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DOCUMENTATION PAGE

(2)

1a. REPORT		1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION/AVAILABILITY OF REPORT	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE		Approved for public release; distribution unlimited.	
4. PERFORMING ORGANIZATION NAME(S)		5. MONITORING ORGANIZATION REPORT NUMBER(S)	
D. Cg		ARO 24513.8-EG	
6a. NAME OF PERFORMING ORGANIZATION	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION	
Univ. of Houston		U. S. Army Research Office	
6c. ADDRESS (City, State, and ZIP Code)		7b. ADDRESS (City, State, and ZIP Code)	
Houston, TX 77006		P. O. Box 12211 Research Triangle Park, NC 27709-2211	
8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
U. S. Army Research Office		DAAL03-87-K-0009	
8c. ADDRESS (City, State, and ZIP Code)		10. SOURCE OF FUNDING NUMBERS	
P. O. Box 12211 Research Triangle Park, NC 27709-2211		PROGRAM ELEMENT NO.	PROJECT NO.
		TASK NO.	WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification)			
Nondestructive Evaluation of Stress Using Ultrasound and Pulsed Heat			
12. PERSONAL AUTHOR(S)			
Wallace L. Anderson			
13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 12/1/86 TO 11/30/88	January 1989	3
16. SUPPLEMENTARY NOTATION			
The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	Nondestructive Evaluation; Ultrasonic Sound; Pulsed Heat; Acoustoelastic Phenomenon; Metal Stress.	
19. ABSTRACT (Continue on reverse if necessary and identify by block number)			
1. Unique instrumentation was developed for high-precision time-resolved ultrasonic velocity measurement. Such instrumentation is not available commercially nor, as far as is known, has such a capability ever been developed previously. It has a significant potential for materials studies and possibly other areas as well, as for instance noninvasive biomedical applications. 2. It was demonstrated that with such instrumentation, applied stress even of modest values can be detected at depths of at least 1 cm in aluminum. Furthermore, such detection was shown to be quantitative, i.e., the amplitude of the effect is proportional to stress magnitude, and its shape is responsive in the predicted manner to locality of the stress. In view of item 3, below, it is evident that this concept is a viable basis for nondestructive characterization of subsurface residual stress in metals.			
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT		21. ABSTRACT SECURITY CLASSIFICATION	
☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS		Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL		22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL

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3. Methods for data inversion to obtain stress profiles from measured velocity were explored and it was found that two techniques give good results with simulated data and relatively large amounts of additive noise, namely: (a) generalized matrix inversion with constraints and (b) least mean squares parameter fitting. *Registered SI - 5*

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FINAL REPORT

NONDESTRUCTIVE EVALUATION OF STRESS USING ULTRASOUND AND PULSED HEAT

**UNIVERSITY OF HOUSTON
ELECTRICAL ENGINEERING DEPARTMENT**

**Period covered by report:
1 December 1986 - 30 November 1988**

**ARO PROJECT NUMBER 24513-EG
CONTRACT NUMBER DAAL03-87-0009**

Submitted by: Wallace L. Anderson

89 2 16 03T

FINAL REPORT
ARO PROJECT NUMBER 24513-EG
CONTRACT NUMBER DAAL03-87-0009
Wallace L. Anderson, Principal Investigator

The problem studied

Investigation was made of a possible method for nondestructive characterization of residual stress in metals, based on a nonlinear acoustoelastic phenomenon involving ultrasonic velocity, stress and temperature. Details have been presented in previous reports.

Summary of important results

1. Unique instrumentation was developed for high-precision time-resolved ultrasonic velocity measurement. Such instrumentation is not available commercially nor, as far as is known, has such a capability ever been developed previously. It has a significant potential for materials studies and possibly other areas as well, as for instance noninvasive biomedical applications.

2. It was demonstrated that with such instrumentation, applied stress even of modest values can be detected at depths of at least 1 cm in aluminum. Furthermore, such detection was shown to be quantitative, i.e., the amplitude of the effect is proportional to stress magnitude, and its shape is responsive in the predicted manner to locality of the stress. In view of item 3, below, it is evident that this concept is a viable basis for nondestructive characterization of subsurface residual stress in metals.

3. Methods for data inversion to obtain stress profiles from measured velocity were explored and it was found that two techniques give good results with simulated data and relatively large amounts of additive noise, namely: (a) generalized matrix inversion with constraints and (b) least mean squares parameter fitting.

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Publications

Anderson, W. L., Peng Xiang and C. E. Jensen, "Subsurface Stress Detection Using Ultrasonics and Time-Varying Temperature", *16th Symposium on Nondestructive Evaluation*, San Antonio, Texas, April 21-23, 1987.

Anderson, W. L., Y. Motiwala and C. E. Jensen, "Thermal Effects on Ultrasonic Waves in the Presence of Stress", *Proceedings Ultrasonics International 87*, Butterworth & Co. Ltd., 1987, pp. 532-536.

Anderson, W. L. and C. E. Jensen, "Instrumentation for Time-Resolved Ultrasound Velocity Measurement", accepted by *IEEE Transactions on Instrumentation and Measurement*.

Anderson, W. L., "Effects of Interaction Between Stress and Temperature on Ultrasound Velocity", *Review of Progress in Quantitative Nondestructive Evaluation*, July 31-August 5, 1988, University of California at San Diego, La Jolla, CA (in print).

Presentations at professional meetings

Anderson, W. L., Peng Xiang and C. E. Jensen, "Subsurface Stress Detection Using Ultrasonics and Time-Varying Temperature", *16th Symposium on Nondestructive Evaluation*, San Antonio, Texas, April 21-23, 1987.

Anderson, W. L., Y. Motiwala and C. E. Jensen, "Thermal Effects on Ultrasonic Waves in the Presence of Stress", presentation at *Ultrasonics International 87*, London, UK, 6-9 July 1987.

Anderson, W. L., "Residual Stress and Thermal Gradient Effects on Ultrasonic Velocity in Metals", 13th Annual Technical Symposium at the University of Houston-Clear Lake", May 11, 1988.

Anderson, W. L. and M-H Shih, "Models for Nondestructive Inference of Metallic Stress", *IASTED International Conference on Applied Simulation and Modelling*, May 18-20, 1988, Galveston, Texas.

Anderson, W. L., "Effects of Interaction Between Stress and Temperature on Ultrasound Velocity", *Review of Progress in Quantitative Nondestructive Evaluation*, July 31-August 5, 1988, University of California at San Diego, La Jolla, CA.