Analytical/Correlation Method

The stage performance calculation for gas phase operation is carried out using the analytical/correlation method as follows:

- (1) From given inlet conditions or the previous stage exit conditions, the total temperature, T_{01} , and total pressure, P_{01} , are obtained.
- (2) Calculate specific heat ratio corresponding to the temperature.
- (3) Calculate the stagnation density

$$\rho_{01} = P_{01} / RT_{01}$$

- (4) Assume a value for Mach number, M_a .
- (5) Calculate the static density and temperature.

$$\rho_1 = \left\{ 1 + (\gamma-1) M_a^2 / 2 \right\}^{-1/(\gamma-1)} \cdot \rho_{01}$$

$$T_1 = \left\{ 1 + (\gamma-1) M_a^2 / 2 \right\}^{-1} \cdot T_{01}$$

- (6) Calculate the acoustic speed

$$a_1 = (\gamma R T_1 g_c)^{0.5}$$

- (7) Calculate the axial velocity

$$V_{z1} = \dot{m} / \rho_1 A_1$$

- (8) Calculate the absolute velocity

$$V_1 = V_{z1} / \cos \alpha_1$$

- (9) Calculate the Mach number, M_c .

$$M_c = V_{z1} / a_1$$

- (10) Compare the assumed value of Mach number, M_a , with the calculated one, M_c . If M_a agrees within prescribed limits with M_c , proceed to the next step. Otherwise, steps (4) to (9) must be repeated.

- (11) Calculate the components of velocity from the velocity diagram at rotor inlet as follows:

$$V_1 = V_{z1} / \cos \alpha_1$$

$$V_{\theta 1} = V_{z1} \tan \alpha_1$$

$$W_{\theta 1} = U_1 - V_{\theta 1}$$

$$W_1 = (V_{z1}^2 + W_{\theta 1}^2)^{0.5}$$

$$\beta_1 = \tan^{-1}(W_{\theta 1} / V_{z1})$$

- (12) Calculate relative Mach number at rotor inlet

$$M_{r1} = W_1 / a_1$$

- (13) Calculate static pressure at rotor inlet

$$p_1 = (T_{01} / T_1)^{\gamma / (\gamma - 1)} \cdot p_{01}$$

- (14) Calculate total pressure at rotor inlet based on the relative Mach number, M_r .

$$P_{o1,r} = \left\{ 1 + (\gamma-1)M_{r1}^2/2 \right\}^{\gamma/(\gamma-1)} \cdot P_1$$

- (15) Assuming V_{z2} , calculate the total pressure loss coefficient across rotor and rotor outlet flow angle.
- (16) Calculate the components of velocity at rotor outlet as follows:

$$W_{\theta 2} = V_{z2} \tan \beta_2$$

$$V_{\theta 2} = U_2 - W_{\theta 2}$$

$$W_2 = (V_{z2}^2 + W_{\theta 2}^2)^{0.5}$$

$$V_2 = (V_{z2}^2 + V_{\theta 2}^2)^{0.5}$$

$$\alpha_2 = \tan^{-1} (V_{\theta 2}/V_{z2})$$

- (17) Calculate the total temperature at rotor outlet.

$$T_{o2} = T_{o1} + (U_2 V_{\theta 2} - U_1 V_{\theta 1})/c_p g_c J$$

- (18) Calculate static temperature at rotor outlet.

$$T_2 = T_{o2} - V_2^2/2c_p g_c J$$

- (19) Calculate acoustic speed at rotor outlet.

$$a_2 = (\gamma R T_2 g_c)^{0.5}$$

- (20) Calculate absolute and relative Mach number at rotor outlet.

$$M_2 = V_2/a_2$$

$$M_{r2} = W_2/a_2$$

(21) Calculate total pressure loss factor across rotor.

$$\frac{P_{02,r}}{P_{01,r}} = \frac{P_{02,ri}}{P_{01,r}} = \bar{\omega}_R \left(1 - \frac{P_1}{P_{01,r}} \right)$$

where

$$\begin{aligned} \frac{P_{02,ri}}{P_{01,r}} &= \left(\frac{T_{02,r}}{T_{01,r}} \right)^{\frac{\gamma}{\gamma-1}} \\ &= \left\{ 1 + \frac{\gamma-1}{2} \frac{U_2^2}{RT_{01,r}} \left(1 - \left(\frac{r_1}{r_2} \right)^2 \right) \right\}^{\frac{\gamma}{\gamma-1}} \end{aligned}$$

(22) Calculate total pressure ratio across rotor, and total and static pressure at rotor outlet.

$$\frac{P_{02}}{P_{01}} = \left(\frac{T_{02}}{T_{01}} \right)^{\frac{\gamma}{\gamma-1}} \cdot \left(\frac{P_{02,r}}{P_{01,r}} \right) \cdot \left(\frac{P_{02,ri}}{P_{01,r}} \right)^{-1}$$

$$P_{02} = \left(\frac{P_{02}}{P_{01}} \right) P_{01}$$

$$P_2 = \left(1 + \frac{\gamma-1}{2} M_2^2 \right)^{-\gamma/(\gamma-1)} \cdot P_{02}$$

(23) Calculate density at rotor outlet.

$$\rho_2 = P_2 / RT_2$$

(24) Calculate the axial velocity at rotor outlet.

$$V_{z2} = \dot{m} / \rho_2 A_2$$

(25) Compare the calculated value of V_{z2} in (24) with the assumed V_{z2} in (15). Iterate steps (15) to (24) until a desired accuracy is obtained.

- (26) Calculate total pressure at rotor outlet.

$$P_{02} = \left\{ 1 + (\gamma - 1)M_2^2/2 \right\}^{\gamma/(\gamma-1)} \cdot p_2$$

- (27) Calculate the total pressure loss coefficient across stator, $\bar{\omega}_s$, and stator outlet angle α_s .

- (28) Calculate total pressure loss factor across stator.

$$\frac{P_{03}}{P_{02}} = 1 - \bar{\omega}_s \left(1 - \frac{P_2}{P_{02}} \right)$$

- (29) Calculate the total pressure ratio and total temperature ratio across the stage.

$$PR = \frac{P_{03}}{P_{01}} = \left(\frac{T_{03}}{T_{01}} \right)^{\frac{\gamma}{\gamma-1}} \cdot \left(\frac{P_{02,r}}{P_{01,r}} \right) \cdot \left(\frac{P_{02,ri}}{P_{01,r}} \right)^{-1} \cdot \left(\frac{P_{03}}{P_{02}} \right)$$

$$TR = T_{03}/T_{01}$$

- (30) Obtain total pressure and temperature at stator outlet.

$$P_{03} = \left(\frac{P_{03}}{P_{02}} \right) \cdot P_{02}$$

$$T_{03} = T_{02}$$

- (31) Calculate the average value of specific heat ratio.

- (32) Calculate the stage efficiency.

$$\eta = \frac{PR^{(\gamma-1)/\gamma} - 1}{TR - 1}$$

A.2.2 Procedure when Small Droplets are Present.

When all of the droplets present at entry to a stage can be categorized as small droplets, the following assumptions are introduced.

- (1) Droplets follow gas phase streamlines.
- (2) A fraction of the droplets impacting the blades undergo rebound. The balance of impacting droplets move over the blade surface in the form of a thin film. The momentum of the thin film is negligible.
- (3) The development of the boundary layer over the blade surface can be based on Reference 25. The following assumptions are made in that Reference: (i) droplets do not interact with one another; (ii) a two phase boundary layer exists; and (iii) the momentum thickness for the two phases can be superposed after they are obtained in two parts.
- (4) The deviation angle remains the same in two phase flow as in single phase flow. The reasoning is that diffusion and transport of particles can be neglected as being small and, in any case, as balancing each other.
- (5) The loss coefficient for two phase flow is thus the sum of the loss coefficient for each phase. The loss coefficient for the liquid phase may also be added in an appropriate form to the stage efficiency for a stage obtained during operation with air in order to obtain the stage efficiency for two phase flow.
- (6) Considering a blade passage flow, between two neighboring blades, away from solid boundaries, the drag due to droplets can be calculated assuming Stokes drag relation. The number of droplets suffering such drag is the sum of the number of non-impacting droplets and the number of rebound droplets.

- (7) The overall loss is obtained by adding the losses described under (5) and (6).

A.2.2.1 Use of Available Stage Characteristics

In dealing with a mixture containing small droplets, it is assumed that (a) gas phase and the small droplets behave in the same fashion in absorbing work input as a gas, and (b) the influence of small droplets arises in the determination of (a) the flow coefficient and (b) the stage losses.

In using gas flow stage characteristics for a mixture with small droplets, the pressure rise for the gas phase, the temperature rise of water and efficiency are determined for the relevant value of flow coefficient from the gas phase characteristics, and then, the efficiency is further modified to account for the presence of small droplets.

The stage performance calculation for a mixture with small droplets can thus be carried out using the available stage characteristics as follows:

- (1) From the previous stage outlet properties, the gas phase total temperature, $T_{01,g}$, and the total pressure, P_{01} , are known.
- (2) Calculate the gas constant, specific heat at constant pressure, and specific heat ratio of the gas phase.
- (3) Calculate the stagnation density of gas phase.
- (4) Assume a value for Mach number, M_a .
- (5) Calculate the static density and static temperature of the gas phase.
- (6) Calculate the acoustic speed in the gas phase.
- (7) Calculate the acoustic speed in the mixture, a .

- (8) Calculate the density of the mixture.

$$\rho_m = \left(\frac{x_g}{\rho_g} + \frac{x_w}{\rho_w} \right)^{-1}$$

- (9) Calculate the axial velocity.

$$V_z = \dot{m}_m / \rho_m A$$

- (10) Calculate the absolute velocity.

$$V_1 = V_z / \cos \alpha_1$$

where α_1 = air outlet angle of the previous stage stator.

- (11) Calculate the Mach number, M_c .

$$M_c = V_1 / a$$

- (12) Compare the assumed Mach number, M_a , with the calculated one, M_c . If M_a agrees reasonably well with M_c , proceed to the next step. Otherwise, steps (4) to (11) must be repeated.

- (13) Calculate the flow coefficient at the entrance of the stage

$$\phi = V_z / U_{tip}$$

- (14) Enter the stage characteristic curve at the foregoing value of ϕ .

The compressor stage characteristics, described in A.2.1.1., which apply to air flow through the compressor, have been utilized in this calculation for obtaining the stage temperature ratio and stage adiabatic efficiency for the mixture of air and small droplets. It may be recalled that the stage temperature rise corresponding to a mixture flow coefficient has to be apportioned between the gas and the liquid phases. The gas phase then undergoes a change in temperature and pressure while the liquid phase undergoes only a temperature change.

Utilizing the stage temperature ratio and adiabatic efficiency, one can then calculate the stage pressure ratio and the change in water temperature. In the current method of calculating stage performance for two phase flow, all of the other effects due to the presence of droplets are taken into account at the exit of the stage under consideration.

(15) Apportion energy input into the mixture.

Regarding apportionment of energy input into the mixture in a stage, one proceeds as follows. The work input is expressed by the following relations:

$$\Delta H_0 = (\Delta H_0)_1 + (\Delta H_0)_2 + (\Delta H_0)_3 + (\Delta H_0)_4$$

where

- ΔH_0 : actual work input in rotor;
- $(\Delta H_0)_1$: work input to gas phase;
- $(\Delta H_0)_2$: work input absorbed by droplets which do not impinge upon blade surface;
- $(\Delta H_0)_3$: work input absorbed by water droplets which impinge upon blade surface, adhere to form a film and are re-entrained from the trailing edge; and
- $(\Delta H_0)_4$: work input absorbed by droplets which impinge upon blade surface and rebound.

Defining mass fractions as follows:

- x_g : mass fraction of gas phase.
- x_{w1} : mass fraction of water which does not impinge upon blade surface
- x_{w2} : mass fraction water which impinges on the blade surface and rebounds
- x_{w3} : mass fraction of water which is re-entrained from the trailing edge.

and noting that

$$x_g + x_{w1} + x_{w2} + x_{w3} = 1,$$

one can express the work input fractions as follows in terms of the stage work done factor, λ .

$$(\Delta H_0)_1 = \lambda U_2 (W_{\theta 1} - W_{\theta 2}) x_g$$

$$(\Delta H_0)_2 = \lambda U_2 (W'_{\theta 1} - W'_{\theta 2}) x_{w1}$$

where $W_{\theta 1}$ and $W'_{\theta 1}$ are relative inlet whirl velocities of the gas phase and water droplets which do not impinge upon the blade surface, respectively, and $W'_{\theta 2}$ and $W_{\theta 2}$ are the same velocities at outlet.

Also, from physical considerations, the angular momentum change of water which impinges on the surface and adheres to form films and is finally re-entrained from the trailing edge can be considered to be negligible. Therefore,

$$(\Delta H_0)_3 = 0$$

Then, $(\Delta H_0)_4$ can be calculated by writing

$$(\Delta H_0)_4 = \Delta H_0 - (\Delta H_0)_1 - (\Delta H_0)_2$$

The total work input, ΔH_0 , is calculated from the stage performance curves. In the present analysis, since we are considering small droplets, the velocity lag between gas phase and water droplet can be considered to be negligible. Accordingly $W'_{\theta 1}$ and $W'_{\theta 2}$ can be set to be the same as $W_{\theta 1}$ and $W_{\theta 2}$.

From $(\Delta H_0)_1$, $(\Delta H_0)_2$, $(\Delta H_0)_3$, and $(\Delta H_0)_4$, the total temperature rise can be calculated for each phase.

- (16) Obtain the total pressure loss because of the increase in momentum thickness of the boundary layer due to the existence of small droplets in the boundary layer.

(17) Obtain the total pressure loss due to the Stokesian drag of water droplets outside boundary layer.

(18) Calculate the stage outlet total pressure as follows:

$$P_{02} = P_{01} - \Delta P_{\theta} - \Delta P_s$$

where P_{02} is the stage outlet total pressure obtained from the available stage characteristics, ΔP_{θ} is the the total pressure loss due to the increase in momentum thickness because of the existence of small droplets in the boundary layer, and ΔP_s is the total pressure loss due to the Stokesian drag of water droplets in the free stream outside the boundary layer.

It may be pointed out that in view of the assumption pertaining to motion of small droplets (with zero relative velocity with respect to gas phase), the correction to stage pressure rise due to Stokesian drag becomes zero for small droplets.

(19) Calculate the stage total pressure ratio.

A.2.2.2 Use of Analytical/Correlation Method

In using the analytical/correlation method for the flow of a mixture with small droplets, the basic procedure is the same as when utilizing available stage characteristics, Appendix Section A.2.2. The pressure rise for the gas phase and the temperature rise of water are determined from the mixture turning angle over a blade. The losses are established based on (a) the relation (due to Lieblein) between the loss coefficient and the pressure loss; the loss coefficient in turn related to the momentum thicknesses of the blade boundary layer due to the gas phase and the droplets; and (b) the Stokesian drag of droplets in the free stream. The latter, of course, is zero for small droplets, by definition.

The stage performance calculation for a mixture with small droplets is carried out using the analytical/correlation method as follows:

(1) From the given inlet condition or the previous stage properties, the gas phase total temperature, $T_{01,g}$, and total pressure, P_{01} , are obtained.

(2) Calculate the gas constant, R_g , specific heat constant pressure, c_{pg} and specific heat ratio of gas phase, γ .

(3) Calculate the stagnation density of gas phase.

$$P_{01,g} = P_{01}/R_g T_{01,g}$$

(4) Assume a value for Mach number, M_a .

(5) Calculate the static density and temperature of gas phase.

$$\rho_{g1} = \left[1 + (\gamma - 1) M_a^2 / 2 \right]^{-1/(\gamma - 1)} \cdot \rho_{01,g}$$

$$T_{g1} = \left[1 + (\gamma - 1) M_a^2 / 2 \right] \cdot T_{01,g}$$

(6) Calculate the acoustic speed in the gas phase a_{g1} .

$$a_{g1} = (\gamma R_g T_{g1} g_c)^{0.5}$$

(7) Calculate the acoustic speed in the mixture, a_1 .

(8) Calculate the density of the mixture

$$\rho_m = \left(\frac{x_g}{\rho_g} + \frac{x_w}{\rho_w} \right)^{-1}$$

(9) Calculate the axial velocity

$$V_{z1} = \dot{m}_m / \rho_1 A_1$$

- (10) Calculate the absolute velocity

$$V_1 = V_{z1} / \cos \alpha_1$$

- (11) Calculate the Mach number, M_c .

$$M_c = V_1 / a_1$$

- (12) Compare the assumed Mach number, M_a , with the calculated one, M_c . If M_a agrees within prescribed limits with M_c , proceed to the next step. Otherwise, steps (4) to (11) must be repeated.

- (13) Calculate the components of velocity at rotor inlet as follows:

$$V_1 = V_{z1} / \cos \alpha_1$$

$$V_{\theta 1} = V_{z1} / \tan \alpha_1$$

$$W_{\theta 1} = U_1 - V_{\theta 1}$$

$$W_1 = (V_{z1}^2 + W_{\theta 1}^2)^{1/2}$$

$$\beta_1 = \tan^{-1}(W_{\theta 1} / V_{z1})$$

- (14) Calculate relative Mach number at rotor inlet

$$M_{r1} = W_1 / a_1$$

- (15) Calculate static pressure at rotor inlet

$$p_1 = (T_{01,g} / T_{g1})^{-\gamma / (\gamma - 1)} \cdot P_{01}$$

- (16) Calculate total pressure at rotor inlet based on the relative Mach number, M_{r_1} .

$$P_{01,r} = \{1 + (\gamma - 1)M_{r_1}^2/2\}^{\gamma/(\gamma - 1)} \cdot p_1$$

- (17) Assuming V_{z2} the total pressure loss coefficient across rotor due to gas phase, $\overline{\omega}_{g,R}$, and rotor outlet angle β_2 .
- (18) Obtain the total pressure loss coefficient due to the increase of momentum thickness because of the existence of small droplets in the boundary layer over a rotor blade surface $\overline{\omega}_{\theta,R}$.
- (19) Obtain the total pressure loss across rotor due to the Stokesian drag of water droplets outside boundary layer $\overline{\omega}_{s,R}$.
- (20) Calculate the components of velocity at rotor outlet as follows:

$$W_{\theta 2} = V_{z2} \tan \beta_2$$

$$V_{\theta 2} = U_2 - W_{\theta 2}$$

$$W_2 = (V_{z2}^2 + W_{\theta 2}^2)^{0.5}$$

$$V_2 = (V_{z2}^2 + V_{\theta 2}^2)^{0.5}$$

$$\alpha_2 = \tan^{-1}(V_{\theta 2}/V_{z2})$$

- (21) Calculate the work input.

$$\Delta H_0 = (U_2 V_{\theta 2} - U_1 V_{\theta 1})/g_c J$$

- (22) Apportion work input to the mixture constituents as described in item (14) of A.2.2.1.

- (23) Calculate static temperature of gas phase at rotor outlet.

$$T_{g2} = T_{02,g} - \frac{V_2^2}{c_{pg} g_c} \text{ J}$$

- (24) Calculate acoustic speed in gas phase.

$$a_{g2} = (\gamma R_g T_{g2} g_c)^{0.5}$$

- (25) Assume $\rho_{g2} = \rho_{g1}$ and calculate the acoustic speed in the mixture, a_2 .

- (26) Calculate absolute and relative Mach numbers at rotor outlet.

$$M_2 = V_2/a_2$$

$$M_{r2} = W_2/a_2$$

- (27) Calculate total pressure loss factor across rotor.

$$\frac{P_{02,r}}{P_{01,r}} = \frac{P_{02,ri}}{P_{01,r}} - (\bar{\omega}_{g,R} + \bar{\omega}_{\theta,R} + \bar{\omega}_{s,R}) \cdot (1 - \frac{P_1}{P_{01,r}})$$

- (28) Calculate total pressure ratio across rotor, and total and static pressures at rotor outlet.

$$\frac{P_{02}}{P_{01}} = \left(\frac{T_{02,g}}{T_{01,g}} \right)^{\frac{\gamma}{\gamma-1}} \cdot \left(\frac{P_{02,r}}{P_{01,r}} \right) \cdot \left(\frac{P_{02,ri}}{P_{01,r}} \right)^{-1}$$

$$P_{02} = \left(\frac{P_{02}}{P_{01}} \right) P_{01}$$

$$P_{12} = \left(1 + \frac{\gamma-1}{2} M_2^2 \right)^{\frac{-\gamma}{\gamma-1}} P_{02}$$

- (29) Calculate static density at rotor outlet.

$$\rho_{g2} = p_2 / R_g T_{g2}$$

- (30) Compare the calculated value of ρ_{g2} in (29) with the assumed value of ρ_{g2} in (25). Iterate steps (25) to (29) until a desired accuracy is obtained.

- (31) Calculate the density of mixture at rotor outlet.

$$\rho_{m2} = \left(\frac{x_g}{\rho_{g2}} + \frac{x_w}{\rho_w} \right)^{-1}$$

- (32) Calculate the axial velocity at rotor outlet.

$$V_{z2} = \dot{m}_m / \rho_m A$$

- (33) Compare the calculated value of V_{z2} in (32) with the assumed value of V_{z2} in (17). Iterate steps (17) to (32) until a desired accuracy is obtained.

- (34) Calculate total pressure at rotor outlet.

$$P_{02} = \left\{ 1 + (\gamma - 1) M_2^2 / 2 \right\}^{\gamma / (\gamma - 1)} \cdot P_2$$

- (35) Calculate the total pressure loss coefficient across stator due to gas phase, $\bar{\omega}_{g,S}$, and stator outlet angle, α_3 .

- (36) Obtain the total pressure loss coefficient due to the increase of momentum thickness because of the existence of small droplets in the boundary layer on a stator blade surface, $\bar{\omega}_{\theta,S}$.

(37) Obtain the total pressure loss across stator due to the Stokesian drag of water droplets in the free stream outside boundary layer $\bar{\omega}_{s,S}$. It may be noted that Stokesian drag is zero in the case of small droplets by definition.

(38) Calculate total pressure loss factor across stator.

$$\frac{P_{03}}{P_{02}} = 1 - (\bar{\omega}_{g,S} + \bar{\omega}_{\theta,S} + \bar{\omega}_{s,S}) \left(1 - \frac{P_2}{P_{02}}\right)$$

(39) Calculate the total pressure ratio and gas phase total temperature ratio across stage.

$$PR = \frac{P_{03}}{P_{01}} = \left(\frac{T_{03,g}}{T_{01,g}}\right)^{\frac{\gamma}{\gamma-1}} \cdot \left(\frac{P_{02,r}}{P_{01,r}}\right) \left(\frac{P_{02,ri}}{P_{01,r}}\right)^{-1} \cdot \left(\frac{P_{03}}{P_{02}}\right)$$

$$TR = T_{03,g} / T_{01,g}$$

(40) Obtain total pressure and gas phase total temperature at stator outlet.

$$P_{03} = \left(\frac{P_{03}}{P_{02}}\right) P_{02}$$

$$T_{03,g} = T_{02,g}$$

(41) Calculate the average value of specific heat ratio.

(42) Calculate the stage efficiency.

$$\eta = \frac{PR^{(\gamma-1)/\gamma} - 1}{TR - 1}$$

A.2.3 Procedure when Large or Large and Small Droplets are Present

It is postulated that when large droplets are present, they always play the more dominant role.

The following assumptions are introduced.

- (1) Droplets move with equal probability in all directions in the forward sector.
- (2) A fraction of the droplets impacting the droplets undergo rebound. The balance of impacting droplets move over the blade surface in the form of a thick film. The momentum of the thick film is appreciable and represents a loss of mixture momentum.
- (3) The development of the boundary layer can be estimated based on the following reasoning: (a) The thick film presents a continuous rough surface; (b) the roughness is at most of the order of droplet thickness; and (c) the boundary layer is fully turbulent and extends over the chord length. A coefficient of friction for the flow can then be based on Ref. 26.
- (4) The deviation angle remains the same as in the case of single phase flow.
- (5) Considering a blade passage flow, between two neighboring blades, away from solid boundaries, the drag due to droplets can be calculated assuming Stokes drag relation. The number of droplets suffering such drag is the sum of the number of non-impacting droplets and the number of rebound droplets.
- (6) The overall loss is therefore obtained by adding the losses described under (2), (3) and (5).

It may be observed that the foregoing procedure for large droplets precludes the use of available stage characteristics and subsequent correction of efficiency due to the presence of droplets. The procedure is also different from the Lieblein analytical/correlation method used in the case of small droplets in that no simple superposition of blade

profile losses is feasible in the case of large droplets. The loss due to Stokesian drag of large droplets in the free stream, of course, is accounted for by simple addition to other losses.

A.2.3.1. Details of Procedure

The stage performance, when large droplets are present, with or without small droplets, is carried out as follows. It may be pointed out that the determination of stage pressure ratio follows the same procedure as in the case of a mixture with small droplets only, Appendix Section A.2.2.2. The determination of the loss coefficient when large droplets are present is wholly different.

- (1) From given initial conditions or from the previous stage properties the gas phase total temperature, $T_{01,g}$ and total pressure, P_{01} , are obtained.
- (2) Calculate the gas constant, R_g , specific heat at constant pressure, c_{pg} , and specific heat ratio, γ .
- (3) Calculate the stagnation density of gas phase,

$$\rho_{01,g} = P_{01}/R_g T_{01,g}$$

- (4) Assume a value for Mach number, M_a .
- (5) Calculate the static density, and temperature of gas phase, as follows,

$$\rho_1 = \left\{ 1 + (\gamma - 1) M_a^2 / 2 \right\}^{-1/(\gamma - 1)} \cdot \rho_{01,g}$$

$$T_{g1} = \left\{ 1 + (\gamma - 1) M_a^2 / 2 \right\}^{-1} \cdot T_{01,g}$$

- (6) Calculate the acoustic speed in the gas phase, a_{g1} .

$$a_{g1} = (\gamma R_g T_{g1} g_c)^{0.5}$$

- (7) Calculate the acoustic speed in the mixture, a_1 .

- (8) Calculate the density of the mixture.

$$\rho_m = \left(\frac{x_g}{\rho_g} + \frac{x_w}{\rho_w} \right)^{-1}$$

- (9) Calculate the axial velocity.

$$V_{z1} = \dot{m}_m / \rho_m A$$

- (10) Calculate the absolute velocity.

$$V_1 = V_{z1} / \cos \alpha_1$$

- (11) Calculate the Mach number, M_c .

$$M_c = V_1 / a_1$$

- (12) Compare the assumed Mach number, M_a , with the calculated one, M_c . If M_a agrees within prescribed limits with M_c , proceed to the next step. Otherwise steps (4) to (11) must be repeated.

- (13) Calculate the components of velocity at rotor inlet as follows:

$$V_1 = V_{z1} / \cos \alpha_1$$

$$V_{\theta 1} = V_{z1} \tan \alpha_1$$

$$W_{\theta 1} = U_1 - V_{\theta 1}$$

$$W_1 = (V_{z1}^2 + W_{\theta 1}^2)^{1/2}$$

$$\beta_1 = \tan^{-1}(W_{\theta 1}/V_{z1})$$

- (14) Calculate relative Mach number at rotor inlet.

$$M_{r1} = W_1/a_1$$

- (15) Calculate static pressure at rotor inlet.

$$P_1 = \left\{ (T_{01,g}/T_g) \right\}^{-\gamma/(\gamma-1)} \cdot P_{01}$$

- (16) Calculate total pressure at rotor inlet based on M_{r1} .

$$P_{01,r} = \left\{ 1 + (\gamma - 1) M_{r1}^2/2 \right\}^{\gamma/(\gamma-1)} \cdot P_1$$

- (17) Assuming V_{z2} , calculate the total pressure loss due to gas phase, $\bar{\omega}_{g,R}$, and rotor outlet angle β_2

- (18) Calculate the total pressure loss coefficient due to the momentum gained by thick water film moving over the rotor blade surface, $\bar{\omega}_{f,R}$.

- (19) Calculate the total pressure loss coefficient due to turbulent flow of mixture over the rough film surface of rotor blade, $\bar{\omega}_{r,R}$.

- (20) Calculate the total pressure loss coefficient due to the Stokesian drag of water droplets in rotor passage, $\bar{\omega}_{s,R}$.

- (21) Calculate the components of velocity diagram at rotor outlets as follows:

$$W_{\theta 2} = V_{z2} \tan \beta_2$$

$$V_{\theta 2} = U_2 - W_{\theta 2}$$

$$W_2 = (V_{z2}^2 + W_{\theta 2}^2)^{0.5}$$

$$V_2 = (V_{z2}^2 + V_{\theta 2}^2)^{0.5}$$

$$\alpha_2 = \tan^{-1}(V_{\theta 2}/V_{z2})$$

- (22) Calculate the work input.

$$\Delta H_0 = (U_2 V_{\theta 2} - U_1 V_{\theta 1})/g_c J$$

- (23) Apportion the energy input in the mixture as described in item (15) of A.2.2.1.

- (24) Calculate static temperature of gas phase at rotor outlet.

$$T_{g2} = T_{02,g} - V_2^2/2c_{pg} g_c J$$

- (25) Calculate the acoustic speed in gas phase.

$$a_{g2} = (\gamma R_g T_{g2} g_c)^{0.5}$$

- (26) Assume $\rho_{g2} = \rho_{g1}$ and calculate the acoustic speed in the mixture a_2 .

- (27) Calculate absolute and relative Mach number at rotor outlet.

$$M_2 = V_2/a_2$$

$$M_{r2} = W_2/a_2$$

- (28) Calculate total pressure loss factor across rotor.

$$\frac{P_{02,r}}{P_{01,r}} = \frac{P_{02,ri}}{P_{01,r}} - (\bar{\omega}_{g,R} + \bar{\omega}_{f,R} + \bar{\omega}_{r,R} + \bar{\omega}_{s,R}) \cdot \left(1 - \frac{P_1}{P_{01,r}}\right)$$

- (29) Calculate total pressure ratio across rotor, and total static pressure at rotor outlet.

$$\frac{P_{02}}{P_{01}} = \left(\frac{T_{02,g}}{T_{01,g}}\right)^{\frac{\gamma}{\gamma-1}} \cdot \left(\frac{P_{02,r}}{P_{01,r}}\right) \cdot \left(\frac{P_{02,ri}}{P_{01,r}}\right)^{-1}$$

$$P_{02} = \left(\frac{P_{02}}{P_{01}}\right) P_{01}$$

$$P_2 = \left(1 + \frac{\gamma-1}{2} M_2^2\right)^{\frac{-\gamma}{\gamma-1}} P_{02}$$

- (30) Calculate static density at rotor outlet.

$$\rho_{g2} = P_2 / R_g T_{g2}$$

- (31) Compare the calculated ρ_{g2} in (27) with the assumed ρ_{g2} in (23). Iterate steps (23) to (27) until a desired accuracy is obtained.

- (32) Calculate the density of mixture.

$$\rho_{m2} = \left(\frac{x_g}{g} + \frac{x_w}{w} \right)^{-1}$$

- (33) Calculate the axial velocity at rotor outlet.

$$V_{z2} = \dot{m}_m / \rho_m A_2$$

(34) Compare the calculated V_{z2} in (33) with the assumed V_{z2} in (34). Iterate steps (17) to (33) until the desired accuracy is obtained.

(35) Calculate total pressure at rotor outlet.

$$P_{02} = \left\{ 1 + (\gamma - 1) M_2^2 / 2 \right\}^{\gamma / (\gamma - 1)} \cdot P_2$$

(36) Calculate the total pressure loss coefficient across stator due to gas phase, $\bar{\omega}_{g,S}$, and stator outlet angle, α_3 .

(37) Calculate the the total pressure loss coefficient due to the momentum gained by thick water film on the stator blade surface, $\bar{\omega}_{f,S}$.

(38) Calculate the total pressure loss coefficient due to turbulent friction over a rough film surface over the stator blade, $\bar{\omega}_{r,S}$.

(39) Obtain the total pressure loss across stator due to Stokesian drag of large water droplets in the free stream outside boundary layer, $\bar{\omega}_{s,S}$.

(40) Calculate total pressure loss factor across the stator.

$$\frac{P_{03}}{P_{02}} = 1 - (\bar{\omega}_{g,S} + \bar{\omega}_{f,S} + \bar{\omega}_{r,S} + \bar{\omega}_{s,S}) \left(1 - \frac{P_2}{P_{02}} \right)$$

(41) Calculate the total pressure ratio and gas phase total temperature ratio across stage.

$$PR = P_{03}/P_{01} = \left(\frac{T_{03,g}}{T_{01,g}} \right)^{\frac{\gamma}{\gamma-1}} \cdot \left(\frac{P_{02,g}}{P_{01,r}} \right) \cdot \left(\frac{P_{02,r}}{P_{01,r}} \right)^{-1} \cdot \left(\frac{P_{03}}{P_{02}} \right)$$

$$TR = T_{03,g}/T_{01,g}$$

- (42) Obtain total pressure and gas phase total temperature at stator outlet.

$$P_{03} = \left(\frac{P_{03}}{P_{02}} \right) \cdot P_{02}$$

$$T_{03,g} = T_{02,g}$$

- (43) Calculate the average value of the specific heat ratio.
- (44) Calculate the stage efficiency.

$$\eta = \frac{PR^{(\gamma-1)/\gamma} - 1}{TR - 1}$$

APPENDIX 3

DETAILED DESCRIPTION OF SUBROUTINES AND EXTERNAL FUNCTIONS

There are 27 subroutines and 13 external functions in this program. Brief descriptions of these subprograms are presented in Chapter III. A more detailed description of each subprograms is presented here. Each of the subroutines and external functions is presented as follows:
(1) Description, (2) Input variables, (3) Output variables, and (4) Usage.

SUBROUTINE WICSPA

(1) Description:

The subroutine WICSPA is used for the calculation of performance based on the inputted stage characteristic curves. A detailed descriptions of calculation procedure is presented in Appendix 2.

(2) Input Variables:

FAIO	initial flow coefficient
ISTAGE	stage at which performance calculation is carried out
MMASS	mass flow rate of mixture.
ALFA1	absolute flow angle at outlet of the previous stage stator
WKDONE	work done factor
DAVE	nominal diameter of small droplet
XDIN	initial water content of small droplet
AK1	constant in Eq. (A.3.6)'
AK3	constant in Eqs. (A.3.1)' and (A.3.2)'

(3) Output Variables:

ETA	stage adiabatic efficiency
BETA1	relative flow angle at rotor inlet
BETA2	relative flow angle at rotor outlet
VZ	axial velocity

ALFA2	absolute flow angle at stator inlet
ALFA3	absolute flow angle at stator outlet
DELTG	rise in total temperature of gas phase across a stage
DELTW	rise in temperature of small droplet across a stage
W1	relative velocity at rotor inlet
W2	relative velocity at rotor outlet
V1	absolute velocity at rotor inlet
V2	absolute velocity at stator inlet
V3	absolute velocity at stator outlet

(4) Usage:

CALL WICSPA (FAIO, ISTAGE, MMASS, ALFA1 ,WKDONE, DAVE,XDIN
ETA, BETA1,BETA2, VZ, ALFA2, ALFA3, DELTG,DELTW
W1,W2, V1,V2,V3, AK1, AK3)

SUBROUTINE WICSPB

(1) Description:

The subroutine WICSPB is used for the calculation of stage performance based on the analytical/correlation method for small droplet. A detailed description of calculation procedure is presented in Appendix 2.

(2) Input Variables:

FAIO	initial flow coefficient
ISTAGE	stage at which performance calculation is carried out
MMASS	mass flow rate of mixture
ALFA1	absolute flow angle at outlet of the previous stage stator
WKDONE	work done factor
DAV	nominal diameter of small droplets

DELV	relative velocity between gas phase and large droplets
XMAS	mass flow rate of small droplets
N	station number (Fig. 5.1)
AK1	constant in Eq. (A.3.6)'
AK2	constant in Eq. (A.3.7)' and (A.3.8)'
AK3	constant in Eq. (A.3.1)' and (A.3.2)'

(3) Output Variables:

OMEGA1	total pressure loss coefficient due to single-phase (gas) flow profile loss in rotor
OMEGA2	total pressure loss coefficient due to loss for small droplets on account of the change in momentum thickness of boundary layer due to the presence of such droplets in rotor
OMEGA3	total pressure loss coefficient due to Stokesian drag of small droplets in the free stream of blade passage in rotor
OMEGA4	total pressure loss coefficient due to single-phase (gas) flow profile loss in stator
OMEGA5	total pressure loss coefficient due to loss for small droplets on account of the change in momentum thickness of boundary layer due to the presence of such droplets in stator
OMEGA6	total pressure loss coefficient due to Stokesian drag of small droplets in the free stream of blade passage in stator
OMEGAT	sum of total pressure loss coefficients

BETA1	relative flow angle at rotor inlet
BETA2	relative flow angle at rotor outlet
VZ	axial velocity
ALFA2	absolute flow angle at stator inlet
ALFA3	absolute flow angle at stator outlet
DELTG	rise in total temperature of gas phase across a stage
DELTW	rise in temperature of small droplet across a stage
W1	relative velocity at rotor inlet
W2	relative velocity at rotor outlet
V1	absolute velocity at rotor inlet
V2	absolute velocity at stator inlet
V3	absolute velocity at stator outlet

(4) Usage:

CALL WICSPB (FA10, ISTAGE, MMASS, ALFA1, WKDONE, DAV,
 DELV, WMAS, N, OMEGA1, OMEGA2, OMEGA3,
 OMEGA4, OMEGA5, OMEGA6, OMEGAT, BETA1,
 BETA2, VZ, ALFA2, ALFA3, DELTG, DELTW, W1,
 W2, V1, V2, V3, AK1, AK2, AK3)

SUBROUTINE WICSPC

(1) Description:

The subroutine WICSPC is used for the calculation of stage performance based on the analytical/correlation method for large droplet. A detailed description of calculation procedure is presented in Appendix 2.

(2) Input Variables:

FAIO	initial flow coefficient
ISTAGE	stage at which performance calculation is carried out
MMASS	mass flow rate of mixture
ALFA1	absolute flow angle at outlet of the previous stage stator
WKDONE	work done factor
DAV	nominal diameter of large droplets
DELV	relative velocity between gas phase and large droplets
WMAS	mass flow rate of small droplets
WMAS	mass flow rate of large droplets
N	station number (Fig. 5.1)
REAVE	Average Reynolds number

DELVU2	relative velocity between gas phase and droplet
DELVL2	relative velocity between gas phase and droplet
AK1	constant in Eq. (A.3.6.)'
AK2	constant in Eq. (A.3.7)' and (A.3.8)'
AK3	constant in Eq. (A.3.1)' and (A.3.2)'

(3) Output Variables:

OMEGA1	total pressure loss coefficient due to the mixture boundary layer formed over rough film surface in rotor
OMEGA2	total pressure loss coefficient due to film formed on rotor blade surface
OMEGA3	total pressure loss coefficient due to Stokesian drag of large droplets in the free stream of blade passage in rotor
OMEGA4	total pressure loss coefficient due to the mixture boundary layer formed over rough film surface in stator
OMEGA5	total pressure loss coefficient due to film formed on stator blade surface
OMEGA6	total pressure loss coefficient due to Stokesian drag of large droplets in the free stream of blade passage in stator

OMEGAT	sum of total pressure loss coefficient
BETA1	relative flow angle at rotor inlet
BETA2	relative flow angle at rotor outlet
VZ	axial velocity
ALFA2	absolute flow angle at stator inlet
ALFA3	absolute flow angle at stator outlet
DELTG	rise in total temperature of gas phase across a stage
DELTW	rise in temperature of small droplet across a stage
W1	relative velocity at rotor inlet
W2	relative velocity at rotor outlet
V1	absolute velocity at rotor inlet
V2	absolute velocity at stator inlet
V3	absolute velocity at stator outlet

(4) Usage:

```
CALL WICSPC (FA10, I$TAGE , M$MASS, ALFA1, WKDONE, DAV,
             DELV, WMAS, W$WMAS, N, OMEGA1, OMEGA2, OMEGA3,
             OMEGA4, OMEGA5, OMEGA6, OMEGAT, BETA1, BETA2,
             VZ, ALFA2, ALFA3, DELTG, DELTW, W1, W2, V1, V2,
             V3, REAVE, DELVU2, DELVL2, AK1, AK2, AK3)
```


SUBROUTINE WICSPD

(1) Description

The subroutine WICSPD is used for the calculation of design point performance. The properties obtained in this subroutine become reference properties for calculation of off-design performance.

(2) Input Variables

AMASS mass flow rate

ISTAGE stage at which performance calculation
 is carried out

(3) Output Variables:

none

(4) Usage:

CALL WICSPD (AMASS, ISTAGE)

SUBROUTINE WICSCC

(1) Description:

Subroutine WICSCC calculates the equivalent pressure ratio, stage adiabatic efficiency, and equivalent temperature ratio for a particular stage from the input stage characteristic curves. The equivalent pressure ratio, ψ , equivalent temperature ratio, τ , and stage adiabatic efficiency, η have been expressed in terms of the stage flow coefficient as follows:

$$\psi = A_1 + B_1\phi + C_1\phi^2 + D_1\phi^3 + E_1\phi^4 + F_1\phi^5 + G_1\phi^6$$

$$\eta = A_2 + B_2\phi + C_2\phi^2 + D_2\phi^3 + E_2\phi^4 + F_2\phi^5 + G_2\phi^6$$

$$\tau = A_3\phi + B_3$$

The definitions of these parameters are as follows:

(i) flow coefficient: ϕ

$$\phi = V_z / U_{tip}$$

(ii) equivalent pressure ratio ψ

$$\psi = \left\{ \left(\frac{U_{tip}^2}{T_{01}} \right)_D \left(\frac{T_{01}}{U_{tip}^2} \right) \left[\left(\frac{P_{02}}{P_{01}} \right)^{(\gamma-1)/\gamma} - 1 \right] + 1 \right\}^{\gamma/(\gamma-1)}$$

(iii) equivalent temperature ratio:

$$\tau = \left(\frac{U_{tip}^2}{T_{01}} \right)_D \cdot \left(\frac{\Delta T_0}{U_{tip}^2} \right)$$

where subscript D indicates the design point.

It should be noted here that the subroutine WICSCC is only suitable for the case of Test Compressor employed in the current investigation. In another case, a replacement of this subroutine is necessary.

(2) Input Variables:

FAI	stage flow coefficient
ISTAGE	stage number

(3) Output Variables:

SAI	equivalent pressure ratio
ETA	stage adiabatic efficiency
TAU	equivalent temperature ratio

(4) Usage:

CALL WICSP (FAI, SAI, ETA, TAU, ISTAGE)

SUBROUTINE WICGSL

(1) Description:

The subroutine WICGSL is used for the calculation of single-phase (gas) flow loss. In the current model, the concept of the equivalent diffusion ratio by Lieblein (Ref.23) and Swan's correlation (Ref.24) have been employed in order to estimate the blade outlet flow angle and loss due to turbulent flow of gaseous phase over the rigid blade surface.

Lieblein has show that the design point loading factor, the Diffusion Factor, does not represent a suitable criterion for loading at off-design conditions, except possibly at

other minimum loss points. This is due to the fact that the basic derivation of the Diffusion Factor has been based on a flow model which corresponds to operation at or near minimum loss. He has therefore suggested a generalized loading parameter. This parameter, the Equivalent Diffusion Ratio, is based on the ratio of the maximum suction surface velocity and trailing edge velocity for a given section cascade. Lieblein has deduced an expression which approximates this velocity ratio in terms of measured overall performance. The Equivalent Diffusion Ratio is suitable for correlation of low speed data. For the general case where the axial velocity ratio may be large, such as in a rotor or stator cascade, the Equivalent Diffusion Ratio, D_{eq} , has been defined as follows:

$$D_{eq} = \frac{\cos\beta_2 V_{z1}}{\cos\beta_1 V_{z2}} \left[1.12 + k (i-i^*)^{1.43} + 0.61 \frac{\cos^2\beta}{\sigma} \cdot K \right] \quad (A.3.1)$$

$$\text{where } K = \tan\beta_1 - \frac{r_2}{r_1} \frac{V_{z2}}{V_{z1}} \cdot \tan\beta_2 - \frac{\omega r_1}{V_{z1}} \left(1 - \frac{r_2^2}{r_1^2} \right)$$

and $k = 0.0117$ for the NACA 65 (A_{10}) blades and $k = 0.007$ for the C_4 circular-arc blades. The Equivalent Diffusion Ratio at minimum loss, D_{eq}^* , is obtained by dropping the term representing the incidence angle effects, that is as follows.

$$D_{eq}^* = \frac{\cos\beta_2 V_{z1}}{\cos\beta_1 V_{z2}} \left\{ 1.12 + 0.61 \frac{\cos^2\beta_1}{\sigma} \cdot K \right\} \quad (A.3.2)$$

The wake momentum thickness can be expressed nondimensionally as follows:

$$\frac{\theta}{c} = \frac{\omega \cos\beta_2}{2\sigma} \left(\frac{\cos\beta_1}{\cos\beta_2} \right)^2 \quad (A.3.3)$$

where c is the chord length of the blades.

At minimum loss, Eq. (A.3.3) yields

$$\left(\frac{\theta}{c}\right) = \frac{\bar{\omega}^* \cos \beta_2}{2\sigma} \left(\frac{\cos \beta_2^*}{\cos \beta_1^*} \right) \quad (\text{A.3.4})$$

Also, from Eq. (A.3.3), the total pressure loss coefficient $\bar{\omega}$, can be expressed as follows:

$$\bar{\omega} = \left(\frac{\theta}{c}\right) \frac{2\sigma}{\cos \beta_2} \left(\frac{\cos \beta_1}{\cos \beta_2} \right)^2 \quad (\text{A.3.5})$$

From the cascade test data, the deviation angle, δ , and the non-dimensional wake momentum thickness, $\frac{\theta}{c}$, are expressed in terms of the D_{eq} , D_{eq}^* , $\left(\frac{\theta}{c}\right)^*$, and inlet Mach number, M , as follows:

$$\delta = \delta^* + \left[6.40 - 9.45(M_1 - 0.60) \right] (D_{eq} - D_{eq}^*) \cdot \text{AK1} \quad (\text{A.3.6})$$

$$\frac{\theta}{c} = \left(\frac{\theta}{c}\right)^* + (0.827M_1 - 2.692M_1^2 - 2.675M_1^3) (D_{eq} - D_{eq}^*)^2 \cdot \text{AK2} \quad (\text{A.3.7})$$

for $D_{eq} \geq D_{eq}^*$

$$\frac{\theta}{c} = \left(\frac{\theta}{c}\right)^* + (2.80M_1 - 8.71M_1^2 + 9.36M_1^3) (D_{eq} - D_{eq}^*)^2 \cdot \text{AK2} \quad (\text{A.3.8})$$

for $D_{eq} < D_{eq}^*$

Using these empirical expressions, the air angle at blade outlet and total pressure loss coefficient at an off-design point can be determined as follows:

- (i) Calculate the inlet angle, β_1 , and the inlet Mach number, M_1 .
- (ii) Calculate the Equivalent Diffusion ratio at minimum loss, D_{eq}^* .

- (iii) Calculate the nondimensional wake momentum thickness at minimum loss, $(\frac{\theta}{c})^*$.
- (iv) Assume the fluid outlet angle, $(\beta_2)_a$.
- (v) Calculate the incidence angle, i , $i = \beta_1 - \beta_1^* + i^*$.
- (vi) Calculate the Equivalent Diffusion Ration D_{eq} .
- (vii) Calculate the deviation angle, δ .
- (viii) Calculate the fluid outlet angle, $(\beta_2)_c$,
 $(\beta_2)_c = \beta_2^* - \delta^* + \delta$.
- (ix) Compare the assumed value of fluid outlet angle, $(\beta_2)_a$, with the calculated value of that, $(\beta_2)_c$ to check if $|(\beta_2)_a - (\beta_2)_c| < \epsilon$ where ϵ is the desired accuracy. Iterate step (iv) to step (ix) until satisfactory accuracy is obtained.
- (x) Calculate the nondimensional wake momentum thickness, $\frac{\theta}{c}$.
- (xi) Calculate the total pressure loss coefficient $\overline{\omega}$.

Figure (A.3.1) shows the flow chart of the calculation procedure to predict the outlet angle and total pressure loss coefficient.

The program also includes a provision for modifying the equations given in Ref.23 and 24. Equations (A.3.1), (A.3.2), (A.3.6), (A.3.7), and (A.3.8) can be modified by introducing constants AK1, AK2, and AK3 as follows.

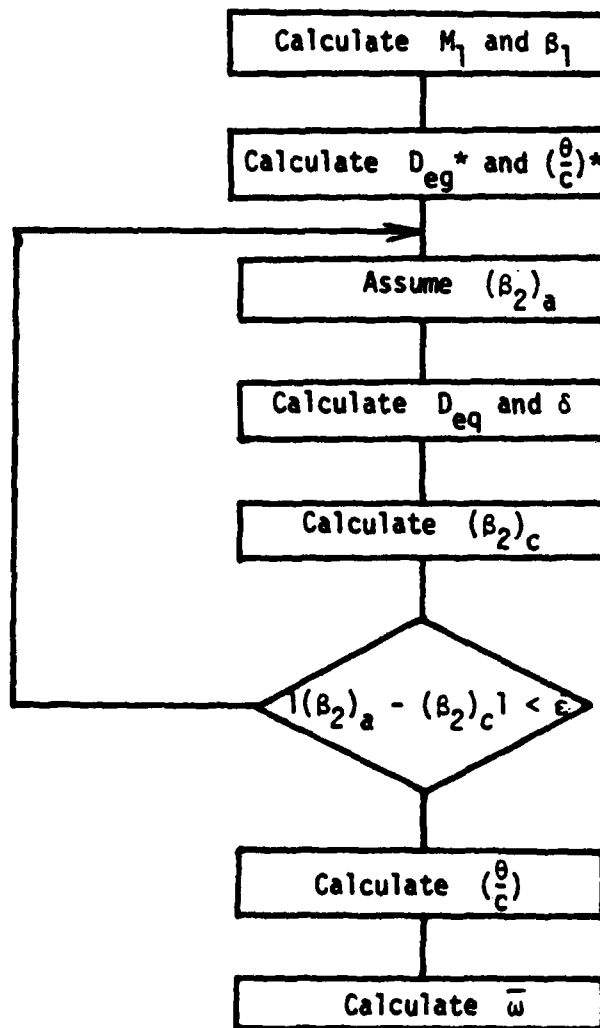


Fig. A.3.1 Procedure for Prediction of Total Pressure Loss Coefficient

$$D_{eq} = \frac{\cos \beta_2}{\cos \beta_1} \frac{V_{z1}}{V_{z2}} \left[1.12 + k (i-i^*)^{1.43} + 0.61 \frac{\cos^2 \beta_1}{\sigma} k \right] \cdot AK3 \quad (A.3.1)'$$

$$D_{eq}^* = \frac{\cos \beta_2}{\cos \beta_1} \frac{V_{z1}}{V_{z2}} \left[1.12 + 0.61 \frac{\cos^2 \beta_1}{\sigma} \right] \cdot AK3 \quad (A.3.2)'$$

$$\delta = \delta^* + \left[6.40 - 9.45 (M_1 - 0.60) \right] (D_{eq} - D_{eq}^*) \cdot AK1 \quad (A.3.6)'$$

$$\frac{\theta}{c} = \left(\frac{\theta}{c} \right)^* + (0.827M_1 - 2.692M_1^2 - 2.695M_1^3) (D_{eq} - D_{eq}^*)^2 \cdot AK2 \quad (A.3.7)'$$

for $D_{eq} > D_{eq}^*$

$$\frac{\theta}{c} = \left(\frac{\theta}{c} \right)^* + (2.80M_1 - 8.71M_1^2 + 9.36M_1^3) (D_{eq} - D_{eq}^*)^2 \cdot AK2 \quad (A.3.8)'$$

for $D_{eq} < D_{eq}^*$

(2) Input Variables:

OMEGAS	total pressure loss coefficient
SIGUMA	solidity
BETA1S	blade inlet flow angle at design point
BETA2S	blade outlet flow angle at design point
AINCIS	incidence at design point
ADEVIS	deviation at design point
AMACH1	blade inlet Mach number
BET1	blade inlet flow angle

X	Mach number below which the effect of Mach number disappears in estimating deviation angle. The value of 0.6 is recommended by Swan (Ref.24).
IDESIN	Index for design point calculation
AK1	constant in Eq.(A.3.6)'
AK2	constant in Eq.(A.3.7)' and (A.3.8)'
AK3	constant in Eq.(A.3.1)' and (A.3.2)'
VZ1	axial velocity at blade inlet
VZ2	axial velocity at blade outlet
UR1	rotor blade speed at blade inlet
R1	radius at blade inlet
R2	radius at blade outlet

(3) Output Variables:

DEQS	equivalent diffusion ratio at design point, D_{eq}^*
DEQN	equivalent diffusion ratio, D_{eq}
SITACS	dimensionless momentum thickness at design point, $(\frac{\theta}{c})^*$
SITACN	dimensionless momentum thickness, $(\frac{\theta}{c})$
BET2N	blade outlet angle
OMEGAN	total pressure loss coefficient

(4) Usage:

CALL WICGSL(OMEGAS, SIGUMA, BET1S, BET2S, AINCIS, ADEVIS,
AMACH1, BET1, DEQS, DEQN, SITACS, SITACN,
BET2N, OMEGAN, X IDESIN, AK1, AK2, AK3, VZ1,
VZ2, UR1, R1, R2)

SUBROUTINE WICSDL

(1) Description:

The subroutine WICSDL is used for the calculation of loss for small droplets on account of the change in momentum thickness of boundary layer due to the presence of such droplets.

In order to estimate the loss pertaining to the increase of momentum thickness due to the existence of small droplets in the boundary layer, Soo's boundary layer analysis for a gas-solids suspension is introduced (Ref. 25). In an isothermal incompressible system, Soo has derived the following equation for suspended particles under the assumption that the number of collisions among particles is negligible when compared to that with the wall,

$$a = \left(\frac{a}{b}\right) \left(\frac{\delta}{x}\right) - \frac{4a^2}{3b^2} \left(\frac{\delta}{x}\right)^{3/4} + \frac{4a^3}{3b^3} \left(\frac{\delta}{x}\right)^{1/2} - \frac{4a^4}{b} \left(\frac{\delta}{x}\right)^{1/4} \\ + \frac{4a^5}{b^5} \ln \left[1 + \frac{b}{a} \left(\frac{\delta}{x}\right)^{1/4} \right] \quad (\text{A.3.9})$$

where

$$a = \frac{0.0225 \left(\frac{\bar{\mu}}{U_p x}\right)^{1/4}}{0.1402 \left(\frac{\rho_{p0}}{\rho_0}\right) + 0.0972}$$

$$b = \frac{\frac{1}{2\sqrt{\pi}} \frac{\rho_{p0}}{\rho_0} \frac{U_{pw} \sqrt{\langle U_{pw}^2 \rangle}}{U^2}}{0.1402 \left(\frac{\rho_{p0}}{\rho} \right) + 0.0972}$$

Neglecting shear due to impact of solid particles, Soo derived the following equation.

$$\frac{\delta}{x} = 0.37 \left(\frac{U x \rho_0}{\mu} \right)^{-1/5} / (1 + 1.442 \rho_{p0}/\rho_0)^{0.8} \quad (A.3.10)$$

The boundary layer thickness, δ , can be obtained from Eqs. (A.3.9) or (A.3.10). In the present model, Eq. (A.3.10) was used.

The momentum thickness, due to liquid phase, θ_p , is given by

$$\begin{aligned} \frac{\theta_p}{\delta} = & \left(\frac{U_p - U_{pw}}{U_p} \right)^2 \frac{m}{(1+m)(2+m)} - \left(\frac{\rho_{p0} - \rho_{pw}}{\rho_{p0}} \right) \cdot \frac{U_{pw}}{U_p} \cdot \frac{1}{\alpha + 1} \\ & + \left(\frac{\rho_{p0} - \rho_{pw}}{\rho_{p0}} \right) \left(\frac{U_p - U_{pw}}{U_p} \right)^2 \\ & \times \left[\frac{\Gamma(\frac{2}{m} + 1) \cdot \Gamma(\alpha + 1)}{\Gamma(\frac{2}{m} + \alpha + 2)} - \frac{\Gamma(\frac{1}{m} + 1) \cdot \Gamma(\alpha + 1)}{\Gamma(\frac{1}{m} + \alpha + 2)} \right] \end{aligned} \quad (A.3.10)$$

where α and m are constants associated with distribution of velocity and density of liquid phase in the boundary layer namely

$$u_p = U_{pw} + (U_p - U_{pw}) \left(\frac{y}{\delta} \right)^{1/m}$$

$$\rho_p = \rho_{pw} - (\rho_{p0} - \rho_{pw}) \left(1 - \frac{y}{\delta} \right)^\alpha$$

For the case of solid, spherical particles of 100 and 200 μ m in diameter in air moving at room conditions with a velocity of 50 to 100 fps, Soo has obtained the following values for the various quantities.

$$n = 7, m = 1.25, \alpha = 2.30,$$

$$\frac{U_p - U_{pw}}{U_p} = 0.812, \frac{\rho_{pw}}{\rho_{p0}} = 1.451$$

Utilizing the above values, Eq. (A.3.10) becomes

$$\frac{\theta_p}{\delta} = 0.1402$$

Following the procedure of Lieblein, the total pressure loss coefficient due to the increase of momentum thickness, $\theta_{p,R}$, because of the existence of small droplets in the boundary layer over rotor blade surface, $\bar{\omega}_{\theta,R}$, can be expressed as follows:

$$\bar{\omega}_{\theta,R} = \left(\frac{\theta_{p,R}}{c} \right) \frac{2\sigma}{\cos\beta_2} \left(\frac{\cos\beta_1}{\cos\beta_2} \right)^2$$

Similarly, the total pressure loss coefficient due to the increase of momentum thickness, $\theta_{p,S}$, because of the existence of small droplets in the boundary layer on stator blade surface $\bar{\omega}_{\theta,S}$, can be expressed as follows:

$$\bar{\omega}_{\theta,S} = \left(\frac{\theta_{p,S}}{c} \right) \frac{2\sigma}{\cos\alpha_3} \left(\frac{\cos\alpha_2}{\cos\alpha_3} \right)^2$$

The stagnation pressure losses corresponding to $\bar{\omega}_{\theta,r}$ and $\bar{\omega}_{\theta,s}$ can be written as follows.

$$\Delta P_{\theta,R} = \frac{1}{2} \rho_1 W_1^2 \bar{\omega}_{\theta,R}$$

$$\Delta P_{\theta,S} = \frac{1}{2} \rho_2 V_2^2 \bar{\omega}_{\theta,S}$$

Thus, the total pressure loss across a stage due to the increase of momentum thickness because of the existence of small droplets in a boundary layer is given by

$$\Delta P_{\theta} = \Delta P_{\theta,R} + \Delta P_{\theta,S}$$

(2) Input Variables

CHORD	chord length
SIGUMA	solidity
BETA1	blade inlet flow angle
BETA2	blade outlet flow angle
UG	average flow velocity
RHOG	density
AMASSW	mass flow rate
AREA	flow area
VZ	axial velocity
IPRINT	index for printout

(3) Output Variables:

OMEGAP	total pressure loss coefficient

SUBROUTINE WICSTL

(1) Description:

The subroutine WICSTL is used for the calculation of loss due to Stokesian drag of droplets in the free stream of blade passage.

In view of the assumption pertaining to motion of small droplets (with zero relative velocity with respect to gas phase), the total pressure loss due to Stokesian drag becomes zero for small droplets.

For large droplets, the model introduced is described below.

The large droplets move with substantial relative velocity with respect to the gas phase and have equal probability of motion in all directions. However, regarding the latter aspect, the droplets are divided into two subclasses with a direction of motion for each class, specified with respect to the gas phase velocity vector. The number of droplets impacting on the blade surface is then proportional to the blade surface area projection normal to the velocity vectors for the two subclasses of droplets.

Referring to Fig. A.3.2., the two subclasses are shown as (1) and (2) which have direction of motion given by γ_1 and γ_2 relative to the gas phase velocity vector. The total number of droplets in subclass (1) is proportional to angle $2\gamma_1$ and those in subclass (2) is proportional to angle $2\gamma_2$ ($180 - 2\gamma_1$). The relative velocity between the gas phase and droplets of subclass (1) is given by the difference between V_{g1} and the component of V_p (the velocity of drop-

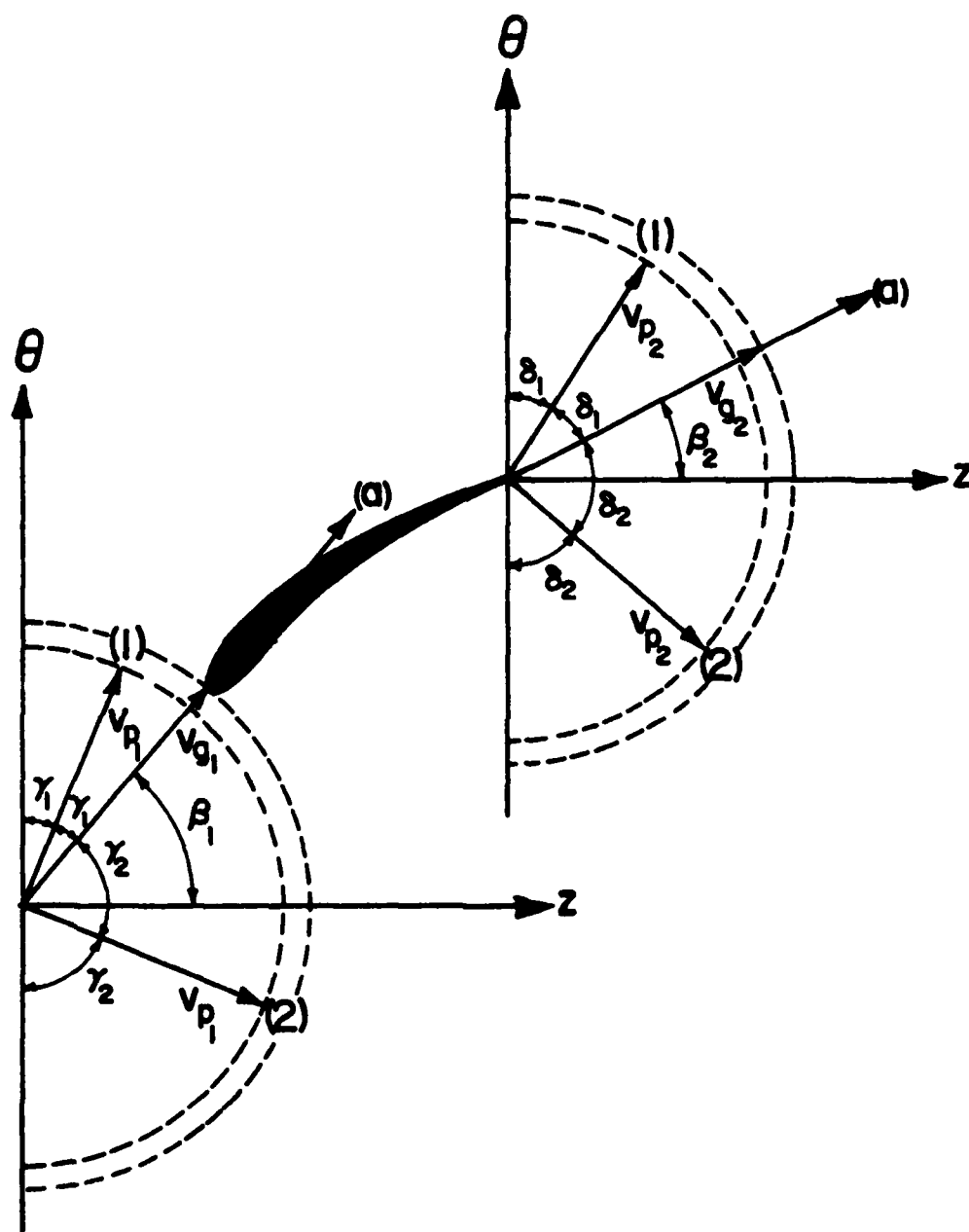


Fig. A.3.2 Model for Motion of Large Droplet

lets in subclass (1) in the direction of V_{g1} . Similarly the relative velocity between the gas phase and the droplets of subclass (2) is given by the difference between V_{g1} and the component of V_{p2} in the direction of V_{g1} . Thus for droplets of subclass (1) the relative velocity is given by the relation,

$$V_{g1} - V_{p1} \cos \gamma_1$$

and for droplets of subclass (2), the relative velocity is given by the relation,

$$V_{g1} - V_{p2} \cos \gamma_2$$

In Fig. A.3.2, the blade outlet conditions are also shown. As at the blade inlet section the relative velocities between the gas phase and droplets of subclasses (1) and (2) may be written as follows:

$$V_{g2} - V_{p1} \cos \delta_1 \quad \text{for subclass (1), and}$$

$$V_{g2} - V_{p2} \cos \delta_2 \quad \text{for subclass (2).}$$

where δ_1 is the inclination of the mean velocity vector for subclass (1) and δ_2 , the inclination of the mean velocity vector at outlet, designated V_{g2} . Once again, at the outlet section, the number of droplets in subclass (1) is proportional to angle $2\delta_1$, and the number of droplets in subclass (2) is proportional to angle $2\delta_2$, or $(180-2\delta_1)$. It is clear that the total number of droplets is divided into two new subclasses at the outlet, based on the directions of motion of droplets relative to the gas phase velocity. The two subclasses at the outlet are the output from the blade row for the given initial and operating conditions.

Based on the foregoing model of motion of large droplets the total pressure loss coefficient due to the Stokesian drag of large water droplets in a rotor passage, $\bar{\omega}_{s,R}$, can be estimated as follows:

The Stokesian drag of water droplets across a rotor blade is given by

$$D = C_D \frac{1}{2} \rho_{g_1} (W_{g_1} - W_{p_1})^2 A_p N_{d,r}$$

Where W_{g_1} and W_{p_1} are relative velocities of gaseous phase and droplets at rotor inlet, A_p , the project area of a droplet, and $N_{d,r}$, the number of droplets that exist in rotor passage. Referring to Fig. A.3.3, the Stokesian drag, D , can also be written as

$$D = (P_{01,r} - P_{02,r}) A_R$$

where $P_{01,r}$ and $P_{02,r}$ are total pressure at station (1) and (2) in rotor coordinate system, and A_R is the average flow area in a rotor blade passage.

From the above equations, the total pressure loss across a rotor blade due to the Stokesian drag, $\Delta P_{s,R}$ becomes

$$P_{s,R} = C_D \frac{1}{2} \rho_{g_1} (W_{g_1} - W_{p_1})^2 A_p N_{d,R} / A_R = D / A_R$$

By definition, the total pressure loss coefficient across a rotor blade due to Stokesian drag, $\bar{\omega}_{s,R}$, can be obtained as follows:

$$\bar{\omega}_{s,R} = \frac{\Delta P_{s,R}}{\frac{1}{2} \rho_1 W_{g_1}^2} = C_D (W_{g_1} - W_{p_1})^2 A_p N_{d,R} / W_{g_1}^2 A_R = \frac{D / A_R}{\frac{1}{2} \rho_1 W_{g_1}^2}$$

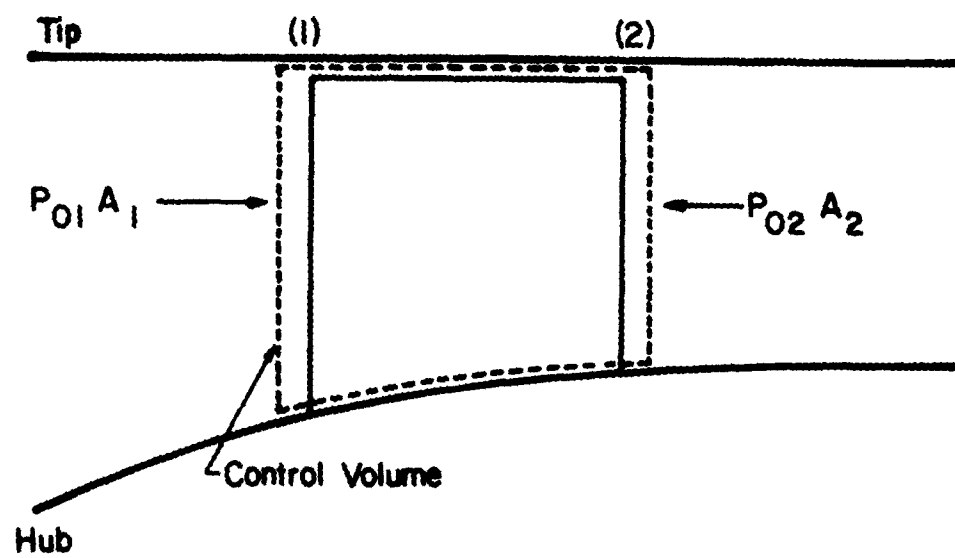


Fig. A.3.3 Control Volume across a Blade

Similarly, the total pressure loss across a stator blade due to Stokesian drag, $\Delta P_{s,S}$ becomes

$$\Delta P_{s,S} = c_D \frac{1}{2} \rho_{g_2} (V_{g_2}^2 - V_{p_2}^2) A_{p d,S} / A_S$$

and the total pressure loss coefficient across a stator blade due to the Stokesian drag, $\bar{\omega}_{s,S}$, can be obtained as follows:

$$\bar{\omega}_{s,S} = \frac{\Delta P_{s,S}}{\frac{1}{2} \rho_2 V_2^2} = c_D (V_{g_2}^2 - V_{p_2}^2) A_{p d,S} / A_S$$

Thus, the total pressure loss across a stage due to Stokesian drag is given by

$$\Delta P_s = \Delta P_{s,R} + \Delta P_{s,S}$$

(2) Input Variables:

ISTAGE	stage at which performance calculation is carried out
IROTOR	index for rotor or stator
DAV	nominál droplet diameter
W1	relative velocity at rotor inlet
W2	relative velocity at rotor outlet
DELV	relative velocity between gas phase and droplet
V2	absolute velocity at stator inlet
V3	absolute velocity at stator outlet
WMASS	mass flow rate of droplet
VZ	axial velocity
N	station number (Fig.5.1)
BETA1	relative flow angle at rotor inlet
BETA2	relative flow angle at rotor outlet

	ALFA2	absolute flow angle at stator inlet
	ALFA3	absolute flow angle at stator outlet
	MMASS	mass flow rate of mixture
(3)		Output Variables:
:	DELVU2	relative velocity between gas phase and large droplet in subclass (1) at blade outlet
:	DELVL2	relative velocity between gas phase and large droplet in subclass (2) at blade outlet
	OMEGRU	total pressure loss coefficient across rotor due to Stokesian drag in subclass (1)
	OMEGRL	total pressure loss coefficient across rotor due to Stokesian drag in subclass(2)
	OMEGSU	total pressure loss coefficient across stator due to Stokesian drag in subclass (1)
	OMEGSL	total pressure loss coefficient across stator due to Stokesian drag in subclass (2)
	DRAGRU	drag force due to large droplet in subclass(1)
	DRAGRL	drag force due to large droplet in subclass(2)
	DRAGSU	drag force due to small droplet in subclass(1)
	DRAGSL	drag force due to small droplet in subclass (2)
	REAVE	average Reynolds number
(4)	Usage:	
:	CALL WICSTL	(ISTAGE, IROTOR, DAV, W1,W2, DELV, V2, V3,
:		WMASS, VZ, N, BETA1, BETA2, ALFA2, ALFA3,
:		MMASS, DELVU2, DELVL2, OMEGRU, OMEGRL, OMEGSU,
:		OMEGSL, DRAGRU, DRAGRL, DRAGSU, DRAGSL, REAVE)

SUBROUTINE WICFML

(1) Description:

The subroutine WICFML is used for the calculation of loss due to film formed on blade surface when large droplets are present either by themselves or along with small droplets.

The momentum gained by the thick water film on the rotor blade surface is given by $\dot{m}_{\text{film}} V_{\text{film}}$ per unit blade length, where $\dot{m}_{\text{film}}$ is the mass flow rate of water film on the rotor blade per unit blade length and V_{film} is the mean velocity of water film.

Considering the difference in viscosity between the two phases, the velocity of water film can be estimated as follows:

$$V_{\text{film}} = \frac{1}{2} \bar{W}_g \frac{\mu_g}{\mu_l}$$

where $\bar{W}_g$ is the mean velocity of gaseous phase, and μ_g and μ_l are the viscosities of gaseous and liquid phases, respectively.

The foregoing momentum can be transformed into an equivalent drag coefficient as follows.

$$C_{D_f} = \dot{m}_{\text{film}} V_{\text{film}} / \frac{1}{2} \rho_{g_1} \bar{W}_g^2 c$$

where ρ_{g_1} is blade inlet density of gaseous phase, and c is the chord length of the blade.

The drag coefficient can then be expressed in the form of a total pressure loss coefficient as follows:

$$C_{D_f} \frac{1}{2} \rho_{g_1} \bar{W}_g^2 c = \Delta P_f \cdot s \cdot \cos \beta_m$$

where s is the blade pitch and β_m is mean flow angle. Noting that $V_z = \bar{W}_g \cos \beta_m$, one obtains the relation, namely

$$\Delta P_f / \frac{1}{2} \rho_{g1} V_z^2 = c_{Df} \left(\frac{c}{s} \right) \frac{1}{\cos^3 \beta_m}$$

Since $\bar{W}_{g1} = V_z / \cos \beta_1$, the total pressure loss coefficient due to the momentum gained by the thick film on the rotor blade surface can be written as follows:

$$\bar{\omega}_f = \Delta P_f / \frac{1}{2} \rho_{g1} \bar{W}_{g1}^2 = c_{Df} \left(\frac{c}{s} \right) \frac{\cos^2 \beta_1}{\cos^3 \beta_m}$$

(2) Input Variables:

WG1	flow velocity at blade inlet
WG2	flow velocity at blade outlet
FMASS	mass flow rate of water film on blade surface per unit blade length
RHOG1	density
CHORD	chord length
SIGUMA	solidity
BETA1	blade inlet flow angle
BETA2	blade outlet flow angle

(3) Output Variables:

CDF	drag coefficient
OMEGAF	total pressure loss coefficient

(4) Usage:

CALL WICFML (WG1, WG2, FMASS, RHOG1, CHORD, SIGUMA, BETA1, BETA2, CDF, OMEGAF)

SUBROUTINE WICRSL

(1) Description:

The subroutine WICRSL is used for the calculation of loss due to the rough surface when large droplets are presented either by themselves or along with small droplets.

Using the experimental results on pipes roughened with sand, L. Prandtl and H. Schlichting carried out a correlation to obtain the friction coefficient on a rough place (Ref. 26). The correlation was based on the logarithmic velocity distribution law for rough pipes in the form, namely

$$\frac{u}{v_*} = 2.5 \ln\left(\frac{y}{k}\right) + B$$

where v_* is friction velocity; k is roughness of surface, and B is a roughness function which depends on the roughness parameter, v_*k/r .

In the completely rough regime, they obtained the following relation for the drag coefficient for a plate.

$$c_{Dr} = (1.81 + 1.62 \log_{10} \frac{x}{k})^{-2.5}$$

In the present case, x is replaced by the chord length, c , and the surface roughness k is assumed to be the same as the order of mean diameter of large droplets.

Thus, the total pressure loss coefficient due to turbulent friction over a rough film surface on a rotor becomes the following.

$$\bar{\omega}_r = c_{Dr} \left(\frac{c}{s}\right) \frac{\cos^2 \beta_1}{\cos^3 \beta_m}$$

(2) Input Variables:

SIGUMA	solidity
BETA1	blade inlet flow angle
BETA2	blade outlet flow angle
CHORD	chord length
DL	droplet diameter

(3) Output Variables:

CDR	drag coefficient
OMEGAR	total pressure loss coefficient

(4) Usage:

CALL WICRSL (SIGUMA, BETA1, BETA2, CHORD, DL, CDR,
OMEGAR)

SUBROUTINE WICVT

(1) Description:

The subroutine WICVT is used for the calculation of velocity triangle components and angles. Typical velocity diagram for a compressor stage is presented in Fig. A.2.1.

(2) Input Variables:

ISTAGE	stage at which performance calculation is carried out
ASPEED	acoustic speed

ALFA1	absolute flow angle at rotor inlet
VZ	axial velocity
AK1	constant in Eq. (A.3.6)'
AK3	constant in Eq. (A.3.1)' and (A.3.2)'

(3) Output Variables:

V1	absolute velocity at rotor inlet
VS1	tangential component of V1
WS1	tangential component of W1
BETA1	relative flow angle at rotor inlet
W1	relative velocity at rotor inlet
BETA2	relative flow angle at rotor outlet
WS2	tangential component of W2
VS2	tangential component of V2
ALFA2	absolute flow angle at rotor outlet
W2	relative velocity at rotor outlet
VZ	absolute velocity at rotor outlet
ALFA3	absolute flow angle at stator outlet
V3	absolute velocity at stator outlet

(4) Usage:

```
CALL WICVT (ISTAGE, ASPEED, ALFA1, VZ, V1, VS1, WS1,
           BETA1, W1, BETA2, WS2, VS2, ALFA2, W2, V2,
           ALFA3, V3, AK1, AK3)
```

SUBROUTINE WICCEN

(1) Description:

The subroutine WICCEN is used for the calculation of spanwise replacement of droplets due to centrifugal action.

Three forces act on a droplet moving through a fluid: (1) the external force consisting of gravitational and centrifugal forces; (2) the buoyancy force, which acts parallel to the external force, but in the opposite direction; and (3) the drag force, which appears whenever there is relative motion between the droplet and the fluid, and acts parallel to the direction of motion but in the opposite direction. In the present case, the direction of motion of a droplet relative to the fluid is not parallel to the direction of the external and buoyant forces, and therefore the drag force makes an angle with the other two forces. However, under the one-dimensional approximation, the lines of action of all forces acting on the droplet are co-linear and therefore the forces may be added in obtaining a balance of momentum, as follows:

$$\frac{m}{g_c} \frac{du}{dt} = F_e - F_b - F_D$$

where F_e , F_b and F_D are the external, buoyancy and drag forces respectively.

The external force can be expressed as the product of mass and acceleration, a_e , of the droplet due to this force, and therefore

$$F_e = \frac{m}{g_c} a_e$$

In the present case, because of the large rotor speeds, the centrifugal acceleration is far larger than the gravitational acceleration. Thus

$$a_e = r\omega^2$$

where r is the radius and ω , the angular velocity. The acceleration can also be written as follows:

$$a_e = V_\theta^2/r$$

where V_θ is the circumferential velocity of the droplet. For droplets passing through a rotor blade passage, the circumferential component of the relative velocity, w_θ , should be used in place of V_θ . When there is a large change in whirl velocity between the inlet and outlet of a blade row, a mean value of velocity may be more applicable.

The buoyancy force is, by Archimedes' Principle, the product of the mass of the fluid displaced by the droplet and the acceleration from the external force. The mass of fluid displaced is $(m/\rho_w)\rho_g$, where ρ_w is the density of water and ρ_g is the density of the surrounding fluid. The buoyancy force is then given

$$F_b = m\rho_g a_e / \rho_w g_c$$

The drag force is expressed by the relation,

$$F_d = C_D \frac{\rho_g u_\infty^2}{2 g_c} A_p$$

where C_D is the drag coefficient and A_p is the projected area of the droplet measured in a plane perpendicular to the direction of motion of the droplet. The drag coefficient

C_D can be expressed in a general form as follows:

$$C_D = b_1 / \text{Re}^n$$

where Re is the Reynolds number based on relative velocity between gas and droplet. The constants b_1 and n are as follows.

$$b_1 = 24.0, \quad n = 1.0 \quad \text{when } \text{Re} < 1.9$$

$$b_1 = 18.5, \quad n = 0.6 \quad \text{when } 1.9 < \text{Re} < 500$$

$$b_1 = 0.44, \quad n = 0.0 \quad \text{when } 500 < \text{Re} < 200,000.$$

The equation of droplet motion then becomes the following:

$$\frac{du}{dt} = A/r - B u^{2-n}$$

where

$$A = (W_\theta)_{\text{ave}}^2 (1 - \rho_g / \rho_w),$$

$$B = 3 u^n b_1 \rho_g^{1-n} / 4 \rho_w D^{1+n}, \quad \text{and}$$

D being the average droplet diameter. Over a small time interval, the equation of motion can be written as follows:

$$\Delta u = (A/r - B u^{2-n}) \Delta t$$

This equation can be used to determine the radial location of a droplet in a stage as follows:

- (i) Select the initial values for u_1 and r_1 .
- (ii) Calculate the Reynolds number to determine the values of b_1 and n .
- (iii) Calculate A and B .

- (iv) Calculate the change of u during time interval Δt .
- (v) Calculate the new velocity u_2 .

$$u_2 = u_1 + \Delta u$$
- (vi) Calculate the change in location of droplet in terms of Δr .

$$\Delta r = (u_1 + u_2) / 2.0 \cdot \Delta t$$
- (vii) Calculate the new radial location.

$$r_2 = r_1 + \Delta r$$
- (viii) Repeat the calculation for new value of u_2 and r_2 and progressively extend the calculation.

The time interval should be sufficiently small in order to obtain reasonable accuracy. As stated in Section 2.1.3 in Chapter II of this Report, the length between the leading and trailing edges of a blade is divided into ten steps. The time interval Δt is then given by the relation, namely

$$\Delta t = \frac{\text{chord}}{V} \times \frac{1}{10}$$

where V is the velocity of moisture in the blade passage.

(2) Input Variables:

RZERO	droplet spanwise location at rotor inlet
UZERO	droplet spanwise velocity at rotor inlet
DD	droplet diameter
VZ	axial velocity
DELZZ	axial length of a stage
ALFAAV	average flow angle
FN	rotor blade rotational speed

IRS	index for rotor or stator
RHOGAS	density
RHUB	radius at hub
XG	mass fraction of gas phase
XA	mass fraction of dry air
XVV	mass fraction of vapor
XCH4	mass fraction of methane
RTIPIN	radius at blade tip

(3) Output Variables:

R2	droplet spanwise location blade outlet
U2	droplet spanwise velocity at blade outlet
ITIP	index for droplet spanwise location
VZTIME	time in which flow pass through a stage

(4) Usage:

CALL WICCEN (RZERO, VZERO, DD, VZ, DELZZ, ALFAAV, FN, IRS,
 RHOGAS, RHUB, R2, U2, ITIP, VZTIME, XG, XA,
 XVV, XCH4, RTIPIN)

SUBROUTINE WICDMS

(1) Description:

The subroutine WICDMS is used for the calculation of amount of small droplets which is centrifuged.

(2) Input Variables:

IPRINT	index for printout
IRAD	index for spanwise location

AMASW1	mass flow rate of water at rotor inlet
AMASWT	mass flow rate of droplet
AMASW	mass flow rate of droplet
R1	droplet spanwise location rotor inlet
R2	droplet spanwise location at rotor outlet
STAREA	streamtube area
RSTAVE	radius of streamtube at its center
RTIP	radius at blade tip

(3) Output Variables:

DMIN	amount of water that is centrifuged and enters into a streamtube
DMOUT	amount of water that is centrifuged and leaves from a streamtube
AMASW2	mass fraction of water at rotor outlet after correction for centrifugal action
DELMAS	net amount of water that is centrifuged

(4) Usage:

CALL WICDMS (IPRINT, IRAD, AMASW1, AMASWT, AMASW, R1,
R2, STAREA, RSTAVE, RTIP, DMIN, DMOUT,
AMASW2, DELMAS)

SUBROUTINE WICDML

(1) Description:

The subroutine WICDML is used for the calculation of amount of large droplets which is centrifuged.

(2) Input Variables:

IPRINT	index for printout
IRAD	index for spanwise location
AMASW1	mass flow rate of water at rotor inlet
AMASWT	mass flow rate of droplet
AMASW	mass flow rate of droplet
R1	droplet spanwise location rotor inlet
R2	droplet spanwise location at rotor outlet
STAREA	streamtube area
RSTAVE	radius of streamtube at its center
RTIP	radius at blade tip

(3) Output Variables:

DMIN	amount of water that is centrifuged and enters into a streamtube
DMOUT	amount of water that is centrifuged and left from a streamtube
AMASW2	mass fraction of water at rotor outlet after correction for centrifugal action.
DELMAS	net amount of water that is centrifuged

(4) CALL WICDML (IPRINT, IRAD, AMASW1, AMASWT, AMASW, R1, R2, STAREA, RSTAVE, RTIP, DMIN, DMOUT, AMASW2, DELMAS)

SUBROUTINE WICDRG

(1) Description:

The subroutine WICDRG is used for the calculation of drag

force on droplet.

(2) Input Variables:

D	droplet nominal diameter
DELV1	relative velocity between droplet and gas phase at blade inlet
RHGAS1	density of gas phase at blade inlet
RHGAS2	density of gas phase at blade outlet

(3) Output Variables:

CD2	drag coefficient
DELV2	relative velocity between droplet and gas phase at blade outlet
DRAG1	drag force
RE	Reynolds number

(4) Usage:

CALL WICDRG (D, DELV1, RHGAS1, RHGAS2, CD2, DELV2, DRAG1,
RE)

SUBROUTINE WICMAC

(1) Description:

Subroutine WICMAC calculates the Mach number in the gas-water droplet mixture. First the acoustic speed in gaseous phase is determined by iteration as follows:

- (i) Assume Mach number and calculate static temperature and density.

$$t = \left(1 + \frac{\gamma-1}{2} M^2\right)^{-1} T_{01}$$

$$\rho = \left(1 + \frac{\gamma-1}{2} M^2\right)^{-1/(\gamma-1)} P_{01} / RT_{01}$$

- (ii) Calculate acoustic speed in gaseous phase

$$a_g = (\gamma R t g_c)^{0.5}$$

- (iii) Calculate the axial velocity

$$V_z = \dot{m} / \rho A$$

- (iv) Calculate absolute velocity

$$V_1 = V_z / \cos \alpha_1$$

- (v) Calculate Mach number

$$M_1 = V_1 / a_g$$

Compare the calculated Mach number with the assumed value in (i). Iterate steps (i) to (v) until the desired accuracy is obtained. After determining the acoustic speed in gaseous phase, Function WICASD is called to determine the acoustic speed in droplet-laden gas flow.

- (2) Input Variables:

ISTAGE stage number

AMASSM mixture mass flow rate

TOIG	total temperature of gaseous phase
PRES	total pressure
XW1	total water content
ALFA	stator outlet angle of the previous stage
RMIX	gas content of gaseous phase
CPMIX	specific heat at constant pressure for gaseous phase

(3) Output Variables:

M	Mach number
VZ	axial velocity
C	acoustic speed in mixture

(4) Usage:

CALL WICMAC (ISTAGE, AMASSM, TOIG, PRES, M, VZ, C, XW1,
ALFA, RMIX, CPMIX)

FUNCTION WICASD

(1) Description:

Function WICASD calculates the acoustic speed in droplet-laden gas flow. The following equation is used (Ref.27).

$$a = \left[\left\{ (1-\sigma_v)\rho_g + \sigma_v\rho_w \right\} \left\{ \frac{1-\sigma_v}{\rho_g a_g^2} + \frac{\sigma_v}{\rho_w a_w^2} \right\} \right]^{-\frac{1}{2}}$$

where

a_g = acoustic speed in gaseous phase

a_w = acoustic speed in water

ρ_g = density of gaseous phase

ρ_w = density of water

σ_v = particulate liquid volume fraction

x_w = particulate liquid mass fraction

$$\sigma_v = x_w \rho_g / \left(\rho_w - x_w (\rho_w - \rho_g) \right)$$

(2) Input Variables:

XW total water content

RHOG density of gas phase

CG acoustic speed of gaseous phase

(3) Output Variable:

WICASD acoustic speed in gas-water droplet mixture

(4) Usage:

WICASD (XW, RHOG, CG)

SUBROUTINE WICBOA

(1) Description:

Subroutine WICBOA calculates the blade outlet flow angle based on Swan's correlation curves (Ref.24). Swan's curves and the concept of equivalent diffusion ratio are also described in Subroutine WICGSL.

(2) Input Variables:

OMEGAS	total pressure loss coefficient at design point
SIGUMA	solidity
BET1S	blade inlet angle at design point
BET2S	blade outlet angle at design point
AINCIS	incidence at design point
ADEVIS	deviation at design point
AMACH1	blade inlet Mach number
BET1	blade inlet flow angle

(3) Output Variables:

DEQS	equivalent diffusion ratio at design point
DEQN	equivalent diffusion ratio
SITACS	ratio of wake momentum thickness to chord design point
SITACN	ratio of wake momentum thickness to chord
BET2N	blade outlet angle

(4) Usage:

CALL WICBOA (OMEGAS, SIGUMA, BET1S, BET2S, AINCIS, ADEVIS,
AMACH1, BET1, DEQS, DEQN, SITACS, SITACN, BET2N)

SUBROUTINE WICEDD

(1) Description:

Subroutine WICEDD is called in Subroutine WICBOA and WICGSL. The equivalent diffusion ratio at design point, D_{eq}^* , and the ratio of wake momentum thickness to chord at design point, $(\frac{\theta}{c})^*$, are obtained from the following equations:

$$D_{eq}^* = \frac{\cos \beta_2}{\cos \beta_1} \frac{V_{z1}}{V_{z2}} (1.12 + 0.61 \frac{\cos^2 \beta_1}{\sigma} K) \cdot AK3$$

$$\left(\frac{\theta}{c}\right) = \frac{\bar{\omega}^* \cos \beta_2^*}{2 \sigma} \left(\frac{\cos \beta_2^*}{\cos \beta_1^*}\right)^2$$

where

$$K = \tan \beta_1^* - \frac{r_1}{r_2} \frac{V_{z2}}{V_{z1}} \tan \beta_2^* - \frac{\omega r_1}{V_{z1}} \left(1 - \frac{r_2^2}{r_1^2}\right)$$

(2) Input Variables:

AK3 constant, normally one
VZ1 axial velocity at blade inlet
VZ2 axial velocity at blade outlet
UR1 rotor blade speed at rotor inlet
R1 radius at blade inlet
R2 radius at blade outlet
BET1S blade inlet flow angle at design point
BET2S blade outlet flow angle at design point
SIGUMA solidity
OMEGAS total pressure loss coefficient at design point

(3) Output Variables:

DEQS equivalent diffusion ratio at design point
SITACS ratio of wake momentum thickness to chord at design point

(4) Usage:

CALL WICEDD (AK3, VZ1, VZ2, UR1, R1, R2, BET1S, BET2S, SIGUMA, OMEGAS, DEQS, SITACS)

FUNCTION WICED

(1) Description:

Function WICED is called in Subroutines WICBOA and WICGSL. The equivalent diffusion ratio is obtained from the following equation.

$$D_{eq} = \frac{\cos\beta_2}{\cos\beta_1} \frac{V_{z1}}{V_{z2}} \left(1.12 + k (i-i^*)^{1.43} + 0.61 \frac{\cos\beta_1}{\sigma} K \right) \cdot AK3$$

where

$$K = \tan\beta_1 - \frac{r_2}{r_1} \frac{V_{z2}}{V_{z1}} \tan\beta_1 - \frac{\omega r_1}{V_{z1}} \left(1 - \frac{r_2^2}{r_1^2} \right)$$

and where $k = 0.0117$ for NACA 65 (A_{10}) blades and $k = 0.007$ for the C4 airfoils.

(2) Input Variables:

AK3 constant, normally one
VZ1 axial velocity at blade inlet
VZ2 axial velocity at blade outlet
UR1 rotor blade speed at rotr inlet
R1 radius at blade inlet
R2 radius at blade outlet
BET1 blade inlet flow angle
BET2 blade outlet flow angle
SIGUMA solidity
AINCIS incidence at design point
AINCI incidence

(3) Output Variable:

WICED equivalent diffusion ratio

(4) Usage:

WICED (AK3, VZ1, VZ2, UR1, R1, R2, BET1, BET2, SIGUMA,
AINCIS, AINCI)

FUNCTION WICMTK

(1) Description:

Function WICMTK is called in Subroutines WICBOA and WICGSL. The ratio of wake momentum thickness and chord are obtained from the following equations.

$$\frac{\theta}{c} = \left(\frac{\theta}{c}\right)^* + (0.827 M_1 + 2.675 M) (D_{eq} - D_{eq}^*)^2 \cdot AK2$$

for $D_{eq} > D_{eq}^*$

$$\frac{\theta}{c} = \left(\frac{\theta}{c}\right)^* + (2.80 M_1 - 8.71 M_1^2 + 9.36 M_1^3) (D_{eq} - D_{eq}^*)^2 \cdot AK2$$

for $D_{eq} < D_{eq}^*$

(2) Input Variables:

AK2	constant, normally one
SITACS	ratio of wake momentum thickness to chord at design point
AMACH1	blade inlet Mach number
DELDEQ	difference between equivalent diffusion ratio and equivalent diffusion ratio at design point.

(3) Output Variables:

WICMTK	ratio of wake momentum thickness to chord

(4) Usage:

WICMTK (SITACS, AMACH1, DELDEQ, AK2)

FUNCTION WICLOS

(1) Description:

Function WICLOS is called in Subroutine WICGSL and calculates the total pressure loss coefficient from the following equation:

$$\bar{\omega} = \left(\frac{\theta}{c}\right) \frac{2\sigma}{\cos\beta_2} \left(\frac{\cos\beta_1}{\cos\beta_2}\right)^2$$

(2) Input Variables:

BET1 blade inlet flow angle
BET2 blade outlet flow angle
SIGUMA solidity
SITA ratio of momentum thickness to chord

(3) Output Variable:

WICLOS total pressure loss coefficient

(4) Usage:

WICLOS (BET1, BET2, SIGUMA, SITA)

SUBROUTINE WICIRS

(1) Description:

Subroutine WICIRS is called at outlet of rotor and performs the calculation of droplet impingement and rebound in rotor passage for small droplet.

(2) Input Variables:

ISTAGE stage number
RTIPIN blade tip radius
XW1 mass fraction of small droplet

XG	mass fraction of gaseous phase
RHOG1	density of gaseous phase
BETA1	rotor inlet relative flow angle
W1	rotor inlet relative velocity

(3) Output Variables:

WW1	amount of water that impacts stagnation region of blade
WW2	amount of water that impact aft of blade
WW	total amount of water that impact blade

(4) Usage:

CALL WICIRS (ISTAGE, RTIPIN, XW1, XG, RHOG1, BETA1, W1,
WW1, WW2, WW)

SUBROUTINE WICIRL

(1) Description:

Subroutine WICIRL is called at outlet of rotor and performs the calculation of droplet impingement and rebound in rotor passage for large droplet.

(2) Input Variables:

ISTAGE	stage number
RTIPIN	blade tip radius
XW1	mass fraction of large droplet
XG	mass fraction of gaseous phase
PHOG1	density of gaseous phase
BETA1	rotor inlet relative flow angle
W1	rotor inlet relative velocity

(3) Output Variables:

WW1	amount of water that impacts upper surface of blade
WW2	amount of water that impact lower surface of blade
WW	total amount of water that impact blade surface

(4) Usage:

CALL WICIRL (ISTAGE, RTIPIN, XW1, XG, RHOG1, BETA1, W1,
WW1, WW2, WW)

SUBROUTINE WICISS

(1) Description:

Subroutine WICISS is called outlet of stator and performs the calculation of droplet impingement and rebound in stator passage for small droplet.

(2) Input Variables:

ISTAGE	stage number
RTIPIN	blade tip radius
XW	mass fraction of small droplet
XG	mass fraction of gaseous phase
RHOG1	density of gaseous phase
ALFA2	stator inlet absolute flow angle
W1	stator inlet absolute velocity

(3) Output Variables;

WW1 amount of water that impact stagnation
 region of blade

WW2 amount of water that impact off of blade

WW total amount of water that impact the blade

(4) Usage:

CALL WICISS (ISTAGE TRIPIN, XW, XG RHOG1, ALFA2, W1,
 WW1, WW2, WW)

SUBROUTINE WICISL

(1) Description:

Subroutine WICISL is called at outlet of stator and performs the calculation of droplet impingement and rebound in stator passage for large droplet.

(2) Input Variable:

ISTAGE stage number

RTIPIN blade tip radius

XW mass fraction of large droplet

XG mass fraction of gaseous phase

RHOG1 density of gaseous phase

ALFA2 stator inlet absolute flow angle

W1 stator inlet absolute velocity

(3) Output Variables:

WW1 amount of water that impact upper surface of
 blade

WW2 amount of water that impact lower surface of
 blade

WW total amount of water that impact on
blade surface

(4) Usage:

CALL WICISL (ISTAGE, RTIPIN, XW, XG, RHOG1, ALFA2, W1,
WW1, WW2, WW)

SUBROUTINE WICWAK

(1) Description:

Subroutine WICWAK is called at rotor outlet and stator outlet, and calculates the droplet size of water that is re-entrained at trailing edge of rotor and stator blades.

The size of droplet which is re-entrained into the wake at the blade trailing edge is calculated as follows:

(i) Assume a value for a droplet diameter, d , that is re-entrained into wake.

(ii) Calculate the stability number, SN.

$$SN = \mu_f^2 / \rho_g \sigma d g_c$$

(iii) Calculate the critical Weber number

$$W_e = 12 \left[1 + (SN)^{0.36} \right]$$

(iv) Calculate the largest stable droplet diameter

$$d_{\max} = \frac{W_e}{\rho_g} \frac{\sigma g_c}{V_g^2}$$

(v) Compare the assumed droplet diameter with the calculated one. Iterate entire steps until the satisfactory agreement is obtained.

(2) Input Variables:

RHOG density of gaseous phase
V velocity of gaseous phase for small droplet
 or relative velocity between droplet and
 gaseous phase for large droplet

(3) Output Variables:

DWAKE droplet size that re-entrained at trailing
 edge in (ft³)
DWAKEM droplet size that re-entrained at trailing
 edge in (μm)

(4) Usage:

CALL WICWAK (RHOG, V, DWAKE, DWAKEM)

SUBROUTINE WICHET

(1) Description:

Subroutine WICHET is called at end of stage to perform the heat transfer calculation between water droplet and gaseous phase. The heat transfer rate can be determined from the following equation

$$\frac{dh}{dt} = h_h A (T_g - T_w)$$

where h_h is the heat transfer coefficient, A , the droplet surface area, T_w , the droplet surface temperature, and T_g , the temperature of the surrounding gas. The heat transfer coefficient can be expressed as follows:

$$h_h = \frac{k_a}{D_d} \cdot Nu$$

where k_a is the thermal conductivity of air, and Nu, the Nusselt Number. The Nusselt number can be expressed in terms of the dimensionless groups as follows:

$$Nu = 2.0 + 0.6 (Re)^{0.50} (Pr)^{0.33}$$

where Re is the Reynolds number based on the relative velocity between the droplet and the surrounding air, and Pr is Prandtl number.

After calculating the temperature rise of the water and gas phase due to the work done by the rotor, the heat transfer calculation is carried out as follows:

- (i) Calculate the average droplet diameter, D_d .
- (ii) Calculate the number of droplets, N_d .

$$N_d = \frac{\dot{m}_w}{\rho_w \frac{4}{3} \pi (D_d/2)^3} \cdot \frac{\Delta z}{V_z}$$

where $\dot{m}_w$ is the mass flow rate of water phase, ρ_w , the density of water, V_z , the axial direction velocity, and Δz , the axial length of one stage.

- (iii) Calculate the droplet surface area, A.
- (iv) Calculate the Nusselt number, Nu.
- (v) Calculate the heat transfer coefficient, h_h .
- (vi) Calculate the stage outlet temperature for droplet and gas without heat transfer, that is

$$T_{g2} = T_{g1} + (\Delta T_g)_{wk}$$

$$T_{w2} = T_{w1} + (\Delta T_w)_{wk}$$

where $(\Delta T_g)_{wk}$ and $(\Delta T_w)_{wk}$ are the temperature rise of gas and water due to work done by rotor.

- (vii) Calculate the amount of heat transferred from the gas to the droplet.

$$\Delta H = h_h A (T_{g2} - T_{w2})$$

- (viii) Calculate the temperatures rise of the droplet and the temperature drop of the surrounding gas.

$$(\Delta H_g)_{ht} = \Delta H / m_g C_s$$

$$(\Delta H_w)_{ht} = \Delta H / m_w C_w$$

where C_w is the specific heat for water and C_s is the humid heat for air-water mixture.

- (ix) Calculate the stage outlet temperature for droplet and gas.

$$T_{g2} = T_{g1} + (\Delta T_g)_{wk} - (\Delta T_g)_{ht}$$

$$T_{w2} = T_{w1} + (\Delta T_w)_{wk} + (\Delta T_w)_{ht}$$

- (X) Using the temperature calculated in step (ix), repeat the steps (vii) to (ix) until a desired accuracy is obtained.

- (2) Input Variables:

TG1	temperature of gaseous phase at stage inlet
TG3	temperature of gaseous phase at stage outlet
TW1	temperature of droplet at stage inlet
TW3	temperature of droplet at stage outlet
DAVEN2	droplet nominal diameter at stage inlet
DEVEN	droplet nominal diameter at stage outlet
DELZI	length of stage
VZ	axial velocity
WMASS1	mass flow rate of water
VMASS1	mass flow rate of water vapor

AMASS	mass flow rate of dry air
CHMASS	mass flow rate of methane
DPG	specific heat constant pressure to gaseous phase
CPW	specific heat of water
RE	Reynolds number based on relative velocity between droplet and gaseous phase.

(3) Output Variables:

DELIGH	temperature drop in gaseous phase due to heat transfer between water droplet and gaseous phase
DELTWH	temperature rise in droplet due to heat transfer between water droplet and gaseous phase

(4) Usage:

CALL WICHET (TG1, TG3, TW3, DAVEN2, DAVEN, DELZI, VZ,
WMASS1, VMASS1, AMASS, CHMASS, CPG, CPW,
DELIGH, DELTWH, RE)

SUBROUTINE WICMAS

(1) Description:

Subroutine WICMAS is called at end of stage to perform the mass transfer calculation between water droplet and gas phases.

The mass transfer rate can be calculated by the following equation

$$\frac{dm}{dt} = h_m A (C_{wb} - C_w)$$

where h_m is the mass transfer coefficient, A , the droplet surface area, C_{wb} , the water vapor concentration at droplet surface, and C_w , the water vapor concentration in fluid flow around droplet.

Since the density represents the mass concentration, and the vapor is almost a perfect gas, the mass transfer rate can be expressed in terms of vapor pressure as follows:

$$\frac{dm}{dt} = h_m A (\rho_{wb} - \rho_w)$$

or

$$\frac{dm}{dt} = h_m A \left(\frac{P_{wb}}{T_{wb}} - \frac{P_w}{T_w} \right) \cdot \frac{1}{R_v}$$

where R_v is the gas constant for water vapor, P_{wb} , the vapor pressure at droplet surface, P_w , the vapor pressure in fluid flowing around droplet, T_{wb} , the vapor temperature at droplet surface, and T_w , the vapor temperature in fluid flowing around droplet.

The surface area, A , for the droplet cloud is given by the relation,

$$A = \pi D_d^2 N_d$$

where D_d is the average droplet diameter, and N_d , the number of droplets.

The mass transfer coefficient, h_m is expressed as follows:

$$h_m = \frac{D_v}{D_d} \cdot Sh$$

A semi-empirical equation for the diffusion coefficient in gases is given by the following: (Reference 28)

$$D_v = 435.7 \frac{T^{3/2}}{p(V_A^{1/3} + V_B^{1/3})^2} \left(\frac{1}{M_A} + \frac{1}{M_B} \right)^{1/2}$$

where D_v is in square centimeters per second, T is in degree Kelvin, p is the total system pressure in newtons per square meter, and V_A and V_B are the molecular volumes of constituents A and B as calculated from the atomic volumes. M_A and M_B are the molecular weights of constituents A and B. For water-air systems, the numerical values of V_A , V_B , M_A and M_B are given as follows:

$$V_A = V_{\text{air}} = 29.9 \quad M_A = M_{\text{air}} = 28.9$$

$$V_B = M_{\text{water}} = 18.8 \quad M_B = M_{\text{water}} = 18.0$$

When the relative velocity between a single droplet and the surrounding fluid approaches zero, the following relationship is used to determine the mass transfer rate: $Sh = 2.0$.

Mass transfer rates increase with increase in relative velocity between the droplet and the surrounding air due to the additional mass transfer caused by the convection in the boundary layer around the droplet. The mass transfer coefficient from a spherical droplet can be expressed in terms of dimensionless groups as follows:

$$Sh = 2.0 + k (Re)^x (Sc)^y$$

where Re is the Reynolds number based on relative velocity, which expresses the ratio of inertial force to viscous force, and Sc is the Schmidt number, which expressed the ratio of kinetic viscosity to molecular diffusivity.

There is much discussion over the values of x , y , and k . The form most widely applied is the Ranz and Marshall equation which is

$$Sh = 2.0 + 0.6 (Re)^{0.50} (Sc)^{0.33}$$

The procedure for determining the mass transfer rate is as follows.

- (i) Calculate the Sherwood number, Sh .
- (ii) Calculate the diffusion coefficient, D_v .
- (iii) Calculate the average droplet size, D_d .
- (iv) Calculate the mass transfer coefficient, h_m .
- (v) Calculate the total number of droplets, N_d .
- (vi) Calculate the total surface area for all droplets.
- (vii) Calculate the water vapor pressure at droplet surface, P_{wb} , based on the droplet surface temperature, T_s .
- (viii) Assume the vapor pressure, p_w , and set $p_w = (p_w)_a$.
- (ix) Calculate the mass transfer rate, $\frac{dm}{dt}$.
- (x) Calculate the new value of water mass flow rate.

$$\dot{m}_w = \dot{m}_w - \frac{dm}{dt}$$
- (xi) Calculate the new value of vapor mass flow rate.

$$\dot{m}_v = \dot{m}_v + \frac{dm}{dt}$$
- (xii) Calculate the specific humidity, W .

$$W = \dot{m}_v / \dot{m}_a$$

 where $\dot{m}_a$ is the air mass flow rate.
- (xiii) Calculate the vapor pressure.
- (xiv) Compare the calculated value, $(p_w)_c$, with the assumed value $(p_w)_a$.
 If $(p_w)_c$ agrees reasonably well with the assumed value $(p_w)_c$ proceed to step (xv). Otherwise, steps (viii) to (xiv) should be repeated.
- (xv) Using the determined p_w , the mass transfer rate is calculated. Also, the specific humidity can be determined by the following equation:

$$W = 0.6219 \frac{P_w}{P - P_w}$$

(2) Input Variables:

HW1	specific humidity at stage inlet
TW1	temperature of droplet at stage inlet
TW2	temperature of droplet at stage outlet
PP1	pressure of gaseous phase stage inlet
PP2	pressure of gaseous phase at stage outlet
TG1	temperature of gaseous phase at stage inlet
TG2	temperature of gaseous phase at stage outlet
DZ	length of stage
VZ	axial velocity
DDAVE1	droplet nominal diameter at stage inlet
DDAVE2	droplet nominal diameter at stage outlet
AMASS	mass flow rate of air
RE	Reynolds number based on relative velocity between droplet and gaseous phase
VMASS1	mass flow rate of water vapor at stage inlet
WMASS1	mass flow rate of water droplet at stage outlet

(3) Output Variables:

HW2	specific humidity at stage outlet
VMASS2	mass flow rate of water vapor at stage outlet
WMASS2	mass flow rate of water droplet at stage outlet
DMDTAV	average mass transfer rate across stage

(4) Usage:

CALL WICMAS (HW1, TW1, TW2, PP1, PP2, TG1, TG2, DZ, PWB1,
PWB2, PW1, PW2, VZ, DDAVE1, DDAVE2, HW2,
VMASS1, VMASS2, WMASS1, WMASS2, DMDTAV,
AMASS, RE)

FUNCTION WICMTR

(1) Description:

Function WICMTR is called in Subroutine WICMTR and calculates the mass transfer rate.

(2) Input Variables:

TTG	temperature of gaseous phase
TTW	temperature of water droplet
PPP	pressure of gaseous phase
DAVW	droplet nominal diameter
VZ	axial velocity
DZ	length of stage
MMASS	mass flow rate of mixture
PW	vapor pressure
RE	Reynolds number based on relative velocity between droplet and gaseous phase

(3) Output Variable:

DMDT	mass transfer rate

(4) Usage:

WICMTR (TTG, TTW, PPP, DAVE, VZ, DZ, MMASS, PW , RE)

FUNCTION WICPWB

(1) Description:

Function WICPWB calculates the saturation pressure for water vapor is a function at temperature as follows:

$$\log_{10} p_s = A - B/T$$

where units are (Kg/cm^2) for p_s and (K) for T. The values of constant A and B are given as follows:

A = 5.97780, B = 2224.4 when $20^\circ\text{C} < T < 100^\circ\text{C}$
A = 5.64850, B = 2101.1 when $100^\circ\text{C} < T < 200^\circ\text{C}$
A = 5.45142, B = 2010.8 when $200^\circ\text{C} < T < 350^\circ\text{C}$

(2) Input Variable:

TWB temperature of gaseous phase

(3) Output Variable:

WICPWB saturation pressure for water vapor

(4) Usage:

WICPWB (TWB)

FUNCTION WICNEW

(1) Description:

Function WICNEW is used to estimate the new trial value in the iteration procedure. Figure A.3.2. shows how to determine the new trial value.

(2) Input Variables:

X1 first trial value

Y1 calculated value corresponds to X1

X2 second trial value

Y2 calculated value corresponds to X2

(3) Output Variable:

WICNEW new trial value

(4) Usage:

WICNEW (X1, Y1, X2, Y2)

FUNCTION WICTAN

(1) Description:

Function WICTAN(X) is used to obtain the ratio of SINE(X) to COSINE(X), that is, TAN(X).

(2) Input Variable:

X angle

(3) Output Variable:

WICTAN value of TAN (X)

(4) Usage:

WICTAN(X)

FUNCTION WICBPT

(1) Description:

Function WICBPT calculates the temperature at boiling point.

(2) Input Variables:

TSTAG temperature

PSTAGE pressure

(3) Output Variable:

WICBPT temperature at boiling point

(4) Usage:

WICBPT (TSTAG, PSTAG)

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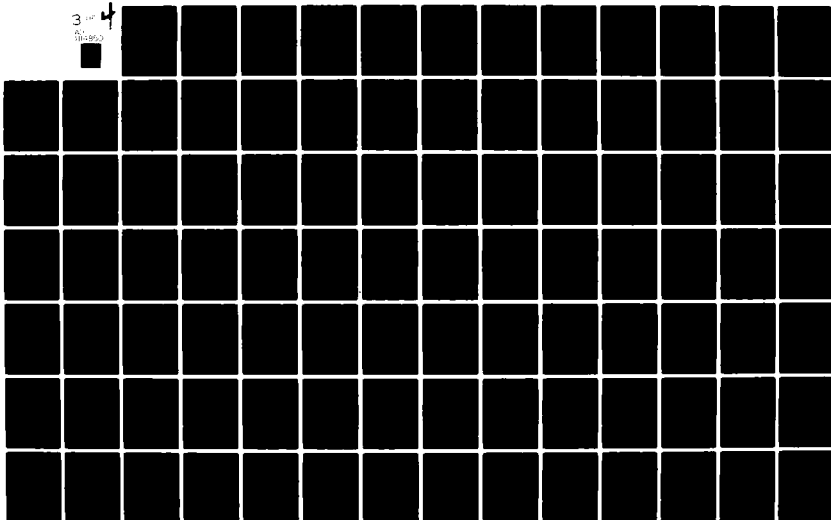
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EFFECT OF WATER ON AXIAL FLOW COMPRESSORS, PART I. ANALYSIS AND--ETC(U)
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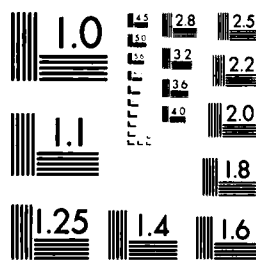
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FUNCTION WICSH

(1) Description

Function WICSH calculates the specific humidity.

(2) Input Variables:

TSTAGE temperature

PSTAG pressure

(3) Output Variable:

WICSH specific humidity

(4) Usage:

WICSH (TSTAG, PSTAG)

SUBROUTINE WICSIZ

(1) Description:

Subroutine WICSIZ is called at outlet of rotor and stator to determine the nominal droplet sizes. It is assumed that two kinds of droplets exist at inlet of compressor; namely, small droplet and large droplet. However, at trailing edge of each blade, the new droplets are re-entrained into blade wake. The droplets which are larger than DLIMIT are treated as large droplets and droplets which are smaller than DLIMIT are treated as small droplets. Each droplet size weighted based on its mass fraction in determining the nominal droplet size. Therefore, at outlet of each blade row, Subroutine WICSIZ gives two nominal diameters; one for small droplet and one for large droplet. It may be noted that only two classes of droplets are recognized in the model.

(2) Input Variables:

WMASSL	mass flow rate of large droplet
WMASSS	mass flow rate of small droplet
AMING1	amount of water which is to be re-entrained into wake, originally small droplet
AMING2	amount of water which is to be re-entrained into wake, originally large droplet and upper part
AMING3	amount of water which is to be re-entrained into wake, originally large droplet and lower part
DL	droplet nominal size for large droplet before impingement
DS	droplet nominal size for small droplet before impingement
D1	droplet size associated with AMING1
D2	droplet size associated with AMING2
D3	droplet size associated with AMING3
DLIMIT	largest droplet diameter which can be treated as small droplet

(3) Output Variables:

AMSL	mass flow rate of small droplet after re-entrainment
AMLGE	mass flow rate of large droplet after re-entrainment
DSLL	droplet nominal size for small droplet
DLGE	droplet nominal size for large droplet

(4) Usage:

CALL WICSIZ (WMASSL, WMASSS, AMING1, AMING2, AMING3, DL, DS, D1, D2, D3, DLIMIT, AMSL, AMLGE, DSLL, DLGE)

SUBROUTINE WICPRP

(1) Description:

Subroutine WICPRP determines the flow properties such as gas constant specific, heat ratio, and specific heat at constant pressure for the gaseous mixture. The working equations are as follows:

$$R_{mix} = x_a \cdot R_a + x_v \cdot R_v + x_c \cdot R_c$$

$$c_{pmix} = x_a \cdot c_{pa} + x_v \cdot c_{pv} + x_c \cdot c_{pc}$$

$$\gamma_{mix} = \left(1.0 - \frac{R_{mix}}{c_{pmix}}\right)^{-1}$$

where

x_a = mass fraction of air in gaseous mixture

x_v = mass fraction of water vapor in gaseous mixture

x_c = mass fraction of methane in gaseous mixture

$$x_a + x_v + x_c = 1$$

R_a = gas constant of air

R_v = gas constant of water vapor

R_c = gas constant of methane

R_{mix} = gas constant of mixture

c_{pa} = specific heat constant pressure for air

c_{pv} = specific heat constant pressure for water vapor

c_{pc} = specific heat at constant pressure for methane

c_{pmix} = specific heat at constant pressure for mixture

r_{mix} = specific heat ratio for mixture

(2) Input Variables:

XAIR mass fraction of air in gaseous mixture

XH2O mass fraction of water vapor in gaseous mixture

XCH4 mass fraction of methane in gaseous mixture

T temperature of gaseous mixture

(3) Output Variables:

RMIX gas constant of gaseous mixture

CPMIX specific heat constant pressure for gaseous mixture

GAMMA specific heat ratio of gaseous mixture

G1 value for $GAMMA / (GAMMA - 1.0)$

G2 value for $(GAMMA - 1.0) / 2.0$

G3 value for $-1.0 / (GAMMA - 1.0)$

(4) Usage:

CALL WICPRP (XAIR, XH2O, XCH4, T, RMIX, CPMIX, GAMMA, G1, G2, G3)

FUNCTION WICCPA

(1) Description

Function WICCPA calculates the specific heat at constant pressure for air as a function of temperature as follows: (Reference 29)

$$c_p = (a + aT + cT^2 + dt^3 + eT^4)R$$

where units are (J/kg-K) for c_p , (K) for T, and (J/kg-K) for R. The values of coefficients a, b, c, d, and e are as follows:

$$a = 3.65359$$

$$b = -1.33736 \times 10^{-10}$$

$$c = 3.29421 \times 10^{-6}$$

$$d = -1.91142 \times 10^{-9}$$

$$e = 0.275462 \times 10^{-12}$$

(2) Input Variable:

T temperature

(3) Output Variable:

WICCPH specific heat constant pressure

(4) Usage:

WICCPH (T)

FUNCTION WICCPH

(1) Description:

Function WICCPH calculates the specific heat at constant pressure for water vapor as a function of temperature as follows: (Reference 29)

$$c_p = (a + bT + cT^2 + dT^3 + eT^4)R$$

where units are (J/kg-K) for c_p , (K) for T, and (J/kg-K) for R. The values of coefficients a, b, c, d, and e are as follows:

$$a = 4.07013$$

$$b = -1.10845 \times 10^{-3}$$

$$c = 4.15212 \times 10^{-6}$$

$$d = -2.96374 \times 10^{-9}$$

$$e = 0.807021 \times 10^{-12}$$

(2) Input Variable:

T temperature

(3) Output Variable:

WICCPH specific heat at constant pressure

(4) Usage:

WICCPH (T)

FUNCTION WICCPH

(1) Description:

Function WICCPH calculates the specific heat at constant pressure for methane as a function of temperature as follows: (Reference 29)

$$c_p = (a + bT + cT^2 + dT^3 + eT^4)R$$

where units are (J/kg-k) for c_p , (K) for T, and (J/kg-K) for R. The values of coefficients a,b,c,d, and e are as follows:

$$a = 3.82619$$

$$b = -3.97946 \times 10^{-3}$$

$$c = 24.5583 \times 10^{-6}$$

$$d = -22.7329 \times 10^{-9}$$

$$e = 6.92760 \times 10^{-12}$$

(2) Input Variable:

T temperature

- (3) Output Variable:
WICCPC specific heat constant pressure
- (4) Usage:
WICCPC (T)

APPENDIX 4

PROGRAM SOURCE LIST

PROGRAM MAIN(INPUT,OUTPUT,TAPES=INPUT,TAPES=OUTPUT)	MAIN	1
C+++++	MAIN	2
C PROGRAM PURDU-WICSTK	MAIN	3
C+++++	MAIN	4
C ABSTRACT:	MAIN	5
C THIS PROGRAM CODE HAS BEEN PRODUCED FOR THE STUDY OF THE AXIAL FLOW	MAIN	6
C COMPRESSOR PERFORMANCE FOR THE GAS-WATER DROPLET MIXTURE FLOW.	MAIN	7
C THE MIXTURE CONSISTES OF TWO TYPES OF DROPLET SIZES AND THREE	MAIN	8
C KINDS OF GASEOUS PHASES.THIS PROGRAM CODE IS WRITTEN ESPECIALLY	MAIN	9
C FOR AIR+WATER VAPOR+METHANE+SMALL DROPLET+LARGE DROPLET.	MAIN	10
C THIS FORTRAN COMPUTER CODE CAN PREDICT THE DESIGN AND OFF-DESIGN	MAIN	11
C PERFORMANCE OF AXIAL FLOW COMPRESSOR. STAGE AND OVERALL PERFORMANCE	MAIN	12
C ARE OBTAINED BY A STAGE-BY-STAGE CALCULATION.	MAIN	13
C THIS COMPUTER PROGRAM CADE HAS BEEN DEVELOPED AT PURDUE UNIVERSITY.	MAIN	14
C THERMAL SCIENCE AND PROPULSION CENTER, WEST LAFAYETTE, INDIANA 47906.	MAIN	15
C UNDER AIR FORCE CONTRACT F33615-78-C-2401, PRINCIPAL INVESTIGATOR: DR.	MAIN	16
C S.N.B.MURTHY. THE AUTHUR OF THIS PROGRAM CODE IS TOSHIKI TSUCHIYA.	MAIN	17
C PURDUE UNIVERSITY, DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS,	MAIN	18
C GRADUATE INSTRUCTOR IN RESEARCH.	MAIN	19
C+++++	MAIN	20
C+++++	MAIN	21
REAL ND, NU, KA, M, Mmass, Mmass1	MAIN	22
REAL Mmass0	MAIN	23
COMMON TD(7), IUNIT	MAIN	24
COMMON CFL, CFT, CFP, CFD, CFM, CFU, CFA	MAIN	25
COMMON JPERFM, RHOG(3), RERUP, RERLOW, RESUP, RESLOW	MAIN	26
COMMON PREB, RRTIP(8), SRTIP(8), AAA1, AAA2, AAA3, SAREA(6), SAREAS(7)	MAIN	27
COMMON P(3), TG(3), XA, XU(3), XCH4, XH(3), XWH(3), XWT(3), TW(3), TWH(3)	MAIN	28
COMMON OMEGS(7), OMEGR(6), GAFR(6), GAPS(6)	MAIN	29
COMMON RRHUB(6), RC(6), RBLADE(6), STAGER(6)	MAIN	30
COMMON SRHUB(7), SC(7), SBLADE(7), STAGES(7)	MAIN	31
COMMON SIGUMR(6), BET1SR(6), BET2SR(6), AINCSP(6), ADEVSR(6)	MAIN	32
COMMON SIGUMS(7), BET1SS(7), BET2SS(7), AINCSS(7), ADEVSS(7)	MAIN	33
COMMON UTIPG(6), UTIP(6), UTIPD(6), UDU(6), UMEAN(6), UHUB(6), U(6), FAI	MAIN	34
COMMON AREA(6), AREAS(7), UU2(6), UTIP2(6), UMEAN2(6), UHUB2(6), IPRINT	MAIN	35
COMMON ICENT, ICENT, FMR1(6), FMA2(6), IDESIN, FAID	MAIN	36
COMMON NS, NS1, RT(6), RM(6), RH(6), ST(6), SM(6), SH(6)	MAIN	37
COMMON DSMASS, AAREA(7), AAREAS(7), PR12D(6), PR13D(6), ETARD(6)	MAIN	38
COMMON DR(6), DS(6), DEGR(6), DEQS(6), BLOCK(6), BLOCKS(7)	MAIN	39
COMMON BET1MR(6), BET2MR(6), BET1MS(7), BET2MS(7), RAD1(6), RAD2(6)	MAIN	40
DIMENSION D(20,3), XD(20,3), XXD(20,3)	MAIN	41
DIMENSION WS(3), WMASS(3), UMASS(3), RHOA(3), RHOM(3), TB(3)	MAIN	42
DIMENSION DELZ(6), ETAA(6)	MAIN	43
DIMENSION XXA(3), XXU(3), DAVE(20)	MAIN	44
DIMENSION TDEW(3)	MAIN	45
DIMENSION DDAVE(20), WMASS(3), WMASS(3)	MAIN	46
DIMENSION TMASS(3), GMASS(3), XAIR(3), XMETAN(3), XGAS(3), FAISTL(6)	MAIN	47
DIMENSION DELB1R(7), DELB1S(7), XG1BLD(7), XG2BLD(7), XG3BLD(7),	MAIN	48
\$XWBLD(7), XWHBLD(7)	MAIN	49
C+++++	MAIN	50
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	51
C	MAIN	52
C READ IUPUT DATA	MAIN	53
C	MAIN	54
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	55
READ(5,99) NS	MAIN	56
99 FORMAT(I1)	MAIN	57
NS1=NS+1	MAIN	58
READ(5,100) (RRHUB(I), I=1, NS)	MAIN	59
100 FORMAT(6F5.3)	MAIN	60
READ(5,111) (RC(I), I=1, NS)	MAIN	61
111 FORMAT(6F5.3)	MAIN	62
READ(5,112) (RBLADE(I), I=1, NS)	MAIN	63
112 FORMAT(6F5.2)	MAIN	64
READ(5,113) (STAGER(I), I=1, NS)	MAIN	65
113 FORMAT(6F5.2)	MAIN	66
READ(5,114) (SRHUB(I), I=1, 7)	MAIN	67
114 FORMAT(7F5.3)	MAIN	68
READ(5,115) (SC(I), I=1, 7)	MAIN	69
115 FORMAT(7F5.3)	MAIN	70

	READ(5,116)(SBLADE(I),I=1,7)	MAIN	71
116	FORMAT(7F5.2)	MAIN	72
	READ(5,117)(SIGUMR(I),I=1,NS)	MAIN	73
117	FORMAT(6F5.3)	MAIN	74
	READ(5,122)(SIGUMS(I),I=1,NS1)	MAIN	75
122	FORMAT(7F5.3)	MAIN	76
	READ(5,127) FNF	MAIN	77
127	FORMAT(F8.2)	MAIN	78
	READ(5,128) XDIN, ICENT, XDDIN, IICENT	MAIN	79
128	FORMAT(F5.3, I1, F5.3, I1)	MAIN	80
	READ(5,129) TOG, TOW, PO	MAIN	81
129	FORMAT(3F7.2)	MAIN	82
	READ(5,130) DIN, DDIN	MAIN	83
130	FORMAT(2F6.1)	MAIN	84
	READ(5,132) FND, T01D, P01D	MAIN	85
132	FORMAT(F7.1, 2F7.2)	MAIN	86
	READ(5,133) XCH4, RHUMID	MAIN	87
133	FORMAT(F5.3, F10.5)	MAIN	88
	READ(5,134) FMWA, FMWU, FMWC	MAIN	89
134	FORMAT(3F7.3)	MAIN	90
	READ(5,135) PREB, DLIMIT	MAIN	91
135	FORMAT(F5.1, F7.1)	MAIN	92
	READ(5,140)(STAGES(I),I=1,NS1)	MAIN	93
140	FORMAT(7F5.2)	MAIN	94
	READ(5,141)(GAPR(I),I=1,NS)	MAIN	95
141	FORMAT(6F7.5)	MAIN	96
	READ(5,142)(GAPS(I),I=1,NS)	MAIN	97
142	FORMAT(6F7.5)	MAIN	98
	READ(5,146)(RRTIP(I),I=1,NS)	MAIN	99
146	FORMAT(6F6.3)	MAIN	100
	READ(5,147)(SRTIP(I),I=1,NS1)	MAIN	101
147	FORMAT(7F6.3)	MAIN	102
	READ(5,148) IPERFM, IUNIT	MAIN	103
148	FORMAT(2I1)	MAIN	104
	READ(5,1491) IRAD	MAIN	105
1491	FORMAT(I1)	MAIN	106
	READ(5,1492)(RT(I),I=1,NS)	MAIN	107
1492	FORMAT(6F5.3)	MAIN	108
	READ(5,1493)(RM(I),I=1,NS)	MAIN	109
1493	FORMAT(6F5.3)	MAIN	110
	READ(5,1494)(RH(I),I=1,NS)	MAIN	111
1494	FORMAT(6F5.3)	MAIN	112
	READ(5,1495)(ST(I),I=1,NS)	MAIN	113
1495	FORMAT(6F5.3)	MAIN	114
	READ(5,1496)(SM(I),I=1,NS)	MAIN	115
1496	FORMAT(6F5.3)	MAIN	116
	READ(5,1497)(SH(I),I=1,NS)	MAIN	117
1497	FORMAT(6F5.3)	MAIN	118
	READ(5,1498)(BLOCK(I),I=1,NS)	MAIN	119
1498	FORMAT(6F5.3)	MAIN	120
	READ(5,1499)(BLOCKS(I),I=1,NS1)	MAIN	121
1499	FORMAT(7F5.3)	MAIN	122
	READ(5,1502)(BET1MR(I),I=1,NS)	MAIN	123
1502	FORMAT(6F5.2)	MAIN	124
	READ(5,1503)(BET2MR(I),I=1,NS)	MAIN	125
1503	FORMAT(6F5.2)	MAIN	126
	READ(5,1504)(BET1MS(I),I=1,NS1)	MAIN	127
1504	FORMAT(7F5.2)	MAIN	128
	READ(5,1505)(BET2MS(I),I=1,NS1)	MAIN	129
1505	FORMAT(7F5.2)	MAIN	130
	READ(5,1506) DSMASS	MAIN	131
1506	FORMAT(F10.6)	MAIN	132
	READ(5,1507)(PR12D(I),I=1,NS)	MAIN	133
1507	FORMAT(6F5.3)	MAIN	134
	READ(5,1508)(PR13D(I),I=1,NS)	MAIN	135
1508	FORMAT(6F5.3)	MAIN	136
	READ(5,1509)(ETARD(I),I=1,NS)	MAIN	137
1509	FORMAT(6F5.3)	MAIN	138
	READ(5,1511)(SAREA(I),I=1,NS)	MAIN	139
1511	FORMAT(F10.7)	MAIN	140

READ(5,1512) (SAREAS(I),I=1,NS1)	MAIN	141
1512 FORMAT(7F10.7)	MAIN	142
READ(5,1513) (DELB1R(I),I=1,NS)	MAIN	143
1513 FORMAT(6F5.2)	MAIN	144
READ(5,1514) (DELB1S(I),I=1,NS1)	MAIN	145
1514 FORMAT(7F5.2)	MAIN	146
READ(5,1515) (XG1BLD(I),I=1,NS)	MAIN	147
1515 FORMAT(6F5.2)	MAIN	148
READ(5,1516) (XG2BLD(I),I=1,NS)	MAIN	149
1516 FORMAT(6F5.2)	MAIN	150
READ(5,1517) (XG3BLD(I),I=1,NS)	MAIN	151
1517 FORMAT(6F5.2)	MAIN	152
READ(5,1518) (XWBLD(I),I=1,NS)	MAIN	153
1518 FORMAT(6F5.2)	MAIN	154
READ(5,1519) (XWWBLD(I),I=1,NS)	MAIN	155
1519 FORMAT(6F5.2)	MAIN	156
READ(5,1520) (BET2SS(I),I=1,NS1)	MAIN	157
1520 FORMAT(7F5.2)	MAIN	158
CFL=2.54	MAIN	159
CFT=1.0/1.8	MAIN	160
CFP=47.880258	MAIN	161
CFD=16.018463	MAIN	162
CFM=0.45359237	MAIN	163
CFU=0.3048	MAIN	164
CFA=0.09290304	MAIN	165
IF(IUNIT.NE.3) GO TO 850	MAIN	166
DO 1560 I=1,NS	MAIN	167
RRHUB(I)=RRHUB(I)*CFL	MAIN	168
RC(I)=RC(I)*CFL	MAIN	169
GAPR(I)=GAPR(I)*CFL	MAIN	170
GAPS(I)=GAPS(I)*CFL	MAIN	171
RRTIP(I)=RRTIP(I)*CFL	MAIN	172
RT(I)=RT(I)*CFL	MAIN	173
RM(I)=RM(I)*CFL	MAIN	174
RH(I)=RH(I)*CFL	MAIN	175
ST(I)=ST(I)*CFL	MAIN	176
SM(I)=SM(I)*CFL	MAIN	177
SH(I)=SH(I)*CFL	MAIN	178
SAREA(I)=SAREA(I)*CFA	MAIN	179
1560 CONTINUE	MAIN	180
DO 1570 I=1,NS1	MAIN	181
SRHUB(I)=SRHUB(I)*CFL	MAIN	182
SC(I)=SC(I)*CFL	MAIN	183
SRTIP(I)=SRTIP(I)*CFL	MAIN	184
SAREAS(I)=SAREAS(I)*CFA	MAIN	185
1570 CONTINUE	MAIN	186
TOG=TOG*CFT	MAIN	187
TOW=TOW*CFT	MAIN	188
P0=P0*CFP	MAIN	189
T01D=T01D*CFT	MAIN	190
P01D=P01D*CFP	MAIN	191
DSMASS=DSMASS*CFM	MAIN	192
IUNIT=2	MAIN	193
850 CONTINUE	MAIN	194
IF(IUNIT.NE.4) GO TO 851	MAIN	195
DO 1561 I=1,NS	MAIN	196
RRHUB(I)=RRHUB(I)/CFL	MAIN	197
RC(I)=RC(I)/CFL	MAIN	198
CAPR(I)=CAPR(I)/CFL	MAIN	199
GAPS(I)=GAPS(I)/CFL	MAIN	200
RRTIP(I)=RRTIP(I)/CFL	MAIN	201
RT(I)=RT(I)/CFL	MAIN	202
RM(I)=RM(I)/CFL	MAIN	203
RH(I)=RH(I)/CFL	MAIN	204
ST(I)=ST(I)/CFL	MAIN	205
SM(I)=SM(I)/CFL	MAIN	206
SH(I)=SH(I)/CFL	MAIN	207
SAREA(I)=SAREA(I)/CFA	MAIN	208
1561 CONTINUE	MAIN	209
DO 1571 I=1,NS1	MAIN	210

	SRHUB(I)=SRHUB(I)/CFL	MAIN	211
	SC(I)=SC(I)/CFL	MAIN	212
	SRTIP(I)=SRTIP(I)/CFL	MAIN	213
	SAREAS(I)=SAREAS(I)/CFA	MAIN	214
1571	CONTINUE	MAIN	215
	TOG=TOG/CFT	MAIN	216
	TOW=TOW/CFT	MAIN	217
	P0=P0/CFP	MAIN	218
	T01D=T01D/CFT	MAIN	219
	P01D=P01D/CFP	MAIN	220
	DSMASS=DSMASS/CFM	MAIN	221
	IUNIT=1	MAIN	222
851	CONTINUE	MAIN	223
	FNFN=FNF*100.0	MAIN	224
	CRPM=FNF*FND	MAIN	225
	IF(IUNIT.EQ.1) FN=FND*FNF*SQR(TOG/518.7)	MAIN	226
	IF(IUNIT.EQ.2) FN=FND*FNF*SQR(TOG/288.17)	MAIN	227
C	+++++	MAIN	228
C	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	229
C		C	230
C	PRINT OUT OF INPUT DATA	C	231
C		C	232
C	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	233
	WRITE(6,1600)	MAIN	234
1600	FORMAT(1H,1X,'***** INPUT DATA *****')	MAIN	235
	\$*****\$)	MAIN	236
	WRITE(6,1610) NS	MAIN	237
1610	FORMAT(1H,1X,'NS(NUMBER OF STAGE)=',I2)	MAIN	238
	IF(IUNIT.EQ.1) WRITE(6,1601)	MAIN	239
1601	FORMAT(1H ,1X,'UNIT=ENGLISH UNIT#')	MAIN	240
	IF(IUNIT.EQ.2) WRITE(6,1602)	MAIN	241
1602	FORMAT(1H ,1X,'UNIT=METRIC UNIT#')	MAIN	242
	WRITE(6,1603) IPERFM	MAIN	243
1603	FORMAT(1H ,1X,'IPERFM=',I1)	MAIN	244
	IF(IRAD.EQ.1) WRITE(6,1604)	MAIN	245
1604	FORMAT(1H ,1X,'PERFORMANCE AT TIP#')	MAIN	246
	IF(IRAD.EQ.2) WRITE(6,1605)	MAIN	247
1605	FORMAT(1H ,1X,'PERFORMANCE AT MEAN#')	MAIN	248
	IF(IRAD.EQ.3) WRITE(6,1606)	MAIN	249
1606	FORMAT(1H ,1X,'PERFORMANCE AT HUB#')	MAIN	250
	WRITE(6,1620)	MAIN	251
1620	FORMAT(1H0,14X,'#1#,5X,#2#,5X,#3#,5X,#4#,5X,#5#,5X,#6#,4X,#IGU#')	MAIN	252
	WRITE(6,1630) (RRHUB(I),I=1,NS)	MAIN	253
1630	FORMAT(1H ,1X,'RRHUB(I)#,3X,6(F5.3,1X))	MAIN	254
	WRITE(6,1640) (RC(I),I=1,NS)	MAIN	255
1640	FORMAT(1H ,1X,'RC(I)#,6X,6(F5.3,1X))	MAIN	256
	WRITE(6,1650) (RBLADE(I),I=1,NS)	MAIN	257
1650	FORMAT(1H ,1X,'RBLADE(I)#,2X,6(F5.2,1X))	MAIN	258
	WRITE(6,1660) (STAGER(I),I=1,NS)	MAIN	259
1660	FORMAT(1H ,1X,'STAGER(I)#,2X,6(F5.2,1X))	MAIN	260
	WRITE(6,1661) (STAGES(I),I=1,NS)	MAIN	261
1661	FORMAT(1H ,1X,'STAGES(I)#,2X,6(F5.2,1X))	MAIN	262
	WRITE(6,1670) (SRHUB(I),I=1,NS1)	MAIN	263
1670	FORMAT(1H ,1X,'SRHUB(I)#,3X,7(F5.3,1X))	MAIN	264
	WRITE(6,1680) (SC(I),I=1,NS)	MAIN	265
1680	FORMAT(1H ,1X,'SC(I)#,6X,6(F5.3,1X))	MAIN	266
	WRITE(6,1690) (SBLADE(I),I=1,NS)	MAIN	267
1690	FORMAT(1H ,1X,'SBLADE(I)#,2X,6(F5.2,1X))	MAIN	268
	WRITE(6,1700) (SIGUMR(I),I=1,NS)	MAIN	269
1700	FORMAT(1H ,1X,'SIGUMR(I)#,2X,6(F5.3,1X))	MAIN	270
	WRITE(6,1750) (SIGUMS(I),I=1,NS)	MAIN	271
1750	FORMAT(1H ,1X,'SIGUMS(I)#,2X,6(F5.3,1X))	MAIN	272
	WRITE(6,1795) (GAPR(I),I=1,NS)	MAIN	273
1795	FORMAT(1H ,1X,'GAPR(I)#,4X,6(F5.3,1X))	MAIN	274
	WRITE(6,1796) (GAPS(I),I=1,NS)	MAIN	275
1796	FORMAT(1H ,1X,'GAPS(I)#,4X,6(F5.3,1X))	MAIN	276
	WRITE(6,1798) (RRTIP(I),I=1,NS)	MAIN	277
1798	FORMAT(1H ,1X,'RRTIP(I)#,3X,6(F5.2,1X))	MAIN	278
	WRITE(6,1799) (SRTIP(I),I=1,NS1)	MAIN	279
1799	FORMAT(1H ,1X,'SRTIP(I)#,3X,7(F5.2,1X))	MAIN	280

WRITE(6,1801) (RT(I),I=1,NS)	MAIN	281
1801 FORMAT(1H,1X,RT(I),6X,6(F5.3,1X))	MAIN	282
WRITE(6,1802) (RM(I),I=1,NS)	MAIN	283
1802 FORMAT(1H,1X,RM(I),6X,6(F5.3,1X))	MAIN	284
WRITE(6,1803) (RH(I),I=1,NS)	MAIN	285
1803 FORMAT(1H,1X,RH(I),6X,6(F5.3,1X))	MAIN	286
WRITE(6,1804) (ST(I),I=1,NS)	MAIN	287
1804 FORMAT(1H,1X,SH(I),6X,6(F5.3,1X))	MAIN	288
WRITE(6,1805) (SM(I),I=1,NS)	MAIN	289
1805 FORMAT(1H,1X,SM(I),6X,6(F5.3,1X))	MAIN	290
WRITE(6,1806) (SH(I),I=1,NS)	MAIN	291
1806 FORMAT(1H,1X,SH(I),6X,6(F5.3,1X))	MAIN	292
WRITE(6,1807) (BLOCK(I),I=1,NS)	MAIN	293
1807 FORMAT(1H,1X,BLOCK(I),3X,6(F5.3,1X))	MAIN	294
WRITE(6,1808) (BLOCKS(I),I=1,NS)	MAIN	295
1808 FORMAT(1H,1X,BLOCKS(I),2X,6(F5.3,1X))	MAIN	296
WRITE(6,1811) (BET1MR(I),I=1,NS)	MAIN	297
1811 FORMAT(1H,1X,BET1MR(I),2X,6(F5.2,1X))	MAIN	298
WRITE(6,1812) (BET2MR(I),I=1,NS)	MAIN	299
1812 FORMAT(1H,1X,BET2MR(I),2X,6(F5.2,1X))	MAIN	300
WRITE(6,1813) (BET1MS(I),I=1,NS1)	MAIN	301
1813 FORMAT(1H,1X,BET1MS(I),2X,7(F5.2,1X))	MAIN	302
WRITE(6,1814) (BET2MS(I),I=1,NS1)	MAIN	303
1814 FORMAT(1H,1X,BET2MS(I),2X,7(F5.2,1X))	MAIN	304
WRITE(6,1815) (PR12D(I),I=1,NS)	MAIN	305
1815 FORMAT(1H,1X,PR12D(I),3X,6(F5.3,1X))	MAIN	306
WRITE(6,1816) (PR13D(I),I=1,NS)	MAIN	307
1816 FORMAT(1H,1X,PR13D(I),3X,6(F5.3,1X))	MAIN	308
WRITE(6,1817) (ETARD(I),I=1,NS)	MAIN	309
1817 FORMAT(1H,1X,ETARD(I),3X,6(F5.3,1X))	MAIN	310
WRITE(6,1818)	MAIN	311
1818 FORMAT(1H1,5X,***** INPUT DATA *****	MAIN	312
\$*****\$)	MAIN	313
WRITE(6,1800) FNF	MAIN	314
1800 FORMAT(1H0,1X,FNF(FRACTION OF DESIGN CORRECTED SPEED)=,F5.3)	MAIN	315
WRITE(6,1810) XDIN,XDDIN,RHUMID,XCH4	MAIN	316
1810 FORMAT(1H0,1X,XDIN(INITIAL WATER CONTENT OF SMALL DROPLET)=,F5.3	MAIN	317
\$,/,2X,XDDIN(INITIAL WATER CONTENT OF LARGE DROPLET)=,F5.3,/,	MAIN	318
\$2X,RHUMID(INITIAL RELATIVE HUMIDITY)=,F6.2,1X,PER CENT=,/,	MAIN	319
\$2X,XCH4(INITIAL METHANE CONTENT)=,F5.3)	MAIN	320
WRITE(6,1820) TOG,TOW,P0	MAIN	321
1820 FORMAT(1H0,1X,TOG(COMPRESSOR INLET TOTAL TEMPRATURE OF GAS)=,	MAIN	322
\$F7.2,/,2X,TOW(COMPRESSOR INLET TEMPERATURE OF DROPLRET)=,F7.2,/,	MAIN	323
\$2X,P0(COMPRESSOR INLET TOTAL PRESSURE)=,F10.2)	MAIN	324
WRITE(6,1830) DIN,DDIN	MAIN	325
1830 FORMAT(1H0,1X,DIN(INITIIL DROPLET DIAMETER OF SMALL DROPLET)=,	MAIN	326
\$F6.1,/,2X,DDIN(INITIAL DROPLET DIAMETER OF LARGE DROPLET)=,F6.1)	MAIN	327
WRITE(6,1850) FND	MAIN	328
1850 FORMAT(1H0,1X,FND(DESIGN ROTATIONAL SPEED)=,F7.1)	MAIN	329
WRITE(6,1851) DSMASS	MAIN	330
1851 FORMAT(1H0,1X,DSMASS(DESIGN MASS FLOW RATE)=,F10.4)	MAIN	331
WRITE(6,1860) TOG	MAIN	332
1860 FORMAT(1H0,1X,COMPRESSOR INLET TATAL TEMPERATURE(GAS PHASE)=,	MAIN	333
\$F7.2)	MAIN	334
WRITE(6,1870) P0	MAIN	335
1870 FORMAT(1H0,1X,COMPRESSOR INLET TOTAL PRESSURE=,F10.2)	MAIN	336
WRITE(6,1880) PREB	MAIN	337
1880 FORMAT(1H0,1X,PREB(PERCENT OF WATER THAT REBOUND AFTER IMPINGE	MAIN	338
\$MENT)=,F5.1,1X,PERCENT=)	MAIN	339
WRITE(6,1900) FN	MAIN	340
1900 FORMAT(1H0,1X,ROTOR SPEED=,F7.1,1X,RPM=)	MAIN	341
WRITE(6,1910) CRPM,FNFN	MAIN	342
1910 FORMAT(1H0,1X,CORRECTED ROTOR SPEED=,F7.1,1X,RPM=,(,2X,F5.1,	MAIN	343
\$PER CENT OF DESIGN CORRECTED SPEED)=)	MAIN	344
IF(IUNIT.NE.2) GO TO 852	MAIN	345
DO 156 I=1,NS	MAIN	346
RRHUB(I)=RRHUB(I)/CFL	MAIN	347
RC(I)=RC(I)/CFL	MAIN	348
GAPR(I)=GAPR(I)/CFL	MAIN	349
GAPS(I)=GAPS(I)/CFL	MAIN	350

RRTIP(I)=RRTIP(I)/CFL	MAIN	351
RT(I)=RT(I)/CFL	MAIN	352
RM(I)=RM(I)/CFL	MAIN	353
RH(I)=RH(I)/CFL	MAIN	354
ST(I)=ST(I)/CFL	MAIN	355
SM(I)=SM(I)/CFL	MAIN	356
SH(I)=SH(I)/CFL	MAIN	357
SAREA(I)=SAREA(I)/CFA	MAIN	358
156 CONTINUE	MAIN	359
DO 157 I=1,NS1	MAIN	360
SRHUB(I)=SRHUB(I)/CFL	MAIN	361
SC(I)=SC(I)/CFL	MAIN	362
SRTIP(I)=SRTIP(I)/CFL	MAIN	363
SAREAS(I)=SAREAS(I)/CFA	MAIN	364
157 CONTINUE	MAIN	365
T0G=T0G/CFT	MAIN	366
T0W=T0W/CFT	MAIN	367
P0=P0/CFP	MAIN	368
T01D=T01D/CFT	MAIN	369
P01D=P01D/CFP	MAIN	370
DSMASS=DSMASS/CFM	MAIN	371
852 CONTINUE	MAIN	372
C+++++	MAIN	373
C OTHER INPUT DATA	MAIN	374
WKDONE=1.0	MAIN	375
IPRINT=1	MAIN	376
DO 153 I=1,NS	MAIN	377
FMR1(I)=0.6	MAIN	378
FMA2(I)=0.6	MAIN	379
153 CONTINUE	MAIN	380
AK1=1.0	MAIN	381
AK2=1.0	MAIN	382
AK3=1.0	MAIN	383
AAAIGU=SAREA(I)	MAIN	384
RU=1545.3	MAIN	385
RHOW=62.54	MAIN	386
CPW=1.00	MAIN	387
RA=RU/FMWA	MAIN	388
RU=RU/FMWU	MAIN	389
RCH=RU/FMWC	MAIN	390
DELU=0.0	MAIN	391
DELUU2=10.0	MAIN	392
DELUL2=10.0	MAIN	393
GC=32.174	MAIN	394
AJ=778.16	MAIN	395
PAI=3.1415926	MAIN	396
DO 150 I=1,NS	MAIN	397
AAREA(I)=PAI*((RRTIP(I)/12.0)**2-(RRHUB(I)/12.0)**2)*BLOCK(I)	MAIN	398
AAREAS(I)=PAI*(SRTIP(I)**2-SRHUB(I)**2)/144.0*BLOCKS(I)	MAIN	399
DELZ(I)=(RC(I)+SC(I))/12.0	MAIN	400
150 CONTINUE	MAIN	401
NS1=NS-1	MAIN	402
AAREAS(NS1)=PAI*(SRTIP(NS1)**2-SRHUB(NS1)**2)/144.0*BLOCKS(NS1)	MAIN	403
AAAR1T=AAREA(I)	MAIN	404
DO 152 I=1,NS	MAIN	405
AREA(I)=SAREA(I)	MAIN	406
AREAS(I)=SAREAS(I)	MAIN	407
152 CONTINUE	MAIN	408
AREAS(NS1)=SAREAS(NS1)	MAIN	409
OT01G=T0G	MAIN	410
OT01D=T0W	MAIN	411
OP01=P0	MAIN	412
DO 151 I=1,NS	MAIN	413
UTIP(I)=RT(I)/12.0*2.0*PAI*FND/60.0	MAIN	414
UTIPG(I)=RRTIP(I)/12.0*2.0*PAI*FND/60.0	MAIN	415
UTIP2(I)=ST(I)/12.0*2.0*PAI*FND/60.0	MAIN	416
UTIPD(I)=RT(I)/12.0*2.0*PAI*FND/60.0	MAIN	417
UOU(I)=(UTIP(I)/UTIPD(I))**2	MAIN	418
UMEAN(I)=RM(I)/12.0*2.0*PAI*FND/60.0	MAIN	419
UMEAN2(I)=SM(I)/12.0*2.0*PAI*FND/60.0	MAIN	420

UHUB(I)=RH(I)/12.0*2.0*PAI*FND/60.0	MAIN	421
UHUB2(I)=SH(I)/12.0*2.0*PAI*FND/60.0	MAIN	422
IF(IRAD.EQ.1) U(I)=UTIP(I)	MAIN	423
IF(IRAD.EQ.2) U(I)=UMEAN(I)	MAIN	424
IF(IRAD.EQ.3) U(I)=UHUB(I)	MAIN	425
IF(IRAD.EQ.1) UU2(I)=UTIP2(I)	MAIN	426
IF(IRAD.EQ.2) UU2(I)=UMEAN2(I)	MAIN	427
IF(IRAD.EQ.3) UU2(I)=UHUB2(I)	MAIN	428
IF(IRAD.EQ.1) RAD1(I)=RT(I)	MAIN	429
IF(IRAD.EQ.1) RAD2(I)=ST(I)	MAIN	430
IF(IRAD.EQ.2) RAD1(I)=RM(I)	MAIN	431
IF(IRAD.EQ.2) RAD2(I)=SM(I)	MAIN	432
IF(IRAD.EQ.3) RAD1(I)=RH(I)	MAIN	433
IF(IRAD.EQ.3) RAD2(I)=SH(I)	MAIN	434
151 CONTINUE	MAIN	435
C+++++	MAIN	436
C BLADE RESETTING	MAIN	437
DO 154 I=1,NS	MAIN	438
BET1MR(I)=BET1MR(I)+DELB1R(I)	MAIN	439
BET2MR(I)=BET2MR(I)+DELB1R(I)	MAIN	440
STAGER(I)=STAGER(I)+DELB1R(I)	MAIN	441
BET1MS(I)=BET1MS(I)+DELB1S(I)	MAIN	442
BET2MS(I)=BET2MS(I)+DELB1S(I)	MAIN	443
STAGES(I)=STAGES(I)+DELB1S(I)	MAIN	444
154 CONTINUE	MAIN	445
TG(I)=T01D	MAIN	446
P(I)=P01D	MAIN	447
CALL WICSPD(DSMAS,ISTAGE)	MAIN	448
C+++++	MAIN	449
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	450
C	C	MAIN
C ROTER SPEED AND RADIUS	C	MAIN
C	C	MAIN
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	454
DO 155 I=1,NS	MAIN	455
UTIP(I)=RT(I)/12.0*2.0*PAI*FN/60.0	MAIN	456
UTIPG(I)=RRIP(I)/12.0*2.0*PAI*FN/60.0	MAIN	457
UTIP2(I)=ST(I)/12.0*2.0*PAI*FN/60.0	MAIN	458
UTIPD(I)=RT(I)/12.0*2.0*PAI*FND/60.0	MAIN	459
UOU(I)=(UTIP(I)/UTIPD(I))**2	MAIN	460
UMEAN(I)=RM(I)/12.0*2.0*PAI*FN/60.0	MAIN	461
UMEAN2(I)=SM(I)/12.0*2.0*PAI*FN/60.0	MAIN	462
UHUB(I)=RH(I)/12.0*2.0*PAI*FN/60.0	MAIN	463
UHUB2(I)=SH(I)/12.0*2.0*PAI*FN/60.0	MAIN	464
IF(IRAD.EQ.1) U(I)=UTIP(I)	MAIN	465
IF(IRAD.EQ.2) U(I)=UMEAN(I)	MAIN	466
IF(IRAD.EQ.3) U(I)=UHUB(I)	MAIN	467
IF(IRAD.EQ.1) UU2(I)=UTIP2(I)	MAIN	468
IF(IRAD.EQ.2) UU2(I)=UMEAN2(I)	MAIN	469
IF(IRAD.EQ.3) UU2(I)=UHUB2(I)	MAIN	470
IF(IRAD.EQ.1) RAD1(I)=RT(I)	MAIN	471
IF(IRAD.EQ.1) RAD2(I)=ST(I)	MAIN	472
IF(IRAD.EQ.2) RAD1(I)=RM(I)	MAIN	473
IF(IRAD.EQ.2) RAD2(I)=SM(I)	MAIN	474
IF(IRAD.EQ.3) RAD1(I)=RH(I)	MAIN	475
IF(IRAD.EQ.3) RAD2(I)=SH(I)	MAIN	476
155 CONTINUE	MAIN	477
C+++++	MAIN	478
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	479
C	C	MAIN
C MASS FLOE RATE	C	MAIN
C	C	MAIN
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	483
901 READ(5,200) FAI	MAIN	484
200 FORMAT(F7.5)	MAIN	485
ISTAGE=0	MAIN	486
N=1	MAIN	487
IF(FAI.GT.1.0) GO TO 998	MAIN	488
IF(IPRINT.EQ.2) WRITE(6,197) FAI	MAIN	489
197 FORMAT(1H1,2X,FAI=,F7.5)	MAIN	490

FAID=FAI	MAIN	491
UZ=UTIPG(1)*FAI	MAIN	492
TG(1)=OT01G	MAIN	493
UZERO=0.0	MAIN	494
UUZERO=0.0	MAIN	495
RZERO=RRHUB(1)	MAIN	496
RRZERO=RRHUB(1)	MAIN	497
ITIP=0	MAIN	498
IITIP=0	MAIN	499
DAVE(N)=0.0	MAIN	500
DDAVE(N)=0.0	MAIN	501
TW(1)=OT01D	MAIN	502
TWW(1)=OT01D	MAIN	503
IF(XDIN.GT.0.0) DAVE(N)=DIN	MAIN	504
IF(XDDIN.GT.0.0) DDAVE(N)=DDIN	MAIN	505
IF(XDIN.GT.0.0) TW(1)=OT01D	MAIN	506
IF(XDDIN.GT.0.0) TWW(1)=OT01D	MAIN	507
P(1)=OP01	MAIN	508
TB(1) = WICBPT(TG(1), P(1))	MAIN	509
WS(1) = WICSH(TG(1), P(1)) * RHUMID/100.0	MAIN	510
PW=WS(1)*P(1)/(WS(1)+0.6219)	MAIN	511
TDEW(1)=WICBPT(TG(1),PW)	MAIN	512
XW(1)=XDIN	MAIN	513
XWW(1)=XDDIN	MAIN	514
XWT(1)=XW(1)+XWW(1)	MAIN	515
XWTQ=XWT(1)	MAIN	516
XU(1)=WS(1)/(1.0+WS(1))*(1.0-XWT(1)-XCH4)	MAIN	517
XA=1.0-XWT(1)-XU(1)-XCH4	MAIN	518
XG=XA+XU(1)+XCH4	MAIN	519
XAIN=XA	MAIN	520
XCH4IN=XCH4	MAIN	521
ISTAGE=1	MAIN	522
CALL WICPRP(XA,XU(1),XCH4,TG(1),RMIX,CPMIX,GAMMA,G1,G2,G3)	MAIN	523
GAMMAI=GAMMA	MAIN	524
RHOG(1)=P(1)/RMIX/TG(1)	MAIN	525
RHOA(1)=P(1)/RA/TG(1)	MAIN	526
AMASSM=-1.0	MAIN	527
AAA2=AAAIGU	MAIN	528
AAA3=AAAIGU	MAIN	529
CALL WICMAC(ISTAGE,AMASSM,TG(1),P(1),M,UZ,C,XWT(1),BET2SS(NS1),	MAIN	530
\$RMIX,CPMIX,AAA3)	MAIN	531
RHOG(1)=(1.0+G2*M**2)**G3*RHOG(1)	MAIN	532
RHOM(1)=1.0/((1.0-XWT(1))/RHOG(1)+XWT(1)/RHOW)	MAIN	533
MMASS = RHOM(1)*FAI*UTIPG(1)*AAA3	MAIN	534
MMASSO=MMASS	MAIN	535
WMASSO=MMASSO*XDIN	MAIN	536
WMASSO=MMASSO*XDDIN	MAIN	537
IF(IPRINT.EQ.2) WRITE(6,5558) MMASSO,XDIN,WMASSO,MMASS	MAIN	538
5558 FORMAT(1H0,2X,4(F10.5,2X))	MAIN	539
DAMY=OT01G/518.7	MAIN	540
DAMY2=OP01/(14.7*144.0)	MAIN	541
CMASS=MMASS*SQRT(DAMY)/DAMY2	MAIN	542
AMASS = XA * MMASS	MAIN	543
WMASS(1)=XW(1)*MMASS	MAIN	544
WMASS(1)=XWW(1)*MMASS	MAIN	545
WTMASS(1)=XWT(1)*MMASS	MAIN	546
UMASS(1)=XU(1)*MMASS	MAIN	547
CHMASS=XCH4*MMASS	MAIN	548
GMASS(1)=MMASS-WTMASS(1)	MAIN	549
CMASS2=GMASS(1)*SQRT(DAMY)/DAMY2	MAIN	550
AMO=AMASS	MAIN	551
UMO=UMASS(1)	MAIN	552
CMO=CHMASS	MAIN	553
GMO=GMASS(1)	MAIN	554
WMO=WMASS(1)	MAIN	555
WMO=WMASS(1)	MAIN	556
WTMO=WTMASS(1)	MAIN	557
TLMO=GMO-WTMO	MAIN	558
TWMASS=WMASSO*AAAR1T/AAAIGU	MAIN	559
TWMASS=WMASSO*AAAR1T/AAAIGU	MAIN	560

WMASTL=TWMAS+TWMAS	MAIN	561
C ++++++	MAIN	562
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	563
C	C	MAIN
C INITIAL VALUES	C	MAIN
C	C	MAIN
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	566
TG(3)=TG(1)	MAIN	567
TW(3)=TW(1)	MAIN	568
TWW(3)=TWW(1)	MAIN	569
P(3)=P(1)	MAIN	570
TB(3)=TB(1)	MAIN	571
WS(3)=WS(1)	MAIN	572
TDEW(3)=TDEW(1)	MAIN	573
XU(3)=XU(1)	MAIN	574
XG=XA+XU(3)+XCH4	MAIN	575
XW(3)=XW(1)	MAIN	576
XWW(3)=XWW(1)	MAIN	577
UMASS(3)=UMASS(1)	MAIN	578
WMASS(3)=WMASS(1)	MAIN	579
WMASS(3)=WMASS(1)	MAIN	580
WCENT=WMASO	MAIN	531
WMCENT=WMASSO	MAIN	582
C ++++++	MAIN	583
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	584
C	C	MAIN
C IGU	C	MAIN
C	C	MAIN
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	586
C IGU IMPINGEMENT	MAIN	587
CALL WICISS(7,RADI1(1), XW(1) , XG , RHOG(1),0.0,UZ,WW1,WW2,WW)	MAIN	588
AMIMPS=WW	MAIN	589
AMWAKS = AMIMPS * (1.0-PREB)	MAIN	590
AMREBS=AMIMPS*PREB	MAIN	591
C ++++++	MAIN	592
C IGU WAKE	MAIN	593
N=2	MAIN	594
DAVE(2)=DAVE(1)	MAIN	595
DDAVE(2)=DDAVE(1)	MAIN	596
ALFA3=BET2SS(NS1)*(FAID/FAI)**(1.0/7.0)	MAIN	597
DWAKEM=0.0	MAIN	598
IF(XDIN.GT.0.0.OR.XDDIN.GT.0.0) GO TO 628	MAIN	599
GO TO 629	MAIN	600
628 CALL WICHAK(RHOG(1),UZ,DWAKE,DWAKEM)	MAIN	601
629 CONTINUE	MAIN	602
C ++++++	MAIN	603
C IGU OUTLET	MAIN	604
WMASS(3) = WMASS(1)	MAIN	605
XW(3) = XW(1)	MAIN	606
PRATIO=1.0	MAIN	607
TRATIO=1.0	MAIN	608
EFF=1.0	MAIN	609
AMIMPR=0.0	MAIN	610
AMREBR=0.0	MAIN	611
AMWAKR=0.0	MAIN	612
DELTGW=0.0	MAIN	613
DELTDW=0.0	MAIN	614
DELTGH=0.0	MAIN	615
DELTDH=0.0	MAIN	616
DELT=0.0	MAIN	617
DELP=0.0	MAIN	618
DMDTAU=0.0	MAIN	619
XU(3)=XU(1)	MAIN	620
XW(3)=XW(1)	MAIN	621
XWW(3)=XWW(1)	MAIN	622
WMASS(3) = WMASS(1)	MAIN	623
WMASS(3)=WMASS(1)	MAIN	624
UMASS(3) = UMASS(1)	MAIN	625
WS(3) = WS(1)	MAIN	626
TDEW(3)=TDEW(1)	MAIN	627
	MAIN	628
	MAIN	629
	MAIN	630

RHOA(3) = RHOA(1)	MAIN	631	
RHOM(3) = RHOM(1)	MAIN	632	
RHOG(3) = RHOG(1)	MAIN	633	
TG(3) = TG(1)	MAIN	634	
TW(3) = TW(1)	MAIN	635	
TWW(3)=TWW(1)	MAIN	636	
P(3) = P(1)	MAIN	637	
TB(3) = TB(1)	MAIN	638	
XU(2)=0.0	MAIN	639	
XW(2) = 0.0	MAIN	640	
XWW(2)=0.0	MAIN	641	
WMASS(2) = 0.0	MAIN	642	
WWMASS(2)=0.0	MAIN	643	
UMASS(2) = 0.0	MAIN	644	
WS(2) = 0.0	MAIN	645	
RHOA(2)=0.0	MAIN	646	
RHOM(2) = 0.0	MAIN	647	
RHOG(2)= 0.0	MAIN	648	
TG(2)=0.0	MAIN	649	
TW(2) = 0.0	MAIN	650	
TWW(2)=0.0	MAIN	651	
P(2) = 0.0	MAIN	652	
TB(2) = 0.0	MAIN	653	
TDEW(2)=0.0	MAIN	654	
GAMMA0=GAMMA	MAIN	655	
RHOG(2)=RHOG(1)	MAIN	656	
C ++++++	MAIN	657	
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	658	
C	C	MAIN	659
C ROTER INLET	C	MAIN	660
C	C	MAIN	661
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	662	
900 Istage=Istage+1	MAIN	663	
IF(IPRINT.EQ.2) WRITE(6,8001) FAIO,Istage	MAIN	664	
8001 FORMAT(1H1,1X,***** 1X,	MAIN	665	
\$=INITIAL FLOW COEFFICIENT=,1X,F5.3,1X, \$(Istage= ,I2,1X,	MAIN	666	
\$=,2X,*****\$)	MAIN	667	
TG(1)=TG(3)	MAIN	668	
TW(1)=TW(3)	MAIN	669	
TWW(1)=TWW(3)	MAIN	670	
P(1)=P(3)	MAIN	671	
TB(1)=TB(3)	MAIN	672	
RHOA(1)=P(1)/RA/TG(1)	MAIN	673	
WS(1)=WS(3)	MAIN	674	
TDEW(1)=TDEW(3)	MAIN	675	
XU(1)=XU(3)	MAIN	676	
XCH4=CHMASS/MMASS	MAIN	677	
XA=AMASS/MMASS	MAIN	678	
XG=XA+XU(1)+XCH4	MAIN	679	
XAIR(1)=XA	MAIN	680	
XMETAN(1)=XCH4	MAIN	681	
XGAS(1)=XG	MAIN	682	
XW(1)=XW(3)	MAIN	683	
XWW(1)=XWW(3)	MAIN	684	
XWT(1)=XW(1)+XWW(1)	MAIN	685	
UMASS(1)=UMASS(3)	MAIN	686	
WMASS(1)=WMASS(3)	MAIN	687	
WWMASS(1)=WWMASS(3)	MAIN	688	
WTMASS(1)=WMASS(1)+WWMASS(1)	MAIN	689	
MMASS=AMASS+CHMASS+UMASS(1)+WTMASS(1)	MAIN	690	
TMASS(1)=MMASS	MAIN	691	
GMASS(1)=TMASS(1)-WTMASS(1)	MAIN	692	
ALFA1=ALFA3	MAIN	693	
CALL WICPRP(XA,XU(1),XCH4,TG(1),RMIX,CPMIX,GAMMA,G1,G2,G3)	MAIN	694	
GAMMA5=GAMMA	MAIN	695	
AAA1=AAA3	MAIN	696	
C ++++++	MAIN	697	
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	698	
C	C	MAIN	699
C STAGE PERFORMANCE CALCULATION	C	MAIN	700

BMWAKR=BMIMPR*(1.0-PREB/100.0)	MAIN	771
BMNOIR=WMASS(1)-BMIMPR	MAIN	772
XWJB=0.0	MAIN	773
IF(WMASS(1).GT.1.0E-6) XWJB=BMWAKR/WMASS(1)	MAIN	774
XWJNOR=BMNOIR/MMASS	MAIN	775
XWJWER=BMREBR/MMASS	MAIN	776
XWJWAR=BMWAKR/MMASS	MAIN	777
IF(IPRINT.EQ.2) WRITE(6,6090) BMIMPR, BMREBR, BMWAKR, BMNOIR, XWJNOR,	MAIN	778
\$XWJWER, XWJWAR	MAIN	779
6090 FORMAT(1H,7(F12.5,1X))	MAIN	780
C ++++++	MAIN	781
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	782
C	C MAIN	783
C ROTOR WAKE	C MAIN	784
C	C MAIN	785
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	786
IF(IPRINT.EQ.2) WRITE(6,8030)	MAIN	787
8030 FORMAT(1H0,= ROTOR WAKE=)	MAIN	788
N=N+1	MAIN	789
ALFA=BETA2	MAIN	790
DWAKEM=0.0	MAIN	791
IF(AMWAKR.GT.0.0) GO TO 630	MAIN	792
GO TO 631	MAIN	793
630 CALL WICWAK(RHOG(1),W2,DWAKE,DWAKEM)	MAIN	794
631 D1=DWAKEM	MAIN	795
IF(D1.LT.0.0) D1=0.0	MAIN	796
IF(D1.GT.DIN) D1=DIN	MAIN	797
AMING1=AMWAKR	MAIN	798
ALFA=BETA2	MAIN	799
RDELU1=DELUV2	MAIN	800
DWAKEM=0.0	MAIN	801
IF(BMWAKR.GT.0.0) GO TO 6310	MAIN	802
GO TO 6311	MAIN	803
6310 CALL WICWAK(RHOG(1),RDELU1,DWAKE,DWAKEM)	MAIN	804
6311 D2=DWAKEM	MAIN	805
IF(D2.LT.0.0) D2=0.0	MAIN	806
IF(D2.GT.DDIN) D2=DDIN	MAIN	807
RUP2=(90.0-BETA2)/180.0	MAIN	808
AMING2=BMWAKR*RUP2	MAIN	809
RDELU2=DELUL2	MAIN	810
DWAKEM=0.0	MAIN	811
IF(BMWAKR.GT.0.0) GO TO 6312	MAIN	812
GO TO 6313	MAIN	813
6312 CALL WICWAK(RHOG(1),RDELU2,DWAKE,DWAKEM)	MAIN	814
6313 D3=DWAKEM	MAIN	815
IF(D3.LT.0.0) D3=0.0	MAIN	816
IF(D3.GT.DDIN) D3=DDIN	MAIN	817
RLOW2=(90.0+BETA2)/180.0	MAIN	818
AMING3=BMWAKR*RLOW2	MAIN	819
WMASS5=WMASS(1)-AMWAKR	MAIN	820
WMASSL=WMASS(1)-BMWAKR	MAIN	821
CALL WICSIZ(WMASSL,WMASS5,AMING1,AMING2,AMING3,DDAVE(1	MAIN	822
\$),DAVE(1),D1,D2,D3,DLIMIT,AMSL,AMLGE,DSL,DLGE)	MAIN	823
WMASS(2)=AMLGE	MAIN	824
WMASS(2)=AMSL	MAIN	825
IF(WMASS(2).LT.0.0) WMASS(2)=0.0	MAIN	826
IF(WMASS(2).LT.0.0) WMASS(2)=0.0	MAIN	827
WTMASS(2)=WMASS(2)+WMASS(2)	MAIN	828
UMASS(2)=UMASS(1)	MAIN	829
MMASS=AMASS+CHMASS+UMASS(2)+WTMASS(2)	MAIN	830
TMASS(2)=MMASS	MAIN	831
GMASS(2)=TMASS(2)-WTMASS(2)	MAIN	832
DAVE(N)=DSL	MAIN	833
DDAVE(N)=DLGE	MAIN	834
XW(2)=WMASS(2)/MMASS	MAIN	835
XWJ(2)=WMASS(2)/MMASS	MAIN	836
XWT(2)=WTMASS(2)/MMASS	MAIN	837
XU(2)=XU(1)	MAIN	838
XCH4=CHMASS/MMASS	MAIN	839
XA=AMASS/MMASS	MAIN	840

XG=XA+XU(2)+XCH4	MAIN	841
XAIR(2)=XA	MAIN	842
XMETAN(2)=XCH4	MAIN	843
XGAS(2)=XG	MAIN	844
WS(2)=UMASS(2)/AMASS	MAIN	845
PW=WS(2)*P(2)/(WS(2)+0.6219)	MAIN	846
TDEW(2)=WICBPT(TG(2),PW)	MAIN	847
RHOA(2)=P(2)/RA/TG(2)	MAIN	848
CALL WICPRP(XA,XU(2),XCH4,TG(2),RMIX,CPMIX,GAMMA,G1,G2,G3)	MAIN	849
RHOG(2)=P(2)/RMIX/TG(2)	MAIN	850
IF(JPERFM.NE.3) BMASS=MMASS	MAIN	851
IF(JPERFM.EQ.3) BMASS=GMASS(2)	MAIN	852
CALL WICMAC(ISTAGE,BMASS,TG(2),P(2),M,UZ,C,XWT(2),ALFA2,	MAIN	853
\$RMIX,CPMIX,AAA2)	MAIN	854
RHOG(2)=(1.0+G2*M**2)**G3*RHOG(2)	MAIN	855
RHOM(2)=1.0/((1.0-XWT(2))/RHOG(2)+XWT(2)/RHOW)	MAIN	856
RHOA(2)=(1.0+G2*M**2)**G3*RHOA(2)	MAIN	857
IF(IPRINT.EQ.2) WRITE(6,614) UZ,ALFA,D1,D2,D3,WMMASS(2),	MAIN	858
\$WMMASS(2),UMASS(2),XU(2),XU(2)	MAIN	859
614 FORMAT(1H,10(F12.5,1X))	MAIN	860
IF(IPRINT.EQ.2) WRITE(6,615)WS(2),DAVE(N),DDAVE(N),RHOM(2),RHOA	MAIN	861
\$(2),RHOM(2),RHOG(2)	MAIN	862
615 FORMAT(1H,7(F12.5,1X))	MAIN	863
IF(UZ.LT.0.0.OR.UZ.GT.1500.0) WRITE(6,6150)	MAIN	864
6150 FORMAT(1H0,=UZ IS TOO HIGH OR TOO LOW: UZ=,F10.4)	MAIN	865
C *****	MAIN	866
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	867
C	MAIN	868
C CENYRIFUGAL ACTION IN ROTOR	MAIN	869
C	MAIN	870
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	871
C CENTRIFUGAL EFFECT IN ROTOR(SMALL DROPLET)	MAIN	872
IF(IPRINT.EQ.2) WRITE(6,8040)	MAIN	873
8040 FORMAT(1H0,=CENTRIFUGAL ACTION IN ROTOR (SMALL DROPLET)=)	MAIN	874
DELMW=0.0	MAIN	875
DELMAS=0.0	MAIN	876
RW=0.0	MAIN	877
RHW=0.0	MAIN	878
IF(WTMASS(1).GT.1.0E-6) RW=WMMASS(1)/WTMASS(1)	MAIN	879
IF(WTMASS(1).GT.1.0E-6) RHW=WMMASS(1)/WTMASS(1)	MAIN	880
AMASW=(WMASSTL-WCENT-WWCENT)*RW	MAIN	881
BMASSW=(WMASSTL-WCENT-WWCENT)*RHW*XUWB	MAIN	882
IF(DAVE(N-1).LT.1.0E-6) GO TO 996	MAIN	883
DD=DAVE(N-1)	MAIN	884
DELZZ=RC(ISTAGE)/12.0	MAIN	885
ALFAAU=(BETA1+BETA2)/2.0	MAIN	886
IRS=2	MAIN	887
RHOGAS=RHOG(2)	MAIN	888
RHUB=RRHUB(ISTAGE)	MAIN	889
CALL WICEN(RZERO,UZERO,DD,UZ,DELZZ,ALFAAU, FN, IRS, RHOGAS,	MAIN	890
1RHUB,R2,U2,ITIP,UZTIME,XG,XA,XU(2),XCH4,RRTIP(ISTAGE))	MAIN	891
CALL WICDMS(IPRINT,IRAD,WMMASS(1),AMASW,AMASH,RZERO,R2,AAREA(ISTA	MAIN	892
\$GE),RADI1(ISTAGE),RRTIP(ISTAGE),DMIN,DMOUT,AMASH2,DELMAS)	MAIN	893
WCENT=DELMAS	MAIN	894
RZERO=R2	MAIN	895
UZERO=U2	MAIN	896
996 DELMW=DELMAS	MAIN	897
C *****	MAIN	898
C CENTRIFUGAL EFFECT IN ROTOR(LARGE DROPLET)	MAIN	899
IF(IPRINT.EQ.2) WRITE(6,8050)	MAIN	900
8050 FORMAT(1H0,= CENTRIFUGAL ACTION IN ROTOR (LARGE DROPLET)=)	MAIN	901
DELMAS=0.0	MAIN	902
DELMW=0.0	MAIN	903
IF(DDAVE(N-1).LT.1.0E-6) GO TO 9996	MAIN	904
DD=DDAVE(N-1)	MAIN	905
DELZZ=RC(ISTAGE)/12.0	MAIN	906
ALFAAU=0.0	MAIN	907
IIRS=2	MAIN	908
RHOGAS=RHOG(2)	MAIN	909
RHUB=RRHUB(ISTAGE)	MAIN	910

CALL WICEN(RRZERO,UZERO,DD,UZ,DELZZ,ALFAU ,FN,IIRS,RHOGAS,	MAIN	911
1RHUB,R2,U2,IITIP,UZTIME,XG,XA,XU(2),XCH4,RR TIP(ISTAGE))	MAIN	912
CALL WICML(IPRINT,IRAD,WMASS(1),BMASH,BMASH,RRZERO,R2,AAREA(IS	MAIN	913
STAGE),RADI1(ISTAGE),RR TIP(ISTAGE),DMIN,DMOUT,AMASH2,DELMAS)	MAIN	914
RRZERO=R2	MAIN	915
UZERO=U2	MAIN	916
9996 DELMW=DELMAS	MAIN	917
WM=WMASS(2)	MAIN	918
WM=WMMASS(2)	MAIN	919
WMASS(2)=WMASS(2)+DELMW	MAIN	920
WMMASS(2)=WMMASS(2)+DELMW	MAIN	921
WTMASS(2)=WMASS(2)+WMMASS(2)	MAIN	922
IF(WTMASS(2).GT.WMASTL) TT=WTMASS(2)/WMASTL	MAIN	923
IF(WTMASS(2).GT.WMASTL) WMASS(2)=WMASS(2)/TT	MAIN	924
IF(WTMASS(2).GT.WMASTL) WMMASS(2)=WMMASS(2)/TT	MAIN	925
DELMW=WMASS(2)-WM	MAIN	926
DELMW=WMMASS(2)-WM	MAIN	927
WTMASS(2)=WMASS(2)+WMMASS(2)	MAIN	928
DELMAS=WTMASS(2)-WTMASS(1)	MAIN	929
MMASS=MMASS+DELMAS	MAIN	930
XW(2)=WMASS(2)/MMASS	MAIN	931
XWW(2)=WMMASS(2)/MMASS	MAIN	932
XU(2)=WMASS(2)/MMASS	MAIN	933
XA=AMASS/MMASS	MAIN	934
XCH4=CHMASS/MMASS	MAIN	935
XG=XA+XU(2)+XCH4	MAIN	936
DELUM=RHOG(2)/RHOW*DELMAS	MAIN	937
WMASS=AMASS-DELUM*(AMASS/GMASS(2))	MAIN	938
WMASS(2)=WMASS(2)-DELUM*(WMASS(2)/GMASS(2))	MAIN	939
CHMASS=CHMASS-DELUM*(CHMASS/GMASS(2))	MAIN	940
MMASS=AMASS+WMASS(2)+CHMASS+WTMASS(2)	MAIN	941
WS(2)=WMASS(2)/MMASS	MAIN	942
WCENT=WCENT+DELMW	MAIN	943
WCENT=WCENT+DELMW	MAIN	944
IF(WMASS(2).LT.1.0E-6) DAVE(N)=0.0	MAIN	945
IF(WMASS(2).LT.1.0E-6) DDAVE(N)=0.0	MAIN	946
C ++++++	MAIN	947
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	948
C	C	MAIN
C STATOR IMPINGEMENT	C	MAIN
C	C	MAIN
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	952
C STATOR IMPINGEMENT(SMALL DROPLET)	MAIN	953
IF(IPRINT.EQ.2) WRITE(6,8060)	MAIN	954
8060 FORMAT(1H,STATOR IMPINGEMENT (SMALL DROPLET)*)	MAIN	955
CALL WICISS(ISTAGE,RADI2(ISTAGE),XW(2),XG,RHOG(2),ALFA2,U2,	MAIN	956
\$W1,W2,W)	MAIN	957
AMIMPS=W	MAIN	958
IF(AMIMPS.GT.WMASS(2)) AMIMPS=WMASS(2)	MAIN	959
IF(AMIMPS.LT.0.0) AMIMPS=0.0	MAIN	960
AMREBS=AMIMPS*PREB/100.0	MAIN	961
AMWAKS=AMIMPS*(1.0-PREB/100.0)	MAIN	962
IF(IPRINT.EQ.2) WRITE(6,617) XW(2),XG,RHOG(2),U2,W,AMIMPS,AMRE	MAIN	963
\$BS,AMWAKS	MAIN	964
617 FORMAT(1H,8(F12.5,1X))	MAIN	965
C ++++++	MAIN	966
C STATOR IMPINGEMENT(LARGE DROPLET)	MAIN	967
IF(IPRINT.EQ.2) WRITE(6,8070)	MAIN	968
8070 FORMAT(1H,STATOR IMPINGEMENT (LARGE DROPLET)*)	MAIN	969
CALL WICISL(ISTAGE,RADI2(ISTAGE),XWW(2),XG,RHOG(2),ALFA2,U2,W1	MAIN	970
\$,W2,W)	MAIN	971
BMIMPS=W	MAIN	972
IF(BMIMPS.LT.0.0) BMIMPS=0.0	MAIN	973
IF(BMIMPS.GT.WMASS(2)) BMIMPS=WMASS(2)	MAIN	974
BMREBS=BMIMPS*PREB/100.0	MAIN	975
BMWAKS=BMIMPS*(1.0-PREB/100.0)	MAIN	976
IF(IPRINT.EQ.2) WRITE(6,6617) XWW(2),XA,RHOG(2),U2,W,BMIMPS,BM	MAIN	977
\$REBS,BMWAKS	MAIN	978
6617 FORMAT(1H,8(F12.5,1X))	MAIN	979
C ++++++	MAIN	980

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	C		981
C	C	MAIN	982
C STATOR WAKE	C	MAIN	993
C	C	MAIN	984
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	C	MAIN	985
IF(IPRINT.EQ.2) WRITE(6,8080)		MAIN	986
8080 FORMAT(1H0,' STATOR WAKE#')		MAIN	987
N=N+1		MAIN	988
ALFA=ALFA3		MAIN	989
DWAKEM=0.0		MAIN	990
IF(AMWAKS.GT.0.0) GO TO 632		MAIN	991
GO TO 633		MAIN	992
632 CALL WICWAK(RHOG(2),U3,DWAKE,DWAKEM)		MAIN	993
633 D1=DWAKEM		MAIN	994
IF(D1.LT.0.0) D1=0.0		MAIN	995
IF(D1.GT.DIN) D1=DIN		MAIN	996
AMING1=AMWAKS		MAIN	997
ALFA=ALFA3		MAIN	998
SDELUV1=DELUV2		MAIN	999
DWAKEM=0.0		MAIN	1000
IF(BMWAKS.GT.0.0) GO TO 6330		MAIN	1001
GO TO 6331		MAIN	1002
6330 CALL WICWAK(RHOG(2),SDELUV1,DWAKE,DWAKEM)		MAIN	1003
6331 D2=DWAKEM		MAIN	1004
IF(D2.LT.0.0) D2=0.0		MAIN	1005
IF(D2.GT.DDIN) D2=DDIN		MAIN	1006
SUP2=(90.0-ALFA3)/180.0		MAIN	1007
AMING2=BMWAKS*SUP2		MAIN	1008
SDELUV2=DELUV2		MAIN	1009
DWAKEM=0.0		MAIN	1010
IF(BMWAKS.GT.0.0) GO TO 6332		MAIN	1011
GO TO 6333		MAIN	1012
6332 CALL WICWAK(RHOG(2),SDELUV2,DWAKE,DWAKEM)		MAIN	1013
6333 D3=DWAKEM		MAIN	1014
IF(D3.LT.0.0) D3=0.0		MAIN	1015
IF(D3.GT.DDIN) D3=DDIN		MAIN	1016
SLOW2=(90.0+ALFA3)/180.0		MAIN	1017
AMING3=BMWAKS*SLOW2		MAIN	1018
WMASSS=WMASS(2)-AMWAKS		MAIN	1019
WMASSL=WMASS(2)-BMWAKS		MAIN	1020
IF(WMASSS.LT.0.0) WMASSS=0.0		MAIN	1021
IF(WMASSL.LT.0.0) WMASSL=0.0		MAIN	1022
CALL WICSIZ(WMASSL,WMASSS,AMING1,AMING2,AMING3,DDAVE(2),DAVE(		MAIN	1023
2),D1,D2,D3,DLIMIT,AMSL,AMLGE,DSL,DLGE)		MAIN	1024
WMASS(3)=AMLGE		MAIN	1025
WMASS(3)=AMSL		MAIN	1026
IF(WMASS(3).LT.0.0) WMASS(3)=0.0		MAIN	1027
IF(WMASS(3).LT.0.0) WMASS(3)=0.0		MAIN	1028
WTMASS(3)=WMASS(2)+WMASS(2)		MAIN	1029
UMASS(3)=UMASS(2)		MAIN	1030
MMASS=AMASS+CHMASS+UMASS(3)+WTMASS(3)		MAIN	1031
TMASS(3)=MMASS		MAIN	1032
GMASS(3)=TMASS(3)-WTMASS(3)		MAIN	1033
DAVE(N)=DSL		MAIN	1034
DDAVE(N)=DLGE		MAIN	1035
XW(3)=WMASS(3)/MMASS		MAIN	1036
XWW(3)=WMASS(3)/MMASS		MAIN	1037
XWT(3)=WTMASS(3)/MMASS		MAIN	1038
XU(3)=XU(2)		MAIN	1039
XA=AMASS/MMASS		MAIN	1040
XCH4=CHMASS/MMASS		MAIN	1041
XG=XAXU(3)+XCH4		MAIN	1042
XAIR(3)=XA		MAIN	1043
XMETAN(3)=XCH4		MAIN	1044
XGAS(3)=XG		MAIN	1045
IF(WMASSO.LT.1.0E-6) WMASSO=WMASS(3)		MAIN	1046
IF(WMASSO.LT.1.0E-6) WMASSO=WMASS(3)		MAIN	1047
IF(WTMASS(3).GT.0.0) RW=WMASS(3)/WTMASS(3)		MAIN	1048
IF(WTMASS(3).GT.0.0) RW=WMASS(3)/WTMASS(3)		MAIN	1049
TG(3)=TG(2)		MAIN	1050

TW(3)=TW(2)	MAIN	1051
IF(IPRINT.EQ.2) WRITE(6,619) RHOA(2),UZ,ALFA,D1,D2,WMASS(3)	MAIN	1052
\$,WMASS(3),UMASS(3),XW(3),XU(3)	MAIN	1053
619 FORMAT(1H,10(F12.5,1X))	MAIN	1054
IF(IPRINT.EQ.2) WRITE(6,620) DAVE(N),TG(3),TW(3)	MAIN	1055
620 FORMAT(1H,3(F12.5,1X))	MAIN	1056
IF(WMASS(2).GT.0.0.AND.WMASS(2).GT.0.0) GO TO 951	MAIN	1057
IF(WMASS(2).GT.0.0) GO TO 951	MAIN	1058
IF(WMASS(2).GT.0.0) GO TO 951	MAIN	1059
WS(3)=WS(2)	MAIN	1060
TB(3)=TB(2)	MAIN	1061
TDEW(3)=TDEW(2)	MAIN	1062
DELTG2=0.0	MAIN	1063
DELTG3=0.0	MAIN	1064
DELTW2=0.0	MAIN	1065
TRATIO=TG(3)/TG(1)	MAIN	1066
DAVE(N)=0.0	MAIN	1067
RHOA(3)=P(3)/RA/TG(3)	MAIN	1068
CALL WICPRP(XA,XU(3),XCH4,TG(3),RMIX,CPMIX,GAMMA,G1,G2,G3)	MAIN	1069
RHOG(3)=P(3)/RMIX/TG(3)	MAIN	1070
IF(JPERFM.NE.3) BMASS=MMASS	MAIN	1071
IF(JPERFM.EQ.3) BMASS=GMASS(3)	MAIN	1072
CALL WICMAC(ISTAGE,BMASS,TG(3),P(3),M,UZ,C,XWT(3),ALFA3,	MAIN	1073
\$RMIX,CPMIX,AAA3)	MAIN	1074
RHOG(3)=(1.0+G2*M**2)**G3*RHOG(3)	MAIN	1075
RHOM(3)=1.0/((1.0-XWT(3))/RHOG(3)+XWT(3)/RHOW)	MAIN	1076
RHOA(3)=(1.0+G2*M**2)**G3*RHOA(3)	MAIN	1077
GO TO 950	MAIN	1078
951 CONTINUE	MAIN	1079
WTMASS(3)=WMASS(3)+WMASS(3)	MAIN	1080
C ++++++	MAIN	1081
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1082
C	C	MAIN 1083
C HEAT TRANSFER CALCULATION	C	MAIN 1084
C	C	MAIN 1085
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1086
C HEAT-TRANSFER (SMALL DROPLET)	MAIN	1087
IF(IPRINT.EQ.2) WRITE(6,8120)	MAIN	1088
8120 FORMAT(1H0,= HEAT TRANSFER=)	MAIN	1089
DELTGH=0.0	MAIN	1090
DELTWH=0.0	MAIN	1091
IF(DAVE(N-2).GT.0.0.AND.DAVE(N).GT.0.0) GO TO 8121	MAIN	1092
GO TO 8122	MAIN	1093
8121 RE=0.0	MAIN	1094
XU1=(XU(1)+XU(3))/2.0	MAIN	1095
XW1=(XW(1)+XW(3))/2.0	MAIN	1096
WMASS1=(WMASS(1)+WMASS(3))/2.0	MAIN	1097
UMASS1=(UMASS(1)+UMASS(3))/2.0	MAIN	1098
CPG1=XA*WICCPA(TG(1))+XU(1)*WICCPH(TG(1))+XCH4*WICCPA(TG(1))	MAIN	1099
CPG3=XA*WICCPA(TG(3))+XU(3)*WICCPH(TG(3))+XCH4*WICCPA(TG(3))	MAIN	1100
CPG=(CPG1+CPG3)/2.0	MAIN	1101
CALL WICHET(TG(1),TG(3),TW(1),TW(3),DAVE(N-2),DAVE(N)	MAIN	1102
\$,DELTZ(ISTAGE),UZ,WMASS1,UMASS1,AMASS,CHMASS,CPG,CPH,DELTGH	MAIN	1103
\$,DELTWH,RE)	MAIN	1104
8122 DELTG2=DELTGH	MAIN	1105
DELTW2=DELTWH	MAIN	1106
C ++++++	MAIN	1107
C HEAT TRANSFER (LARGE DROPLET)	MAIN	1108
DELTGH=0.0	MAIN	1109
DELTWH=0.0	MAIN	1110
IF(DDAVE(N-2).GT.0.0.AND.DAVE(N).GT.0.0) GO TO 8123	MAIN	1111
GO TO 8124	MAIN	1112
8123 RE=0.0	MAIN	1113
IF(DDAVE(N-1).GT.0.0) RE=REAVE	MAIN	1114
XU1=(XU(1)+XU(3))/2.0	MAIN	1115
XW1=(XW(1)+XW(3))/2.0	MAIN	1116
WMASS1=(WMASS(1)+WMASS(3))/2.0	MAIN	1117
UMASS1=(UMASS(1)+UMASS(3))/2.0	MAIN	1118
CPG1=XA*WICCPA(TG(1))+XU(1)*WICCPH(TG(1))+XCH4*WICCPA(TG(1))	MAIN	1119
CPG3=XA*WICCPA(TG(3))+XU(3)*WICCPH(TG(3))+XCH4*WICCPA(TG(3))	MAIN	1120

CPG=(CPG1+CPG3)/2.0	MAIN	1121
CALL WICMET(TG(1),TG(3),TW(1),TW(3),DDAVE(N-2),DDAVE(N)	MAIN	1122
\$,DELZ(ISTAGE),UZ,WMASS1,UMASS1,AMASS,CHMASS,CPG,CPW,DELTGH	MAIN	1123
\$,DELTWH,RE)	MAIN	1124
8124 DELTG3=DELTGH	MAIN	1125
DELTW3=DELTWH	MAIN	1126
TG(3)=TG(1)+DELTG1-DELTG2-DELTG3	MAIN	1127
TW(3)=TW(1)+DELTW1+DELTW2	MAIN	1128
TWW(3)=TWW(1)+DELTW3	MAIN	1129
TRATIO=TG(3)/TG(1)	MAIN	1130
IF(IPRINT.EQ.2) WRITE(6,627) DELTG2,DELTW2,DELTG3,DELTW3,TG(3),	MAIN	1131
\$TW(3),TWW(3),TRATIO	MAIN	1132
627 FORMAT(1H,8(F15.6,1X))	MAIN	1133
C ++++++	MAIN	1134
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1135
C	C	1136
C MASS TRANSFER CALCULATION	C	1137
C	C	1138
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1139
IF(IPRINT.EQ.2) WRITE(6,8130)	MAIN	1140
8130 FORMAT(1H0,= MASS TRANSFER=)	MAIN	1141
DAVEN2=DAVE(N-2)	MAIN	1142
DAVEN=DAVE(N)	MAIN	1143
DZ=DELZ(ISTAGE)	MAIN	1144
RE=0.0	MAIN	1145
DMDTAU=0.0	MAIN	1146
IF(DAVE(N-2).GT.0.0.AND.DAVE(N).GT.0.0) GO TO 636	MAIN	1147
GO TO 637	MAIN	1148
636 CALL WICMAS(WS(1),TW(1),TW(3),P(1),P(3),TG(1),TG(3),DZ,PWB1,PWB2	MAIN	1149
\$,PW1,PW2,UZ,DAVEN2,DAVEN,HW2,UMASS(1),UMASS2,WMASS(1),WMASS2,	MAIN	1150
\$DMDTAU,AMASS,RE)	MAIN	1151
637 DMDTA1=DMDTAU	MAIN	1152
IF(DMDTA1.LT.0.0) DMDTA1=0.0	MAIN	1153
DAVEN2=DDAVE(N-2)	MAIN	1154
DAVEN=DDAVE(N)	MAIN	1155
DZ=DELZ(ISTAGE)	MAIN	1156
RE=0.0	MAIN	1157
DMDTAU=0.0	MAIN	1158
IF(DDAVE(N-1).GT.0.0.AND.DDAVE(N).GT.0.0) RE=REAVE	MAIN	1159
IF(DDAVE(N-2).GT.0.0.AND.DDAVE(N).GT.0.0) GO TO 6360	MAIN	1160
GO TO 6370	MAIN	1161
6360 CALL WICMAS(WS(1),TW(1),TW(3),P(1),P(3),TG(1),TG(3),DZ,PWB1,PWB2	MAIN	1162
\$,PW1,PW2,UZ,DAVEN2,DAVEN,HW2,UMASS(1),UMASS2,WMASS(1),WMASS2,	MAIN	1163
\$DMDTAU,AMASS,RE)	MAIN	1164
6370 DMDTA2=DMDTAU	MAIN	1165
IF(DMDTA2.LT.0.0) DMDTA2=0.0	MAIN	1166
WMASS(3)=WMASS(3)-DMDTA1	MAIN	1167
WWMASS(3)=WWMASS(3)-DMDTA2	MAIN	1168
WMASTL=WMASTL-(DMDTA1+DMDTA2)*AAREAS(ISTAGE)/AAAR	MAIN	1169
IF(WMASTL.LT.0.0) WMASTL=0.0	MAIN	1170
IF(WMASS(3).LT.0.0) WMASS(3)=0.0	MAIN	1171
IF(WWMASS(3).LT.0.0) WWMASS(3)=0.0	MAIN	1172
WTMASS(3)=WMASS(3)+WWMASS(3)	MAIN	1173
UMASS(3)=UMASS(3)+DMDTA1+DMDTA2	MAIN	1174
MMASS=AMASS+CHMASS+UMASS(3)+WTMASS(3)	MAIN	1175
TMASS(3)=MMASS	MAIN	1176
GMASS(3)=TMASS(3)-WTMASS(3)	MAIN	1177
XW(3)=WMASS(3)/MMASS	MAIN	1178
XWW(3)=WWMASS(3)/MMASS	MAIN	1179
XWT(3)=WTMASS(3)/MMASS	MAIN	1180
XU(3)=UMASS(3)/MMASS	MAIN	1181
XA=AMASS/MMASS	MAIN	1182
XCH4=CHMASS/MMASS	MAIN	1183
XG=XA+XU(3)+XCH4	MAIN	1184
XAIR(3)=XA	MAIN	1185
XMETAN(3)=XCH4	MAIN	1186
XGAS(3)=XG	MAIN	1187
WS(3)=UMASS(3)/AMASS	MAIN	1188
PW=WS(3)*P(3)/(WS(3)+0.6219)	MAIN	1189
TDEW(3)=WICBPT(TG(3),PW)	MAIN	1190

RHOA(3)=P(3)/RA/TG(3)	MAIN	1191
CALL WICPRP(XA,XU(3),XCH4,TG(3),RMIX,CPMIX,GAMMA,G1,G2,G3)	MAIN	1192
RHOG(3)=P(3)/RMIX/TG(3)	MAIN	1193
IF(JPERFM.NE.3) BMASS=MMASS	MAIN	1194
IF(JPERFM.EQ.3) BMASS=GMASS(3)	MAIN	1195
CALL WICMAC(ISTAGE,BMASS,TG(3),P(3),M,UZ,C,XWT(3),ALFA3,	MAIN	1196
\$RMIX,CPMIX,AAA3)	MAIN	1197
RHOG(3)=(1.0+G2*M**2)**G3*RHOG(3)	MAIN	1198
RHOM(3)=1.0/((1.0-XWT(3))/RHOG(3)+XWT(3)/RHOW)	MAIN	1199
RHOA(3)=(1.0+G2*M**2)**G3*RHOG(3)	MAIN	1200
TB(3)=WICBPT(TG(3),P(3))	MAIN	1201
IF(IPRINT.EQ.2) WRITE(6,624) WWMASS(3),XWW(3),DDAVE(N),WMASS(3),	MAIN	1202
\$UMASS(3),XW(3),XU(3),WS(3),DAVE(N)	MAIN	1203
624 FORMAT(1H ,9(F12.5,1X))	MAIN	1204
IF(IPRINT.EQ.2) WRITE(6,625) RHOA(3),RHOM(3),RHOG(3),DMDTA1,DMD	MAIN	1205
\$TA2,PH2,TW(3),TG(3)	MAIN	1206
625 FORMAT(1H ,8(F12.5,1X))	MAIN	1207
950 DELTGW=DELTG1	MAIN	1208
DELTGW=DELTW1	MAIN	1209
DELTGH=-DELTG2-DELTG3	MAIN	1210
DELTGH=DELTW2	MAIN	1211
DELP=P(3)-P(1)	MAIN	1212
GAMMAO=GAMMA	MAIN	1213
TB(3)=WICBPT(TG(3),P(3))	MAIN	1214
C ++++++	MAIN	1215
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1216
C	C	MAIN
C OUTPUT(STAGE PERFORMANCE)	C	MAIN
C	C	MAIN
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1219
IF(IUNIT.NE.2) GO TO 853	MAIN	1220
WMASS(1)=WMASS(1)*CFM	MAIN	1221
WMASS(3)=WMASS(3)*CFM	MAIN	1222
WWMASS(1)=WWMASS(1)*CFM	MAIN	1223
WWMASS(3)=WWMASS(3)*CFM	MAIN	1224
WTMASS(1)=WTMASS(1)*CFM	MAIN	1225
WTMASS(3)=WTMASS(3)*CFM	MAIN	1226
AMASS=AMASS*CFM	MAIN	1227
CHMASS=CHMASS*CFM	MAIN	1228
UMASS(1)=UMASS(1)*CFM	MAIN	1229
UMASS(3)=UMASS(3)*CFM	MAIN	1230
GMASS(1)=GMASS(1)*CFM	MAIN	1231
GMASS(3)=GMASS(3)*CFM	MAIN	1232
TMASS(1)=TMASS(1)*CFM	MAIN	1233
TMASS(3)=TMASS(3)*CFM	MAIN	1234
RHOA(1)=RHOA(1)*CFD	MAIN	1235
RHOA(2)=RHOA(2)*CFD	MAIN	1236
RHOA(3)=RHOA(3)*CFD	MAIN	1237
RHOM(1)=RHOM(1)*CFD	MAIN	1238
RHOM(2)=RHOM(2)*CFD	MAIN	1239
RHOM(3)=RHOM(3)*CFD	MAIN	1240
RHOG(1)=RHOG(1)*CFD	MAIN	1241
RHOG(2)=RHOG(2)*CFD	MAIN	1242
RHOG(3)=RHOG(3)*CFD	MAIN	1243
TG(1)=TG(1)*CFT	MAIN	1244
TG(2)=TG(2)*CFT	MAIN	1245
TG(3)=TG(3)*CFT	MAIN	1246
TW(1)=TW(1)*CFT	MAIN	1247
TW(2)=TW(2)*CFT	MAIN	1248
TW(3)=TW(3)*CFT	MAIN	1249
TWW(1)=TWW(1)*CFT	MAIN	1250
TWW(2)=TWW(2)*CFT	MAIN	1251
TWW(3)=TWW(3)*CFT	MAIN	1252
P(1)=P(1)*CFP	MAIN	1253
P(2)=P(2)*CFP	MAIN	1254
P(3)=P(3)*CFP	MAIN	1255
TB(1)=TB(1)*CFT	MAIN	1256
TB(2)=TB(2)*CFT	MAIN	1257
TB(3)=TB(3)*CFT	MAIN	1258
TDEW(1)=TDEW(1)*CFT	MAIN	1259
	MAIN	1260

TDEW(2)=TDEW(2)*CFT	MAIN	1261
TDEW(3)=TDEW(3)*CFT	MAIN	1262
853 CONTINUE	MAIN	1263
WRITE(6,409) FAID,ISTAGE	MAIN	1264
400 FORMAT(1H1,1X,***** #,1X,	MAIN	1265
\$=INITIAL FLOW COEFFICIENT=#,1X,F7.5,1X,=(ISTAGE= #,12,1X,	MAIN	1266
\$=) #,2X,***** #)	MAIN	1267
PRATIO=P(3)/P(1)	MAIN	1268
TRATIO=TG(3)/TG(1)	MAIN	1269
GAMMAU=(GAMMA5+GAMMA0)/2.0	MAIN	1270
G4=(GAMMAU-1.0)/GAMMAU	MAIN	1271
ETAA(ISTAGE)=(PRATIO**G4-1.0)/(TRATIO-1.0)	MAIN	1272
WRITE(6,402) JPERFM	MAIN	1273
402 FORMAT(1H0,5X,=STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT#,	MAIN	1274
\$=(JPERFM=#,11,#)=)	MAIN	1275
WRITE(6,401) PRATIO,TRATIO,ETAA(ISTAGE)	MAIN	1276
401 FORMAT(1H0,5X,=STAGE TOTAL PRESSURE RATIO=#,F12.5,/,	MAIN	1277
\$6X,=STAGE TOTAL TEMPERATURE RATIO=#,F12.5,/,	MAIN	1278
\$6X,=STAGE ADIABATIC EFFICIENCY=#,F12.5)	MAIN	1279
WRITE(6,4025)	MAIN	1280
4025 FORMAT(1H0,12X,=**STAGE INLET**#,4X,=**STAGE OUTLET**#,	MAIN	1281
\$4X,=**STAGE OUTLET**#)	MAIN	1282
WRITE(6,4026)	MAIN	1283
4026 FORMAT(1H ,33X,=(BEFORE INTER-#,6X,=(AFTER INTER-#)	MAIN	1284
WRITE(6,4027)	MAIN	1285
4027 FORMAT(1H ,34X,=STAGE ADJUST-#,7X,=STAGE ADJUST-#)	MAIN	1286
WRITE(6,4028)	MAIN	1287
4028 FORMAT(1H ,34X,=MENT) #,15X,=MENT) #)	MAIN	1288
WRITE(6,405) XU(1), XU(1), XU(3)	MAIN	1289
405 FORMAT(1H ,5X,=XU=#,3(F15.5,5X))	MAIN	1290
WRITE(6,406) XW(1), XW(1), XW(3)	MAIN	1291
406 FORMAT(1H ,5X,=XW=#,3(F15.5,5X))	MAIN	1292
WRITE(6,4060) XWN(1),XWN(1),XWN(3)	MAIN	1293
4060 FORMAT(1H ,5X,=XWN=#,3(F15.5,5X))	MAIN	1294
WRITE(6,4061) XWT(1),XWT(1),XWT(3)	MAIN	1295
4061 FORMAT(1H ,5X,=XWT=#,3(F15.5,5X))	MAIN	1296
WRITE(6,4062) XAIR(1),XAIR(1),XAIR(3)	MAIN	1297
4062 FORMAT(1H ,5X,=XAIR=#,3(F15.5,5X))	MAIN	1298
WRITE(6,4063) XMETAN(1),XMETAN(1),XMETAN(3)	MAIN	1299
4063 FORMAT(1H ,5X,=XMETAN=#,3(F15.5,5X))	MAIN	1300
WRITE(6,4064) XGAS(1),XGAS(1),XGAS(3)	MAIN	1301
4064 FORMAT(1H ,5X,=XGAS=#,3(F15.5,5X))	MAIN	1302
WRITE(6,407) WMASS(1), WMASS(1), WMASS(3)	MAIN	1303
407 FORMAT(1H ,5X,=WMASS=#,3(F15.5,5X))	MAIN	1304
WRITE(6,4070) WNMASS(1),WNMASS(1),WNMASS(3)	MAIN	1305
4070 FORMAT(1H ,5X,=WNMASS=#,3(F15.5,5X))	MAIN	1306
WRITE(6,4071) WTHASS(1),WTHASS(1),WTHASS(3)	MAIN	1307
4071 FORMAT(1H ,5X,=WTHASS=#,3(F15.5,5X))	MAIN	1308
WRITE(6,4072) AMASS,AMASS,AMASS	MAIN	1309
4072 FORMAT(1H ,5X,=AMASS=#,3(F15.5,5X))	MAIN	1310
WRITE(6,4073) CHMASS,CHMASS,CHMASS	MAIN	1311
4073 FORMAT(1H ,5X,=CHMASS=#,3(F15.5,5X))	MAIN	1312
WRITE(6,408) UMASS(1), UMASS(1), UMASS(3)	MAIN	1313
408 FORMAT(1H ,5X,=UMASS=#,3(F15.5,5X))	MAIN	1314
WRITE(6,4080) GMASS(1),GMASS(1),GMASS(3)	MAIN	1315
4080 FORMAT(1H ,5X,=GMASS=#,3(F15.5,5X))	MAIN	1316
WRITE(6,4081) TMASS(1),TMASS(1),TMASS(3)	MAIN	1317
4081 FORMAT(1H ,5X,=TMASS=#,3(F15.5,5X))	MAIN	1318
WRITE(6,409) WS(1), WS(1), WS(3)	MAIN	1319
409 FORMAT(1H ,1X,=WS=#,3(F15.5,5X))	MAIN	1320
WRITE(6,410) RHOA(1), RHOA(2), RHOA(3)	MAIN	1321
410 FORMAT(1H ,5X,=RHOA=#,3(F15.5,5X))	MAIN	1322
WRITE(6,411) RHOM(1), RHOM(2),RHOM(3)	MAIN	1323
411 FORMAT(1H ,5X,=RHOM=#,3(F15.5,5X))	MAIN	1324
WRITE(6,412) RHOG(1),RHOG(2),RHOG(3)	MAIN	1325
412 FORMAT(1H ,5X,=RHOG=#,3(F15.5,5X))	MAIN	1326
WRITE(6,413) TC(1),TC(2),TC(3)	MAIN	1327
413 FORMAT(1H ,5X,=TC=#,3(F15.5,5X))	MAIN	1328
WRITE(6,414) TW(1), TW(2), TW(3)	MAIN	1329
414 FORMAT(1H ,5X,=TW=#,3(F15.5,5X))	MAIN	1330

WRITE(6,4140) TWW(1),TWW(2),TWW(3)	MAIN	1331
4140 FORMAT(1H,5X,#TWW=#,3(F15.5,5X))	MAIN	1332
WRITE(6,415) P(1),P(2),P(3)	MAIN	1333
415 FORMAT(1H,5X,#P=#,3(F15.5,5X))	MAIN	1334
WRITE(6,416) TB(1),TB(2),TB(3)	MAIN	1335
416 FORMAT(1H,5X,#TB=#,3(F15.5,5X))	MAIN	1336
WRITE(6,422) TDEW(1),TDEW(2),TDEW(3)	MAIN	1337
422 FORMAT(1H,5X,#TDEW=#,3(F15.5,5X))	MAIN	1338
IF(IUNIT.NE.2) GO TO 854	MAIN	1339
WMASS(1)=WMASS(1)/CFM	MAIN	1340
WMASS(3)=WMASS(3)/CFM	MAIN	1341
WWMASS(1)=WWMASS(1)/CFM	MAIN	1342
WWMASS(3)=WWMASS(3)/CFM	MAIN	1343
WTMASS(1)=WTMASS(1)/CFM	MAIN	1344
WTMASS(3)=WTMASS(3)/CFM	MAIN	1345
AMASS=AMASS/CFM	MAIN	1346
CHMASS=CHMASS/CFM	MAIN	1347
UMASS(1)=UMASS(1)/CFM	MAIN	1348
UMASS(3)=UMASS(3)/CFM	MAIN	1349
GMASS(1)=GMASS(1)/CFM	MAIN	1350
GMASS(3)=GMASS(3)/CFM	MAIN	1351
THMASS(1)=THMASS(1)/CFM	MAIN	1352
THMASS(3)=THMASS(3)/CFM	MAIN	1353
RHOA(1)=RHOA(1)/CFD	MAIN	1354
RHOA(2)=RHOA(2)/CFD	MAIN	1355
RHOA(3)=RHOA(3)/CFD	MAIN	1356
RHOM(1)=RHOM(1)/CFD	MAIN	1357
RHOM(2)=RHOM(2)/CFD	MAIN	1358
RHOM(3)=RHOM(3)/CFD	MAIN	1359
RHOG(1)=RHOG(1)/CFD	MAIN	1360
RHOG(2)=RHOG(2)/CFD	MAIN	1361
RHOG(3)=RHOG(3)/CFD	MAIN	1362
TG(2)=TG(2)/CFT	MAIN	1363
TG(3)=TG(3)/CFT	MAIN	1364
TW(1)=TW(1)/CFT	MAIN	1365
TW(2)=TW(2)/CFT	MAIN	1366
TW(3)=TW(3)/CFT	MAIN	1367
TWW(1)=TWW(1)/CFT	MAIN	1368
TWW(2)=TWW(2)/CFT	MAIN	1369
TWW(3)=TWW(3)/CFT	MAIN	1370
P(1)=P(1)/CFP	MAIN	1371
P(2)=P(2)/CFP	MAIN	1372
P(3)=P(3)/CFP	MAIN	1373
TB(1)=TB(1)/CFT	MAIN	1374
TB(2)=TB(2)/CFT	MAIN	1375
TB(3)=TB(3)/CFT	MAIN	1376
TDEW(1)=TDEW(1)/CFT	MAIN	1377
TDEW(2)=TDEW(2)/CFT	MAIN	1378
TDEW(3)=TDEW(3)/CFT	MAIN	1379
854 CONTINUE	MAIN	1380
C *****	MAIN	1381
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1382
C	C	MAIN 1383
C BOILING	C	MAIN 1384
C	C	MAIN 1385
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1386
IF(XDIN.GT.0.0) GO TO 450	MAIN	1387
GO TO 450	MAIN	1388
460 IF(TW(3).LT.TB(3)) GO TO 450	MAIN	1389
HU=1115.3272-0.6840905*(TB(3)-460.0)	MAIN	1390
DAMY=CPG/HU*(TG(3)-TB(3))	MAIN	1391
XE=DAMY/(DAMY+1.0)	MAIN	1392
IF(XE.GT.XW(3)) GO TO 451	MAIN	1393
XEVAPD=XE	MAIN	1394
TW(3)=TB(3)	MAIN	1395
TG(3)=TB(3)	MAIN	1396
XW(3)=XW(3)-XEVAPD	MAIN	1397
XU(3)=XU(3)+XEVAPD	MAIN	1398
GO TO 452	MAIN	1399
451 XEVAPD=XW(3)	MAIN	1400

TH(3)=0.0	MAIN	1401
TG(3)=TG(3)-XW(3)/(1.0-XW(3))*HU/CPG	MAIN	1402
XW(3)=0.0	MAIN	1403
XU(3)=XU(3)+XEVAPO	MAIN	1404
452 WMASS(3)=XW(3)*MMASS	MAIN	1405
UMASS(3)=XU(3)*MMASS	MAIN	1406
GMASS(3)=UMASS(3)+AMASS	MAIN	1407
IF(IPRINT.EQ.2) WRITE(6,453)	MAIN	1408
453 FORMAT(1H0, #BOILING#)	MAIN	1409
IF(IPRINT.EQ.2) WRITE(6,454) HU, XEVAPO, TH(3), TG(3), XW(3), XU(3)	MAIN	1410
\$, WMASS(3), GMASS, UMMASS(3), MMASS	MAIN	1411
454 FORMAT(1H0, 10(F10.5, 2X))	MAIN	1412
450 CONTINUE	MAIN	1413
C+++++	MAIN	1414
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1415
C	C	MAIN 1416
C BLEED	C	MAIN 1417
C	C	MAIN 1418
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1419
AMASS=AMASS*(1.0+XG1BLD(ISTAGE))	MAIN	1420
CHMASS=CHMASS*(1.0+XG3BLD(ISTAGE))	MAIN	1421
UMASS(3)=UMASS(3)*(1.0+XG2BLD(ISTAGE))	MAIN	1422
WMASS(3)=WMASS(3)*(1.0+XWBLD(ISTAGE))	MAIN	1423
WMASS(3)=WMASS(3)*(1.0+XWBLD(ISTAGE))	MAIN	1424
WTMASS(3)=WMASS(3)+WMASS(3)	MAIN	1425
MMASS=AMASS+CHMASS+UMASS(3)+WTMASS(3)	MAIN	1426
TMASS(3)=MMASS	MAIN	1427
GMASS(3)=TMASS(3)-WTMASS(3)	MAIN	1428
XW(3)=WMASS(3)/MMASS	MAIN	1429
XW(3)=WMASS(3)/MMASS	MAIN	1430
XWT(3)=WTMASS(3)/MMASS	MAIN	1431
XU(3)=UMASS(3)/MMASS	MAIN	1432
XA=AMASS/MMASS	MAIN	1433
XCH4=CHMASS/MMASS	MAIN	1434
XG=XA+XU(3)+XCH4	MAIN	1435
XAIR(3)=XA	MAIN	1436
XMETAN(3)=XCH4	MAIN	1437
XGAS(3)=XG	MAIN	1438
C+++++	MAIN	1439
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1440
C	C	MAIN 1441
C REPEAT	C	MAIN 1442
C	C	MAIN 1443
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1444
IF(ISTAGE.EQ.NS) GO TO 902	MAIN	1445
GO TO 900	MAIN	1446
902 QUALPR=P(3)/OP01	MAIN	1447
QUALTR=TG(3)/OT01G	MAIN	1448
GAMMAU=(GAMMAI+GAMMAO)/2.0	MAIN	1449
G4=(GAMMAU-1.0)/GAMMAU	MAIN	1450
QUALEF=(QUALPR**G4-1.0)/(QUALTR-1.0)	MAIN	1451
OELTG=TG(3)-OT01G	MAIN	1452
OELTH=0.0	MAIN	1453
DELTW=0.0	MAIN	1454
DELMT=0.0	MAIN	1455
DELMWT=0.0	MAIN	1456
DELMG=0.0	MAIN	1457
IF(XDIN.GT.0.0) ODELTH=TW(3)-OT01D	MAIN	1458
IF(XDDIN.GT.0.0) DELTW=TW(3)-OT01D	MAIN	1459
DELMT=(MMASS-TLMO)/TLMO	MAIN	1460
IF(WTMO.GT.0.0) DELMWT=(WTMASS(3)-WTMO)/WTMO	MAIN	1461
DELMG=(GMASS(3)-GMO)/GMO	MAIN	1462
C+++++	MAIN	1463
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1464
C	C	MAIN 1465
C OUTPUT (OVERALL PERFORMANCE)	C	MAIN 1466
C	C	MAIN 1467
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	MAIN	1468
CMMASS=CMMASS*AAAR1T/AAAIU	MAIN	1469
C2MASS=CMMASS2*AAAR1T/AAAIU	MAIN	1470

IF(IUNIT,NE.2) GO TO 855	MAIN	1471
T0G=T0G/CFT	MAIN	1472
P0=P0/CFP	MAIN	1473
CMASS=CMASS/CFM	MAIN	1474
CCMASS=CCMASS/CFM	MAIN	1475
CMASS2=CMASS2/CFM	MAIN	1476
C2MASS=C2MASS/CFM	MAIN	1477
ODELTG=ODELTG/CFT	MAIN	1478
855 CONTINUE	MAIN	1479
WRITE(6,421)	MAIN	1480
421 FORMAT(1H1,***** OVERALL PERFORMANCE *****)	MAIN	1481
WRITE(6,422) FAIO	MAIN	1482
4220 FORMAT(1H0,1X,INITIAL FLOW COEFFICIENT=F7.5)	MAIN	1483
WRITE(6,423) CRPM,FNF	MAIN	1484
423 FORMAT(1H0,1X,CORRECTED SPEED=F7.1,5X,F5.3,1X,	MAIN	1485
\$FRACTION OF DEIGN CORRECTED SPEED\$)	MAIN	1486
WRITE(6,424)XDIN,XDDIN,XWTO,RHUMID,XCH4IN	MAIN	1487
424 FORMAT(1H0,1X,INITIAL WATER CONTENT(SMALL DROPLET)=F5.3,/,	MAIN	1488
\$2X,INITIAL WATER CONTENT(LARGE DROPLET)=F5.3,/,	MAIN	1489
\$2X,INITIAL WATER CONTENT(TOTAL)=F5.3,/,	MAIN	1490
\$2X,INITIAL RELATIVE HUMIDITY=F5.1,1X,PER CENT=,/,	MAIN	1491
\$2X,INITIAL METHANE CONTENT=F5.3)	MAIN	1492
WRITE(6,425) T0G	MAIN	1493
425 FORMAT(1H0,1X,COMPRESSOR INLET TOTAL TEMPERATURE=F8.2)	MAIN	1494
WRITE(6,426) P0	MAIN	1495
426 FORMAT(1H0,1X,COMPRESSOR INLET TOTAL PRESSURE=F10.2)	MAIN	1496
CCMASS=CMASS*AAAR1T/AAAIGU	MAIN	1497
C2MASS=CMASS2*AAAR1T/AAAIGU	MAIN	1498
WRITE(6,427) CMASS,CCMASS	MAIN	1499
427 FORMAT(1H0,1X,CORRECTED MASS FLOW RATE OF MIXTURE=F6.3,	MAIN	1500
\$=(F6.3,=)	MAIN	1501
WRITE(6,428) CMASS2,C2MASS	MAIN	1502
428 FORMAT(1H0,1X,CORRECTED MASS FLOW RATE OF GAS PHASE =F6.3,	MAIN	1503
\$=(F6.3,=)	MAIN	1504
WRITE(6,429) OVALPR	MAIN	1505
429 FORMAT(1H0,1X,OVERALL TOTAL PRESSURE RATIO=F6.4)	MAIN	1506
WRITE(6,430) OVALTR	MAIN	1507
430 FORMAT(1H0,1X,OVERALL TOTAL TEMPERATURE RATIO=F6.4)	MAIN	1508
WRITE(6,431) OVALEF	MAIN	1509
431 FORMAT(1H0,1X,OVERALL ADIABATIC EFFICIENCY=F6.4)	MAIN	1510
WRITE(6,432) ODELTG	MAIN	1511
432 FORMAT(1H0,1X,OVERALL TEMPERATURE RISE OF GAS PHASE=F8.3)	MAIN	1512
IF(IUNIT,NE.2) GO TO 856	MAIN	1513
T0G=T0G/CFT	MAIN	1514
P0=P0/CFP	MAIN	1515
CMASS=CMASS/CFM	MAIN	1516
CCMASS=CCMASS/CFM	MAIN	1517
CMASS2=CMASS2/CFM	MAIN	1518
C2MASS=C2MASS/CFM	MAIN	1519
ODELTG=ODELTG/CFT	MAIN	1520
856 CONTINUE	MAIN	1521
GO TO 901	MAIN	1522
998 STOP	MAIN	1523
END	MAIN	1524
C ++++++	WICSPA	1
C ++++++	WICSPA	2
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICSPA	3
C	C WICSPA	4
C SUBROUTINE WICSPA	C WICSPA	5
C	C WICSPA	6
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICSPA	7
SUBROUTINE WICSPA(FAIO,ISTAGE,MMASS,ALFA1,WKDONE,DAVE,XDIN,ETA,	WICSPA	8
\$BETA1,BETA2,UZ,ALFA2,ALFA3,DELTG,DELTH,W1,W2,U1,U2,U3,AK1,AK3)	WICSPA	9
REAL M,MMASS	WICSPA	10
COMMON TD(7),IUNIT	WICSPA	11
COMMON CFL,CFT,CFP,CFD,CFM,CFU,CFA	WICSPA	12
COMMON JPERFM,RHOG(3),PERUP,RELOW,RESUP,RESLOW	WICSPA	13
COMMON PREB,RRIP(8),SRTIP(8),AAA1,AAA2,AAA3,SAREA(6),SAREAS(7)	WICSPA	14
COMMON P(3),TG(3),XA,XU(3),XCH4,XW(3),XWU(3),XWT(3),TW(3),TWW(3)	WICSPA	15
COMMON OMEGS(7),OMEGR(6),GAPR(6),GAPS(6)	WICSPA	16

COMMON RRHUB(6) , RC(6) , RBLADE(6) , STAGER(6)	WICSPA	17
COMMON SRHUB(7) , SC(7) , SBLADE(7) , STAGES(7)	WICSPA	18
COMMON SIGUMR(6) , BET1SR(6) , BET2SR(6) , AINCSP(6) , ADEVSR(6)	WICSPA	19
COMMON SIGUMS(7) , BET1SS(7) , BET2SS(7) , AINCSS(7) , ADEVSS(7)	WICSPA	20
COMMON UTIPG(6),UTIP(6),UTIPD(6),UOU(6),UMEAN(6),UHUB(6),U(6),FAI	WICSPA	21
COMMON AREA(6),AREAS(7),UU2(6),UTIP2(6),UMEAN2(6),UHUB2(6),IPRINT	WICSPA	22
COMMON ICENT,ICENT,FMR1(6),FMA2(6),IDESIN,FAID	WICSPA	23
COMMON NS,NS1,RT(6),RM(6),RH(6),ST(6),SM(6),SH(6)	WICSPA	24
COMMON DSMASS,AAREA(7),AAREAS(7),PR12D(6),PR13D(6),ETARD(6)	WICSPA	25
COMMON DR(6),DS(6),DEQR(6),DEQS(6),BLOCK(6),BLOCKS(7)	WICSPA	26
COMMON BET1MR(6),BET2MR(6),BET1MS(7),BET2MS(7),RADI1(6),RADI2(6)	WICSPA	27
DIMENSION RHOM(3),ETAA(8)	WICSPA	28
CPW=1.0	WICSPA	29
RHOW=62.3	WICSPA	30
CALL WICPRP(XA,XU(1),XCH4,TG(1),RMIX,CPMIX,GAMMA,G1,G2,G3)	WICSPA	31
RHOG(1)=P(1)/RMIX/TG(1)	WICSPA	32
BMASS=MMASS	WICSPA	33
CALL WICMAC(ISTAGE,BMASS,TG(1),P(1),M,UZ,C,XWT(1),ALFA1,	WICSPA	34
\$RMIX,CPMIX,AREA(ISTAGE))	WICSPA	35
ASPEED=C	WICSPA	36
RHOG(1)=(1.0+G2*M **2)**G3/RHOG(1)	WICSPA	37
RHOM(1)=1.0/((1.0-XWT(1))/RHOG(1)+XWT(1)/RHOW)	WICSPA	38
UZ=BMASS/RHOM(1)/AREA(ISTAGE)	WICSPA	39
UZZ=UZ	WICSPA	40
FAI=UZ/UTIPG(ISTAGE)	WICSPA	41
IF(IPRINT.EQ.2) WRITE(6,602) ISTAGE	WICSPA	42
602 FORMAT(1H1,1X,\$ROTER INLET ISTAGE=#,I2)	WICSPA	43
XG=XA+XU(1)+XCH4	WICSPA	44
IF(IPRINT.EQ.2) WRITE(6,601) ASPEED,RHOG(1),RHOM(1),XG,XWT(1),	WICSPA	45
\$RHOG(1),FAI,UZ,UTIP	WICSPA	46
601 FORMAT(1H0,9(F12.5,1X))	WICSPA	47
C *****	WICSPA	48
C VELOCITY TRIANGLE	WICSPA	49
CALL WICUT(ISTAGE,ASPEED,ALFA1,UZ,U1,US1,WS1,BETA1,W1,BETA2,	WICSPA	50
\$WS2,US2,ALFA2,W2,U2,ALFA3,U3,AK1,AK3)	WICSPA	51
DELWS=WS1-WS2	WICSPA	52
IF(IPRINT.EQ.2) WRITE(6,605)	WICSPA	53
605 FORMAT(1H0,1X,\$UEL TRI#)	WICSPA	54
IF(IPRINT.EQ.2) WRITE(6,606) ALFA1,UZ,U1,US1,WS1,BETA1,W1,BETA2,	WICSPA	55
\$WS2,US2	WICSPA	56
606 FORMAT(1H0,10(F12.5,1X))	WICSPA	57
IF(IPRINT.EQ.2) WRITE(6,607) ALFA2,W2,U2,ALFA3,DELWS,U3	WICSPA	58
607 FORMAT(1H ,6(F12.5,1X))	WICSPA	59
C *****	WICSPA	60
C PERFORMANCE CURVE	WICSPA	61
CALL WICSCC(FAI,SAI,ETA,TAU,ISTAGE)	WICSPA	62
ETAA(ISTAGE)=ETA	WICSPA	63
IF(SAI.GT.1.0.AND.ETA.GT.0.0) GO TO 203	WICSPA	64
IF(IPRINT.EQ.2) WRITE(6,204) ISTAGE,FAI,SAI,ETA,TAU	WICSPA	65
204 FORMAT(1H0,\$FAI IS TOO BIG OR TOO SMALLE AT ISTAGE=#,	WICSPA	66
\$I2,2X,4(F6.4,5X))	WICSPA	67
GO TO 901	WICSPA	68
203 DELT=TAU*TD(ISTAGE)*UOU(ISTAGE)	WICSPA	69
DELHIN=WICCPA(TG(1))*DELT	WICSPA	70
DELHM=DELHIN	WICSPA	71
DELHG=DELHM*(1.0-XW(1))	WICSPA	72
DELHW=DELHM*XW(1)	WICSPA	73
DELHWW=0.0	WICSPA	74
DELTWW=0.0	WICSPA	75
CPG=CPMIX	WICSPA	76
DELTG=DELHG/CPG/(XU(1)+XA+XCH4)	WICSPA	77
IF(XDIN.GT.0.0) GO TO 850	WICSPA	78
DELTW=0.0	WICSPA	79
GO TO 851	WICSPA	80
850 DELTW=DELHW/CPW/XW(1)	WICSPA	81
851 PRATIO=(DELTG/TG(1)*ETA+1.0)**G1	WICSPA	82
P(3)=PRATIO*P(1)	WICSPA	83
P(2)=P(3)	WICSPA	84
TG(2)=TG(1)+DELTG	WICSPA	85
TW(2)=TW(1)+DELTW	WICSPA	86

TG(3)=TG(2)	WICSPA	87
TW(3)=TW(2)	WICSPA	88
IF(IPRINT.EQ.2) WRITE(6,603)	WICSPA	89
603 FORMAT(1H0,1X, #PERFORMANCE CURVE#)	WICSPA	90
IF(IPRINT.EQ.2) WRITE(6,604) FAI,SAI,ETA,TAU,DELT,PRATIO,P(3),	WICSPA	91
\$DELHIN	WICSPA	92
604 FORMAT(1H ,8(F12.5,1X))	WICSPA	93
IF(IPRINT.EQ.2) WRITE(6,650) DELT, DELHM, DELHG, DELHW, DELTG, DELTH	WICSPA	94
650 FORMAT(1H ,6(F12.5,1X))	WICSPA	95
901 RETURN	WICSPA	96
END	WICSPA	97
C ++++++	WICSCC	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICSCC	2
C	WICSCC	3
C SUBROUTINE WICSCC	WICSCC	4
C	WICSCC	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICSCC	6
SUBROUTINE WICSCC(FAI,SAI,ETA,TAU,ISTAGE)	WICSCC	7
X=FAI	WICSCC	8
IF(ISTAGE.EQ.1) GO TO 11	WICSCC	9
IF(ISTAGE.EQ.2) GO TO 12	WICSCC	10
IF(ISTAGE.EQ.3) GO TO 13	WICSCC	11
IF(ISTAGE.EQ.4) GO TO 14	WICSCC	12
IF(ISTAGE.EQ.5) GO TO 15	WICSCC	13
IF(ISTAGE.EQ.6) GO TO 16	WICSCC	14
11 A1=26.456	WICSCC	15
B1=-366.48033	WICSCC	16
C1=2161.46222	WICSCC	17
D1=-6670.16668	WICSCC	18
E1=11405.55557	WICSCC	19
F1=-10280.00001	WICSCC	20
G1=3822.22223	WICSCC	21
A2=-120.02	WICSCC	22
B2=1599.02	WICSCC	23
C2=-8730.12223	WICSCC	24
D2=25068.33336	WICSCC	25
E2=-39922.22228	WICSCC	26
F2=33466.66671	WICSCC	27
G2=-11555.55557	WICSCC	28
A3=-0.34	WICSCC	29
B3=0.226	WICSCC	30
GO TO 200	WICSCC	31
12 A1=-4.285	WICSCC	32
B1=65.44567	WICSCC	33
C1=-332.95889	WICSCC	34
D1=907.0	WICSCC	35
E1=-1375.55556	WICSCC	36
F1=1093.33334	WICSCC	37
G1=-355.55556	WICSCC	38
A2=116.32	WICSCC	39
B2=-1354.73334	WICSCC	40
C2=6515.80003	WICSCC	41
D2=-16503.33341	WICSCC	42
E2=23266.66677	WICSCC	43
F2=-17333.33341	WICSCC	44
G2=5333.33336	WICSCC	45
A3=-0.055	WICSCC	46
B3=0.095	WICSCC	47
GO TO 200	WICSCC	48
13 A1=154.07500	WICSCC	49
B1=-1761.37834	WICSCC	50
C1=8374.33337	WICSCC	51
D1=-21034.16676	WICSCC	52
E1=29450.00013	WICSCC	53
F1=-21800.00010	WICSCC	54
G1=6666.66670	WICSCC	55
A2=-492.54	WICSCC	56
B2=5539.88003	WICSCC	57
C2=-25815.48301	WICSCC	58
D2=63806.66696	WICSCC	59

\$AK3)	WICSPB	10
REAL M,MMASS	WICSPB	11
COMMON TD(7),TUNIT	WICSPB	12
COMMON CFL,CFT,CFP,CFD,CFM,CFU,CFA	WICSPB	13
COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW	WICSPB	14
COMMON PREB,RRIP(8),SRTIP(8),AAA1,AAA2,AAA3,SAREA(6),SAREAS(7)	WICSPB	15
COMMON P(3),TG(3),XA,XU(3),XCH4,XH(3),XW(3),XWT(3),TW(3),TWH(3)	WICSPB	16
COMMON OMEGS(7),OMEGR(6),GAPR(6),GAPS(6)	WICSPB	17
COMMON RRHUB(6),RC(6),RBLADE(6),STAGER(6)	WICSPB	18
COMMON SRHUB(7),SC(7),SBLADE(7),STAGES(7)	WICSPB	19
COMMON SIGUMR(6),BET1SR(6),BET2SR(6),AINCSP(6),ADEUSR(6)	WICSPB	20
COMMON SIGUMS(7),BET1SS(7),BET2SS(7),AINCSS(7),ADEUSS(7)	WICSPB	21
COMMON UTIPG(6),UTIP(6),UTIPD(6),UOU(6),UMEAN(6),UHUB(6),U(6),FAI	WICSPB	22
COMMON AREA(6),AREAS(7),UU2(6),UTIP2(6),UMEAN2(6),UHUB2(6),IPRINT	WICSPB	23
COMMON ICENT,IICENT,FMR1(6),FMA2(6),IDESIN,FAID	WICSPB	24
COMMON NS,NS1,RT(6),RM(6),RH(6),ST(6),SM(6),SH(6)	WICSPB	25
COMMON DSMASS,AAREA(7),AAREAS(7),PR12D(6),PR13D(6),ETARD(6)	WICSPB	26
COMMON DR(6),DS(6),DEQR(6),DEQS(6),BLOCK(6),BLOCKS(7)	WICSPB	27
COMMON BET1MR(6),BET2MR(6),BET1MS(7),BET2MS(7),RADI1(6),RADI2(6)	WICSPB	28
DIMENSION RHOM(3),ETAA(6)	WICSPB	29
AJ=778.26	WICSPB	30
PAI=3.1415926	WICSPB	31
CPW=1.0	WICSPB	32
RHOW=62.3	WICSPB	33
GC=32.174	WICSPB	34
CALL WICPRP(XA,XU(1),XCH4,TG(1),RMIX,CPMIX,GAMMA,G1,G2,G3)	WICSPB	35
GAMMA1=GAMMA	WICSPB	36
RHOG(1)=P(1)/RMIX/TG(1)	WICSPB	37
BMASS=MMASS	WICSPB	38
AAA2=AREAS(ISTAGE)	WICSPB	39
AAA3=AREA(ISTAGE+1)	WICSPB	40
IF(ISTAGE.EQ.NS) AAA3=AAA2	WICSPB	41
CALL WIMAC(ISTAGE,BMASS,TG(1),P(1),M,UZ,C,XWT(1),ALFA1,	WICSPB	42
\$RMIX,CPMIX,AAA1)	WICSPB	43
ASPEED=C	WICSPB	44
ASPD1=ASPEED	WICSPB	45
RHOG(1)=(1.0+G2*M **2)**G3*RHOG(1)	WICSPB	46
RHOM(1)=1.0/((1.0-XWT(1))/RHOG(1)+XWT(1)/RHOW)	WICSPB	47
UZ1=UZ	WICSPB	48
UZZ=UZ	WICSPB	49
FAI1=UZ1/UTIPG(ISTAGE)	WICSPB	50
ALFA1R = ALFA1 * PAI / 180.0	WICSPB	51
U1 = UZ / COS (ALFA1R)	WICSPB	52
US1 = UZ * TAN (ALFA1R)	WICSPB	53
WS1 = U(ISTAGE)- US1	WICSPB	54
T = WS1 / UZ	WICSPB	55
BETA1R = ATAN (T)	WICSPB	56
BETA1 = BETA1R * 180.0 / PAI	WICSPB	57
TT = UZ **2 + WS1 **2	WICSPB	58
W1 = SQRT (TT)	WICSPB	59
AMACH1 = W1 / ASPEED	WICSPB	60
AMAC1=U1/ASPEED	WICSPB	61
TS1=TG(1)/(1.0+G2*AMAC1**2)	WICSPB	62
PS1=(TG(1)/TS1)**(-G1)*P(1)	WICSPB	63
PREL1=(1.0+G2*AMACH1**2)**G1*PS1	WICSPB	64
TREL1=(1.0+G2*AMACH1**2)*TS1	WICSPB	65
JJJ=1	WICSPB	66
2000 UZZAS=UZ	WICSPB	67
CALL WICGSL(OMEGR(ISTAGE),SIGUMR(ISTAGE),BET1SR(ISTAGE),BET2SR(ISTAGE),AINCSP(ISTAGE),ADEUSR(ISTAGE),AMACH1,BETA1,DEQ,DEQN,SITACS,	WICSPB	68
\$SITACN,BET2N,OMEGAN,FMR1(ISTAGE),IDESIN,AK1,AK2,AK3,UZ1,UZZAS,	WICSPB	69
\$U(ISTAGE),RADI1(ISTAGE),RADI2(ISTAGE))	WICSPB	70
IF(IPRINT.EQ.2) WRITE(6,190) OMEGR(ISTAGE),SIGUMR(ISTAGE),	WICSPB	71
\$BET1SR(ISTAGE),BET2SR(ISTAGE),AINCSP(ISTAGE),ADEUSR(ISTAGE),	WICSPB	72
\$AMACH1,BETA1,DEQ,DEQN,SITACS,SITACN,BET2N,OMEGAN	WICSPB	73
190 FORMAT(1H0,1X,14(F7.3,2X))	WICSPB	74
DEQRR=DEQN	WICSPB	75
SITACR=SITACN	WICSPB	76
AINCIR=BETA1-BET1MR(ISTAGE)	WICSPB	77
ADEVIR=BET2N-BET2MR(ISTAGE)	WICSPB	78
	WICSPB	79

IF(IPRINT.EQ.2) WRITE(6,191) AINCIR,AINCSP(ISTAGE),ADEVIR,	WICSPB	80
\$ADEUSR(ISTAGE)	WICSPB	81
191 FORMAT(1H0,1X,4(F7.3,2X))	WICSPB	82
OMEGA1=OMEGAN	WICSPB	83
BETA2=BET2N	WICSPB	84
BETA2R=BETA2*PAI/180.0	WICSPB	85
W2=UZ/COS(BETA2R)	WICSPB	86
UG=(W1+W2)/2.0	WICSPB	87
OMEGAP=0.0	WICSPB	88
IF(XH(1).GT.0.0)	WICSPB	89
\$CALL WICSDL(RC(ISTAGE),SIGLMR(ISTAGE),BETA1,BETA2,UG,RHOG(1),	WICSPB	90
\$WMAS,AAA1,UZ,IPRINT,OMEGAP)	WICSPB	91
OMEGA2=OMEGAP	WICSPB	92
DELP2=OMEGA2*0.5*RHOG(1)/GC*(W1**2)	WICSPB	93
OMEGA3=0.0	WICSPB	94
DELP3=0.0	WICSPB	95
BETA2R = BETA2 * PAI / 180.0	WICSPB	96
JJ=1	WICSPB	97
200 UZAS=UZ	WICSPB	98
WS2 = UZ * TAN (BETA2R)	WICSPB	99
US2 = UU2(ISTAGE) - WS2	WICSPB	100
IF(US2.LT.0.0) GO TO 999	WICSPB	101
TTT=US2/UZ	WICSPB	102
ALFA2R = ATAN (TTT)	WICSPB	103
ALFA2 = ALFA2R * 180.0 / PAI	WICSPB	104
TTTT = UZ ** 2 + WS2 ** 2	WICSPB	105
W2 = SQRT (TTTT)	WICSPB	106
TTTTT = UZ ** 2 + US2 ** 2	WICSPB	107
U2 = SQRT (TTTTT)	WICSPB	108
DELH=HKDONE*(UU2(ISTAGE)*US2-U(ISTAGE)*U1)/GC/AJ	WICSPB	109
XG=1.0-XWT(1)	WICSPB	110
CALL WICIRS(ISTAGE,RRTP(ISTAGE),XH(1),XG,RHOG(1),BETA1,W1,W11,	WICSPB	111
\$WH2,W1)	WICSPB	112
AMIMPR=WH	WICSPB	113
IF(AMIMPR.GT.WMAS) AMIMPR=WMAS	WICSPB	114
PREB=50.0	WICSPB	115
AMREBR=AMIMPR*PREB/100.0	WICSPB	116
AMWAKR=AMIMPR*(1.0-PREB/100.0)	WICSPB	117
AMNOIR=WMAS-AMIMPR	WICSPB	118
XWNOIR=AMNOIR/MMASS	WICSPB	119
XWREBR=AMREBR/MMASS	WICSPB	120
XWAKR=AMWAKR/MMASS	WICSPB	121
XW1=0.0	WICSPB	122
XW2=0.0	WICSPB	123
XW3=0.0	WICSPB	124
IF(WMAS.GT.0.0) XW1=AMNOIR/WMAS	WICSPB	125
IF(WMAS.GT.0.0) XW2=AMWAKR/WMAS	WICSPB	126
IF(WMAS.GT.0.0) XW3=AMREBR/WMAS	WICSPB	127
DELTG=DELH/CPMIX	WICSPB	128
DELTW1=DELH/CPW	WICSPB	129
DELTW2=DELH/CPW	WICSPB	130
DELTW3=0.0	WICSPB	131
DELTW=XW1*DELTW1+XW2*DELTW2+XW3*DELTW3	WICSPB	132
TH(2)=TH(1)+DELTW	WICSPB	133
TG(2)=TG(1)+DELTG	WICSPB	134
TS2=TG(2)-U2**2/(2.0*CPMIX*GC*AJ)	WICSPB	135
AG2=(GAMMA*RMIX*TS2*GC)**0.5	WICSPB	136
ASPEED=WICASD(XWT(1),RHOG(1),AG2)	WICSPB	137
AMAC2=U2/ASPEED	WICSPB	138
AMACH2=W2/ASPEED	WICSPB	139
PP1=GAMMA*RMIX*TREL1*GC	WICSPB	140
PP2=(UU2(ISTAGE)/U(ISTAGE))**2-1.0	WICSPB	141
PP3=1.0+G2*U(ISTAGE)**2/PP1*PP2	WICSPB	142
PP=PP3**G1	WICSPB	143
PRREL=PP-(OMEGA1+OMEGA2+OMEGA3)*(1.0-PS1/PREL1)	WICSPB	144
PR12=(TG(2)/TG(1))**G1*PRREL/PP	WICSPB	145
P(2)=PR12*P(1)	WICSPB	146
PS2=(1.0+G2*AMAC2**2)**(-G1)*P(2)	WICSPB	147
RHOG2=PS2/RMIX/TS2	WICSPB	148
RHOG(2)=RHOG2	WICSPB	149

RHOM2=1.0/(XG/RHOG2+XWT(1)/RHOW)	WICSPB	150
UZ=BMASS/RHOM2/AAA2	WICSPB	151
UZ2=UZ	WICSPB	152
EPS=1.0E-4	WICSPB	153
IF(JJ.EQ.2) GO TO 201	WICSPB	154
IF(JJ.GT.2) GO TO 202	WICSPB	155
X1=UZAS	WICSPB	156
Y1=UZ2	WICSPB	157
UZ=UZ2	WICSPB	158
JJ=JJ+1	WICSPB	159
GO TO 200	WICSPB	160
201 X2=UZAS	WICSPB	161
Y2=UZ2	WICSPB	162
UZ=WICNEW(X1,Y1,X2,Y2)	WICSPB	163
IF(IPRINT.EQ.2) WRITE(6,203) JJ,UZ	WICSPB	164
203 FORMAT(1H ,1X,I1,2X,=UZ2=,F10.5)	WICSPB	165
JJ=JJ+1	WICSPB	166
IF(UZ.LT.0.0.OR.UZ.GT.ASPEED) GO TO 999	WICSPB	167
GO TO 200	WICSPB	168
202 IF(ABS((UZAS-UZ2)/UZAS).LT.EPS) GO TO 300	WICSPB	169
X1=X2	WICSPB	170
Y1=Y2	WICSPB	171
X2=UZAS	WICSPB	172
Y2=UZ2	WICSPB	173
UZ=WICNEW(X1,Y1,X2,Y2)	WICSPB	174
IF(IPRINT.EQ.2) WRITE(6,204) JJ,UZ	WICSPB	175
204 FORMAT(1H0,1X,I1,2X,=UZ2=,F10.5)	WICSPB	176
JJ=JJ+1	WICSPB	177
IF(UZ.LT.0.0.OR.UZ.GT.ASPEED) GO TO 999	WICSPB	178
IF(JJ.EQ.20) GO TO 300	WICSPB	179
GO TO 200	WICSPB	180
300 UZ2CL=UZ	WICSPB	181
IF(JJJ.EQ.2) GO TO 2010	WICSPB	182
IF(JJJ.GT.2) GO TO 2020	WICSPB	183
XX1=UZ2AS	WICSPB	184
YY1=UZ2CL	WICSPB	185
JJJ=JJJ+1	WICSPB	186
GO TO 2000	WICSPB	187
2010 XX2=UZ2AS	WICSPB	188
YY2=UZ2CL	WICSPB	189
UZ=WICNEW(XX1,YY1,XX2,YY2)	WICSPB	190
IF(IPRINT.EQ.2) WRITE(6,2030) JJJ,UZ	WICSPB	191
2030 FORMAT(1H ,1X,I2,=UZ22=,F10.5)	WICSPB	192
JJJ=JJJ+1	WICSPB	193
GO TO 2000	WICSPB	194
2020 IF(ABS((UZ2AS-UZ2CL)/UZ2AS).LT.EPS) GO TO 3000	WICSPB	195
XX1=XX2	WICSPB	196
YY1=YY2	WICSPB	197
XX2=UZ2AS	WICSPB	198
YY2=UZ2CL	WICSPB	199
UZ=WICNEW(XX1,YY1,XX2,YY2)	WICSPB	200
IF(IPRINT.EQ.2) WRITE(6,2040) JJJ,UZ	WICSPB	201
2040 FORMAT(1H ,1X,I2,=UZ22=,F10.5)	WICSPB	202
JJJ=JJJ+1	WICSPB	203
IF(JJJ.EQ.20) GO TO 3000	WICSPB	204
GO TO 2000	WICSPB	205
3000 UZ2=UZ2CL	WICSPB	206
FAI2=UZ2/UTIPG(ISTAGE)	WICSPB	207
P(2)=(1.0+G2*AMAC2**2)**G1*PS2	WICSPB	208
JJJJ=1	WICSPB	209
3001 UZ3AS=UZ	WICSPB	210
CALL WICGSL(OMEGS(ISTAGE),SIGUMS(ISTAGE),BET1SS(ISTAGE),	WICSPB	211
\$BET2SS(ISTAGE),AINCSS(ISTAGE),ADEUSS(ISTAGE),AMAC2,ALFA2,DEQS,	WICSPB	212
\$DEQN,SITACS,SITACN,BET2N,OMEGAN,FMA2(ISTAGE),IDESIN,AK1,AK2,AK3,	WICSPB	213
\$UZ2,UZ3AS,0.0,RADI2(ISTAGE),RADI1(ISTAGE+1))	WICSPB	214
ASPED2=ASPEED	WICSPB	215
DEQS=DEQN	WICSPB	216
SITACS=SITACN	WICSPB	217
AINCIS=ALFA2-BET1MS(ISTAGE)	WICSPB	218
ADEVIS=BET2N-BET2MS(ISTAGE)	WICSPB	219

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      IF(IPRINT.EQ.2) WRITE(6,302) AINCIS,AINCSS(ISTAGE),ADEVIS,
      $ADEUSS(ISTAGE)
302  FORMAT(1H0,1X,4(F7.3,2X))
      OMEGA4=OMEGAN
      ALFA3=BET2N
      ALFA3R=ALFA3*PAI/180.0
      U3=UZ/COS(ALFA3R)
      UG=(U2+U3)/2.0
      OMEGAP=0.0
      IF(XW(1).GT.0.0)
      $CALL WICSDL(SC(ISTAGE),SIGUMS(ISTAGE),ALFA2,ALFA3,UG,RHOG(2)
      $,WMAS,AAA2,UZ,IPRINT,OMEGAP)
      OMEGA5=OMEGAP
      DELP5=OMEGAS*0.5*RHOG(2)/GC*(U2**2)
      DELP6=0.0
      OMEGA6=0.0
      PR23=1.0-(OMEGA4+OMEGA5+OMEGA6)*(1.0-PS2/P(2))
      PR13I=(TG(2)/TG(1))*G1
      PR13=(TG(2)/TG(1))*G1*PRREL*PR23/PP
      P(3)=PR13*P(1)
      TG(3)=TG(2)
      TS3=TG(3)-U3**2/(2.0*CPMIX*GC*AJ)
      AG3=(GAMMA*RMIX*TS3*GC)**0.5
      ASPEED=WICASD(XWT(1),RHOG(2),AG3)
      ASPED3=ASPEED
      AMAC3=U3/ASPEED
      PS3=(1.0+G2*AMAC3**2)**(-G1)*P(3)
      RHOG3=PS3/RMIX/TS3
      RHOG(3)=RHOG3
      RHOM3=1.0/(XG/RHOG3+XWT(1)/RHOW)
      UZ=BMASS/RHOM3/AAA3
      UZ3CL=UZ
      IF(JJJJ.EQ.2) GO TO 3010
      IF(JJJJ.GT.2) GO TO 3020
      XXX1=UZ3AS
      YYY1=UZ3CL
      JJJJ=JJJJ+1
      GO TO 3001
3010  XXX2=UZ3AS
      YYY2=UZ3CL
      UZ=WICNEW(XXX1,YYY1,XXX2,YYY2)
      IF(IPRINT.EQ.2) WRITE(6,3030) JJJJ,UZ
3030  FORMAT(1H,1X,I2,2X,=UZ33=,F10.5)
      JJJJ=JJJJ+1
      GO TO 3001
3020  IF(ABS((UZ3AS-UZ3CL)/UZ3AS).LT.EPS) GO TO 4000
      XXX1=XXX2
      YYY1=YYY2
      XXX2=UZ3AS
      YYY2=UZ3CL
      UZ=WICNEW(XXX1,YYY1,XXX2,YYY2)
      IF(IPRINT.EQ.2) WRITE(6,3040) JJJJ,UZ
3040  FORMAT(1H,1X,I2,=UZ33=,F10.5)
      JJJJ=JJJJ+1
      IF(JJJJ.EQ.20) GO TO 999
      GO TO 3001
4000  UZ3=UZ3CL
      FAI3=UZ3/UTIPG(ISTAGE+1)
      TW(3)=TW(2)
      OMEGTR=OMEGA1+OMEGA2+OMEGA3
      OMEGTS=OMEGA4+OMEGA5+OMEGA6
      POME1=OMEGA1/OMEGTR*100.0
      POME2=OMEGA2/OMEGTR*100.0
      POME3=OMEGA3/OMEGTR*100.0
      POME4=OMEGA4/OMEGTS*100.0
      POME5=OMEGA5/OMEGTS*100.0
      POME6=OMEGA6/OMEGTS*100.0
      PRATIO=P(3)/P(1)
      TRATIO=TG(3)/TG(1)
      CALL WICPRP(XA,XU(3),XCH4,TG(3),RMIX,CPMIX,GAMMA,G1,G2,G3)

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WICSPB 220
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WICSPB 289

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GAMMA2=GAMMA	WICSPB	290
GAMMAU=(GAMMA1+GAMMA2)/2.0	WICSPB	291
G4=(GAMMAU-1.0)/GAMMAU	WICSPB	292
ETAA(ISTAGE)=(PRATIO**G4-1.0)/(TRATIO-1.0)	WICSPB	293
IF(IUNIT.NE.2) GO TO 857	WICSPB	294
UTIPG(ISTAGE)=UTIPG(ISTAGE)*CFU	WICSPB	295
P(1)=P(1)*CFP	WICSPB	296
P(2)=P(2)*CFP	WICSPB	297
P(3)=P(3)*CFP	WICSPB	298
PS1=PS1*CFP	WICSPB	299
PS2=PS2*CFP	WICSPB	300
PS3=PS3*CFP	WICSPB	301
TG(1)=TG(1)*CFT	WICSPB	302
TG(2)=TG(2)*CFT	WICSPB	303
TG(3)=TG(3)*CFT	WICSPB	304
TS1=TS1*CFT	WICSPB	305
TS2=TS2*CFT	WICSPB	306
TS3=TS3*CFT	WICSPB	307
RHOG(1)=RHOG(1)*CFD	WICSPB	308
RHOG2=RHOG2*CFD	WICSPB	309
RHOG3=RHOG3*CFD	WICSPB	310
RHOM(1)=RHOM(1)*CFD	WICSPB	311
RHOM2=RHOM2*CFD	WICSPB	312
RHOM3=RHOM3*CFD	WICSPB	313
UZ1=UZ1*CFU	WICSPB	314
UZ2=UZ2*CFU	WICSPB	315
UZ3=UZ3*CFU	WICSPB	316
U1=U1*CFU	WICSPB	317
U2=U2*CFU	WICSPB	318
U3=U3*CFU	WICSPB	319
W1=W1*CFU	WICSPB	320
W2=W2*CFU	WICSPB	321
U(ISTAGE)=U(ISTAGE)*CFU	WICSPB	322
UU2(ISTAGE)=UU2(ISTAGE)*CFU	WICSPB	323
U(ISTAGE+1)=U(ISTAGE+1)*CFU	WICSPB	324
VS1=VS1*CFU	WICSPB	325
VS2=VS2*CFU	WICSPB	326
WS1=WS1*CFU	WICSPB	327
WS2=WS2*CFU	WICSPB	328
ASPED1=ASPED1*CFU	WICSPB	329
ASPED2=ASPED2*CFU	WICSPB	330
ASPED3=ASPED3*CFU	WICSPB	331
AAA1=AAA1*CFA	WICSPB	332
AAA2=AAA2*CFA	WICSPB	333
AAA3=AAA3*CFA	WICSPB	334
857 CONTINUE	WICSPB	335
WRITE(6,404) FAID,ISTAGE	WICSPB	336
404 FORMAT(1H1,1X,/,*****/,1X,	WICSPB	337
\$/INITIAL FLOW COEFFICIENT=/,1X,F7.5,1X,/(STAGE=/,I2,1X,	WICSPB	338
\$/),2X,/,*****/)	WICSPB	339
WRITE(6,401) PRATIO,TRATIO,ETAA(ISTAGE)	WICSPB	340
401 FORMAT(1H0,5X,/\$STAGE TOTAL PRESSURE RATIO=/,F12.5,/,	WICSPB	341
\$/6X,/\$STAGE TOTAL TEMPERATURE RATIO=/,F12.5,/,	WICSPB	342
\$/6X,/\$STAGE ADIABATIC EFFICIENCY=/,F12.5)	WICSPB	343
WRITE(6,402) FAI1,UZ1,UTIPG(ISTAGE)	WICSPB	344
402 FORMAT(1H0,5X,/\$STAGE FLOW COEFFICIENT=/,F5.3,/,	WICSPB	345
\$/6X,/\$AXIAL VELOCITY=/,F7.2,/,	WICSPB	346
\$/6X,/\$ROTOR SPEED=/,F7.2,/))	WICSPB	347
WRITE(6,403) PR13,PR13I,PRREL,PR23	WICSPB	348
403 FORMAT(1H,5X,/\$STAGE TOTAL PRESSURE RATIO(ACTUAL)=/,F12.5,/,	WICSPB	349
\$/6X,/\$STAGE TOTAL PRESSURE RATIO(IDEAL)=/,F12.5,/,	WICSPB	350
\$/6X,/\$LOSS FACTOR IN ROTOR=/,F12.5,/,	WICSPB	351
\$/6X,/\$LOSS FACTOR IN STATOR=/,F12.5,/))	WICSPB	352
WRITE(6,405)	WICSPB	353
405 FORMAT(1H0,24X,/\$ROTOR INLET* \$ROTOR OUTLET* \$STATOR OUTLET*)	WICSPB	354
WRITE(6,406) P(1),P(2),P(3)	WICSPB	355
406 FORMAT(1H,1X,/\$TOTAL PRESSURE=,10X,3(F10.2,5X))	WICSPB	356
WRITE(6,407) PS1,PS2,PS3	WICSPB	357
407 FORMAT(1H,1X,/\$STATIC PRESSURE=,9X,3(F10.2,5X))	WICSPB	358
WRITE(6,408) TG(1),TG(2),TG(3)	WICSPB	359

408	FORMAT(1H,1X,*,TOTAL TEMPERATURE(GAS)*,3X,3(F10.4,5X))	WICSPB	360
	WRITE(6,409) TS1,TS2,TS3	WICSPB	361
409	FORMAT(1H,1X,*,STATIC TEMPERATURE(GAS)*,1X,3(F10.4,5X))	WICSPB	362
	WRITE(6,410) RHOG(1),RHOG2,RHOG3	WICSPB	363
410	FORMAT(1H,1X,*,STATIC DENSITY(GAS)*,5X,3(F10.4,5X))	WICSPB	364
	WRITE(6,411) RHOM(1),RHOM2,RHOM3	WICSPB	365
411	FORMAT(1H,1X,*,STATIC DENSITY(MIXTURE)*,1X,3(F10.4,5X))	WICSPB	366
	WRITE(6,412) UZ1,UZ2,UZ3	WICSPB	367
412	FORMAT(1H0,1X,*,AXIAL VELOCITY*,10X,3(F10.4,5X))	WICSPB	368
	WRITE(6,413) U1,U2,U3	WICSPB	369
413	FORMAT(1H,1X,*,ABSOLUTE VELOCITY*,7X,3(F10.4,5X))	WICSPB	370
	WRITE(6,414) W1,W2	WICSPB	371
414	FORMAT(1H,1X,*,RELATIVE VELOCITY*,7X,2(F10.4,5X))	WICSPB	372
	WRITE(6,415) U(ISTAGE),UU2(ISTAGE),U(ISTAGE+1)	WICSPB	373
415	FORMAT(1H,1X,*,BLADE SPEED*,13X,3(F10.4,5X))	WICSPB	374
	WRITE(6,416) VS1,VS2	WICSPB	375
416	FORMAT(1H,1X,*,TANG. COMP. OF ABS. VEL.*,2(F10.4,5X))	WICSPB	376
	WRITE(6,417) WS1,WS2	WICSPB	377
417	FORMAT(1H,1X,*,TANG. COMP. OF REL. VEL.*,2(F10.4,5X))	WICSPB	378
	WRITE(6,418) ASPED1,ASPED2,ASPED3	WICSPB	379
418	FORMAT(1H,1X,*,ACOUSTIC SPEED*,10X,3(F10.4,5X))	WICSPB	380
	WRITE(6,419) AMAC1,AMAC2,AMAC3	WICSPB	381
419	FORMAT(1H,1X,*,ABSOLUTE MACH NUMBER*,4X,3(F10.4,5X))	WICSPB	382
	WRITE(6,420) AMACH1,AMACH2	WICSPB	383
420	FORMAT(1H,1X,*,RELATIVE MACH NUMBER*,4X,2(F10.4,5X))	WICSPB	384
	WRITE(6,421) FAI1,FAI2,FAI3	WICSPB	385
421	FORMAT(1H0,1X,*,FLOW COEFFICIENT*,8X,3(F10.4,5X))	WICSPB	386
	WRITE(6,422) AAA1,AAA2,AAA3	WICSPB	387
422	FORMAT(1H,1X,*,FLOW AREA*,15X,3(F10.4,5X))	WICSPB	388
	WRITE(6,423) ALFA1,ALFA2,ALFA3	WICSPB	389
423	FORMAT(1H0,1X,*,ABSOLUTE FLOW ANGLE*,5X,3(F10.4,5X))	WICSPB	390
	WRITE(6,424) BETA1,BETA2	WICSPB	391
424	FORMAT(1H,1X,*,RELATIVE FLOW ANGLE*,5X,3(F10.4,5X))	WICSPB	392
	WRITE(6,425) AINCIR,AINCIS	WICSPB	393
425	FORMAT(1H,1X,*,INCIDENCE*,16X,2(F10.4,5X))	WICSPB	394
	WRITE(6,426) ADEVIR,ADEVIS	WICSPB	395
426	FORMAT(1H,1X,*,DEVIATION*,30X,2(F10.4,5X))	WICSPB	396
	IF(IUNIT.NE.2) GO TO 858	WICSPB	397
	UTIPG(ISTAGE)=UTIPG(ISTAGE)/CFU	WICSPB	398
	P(1)=P(1)/CFP	WICSPB	399
	P(2)=P(2)/CFP	WICSPB	400
	P(3)=P(3)/CFP	WICSPB	401
	PS1=PS1/CFP	WICSPB	402
	PS2=PS2/CFP	WICSPB	403
	PS3=PS3/CFP	WICSPB	404
	TG(1)=TG(1)/CFT	WICSPB	405
	TG(2)=TG(2)/CFT	WICSPB	406
	TG(3)=TG(3)/CFT	WICSPB	407
	TS1=TS1/CFT	WICSPB	408
	TS2=TS2/CFT	WICSPB	409
	TS3=TS3/CFT	WICSPB	410
	RHOG(1)=RHOG(1)/CFD	WICSPB	411
	RHOG2=RHOG2/CFD	WICSPB	412
	RHOG3=RHOG3/CFD	WICSPB	413
	RHOM(1)=RHOM(1)/CFD	WICSPB	414
	RHOM2=RHOM2/CFD	WICSPB	415
	RHOM3=RHOM3/CFD	WICSPB	416
	UZ1=UZ1/CFU	WICSPB	417
	UZ2=UZ2/CFU	WICSPB	418
	UZ3=UZ3/CFU	WICSPB	419
	U1=U1/CFU	WICSPB	420
	U2=U2/CFU	WICSPB	421
	U3=U3/CFU	WICSPB	422
	W1=W1/CFU	WICSPB	423
	W2=W2/CFU	WICSPB	424
	U(ISTAGE)=U(ISTAGE)/CFU	WICSPB	425
	UU2(ISTAGE)=UU2(ISTAGE)/CFU	WICSPB	426
	U(ISTAGE+1)=U(ISTAGE+1)/CFU	WICSPB	427
	VS1=VS1/CFU	WICSPB	428
	VS2=VS2/CFU	WICSPB	429

WS1=WS1/CFU	WICSPB	430
WS2=WS2/CFU	WICSPB	431
ASPED1=ASPED1/CFU	WICSPB	432
ASPED2=ASPED2/CFU	WICSPB	433
ASPED3=ASPED3/CFU	WICSPB	434
AAA1=AAA1/CFA	WICSPB	435
AAA2=AAA2/CFA	WICSPB	436
AAA3=AAA3/CFA	WICSPB	437
858 CONTINUE	WICSPB	438
999 RETURN	WICSPB	439
END	WICSPB	440
C+++++	WICSPC	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICSFC	2
C	C	3
C SUBROUTINE WICSPC	C	4
C	C	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICSPC	6
SUBROUTINE WICSPC(FAIO, ISTAGE, MMAS, ALFA1, MKDONE, DAU, DELU, WMAS,	WICSPC	7
\$WMAS, N,	WICSPC	8
\$OMEGA1, OMEGA2, OMEGA3, OMEGA4, OMEGA5, OMEGA6, OMEGAT,	WICSPC	9
\$BETA1, BETA2, UZ, ALFA2, ALFA3, DELTG, DELTH, W1, W2, U1, U2, U3, REAVE,	WICSPC	10
\$DELVU2, DELVL2, AK1, AK2, AK3)	WICSPC	11
REAL M, MMAS	WICSPC	12
COMMON TD(7), IUNIT	WICSPC	13
COMMON CFL, CFT, CFP, CFD, CFM, CFU, CFA	WICSPC	14
COMMON JPERFM, RHOG(3), RERUP, RERLOW, RESUP, RESLOW	WICSPC	15
COMMON PREB, RRTIP(8), SRTIP(8), AAA1, AAA2, AAA3, SAREA(6), SAREAS(7)	WICSPC	16
COMMON P(3), TG(3), XA, XU(3), XCH4, XW(3), XWW(3), XWT(3), TW(3), TWW(3)	WICSPC	17
COMMON OMEGS(7), OMEGR(6), GAPR(6), GAPS(6)	WICSPC	18
COMMON RRHUB(6), RC(6), RBLADE(6), STAGER(6)	WICSPC	19
COMMON SRHUB(7), SC(7), SBLADE(7), STAGES(7)	WICSPC	20
COMMON SIGUMR(6), BET1SR(6), BET2SR(6), AINCSR(6), ADEVSR(6)	WICSPC	21
COMMON SIGUMS(7), BET1SS(7), BET2SS(7), AINCSS(7), ADEVSS(7)	WICSPC	22
COMMON UTIPG(6), UTIP(6), UTIPD(6), UOU(6), UMEAN(6), UHUB(6), U(6), FAI	WICSPC	23
COMMON AREA(6), AREAS(7), UU2(6), UTIP2(6), UMEAN2(6), UHUB2(6), IPRINT	WICSPC	24
COMMON ICENT, IICENT, FMR1(6), FMA2(6), IDESIN, FAID	WICSPC	25
COMMON NS, NS1, RT(6), RM(6), RH(6), ST(6), SM(6), SH(6)	WICSPC	26
COMMON DSMASS, AAREA(7), AAREAS(7), PR12D(6), PR13D(6), ETARD(6)	WICSPC	27
COMMON DR(6), DS(6), DEQR(6), DEQS(6), BLOCK(6), BLOCKS(7)	WICSPC	28
COMMON BET1MR(6), BET2MR(6), BET1MS(7), BET2MS(7), RAD11(6), RAD12(6)	WICSPC	29
DIMENSION RHOM(3), ETAA(6)	WICSPC	30
IPRINT=1	WICSPC	31
CPW=1.0	WICSPC	32
RHOW=62.3	WICSPC	33
GC=32.174	WICSPC	34
AJ=778.26	WICSPC	35
PAI=3.1415926	WICSPC	36
CALL WICPRP(XA, XU(1), XCH4, TG(1), RMIX, CPMIX, GAMMA, G1, G2, G3)	WICSPC	37
GAMMA1=GAMMA	WICSPC	38
RHOG(1)=P(1)/RMIX/TG(1)	WICSPC	39
BMASS=MMAS-WMAS-WWMAS	WICSPC	40
AAA2=AREAS(ISTAGE)	WICSPC	41
AAA3=AREA(ISTAGE+1)	WICSPC	42
IF(ISTAGE .GT. NS) AAA3=AAA2	WICSPC	43
CALL WICMAC(ISTAGE, BMASS, TG(1), P(1), M, UZ, C, XWT(1), ALFA1,	WICSPC	44
\$RMIX, CPMIX, AAA1)	WICSPC	45
ASPEED=C	WICSPC	46
ASPED1=ASPEED	WICSPC	47
RHOG(1)=(1.0+G2*M **2)**G3/RHOG(1)	WICSPC	48
RHOM(1)=1.0/((1.0-XWT(1))/RHOG(1)+XWT(1)/RHOW)	WICSPC	49
UZ1=UZ	WICSPC	50
UZZ=UZ	WICSPC	51
FAI1=UZ1/UTIPG(ISTAGE)	WICSPC	52
ALFA1R = ALFA1 * PAI / 180.0	WICSPC	53
U1 = UZ / COS (ALFA1R)	WICSPC	54
US1 = UZ * TAN (ALFA1R)	WICSPC	55
WS1 = U(ISTAGE)- US1	WICSPC	56
T = WS1 / UZ	WICSPC	57
BETA1R = ATAN (T)	WICSPC	58
BETA1 = BETA1R * 180.0 / PAI	WICSPC	59

TT = UZ **2 + W1 **2	WICSPC	60
W1 = SQRT (TT)	WICSPC	61
AMACH1 = W1 / ASPEED	WICSPC	62
AMAC1=U1/ASPEED	WICSPC	63
TS1=TG(1)/(1.0+G2*AMAC1**2)	WICSPC	64
PS1=(TG(1)/TS1)**(-G1)*P(1)	WICSPC	65
PREL1=(1.0+G2*AMACH1**2)**G1*PS1	WICSPC	66
TREL1=(1.0+G2*AMACH1**2)*TS1	WICSPC	67
TG(2)=TG(1)	WICSPC	68
P(2)=P(1)	WICSPC	69
ALFA2=BET1SS(ISTAGE)	WICSPC	70
JJJ=1	WICSPC	71
2000 UZ2AS=UZ	WICSPC	72
CALL WICGSL(OMEGR(ISTAGE),SIGUMR(ISTAGE),BET1SR(ISTAGE),BET2SR(	WICSPC	73
\$ISTAGE),AINC SR(ISTAGE),ADEUSR(ISTAGE),AMACH1,BETA1,DEQS,DEQN,	WICSPC	74
\$SITACS,SITACN,BET2N,OMEGAN,FMR1(ISTAGE),IDESIN,AK1,AK2,AK3,UZ1,	WICSPC	75
\$UZ2AS,U(ISTAGE),RADI1(ISTAGE),RADI2(ISTAGE))	WICSPC	76
OMEGA7=OMEGAN	WICSPC	77
BETA2=BET2N	WICSPC	78
BETA1R=BETA1*PAI/180.0	WICSPC	79
BETA2R=BETA2*PAI/180.0	WICSPC	80
BETAUE=(BETA1R+BETA2R)/2.0	WICSPC	81
TANGT=WICTAN(BETA1R)-WICTAN(BETA2R)	WICSPC	82
CSAU=COS(BETAUE)	WICSPC	83
CS1=COS(BETA1R)	WICSPC	84
CL=2.0/SIGUMR(ISTAGE)*TANGT*CSAU	WICSPC	85
CDS=0.018*(CL**2)	WICSPC	86
OMEGSE=CDS*SIGUMR(ISTAGE)*(CS1**2)/(CSAU**3)	WICSPC	87
H=RR TIP(ISTAGE)-RRHUB(ISTAGE)	WICSPC	88
SHR=RC(ISTAGE)/H/SIGUMR(ISTAGE)	WICSPC	89
CDA=0.020*SHR	WICSPC	90
OMEGAN=CDA*SIGUMR(ISTAGE)*(CS1**2)/(CSAU**3)	WICSPC	91
IF(IPRINT.EQ.2) WRITE(6,2001) OMEGA1,OMEGSE,OMEGAN,OMEGA7,CDS,CDA	WICSPC	92
2001 FORMAT(1H0,6F10.6)	WICSPC	93
OMES1=OMEGSE	WICSPC	94
OMEA1=OMEGAN	WICSPC	95
AINCIR=BETA1-BET1MR(ISTAGE)	WICSPC	96
ADEVIR=BET2N-BET2MR(ISTAGE)	WICSPC	97
BETA2R=BETA2*PAI/180.0	WICSPC	98
W2=UZ/COS(BETA2R)	WICSPC	99
UG=(W1+W2)/2.0	WICSPC	100
CALL WICRSL(SIGUMR(ISTAGE),BETA1,BETA2,RC(ISTAGE),DAU,CDR,OMEGAR)	WICSPC	101
DELP1=OMEGA1*0.5*RHO G(1)/GC*(W1**2)	WICSPC	102
IF(IPRINT.EQ.2) WRITE(6,2002) OMEGA1,DELP1	WICSPC	103
2002 FORMAT(1H ,1X,#OMEGA1=#,2F10.5)	WICSPC	104
XG=1.0-XUT(1)	WICSPC	105
CALL WICIRL(ISTAGE,RR TIP(ISTAGE),XW(1),XG,RHO G(1),BETA1,W1,W1,W1,W1	WICSPC	106
\$2,W1)	WICSPC	107
BMIMPR=W1	WICSPC	108
IF(BMIMPR.GT.W1MAS) BMIMPR=W1MAS	WICSPC	109
BMREBR=BMIMPR*PREB/100.0	WICSPC	110
BMWAKR=BMIMPR*(1.0-PREB/100.0)	WICSPC	111
BMNOIR=W1MAS-BMIMPR	WICSPC	112
XWUNOR=BMNOIR/MMASS	WICSPC	113
XWWRER=BMREBR/MMASS	WICSPC	114
XWUWAR=BMWAKR/MMASS	WICSPC	115
IF(IPRINT.EQ.2) WRITE(6,6090) BMIMPR,BMREBR,BMWAKR,BMNOIR,XWUNOR,	WICSPC	116
\$XWWRER,XWUWAR	WICSPC	117
6090 FORMAT(1H ,7(F12.5,1X))	WICSPC	118
RST1=RADI1(ISTAGE)**2-AAA1*144.0/2.0/PAI	WICSPC	119
RST1=SQRT(RST1)	WICSPC	120
RST2=2.0*RADI1(ISTAGE)**2-RST1**2	WICSPC	121
RST2=SQRT(RST2)	WICSPC	122
DELR=(RST2-RST1)/12.0	WICSPC	123
FMASSR=BMWAKR/DELR	WICSPC	124
CALL WICFML(W1,W2,FMASSR,RHO G(1),RC(ISTAGE),SIGUMR(ISTAGE),BETA1,	WICSPC	125
\$BETA2,CDF,OMEGAF)	WICSPC	126
OMEGA2=OMEGAF	WICSPC	127
DELP2=OMEGA2*0.5*RHO G(1)/GC*(W1**2)	WICSPC	128
IF(IPRINT.EQ.2) WRITE(6,6091) OMEGA2,DELP2	WICSPC	129

6091	FORMAT(1H,1X,2F10.5)	WICSPC	130
	U2=0.0	WICSPC	131
	U3=0.0	WICSPC	132
	ALFA=0.0	WICSPC	133
	ALFA3=0.0	WICSPC	134
	CALL WICSTL(ISTAGE,1,DAU,W1,W2,DELU,U2,U3,WIMAS,UZ,N,BETA1,BETA2,	WICSPC	135
	\$ALFA2,ALFA3,BMASS,DELUU2,DELU2,OMEGRU,OMEGRL,OMEGSU,OMEGSL,	WICSPC	136
	\$DRAGRU,DRAGRL,DRAGSU,DRAGSL,REAVE)	WICSPC	137
	OMEGA3=OMEGRU+OMEGRL	WICSPC	138
	DELP3=OMEGA3*0.5*RHO(1)/GC*(W1**2)	WICSPC	139
	IF(IPRINT.EQ.2) WRITE(6,6092) OMEGA3,DELP3	WICSPC	140
6092	FORMAT(1H,1X,2F10.5)	WICSPC	141
	REAVE1=REAVE	WICSPC	142
	BETA2R = BETA2 * PAI / 180.0	WICSPC	143
	JJ=1	WICSPC	144
200	UZAS=UZ	WICSPC	145
	WS2 = UZ * TAN (BETA2R)	WICSPC	146
	US2 = UU2(ISTAGE) - WS2	WICSPC	147
	TTT=US2/UZ	WICSPC	148
	ALFA2R = ATAN (TTT)	WICSPC	149
	ALFA2 = ALFA2R * 180.0 / PAI	WICSPC	150
	TTTT = UZ ** 2 + WS2 ** 2	WICSPC	151
	W2 = SORT (TTTT)	WICSPC	152
	TTTTT = UZ ** 2 + US2 ** 2	WICSPC	153
	U2 = SQR (TTTTT)	WICSPC	154
	DELH=WKDONE*(UU2(ISTAGE)*US2-U(ISTAGE)*U1)/GC/AJ	WICSPC	155
	CALL WICIRS(ISTAGE,RTIP(ISTAGE),XW(1),XG,RHO(1),BETA1,W1,W1,	WICSPC	156
	\$W2,W1)	WICSPC	157
	AMIMPR=W1	WICSPC	158
	IF(AMIMPR.GT.WMAS) AMIMPR=WMAS	WICSPC	159
	PRES=50.0	WICSPC	160
	AMREBR=AMIMPR*PRES/100.0	WICSPC	161
	AMWAKR=AMIMPR*(1.0-PRES/100.0)	WICSPC	162
	AMNOIR=WMAS-AMIMPR	WICSPC	163
	XW1=0.0	WICSPC	164
	XW2=0.0	WICSPC	165
	XW3=0.0	WICSPC	166
	IF(WMAS.GT.0.0) XW1=AMNOIR/WMAS	WICSPC	167
	IF(WMAS.GT.0.0) XW2=AMWAKR/WMAS	WICSPC	168
	IF(WMAS.GT.0.0) XW3=AMREBR/WMAS	WICSPC	169
	DELTG=DELH/CPMIX	WICSPC	170
	DELTW1=DELH/CPW	WICSPC	171
	DELTW2=DELH/CPW	WICSPC	172
	DELTW3=0.0	WICSPC	173
	DELTW=XW1*DELTW1+XW2*DELTW2+XW3*DELTW3	WICSPC	174
	DETW1=0.0	WICSPC	175
	DETW2=0.0	WICSPC	176
	DETW3=0.0	WICSPC	177
	DELTW=0.0	WICSPC	178
	TW(2)=TW(1)+DELTW	WICSPC	179
	TWW(2)=TWW(1)+DELTW	WICSPC	180
	TG(2)=TG(1)+DELTG	WICSPC	181
	TS2=TG(2)-U2**2/(2.0*CPMIX*GC*AJ)	WICSPC	182
	AG2=(GAMMA*RMIX*TS2*GC)**0.5	WICSPC	183
	ASPEED=WICASD(XW(1),RHO(1),AG2)	WICSPC	184
	ASPED2=ASPEED	WICSPC	185
	AMAC2=U2/ASPEED	WICSPC	186
	AMACH2=W2/ASPEED	WICSPC	187
	PP1=GAMMA*RMIX*TREL1*GC	WICSPC	188
	PP2=(UU2(ISTAGE)/U(ISTAGE))**2-1.0	WICSPC	189
	PP3=1.0+G2*U(ISTAGE)**2/PP1*PP2	WICSPC	190
	PP=PP3**G1	WICSPC	191
	PRREL=PP-(OMEGA7+OMEGA1+OMEGA2+OMEGA3)*(1.0-PS1/PREL1)	WICSPC	192
	PR12=(TG(2)/TG(1))**G1*PRREL/PP	WICSPC	193
	P(2)=PR12*P(1)	WICSPC	194
	PS2=(1.0+G2*AMAC2**2)**(-G1)*P(2)	WICSPC	195
	RHO2=PS2/RMIX/TS2	WICSPC	196
	RHO(2)=RHO2	WICSPC	197
	RHOM2=1.0/(XG/RHO2+XW(1)/RHO)	WICSPC	198
	UZ=BMASS/RHO2/AA2	WICSPC	199

UZZ=UZ	WICSPC	200
EPS=1.0E-4	WICSPC	201
IF(JJ.EQ.2) GO TO 201	WICSPC	202
IF(JJ.GT.2) GO TO 202	WICSPC	203
X1=UZAS	WICSPC	204
Y1=UZ2	WICSPC	205
UZ=UZ2	WICSPC	206
JJ=JJ+1	WICSPC	207
IF(UZ.LT.0.0.OR.UZ.GT.ASPEED) GO TO 999	WICSPC	208
GO TO 200	WICSPC	209
201 X2=UZAS	WICSPC	210
Y2=UZ2	WICSPC	211
UZ=WICNEW(X1,Y1,X2,Y2)	WICSPC	212
IF(IPRINT.EQ.2) WRITE(6,203) JJ,UZ	WICSPC	213
203 FORMAT(1H,1X,I1,2X,=UZ2=,F10.5)	WICSPC	214
JJ=JJ+1	WICSPC	215
IF(UZ.LT.0.0.OR.UZ.GT.ASPEED) GO TO 999	WICSPC	216
GO TO 200	WICSPC	217
202 IF(ABS((UZAS-UZ2)/UZAS).LT.EPS) GO TO 300	WICSPC	218
X1=X2	WICSPC	219
Y1=Y2	WICSPC	220
X2=UZAS	WICSPC	221
Y2=UZ2	WICSPC	222
UZ=WICNEW(X1,Y1,X2,Y2)	WICSPC	223
IF(IPRINT.EQ.2) WRITE(6,204) JJ,UZ	WICSPC	224
204 FORMAT(1H0,1X,I1,2X,=UZ2=,F10.5)	WICSPC	225
JJ=JJ+1	WICSPC	226
IF(UZ.LT.0.0.OR.UZ.GT.ASPEED) GO TO 999	WICSPC	227
IF(JJ.EQ.20) GO TO 999	WICSPC	228
GO TO 200	WICSPC	229
300 UZ2CL=UZ	WICSPC	230
IF(JJJ.EQ.2) GO TO 2010	WICSPC	231
IF(JJJ.GT.2) GO TO 2020	WICSPC	232
XX1=UZ2AS	WICSPC	233
YY1=UZ2CL	WICSPC	234
JJJ=JJJ+1	WICSPC	235
GO TO 2000	WICSPC	236
2010 XX2=UZ2AS	WICSPC	237
YY2=UZ2CL	WICSPC	238
UZ=WICNEW(XX1,YY1,XX2,YY2)	WICSPC	239
IF(IPRINT.EQ.2) WRITE(6,2030) JJJ,UZ	WICSPC	240
2030 FORMAT(1H,1X,I2,=UZ22=,F10.5)	WICSPC	241
JJJ=JJJ+1	WICSPC	242
GO TO 2000	WICSPC	243
2020 IF(ABS((UZ2AS-UZ2CL)/UZ2AS).LT.EPS) GO TO 3000	WICSPC	244
XX1=XX2	WICSPC	245
YY1=YY2	WICSPC	246
XX2=UZ2AS	WICSPC	247
YY2=UZ2CL	WICSPC	248
UZ=WICNEW(XX1,YY1,XX2,YY2)	WICSPC	249
IF(IPRINT.EQ.2) WRITE(6,2040) JJJ,UZ	WICSPC	250
2040 FORMAT(1H,1X,I2,=UZ22=,F10.5)	WICSPC	251
JJJ=JJJ+1	WICSPC	252
IF(JJJ.EQ.20) GO TO 3000	WICSPC	253
GO TO 2000	WICSPC	254
3000 UZ2=UZ2CL	WICSPC	255
FAI2=UZ2/UTIPG(ISTAGE)	WICSPC	256
P(2)=(1.0+G2*AMAC2**2)**G1*PS2	WICSPC	257
JJJJ=1	WICSPC	258
3001 UZ3AS=UZ	WICSPC	259
CALL WICGSL(OMEGS(ISTAGE),SIGUMS(ISTAGE),BET1SS(ISTAGE),BET2SS	WICSPC	260
\$(ISTAGE),AINCSS(ISTAGE),ADEUSS(ISTAGE),AMAC2,ALFA2,DEQS,DEQN,	WICSPC	261
\$SITACS,SITACN,BET2N,OMEGAN,FMA2(ISTAGE),IDESIN,AK1,AK2,AK3,UZ2,	WICSPC	262
\$UZ3AS,0.0,RADI2(ISTAGE),RADI1(ISTAGE+1))	WICSPC	263
OMEGA8=OMEGAN	WICSPC	264
ALFA3=BET2N	WICSPC	265
ALFA1R=ALFA2*PAI/180.0	WICSPC	266
ALFA2R=ALFA3*PAI/180.0	WICSPC	267
ALFAAU=(ALFA1R+ALFA2R)/2.0	WICSPC	268
TANGT=WICTAN(ALFA1R)-WICTAN(ALFA2R)	WICSPC	269

CSAU=COS(ALFAAU)	WICSPC	270
CS1=COS(ALFA1R)	WICSPC	271
CL=2.0/SIGUMS(ISTAGE)*TANGT*CSAU	WICSPC	272
CDS=0.018*(CL**2)	WICSPC	273
OMEGSE=CDS*SIGUMS(ISTAGE)*(CS1**2)/(CSAU**3)	WICSPC	274
H=SRTIP(ISTAGE)-SRHUB(ISTAGE)	WICSPC	275
SHR=SC(ISTAGE)/H/SIGUMR(ISTAGE)	WICSPC	276
CDA=0.020*SHR	WICSPC	277
OMEGAN=CDA*SIGUMS(ISTAGE)*(CS1**2)/(CSAU**3)	WICSPC	278
IF(IPRINT.EQ.2) WRITE(6,3002)	WICSPC	279
\$OMEGA4, OMEGSE, OMEGAN, OMEGA8, CDS, CDA	WICSPC	280
3002 FORMAT(1H, 6F10.5)	WICSPC	281
OMES2=OMEGSE	WICSPC	282
OMEA2=OMEGAN	WICSPC	283
AINCIS=ALFA2-BET1MS(ISTAGE)	WICSPC	284
ADEUIS=BET2N-BET2MS(ISTAGE)	WICSPC	285
ALFA3R=ALFA3*PAI/180.0	WICSPC	286
U3=UZ/COS(ALFA3R)	WICSPC	287
CALL WICRSL(SIGUMS(ISTAGE), ALFA2, ALFA3, SC(ISTAGE), DAV, CDR, OMEGAR)	WICSPC	288
DELP4=OMEGA4*0.5*RHO2/GC*(U2**2)	WICSPC	289
IF(IPRINT.EQ.2) WRITE(6,3003) OMEGA4, DELP4	WICSPC	290
3003 FORMAT(1H, 1X, #OMEGA4=#, 2F10.5)	WICSPC	291
CALL WICISL(ISTAGE, SRTIP(ISTAGE), XWW(2), XG, RHO2, ALFA2, U2, WW1	WICSPC	292
\$, WW2, WW)	WICSPC	293
BMIMPS=WW	WICSPC	294
IF(BMIMPS.GT.WWMAS) BMIMPS=WWMAS	WICSPC	295
BMREBS=BMIMPS*PREB/100.0	WICSPC	296
BMWAKS=BMIMPS*(1.0-PREB/100.0)	WICSPC	297
IF(IPRINT.EQ.2) WRITE(6,6616)	WICSPC	298
6616 FORMAT(1H, 1X, #IMPINS#)	WICSPC	299
IF(IPRINT.EQ.2) WRITE(6,6617) XWW(2), XA, RHO2, UZ, WW, BMIMPS, BM	WICSPC	300
\$REBS, BMWAKS	WICSPC	301
6617 FORMAT(1H, 8(F12.5, 1X))	WICSPC	302
RST1=RADI2(ISTAGE)**2-AAA2*144.0/2.0/PAI	WICSPC	303
RST1=SQRT(RST1)	WICSPC	304
RST2=2.0*RADI2(ISTAGE)**2-RST1**2	WICSPC	305
RST2=SQRT(RST2)	WICSPC	306
DELR=(RST2-RST1)/12.0	WICSPC	307
FMASSS=BMWAKS/DELR	WICSPC	308
CALL WICFML(U2, U3, FMASSS, RHO2, SC(ISTAGE), SIGUMS(ISTAGE), BETA1,	WICSPC	309
\$BETA2, CDF, OMEGAF)	WICSPC	310
OMEGA5=OMEGAF	WICSPC	311
DELP5=OMEGA5*0.5*RHO2/GC*(U2**2)	WICSPC	312
IF(IPRINT.EQ.2) WRITE(6,6618) OMEGA5, DELP5	WICSPC	313
6618 FORMAT(1H, 1X, #OMEGA5=#, 2F10.5)	WICSPC	314
CALL WICSTL(ISTAGE, 2, DAV, W1, W2, DELU, U2, U3, WWMAS, UZ, N, BETA1, BETA2,	WICSPC	315
\$ALFA2, ALFA3, BMAS, DELU2, DELUL2, OMEGRU, OMEGRL, OMEGSU, OMEGSL,	WICSPC	316
\$DRAGRU, DRAGRL, DRAGSU, DRAGSL, REAVE)	WICSPC	317
OMEGA6=OMEGSU+OMEGSL	WICSPC	318
DELP6=OMEGA6*0.5*RHO2/GC*(U2**2)	WICSPC	319
IF(IPRINT.EQ.2) WRITE(6,6619) OMEGA6, DELP6	WICSPC	320
6619 FORMAT(1H, 1X, #OMEGA6=#, 2F10.5)	WICSPC	321
REAVE2=REAVE	WICSPC	322
REAVE=(REAVE1+REAVE2)*0.5	WICSPC	323
PR23=1.0-(OMEGA8+OMEGA4+OMEGAS+OMEGA6)*(1.0-PS2/P(2))	WICSPC	324
PR13=(TG(2)/TG(1))*G1*PRREL*PR23/PP	WICSPC	325
PR13I=(TG(2)/TG(1))*G1	WICSPC	326
P(3)=PR13*P(1)	WICSPC	327
TG(3)=TG(2)	WICSPC	328
TS3=TG(3)-U3**2/(2.0*CPMIX*GC*AJ)	WICSPC	329
AG3=(GAMMA*RMIX*TS3*GC)**0.5	WICSPC	330
ASPEED=WICASD(XWT(1), RHO2, AG3)	WICSPC	331
ASPED3=ASPEED	WICSPC	332
AMAC3=U3/ASPEED	WICSPC	333
PS3=(1.0+G2*AMAC3**2)*(-G1)*P(3)	WICSPC	334
RHO3=PS3/RMIX/TS3	WICSPC	335
RHO3(3)=RHO3	WICSPC	336
RHO13=1.0/(XG/RHO3+XWT(1)/RHO4)	WICSPC	337
UZ=BMAS/RHO3/AAA3	WICSPC	338
UZ3CL=UZ	WICSPC	339

IF(JJJJ.EQ.2) GO TO 3010	WICSPC	340
IF(JJJJ.GT.2) GO TO 3020	WICSPC	341
XXX1=UZ3AS	WICSPC	342
YYY1=UZ3CL	WICSPC	343
JJJJ=JJJJ+1	WICSPC	344
GO TO 3001	WICSPC	345
3010 XXX2=UZ3AS	WICSPC	346
YYY2=UZ3CL	WICSPC	347
UZ=WICNEW(XXX1,YYY1,XXX2,YYY2)	WICSPC	348
IF(IPRINT.EQ.2) WRITE(6,3030) JJJJ,UZ	WICSPC	349
3030 FORMAT(1H,1X,I2,2X,=UZ33=,F10.5)	WICSPC	350
JJJJ=JJJJ+1	WICSPC	351
GO TO 3001	WICSPC	352
3020 IF(ABS((UZ3AS-UZ3CL)/UZ3AS).LT.EPS) GO TO 4000	WICSPC	353
XXX1=XXX2	WICSPC	354
YYY1=YYY2	WICSPC	355
XXX2=UZ3AS	WICSPC	356
YYY2=UZ3CL	WICSPC	357
UZ=WICNEW(XXX1,YYY1,XXX2,YYY2)	WICSPC	358
IF(IPRINT.EQ.2) WRITE(6,3040) JJJJ,UZ	WICSPC	359
3040 FORMAT(1H,1X,I2,=UZ33=,F10.5)	WICSPC	360
JJJJ=JJJJ+1	WICSPC	361
IF(JJJJ.EQ.20) GO TO 4000	WICSPC	362
GO TO 3001	WICSPC	363
4000 UZ3=UZ3CL	WICSPC	364
FAI3=UZ3/UTIPG(ISTAGE+1)	WICSPC	365
TW(3)=TW(2)	WICSPC	366
TW(3)=TW(2)	WICSPC	367
OMEGTR=OMEGA1+OMEGA2+OMEGA3+OMEGA7	WICSPC	368
OMEGTS=OMEGA4+OMEGA5+OMEGA6+OMEGA8	WICSPC	369
POMEG1=OMEGA1/OMEGTR*100.0	WICSPC	370
POMEG2=OMEGA2/OMEGTR*100.0	WICSPC	371
POMEG3=OMEGA3/OMEGTR*100.0	WICSPC	372
POMEG4=OMEGA4/OMEGTS*100.0	WICSPC	373
POMEG5=OMEGA5/OMEGTS*100.0	WICSPC	374
POMEG6=OMEGA6/OMEGTS*100.0	WICSPC	375
POMEG7=OMEGA7/OMEGTR*100.0	WICSPC	376
POMEG8=OMEGA8/OMEGTS*100.0	WICSPC	377
PRATIO=P(3)/P(1)	WICSPC	378
TRATIO=TG(3)/TG(1)	WICSPC	379
CALL WICPRP(XA,XU(3),XCH4,TG(3),RMIX,CPMIX,GAMMA,G1,G2,G3)	WICSPC	380
GAMMA2=GAMMA	WICSPC	381
GAMMAU=(GAMMA1+GAMMA2)/2.0	WICSPC	382
G4=(GAMMAU-1.0)/GAMMAU	WICSPC	383
ETAA(ISTAGE)=(PRATIO**G4-1.0)/(TRATIO-1.0)	WICSPC	384
IF(IUNIT.NE.2) GO TO 859	WICSPC	385
UTIPG(ISTAGE)=UTIPG(ISTAGE)*CFU	WICSPC	386
P(1)=P(1)*CFP	WICSPC	387
P(2)=P(2)*CFP	WICSPC	388
P(3)=P(3)*CFP	WICSPC	389
PS1=PS1*CFP	WICSPC	390
PS2=PS2*CFP	WICSPC	391
PS3=PS3*CFP	WICSPC	392
TG(1)=TG(1)*CFT	WICSPC	393
TG(2)=TG(2)*CFT	WICSPC	394
TG(3)=TG(3)*CFT	WICSPC	395
TS1=TS1*CFT	WICSPC	396
TS2=TS2*CFT	WICSPC	397
TS3=TS3*CFT	WICSPC	398
RHOG(1)=RHOG(1)*CFD	WICSPC	399
RHOG2=RHOG2*CFD	WICSPC	400
RHOG3=RHOG3*CFD	WICSPC	401
RHOM(1)=RHOM(1)*CFD	WICSPC	402
RHOM2=RHOM2*CFD	WICSPC	403
RHOM3=RHOM3*CFD	WICSPC	404
UZ1=UZ1*CFU	WICSPC	405
UZ2=UZ2*CFU	WICSPC	406
UZ3=UZ3*CFU	WICSPC	407
U1=U1*CFU	WICSPC	408
U2=U2*CFU	WICSPC	409

U3=U3*CFU	WICSPC	410
W1=W1*CFU	WICSPC	411
W2=W2*CFU	WICSPC	412
U(ISTAGE)=U(ISTAGE)*CFU	WICSPC	413
UU2(ISTAGE)=UU2(ISTAGE)*CFU	WICSPC	414
U(ISTAGE+1)=U(ISTAGE+1)*CFU	WICSPC	415
US1=US1*CFU	WICSPC	416
US2=US2*CFU	WICSPC	417
WS1=WS1*CFU	WICSPC	418
WS2=WS2*CFU	WICSPC	419
ASPED1=ASPED1*CFU	WICSPC	420
ASPED2=ASPED2*CFU	WICSPC	421
ASPED3=ASPED3*CFU	WICSPC	422
AAA1=AAA1*CFA	WICSPC	423
AAA2=AAA2*CFA	WICSPC	424
AAA3=AAA3*CFA	WICSPC	425
859 CONTINUE	WICSPC	426
WRITE(6,404) FAIO,ISTAGE	WICSPC	427
404 FORMAT(1H,1X,***** #,1X,	WICSPC	428
\$=INITIAL FLOW COEFFICIENT=#,1X,F7.5,1X,=(STAGE=#,I2,1X,	WICSPC	429
\$=),2X,*****#)	WICSPC	430
WRITE(6,401) PRATIO,TRATIO,ETAA(ISTAGE)	WICSPC	431
401 FORMAT(1H0,5X,=STAGE TOTAL PRESSURE RATIO=#,F12.5,/,	WICSPC	432
\$GX,=STAGE TOTAL TEMPERATURE RATIO=#,F12.5,/,	WICSPC	433
\$GX,=STAGE ADIABATIC EFFICIENCY=#,F12.5)	WICSPC	434
WRITE(6,402) FAI1,UZ1,UTIPG(ISTAGE)	WICSPC	435
402 FORMAT(1H0,5X,=STAGE FLOW COEFFICIENT=#,F5.3,/,	WICSPC	436
\$GX,=AXIAL VELOCITY=#,F7.2,/,	WICSPC	437
\$GX,=ROTOR SPEED=#,F7.2,.)	WICSPC	438
WRITE(6,403) PR13,PR13I,PRREL,PR23	WICSPC	439
403 FORMAT(1H,5X,=STAGE TOTAL PRESSURE RATIO(ACTUAL)=#,F12.5,/,	WICSPC	440
\$GX,=STAGE TOTAL PRESSURE RATIO(IDEAL)=#,F12.5,/,	WICSPC	441
\$GX,=LOSS FACTOR IN ROTOR=#,F12.5,/,	WICSPC	442
\$GX,=LOSS FACTOR IN STATOR=#,F12.5,.)	WICSPC	443
WRITE(6,405)	WICSPC	444
405 FORMAT(1H0,24X,=ROTOR INLET* *ROTOR OUTLET* *STATOR OUTLET=#)	WICSPC	445
WRITE(6,406) P(1),P(2),P(3)	WICSPC	446
406 FORMAT(1H,1X,=TOTAL PRESSURE#,10X,3(F10.2,5X))	WICSPC	447
WRITE(6,407) PS1,PS2,PS3	WICSPC	448
407 FORMAT(1H,1X,=STATIC PRESSURE#,9X,3(F10.2,5X))	WICSPC	449
WRITE(6,408) TG(1),TG(2),TG(3)	WICSPC	450
408 FORMAT(1H,1X,=TOTAL TEMPERATURE(GAS)#,3X,3(F10.4,5X))	WICSPC	451
WRITE(6,409) TS1,TS2,TS3	WICSPC	452
409 FORMAT(1H,1X,=STATIC TEMPERATURE(GAS)#,1X,3(F10.4,5X))	WICSPC	453
WRITE(6,410) RHOG(1),RHOG2,RHOG3	WICSPC	454
410 FORMAT(1H,1X,=STATIC DENSITY(GAS)#,5X,3(F10.4,5X))	WICSPC	455
WRITE(6,411) RHOM(1),RHOM2,RHOM3	WICSPC	456
411 FORMAT(1H,1X,=STATIC DENSITY(MIXTURE)#,1X,3(F10.4,5X))	WICSPC	457
WRITE(6,412) UZ1,UZ2,UZ3	WICSPC	458
412 FORMAT(1H0,1X,=AXIAL VELOCITY#,10X,3(F10.4,5X))	WICSPC	459
WRITE(6,413) U1,U2,U3	WICSPC	460
413 FORMAT(1H,1X,=ABSOLUTE VELOCITY#,7X,3(F10.4,5X))	WICSPC	461
WRITE(6,414) W1,W2	WICSPC	462
414 FORMAT(1H,1X,=RELATIVE VELOCITY#,7X,2(F10.4,5X))	WICSPC	463
WRITE(6,415) U(ISTAGE),UU2(ISTAGE),U(ISTAGE+1)	WICSPC	464
415 FORMAT(1H,1X,=BLADE SPEED#,13X,3(F10.4,5X))	WICSPC	465
WRITE(6,416) US1,US2	WICSPC	466
416 FORMAT(1H,1X,=TANG. COMP. OF ABS. VEL.#,2(F10.4,5X))	WICSPC	467
WRITE(6,417) WS1,WS2	WICSPC	468
417 FORMAT(1H,1X,=TANG. COMP. OF REL. VEL.#,2(F10.4,5X))	WICSPC	469
WRITE(6,418) ASPED1,ASPED2,ASPED3	WICSPC	470
418 FORMAT(1H,1X,=ACOUSTIC SPEED#,10X,3(F10.4,5X))	WICSPC	471
WRITE(6,419) AMAC1,AMAC2,AMAC3	WICSPC	472
419 FORMAT(1H,1X,=ABSOLUTE MACH NUMBER#,4X,3(F10.4,5X))	WICSPC	473
WRITE(6,420) AMACH1,AMACH2	WICSPC	474
420 FORMAT(1H,1X,=RELATIVE MACH NUMBER#,4X,2(F10.4,5X))	WICSPC	475
WRITE(6,421) FAI1,FAI2,FAI3	WICSPC	476
421 FORMAT(1H0,1X,=FLOW COEFFICIENT#,8X,3(F10.4,5X))	WICSPC	477
WRITE(6,422) AAA1,AAA2,AAA3	WICSPC	478
422 FORMAT(1H,1X,=FLOW AREA#,15X,3(F10.4,5X))	WICSPC	479

WRITE(6,423) ALFA1,ALFA2,ALFA3	WICSPC	480
423 FORMAT(1H0,1X,*,ABSOLUTE FLOW ANGLE*,5X,3(F10.4,5X))	WICSPC	481
WRITE(6,424) BETA1,BETA2	WICSPC	482
424 FORMAT(1H,1X,*,RELATIVE FLOW ANGLE*,5X,3(F10.4,5X))	WICSPC	483
WRITE(6,425) AINCIR,AINCIS	WICSPC	484
425 FORMAT(1H,1X,*,INCIDENCE*,16X,2(F10.4,5X))	WICSPC	485
WRITE(6,426) ADEVIR,ADEVIS	WICSPC	486
426 FORMAT(1H,1X,*,DEVIATION*,30X,2(F10.4,5X))	WICSPC	487
IF(IUNIT.NE.2) GO TO 860	WICSPC	488
UTIPG(ISTAGE)=UTIPG(ISTAGE)/CFU	WICSPC	489
P(1)=P(1)/CFP	WICSPC	490
P(2)=P(2)/CFP	WICSPC	491
P(3)=P(3)/CFP	WICSPC	492
PS1=PS1/CFP	WICSPC	493
PS2=PS2/CFP	WICSPC	494
PS3=PS3/CFP	WICSPC	495
TG(1)=TG(1)/CFT	WICSPC	496
TG(2)=TG(2)/CFT	WICSPC	497
TG(3)=TG(3)/CFT	WICSPC	498
TS1=TS1/CFT	WICSPC	499
TS2=TS2/CFT	WICSPC	500
TS3=TS3/CFT	WICSPC	501
RHOG(1)=RHOG(1)/CFD	WICSPC	502
RHOG2=RHOG2/CFD	WICSPC	503
RHOG3=RHOG3/CFD	WICSPC	504
RHOM(1)=RHOM(1)/CFD	WICSPC	505
RHOM2=RHOM2/CFD	WICSPC	506
RHOM3=RHOM3/CFD	WICSPC	507
UZ1=UZ1/CFU	WICSPC	508
UZ2=UZ2/CFU	WICSPC	509
UZ3=UZ3/CFU	WICSPC	510
U1=U1/CFU	WICSPC	511
U2=U2/CFU	WICSPC	512
U3=U3/CFU	WICSPC	513
W1=W1/CFU	WICSPC	514
W2=W2/CFU	WICSPC	515
U(ISTAGE)=U(ISTAGE)/CFU	WICSPC	516
UU2(ISTAGE)=UU2(ISTAGE)/CFU	WICSPC	517
U(ISTAGE+1)=U(ISTAGE+1)/CFU	WICSPC	518
US1=US1/CFU	WICSPC	519
US2=US2/CFU	WICSPC	520
WS1=WS1/CFU	WICSPC	521
WS2=WS2/CFU	WICSPC	522
ASPED1=ASPED1/CFU	WICSPC	523
ASPED2=ASPED2/CFU	WICSPC	524
ASPED3=ASPED3/CFU	WICSPC	525
AAA1=AAA1/CFA	WICSPC	526
AAA2=AAA2/CFA	WICSPC	527
AAA3=AAA3/CFA	WICSPC	528
860 CONTINUE	WICSPC	529
999 RETURN	WICSPC	530
END	WICSPC	531
C *****	WICMAC	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICMAC	2
C	WICMAC	3
C SUBROUTINE WICMAC	WICMAC	4
C	WICMAC	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICMAC	6
SUBROUTINE WICMAC(ISTAGE,AMASSM,T0IG,PRES,M,UZ,C,XW1,ALFA,	WICMAC	7
\$RMIX,CPMIX,AREA1)	WICMAC	8
REAL M,MA1,MC1,MA2,MC2,MANEW,MCNEW	WICMAC	9
COMMON TD(?),IUNIT	WICMAC	10
COMMON CFL,CFT,CFP,CFD,CFM,CFU,CFA	WICMAC	11
COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW	WICMAC	12
COMMON PREB,RTIP(8),SRTIP(8),AAA1,AAA2,AAA3,SAREA(6),SAREAS(7)	WICMAC	13
COMMON P(3),TG(3),XA,XU(3),XCH4,XW(3),XW4(3),XWT(3),TW(3),TWW(3)	WICMAC	14
COMMON OMEGS(7),OMEGR(6),GAPR(6),GAPS(6)	WICMAC	15
COMMON RRHUB(6),RC(6),RBLADE(6),STAGER(6)	WICMAC	16
COMMON SRHUB(7),SC(7),SBLADE(7),STAGES(7)	WICMAC	17
COMMON SIGUMR(6),BET1SR(6),BET2SR(6),AINCSP(6),ADEUSR(6)	WICMAC	18

COMMON SIGUMS(7) , BET1SS(7) , BET2SS(7) , AINCSS(7) , ADEUSS(7)	WICMAC	19
COMMON UTIPG(6),UTIP(6),UTIPD(6),UOU(6),UMEAN(6),UHUB(6),U(6),FAI	WICMAC	20
COMMON AREA(6),AREAS(7),UU2(6),UTIP2(6),UMEAN2(6),UHUB2(6),IPRINT	WICMAC	21
COMMON ICENT, IICENT, FMR1(6), FMA2(6), IDESIN, FAID	WICMAC	22
COMMON NS, NS1, RT(6), RM(6), RH(6), ST(6), SM(6), SH(6)	WICMAC	23
COMMON DSMASS, AAREA(7), AAREAS(7), PR12D(6), PR13D(6), ETARD(6)	WICMAC	24
COMMON DR(6), DS(6), DEQR(6), DEQS(6), BLOCK(6), BLOCKS(7)	WICMAC	25
COMMON BET1MR(6), BET2MR(6), BET1MS(7), BET2MS(7), RAD11(6), RAD12(6)	WICMAC	26
GAMMA=1.0/((1.0-RMIX/CPMIX/778.0)	WICMAC	27
G2=(GAMMA-1.0)/2.0	WICMAC	28
G3=-1.0/(GAMMA-1.0)	WICMAC	29
MA1=0.5	WICMAC	30
RHOG1=PRES/RMIX/T01G	WICMAC	31
RHOGS=(1.0+G2*MA1**2)**G3*RHOG1	WICMAC	32
RHOW=62.4	WICMAC	33
RHOMS=1.0/((1.0-XW1)/RHOGS+XW1/RHOW)	WICMAC	34
TS=T01G/(1.0+G2*MA1**2)	WICMAC	35
A=SQRT(GAMMA*RMIX*TS*32.174)	WICMAC	36
C=WICASD(XW1, RHOGS, A)	WICMAC	37
IF(JPERFM.NE.3) UZ=AMASSM/RHOMS/AREA1	WICMAC	38
IF(JPERFM.EQ.3) UZ=AMASSM/RHOGS/AREA1	WICMAC	39
IF(AMASSM.LT.0.001) UZ=UTIPG(ISTAGE)*FAI	WICMAC	40
ALFAR=ALFA*3.1415927/180.0	WICMAC	41
MC1=UZ/C/COS(ALFAR)	WICMAC	42
MA2=0.6	WICMAC	43
RHOGS=(1.0+G2*MA2**2)**G3*RHOG1	WICMAC	44
RHOMS=1.0/((1.0-XW1)/RHOGS+XW1/RHOW)	WICMAC	45
TS=T01G/(1.0+G2*MA2**2)	WICMAC	46
A=SQRT(GAMMA*RMIX*TS*32.174)	WICMAC	47
C=WICASD(XW1, RHOGS, A)	WICMAC	48
IF(JPERFM.NE.3) UZ=AMASSM/RHOMS/AREA1	WICMAC	49
IF(JPERFM.EQ.3) UZ=AMASSM/RHOGS/AREA1	WICMAC	50
IF(AMASSM.LT.0.001) UZ=UTIPG(ISTAGE)*FAI	WICMAC	51
MC2=UZ/C/COS(ALFAR)	WICMAC	52
J=1	WICMAC	53
300 MANEW=WICNEW(MA1, MC1, MA2, MC2)	WICMAC	54
RHOGS=(1.0+G2*MANEW**2)**G3*RHOG1	WICMAC	55
RHOMS=1.0/((1.0-XW1)/RHOGS+XW1/RHOW)	WICMAC	56
TS=T01G/(1.0+G2*MANEW**2)	WICMAC	57
A=SQRT(GAMMA*RMIX*TS*32.174)	WICMAC	58
C=WICASD(XW1, RHOGS, A)	WICMAC	59
IF(JPERFM.NE.3) UZ=AMASSM/RHOMS/AREA1	WICMAC	60
IF(JPERFM.EQ.3) UZ=AMASSM/RHOGS/AREA1	WICMAC	61
IF(AMASSM.LT.0.001) UZ=UTIPG(ISTAGE)*FAI	WICMAC	62
MCNEW=UZ/C/COS(ALFAR)	WICMAC	63
ERROR=ABS(MANEW-MCNEW)	WICMAC	64
ERROR=ERROR/MANEW	WICMAC	65
EPS=1.0E-6	WICMAC	66
IF(ERROR.LT.EPS) GO TO 200	WICMAC	67
MA1=MA2	WICMAC	68
MC1=MC2	WICMAC	69
MA2=MANEW	WICMAC	70
MC2=MCNEW	WICMAC	71
J=J+1	WICMAC	72
IF(J.LT.50) GO TO 300	WICMAC	73
WRITE(6,403) ISTAGE	WICMAC	74
403 FORMAT(1H0, #MZ DOES NOT CONVERGE AT STAGE=#, I1)	WICMAC	75
GO TO 998	WICMAC	76
200 M=MANEW	WICMAC	77
IF(AMASSM.LT.0.001) ISTAGE=0	WICMAC	78
998 RETURN	WICMAC	79
END	WICMAC	80
C+++++	WICASD	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICASD	2
C	WICASD	3
C FUNCTION WICASD	WICASD	4
C	WICASD	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICASD	6
FUNCTION WICASD (XW , RHOG , CG)	WICASD	7
RHOW=62.2567	WICASD	8

226

227

C		C	WICIRS	3
C	SUBROUTINE WICIRS	C	WICIRS	4
C		C	WICIRS	5
C	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	C	WICIRS	6
	SUBROUTINE WICIRS(ISTAGE,R,XW1,XG,RHOG1,BETA1,W1,		WICIRS	7
	IWW1 , WW2 , WW)		WICIRS	8
	REAL LWC		WICIRS	9
	COMMON TD(7),IUNIT		WICIRS	10
	COMMON CFL,CFT,CFP,CFD,CFM,CFU,CFA		WICIRS	11
	COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW		WICIRS	12
	COMMON PREB,RTIP(8),SRTIP(8),AAA1,AAA2,AAA3,SAREA(6),SAREAS(7)		WICIRS	13
	COMMON P(3),TG(3),XA,XU(3),XCH4,XW(3),XWW(3),XWT(3),TW(3),TWW(3)		WICIRS	14
	COMMON OMEGS(7),OMEGR(6),GAPR(6),GAPS(6)		WICIRS	15
	COMMON RRHUB(6) , RC(6) , RBLADE(6) , STAGER(6)		WICIRS	16
	COMMON SRHUB(7) , SC(7) , SBLADE(7) , STAGES(7)		WICIRS	17
	COMMON SIGUMR(6) , BET1SR(6) , BET2SR(6) , AINCSR(6) , ADEUSR(6)		WICIRS	18
	COMMON SIGUMS(7) , BET1SS(7) , BET2SS(7) , AINCSS(7) , ADEUSS(7)		WICIRS	19
	COMMON UTIPG(6),UTIP(6),UTIPD(6),UOU(6),UMEAN(6),UHUB(6),U(6),FAI		WICIRS	20
	COMMON AREA(6),AREAS(7),UU2(6),UTIP2(6),UMEAN2(6),UHUB2(6),IPRINT		WICIRS	21
	COMMON ICENT,IICENT,FMR1(6),FMA2(6),IDESIN,FAID		WICIRS	22
	COMMON NS,NS1,RT(6),RM(6),RH(6),ST(6),SM(6),SH(6)		WICIRS	23
	COMMON DSMASS,AAREA(7),AAREAS(7),PR12D(6),PR13D(6),ETARD(6)		WICIRS	24
	COMMON DR(6),DS(6),DEQR(6),DEQS(6),BLOCK(6),BLOCKS(7)		WICIRS	25
	COMMON BET1MR(6),BET2MR(6),BET1MS(7),BET2MS(7),RADI1(6),RADI2(6)		WICIRS	26
	N = ISTAGE		WICIRS	27
	PAI = 3.1415926		WICIRS	28
	B1 = 1.0		WICIRS	29
	B2R = (90.0 - BETA1 + STAGER (N)) * PAI / 180.0		WICIRS	30
	B2 = COS (B2R)		WICIRS	31
	LWC=XW1/XG*RHOG1		WICIRS	32
	DS1=0.07*RC(N)		WICIRS	33
	BETA1R = BETA1* PAI / 180.0		WICIRS	34
	DS2 = 2.0 * PAI * R / RBLADE(N) * COS (BETA1R) /		WICIRS	35
	\$COS(B2R)		WICIRS	36
	IF(DS2.GE.RC(N)) DS2=RC(N)		WICIRS	37
	H=(AAA1*144.0)/(2.0*PAI*R)		WICIRS	38
	A1=DS1*H*RBLADE(N)/144.0		WICIRS	39
	A2=DS2*H*RBLADE(N)/144.0		WICIRS	40
	WW1 = LWC * W1 * B1 * A1		WICIRS	41
	WW2 = LWC * W1 * B2 * A2		WICIRS	42
	WW = WW1 + WW2		WICIRS	43
	RETURN		WICIRS	44
	END		WICIRS	45
C	+++++	C	WICISS	1
C	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	C	WICISS	2
C		C	WICISS	3
C	SUBROUTINE WICISS	C	WICISS	4
C		C	WICISS	5
C	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	C	WICISS	6
	SUBROUTINE WICISS(ISTAGE ,R ,XW1 , XG , RHOGAS,ALFA2,U1 ,		WICISS	7
	\$WW1,WW2,WW)		WICISS	8
	REAL LWC		WICISS	9
	COMMON TD(7),IUNIT		WICISS	10
	COMMON CFL,CFT,CFP,CFD,CFM,CFU,CFA		WICISS	11
	COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW		WICISS	12
	COMMON PREB,RTIP(8),SRTIP(8),AAA1,AAA2,AAA3,SAREA(6),SAREAS(7)		WICISS	13
	COMMON P(3),TG(3),XA,XU(3),XCH4,XW(3),XWW(3),XWT(3),TW(3),TWW(3)		WICISS	14
	COMMON OMEGS(7),OMEGR(6),GAPR(6),GAPS(6)		WICISS	15
	COMMON RRHUB(6) , RC(6) , RBLADE(6) , STAGER(6)		WICISS	16
	COMMON SRHUB(7) , SC(7) , SBLADE(7) , STAGES(7)		WICISS	17
	COMMON SIGUMR(6) , BET1SR(6) , BET2SR(6) , AINCSR(6) , ADEUSR(6)		WICISS	18
	COMMON SIGUMS(7) , BET1SS(7) , BET2SS(7) , AINCSS(7) , ADEUSS(7)		WICISS	19
	COMMON UTIPG(6),UTIP(6),UTIPD(6),UOU(6),UMEAN(6),UHUB(6),U(6),FAI		WICISS	20
	COMMON AREA(6),AREAS(7),UU2(6),UTIP2(6),UMEAN2(6),UHUB2(6),IPRINT		WICISS	21
	COMMON ICENT,IICENT,FMR1(6),FMA2(6),IDESIN,FAID		WICISS	22
	COMMON NS,NS1,RT(6),RM(6),RH(6),ST(6),SM(6),SH(6)		WICISS	23
	COMMON DSMASS,AAREA(7),AAREAS(7),PR12D(6),PR13D(6),ETARD(6)		WICISS	24
	COMMON DR(6),DS(6),DEQR(6),DEQS(6),BLOCK(6),BLOCKS(7)		WICISS	25
	COMMON BET1MR(6),BET2MR(6),BET1MS(7),BET2MS(7),RADI1(6),RADI2(6)		WICISS	26
	LWC = XW1/ XG * RHOGAS		WICISS	27

[illegible]

WW2=LWC*U2*B2*A2	WICIRL	55
WW=WW1+WW2	WICIRL	56
RETURN	WICIRL	57
END	WICIRL	58
C *****	WICWAK	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICWAK	2
C	WICWAK	3
C SUBROUTINE WICWAK	WICWAK	4
C	WICWAK	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICWAK	6
SUBROUTINE WICWAK (RHOG , U , DWAKE , DWAKEM)	WICWAK	7
VISCOF=1.20E-3	WICWAK	8
SIGUMA = 4.6534E-3	WICWAK	9
GC = 32.174	WICWAK	10
WE=21.0	WICWAK	11
DWAKE1 = (WE * SIGUMA * GC) / RHOG / U ** 2	WICWAK	12
SN=VISCOF**2/(RHOG*SIGUMA*DWAKE1*GC)	WICWAK	13
WELIMT=12.0*(1.0+SN**0.36)	WICWAK	14
D1=WELIMT*SIGUMA*GC/(RHOG*U**2)	WICWAK	15
WE=22.0	WICWAK	16
DWAKE2=(WE*SIGUMA*GC)/RHOG/U**2	WICWAK	17
SN=VISCOF**2/(RHOG*SIGUMA*DWAKE2*GC)	WICWAK	18
WELINT=12.0*(1.0+SN**0.36)	WICWAK	19
D2=WELINT*SIGUMA*GC/(RHOG*U**2)	WICWAK	20
XXXX=WICNEW(DWAKE1,D1,DWAKE2,D2)	WICWAK	21
SN=VISCOF**2/(RHOG*SIGUMA*XXXX*GC)	WICWAK	22
WELIMT=12.0*(1.0+SN**0.36)	WICWAK	23
DWAKE=WELIMT*SIGUMA*GC/(RHOG*U**2)	WICWAK	24
DWAKEM = DWAKE / 3.2802 * 1.0E6	WICWAK	25
RETURN	WICWAK	26
END	WICWAK	27
C*****	WICHET	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICHET	2
C	WICHET	3
C SUBROUTINE WICHET	WICHET	4
C	WICHET	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICHET	6
SUBROUTINE WICHET(TG1,TG3,TW1,TW3,DAVEN2,DAVEN,	WICHET	7
\$DELZI,U2,WMASS1,UMASS1,AMASS,CHMASS,CPG,CPW,DELTGH,DELTWH,RE)	WICHET	8
DIMENSION DELHET(51)	WICHET	9
REAL ND , KA , NU , MMASS,NU	WICHET	10
DELTGH=0.0	WICHET	11
DELTWH=0.0	WICHET	12
IF(WMASS1.LT.1.0E-6) GO TO 11	WICHET	13
PAI = 3.1415927	WICHET	14
DAVEAU=(DAVEN2+DAVEN)/2.0*1.0E-6*3.2802	WICHET	15
IF(DAVEAU.LT.1.0E-6) GO TO 11	WICHET	16
RHOW = 62.54	WICHET	17
ND = WMASS1 / (RHOW * 4.0 / 3.0 * PAI * (DAVEAU / 2.0) ** 3)	WICHET	18
KA = 0.015 / 3600.0	WICHET	19
PR=0.7	WICHET	20
NU=2.0+0.6*SQRT(RE)*PR**0.33	WICHET	21
HCONVE = KA / DAVEAU * NU	WICHET	22
J = 1	WICHET	23
10 DELT=((TG1-TW1)+(TG3-TW3))/2.0	WICHET	24
DELHH = HCONVE * 4.0 * PAI * (DAVEAU / 2.0) **2*DELT *	WICHET	25
\$ND*DELZI/U2	WICHET	26
GMASS1=UMASS1+AMASS+CHMASS	WICHET	27
DELTGH=DELHH/(GMASS1*CPG)	WICHET	28
DELTWH=DELHH/(WMASS1*CPW)	WICHET	29
TG3=TG3-DELTGH	WICHET	30
TW3=TW3+DELTWH	WICHET	31
DELHET(J)=DELHH	WICHET	32
J=J+1	WICHET	33
IF(J.EQ.2) GO TO 10	WICHET	34
EROR=ABS(DELHET(J-1)-DELHET(J-2))	WICHET	35
EPS=0.0001	WICHET	36
IF(J.GT.50) GO TO 11	WICHET	37
IF(EROR.GT.EPS) GO TO 10	WICHET	38
11 RETURN	WICHET	39

	END	WICBPT	23
C	+++++	WICSH	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC		WICSH	2
C		WICSH	3
C FUNCTION WICSH		WICSH	4
C		WICSH	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC		WICSH	6
FUNCTION WICSH(TSTAG,PSTAG)		WICSH	7
TSTAGC=(TSTAG-492.0)/1.8		WICSH	8
IF(TSTAGC.LT.100.0) GO TO 40		WICSH	9
IF(TSTAGC.GE.100.0.AND.TSTAGC.LT.200.0) GO TO 41		WICSH	10
A=5.45142		WICSH	11
B=2010.8		WICSH	12
GO TO 42		WICSH	13
40 A=5.9778		WICSH	14
B=2224.4		WICSH	15
GO TO 42		WICSH	16
41 A=5.6485		WICSH	17
B=2101.1		WICSH	18
42 AA=A-B/(TSTAGC+273.0)		WICSH	19
PS=10.0**AA		WICSH	20
PS=PS/4.88247E-4		WICSH	21
WICSH=0.6218847*PS/(PSTAG-PS)		WICSH	22
RETURN		WICSH	23
END		WICSH	24
C	+++++	WICTAN	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC		WICTAN	2
C		WICTAN	3
C FUNCTION WICTAN		WICTAN	4
C		WICTAN	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC		WICTAN	6
FUNCTION WICTAN(X)		WICTAN	7
A=COS(X)		WICTAN	8
B=SIN(X)		WICTAN	9
WICTAN=B/A		WICTAN	10
RETURN		WICTAN	11
END		WICTAN	12
C	+++++	WICCEN	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC		WICCEN	2
C		WICCEN	3
C SUBROUTINE WICCEN		WICCEN	4
C		WICCEN	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC		WICCEN	6
SUBROUTINE WICCEN(RZERO,UZERO,DD,UZ,DELZZ,ALFAAU,FN,IRS,RHOGAS		WICCEN	7
IRHUB,R2,UZ,ITIP,UZTIME,XG,XA,XUU,XCH4,RTIPIN)		WICCEN	8
REAL N		WICCEN	9
PAI=3.1415926		WICCEN	10
ALFAAR=ALFAAU*PAI/180.0		WICCEN	11
IF(DD.LT.1.0E-6) GO TO 12		WICCEN	12
D=DD*1.0E-6*3.2902		WICCEN	13
RHOA=RHOGAS		WICCEN	14
RHOD=62.37		WICCEN	15
XXAA=XG/XG		WICCEN	16
XXUU=XUU/XG		WICCEN	17
XXCC=XCH4/XG		WICCEN	18
VISCO=(XXAA*0.05715+XXUU*0.03293+XXCC*0.035)/3600.0		WICCEN	19
ENDTIM=DELZZ/UZ		WICCEN	20
JJ=10		WICCEN	21
DELTIM=ENDTIM/FLOAT(JJ)		WICCEN	22
R1=RZERO		WICCEN	23
U1=UZERO		WICCEN	24
TIME=0.0		WICCEN	25
JJJ=1		WICCEN	26
11 RE=D*U1/VISCO		WICCEN	27
B1=0.44		WICCEN	28
N=0.0		WICCEN	29
IF(RE.LT.1.9) B1=24.0		WICCEN	30
IF(RE.LT.1.9) N=1.0		WICCEN	31
IF(RE.GT.1.9.AND.RE.LT.500.0) B1=18.5		WICCEN	32
IF(RE.GT.1.9.AND.RE.LT.500.0) N=0.6		WICCEN	33

B=((VISCO**N)*B1*PAI*(RHOA**(1.0-N))*6.0)/(8.0*RHOD*PAI)	WICCN	34
C=B/(B**(1.0+N))	WICCN	35
UW1=R1/12.0*2.0*PAI*FN/60.0	WICCN	36
IF(R1.GT.RTIPIN) UW1=RTIPIN/12.0*2.0*PAI*FN/60.0	WICCN	37
UW2=UZ*WICTAN(ALFAAR)	WICCN	38
IF(ALFAAU.LT.1.0) UW=UW1	WICCN	39
IF(ALFAAU.GT.1.0) UW=UW1/2.0	WICCN	40
A=UW*UW*(1.0-RHOA/RHOD)	WICCN	41
DELU=(A/R1*12.0-C*U1**(2.0-N))*DELTIM	WICCN	42
U2=U1+DELU	WICCN	43
UAVE=U1+DELU/2.0	WICCN	44
DELR=UAVE*DELTIM*12.0	WICCN	45
R2=R1+DELR	WICCN	46
TIME=TIME+DELTIM	WICCN	47
IPRINT=1	WICCN	48
IF(IPRINT.EQ.2)	WICCN	49
\$WRITE(6,101) R1,UW,A,U1,DELU,U2,UAVE,DELR,R2,TIME	WICCN	50
101 FORMAT(1H,7(F11.4,2X),E10.4,2X,F10.4,2X,E10.4)	WICCN	51
U1=U2	WICCN	52
R1=R2	WICCN	53
JJJ=JJJ+1	WICCN	54
UZTIME=UZ*TIME*12.0	WICCN	55
IF(TIME.GT.ENDTIM) GO TO 12	WICCN	56
IF(JJJ.EQ.JJ) GO TO 12	WICCN	57
GO TO 11	WICCN	58
12 RETURN	WICCN	59
END	WICCN	60
C *****	WICDMS	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICDMS	2
C	C	3
C SUBROUTINE WICDMS	C	4
C	C	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICDMS	6
SUBROUTINE WICDMS(IPRINT, IRAD, AMASW1, AMASW2, AMASH, R1, R2, STAREA,	WICDMS	7
\$RSTAVE, RTIP, DMIN, DMOUT, AMASW2, DELMAS)	WICDMS	8
PAI=3.1415926	WICDMS	9
RST1=RSTAVE	WICDMS	10
A1=STAREA	WICDMS	11
A2=PAI*(R2**2-R1**2)/144.0	WICDMS	12
A2=A2*0.5	WICDMS	13
DMCENT=A2/A1*AMASH	WICDMS	14
120 IF(DMCENT.LT.0.0) DMCENT=0.0	WICDMS	15
IF(DMCENT.GT.AMASW2) DMCENT=AMASW2	WICDMS	16
IF(R1.GT.RST1) GO TO 110	WICDMS	17
DMIN=DMCENT	WICDMS	18
DMOUT=DMCENT	WICDMS	19
GO TO 100	WICDMS	20
110 CONTINUE	WICDMS	21
DMIN=0.0	WICDMS	22
DMOUT=DMCENT	WICDMS	23
100 IF(IRAD.EQ.1) DMOUT=0.0	WICDMS	24
IF(IRAD.EQ.3) DMIN=0.0	WICDMS	25
AMASW2=AMASH1+DMIN-DMOUT	WICDMS	26
IF(AMASW2.LT.0.0) AMASW2=0.0	WICDMS	27
IF(AMASW2.GT.AMASW2) AMASW2=AMASW2	WICDMS	28
DELMAS=AMASW2-AMASH1	WICDMS	29
IF(IPRINT.EQ.2) WRITE(6,200) AMASW2, AMASH1, DMIN, DMOUT, DMCENT,	WICDMS	30
\$AMASW2, AMASH, DELMAS	WICDMS	31
200 FORMAT(1H0,8(F10.5,3X))	WICDMS	32
RETURN	WICDMS	33
END	WICDMS	34
C *****	WICDML	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICDML	2
C	C	3
C SUBROUTINE WICDML	C	4
C	C	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICDML	6
SUBROUTINE WICDML(IPRINT, IRAD, AMASW1, AMASW2, AMASH, R1, R2, STAREA,	WICDML	7
\$RSTAVE, RTIP, DMIN, DMOUT, AMASW2, DELMAS)	WICDML	8
PAI=3.1415926	WICDML	9

RST1=RSTAVE	WICDML	10
A1=STAREA	WICDML	11
A2=PAI*(R2**2-R1**2)/144.0	WICDML	12
A2=A2*0.5	WICDML	13
DMCENT=A2/A1*AMASH	WICDML	14
120 IF(DMCENT.LT.0.0) DMCENT=0.0	WICDML	15
IF(DMCENT.GT.AMASWT) DMCENT=AMASWT	WICDML	16
IF(R1.GT.RST1) GO TO 110	WICDML	17
DMIN=DMCENT	WICDML	18
DMOUT=DMCENT	WICDML	19
GO TO 100	WICDML	20
110 CONTINUE	WICDML	21
DMIN=0.0	WICDML	22
DMOUT=DMCENT	WICDML	23
100 IF(IRAD.EQ.1) DMOUT=0.0	WICDML	24
IF(IRAD.EQ.3) DMIN=0.0	WICDML	25
AMASH2=AMASH1+DMIN-DMOUT	WICDML	26
IF(AMASH2.LT.0.0) AMASH2=0.0	WICDML	27
IF(AMASH2.GT.AMASWT) AMASH2=AMASWT	WICDML	28
DELMAS=AMASH2-AMASH1	WICDML	29
IF(IPRINT.EQ.2) WRITE(6,200) AMASH2,AMASH1,DMIN,DMOUT,DMCENT,	WICDML	30
\$AMASWT,AMASH,DELMAS	WICDML	31
200 FORMAT(1H0,8(F10.5,3X))	WICDML	32
RETURN	WICDML	33
END	WICDML	34
C *****	WICDRG	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICDRG	2
C	WICDRG	3
C SUBROUTINE WICDRG	WICDRG	4
C	WICDRG	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICDRG	6
SUBROUTINE WICDRG(D,DELU1,RHGAS1,RHGAS2,CD2,DELU2,DRAG1,RE)	WICDRG	7
REAL N,N1	WICDRG	8
GC=32.174	WICDRG	9
IPRINT=1	WICDRG	10
VISCOG=12.0E-6	WICDRG	11
PAI=3.1415927	WICDRG	12
IF(D.GT.0.0) GO TO 300	WICDRG	13
CD2=0.0	WICDRG	14
DELU2=0.0	WICDRG	15
DRAG1=0.0	WICDRG	16
RE=0.0	WICDRG	17
GO TO 301	WICDRG	18
300 RE1=(RHGAS1*D*DELU1)/VISCOG	WICDRG	19
RE=RE1	WICDRG	20
B11=0.44	WICDRG	21
N1=0.0	WICDRG	22
IF(RE.LT.1.9) B11=24.0	WICDRG	23
IF(RE.LT.1.9) N1=1.0	WICDRG	24
IF(RE.GT.1.9.AND.RE.LT.500.0) B11=18.5	WICDRG	25
IF(RE.GT.1.9.AND.RE.LT.500.0) N1=0.6	WICDRG	26
CD1=B11/(RE1*N1)	WICDRG	27
DRAG1=0.5*RHGAS1*(DELU1**2)*(PAI*D**2)*CD1	WICDRG	28
\$/GC	WICDRG	29
DAMY=DRAG1*GC/(CD1*0.5*RHGAS2*(PAI*D**2))	WICDRG	30
IF(IPRINT.EQ.2) WRITE(6,200) D,DELU1,RHGAS1,RHGAS2,RE1,B11,N1,	WICDRG	31
\$CD1,DRAG1,DAMY	WICDRG	32
200 FORMAT(1H0,10(F10.5,2X))	WICDRG	33
DELU2=SQRT(DAMY)	WICDRG	34
RE2=RHGAS2*D*DELU2/VISCOG	WICDRG	35
B1=0.44	WICDRG	36
N=0.0	WICDRG	37
IF(RE2.LT.1.9) B1=24.0	WICDRG	38
IF(RE2.LT.1.9) N=1.0	WICDRG	39
IF(RE2.GT.1.9.AND.RE2.LT.500.0) B1=18.5	WICDRG	40
IF(RE2.GT.1.9.AND.RE2.LT.500.0) N=0.6	WICDRG	41
CD2=B1/(RE2*N)	WICDRG	42
IF(IPRINT.EQ.2) WRITE(6,101) RE1,B11,N1,CD1,DELU1,RE2,B1,N,CD2,	WICDRG	43
\$DELU2	WICDRG	44
101 FORMAT(1H0,2X,10(F10.5,2X))	WICDRG	45

RE=(RE1+RE2)/2.0	WICDRG	46
301 RETURN	WICDRG	47
END	WICDRG	48
C ++++++	WICSIZ	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICSIZ	2
C	WICSIZ	3
C SUBROUTINE WICSIZ	WICSIZ	4
C	WICSIZ	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICSIZ	6
SUBROUTINE WICSIZ(WMASSL,WMASSS,AMING1,AMING2,AMING3,DL,DS,D1,D2,	WICSIZ	7
\$D3,DLIMIT,AMSL,AMLGE,DSL,DLGE)	WICSIZ	8
TMASS1=WMASSL+WMASSS+AMING1+AMING2+AMING3	WICSIZ	9
AML=0.0	WICSIZ	10
AMS=0.0	WICSIZ	11
IF(DL.GT.DLIMIT) AML=AML+WMASSL	WICSIZ	12
IF(DL.LT.DLIMIT) AMS=AMS+WMASSL	WICSIZ	13
IF(DS.GT.DLIMIT) AML=AML+WMASSS	WICSIZ	14
IF(DS.LT.DLIMIT) AMS=AMS+WMASSS	WICSIZ	15
IF(D1.GT.DLIMIT) AML=AML+AMING1	WICSIZ	16
IF(D1.LT.DLIMIT) AMS=AMS+AMING1	WICSIZ	17
IF(D2.GT.DLIMIT) AML=AML+AMING2	WICSIZ	18
IF(D2.LT.DLIMIT) AMS=AMS+AMING2	WICSIZ	19
IF(D3.GT.DLIMIT) AML=AML+AMING3	WICSIZ	20
IF(D3.LT.DLIMIT) AMS=AMS+AMING3	WICSIZ	21
TMASS2=AML+AMS	WICSIZ	22
ERROR=ABS(TMASS1-TMASS2)	WICSIZ	23
IF(ERROR.LT.1.0E-6) GO TO 100	WICSIZ	24
IF(TMASS2.LT.1.0E-6) GO TO 100	WICSIZ	25
TT=TMASS1/TMASS2	WICSIZ	26
IF(TT.LT.1.0) AML=AML/TT	WICSIZ	27
IF(TT.LT.1.0) AMS=AMS/TT	WICSIZ	28
IF(TT.GT.1.0) AML=AML*TT	WICSIZ	29
IF(TT.GT.1.0) AMS=AMS*TT	WICSIZ	30
100 AMLGE=AML	WICSIZ	31
AMSL=AMS	WICSIZ	32
ADL=0.0	WICSIZ	33
ADS=0.0	WICSIZ	34
IF(DL.GT.DLIMIT.AND.AML.GT.0.0) ADL=ADL+DL*(WMASSL/AML)	WICSIZ	35
IF(DL.LT.DLIMIT.AND.AMS.GT.0.0) ADS=ADS+DL*(WMASSL/AMS)	WICSIZ	36
IF(DS.GT.DLIMIT.AND.AML.GT.0.0) ADL=ADL+DS*(WMASSS/AML)	WICSIZ	37
IF(DS.LT.DLIMIT.AND.AMS.GT.0.0) ADS=ADS+DS*(WMASSS/AMS)	WICSIZ	38
IF(D1.GT.DLIMIT.AND.AML.GT.0.0) ADL=ADL+D1*(AMING1/AML)	WICSIZ	39
IF(D1.LT.DLIMIT.AND.AMS.GT.0.0) ADS=ADS+D1*(AMING1/AMS)	WICSIZ	40
IF(D2.GT.DLIMIT.AND.AML.GT.0.0) ADL=ADL+D2*(AMING2/AML)	WICSIZ	41
IF(D2.LT.DLIMIT.AND.AMS.GT.0.0) ADS=ADS+D2*(AMING2/AMS)	WICSIZ	42
IF(D3.GT.DLIMIT.AND.AML.GT.0.0) ADL=ADL+D3*(AMING3/AML)	WICSIZ	43
IF(D3.LT.DLIMIT.AND.AMS.GT.0.0) ADS=ADS+D3*(AMING3/AMS)	WICSIZ	44
DLGE=ADL	WICSIZ	45
DSL=ADS	WICSIZ	46
IF(DL.GT.0.0.AND.DLGE.GT.DL) DLGE=DL	WICSIZ	47
IF(DS.GT.0.0.AND.DSL.GT.DS) DSL=DS	WICSIZ	48
RETURN	WICSIZ	49
END	WICSIZ	50
C ++++++	WICPRP	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICPRP	2
C	WICPRP	3
C SUBROUTINE WICPRP	WICPRP	4
C	WICPRP	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICPRP	6
SUBROUTINE WICPRP(XAIR,XH2O,XCH4,T,RMIX,CPMIX,GAMMA,G1,G2,G3)	WICPRP	7
C T IN R	WICPRP	8
C CPMIX IN BTU/LBM-R	WICPRP	9
C RMIX IN LBF-FT/LBM-R	WICPRP	10
RAIR=1545.3/28.964	WICPRP	11
RH2O=1545.3/18.016	WICPRP	12
RCH4=1545.3/16.043	WICPRP	13
XXAIR=XAIR/(XAIR+XH2O+XCH4)	WICPRP	14
XXH2O=XH2O/(XAIR+XH2O+XCH4)	WICPRP	15
XXCH4=XCH4/(XAIR+XH2O+XCH4)	WICPRP	16
RMIX=XXAIR*RAIR+XXH2O*RH2O+XXCH4*RCH4	WICPRP	17

CPMIX=XXAIR*WICCPA(T)+XXH2O*WICCPH(T)+XXCH4*WICCPC(T)	WICPRP	18	
GAMMA=1.0/(1.0-RMIX/CPMIX/778.0)	WICPRP	19	
G1=GAMMA/(GAMMA-1.0)	WICPRP	20	
G2=(GAMMA-1.0)/2.0	WICPRP	21	
G3=-1.0/(GAMMA-1.0)	WICPRP	22	
RETURN	WICPRP	23	
END	WICPRP	24	
C *****	WICCPA	1	
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICCPA	2	
C	C	WICCPA	3
C FUNCTION WICCPA	C	WICCPA	4
C	C	WICCPA	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICCPA	6	
FUNCTION WICCPA(T)	WICCPA	7	
C T IN R	WICCPA	8	
C CPAIR IN BTU/LBM-R	WICCPA	9	
TK=5.0/9.0*T	WICCPA	10	
A=3.65359	WICCPA	11	
B=-1.33736E-3	WICCPA	12	
C=3.29421E-6	WICCPA	13	
D=-1.91142E-9	WICCPA	14	
E=0.275462E-12	WICCPA	15	
R=8314.3/28.964	WICCPA	16	
CP=(A+B*TK+C*TK**2+D*TK**3+E*TK**4)*R	WICCPA	17	
WICCPA=CP*2.3885E-4	WICCPA	18	
RETURN	WICCPA	19	
END	WICCPA	20	
C *****	WICCPH	1	
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICCPH	2	
C	C	WICCPH	3
C FUNCTION WICCPH	C	WICCPH	4
C	C	WICCPH	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICCPH	6	
FUNCTION WICCPH(T)	WICCPH	7	
C T IN R	WICCPH	8	
C CPH2O IN BTU/LBM-R	WICCPH	9	
TK=5.0/9.0*T	WICCPH	10	
A=4.07013	WICCPH	11	
B=-1.10845E-3	WICCPH	12	
C=4.15212E-6	WICCPH	13	
D=-2.96374E-9	WICCPH	14	
E=0.807021E-12	WICCPH	15	
R=8314.3/18.016	WICCPH	16	
CP=(A+B*TK+C*TK**2+D*TK**3+E*TK**4)*R	WICCPH	17	
WICCPH=CP*2.3885E-4	WICCPH	18	
RETURN	WICCPH	19	
END	WICCPH	20	
C *****	WICCPC	1	
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICCPC	2	
C	C	WICCPC	3
C FUNCTION WICCPC	C	WICCPC	4
C	C	WICCPC	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICCPC	6	
FUNCTION WICCPC(T)	WICCPC	7	
C T IN R	WICCPC	8	
C CPCH4 IN BTU/LBM-R	WICCPC	9	
TK=5.0/9.0*T	WICCPC	10	
A=3.82619	WICCPC	11	
B=-3.97946E-3	WICCPC	12	
C=24.5583E-6	WICCPC	13	
D=-22.7329E-9	WICCPC	14	
E=6.96270E-12	WICCPC	15	
R=8314.3/16.043	WICCPC	16	
CP=(A+B*TK+C*TK**2+D*TK**3+E*TK**4)*R	WICCPC	17	
WICCPC=CP*2.3885E-4	WICCPC	18	
RETURN	WICCPC	19	
END	WICCPC	20	
C *****	WICGSL	1	
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICGSL	2	
C	C	WICGSL	3

C	SUBROUTINE WICGSL		C	WICGSL	4
C			C	WICGSL	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC				WICGSL	6
	SUBROUTINE WICGSL(OMEGAS,SIGUMA,BET1S,BET2S,AINCIS,ADEVIS,AMACH1,			WICGSL	7
	IBET1,DEQS,DEQN,SITACS,SITACN,BET2N,OMEGAN,X,IDESIN,AK1,AK2,AK3			WICGSL	8
	2,UZ1,UZ2,UR1,R1,R2)			WICGSL	9
	CALL WICEDD(AK3,UZ1,UZ2,UR1,R1,R2,BET1S,BET2S,SIGUMA,OMEGAS,			WICGSL	10
	\$DEQS,SITACS)			WICGSL	11
	AINCI=BET1-BET1S+AINCIS			WICGSL	12
	BET2A=BET2S			WICGSL	13
	X1=BET2A			WICGSL	14
	DELDEQ=WICED(AK3,UZ1,UZ2,UR1,R1,R2,BET1,X1,SIGUMA,AINCIS,AINCI)			WICGSL	15
	\$-DEQS			WICGSL	16
	ADEVI=ADEVIS+(6.40-9.45*AMACH1+9.45*X)*DELDEQ*AK1			WICGSL	17
	IF(AMACH1.LT.X) ADEVI=ADEVIS+6.40*DELDEQ*AK1			WICGSL	18
	BET2C=BET2S-ADEVIS+ADEVI			WICGSL	19
	Y1=BET2C			WICGSL	20
	N=1			WICGSL	21
12	IF(N.GT.1) GO TO 10			WICGSL	22
	BET2A=BET2S*1.1			WICGSL	23
10	X2=BET2A			WICGSL	24
	DEQN=WICED(AK3,UZ1,UZ2,UR1,R1,R2,BET1,X2,SIGUMA,AINCIS,AINCI)			WICGSL	25
	DELDEQ=DEQN-DEQS			WICGSL	26
	ADEVI=ADEVIS+(6.40-9.45*AMACH1+9.45*X)*DELDEQ*AK1			WICGSL	27
	IF(AMACH1.LT.X) ADEVI=ADEVIS+6.40*DELDEQ*AK1			WICGSL	28
	BET2C=BET2S-ADEVIS+ADEVI			WICGSL	29
	Y2=BET2C			WICGSL	30
	DELDET=ABS((X2-Y2)/X2)			WICGSL	31
	EPS=1.0E-6			WICGSL	32
	IF(DELBET.LE.EPS) GO TO 11			WICGSL	33
	BET2A=WICNEW(X1,Y1,X2,Y2)			WICGSL	34
	X1=X2			WICGSL	35
	Y1=Y2			WICGSL	36
	N=N+1			WICGSL	37
	IF(N.GT.50) GO TO 13			WICGSL	38
	GO TO 12			WICGSL	39
11	BET2N=X2			WICGSL	40
	GO TO 14			WICGSL	41
13	WRITE(6,201)			WICGSL	42
201	FORMAT(1H0,'DO NOT CONVERGE')			WICGSL	43
	GO TO 15			WICGSL	44
14	SITACN=WICMTK(SITACS,AMACH1,DELDEQ,AK2)			WICGSL	45
	OMEGAN=WICLOS(BET1,BET2N,SIGUMA,SITACN)			WICGSL	46
	SSS=SITACN-SITACS			WICGSL	47
15	RETURN			WICGSL	48
	END			WICGSL	49
C	+++++			WICSGL	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC				WICSGL	2
C			C	WICSGL	3
C SUBROUTINE WICSGL			C	WICSGL	4
C			C	WICSGL	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC				WICSGL	6
	SUBROUTINE WICSGL(CHORD,SIGMA,BETA1,BETA2,UG,RHO,G,			WICSGL	7
	\$AMASSH,AREA,UZ,IPRINT,OMEGA,P)			WICSGL	8
	PAI=3.1415926			WICSGL	9
	RHOG0=RHO/G			WICSGL	10
	RHOP0=AMASSH/AREA/UZ			WICSGL	11
	RR=RHOP0/RHOG0			WICSGL	12
	VISCOG=0.128E-4			WICSGL	13
	C=CHORD/12.0			WICSGL	14
	RE=UG*C*RHOG0/VISCOG			WICSGL	15
	DELP=0.37/(RE**0.2)/(1.0+1.442*RR)**0.8			WICSGL	16
	DELC=0.1402*DELC			WICSGL	17
	BETA1R=BETA1*PAI/180.0			WICSGL	18
	BETA2R=BETA2*PAI/180.0			WICSGL	19
	OMEGA=DELP*2.0*SIGMA/COS(BETA2R)*(COS(BETA1R)/COS(BETA2R))**2			WICSGL	20
	RETURN			WICSGL	21
	END			WICSGL	22
C	+++++			WICSGL	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC				WICSGL	2

[illegible]

OMEGRL=DELPRL/(0.5*RHO(1)/GC*W1**2)	WICSTL	73
CDRL=CDRL*DELUL2**2*PAI/4.0*DD**2*TNL/VAUE**2/RC(ISTAGE)*12.0	WICSTL	74
IF(IPRINT.EQ.2) WRITE(6,2002)	WICSTL	75
2002 FORMAT(1H0, 'DROPLET DRAG SUMMARY')	WICSTL	76
IF(IPRINT.EQ.2) WRITE(6,720) DELUU1, DELUU2, DELUL1, DELUL2, CDRU, CD	WICSTL	77
\$RUU, CDRL, CDRL	WICSTL	78
\$, DRAGU, DRAGL	WICSTL	79
720 FORMAT(1H0, 10(F10.5, 2X))	WICSTL	80
RUP1=(90.0-BETA1)/180.0	WICSTL	81
RLOW1=(90.0+BETA1)/180.0	WICSTL	82
RUP2=(90.0-BETA2)/180.0	WICSTL	83
RLOW2=(90.0+BETA2)/180.0	WICSTL	84
REAVE=RERUP*(RUP1+RUP2)*0.5+RERLOW*(RLOW1+RLOW2)*0.5	WICSTL	85
IF(IPRINT.EQ.2) WRITE(6,2010) RUP1, RUP2, RLOW1, RLOW2	WICSTL	86
2010 FORMAT(1H0, 4(F10.5, 2X))	WICSTL	87
GO TO 200	WICSTL	88
C DROPLET DRAG IN STATOR	WICSTL	89
100 DD=DAU*1.0E-6*3.28	WICSTL	90
UG1=W1	WICSTL	91
UP1=UG1-DELU	WICSTL	92
A1=WMASS*SC(ISTAGE)/12.0/UZ	WICSTL	93
A2=RHOW*4.0/3.0*PAI*(DD/2.0)**3	WICSTL	94
TN=0.0	WICSTL	95
IF(WMASS.GT.0.0) GO TO 5002	WICSTL	96
GO TO 5003	WICSTL	97
5002 TN=A1/A2	WICSTL	98
5003 VAUE=(U3+U2)/2.0	WICSTL	99
DELUU1=DELUU2	WICSTL	100
TNU=TN*(180.0-ALFA2-ALFA3)/360.0	WICSTL	101
IF(IPRINT.EQ.2) WRITE(6,2005)	WICSTL	102
2005 FORMAT(1H0, 'DROPLET DRAG IN STATOR (UPPER PART)')	WICSTL	103
CALL WICDRG(DD, DELUU1, RHOG(2), RHOG(2), CD2, DELU2, DRAG1, RE)	WICSTL	104
DELUU2=DELU2	WICSTL	105
CDSU=CD2	WICSTL	106
RESUP=RE	WICSTL	107
DRAGSU=DRAG1*TNU	WICSTL	108
AREA2=PAI*(SRIP(ISTAGE)**2-SRHUB(ISTAGE)**2)/144.0/10.0	WICSTL	109
DELPUS=DRAGSU/AREA2	WICSTL	110
OMEGSU=DELPUS/(0.5*RHO(2)/GC*U2**2)	WICSTL	111
CDSUU=CDSU*DELUU2**2*PAI/4.0*DD**2*TNU/VAUE**2/SC(ISTAGE)*12.0	WICSTL	112
DELUL1=DELUL2	WICSTL	113
TNL=TN*(180.0+ALFA2+ALFA3)/360.0	WICSTL	114
IF(IPRINT.EQ.2) WRITE(6,2006)	WICSTL	115
2006 FORMAT(1H0, 'DROPLET DRAG IN STATOR (LOWER PART)')	WICSTL	116
CALL WICDRG(DD, DELUL1, RHOG(2), RHOG(2), CD2, DELU2, DRAG1, RE)	WICSTL	117
DELUL2=DELU2	WICSTL	118
CDSL=CD2	WICSTL	119
RESLOW=RE	WICSTL	120
DRAGSL=DRAG1*TNL	WICSTL	121
DELPUS=DRAGSL/AREA2	WICSTL	122
OMEGSL=DELPUS/(0.5*RHO(2)/GC*U2**2)	WICSTL	123
CDSL=CDSL*DELUL2**2*PAI/4.0*DD**2*TNL/VAUE**2/SC(ISTAGE)*12.0	WICSTL	124
IF(IPRINT.EQ.2) WRITE(6,2007)	WICSTL	125
2007 FORMAT(1H0, 'DROPLET DRAG IN STATOR (SUMMARY)')	WICSTL	126
IF(IPRINT.EQ.2) WRITE(6,721) DELUU1, DELUU2, DELUL1, DELUL2, CDSU, CD	WICSTL	127
\$SUU, CDSL, CDSL	WICSTL	128
^, DRAGSU, DRAGSL	WICSTL	129
721 FORMAT(1H0, 10(F10.5, 2X))	WICSTL	130
SUP1=(90.0-ALFA2)/180.0	WICSTL	131
SLOW1=(90.0+ALFA2)/180.0	WICSTL	132
SUP2=(90.0-ALFA3)/180.0	WICSTL	133
SLOW2=(90.0+ALFA3)/180.0	WICSTL	134
REAVE=RESUP*(SUP1+SUP2)*0.5+RESLOW*(SLOW1+SLOW2)*0.5	WICSTL	135
IF(IPRINT.EQ.2) WRITE(6,2011) SUP1, SUP2, SLOW1, SLOW2	WICSTL	136
2011 FORMAT(1H0, 4(F10.5, 2X))	WICSTL	137
200 RETURN	WICSTL	138
END	WICSTL	139
C *****	WICFNL	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICFNL	2
C	WICFNL	3

C SUBROUTINE WICFML	C	C
C	C	C
C*****	C	C
SUBROUTINE WICFML(WG1,WG2,FMASS,RHOG1,CHORD,SIGUMA,BETA1,BETA2,	WICFML	6
\$CNT,OMEGAF)	WICFML	7
PAI=3.1415926	WICFML	8
VISCOSG=0.128E-4	WICFML	9
VISCOL=6.500E-4	WICFML	10
CH=CHORD/12.0	WICFML	11
HCAVE=0.5*(WG1+WG2)	WICFML	12
UFILM=0.5*HCAVE*VISCOSG/VISCOL	WICFML	13
(CDF=FMASS*UFILM/(0.5*RHOG1*WG1*WC1*C)	WICFML	14
BETA1R=BETA1*PAI/180.0	WICFML	15
BETA2R=BETA2*PAI/180.0	WICFML	16
BETA3R=0.5*(BETA1R+BETA2R)	WICFML	17
CS1=COS(BETA1R)**2	WICFML	18
CS2=COS(BETA2R)**2	WICFML	19
OMEGAF=CDF*SIGUMA*CS1/CS2	WICFML	20
RETURN	WICFML	21
END	WICFML	22
C *****	WICFML	23
C*****	WICFML	24
C SUBROUTINE WICRSL	WICRSL	1
C	WICRSL	2
C	WICRSL	3
C	WICRSL	4
C	WICRSL	5
C*****	WICRSL	6
SUBROUTINE WICRSL(SIGUMA,BETA1,PETA2,CHORD,DL,CDR,OMEGAR)	WICRSL	7
PAI=3.1415926	WICRSL	8
VF(DL.LT.1.0E-6) CDR=0.0	WICRSL	9
IF(DL.LT.1.0E-6) OMEGAR=0.0	WICRSL	10
IF(DL.LT.1.0E-6) GO TO 10	WICRSL	11
BETA1R=BETA1*PAI/180.0	WICRSL	12
BETA2R=BETA2*PAI/180.0	WICRSL	13
BETA3R=0.5*(BETA1R+BETA2R)	WICRSL	14
CS1=COS(BETA1R)**2	WICRSL	15
CS2=COS(BETA2R)**2	WICRSL	16
C=CHORD*2.54*0.01*1.0E6	WICRSL	17
A=C/DL	WICRSL	18
IF(A.LT.1000) A=1000	WICRSL	19
CDR=1.89+1.62*ALOG10(A)	WICRSL	20
CDR=1.0/CDR**2.5	WICRSL	21
OMEGAR=CDR*SIGUMA*CS1/CS2	WICRSL	22
10 RETURN	WICRSL	23
END	WICRSL	24
C *****	WICUT	1
C*****	WICUT	2
C SUBROUTINE WICUT	WICUT	3
C	WICUT	4
C	WICUT	5
C*****	WICUT	6
SUBROUTINE WICUT(ISTAGE,ASPEED,ALFA1,UZ,V1,	WICUT	7
IUS1 , WS1 , BETA1 , W1 , BETA2 , WS2 , US2 , ALFA2 , W2 , U2 ,	WICUT	8
INLFA3 ,U3,AK1,AK3)	WICUT	9
COMMON TD(7),IUNIT	WICUT	10
COMMON CFL,CFT,CFF,CFD,CFM,CFU,CFA	WICUT	11
COMMON JPFCFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW	WICUT	12
COMMON PREB,ERTIP(8),SRTIP(8),AAA1,AAAZ,AAA3,SAREA(6),SAREAS(7)	WICUT	13
COMMON P(3),TG(3),XA,XU(3),XCH4,XW(3),XWH(3),XWT(3),TW(3),TWH(3)	WICUT	14
COMMON OMEGS(7),UMEDR(6),GAPR(6),GAPS(6)	WICUT	15
COMMON PRHUB(6),PC(6),PBLADE(6),STAGER(6)	WICUT	16
COMMON SRHUS(7),SC(7),UBLADE(7),STAGES(7)	WICUT	17
COMMON SIGUR(6),BET1SR(6),BET2SR(6),AINCSP(6),ADEUSR(6)	WICUT	18
COMMON SIGUME(6),BET1SS(7),BET2SS(7),AINCSS(7),ADEUSS(7)	WICUT	19
COMMON UTIPG(6),UTIP(6),UTIPD(6),UUU(6),UMEAN(6),UHUB(6),U(6),FAI	WICUT	20
COMMON AREA(6),AREAS(7),UU2(6),UTIP2(6),UMEAN2(6),UHUB2(6),IFPRINT	WICUT	21
COMMON ICENT,ICEHT,PRR1(G),FMA2(6),IDESIN,FAID	WICUT	22
COMMON NS,N31,RT(6),RH(6),ST(6),SM(6),SH(6)	WICUT	23
COMMON DSMASS,HAMEAC(7),HAREAS(7),PRI2D(6),PRI3D(6),ETARD(6)	WICUT	24
COMMON DR(L),DS(6),DEOR(6),DEQS(6),BLOCK(6),BLOCKS(7)	WICUT	25
COMMON BET1HR(6),BET2HR(6),BET1HS(7),BET2HS(7),RADII(6),RADIS(6)	WICUT	26

PAI = 3.1415927	WICUT	27
ALFA1R = ALFA1 * PAI / 180.0	WICUT	28
U1 = U2 / COS (ALFA1R)	WICUT	29
US1 = U2 * TAN (ALFA1R)	WICUT	30
WS1 = U(ISTAGE) - US1	WICUT	31
T = WS1 / U2	WICUT	32
BETA1R = ATAN (T)	WICUT	33
BETA1 = BETA1R * 180.0 / PAI	WICUT	34
TT = U2 **2 + WS1 **2	WICUT	35
W1 = SQRT (TT)	WICUT	36
AMACH1 = W1 / ASPEED	WICUT	37
CALL WICBOA (OMEGS(ISTAGE), SIGUMR (ISTAGE) , BET1SR (ISTAGE	WICUT	38
1), BET2SR(ISTAGE),	WICUT	39
1 AINCSR (ISTAGE) , ADEUSR (ISTAGE) ,	WICUT	40
1AMACH1 , BETA1 , DEQS, DEQN, SITACS, SITACN, BET2N , FMR1(ISTAGE),	WICUT	41
1AK1, AK3, U2, U(ISTAGE), RADII1(ISTAGE), RADII2(ISTAGE))	WICUT	42
BETA2 = BET2N	WICUT	43
BETA2R = BETA2 * PAI / 180.0	WICUT	44
US2 = U2 * TAN (BETA2R)	WICUT	45
US2 = U(ISTAGE) - US2	WICUT	46
TTT=US2/U2	WICUT	47
ALFA2R = ATAN (TTT)	WICUT	48
ALFA2 = ALFA2R * 180.0 / PAI	WICUT	49
TTTT = U2 ** 2 + US2 ** 2	WICUT	50
W2 = SQRT (TTTT)	WICUT	51
TTTTT = U2 ** 2 + US2 ** 2	WICUT	52
U2 = SQRT (TTTTT)	WICUT	53
AMACH2 = U2 / ASPEED	WICUT	54
CALL WICBOA (OMEGS(ISTAGE), SIGUMS(ISTAGE) , BET1SS(ISTAGE) ,	WICUT	55
1LET2SS (ISTAGE) , AINCSS (ISTAGE) , ADEUSS (ISTAGE) ,	WICUT	56
1AMACH2 , ALFA2 , DEQS, DEQN, SITACS, SITACN, BET2N, FMA2(ISTAGE),	WICUT	57
1AK1, AK3, U2, U(ISTAGE), RADII1(ISTAGE+1))	WICUT	58
ALFA3 = BET2N	WICUT	59
ALFA3R=ALFA3*PAI/180.0	WICUT	60
US=U2/COS(ALFA3R)	WICUT	61
RETURN	WICUT	62
END	WICUT	63
C+++++	WICSPD	1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICSPD	2
C	C WICSPD	3
C SUBROUTINE WICSPD	C WICSPD	4
C	C WICSPD	5
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	WICSPD	6
SUBROUTINE WICSPD(AMAS, ISTAGE)	WICSPD	7
REAL H, HIN, M1, M2, M1REL, M2REL	WICSPD	8
COMMON TD(7), IUNIT	WICSPD	9
COMMON CFL, CFT, CFP, CFD, CFM, CFU, CFA	WICSPD	10
COMMON JPERFM, RHUG(3), BERUP, RERLOW, RESUP, RESLOW	WICSPD	11
COMMON PREB, RRTIP(8), SRTIP(8), AAA1, AAA2, AAA3, SAREA(6), SAREAS(7)	WICSPD	12
COMMON P(3), TG(3), XA, XU(3), XCH4, XW(3), XWU(3), XWT(3), TW(3), TWW(3)	WICSPD	13
COMMON OMEGS(7), OMEGR(6), GAPR(6), GAPS(6)	WICSPD	14
COMMON RRHUB(6), RC(6), RBLADE(6), STAGER(6)	WICSPD	15
COMMON SPHUB(7), SC(7), SBLADE(7), STAGES(7)	WICSPD	16
COMMON SIGUMR(6), BET1SR(6), BET2SR(6), AINCSR(6), ADEUSR(6)	WICSPD	17
COMMON SIGUMS(7), BET1SS(7), BET2SS(7), AINCSS(7), ADEUSS(7)	WICSPD	18
COMMON UTIPC(6), UTIP(6), UTIPD(6), UOU(6), UMEAN(6), UHUB(6), U(6), FAI	WICSPD	19
COMMON AREA(6), AREAS(7), UU2(6), UTIP2(6), UMEAN2(6), UHUB2(6), IPRINT	WICSPD	20
COMMON ICENT, IICENT, FMR1(6), FMA2(6), IDESIN, FAID	WICSPD	21
COMMON NS, NS1, RT(6), RH(6), RH(6), ST(6), SM(6), SH(6)	WICSPD	22
COMMON DSMASS, AAREA(7), AAREAS(7), PR12D(6), PR13D(6), ETARD(6)	WICSPD	23
COMMON DR(6), DS(6), DEQR(6), DEQS(6), BLOCK(6), BLOCKS(7)	WICSPD	24
COMMON BET1MR(6), BET2MR(6), BET1MS(7), BET2MS(7), RADII1(6), RADII2(6)	WICSPD	25
AJ=778.26	WICSPD	26
PAI=3.1415926	WICSPD	27
CC=32.174	WICSPD	28
TREF=518.70	WICSPD	29
PREF=14.7*144.0	WICSPD	30
AAAR1T=PAI*(RRTIP(1)**2-RRHUB(1)**2)/144.0*BLOCK(1)	WICSPD	31
CHASS=AMASS*SQRT(TC(1)/TREF)/(P(1)/PREF)*AAAR1T/SAREA(1)	WICSPD	32
C IGV INLET	WICSPD	33

ISTAGE=NS1	WICSPD	24
CALL WICPRP(1.0,0.0,0.0,TG(1),RMIX,CPMIX,GAMMA,G1,G2,G3)	WICSPD	25
CALL WICMAC(ISTAGE,AMASS,TG(1),P(1),M,UZ,C,0.0,0.0,RMIX,CPMIX,ARE	WICSPD	26
SAS(NS1))	WICSPD	27
UZIN=UZ	WICSPD	28
AIN=C	WICSPD	29
MIN=M	WICSPD	30
TOIN=TG(1)	WICSPD	31
POIN=P(1)	WICSPD	32
PSIN=P(1)/(1.0+G2*M**2)**G1	WICSPD	33
TSIN=TG(1)/(1.0+G2*M**2)	WICSPD	34
RHOGIN=PSIN/RMIX/TSIN	WICSPD	35
FAIN=UZIN/UTIPG(1)	WICSPD	36
FAID=FAIN	WICSPD	37
GAMMAIN=GAMMA	WICSPD	38
TOIN=TG(1)	WICSPD	39
POIN=P(1)	WICSPD	40
C ICU INLET PRINTOUT	WICSPD	41
IF(IUNIT.NE.2) GO TO 851	WICSPD	42
TOIN=TOIN/CFT	WICSPD	43
POIN=POIN/CFP	WICSPD	44
TSIN=TSIN/CFT	WICSPD	45
PSIN=PSIN/CFP	WICSPD	46
RHOGIN=RHOGIN/CFD	WICSPD	47
AIN=AIN/CFU	WICSPD	48
UZIN=UZIN/CFU	WICSPD	49
AREAS(NS1)=AREAS(NS1)*CFA	WICSPD	50
851 CONTINUE	WICSPD	51
WRITE(6,1000)	WICSPD	52
1000 FORMAT(1H1,***** DESIGN POINT INFORMATION *****	WICSPD	53
S****)	WICSPD	54
WRITE(6,1010)	WICSPD	55
1010 FORMAT(1H0,1X,***** COMPRESSOR INLET *****)	WICSPD	56
WRITE(6,1020) TOIN,POIN,TSIN,PSIN,RHOGIN	WICSPD	57
1020 FORMAT(1H0,1X,#TOTAL TEMPERATURE AT COMPRESSOR INLET=#,F10.5,/,	WICSPD	58
\$2X,#TOTAL PRESSURE AT COMPRESSOR INLET=#,F10.2,/,	WICSPD	59
\$2X,#STATIC TEMPERATURE AT COMPRESSOR INLET=#,F10.5,/,	WICSPD	60
\$2X,#STATIC PRESSURE AT COMPRESSOR INLET=#,F10.2,/,	WICSPD	61
\$2X,#STATIC DENSITY AT COMPRESSOR INLET=#,F10.5)	WICSPD	62
WRITE(6,1030) AIN,UZIN,MIN,AREAS(NS1),FAIN	WICSPD	63
1030 FORMAT(1H0,1X,#ACOUSTIC SPEED AT COMPRESSOR INLET=#,F10.5,/,	WICSPD	64
\$2X,#AXIAL VELOCITY AT COMPRESSOR INLET=#,F10.5,/,	WICSPD	65
\$2X,#MACH NUMBER AT COMPRESSOR INLET=#,F10.5,/,	WICSPD	66
\$2X,#STREAMTUBE AREA AT COMPRESSOR INLET=#,F10.5,/,	WICSPD	67
\$2X,#FLOW COEFFICIENT AT COMPRESSOR INLET=#,F10.5)	WICSPD	68
IF(IUNIT.NE.2) GO TO 852	WICSPD	69
TOIN=TOIN/CFT	WICSPD	70
POIN=POIN/CFP	WICSPD	71
TSIN=TSIN/CFT	WICSPD	72
PSIN=PSIN/CFP	WICSPD	73
RHOGIN=RHOGIN/CFD	WICSPD	74
AIN=AIN/CFU	WICSPD	75
UZIN=UZIN/CFU	WICSPD	76
AREAS(NS1)=AREAS(NS1)/CFA	WICSPD	77
852 CONTINUE	WICSPD	78
C ROTOR INLET	WICSPD	79
ISTAGE=1	WICSPD	80
100 I=ISTAGE-1	WICSPD	81
IF(I.EQ.0) I=NS1	WICSPD	82
ALFA1=BET2SS(I)	WICSPD	83
ADEUSS(I)=ALFA1-BET2MS(I)	WICSPD	84
CALL WICMAC(ISTAGE,AMASS,TG(1),P(1),M,UZ,C,0.0,ALFA1,RMIX,	WICSPD	85
\$CPMIX,AREAS(ISTAGE))	WICSPD	86
CPMIX1=CPMIX	WICSPD	87
GAMMA1=GAMMA	WICSPD	88
UZ1=UZ	WICSPD	89
A1=C	WICSPD	90
M1=M	WICSPD	91
PS1=P(1)/(1.0+G2*M1**2)**G1	WICSPD	92
TS1=TG(1)/(1.0+G2*M1**2)	WICSPD	93

RHOGS1=PS1/RMIX/TS1	WICSPD	104
FAIRIN=U21/UTIPG(ISTAGE)	WICSPD	105
ALFA1R=ALFA1*PAI/180.0	WICSPD	106
U1=U21/COS(ALFA1R)	WICSPD	107
US1=U21*WICTAN(ALFA1R)	WICSPD	108
WS1=U(ISTAGE)-US1	WICSPD	109
WU=WS1/U21	WICSPD	110
BETA1R=ATAN(WU)	WICSPD	111
BETA1=BETA1R*180.0/PAI	WICSPD	112
BET1SR(ISTAGE)=BETA1	WICSPD	113
AINCSR(ISTAGE)=BETA1-BET1MR(ISTAGE)	WICSPD	114
W1=U21/COS(BETA1R)	WICSPD	115
M1REL=W1/A1	WICSPD	116
TREL1=(1.0+G2*M1REL**2)*TS1	WICSPD	117
PREL1=(1.0+G2*M1REL**2)**G1*PS1	WICSPD	118
IF(ISTAGE.GE.2) DS(ISTAGE-1)=1.0-U1/U2+ABS(US2-US1)/2.0/	WICSPD	119
\$SIGUMS(ISTAGE-1)/U2	WICSPD	120
IF(ISTAGE.GE.2) DEQS(ISTAGE-1)=COS(ALFA1R)/COS(ALFA2R)*	WICSPD	121
\$(1.12+0.61*COS(ALFA2R)**2/SIGUMS(ISTAGE-1)*(WICTAN(ALFA2R)-	WICSPD	122
\$WICTAN(ALFA1R)))	WICSPD	123
IF(ISTAGE.GT.NS) GO TO 101	WICSPD	124
C ROTOR OUTLET	WICSPD	125
P(2)=PR12D(ISTAGE)*P(1)	WICSPD	126
TR12=(PR12D(ISTAGE)**(1.0/G1)-1.0)/ETARD(ISTAGE)+1.0	WICSPD	127
TG(2)=TR12*TG(1)	WICSPD	128
CALL WICPRP(1.0,0.0,0.0,TG(2),RMIX,CPMIX,GAMMA,G1,G2,G3)	WICSPD	129
GAMMA2=GAMMA	WICSPD	130
CPMIX2=CPMIX	WICSPD	131
GAMMAU=(GAMMA1+GAMMA2)/2.0	WICSPD	132
CPMIXU=(CPMIX1+CPMIX2)/2.0	WICSPD	133
G1AU=GAMMAU/(GAMMAU-1.0)	WICSPD	134
G2AU=(GAMMAU-1.0)/2.0	WICSPD	135
PR13I=(TG(2)/TG(1))*G1AU	WICSPD	136
DELT=TG(2)-TG(1)	WICSPD	137
US2=(U(ISTAGE)*US1+DELT*CPMIXU*GC*AJ)/UU2(ISTAGE)	WICSPD	138
JJ=1	WICSPD	139
U22AS=U21	WICSPD	140
200 US2U22=US2/U22AS	WICSPD	141
ALFA2R=ATAN(US2U22)	WICSPD	142
ALFA2=ALFA2R*180.0/PAI	WICSPD	143
BET1SS(ISTAGE)=ALFA2	WICSPD	144
AINCSS(ISTAGE)=ALFA2-BET1MS(ISTAGE)	WICSPD	145
WS2=UU2(ISTAGE)-US2	WICSPD	146
WS2U22=WS2/U22AS	WICSPD	147
BETA2R=ATAN(WS2U22)	WICSPD	148
BETA2=BETA2R*180.0/PAI	WICSPD	149
BET2SR(ISTAGE)=BETA2	WICSPD	150
ADEUSR(ISTAGE)=BETA2-BET2MR(ISTAGE)	WICSPD	151
U2=U22AS/COS(ALFA2R)	WICSPD	152
W2=U22AS/COS(BETA2R)	WICSPD	153
TS2=TG(2)-U2**2/(2.0*CPMIX2*GC*AJ)	WICSPD	154
A2=SQRT(GAMMA2*RMIX*TS2*GC)	WICSPD	155
M2=U2/A2	WICSPD	156
PS2=P(2)/(1.0+G2*M2**2)**G1	WICSPD	157
RHOGS2=PS2/RMIX/TS2	WICSPD	158
M2REL=W2/A2	WICSPD	159
TREL2=(1.0+G2*M2REL**2)*TS2	WICSPD	160
PREL2=(1.0+M2REL**2)**G1*PS2	WICSPD	161
U22CL=f MASS/(RHOGS2*AREAS(ISTAGE))	WICSPD	162
EPS=1.0E-6	WICSPD	163
IF(JJ.EQ.2) GO TO 201	WICSPD	164
IF(JJ.GT.2) GO TO 202	WICSPD	165
X1=U22AS	WICSPD	166
Y1=U22CL	WICSPD	167
U22AS=U22CL	WICSPD	168
JJ=JJ+1	WICSPD	169
GO TO 200	WICSPD	170
201 X2=U22AS	WICSPD	171
Y2=U22CL	WICSPD	172
U22AS=WICNEW(X1,Y1,X2,Y2)	WICSPD	173

JJ=JJ+1	WICSPD	174
GO TO 200	WICSPD	175
202 IF((ABS(UZ2AS-UZ2CL)/UZ2AS).LT.EPS) GO TO 300	WICSPD	176
X1=X2	WICSPD	177
Y1=Y2	WICSPD	178
X2=UZ2AS	WICSPD	179
Y2=UZ2CL	WICSPD	180
UZ2AS=WICNEW(X1,Y1,X2,Y2)	WICSPD	181
JJ=JJ+1	WICSPD	182
GO TO 200	WICSPD	183
300 UZ2=UZ2CL	WICSPD	184
FAIOUT=UZ2/UTIPG(ISTAGE)	WICSPD	185
DR(ISTAGE)=1.0-W2/W1+ABS(WS1-WS2)/2.0/SIGUMR(ISTAGE)/W1	WICSPD	186
DEOR(ISTAGE)=COS(BETA2R)/COS(BETA1R)*	WICSPD	187
S*(1.12+0.61*COS(BETA1R)**2/SIGUMR(ISTAGE))*	WICSPD	188
S*(WICTAN(BETA1R)-WICTAN(BETA2R)))	WICSPD	189
PRRELI=(1.0+C2AU*U(ISTAGE)**2/(GAMMAU*RMIX*TREL1*GC)	WICSPD	190
S*(UU2(ISTAGE)/U(ISTAGE))**2-1.0)**G1AU	WICSPD	191
PLOSSR=PR12D(ISTAGE)/(TG(2)/TG(1))**G1AU*PRRELI	WICSPD	192
IF(PRELI.LT.PLOSSR) PRELI=1.0	WICSPD	193
ONECR(ISTAGE)=(PRELI-PLOSSR)/(1.0-PS1/PRELI)	WICSPD	194
C STATOR OUTLET	WICSPD	195
PLOSSS=PR13D(ISTAGE)/PR12D(ISTAGE)	WICSPD	196
PR13=(TG(2)/TG(1))**G1AU*PLOSSR*PLOSSS/PRELI	WICSPD	197
ONEGS(ISTAGE)=(1.0-PLOSSS)/(1.0-PS2/P(2))	WICSPD	198
ETASG=(PR13**((1.0/G1AU)-1.0)/(TR12-1.0)	WICSPD	199
P(3)=PR13*P(1)	WICSPD	200
TG(3)=TG(2)	WICSPD	201
TD(ISTAGE)=TG(1)	WICSPD	202
C PRINTOUT OF STAGE PERFORMANCE	WICSPD	203
IF(IUNIT.NE.2) GO TO 863	WICSPD	204
TG(1)=TG(1)*CFT	WICSPD	205
TG(2)=TG(2)*CFT	WICSPD	206
P(1)=P(1)*CFP	WICSPD	207
P(2)=P(2)*CFP	WICSPD	208
TS1=TS1*CFT	WICSPD	209
TS2=TS2*CFT	WICSPD	210
PS1=PS1*CFP	WICSPD	211
PS2=PS2*CFP	WICSPD	212
RHOCS1=RHOCS1*CFD	WICSPD	213
RHOCS2=RHOCS2*CFD	WICSPD	214
UZ1=UZ1*CFU	WICSPD	215
UZ2=UZ2*CFU	WICSPD	216
U1=U1*CFU	WICSPD	217
U2=U2*CFU	WICSPD	218
W1=W1*CFU	WICSPD	219
W2=W2*CFU	WICSPD	220
WS1=WS1*CFU	WICSPD	221
WS2=WS2*CFU	WICSPD	222
US1=US1*CFU	WICSPD	223
US2=US2*CFU	WICSPD	224
U(ISTAGE)=U(ISTAGE)*CFU	WICSPD	225
UU2(ISTAGE)=UU2(ISTAGE)*CFU	WICSPD	226
TREL1=TREL1*CFT	WICSPD	227
PREL1=PREL1*CFP	WICSPD	228
TREL2=TREL2*CFT	WICSPD	229
PREL2=PREL2*CFP	WICSPD	230
AREA(ISTAGE)=AREA(ISTAGE)*CFA	WICSPD	231
AREAS(ISTAGE)=AREAS(ISTAGE)*CFA	WICSPD	232
RADI1(ISTAGE)=RADI1(ISTAGE)*CFL	WICSPD	233
RADI2(ISTAGE)=RADI2(ISTAGE)*CFL	WICSPD	234
863 CONTINUE	WICSPD	235
WRITE(G,1000)	WICSPD	236
WRITE(G,1100) ISTAGE	WICSPD	237
1100 FORMAT(IH0,1X,***** STAGE=,I2,*****)	WICSPD	238
WRITE(G,1101)	WICSPD	239
1101 FORMAT(IH0,16X,=TOTAL=,8X,=TOTAL=,7X,=STATIC=,7X,=STATIC=,7X,	WICSPD	240
S=STATIC=,7X,=TEMP=,7X,=PRESSURE=,7X,=TEMP=,7X,=PRESSURE=,6X,	WICSPD	241
S=DENSITY=)	WICSPD	242
WRITE(G,1110) TG(1),P(1),TS1,PS1,RHOCS1	WICSPD	243

1110	FORMAT(1H0,1X,*,ROTOR INLET*,1X,5(F10.3,3X))	WICSPD	244
	WRITE(6,1120) TG(2),P(2),TS2,PS2,RHOGS2	WICSPD	245
1120	FORMAT(1H,1X,*,ROTOR OUTLET*,5(F10.3,3X))	WICSPD	246
	WRITE(6,1111)	WICSPD	247
1111	FORMAT(1H0,16X,*,AXIAL*,6X,*,ABSOLUTE*,5X,*,RELATIVE*,5X,*,TAN COMP*,	WICSPD	248
	\$5X,*,TAN COMP*,/,15X,*,VELOCITY*,5X,*,VELOCITY*,5X,*,VELOCITY*,4X,	WICSPD	249
	\$*OF ABS UEL*,3X,*OF REL UEL*)	WICSPD	250
	WRITE(6,1130) UZ1,U1,W1,US1,WS1	WICSPD	251
1130	FORMAT(1H0,1X,*,ROTOR INLET*,1X,5(F10.5,3X))	WICSPD	252
	WRITE(6,1140) UZ2,U2,W2,US2,WS2	WICSPD	253
1140	FORMAT(1H,1X,*,ROTOR OUTLET*,5(F10.5,3X))	WICSPD	254
	WRITE(6,1141)	WICSPD	255
1141	FORMAT(1H0,15X,*,ROTOR*,7X,*,ABS MACH*,5X,*,REL MACH*,5X,*,REL TOTAL*,	WICSPD	256
	\$4X,*,REL TOTAL*,/,16X,*,SPEED*,8X,*,NUMBER*,7X,*,NUMBER*,7X,*,TEMP*,8X,	WICSPD	257
	\$*PRESSURE*)	WICSPD	258
	WRITE(6,1150) U(ISTAGE),M1,M1REL,TREL1,PREL1	WICSPD	259
1150	FORMAT(1H0,1X,*,ROTOR INLET*,1X,5(F10.3,3X))	WICSPD	260
	WRITE(6,1160) UU2(ISTAGE),M2,M2REL,TREL2,PREL2	WICSPD	261
1160	FORMAT(1H,1X,*,ROTOR OUTLET*,5(F10.3,3X))	WICSPD	262
	I=ISTAGE	WICSPD	263
	IF(ISTAGE.EQ.1) I=8	WICSPD	264
	WRITE(6,1161)	WICSPD	265
1161	FORMAT(1H0,14X,*,ABS FLOW*,5X,*,REL FLOW*,4X,*,STREAMTUBE*,18X,	WICSPD	266
	\$*FLOW*,/,16X,*,ANGLE*,8X,*,ANGLE*,8X,*,AREA*,9X,*,RADIUS*,5X,	WICSPD	267
	\$*COEFFICIENT*)	WICSPD	268
	WRITE(6,1170) BET2SS(I-1),BET1SR(ISTAGE),AREA(ISTAGE),	WICSPD	269
	\$RADI1(ISTAGE),FAIRIN	WICSPD	270
1170	FORMAT(1H0,1X,*,ROTOR INLET*,1X,5(F10.5,3X))	WICSPD	271
	WRITE(6,1180) BET1SS(ISTAGE),BET2SR(ISTAGE),AREAS(ISTAGE),	WICSPD	272
	\$RADI2(ISTAGE),FAIOUT	WICSPD	273
1180	FORMAT(1H,1X,*,ROTOR OUTLET*,5(F10.5,3X))	WICSPD	274
	WRITE(6,1190) PR13,ETASG,PR12D(ISTAGE),ETARD(ISTAGE),TR12	WICSPD	275
1190	FORMAT(1H0,1X,*,STAGE TOTAL PRESSURE RATIO AT DESIGN POINT=*,F10.5,	WICSPD	276
	\$/,2X,*,STAGE ADIABATIC EFFICIENCY AT DESIGN POINT=*,F10.5,/,2X,	WICSPD	277
	\$*ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT=*,F10.5,/,2X,	WICSPD	278
	\$*ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT=*,F10.5,/,2X,	WICSPD	279
	\$*ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT=*,F10.5)	WICSPD	280
	IF(IUNIT.NE.2) GO TO 864	WICSPD	281
	TG(1)=TG(1)/CFT	WICSPD	282
	TG(2)=TG(2)/CFT	WICSPD	283
	P(1)=P(1)/CFP	WICSPD	284
	P(2)=P(2)/CFP	WICSPD	285
	TS1=TS1/CFT	WICSPD	286
	TS2=TS2/CFT	WICSPD	287
	PS1=PS1/CFP	WICSPD	288
	PS2=PS2/CFP	WICSPD	289
	RHOGS1=RHOGS1/CFD	WICSPD	290
	RHOGS2=RHOGS2/CFD	WICSPD	291
	UZ1=UZ1/CFU	WICSPD	292
	UZ2=UZ2/CFU	WICSPD	293
	U1=U1/CFU	WICSPD	294
	U2=U2/CFU	WICSPD	295
	W1=W1/CFU	WICSPD	296
	W2=W2/CFU	WICSPD	297
	US1=US1/CFU	WICSPD	298
	US2=US2/CFU	WICSPD	299
	WS1=WS1/CFU	WICSPD	300
	WS2=WS2/CFU	WICSPD	301
	U(ISTAGE)=U(ISTAGE)/CFU	WICSPD	302
	UU2(ISTAGE)=UU2(ISTAGE)/CFU	WICSPD	303
	TREL1=TREL1/CFT	WICSPD	304
	PREL1=PREL1/CFP	WICSPD	305
	TREL2=TREL2/CFT	WICSPD	306
	PREL2=PREL2/CFP	WICSPD	307
	AREA(ISTAGE)=AREA(ISTAGE)/CFA	WICSPD	308
	AREAS(ISTAGE)=AREAS(ISTAGE)/CFA	WICSPD	309
	RADI2(ISTAGE)=RADI2(ISTAGE)/CFL	WICSPD	310
864	CONTINUE	WICSPD	311
C REPEAT		WICSPD	312
	TG(1)=TG(3)	WICSPD	313

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      P(1)=P(3)
      IF(ISTAGE.EQ.NS) ADEUSS(NS)=BET2SS(NS)-BET2MS(NS)
      ISTATE=ISTAGE+1
      IF(ISTAGE.EQ.NS1) GO TO 101
      GO TO 100
C OVERALL PERFORMANCE AT DESIGN POINT
101 QUALPR=P(3)/POIN
    QUALTR=TC(3)/TOIN
    GAMMAU=(GAMMAIN+GAMMA)/2.0
    CIAU=GAMMAU/(GAMMAU-1.0)
    QUALEF=(QUALPR**((1.0/GIAU)-1.0))/(QUALTR-1.0)
    QUALDT=TC(3)-TOIN
C PRINTOUT OF OVERALL PERFORMANCE AT DESIGN POINT
    IF(IUNIT.NE.2) GO TO 865
    TOIN=TOIN/CFT
    POIN=POIN/CFP
    CMASS=CMASS/CFM
    QUALDT=QUALDT/CFT
    DO 422 I=1,NS
      TD(I)=TD(I)*CFT
422 CONTINUE
865 CONTINUE
    WRITE(6,1000)
    WRITE(6,421)
421 FORMAT(1H0,***** OVERALL PERFORMANCE AT DESIGN POINT ****
$*****$)
    WRITE(6,425) TOIN
425 FORMAT(1H0,1X,#COMPRESSOR INLET TOTAL TEMPERATURE=#,F8.2)
    WRITE(6,426) POIN
426 FORMAT(1H0,1X,#COMPRESSOR INLET TOTAL PRESSURE=#,F10.2)
    WRITE(6,427) CMASS
427 FORMAT(1H0,1X,#CORRECTED MASS FLOW RATE=#,F6.3)
    WRITE(6,429) QUALPR
429 FORMAT(1H0,1X,#OVERALL TOTAL PRESSURE RATIO=#,F6.4)
    WRITE(6,430) QUALTP
430 FORMAT(1H0,1X,#OVERALL TOTAL TEMPERATURE RATIO=#,F6.4)
    WRITE(6,431) QUALEF
431 FORMAT(1H0,1X,#OVERALL ADIABATIC EFFICIENCY=#,F6.4)
    WRITE(6,432) QUALDT
432 FORMAT(1H0,1X,#OVERALL TEMPERATURE RISE=#,F8.3)
    WRITE(6,1621)
1621 FORMAT(1H0,14X,#1#,5X,#2#,5X,#3#,5X,#4#,5X,#5#,5X,#6#,4X,#IGU#)
    WRITE(6,1710) (BET1SR(I),I=1,NS)
1710 FORMAT(1H,1X,#BET1SR(I)#,2X,6(F5.2,1X))
    WRITE(6,1720) (BET2SR(I),I=1,NS)
1720 FORMAT(1H,1X,#BET2SR(I)#,2X,6(F5.2,1X))
    WRITE(6,1730) (AINC1SR(I),I=1,NS)
1730 FORMAT(1H,1X,#AINC1SR(I)#,2X,6(F5.2,1X))
    WRITE(6,1740) (ADEUSR(I),I=1,NS)
1740 FORMAT(1H,1X,#ADEUSR(I)#,2X,6(F5.2,1X))
    WRITE(6,1760) (BET1SS(I),I=1,NS)
1760 FORMAT(1H,1X,#BET1SS(I)#,2X,6(F5.2,1X))
    WRITE(6,1770) (BET2SS(I),I=1,NS)
1770 FORMAT(1H,1X,#BET2SS(I)#,2X,7(F5.2,1X))
    WRITE(6,1780) (AINC2SS(I),I=1,NS)
1780 FORMAT(1H,1X,#AINC2SS(I)#,2X,6(F5.2,1X))
    WRITE(6,1790) (ADEUSS(I),I=1,NS)
1790 FORMAT(1H,1X,#ADEUSS(I)#,2X,6(F5.2,1X))
    WRITE(6,1791) (TE(I),I=1,NS)
1791 FORMAT(1H,1X,#TE(I)#,6X,6(F5.1,1X))
    WRITE(6,1793) (OMEGS(I),I=1,NS)
1793 FORMAT(1H,1X,#OMEGS(I)#,3X,6(F5.3,1X))
    WRITE(6,1794) (OMEGR(I),I=1,NS)
1794 FORMAT(1H,1X,#OMEGR(I)#,3X,6(F5.3,1X))
    IF(IUNIT.NE.2) GO TO 866
    TOIN=TOIN/CFT
    POIN=POIN/CFP
    CMASS=CMASS/CFM
    QUALDT=QUALDT/CFT
    DO 423 I=1,NS

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WICSPD 314
WICSPD 315
WICSPD 316
WICSPD 317
WICSPD 318
WICSPD 319
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WICSPD 381
WICSPD 382
WICSPD 383

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TD(I)=TD(I)*CFT
423 CONTINUE
868 CONTINUE
RETURN
END

WICSPD 384
WICSPD 385
WICSPD 386
WICSPD 387
WICSPD 388

APPENDIX 5
PRINTOUT OF TEST CASE

A.5.1 Test Case Part I

***** INPUT DATA *****

NS(NUMBER OF STAGE)= 6
UNIT=ENGLISH UNIT
IPERF=2
PERFORMANCE AT MEAN

	1	2	3	4	5	6	IGU
RRHUB(I)	.770	1.035	1.232	1.378	1.489	1.572	
RC(I)	.605	.554	.534	.510	.483	.456	
RDLADE(I)	16.00	20.00	20.00	25.00	28.00	32.00	
STAGER(I)	34.25	29.96	27.37	28.30	29.17	29.75	
STAGES(I)	23.67	25.62	26.94	28.41	29.82	38.99	
SRHUB(I)	.923	1.145	1.311	1.445	1.538	1.580	.774
SC(I)	.442	.412	.412	.412	.412	.412	
SBLADE(I)	14.00	26.00	28.00	32.00	36.00	30.00	
SIGUMR(I)	1.052	1.120	1.037	1.182	1.211	1.283	
SIGUMS(I)	.640	1.061	1.093	1.199	1.311	1.087	
GAPR(I)	.125	.125	.125	.125	.125	.125	
GAPS(I)	.125	.125	.125	.125	.125	.125	
RRTIP(I)	2.16	2.16	2.16	2.16	2.16	2.16	
SRTIP(I)	2.16	2.16	2.16	2.16	2.16	2.16	2.16
RT(I)	2.149	2.151	2.148	2.149	2.149	2.147	
RM(I)	1.426	1.575	1.642	1.722	1.789	1.836	
RH(I)	.781	1.056	1.252	1.411	1.533	1.621	
ST(I)	2.147	2.138	2.127	2.123	2.118	2.100	
SM(I)	1.502	1.573	1.637	1.712	1.766	1.784	
SH(I)	.934	1.152	1.318	1.453	1.548	1.592	
BLOCK(I)	.983	.976	.967	.949	.923	.902	
BLOCKS(I)	.978	.966	.945	.923	.908	.863	
BET1NR(I)	42.72	42.74	41.62	42.85	44.00	45.07	
BET2MR(I)	25.79	17.17	13.12	13.76	14.33	14.43	
BET1MS(I)	35.15	40.11	43.35	45.00	46.31	48.71	0
BET2MS(I)	12.19	11.13	10.51	11.81	13.32	29.28	21.99
PR12D(I)	1.154	1.165	1.221	1.237	1.230	1.215	
PR13D(I)	1.152	1.159	1.213	1.228	1.221	1.208	
ETARD(I)	.566	.966	.968	.965	.962	.954	

***** INPUT DATA *****

FNF(FRACTION OF DESIGN CORRECTED SPEED)=1.000
 XDIN(INITIAL WATER CONTENT OF SMALL DROPLET)= 0
 XDDIN(INITIAL WATER CONTENT OF LARGE DROPLET)= 0
 RHUMID(INITIAL RELATIVE HUMIDITY)= .00 PER CENT
 XCH4(INITIAL METHANE CONTENT)= 0
 TOG(COMPRESSOR INLET TOTAL TEMPRATURE OF GAS)= 518.70
 TOW(COMPRESSOR INLET TEMPERATURE OF DROPLRET)= 513.70
 P0(COMPRESSOR INLET TOTAL PRESSURE)= 2116.80
 DIN(INITIIL DROPLET DIAMETER OF SMALL DROPLET)= 20.0
 DDIN(INITIAL DROPLET DIAMETER OF LARGE DROPLET)= 600.0
 FND(DESIGN ROTATIONAL SPEED)=51120.0
 DSMASS(DESIGN MASS FLOW RATE)= .3755
 COMPRESSOR INLET TATAL TEMPERATURE(GAS PHASE) 518.70
 COMPRESSOR INLET TOTAL PRESSURE= 2116.80
 PREB(PERCENT OF WATER THAT REBOUND AFTER IMPINGE MENT)= 50.0 PERCENT
 ROTOR SPEED=51120.0 RPM
 CORRECTED ROTOR SPEED= 51120.0 RPM(100.0PER CENT OF DESIGN CORRECTED SPEED)

***** DESIGN POINT INFORMATION ***** **

***** COMPRESSOR INLET *****

TOTAL TEMPERATURE AT COMPRESSOR INLET= 518.70000
TOTAL PRESSURE AT COMPRESSOR INLET= 2116.80
STATIC TEMPERATURE AT COMPRESSOR INLET= 496.28109
STATIC PRESSURE AT COMPRESSOR INLET= 1813.73
STATIC DENSITY AT COMPRESSOR INLET= .06850

ACOUSTIC SPEED AT COMPRESSOR INLET=1092.25914
AXIAL VELOCITY AT COMPRESSOR INLET= 518.81873
MACH NUMBER AT COMPRESSOR INLET= .47500
STREAMTUBE AREA AT COMPRESSOR INLET= .01057
FLOW COEFFICIENT AT COMPRESSOR INLET= .53817

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 1 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	518.700	2116.300	492.637	1767.579	.067
ROTOR OUTLET	541.148	2442.787	508.269	1961.576	.072
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	538.76531	559.39838	725.32398	150.52734	485.62003
ROTOR OUTLET	525.97105	628.55682	618.75550	344.14838	325.90306
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	636.147	.514	.667	536.454	2381.210
ROTOR OUTLET	670.051	.569	.560	540.141	5091.790
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	15.61000	42.03015	.01036	1.42600	.55886
ROTOR OUTLET	33.19714	31.78325	.00987	1.50200	.54559
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT=					1.15200
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT=					.95383
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT=					1.15400
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT=					.96600
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT=					1.04323

***** DESIGN POINT INFORMATION ***** ***

***** STAGE= 2 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	541.148	2438.554	511.984	2008.852	.074
ROTOR OUTLET	566.141	2840.915	522.316	2142.394	.077
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	549.21299	591.88727	730.68951	220.67086	481.94632
ROTOR OUTLET	581.16447	725.94045	639.44211	435.01464	266.71034
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	702.617	.534	.659	556.431	2688.136
ROTOR OUTLET	701.725	.648	.571	556.331	5751.007
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	21.89000	41.26765	.00930	1.57500	.56970
ROTOR OUTLET	36.81569	24.65154	.00841	1.57300	.60285

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.15900
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .93231
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.16500
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96600
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.04618

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 3 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	566.141	2826.284	535.362	2323.868	.081
ROTOR OUTLET	600.462	3450.892	549.786	2533.049	.086
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	574.81563	608.26663	784.29006	198.93541	533.57089
ROTOR OUTLET	614.43880	781.11343	662.59507	482.28650	247.98627
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	732.506	.536	.692	586.533	3199.070
ROTOR OUTLET	730.276	.680	.577	586.263	6929.751
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	19.09000	42.86892	.00803	1.64200	.59626
ROTOR OUTLET	38.12932	21.97990	.00708	1.63700	.63736
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT=			1.21300		
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT=			.33464		
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT=			1.22100		
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT=			.96800		
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT=			1.06062		

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 4 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	600.462	3428.282	569.069	2839.989	.094
ROTOR OUTLET	639.381	4240.785	585.841	3118.959	.100
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	580.04590	614.69778	809.54747	203.47020	564.72459
ROTOR OUTLET	619.63965	803.61317	668.93304	511.70446	252.02926
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	768.195	.526	.692	623.519	3912.431
ROTOR OUTLET	763.734	.678	.564	622.951	8231.914
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	19.33000	44.23321	.00692	1.72200	.60169
ROTOR OUTLET	39.55025	22.13332	.00607	1.71200	.64276

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.22800
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .93002
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.23700
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .95500
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.06481

***** DESIGN POINT INFORMATION ***** ***

***** STAGE= 5 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	639.381	4209.930	606.962	3506.755	.108
ROTOR OUTLET	679.732	5178.214	625.197	3857.244	.116
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	586.84149	625.22167	826.78513	215.68308	582.40082
ROTOR OUTLET	617.08868	811.98444	669.65381	527.75042	260.07304
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	798.084	.518	.685	663.653	4798.526
ROTOR OUTLET	787.823	.663	.547	662.302	9691.778
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	20.18000	44.78240	.00591	1.78900	.60873
ROTOR OUTLET	40.53794	22.85308	.00526	1.76600	.64011

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.22100
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .32580
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.23000
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96200
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.06311

***** DESIGN POINT INFORMATION *****

***** STAGE= 6 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	079.732	5140.325	646.933	4318.954	.125
ROTOR OUTLET	720.259	6245.495	665.989	4736.291	.133
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	587.19574	629.60666	833.74045	227.16890	591.88199
ROTOR OUTLET	603.39773	811.09676	654.61329	542.02320	253.83017
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	819.051	.506	.669	704.449	5829.034
ROTOR OUTLET	795.853	.642	.518	701.350	10970.182
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	21.15000	45.22772	.00511	1.83500	.60910
ROTOR OUTLET	41.93288	22.81494	.00467	1.78400	.62591
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT=					1.20800
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT=					.92365
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT=					1.21500
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT=					.93400
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT=					1.05962

***** DESIGN POINT INFORMATION *****

***** OVERALL PERFORMANCE AT DESIGN POINT *****

COMPRESSOR INLET TOTAL TEMPERATURE= 518.70

COMPRESSOR INLET TOTAL PRESSURE= 2116.80

CORRECTED MASS FLOW RATE= 3.168

OVERALL TOTAL PRESSURE RATIO=2.9334

OVERALL TOTAL TEMPERATURE RATIO=1.3886

OVERALL ADIABATIC EFFICIENCY= .9223

OVERALL TEMPERATURE RISE= 201.559

	1	2	3	4	5	6	IGU
DET1SR(I)	42.03	41.27	42.87	44.23	44.78	45.23	
DET2SR(I)	31.78	24.65	21.98	22.13	22.85	22.81	
AINCSR(I)	-.65	-1.47	1.25	1.38	.78	.16	
ADEUSR(I)	5.99	7.48	8.86	8.37	8.52	8.38	
DET1SS(I)	33.20	36.82	38.13	39.55	40.54	41.93	
DET2SS(I)	21.89	19.09	19.33	20.18	21.15	34.86	15.61
AINCSS(I)	-1.95	-3.29	-5.23	-5.45	-5.77	-6.78	
ADEUSS(I)	9.70	7.96	8.82	8.37	7.83	5.58	
TB(I)	518.7	541.1	566.1	600.5	639.4	679.7	
OMEGS(I)	.009	.021	.025	.028	.029	.024	
OMEGR(I)	.020	.021	.024	.028	.030	.036	

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 1) *****

STAGE TOTAL PRESSURE RATIO= 1.18052
 STAGE TOTAL TEMPERATURE RATIO= 1.05118
 STAGE ADIABATIC EFFICIENCY= .94929

STAGE FLOW COEFFICIENT= .500
 AXIAL VELOCITY= 482.12
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.18052
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.19072
 LOSS FACTOR IN ROTOR= 1.01779
 LOSS FACTOR IN STATOR= .99767

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2116.80	2504.78	2498.93
STATIC PRESSURE	1833.16	2064.66	2151.05
TOTAL TEMPERATURE(GAS)	518.7000	545.2462	545.2462
STATIC TEMPERATURE(GAS)	497.7954	515.9463	522.3760
STATIC DENSITY(GAS)	.0690	.0750	.0772
STATIC DENSITY(MIXTURE)	.0690	.0750	.0772
AXIAL VELOCITY	482.1211	465.8891	480.6390
ABSOLUTE VELOCITY	500.9898	593.2170	524.1017
RELATIVE VELOCITY	694.5426	555.6590	
BLADE SPEED	636.1474	670.0514	702.6172
TANG. COMP. OF ABS. VEL.	136.1987	367.2243	
TANG. COMP. OF REL. VEL.	499.9486	302.8271	
ACOUSTIC SPEED	1093.9243	1120.9182	1120.6073
ABSOLUTE MACH NUMBER	.4580	.5327	.4677
RELATIVE MACH NUMBER	.6349	.4989	
FLOW COEFFICIENT	.5001	.4833	.4986
FLOW AREA	.0104	.0099	.0093
ABSOLUTE FLOW ANGLE	15.7749	38.2460	23.5019
RELATIVE FLOW ANGLE	46.0400	33.0238	
INCIDENCE	3.3200	3.0960	
DEVIATION		7.2338	11.3119

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 1) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.18052
 STAGE TOTAL TEMPERATURE RATIO= 1.05118
 STAGE ADIABATIC EFFICIENCY= .94929

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWN=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	.34491	.34491	.34491
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	.34491	.34491	.34491
TMASS=	.34491	.34491	.34491
WS=	.00000	.00000	.00000
RHOA=	.07649	.07500	.07718
RHOM=	.06904	.07500	.07718
RHOG=	.06902	.07500	.07718
TG=	518.70000	545.24617	545.24617
TW=	513.70000	513.70000	513.70000
TWN=	513.70000	0	513.70000
P=	2116.80000	2504.77696	2498.92898
TB=	671.40656	0	679.62039
TDEW=	271.99506	273.35228	273.35228

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 2) *****

STAGE TOTAL PRESSURE RATIO= 1.18150
 STAGE TOTAL TEMPERATURE RATIO= 1.05273
 STAGE ADIABATIC EFFICIENCY= .92538

STAGE FLOW COEFFICIENT= .499
 AXIAL VELOCITY= 480.65
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.18150
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.19700
 LOSS FACTOR IN ROTOR= .99305
 LOSS FACTOR IN STATOR= .99331

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2498.93	2972.36	2952.48
STATIC PRESSURE	2151.02	2334.66	2553.83
TOTAL TEMPERATURE(GAS)	545.2462	573.9966	573.9966
STATIC TEMPERATURE(GAS)	522.3793	535.7319	550.6973
STATIC DENSITY(GAS)	.0772	.0817	.0869
STATIC DENSITY(MIXTURE)	.0772	.0817	.0869
AXIAL VELOCITY	480.6495	502.3934	494.1596
ABSOLUTE VELOCITY	524.1276	678.1185	529.1491
RELATIVE VELOCITY	688.9633	559.5039	
BLADE SPEED	702.6172	701.7250	732.5063
TANG. COMP. OF ABS. VEL.	209.0116	455.4619	
TANG. COMP. OF REL. VEL.	493.6056	246.2631	
ACOUSTIC SPEED	1120.4811	1150.2843	1150.4507
ABSOLUTE MACH NUMBER	.4678	.5976	.4599
RELATIVE MACH NUMBER	.6149	.4931	
FLOW COEFFICIENT	.4986	.5211	.5126
FLOW AREA	.0093	.0084	.0080
ABSOLUTE FLOW ANGLE	23.5019	42.1950	20.9539
RELATIVE FLOW ANGLE	45.7619	26.1132	
INCIDENCE	3.0219	2.0850	
DEVIATION		8.9432	9.8239

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 2) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.18150
 STAGE TOTAL TEMPERATURE RATIO= 1.05273
 STAGE ADIABATIC EFFICIENCY= .92538

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WWMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	.34491	.34491	.34491
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	.34491	.34491	.34491
TMASS=	.34491	.34491	.34491
WS=	.00000	.00000	.00000
RHOA=	.08590	.08168	.08692
RHOM=	.06904	.08168	.08692
RHOG=	.07718	.08168	.08692
TG=	545.24617	573.99661	573.99661
TW=	513.70000	513.70000	513.70000
TWH=	513.70000	0	513.70000
P=	2498.92898	2972.35955	2952.48188
TB=	679.62039	0	688.08016
TDEW=	273.35228	274.74655	274.74655

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 3) *****

STAGE TOTAL PRESSURE RATIO= 1.22966
 STAGE TOTAL TEMPERATURE RATIO= 1.06596
 STAGE ADIABATIC EFFICIENCY= .92118

STAGE FLOW COEFFICIENT= .513
 AXIAL VELOCITY= 494.17
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.22966
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.25071
 LOSS FACTOR IN ROTOR= .99061
 LOSS FACTOR IN STATOR= .99091

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2952.48	3663.87	3630.55
STATIC PRESSURE	2553.80	2827.58	3166.80
TOTAL TEMPERATURE(GAS)	573.9966	611.8566	611.8566
STATIC TEMPERATURE(GAS)	550.7079	568.2392	588.4487
STATIC DENSITY(GAS)	.0869	.0933	.1009
STATIC DENSITY(MIXTURE)	.0869	.0933	.1009
AXIAL VELOCITY	494.1744	522.5140	494.0333
ABSOLUTE VELOCITY	529.1692	724.3096	530.6107
RELATIVE VELOCITY	734.4023	570.3622	
BLADE SPEED	732.5063	730.2758	768.1948
TANG. COMP. OF ABS. VEL.	189.2399	501.6010	
TANG. COMP. OF REL. VEL.	543.2664	228.6748	
ACOUSTIC SPEED	1150.2627	1188.4867	1189.0241
ABSOLUTE MACH NUMBER	.4600	.6199	.4463
RELATIVE MACH NUMBER	.6385	.4881	
FLOW COEFFICIENT	.5126	.5420	.5125
FLOW AREA	.0080	.0071	.0069
ABSOLUTE FLOW ANGLE	20.9539	43.8301	21.4115
RELATIVE FLOW ANGLE	47.7092	23.6363	
INCIDENCE	6.0892	.4701	
DEVIATION		10.5163	10.9015

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 3) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.22966
 STAGE TOTAL TEMPERATURE RATIO= 1.06596
 STAGE ADIABATIC EFFICIENCY= .92118

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00000	.00000	.00000
XV=	0	0	0
XW=	0	0	0
XHT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	.34491	.34491	.34491
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	.34491	.34491	.34491
TMASS=	.34491	.34491	.34491
WS=	.00000	.00000	.00000
RHOA=	.09641	.09326	.10086
RHOM=	.06904	.09326	.10086
RHOG=	.08692	.09326	.10086
TG=	573.99661	611.85659	611.85659
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	2952.48188	3663.87348	3630.55342
TB=	688.08016	0	698.86348
TDEW=	274.74655	276.46988	276.46988

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 4) *****

STAGE TOTAL PRESSURE RATIO= 1.24218
 STAGE TOTAL TEMPERATURE RATIO= 1.06978
 STAGE ADIABATIC EFFICIENCY= .91298

STAGE FLOW COEFFICIENT= .513
 AXIAL VELOCITY= 494.07
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.24218
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.26694
 LOSS FACTOR IN ROTOR= .98759
 LOSS FACTOR IN STATOR= .98968

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	3630.55	4556.82	4509.80
STATIC PRESSURE	3166.66	3525.69	3957.68
TOTAL TEMPERATURE(GAS)	611.8566	654.5529	654.5529
STATIC TEMPERATURE(GAS)	588.4681	608.4010	630.6384
STATIC DENSITY(GAS)	.1009	.1086	.1176
STATIC DENSITY(MIXTURE)	.1009	.1086	.1176
AXIAL VELOCITY	494.0715	522.8404	496.2018
ABSOLUTE VELOCITY	530.6990	745.6155	536.7235
RELATIVE VELOCITY	757.6978	572.0630	
BLADE SPEED	768.1948	763.7337	798.0839
TANG. COMP. OF ABS. VEL.	193.7390	531.5829	
TANG. COMP. OF REL. VEL.	574.4558	232.1508	
ACOUSTIC SPEED	1188.6880	1230.0789	1230.5425
ABSOLUTE MACH NUMBER	.4465	.6169	.4362
RELATIVE MACH NUMBER	.6374	.4733	
FLOW COEFFICIENT	.5125	.5423	.5147
FLOW AREA	.0069	.0061	.0059
ABSOLUTE FLOW ANGLE	21.4115	45.4750	22.4163
RELATIVE FLOW ANGLE	49.3022	23.9421	
INCIDENCE	6.4522	.4750	
DEVIATION		10.1821	10.6063

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 4) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.24218
 STAGE TOTAL TEMPERATURE RATIO= 1.06978
 STAGE ADIABATIC EFFICIENCY= .91298

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WWMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	.34491	.34491	.34491
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	.34491	.34491	.34491
TMASS=	.34491	.34491	.34491
WS=	.00000	.00000	.00000
RHOA=	.11122	.10860	.11762
RHOM=	.06904	.10860	.11762
RHOG=	.10086	.10860	.11762
TG=	611.85659	654.55293	654.55293
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	3630.55342	4556.82036	4509.79574
TB=	698.86348	0	710.54436
TDEW=	276.46988	278.29004	278.29004

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 5) *****

STAGE TOTAL PRESSURE RATIO= 1.23414
 STAGE TOTAL TEMPERATURE RATIO= 1.06793
 STAGE ADIABATIC EFFICIENCY= .90663

STAGE FLOW COEFFICIENT= .515
 AXIAL VELOCITY= 496.25
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.23414
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.25990
 LOSS FACTOR IN ROTOR= .98308
 LOSS FACTOR IN STATOR= .98949

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	4509.80	5624.85	5565.72
STATIC PRESSURE	3957.52	4401.30	4921.73
TOTAL TEMPERATURE(GAS)	654.5529	699.0183	699.0183
STATIC TEMPERATURE(GAS)	630.6739	651.9165	674.9958
STATIC DENSITY(GAS)	.1176	.1265	.1367
STATIC DENSITY(MIXTURE)	.1176	.1265	.1367
AXIAL VELOCITY	496.2499	517.9326	493.7867
ABSOLUTE VELOCITY	536.8130	754.0599	538.5133
RELATIVE VELOCITY	773.5389	570.7437	
BLADE SPEED	798.0839	787.8235	819.0509
TANG. COMP. OF ABS. VEL.	204.7050	548.0439	
TANG. COMP. OF REL. VEL.	593.3789	239.7796	
ACOUSTIC SPEED	1230.0502	1272.1584	1272.5386
ABSOLUTE MACH NUMBER	.4364	.6030	.4232
RELATIVE MACH NUMBER	.6289	.4564	
FLOW COEFFICIENT	.5148	.5373	.5122
FLOW AREA	.0059	.0053	.0051
ABSOLUTE FLOW ANGLE	22.4163	46.6180	23.5232
RELATIVE FLOW ANGLE	50.0939	24.8420	
INCIDENCE	6.0939	.3080	
DEVIATION		10.5120	10.2032

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 5) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.23414
 STAGE TOTAL TEMPERATURE RATIO= 1.06793
 STAGE ADIABATIC EFFICIENCY= .90663

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	.34491	.34491	.34491
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	.34491	.34491	.34491
TMASS=	.34491	.34491	.34491
WS=	.00000	.00000	.00000
RHOA=	.12914	.12651	.13665
RHOM=	.06904	.12651	.13665
RHOC=	.11762	.12651	.13665
TG=	654.55293	699.01831	699.01831
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	4509.79574	5624.84868	5565.71763
TB=	710.54436	0	725.30379
TDEW=	278.29004	270.78298	270.78298

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 6) *****

STAGE TOTAL PRESSURE RATIO= 1.21895
 STAGE TOTAL TEMPERATURE RATIO= 1.06377
 STAGE ADIABATIC EFFICIENCY= .90463

STAGE FLOW COEFFICIENT= .512
 AXIAL VELOCITY= 493.84
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.21895
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.24345
 LOSS FACTOR IN ROTOR= .97403
 LOSS FACTOR IN STATOR= .99138

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	5565.72	6843.38	6784.36
STATIC PRESSURE	4921.56	5436.20	5876.36
TOTAL TEMPERATURE(GAS)	699.0183	743.5938	743.5938
STATIC TEMPERATURE(GAS)	675.0454	696.5955	713.9007
STATIC DENSITY(GAS)	.1367	.1463	.1543
STATIC DENSITY(MIXTURE)	.1367	.1463	.1543
AXIAL VELOCITY	493.8405	505.0266	478.8044
ABSOLUTE VELOCITY	538.5989	754.2557	599.5224
RELATIVE VELOCITY	780.2545	557.2913	
BLADE SPEED	819.0509	795.8534	.5000
TANG. COMP. OF ABS. VEL.	214.9659	560.2230	
TANG. COMP. OF REL. VEL.	604.0850	235.6304	
ACOUSTIC SPEED	1271.8989	1307.3852	1307.9918
ABSOLUTE MACH NUMBER	.4235	.5838	.4584
RELATIVE MACH NUMBER	.6135	.4313	
FLOW COEFFICIENT	.5123	.5239	.4994
FLOW AREA	.0051	.0047	.0047
ABSOLUTE FLOW ANGLE	23.5232	47.9662	37.0059
RELATIVE FLOW ANGLE	50.7339	25.0124	
INCIDENCE	5.6639	-.7438	
DEVIATION		10.5824	7.7259

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 6) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.21895
 STAGE TOTAL TEMPERATURE RATIO= 1.06377
 STAGE ADIABATIC EFFICIENCY= .90463

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XNW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WNMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	.34491	.34491	.34491
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	.34491	.34491	.34491
TMASS=	.34491	.34491	.34491
WS=	.00000	.00000	.00000
RHOA=	.14924	.14623	.15426
RHOM=	.06904	.14623	.15426
RHOG=	.13665	.14623	.15426
TG=	699.01831	743.59381	743.59381
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	5565.71763	6843.37717	6784.35886
TB=	725.30379	0	737.46504
TDEW=	270.78298	272.44415	272.44415

***** OVERALL PERFORMANCE *****

INITIAL FLOW COEFFICIENT= .50000

CORRECTED SPEED=51120.0 1.000 FRACTION OF DEIGN CORRECTED SPEED

INITIAL WATER CONTENT(SMALL DROPLET)= 0

INITIAL WATER CONTENT(LARGE DROPLET)= 0

INITIAL WATER CONTENT(TOTAL)= 0

INITIAL RELATIVE HUMIDITY= .0 PER CENT

INITIAL METHANE CONTENT= 0

COMPRESSOR INLET TOTAL TEMPERATURE= 518.70

COMPRESSOR INLET TOTAL PRESSURE= 2116.80

CORRECTED MASS FLOW RATE OF MIXTURE= .345(2.910)

CORRECTED MASS FLOW RATE OF GAS PHASE .345(2.910)

OVERALL TOTAL PRESSURE RATIO=3.2050

OVERALL TOTAL TEMPERATURE RATIO=1.4336

OVERALL ADIABATIC EFFICIENCY= .9057

OVERALL TEMPERATURE RISE OF GAS PHASE= 224.894

AD-A114 850

PURDUE UNIV LAFAYETTE IN SCHOOL OF MECHANICAL ENGINEERING F/S 21/5
EFFECT OF WATER ON AXIAL FLOW COMPRESSORS. PART 1. ANALYSIS AND--ETC(U)
JUN 81 T TSUCHIYA, S N MURTHY F33615-78-C-2401

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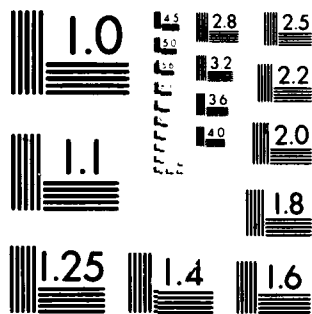
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

A.5.2 Test Case Part II

***** INPUT DATA *****

NS(NUMBER OF STAGE)= 6
UNIT=ENGLISH UNIT
IPERF=2
PERFORMANCE AT MEAN

	1	2	3	4	5	6	IGU
RRHUB(I)	.770	1.035	1.232	1.378	1.489	1.572	
RC(I)	.605	.554	.534	.510	.483	.456	
RBLADE(I)	16.00	20.00	20.00	25.00	28.00	32.00	
STAGER(I)	34.25	29.96	27.37	28.30	29.17	29.75	
STAGES(I)	23.67	25.62	26.94	28.41	29.82	38.99	
SRHUB(I)	.923	1.145	1.311	1.445	1.538	1.580	.774
SC(I)	.442	.412	.412	.412	.412	.412	
SBLADE(I)	14.00	26.00	28.00	32.00	36.00	30.00	
SIGUMR(I)	1.052	1.120	1.037	1.182	1.211	1.283	
SIGUMS(I)	.640	1.061	1.093	1.199	1.311	1.087	
CAPR(I)	.125	.125	.125	.125	.125	.125	
GAPS(I)	.125	.125	.125	.125	.125	.125	
RRTIP(I)	2.16	2.16	2.16	2.16	2.16	2.16	
SRTIP(I)	2.16	2.16	2.16	2.16	2.16	2.16	2.16
RT(I)	2.149	2.151	2.148	2.149	2.149	2.147	
RM(I)	1.426	1.575	1.642	1.722	1.789	1.836	
RH(I)	.781	1.056	1.252	1.411	1.533	1.621	
ST(I)	2.147	2.138	2.127	2.123	2.118	2.100	
SM(I)	1.502	1.573	1.637	1.712	1.766	1.784	
SH(I)	.934	1.152	1.318	1.453	1.548	1.592	
BLOCK(I)	.983	.976	.967	.949	.923	.902	
BLOCKS(I)	.978	.966	.945	.928	.908	.863	
BET1MR(I)	42.72	42.74	41.62	42.85	44.00	45.07	
BET2MR(I)	25.79	17.17	13.12	13.76	14.33	14.43	
BET1MS(I)	35.15	40.11	43.36	45.00	46.31	48.71	0
BET2MS(I)	12.19	11.13	10.51	11.81	13.32	29.28	21.99
PR12D(I)	1.154	1.165	1.221	1.237	1.230	1.215	
PR13D(I)	1.152	1.159	1.213	1.228	1.221	1.208	
ETARD(I)	.966	.966	.968	.965	.962	.954	

***** INPUT DATA *****

FNF(FRACTION OF DESIGN CORRECTED SPEED)=1.000
XDIN(INITIAL WATER CONTENT OF SMALL DROPLET)= .040
XDDIN(INITIAL WATER CONTENT OF LARGE DROPLET)= 0
RHUMID(INITIAL RELATIVE HUMIDITY)= .00 PER CENT
XCH4(INITIAL METHANE CONTENT)= 0
TOG(COMPRESSOR INLET TOTAL TEMPRATURE OF GAS)= 518.70
TOW(COMPRESSOR INLET TEMPERATURE OF DROPLRET)= 513.70
PO(COMPRESSOR INLET TOTAL PRESSURE)= 2116.80
DIN(INITIIL DROPLET DIAMETER OF SMALL DROPLET)= 20.0
DDIN(INITIAL DROPLET DIAMETER OF LARGE DROPLET)= 600.0
FND(DESIGN ROTATIONAL SPEED)=51120.0
DSMASS(DESIGN MASS FLOW RATE)= .3755
COMPRESSOR INLET TATAL TEMPERATURE(GAS PHASE) 518.70
COMPRESSOR INLET TOTAL PRESSURE= 2116.80
PREB(PERCENT OF WATER THAT REBOUND AFTER IMPINGE MENT)= 50.0 PERCENT
ROTOR SPEED=51120.0 RPM
CORRECTED ROTOR SPEED= 51120.0 RPM(100.0PER CENT OF DESIGN CORRECTED SPEED)

***** DESIGN POINT INFORMATION *****

***** COMPRESSOR INLET *****

TOTAL TEMPERATURE AT COMPRESSOR INLET= 518.70000
TOTAL PRESSURE AT COMPRESSOR INLET= 2116.80
STATIC TEMPERATURE AT COMPRESSOR INLET= 496.28109
STATIC PRESSURE AT COMPRESSOR INLET= 1813.73
STATIC DENSITY AT COMPRESSOR INLET= .06850

ACOUSTIC SPEED AT COMPRESSOR INLET=1092.25914
AXIAL VELOCITY AT COMPRESSOR INLET= 518.81873
MACH NUMBER AT COMPRESSOR INLET= .47500
STREAMTUBE AREA AT COMPRESSOR INLET= .01057
FLOW COEFFICIENT AT COMPRESSOR INLET= .53817

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 1 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	518.700	2116.800	492.637	1767.579	.067
ROTOR OUTLET	541.148	2442.787	508.269	1961.576	.072
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	538.76531	559.39838	725.32398	150.52734	485.62003
ROTOR OUTLET	525.97105	628.55682	618.75550	344.14838	325.90306
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	636.147	.514	.667	536.454	2381.210
ROTOR OUTLET	670.051	.569	.560	540.141	5091.790
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	15.61000	42.03015	.01036	1.42600	.55886
ROTOR OUTLET	33.19714	31.78325	.00987	1.50200	.54559
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.15200					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .95383					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.15400					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96600					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.04328					

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 2 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	541.148	2438.554	511.984	2008.852	.074
ROTOR OUTLET	566.141	2840.915	522.316	2142.394	.077
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	549.21299	591.88727	730.68951	220.67086	481.94632
ROTOR OUTLET	581.16447	725.94045	639.44211	435.01464	266.71034
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	702.617	.534	.659	556.431	2688.136
ROTOR OUTLET	701.725	.648	.571	556.331	5751.007
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	21.89000	41.26765	.00930	1.57500	.56970
ROTOR OUTLET	36.81569	24.65154	.00841	1.57300	.60285
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.15900					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .93231					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.16500					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96600					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.04618					

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 3 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	566.141	2826.284	535.362	2323.868	.081
ROTOR OUTLET	600.462	3450.892	549.786	2533.049	.086
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	574.81563	608.26663	784.29006	198.93541	533.57089
ROTOR OUTLET	614.43880	781.11343	662.59507	482.28950	247.98627
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	732.506	.536	.692	586.533	3199.070
ROTOR OUTLET	730.276	.680	.577	586.263	6929.751
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	19.09000	42.86892	.00803	1.64200	.59626
ROTOR OUTLET	38.12932	21.97890	.00708	1.63700	.63736
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.21300					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .93464					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.22100					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96800					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.06062					

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 4 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	600.462	3428.282	569.069	2839.988	.094
ROTOR OUTLET	639.381	4240.785	585.841	3118.959	.100
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	580.04590	614.69778	809.54747	203.47020	564.72459
ROTOR OUTLET	619.63965	803.61317	668.93304	511.70446	252.02926
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	768.195	.526	.692	623.519	3912.431
ROTOR OUTLET	763.734	.678	.564	622.951	8231.914
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	19.33000	44.23321	.00692	1.72200	.60169
ROTOR OUTLET	39.55025	22.13332	.00607	1.71200	.64276

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.22800
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .93002
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.23700
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96500
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.06481

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 5 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	639.381	4209.930	606.962	3506.755	.108
ROTOR OUTLET	679.732	5178.214	625.197	3857.244	.116
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	586.84149	625.22167	826.78513	215.68308	582.40082
ROTOR OUTLET	617.08868	811.98444	669.65381	527.75042	260.07304
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	798.084	.518	.685	663.653	4798.526
ROTOR OUTLET	787.823	.663	.547	662.302	9691.778
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	20.18000	44.78240	.00591	1.78900	.60873
ROTOR OUTLET	40.53794	22.85308	.00526	1.76600	.64011
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.22100					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .92580					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.23000					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96200					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.06311					

***** DESIGN POINT INFORMATION ***** ***

***** STAGE= 6 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	679.732	5140.325	646.933	4318.954	.125
ROTOR OUTLET	720.259	6245.495	665.989	4736.291	.133
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	587.19574	629.60666	833.74045	227.16890	591.88199
ROTOR OUTLET	603.39773	811.09676	654.61329	542.02320	253.83017
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	819.051	.506	.669	704.449	5829.034
ROTOR OUTLET	795.853	.642	.518	701.350	10970.182
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	21.15000	45.22772	.00511	1.83600	.60910
ROTOR OUTLET	41.93288	22.81494	.00467	1.78400	.62591

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.20800
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .92365
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.21500
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .95400
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.05962

***** DESIGN POINT INFORMATION ***** ***

***** OVERALL PERFORMANCE AT DESIGN POINT **** *****

COMPRESSOR INLET TOTAL TEMPERATURE= 518.70

COMPRESSOR INLET TOTAL PRESSURE= 2116.80

CORRECTED MASS FLOW RATE= 3.168

OVERALL TOTAL PRESSURE RATIO=2.9334

OVERALL TOTAL TEMPERATURE RATIO=1.3886

OVERALL ADIABATIC EFFICIENCY= .9223

OVERALL TEMPERATURE RISE= 201.559

	1	2	3	4	5	6	IGU
BET1SR(I)	42.03	41.27	42.87	44.23	44.78	45.23	
BET2SR(I)	31.78	24.65	21.98	22.13	22.85	22.81	
AINCSR(I)	-.69	-1.47	1.25	1.38	.78	.16	
ADEVSR(I)	5.99	7.48	8.86	8.37	8.52	8.38	
BET1SS(I)	33.20	36.82	38.13	39.55	40.54	41.93	
BET2SS(I)	21.89	19.09	19.33	20.18	21.15	34.86	15.61
AINCSS(I)	-1.95	-3.29	-5.23	-5.45	-5.77	-6.78	
ADEVSS(I)	9.70	7.96	8.82	8.37	7.83	5.58	
TD(I)	518.7	541.1	566.1	600.5	639.4	679.7	
OMEGS(I)	.009	.021	.025	.028	.029	.024	
OMEGR(I)	.020	.021	.024	.028	.030	.036	

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 1) *****

STAGE TOTAL PRESSURE RATIO= 1.17523
 STAGE TOTAL TEMPERATURE RATIO= 1.05076
 STAGE ADIABATIC EFFICIENCY= .93056

STAGE FLOW COEFFICIENT= .500
 AXIAL VELOCITY= 482.13
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.17523
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.18907
 LOSS FACTOR IN ROTOR= 1.01550
 LOSS FACTOR IN STATOR= .99678

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2116.80	2495.77	2487.73
STATIC PRESSURE	1821.98	2038.83	2123.98
TOTAL TEMPERATURE(GAS)	518.7000	545.0303	545.0303
STATIC TEMPERATURE(GAS)	496.9259	515.5746	521.8709
STATIC DENSITY(GAS)	.0687	.0741	.0763
STATIC DENSITY(MIXTURE)	.0716	.0772	.0795
AXIAL VELOCITY	482.1269	469.4052	484.1839
ABSOLUTE VELOCITY	500.9958	594.7932	527.4057
RELATIVE VELOCITY	694.5454	559.6606	
BLADE SPEED	636.1474	670.0514	702.6172
TANG. COMP. OF ABS. VEL.	136.2004	365.2913	
TANG. COMP. OF REL. VEL.	499.9470	304.7602	
ACOUSTIC SPEED	1070.9353	1097.8191	1097.4899
ABSOLUTE MACH NUMBER	.4678	.5453	.4806
RELATIVE MACH NUMBER	.6485	.5131	
FLOW COEFFICIENT	.5001	.4869	.5022
FLOW AREA	.0104	.0099	.0093
ABSOLUTE FLOW ANGLE	15.7749	37.8901	23.3618
RELATIVE FLOW ANGLE	46.0395	32.9935	
INCIDENCE	3.3195	2.7401	
DEVIATION		7.2035	11.1718

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 1) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.17523
 STAGE TOTAL TEMPERATURE RATIO= 1.05076
 STAGE ADIABATIC EFFICIENCY= .93059

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00000	.00000	.00003
XW=	.04000	.04000	.03997
XWH=	0	0	0
XWT=	.04000	.04000	.03997
XAIR=	.96000	.96000	.96000
XMETAN=	0	0	0
XGAS	.96000	.96000	.96003
WMASS=	.01431	.01431	.01430
WMASS=	0	0	0
WTMASS=	.01431	.01431	.01430
AMASS=	.34340	.34340	.34340
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00001
GMASS=	.34340	.34340	.34341
TMASS=	.35771	.35771	.35771
WS=	.00000	.00000	.00004
RHOA=	.07649	.07432	.06829
RHOM=	.07160	.07741	.07961
RHOG=	.06872	.07432	.07643
TG=	518.70000	545.03032	545.02935
TW=	513.70000	519.12521	519.13056
TWH=	513.70000	0	513.70000
P=	2116.80000	2495.76975	2487.72825
TB=	671.40656	0	679.39541
TDEW=	271.99506	273.32309	395.40315

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 2) *****

STAGE TOTAL PRESSURE RATIO= 1.17581
 STAGE TOTAL TEMPERATURE RATIO= 1.05225
 STAGE ADIABATIC EFFICIENCY= .90620

STAGE FLOW COEFFICIENT= .501
 AXIAL VELOCITY= 483.25
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.17581
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.19510
 LOSS FACTOR IN ROTOR= .99123
 LOSS FACTOR IN STATOR= .99193

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2487.73	2948.91	2925.11
STATIC PRESSURE	2124.70	2286.71	2506.57
TOTAL TEMPERATURE(GAS)	545.0293	573.5085	573.5085
STATIC TEMPERATURE(GAS)	521.0067	534.8122	549.7050
STATIC DENSITY(GAS)	.0764	.0801	.0855
STATIC DENSITY(MIXTURE)	.0796	.0835	.0890
AXIAL VELOCITY	483.2456	509.8557	500.4203
ABSOLUTE VELOCITY	526.4003	681.9413	534.8508
RELATIVE VELOCITY	690.9735	567.3462	
BLADE SPEED	702.6172	701.7250	732.5063
TANG. COMP. OF ABS. VEL.	208.7366	452.8698	
TANG. COMP. OF REL. VEL.	493.8806	248.8552	
ACOUSTIC SPEED	1096.4867	1126.0773	1126.2833
ABSOLUTE MACH NUMBER	.4801	.6139	.4749
RELATIVE MACH NUMBER	.6302	.5107	
FLOW COEFFICIENT	.5013	.5289	.5191
FLOW AREA	.0093	.0084	.0080
ABSOLUTE FLOW ANGLE	23.3618	41.6125	20.6723
RELATIVE FLOW ANGLE	45.6236	26.0165	
INCIDENCE	2.8836	1.5025	
DEVIATION		8.8465	9.5423

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 2) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.17581
 STAGE TOTAL TEMPERATURE RATIO= 1.05225
 STAGE ADIABATIC EFFICIENCY= .90625

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00003	.00003	.00011
XW=	.03997	.03997	.03989
XWH=	0	0	0
XWT=	.03997	.03997	.03989
XAIR=	.96000	.96000	.96000
XMETAN=	0	0	0
XGAS=	.96003	.96003	.96011
WMASS=	.01430	.01430	.01427
WMASS=	0	0	0
WTMASS=	.01430	.01430	.01427
AMASS=	.34340	.34340	.34340
CHMASS=	0	0	0
UMASS=	.00001	.00001	.00004
GMASS=	.34341	.34341	.34344
TMASS=	.35771	.35771	.35771
WS=	.00004	.00004	.00011
RHOA=	.08555	.08043	.07670
RHOM=	.07160	.08377	.08918
RHOG=	.07643	.08043	.08563
TC=	545.02935	573.50850	573.50651
TW=	519.13056	524.60917	524.62018
TWH=	513.70000	0	513.70000
P=	2487.72825	2948.91283	2925.10631
TB=	679.39541	0	687.60211
TDEW=	395.40315	398.30836	418.76408

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 3) *****

STAGE TOTAL PRESSURE RATIO= 1.22461
 STAGE TOTAL TEMPERATURE RATIO= 1.06555
 STAGE ADIABATIC EFFICIENCY= .90795

STAGE FLOW COEFFICIENT= .518
 AXIAL VELOCITY= 499.52
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.22461
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.24902
 LOSS FACTOR IN ROTOR= .98903
 LOSS FACTOR IN STATOR= .98975

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2925.11	3619.23	3582.11
STATIC PRESSURE	2507.36	2750.82	3093.78
TOTAL TEMPERATURE(GAS)	573.5065	611.0987	611.0987
STATIC TEMPERATURE(GAS)	548.8198	566.7669	587.0191
STATIC DENSITY(GAS)	.0856	.0910	.0988
STATIC DENSITY(MIXTURE)	.0892	.0947	.1029
AXIAL VELOCITY	499.5199	533.4818	502.3745
ABSOLUTE VELOCITY	533.8950	730.2472	538.1919
RELATIVE VELOCITY	738.5713	581.5931	
BLADE SPEED	732.5063	730.2758	768.1948
TANG. COMP. OF ABS. VEL.	188.4774	498.6562	
TANG. COMP. OF REL. VEL.	544.0289	231.6196	
ACOUSTIC SPEED	1125.2535	1163.7666	1163.7592
ABSOLUTE MACH NUMBER	.4745	.6386	.4625
RELATIVE MACH NUMBER	.6564	.5086	
FLOW COEFFICIENT	.5182	.5534	.5211
FLOW AREA	.0080	.0071	.0069
ABSOLUTE FLOW ANGLE	20.6723	43.0675	21.0210
RELATIVE FLOW ANGLE	47.4423	23.4688	
INCIDENCE	5.8223	-.2925	
DEVIATION		10.3488	10.5110

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 3) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.22461
 STAGE TOTAL TEMPERATURE RATIO= 1.06554
 STAGE ADIABATIC EFFICIENCY= .90801

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00011	.00011	.00023
XW=	.03989	.03989	.03977
XWU=	0	0	0
XWT=	.03989	.03989	.03977
XAIR=	.96000	.96000	.96000
XMETAN=	0	0	0
XGAS=	.96011	.96011	.96023
WMASS=	.01427	.01427	.01422
WMU=	0	0	0
WTMASS=	.01427	.01427	.01422
AMASS=	.34340	.34340	.34340
CHMASS=	0	0	0
UMASS=	.00004	.00004	.00008
GMASS=	.34344	.34344	.34348
TMASS=	.35771	.35771	.35771
WS=	.00011	.00011	.00024
RHOA=	.09560	.09133	.08912
RHOM=	.07160	.09511	.10303
RHOG=	.08563	.09132	.09894
TG=	573.50651	611.09874	611.09555
TW=	524.62018	531.47995	531.49766
TWU=	513.70000	0	513.70000
P=	2925.10631	3619.22732	3582.11448
TB=	687.60211	0	698.15264
TDEW=	418.76408	422.85381	437.94261

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 4) *****

STAGE TOTAL PRESSURE RATIO= 1.23734
 STAGE TOTAL TEMPERATURE RATIO= 1.06937
 STAGE ADIABATIC EFFICIENCY= .90133

STAGE FLOW COEFFICIENT= .520
 AXIAL VELOCITY= 501.59
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.23734
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.26524
 LOSS FACTOR IN ROTOR= .98600
 LOSS FACTOR IN STATOR= .98874

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	3582.11	4482.78	4432.28
STATIC PRESSURE	3094.58	3413.81	3849.29
TOTAL TEMPERATURE(GAS)	611.0955	653.4876	653.4876
STATIC TEMPERATURE(GAS)	586.1317	606.4676	628.7251
STATIC DENSITY(GAS)	.0989	.1055	.1147
STATIC DENSITY(MIXTURE)	.1030	.1099	.1195
AXIAL VELOCITY	501.5901	536.1439	506.6302
ABSOLUTE VELOCITY	537.3515	752.6615	546.2044
RELATIVE VELOCITY	763.3644	585.5788	
BLADE SPEED	768.1948	763.7337	798.0839
TANG. COMP. OF ABS. VEL.	192.7537	528.2509	
TANG. COMP. OF REL. VEL.	575.4411	235.4829	
ACOUSTIC SPEED	1162.6546	1204.1692	1204.1634
ABSOLUTE MACH NUMBER	.4622	.6364	.4536
RELATIVE MACH NUMBER	.6566	.4951	
FLOW COEFFICIENT	.5203	.5561	.5255
FLOW AREA	.0069	.0061	.0059
ABSOLUTE FLOW ANGLE	21.0210	44.5751	21.9444
RELATIVE FLOW ANGLE	48.9226	23.7118	
INCIDENCE	6.0726	-.4249	
DEVIATION		9.9518	10.1344

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 4) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.23734
STAGE TOTAL TEMPERATURE RATIO= 1.06936
STAGE ADIABATIC EFFICIENCY= .90140

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00023	.00023	.00043
XW=	.03977	.03977	.03957
XWN=	0	0	0
XWT=	.03977	.03977	.03957
XAIR=	.96000	.96000	.96000
XMETAN=	0	0	0
XGAS=	.96023	.96023	.96043
WMASS=	.01422	.01422	.01416
WNMASS=	0	0	0
WTMASS=	.01422	.01422	.01416
AMASS=	.34340	.34340	.34340
CHMASS=	0	0	0
UMASS=	.00008	.00008	.00015
GMASS=	.34348	.34348	.34355
TMASS=	.35771	.35771	.35771
WS=	.00024	.00024	.00044
RHOA=	.10987	.10590	.10390
RHOM=	.07160	.11027	.11964
RHOG=	.09894	.10589	.11491
TG=	611.09555	653.48757	653.48292
TW=	531.49766	538.61927	538.64525
TWH=	513.70000	0	513.70000
P=	3582.11448	4482.77596	4432.28162
TB=	698.15264	0	709.59620
TDEW=	437.94261	442.65883	455.51405

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 5) *****

STAGE TOTAL PRESSURE RATIO= 1.22960
 STAGE TOTAL TEMPERATURE RATIO= 1.06748
 STAGE ADIABATIC EFFICIENCY= .89617

STAGE FLOW COEFFICIENT= .525
 AXIAL VELOCITY= 505.96
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.22960
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.25805
 LOSS FACTOR IN ROTOR= .98167
 LOSS FACTOR IN STATOR= .98872

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	4432.28	5512.15	5449.96
STATIC PRESSURE	3850.09	4245.77	4768.53
TOTAL TEMPERATURE(GAS)	653.4829	697.5827	697.5827
STATIC TEMPERATURE(GAS)	627.8227	649.5072	672.5710
STATIC DENSITY(GAS)	.1149	.1225	.1329
STATIC DENSITY(MIXTURE)	.1196	.1275	.1383
AXIAL VELOCITY	505.9606	532.9952	505.9950
ABSOLUTE VELOCITY	545.4824	761.9382	549.5787
RELATIVE VELOCITY	780.4550	585.9152	
BLADE SPEED	798.0839	787.8235	819.0509
TANG. COMP. OF ABS. VEL.	203.8501	544.4869	
TANG. COMP. OF REL. VEL.	594.2338	243.3366	
ACOUSTIC SPEED	1202.9772	1244.6349	1245.1170
ABSOLUTE MACH NUMBER	.4534	.6227	.4414
RELATIVE MACH NUMBER	.6488	.4789	
FLOW COEFFICIENT	.5248	.5529	.5249
FLOW AREA	.0059	.0053	.0051
ABSOLUTE FLOW ANGLE	21.9444	45.6111	22.9819
RELATIVE FLOW ANGLE	49.5873	24.5389	
INCIDENCE	5.5873	-.6989	
DEVIATION		10.2089	9.6619

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 5) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERF=2)

STAGE TOTAL PRESSURE RATIO= 1.22960
STAGE TOTAL TEMPERATURE RATIO= 1.06747
STAGE ADIABATIC EFFICIENCY= .89626

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00043	.00043	.00069
XW=	.03957	.03957	.03931
XWH=	0	0	0
XWT=	.03957	.03957	.03931
XAIR=	.96000	.96000	.96000
XMETAN=	0	0	0
XGAS=	.96043	.96043	.96069
WMASS=	.01416	.01416	.01406
WWMASS=	0	0	0
WTMASS=	.01416	.01416	.01406
AMASS=	.34340	.34340	.34340
CHMASS=	0	0	0
UMASS=	.00015	.00015	.00025
GMASS=	.34355	.34355	.34365
TMASS=	.35771	.35771	.35771
WS=	.00044	.00044	.00072
RHOA=	.12713	.12295	.12090
RHOM=	.07160	.12797	.13846
RHOG=	.11491	.12291	.13303
TG=	653.48292	697.58272	697.57655
TW=	538.64525	545.85731	545.89207
TWH=	513.70000	0	513.70000
P=	4432.28162	5512.15360	5449.95512
TB=	709.59620	0	724.03629
TDEH=	455.51405	452.07093	463.59244

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 6) *****

STAGE TOTAL PRESSURE RATIO= 1.21465
 STAGE TOTAL TEMPERATURE RATIO= 1.06335
 STAGE ADIABATIC EFFICIENCY= .89377

STAGE FLOW COEFFICIENT= .524
 AXIAL VELOCITY= 505.48
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.21465
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.24176
 LOSS FACTOR IN ROTOR= .97277
 LOSS FACTOR IN STATOR= .99051

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	5449.96	6683.24	6619.79
STATIC PRESSURE	4769.14	5228.99	5656.21
TOTAL TEMPERATURE(GAS)	697.5765	741.7702	741.7702
STATIC TEMPERATURE(GAS)	671.6630	693.7308	710.6187
STATIC DENSITY(GAS)	.1330	.1412	.1491
STATIC DENSITY(MIXTURE)	.1385	.1470	.1552
AXIAL VELOCITY	505.4755	521.2389	493.6021
ABSOLUTE VELOCITY	549.0550	762.7687	614.2333
RELATIVE VELOCITY	788.1246	573.4053	
BLADE SPEED	819.0509	795.8534	.5000
TANG. COMP. OF ABS. VEL.	214.3734	556.8897	
TANG. COMP. OF REL. VEL.	604.6775	238.9637	
ACOUSTIC SPEED	1243.8832	1279.4619	1279.4537
ABSOLUTE MACH NUMBER	.4414	.6034	.4801
RELATIVE MACH NUMBER	.6336	.4536	
FLOW COEFFICIENT	.5243	.5407	.5149
FLOW AREA	.0051	.0047	.0047
ABSOLUTE FLOW ANGLE	22.9819	46.8939	36.5240
RELATIVE FLOW ANGLE	50.1063	24.6292	
INCIDENCE	5.0363	-1.8161	
DEVIATION		10.1992	7.2440

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 6) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.21465
STAGE TOTAL TEMPERATURE RATIO= 1.06334
STAGE ADIABATIC EFFICIENCY= .89388

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00069	.00069	.00105
XU=	.03931	.03931	.03895
XUW=	0	0	0
XUT=	.03931	.03931	.03895
XAIR=	.96000	.96000	.96000
XMETAN=	0	0	0
XGAS=	.96069	.96069	.96105
WMASS=	.01406	.01406	.01393
WMASS=	0	0	0
WTMASS=	.01406	.01406	.01393
AMASS=	.34340	.34340	.34340
CHMASS=	0	0	0
UMASS=	.00025	.00025	.00038
GMASS=	.34365	.34365	.34377
TMASS=	.35771	.35771	.35771
WS=	.00072	.00072	.00110
RHOA=	.14644	.14172	.13343
RHOM=	.07160	.14744	.15538
RHOG=	.13303	.14165	.14935
TG=	697.57655	741.77019	741.76245
TW=	545.89207	552.83791	552.88194
TUW=	513.70000	0	513.70000
P=	5449.95512	6683.24452	6619.79326
TB=	724.03629	0	735.93466
TDEW=	463.59244	468.68226	479.11464

***** OVERALL PERFORMANCE *****

INITIAL FLOW COEFFICIENT= .50000

CORRECTED SPEED=51120.0 1.000 FRACTION OF DEIGN CORRECTED SPEED

INITIAL WATER CONTENT(SMALL DROPLET)= .040

INITIAL WATER CONTENT(LARGE DROPLET)= 0

INITIAL WATER CONTENT(TOTAL)= .040

INITIAL RELATIVE HUMIDITY= .0 PER CENT

INITIAL METHANE CONTENT= 0

COMPRESSOR INLET TOTAL TEMPERATURE= 518.70

COMPRESSOR INLET TOTAL PRESSURE= 2116.80

CORRECTED MASS FLOW RATE OF MIXTURE= .358(3.018)

CORRECTED MASS FLOW RATE OF GAS PHASE .343(2.897)

OVERALL TOTAL PRESSURE RATIO=3.1273

OVERALL TOTAL TEMPERATURE RATIO=1.4300

OVERALL ADIABATIC EFFICIENCY= .8905

OVERALL TEMPERATURE RISE OF GAS PHASE= 223.062

A.5.3 Test Case Part III

***** INPUT DATA *****

NS(NUMBER OF STAGE)= 6
UNIT=ENGLISH UNIT
IPERFM=2
PERFORMANCE AT MEAN

	1	2	3	4	5	6	IGU
RRHUB(I)	.770	1.035	1.232	1.378	1.489	1.572	
RC(I)	.605	.554	.534	.510	.483	.456	
RBLADE(I)	16.00	20.00	20.00	25.00	28.00	32.00	
STAGER(I)	34.25	29.96	27.37	28.30	29.17	29.75	
STAGES(I)	23.67	25.62	26.94	28.41	29.82	38.99	
SRHUB(I)	.923	1.145	1.311	1.445	1.538	1.580	.774
SC(I)	.442	.412	.412	.412	.412	.412	
SBLADE(I)	14.00	26.00	28.00	32.00	36.00	30.00	
SIGUMR(I)	1.052	1.120	1.037	1.182	1.211	1.283	
SIGUMS(I)	.640	1.061	1.093	1.199	1.311	1.087	
GAPR(I)	.125	.125	.125	.125	.125	.125	
GAPS(I)	.125	.125	.125	.125	.125	.125	
RRTIP(I)	2.16	2.16	2.16	2.16	2.16	2.16	
SRTIP(I)	2.16	2.16	2.16	2.16	2.16	2.16	2.16
RT(I)	2.149	2.151	2.148	2.149	2.149	2.147	
RM(I)	1.426	1.575	1.642	1.722	1.789	1.836	
RH(I)	.781	1.056	1.252	1.411	1.533	1.621	
ST(I)	2.147	2.138	2.127	2.123	2.118	2.100	
SM(I)	1.502	1.573	1.637	1.712	1.766	1.784	
SH(I)	.934	1.152	1.318	1.453	1.548	1.592	
BLUCK(I)	.983	.976	.967	.949	.923	.902	
BLOCKS(I)	.978	.966	.945	.928	.908	.863	
BET1MR(I)	42.72	42.74	41.62	42.85	44.00	45.07	
BET2MR(I)	25.79	17.17	13.12	13.76	14.33	14.43	
BET1MS(I)	35.15	40.11	43.36	45.00	46.31	48.71	0
BET2MS(I)	12.19	11.13	10.51	11.81	13.32	29.28	21.99
PR12D(I)	1.154	1.165	1.221	1.237	1.230	1.215	
PR13D(I)	1.152	1.159	1.213	1.228	1.221	1.208	
ETARD(I)	.966	.966	.968	.965	.962	.954	

***** INPUT DATA *****

FNF(FRACTION OF DESIGN CORRECTED SPEED)=1.000
XDIN(INITIAL WATER CONTENT OF SMALL DROPLET)= 0
XDDIN(INITIAL WATER CONTENT OF LARGE DROPLET)= .040
RHUMID(INITIAL RELATIVE HUMIDITY)= .00 PER CENT
XCH4(INITIAL METHANE CONTENT)= 0
TOG(COMPRESSOR INLET TOTAL TEMPRATURE OF GAS)= 518.70
TOW(COMPRESSOR INLET TEMPERATURE OF DROPLRET)= 513.70
PO(COMPRESSOR INLET TOTAL PRESSURE)= 2116.80
DIN(INITIIL DROPLET DIAMETER OF SMALL DROPLET)= 20.0
DDIN(INITIAL DROPLET DIAMETER OF LARGE DROPLET)= 600.0
FND(DESIGN ROTATIONAL SPEED)=51120.0
DSMASS(DESIGN MASS FLOW RATE)= .3755
COMPRESSOR INLET TATAL TEMPERATURE(GAS PHASE) 518.70
COMPRESSOR INLET TOTAL PRESSURE= 2116.80
PREB(PERCENT OF WATER THAT REBOUND AFTER IMPINGE MENT)= 50.0 PERCENT
ROTOR SPEED=51120.0 RPM
CORRECTED ROTOR SPEED= 51120.0 RPM(100.0PER CENT OF DESIGN CORRECTED SPEED)

***** DESIGN POINT INFORMATION ***** **

***** COMPRESSOR INLET *****

TOTAL TEMPERATURE AT COMPRESSOR INLET= 518.70000
TOTAL PRESSURE AT COMPRESSOR INLET= 2116.80
STATIC TEMPERATURE AT COMPRESSOR INLET= 496.28109
STATIC PRESSURE AT COMPRESSOR INLET= 1813.73
STATIC DENSITY AT COMPRESSOR INLET= .06850

ACOUSTIC SPEED AT COMPRESSOR INLET=1092.25914
AXIAL VELOCITY AT COMPRESSOR INLET= 518.81873
MACH NUMBER AT COMPRESSOR INLET= .47500
STREAMTUBE AREA AT COMPRESSOR INLET= .01057
FLOW COEFFICIENT AT COMPRESSOR INLET= .53817

***** DESIGN POINT INFORMATION ***** ***

***** STAGE= 1 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	518.700	2116.800	492.637	1767.579	.067
ROTOR OUTLET	541.148	2442.787	508.269	1961.576	.072
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	538.76531	559.39838	725.32398	150.52734	485.62003
ROTOR OUTLET	525.97105	628.55682	618.75550	344.14838	325.90306
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	636.147	.514	.667	536.454	2381.210
ROTOR OUTLET	670.051	.569	.560	540.141	5091.790
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	15.61000	42.03015	.01036	1.42600	.55886
ROTOR OUTLET	33.19714	31.78325	.00987	1.50200	.54559

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.15200
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .95383
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.15400
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96600
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.04328

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 2 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	541.148	2438.554	511.984	2008.852	.074
ROTOR OUTLET	566.141	2840.915	522.316	2142.394	.077
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	549.21299	591.88727	730.68951	220.67086	481.94632
ROTOR OUTLET	581.16447	725.94045	639.44211	435.01464	266.71034
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	702.617	.534	.659	556.431	2688.136
ROTOR OUTLET	701.725	.648	.571	556.331	5751.007
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	21.89000	41.26765	.00930	1.57500	.56970
ROTOR OUTLET	36.81569	24.65154	.00841	1.57300	.60285
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.15900					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .93231					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.16500					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96600					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.04618					

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 3 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	566.141	2826.284	535.362	2323.868	.081
ROTOR OUTLET	600.462	3450.892	549.786	2533.049	.086
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	574.81563	608.26663	784.29006	198.93541	533.57089
ROTOR OUTLET	614.43880	781.11343	662.59507	482.28950	247.98627
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	732.506	.536	.692	586.533	3199.070
ROTOR OUTLET	730.276	.680	.577	586.263	6929.751
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	19.09000	42.86892	.00803	1.64200	.59626
ROTOR OUTLET	38.12932	21.97890	.00708	1.63700	.63736
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.21300					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .93464					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.22100					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96800					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.06062					

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 4 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	600.462	3428.282	569.069	2839.988	.094
ROTOR OUTLET	639.381	4240.785	585.841	3118.959	.100
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	580.04590	614.69778	809.54747	203.47020	564.72459
ROTOR OUTLET	619.63965	803.61317	668.93304	511.70446	252.02926
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	768.195	.526	.692	623.519	3912.431
ROTOR OUTLET	763.734	.678	.564	622.951	8231.914
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	19.33000	44.23321	.00692	1.72200	.60169
ROTOR OUTLET	39.55025	22.13332	.00607	1.71200	.64276

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.22800
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .93002
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.23700
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .96500
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.06481

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 5 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	639.381	4209.930	606.982	3506.755	.108
ROTOR OUTLET	679.732	5178.214	625.197	3857.244	.116
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	586.84149	625.22167	826.78513	215.68308	582.40082
ROTOR OUTLET	617.08868	811.98444	669.65381	527.75042	260.07304
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	798.084	.518	.685	663.653	4798.526
ROTOR OUTLET	787.823	.663	.547	662.302	9691.778
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	20.18000	44.78240	.00591	1.78900	.60873
ROTOR OUTLET	40.53794	22.85308	.00526	1.76600	.64011
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT=					1.22100
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT=					.92580
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT=					1.23000
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT=					.96200
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT=					1.06311

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 6 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	679.732	5140.325	646.933	4318.954	.125
ROTOR OUTLET	720.259	6245.495	665.989	4736.291	.133
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	587.19574	629.60666	833.74045	227.16890	591.88199
ROTOR OUTLET	603.39773	811.09676	654.61329	542.02320	253.83017
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	819.051	.506	.669	704.449	5829.034
ROTOR OUTLET	795.853	.642	.518	701.350	10970.182
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	21.15000	45.22772	.00511	1.83600	.60910
ROTOR OUTLET	41.93288	22.81494	.00467	1.78400	.62591
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.20800					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .92365					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.21500					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .95400					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.05962					

***** DESIGN POINT INFORMATION *****

***** OVERALL PERFORMANCE AT DESIGN POINT ****

COMPRESSOR INLET TOTAL TEMPERATURE= 518.70

COMPRESSOR INLET TOTAL PRESSURE= 2116.80

CORRECTED MASS FLOW RATE= 3.168

OVERALL TOTAL PRESSURE RATIO=2.9334

OVERALL TOTAL TEMPERATURE RATIO=1.3886

OVERALL ADIABATIC EFFICIENCY= .9223

OVERALL TEMPERATURE RISE= 201.559

	1	2	3	4	5	6	IGU
BET1SR(I)	42.03	41.27	42.87	44.23	44.78	45.23	
BET2SR(I)	31.78	24.65	21.98	22.13	22.85	22.81	
AINCSR(I)	-.69	-1.47	1.25	1.38	.78	.16	
ADEUSR(I)	5.99	7.48	8.86	8.37	8.52	8.38	
BET1SS(I)	33.20	36.82	38.13	39.55	40.54	41.93	
BET2SS(I)	21.89	19.09	19.33	20.18	21.15	34.86	15.61
AINCSS(I)	-1.95	-3.29	-5.23	-5.45	-5.77	-6.78	
ADEUSS(I)	9.70	7.96	8.82	8.37	7.83	5.58	
TD(I)	518.7	541.1	566.1	600.5	639.4	679.7	
OMEGS(I)	.009	.021	.025	.028	.029	.024	
OMEGR(I)	.020	.021	.024	.028	.030	.036	

***** INITIAL FLOW COEFFICIENT- .50000 (STAGE= 1) *****

STAGE TOTAL PRESSURE RATIO= 1.16790
 STAGE TOTAL TEMPERATURE RATIO= 1.05044
 STAGE ADIABATIC EFFICIENCY= .89932

STAGE FLOW COEFFICIENT= .500
 AXIAL VELOCITY= 482.10
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.16790
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.18781
 LOSS FACTOR IN ROTOR= 1.01167
 LOSS FACTOR IN STATOR= .99536

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2116.80	2483.73	2472.21
STATIC PRESSURE	1822.02	2027.51	2105.98
TOTAL TEMPERATURE(GAS)	518.7000	544.8657	544.8657
STATIC TEMPERATURE(GAS)	496.9285	515.3151	521.3902
STATIC DENSITY(GAS)	.0687	.0737	.0757
STATIC DENSITY(MIXTURE)	.0716	.0768	.0789
AXIAL VELOCITY	482.0985	471.7651	487.8474
ABSOLUTE VELOCITY	500.9664	595.7508	530.9922
RELATIVE VELOCITY	694.5315	562.4474	
BLADE SPEED	636.1474	670.0514	702.6172
TANG. COMP. OF ABS. VEL.	136.1924	363.8085	
TANG. COMP. OF REL. VEL.	499.9550	306.2429	
ACOUSTIC SPEED	1070.9380	1090.5707	1096.9841
ABSOLUTE MACH NUMBER	.4678	.5463	.4840
RELATIVE MACH NUMBER	.6485	.5157	
FLOW COEFFICIENT	.5001	.4894	.5060
FLOW AREA	.0104	.0099	.0093
ABSOLUTE FLOW ANGLE	15.7749	37.6381	23.2615
RELATIVE FLOW ANGLE	46.0417	32.9893	
INCIDENCE	3.3217	2.4881	
DEVIATION		7.1993	11.0715

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 1) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=3)

STAGE TOTAL PRESSURE RATIO= 1.16790
 STAGE TOTAL TEMPERATURE RATIO= 1.05044
 STAGE ADIABATIC EFFICIENCY= .89932

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00000	.00000	.00000
XW=	0	0	.01801
XUW=	.04000	.04000	.02199
XWT=	.04000	.04000	.04000
XAIR=	.96000	.96000	.96000
XMETAN=	0	0	0
XGAS	.96000	.96000	.96000
WMASS=	0	0	.00644
WMASS=	.01431	.01431	.00786
WTMASS=	.01431	.01431	.01431
AMASS=	.34340	.34340	.34340
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	.34340	.34340	.34340
TMASS=	.35771	.35771	.35771
WS=	.00000	.00000	.00000
RHOA=	.07649	.07395	.06767
RHOM=	.07160	.07702	.07902
RHOG=	.06872	.07395	.07586
TG=	518.70000	544.86572	544.86571
TW=	513.70000	513.70000	513.70000
TUW=	513.70000	513.70000	513.70012
P=	2116.80000	2483.73050	2472.21005
TB=	671.40656	0	679.08227
TDEW=	271.99506	273.28391	339.24784

***** INITIAL FLOW COEFFICIENT- .50000 (STAGE= 2) *****

STAGE TOTAL PRESSURE RATIO= 1.16781
 STAGE TOTAL TEMPERATURE RATIO= 1.05175
 STAGE ADIABATIC EFFICIENCY= .87555

STAGE FLOW COEFFICIENT= .505
 AXIAL VELOCITY= 486.86
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.16781
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.19311
 LOSS FACTOR IN ROTOR= .98822
 LOSS FACTOR IN STATOR= .98982

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2472.21	2916.76	2887.07
STATIC PRESSURE	2106.74	2255.26	2462.37
TOTAL TEMPERATURE(GAS)	544.8657	573.0631	573.0631
STATIC TEMPERATURE(GAS)	520.5178	533.9732	548.5689
STATIC DENSITY(GAS)	.0759	.0792	.0841
STATIC DENSITY(MIXTURE)	.0790	.0825	.0876
AXIAL VELOCITY	486.8556	516.0982	508.2930
ABSOLUTE VELOCITY	529.9329	685.3880	542.5448
RELATIVE VELOCITY	693.1121	573.7782	
BLADE SPEED	702.6172	701.7250	732.5063
TANG. COMP. OF ABS. VEL.	209.2856	450.9981	
TANG. COMP. OF REL. VEL.	493.3315	250.7269	
ACOUSTIC SPEED	1095.9433	1110.0181	1125.0890
ABSOLUTE MACH NUMBER	.4835	.6175	.4822
RELATIVE MACH NUMBER	.6324	.5169	
FLOW COEFFICIENT	.5050	.5354	.5273
FLOW AREA	.0093	.0084	.0080
ABSOLUTE FLOW ANGLE	23.2615	41.1489	20.4692
RELATIVE FLOW ANGLE	45.3785	25.9111	
INCIDENCE	2.6385	1.0389	
DEVIATION		8.7411	9.3392

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 2) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=3)

STAGE TOTAL PRESSURE RATIO= 1.16781
 STAGE TOTAL TEMPERATURE RATIO= 1.05175
 STAGE ADIABATIC EFFICIENCY= .87561

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00000	.00000	.00012
XN=	.01801	.01801	.02726
XHN=	.02199	.02199	.01262
XHT=	.04000	.04000	.03988
XAIR=	.96000	.96000	.96000
XMETAN=	0	0	0
XCAS	.96000	.96000	.96012
WMASS=	.00644	.00644	.00975
WMASS=	.00786	.00786	.00452
WTMASS=	.01431	.01431	.01427
AMASS=	.34340	.34340	.34340
CMMASS=	0	0	0
UMASS=	.00000	.00000	.00004
GMASS=	.34340	.34340	.34344
TMASS=	.35771	.35771	.35771
HS=	.00000	.00000	.00012
RHOA=	.08504	.07945	.07525
RHOM=	.07160	.08276	.08779
RHOG=	.07586	.07945	.08429
TG=	544.86571	573.06306	573.06071
TW=	513.70000	519.14631	519.16899
TWH=	513.70012	513.70012	513.70036
P=	2472.21005	2916.76359	2887.07247
TB=	679.08227	0	686.93158
TDEW=	339.24784	341.32476	419.65418

***** INITIAL FLOW COEFFICIENT- .50000 (STAGE= 3) *****

STAGE TOTAL PRESSURE RATIO= 1.21691
 STAGE TOTAL TEMPERATURE RATIO= 1.06493
 STAGE ADIABATIC EFFICIENCY= .88732

STAGE FLOW COEFFICIENT= .526
 AXIAL VELOCITY= 507.38
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.21691
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.24647
 LOSS FACTOR IN ROTOR= .98667
 LOSS FACTOR IN STATOR= .98789

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2887.07	3556.35	3513.29
STATIC PRESSURE	2463.17	2688.47	3014.69
TOTAL TEMPERATURE(GAS)	573.0607	610.2670	610.2670
STATIC TEMPERATURE(GAS)	547.6584	565.1550	585.1747
STATIC DENSITY(GAS)	.0843	.0892	.0966
STATIC DENSITY(MIXTURE)	.0878	.0929	.1006
AXIAL VELOCITY	507.3826	544.2751	513.9069
ABSOLUTE VELOCITY	541.5777	736.6414	549.3895
RELATIVE VELOCITY	743.2430	592.3993	
BLADE SPEED	732.5063	730.2758	768.1948
TANG. COMP. OF ABS. VEL.	189.3921	496.3922	
TANG. COMP. OF REL. VEL.	543.1142	233.8835	
ACOUSTIC SPEED	1124.0705	1141.8852	1161.9377
ABSOLUTE MACH NUMBER	.4818	.6451	.4728
RELATIVE MACH NUMBER	.6612	.5188	
FLOW COEFFICIENT	.5263	.5646	.5331
FLOW AREA	.0080	.0071	.0069
ABSOLUTE FLOW ANGLE	20.4692	42.3656	20.7047
RELATIVE FLOW ANGLE	46.9481	23.2540	
INCIDENCE	5.3281	-.9944	
DEVIATION		10.1340	10.1947

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 3) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=3)

STAGE TOTAL PRESSURE RATIO= 1.21691
 STAGE TOTAL TEMPERATURE RATIO= 1.06490
 STAGE ADIABATIC EFFICIENCY= .88760

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00012	.00012	.00077
XU=	.02726	.02726	.03181
XUW=	.01262	.01262	.00743
XWT=	.03988	.03988	.03923
XAIR=	.96000	.96000	.96000
XMETAN=	0	0	0
XCAS	.96012	.96012	.96077
WMASS=	.00975	.00975	.01138
WMWASS=	.00452	.00452	.00266
WTWASS=	.01427	.01427	.01403
AMASS=	.34340	.34340	.34340
CMWASS=	0	0	0
UMASS=	.00004	.00004	.00027
GMWASS=	.34344	.34344	.34367
TMWASS=	.35771	.35771	.35771
WS=	.00012	.00012	.00080
RHOA=	.09443	.08952	.08667
RHOM=	.07160	.09323	.10063
RHOG=	.08429	.08951	.09668
TC=	573.06071	610.26699	610.25190
TW=	519.16899	526.02007	526.13187
TUW=	513.70036	513.70036	513.70075
P=	2887.07247	3556.34709	3513.29461
TB=	686.93158	0	697.12854
TDEW=	419.65418	423.67496	463.62629

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 4) *****

STAGE TOTAL PRESSURE RATIO= 1.23667
 STAGE TOTAL TEMPERATURE RATIO= 1.06871
 STAGE ADIABATIC EFFICIENCY= .90751

STAGE FLOW COEFFICIENT= .533
 AXIAL VELOCITY= 513.61
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.23667
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.26254
 LOSS FACTOR IN ROTOR= .98671
 LOSS FACTOR IN STATOR= .98960

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	3513.29	4390.45	4344.80
STATIC PRESSURE	3014.95	3322.28	3749.71
TOTAL TEMPERATURE(GAS)	610.2519	652.1841	652.1841
STATIC TEMPERATURE(GAS)	584.2131	604.1817	626.3816
STATIC DENSITY(GAS)	.0967	.1030	.1121
STATIC DENSITY(MIXTURE)	.1006	.1072	.1167
AXIAL VELOCITY	513.6087	549.3247	518.6059
ABSOLUTE VELOCITY	549.0705	760.6511	557.6792
RELATIVE VELOCITY	770.2922	598.5017	
BLADE SPEED	768.1948	763.7337	798.0839
TANG. COMP. OF ABS. VEL.	194.1249	526.1487	
TANG. COMP. OF REL. VEL.	574.0699	237.5850	
ACOUSTIC SPEED	1161.2398	1202.4310	1202.4238
ABSOLUTE MACH NUMBER	.4728	.6441	.4638
RELATIVE MACH NUMBER	.6633	.5068	
FLOW COEFFICIENT	.5328	.5698	.5380
FLOW AREA	.0069	.0061	.0059
ABSOLUTE FLOW ANGLE	20.7047	43.7655	21.5751
RELATIVE FLOW ANGLE	48.1816	23.3887	
INCIDENCE	5.3316	-1.2345	
DEVIATION		9.6287	9.7651

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 4) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.23667
STAGE TOTAL TEMPERATURE RATIO= 1.06864
STAGE ADIABATIC EFFICIENCY= .90822

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00077	.00077	.00248
XW=	.03181	.03181	.03307
XWW=	.00743	.00743	.00445
XWT=	.03923	.03923	.03752
XAIR=	.96000	.96000	.96000
XMETAN=	0	0	0
XGAS	.96077	.96077	.96248
WMASS=	.01138	.01138	.01183
WMASS=	.00266	.00266	.00159
WTMASS=	.01403	.01403	.01342
AMASS=	.34340	.34340	.34340
CHMASS=	0	0	0
UMASS=	.00027	.00027	.00089
GMASS=	.34367	.34367	.34429
TMASS=	.35771	.35771	.35771
WS=	.00080	.00080	.00259
RHOA=	.10791	.10346	.10094
RHOM=	.07160	.10763	.11655
RHOG=	.09668	.10341	.11218
TC=	610.25190	652.18409	652.14134
TW=	526.13187	533.30984	533.59527
TWW=	513.70075	513.70036	513.70137
P=	3513.29461	4390.44609	4344.79698
TB=	697.12854	0	708.50906
TDEW=	463.62629	468.88156	498.37453

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 5) *****

STAGE TOTAL PRESSURE RATIO= 1.22899
 STAGE TOTAL TEMPERATURE RATIO= 1.06675
 STAGE ADIABATIC EFFICIENCY= .90336

STAGE FLOW COEFFICIENT= .539
 AXIAL VELOCITY= 519.37
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.22899
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.25515
 LOSS FACTOR IN ROTOR= .98250
 LOSS FACTOR IN STATOR= .96967

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	4344.80	5395.45	5339.72
STATIC PRESSURE	3748.75	4131.68	4643.21
TOTAL TEMPERATURE(GAS)	652.1413	695.6709	695.6709
STATIC TEMPERATURE(GAS)	625.3469	646.6178	669.5503
STATIC DENSITY(GAS)	.1122	.1196	.1298
STATIC DENSITY(MIXTURE)	.1165	.1242	.1348
AXIAL VELOCITY	519.3675	547.1502	519.0957
ABSOLUTE VELOCITY	558.4980	770.3315	562.1291
RELATIVE VELOCITY	788.0677	599.7321	
BLADE SPEED	798.0839	787.8235	819.0509
TANG. COMP. OF ABS. VEL.	205.3714	542.2521	
TANG. COMP. OF REL. VEL.	592.7125	245.5713	
ACOUSTIC SPEED	1202.5460	1243.7812	1244.3279
ABSOLUTE MACH NUMBER	.4644	.6300	.4518
RELATIVE MACH NUMBER	.6553	.4904	
FLOW COEFFICIENT	.5387	.5676	.5385
FLOW AREA	.0059	.0053	.0051
ABSOLUTE FLOW ANGLE	21.5751	44.7424	22.5764
RELATIVE FLOW ANGLE	48.7734	24.1714	
INCIDENCE	4.7734	-1.5676	
DEVIATION		9.8414	9.2564

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 5) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.22899
STAGE TOTAL TEMPERATURE RATIO= 1.06664
STAGE ADIABATIC EFFICIENCY= .90448

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00248	.00248	.00559
XU=	.03307	.03307	.03080
XU=	.00445	.00445	0
XWT=	.03752	.03752	.03080
XAIR=	.96000	.96000	.96360
XMETAN=	0	0	0
XGAS	.96248	.96248	.96920
WMASS=	.01183	.01183	.01098
WMASS=	.00159	.00159	0
WTMASS=	.01342	.01342	.01098
AMASS=	.34340	.34340	.34340
CHMASS=	0	0	0
UMASS=	.00089	.00089	.00199
GMASS=	.34429	.34429	.34539
TMASS=	.35771	.35771	.35637
US=	.00259	.00259	.00580
RHOA=	.12487	.12017	.11734
RHOM=	.07160	.12465	.13382
RHOG=	.11218	.11998	.12971
TG=	652.14134	695.67091	695.59860
TH=	533.59527	540.88803	541.37489
TW=	513.70137	513.70036	513.70155
P=	4344.79698	5395.45042	5339.72029
TB=	708.50906	0	722.80827
TDEW=	498.37453	496.93587	520.46557

***** INITIAL FLOW COEFFICIENT= .50000 (STAGE= 6) *****

STAGE TOTAL PRESSURE RATIO= 1.21378
 STAGE TOTAL TEMPERATURE RATIO= 1.06246
 STAGE ADIABATIC EFFICIENCY= .90205

STAGE FLOW COEFFICIENT= .540
 AXIAL VELOCITY= 521.03
 ROTOR SPEED= 964.04

STAGE TOTAL PRESSURE RATIO(ACTUAL)= 1.21378
 STAGE TOTAL PRESSURE RATIO(IDEAL)= 1.23841
 LOSS FACTOR IN ROTOR= .97381
 LOSS FACTOR IN STATOR= .99141

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	5339.72	6537.40	6481.27
STATIC PRESSURE	4643.05	5093.62	5499.02
TOTAL TEMPERATURE(GAS)	695.5986	739.0448	739.0448
STATIC TEMPERATURE(GAS)	668.5834	690.0533	706.4154
STATIC DENSITY(GAS)	.1297	.1379	.1454
STATIC DENSITY(MIXTURE)	.1338	.1422	.1500
AXIAL VELOCITY	521.0291	536.5871	508.8163
ABSOLUTE VELOCITY	564.2700	771.9356	629.9781
RELATIVE VELOCITY	796.4797	588.1877	
BLADE SPEED	819.0509	795.8534	.5000
TANG. COMP. OF ABS. VEL.	216.6319	554.9404	
TANG. COMP. OF REL. VEL.	602.4190	240.9130	
ACOUSTIC SPEED	1248.0901	1282.9307	1282.9214
ABSOLUTE MACH NUMBER	.4521	.6088	.4910
RELATIVE MACH NUMBER	.6382	.4639	
FLOW COEFFICIENT	.5405	.5566	.5307
FLOW AREA	.0051	.0047	.0047
ABSOLUTE FLOW ANGLE	22.5764	45.9633	36.1308
RELATIVE FLOW ANGLE	49.1436	24.1788	
INCIDENCE	4.0736	-2.7467	
DEVIATION		9.7488	6.8508

***** INITIAL FLOW COEFFICIENT= .50000 (ISTAGE= 6) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.21378
 STAGE TOTAL TEMPERATURE RATIO= 1.06219
 STAGE ADIABATIC EFFICIENCY= .90445

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00559	.00559	.01742
XU=	.03080	.03080	.01898
XU=	0	0	0
XUT=	.03080	.03080	.01898
XAIR=	.96360	.96360	.96360
XMETAN=	0	0	0
XGAS=	.96920	.96920	.98102
WMASS=	.01098	.01098	.00676
WMASS=	0	0	0
WMASS=	.01098	.01098	.00676
AMASS=	.34340	.34340	.34340
CMASS=	0	0	0
UMASS=	.00199	.00199	.00621
GMASS=	.34539	.34539	.34961
TMASS=	.35637	.35637	.35637
WS=	.00580	.00580	.01807
RHOA=	.14388	.13869	.12770
RHOM=	.07160	.14259	.14690
RHOG=	.12971	.13821	.14412
TC=	695.59860	739.04479	738.85892
TH=	541.37489	548.44179	549.82046
TU=	513.70155	513.70036	513.70155
P=	5339.72029	6537.39986	6481.26579
TB=	722.80827	0	734.62173
TDEW=	520.46557	526.83752	564.70213

***** OVERALL PERFORMANCE *****

INITIAL FLOW COEFFICIENT= .50000

CORRECTED SPEED=51120.0 1.000 FRACTION OF DESIGN CORRECTED SPEED

INITIAL WATER CONTENT(SMALL DROPLET)= 0

INITIAL WATER CONTENT(LARGE DROPLET)= .040

INITIAL WATER CONTENT(TOTAL)= .040

INITIAL RELATIVE HUMIDITY= .0 PER CENT

INITIAL METHANE CONTENT= 0

COMPRESSOR INLET TOTAL TEMPERATURE= 518.70

COMPRESSOR INLET TOTAL PRESSURE= 2116.80

CORRECTED MASS FLOW RATE OF MIXTURE= .358(3.018)

CORRECTED MASS FLOW RATE OF GAS PHASE .343(2.897)

OVERALL TOTAL PRESSURE RATIO=3.0618

OVERALL TOTAL TEMPERATURE RATIO=1.4244

OVERALL ADIABATIC EFFICIENCY= .8805

OVERALL TEMPERATURE RISE OF GAS PHASE= 220.159

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—88