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13. ABSTRACT *(Maximum 200 words)*

This research was to develop methods based on a new approach to probability to the uncertainty in the factor of safety for engineering devices, structures and materials relative to strength and imposed stress. Also, to develop probability methods capable of analyzing strength/stress problems in three physical dimensions.

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FAILURE DATA ANALYSIS BASED ON ENGINEERING & GEOMETRIC PRINCIPLES

ARO FINAL REPORT

Richard E. Barlow and Max B. Mendel

February 1, 1991 to February 28, 1995

U.S. ARMY RESEARCH OFFICE

Contract/Grant Number: DAAL03-91--G-0046

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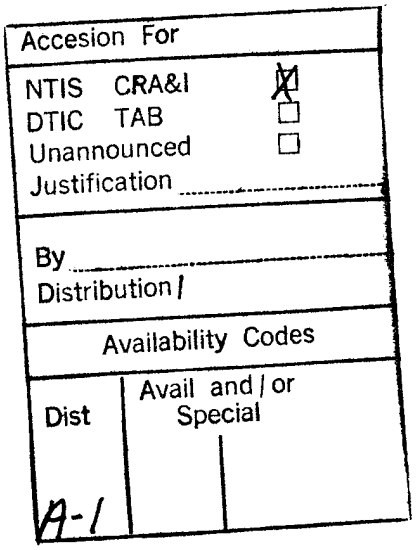

A. STATEMENT OF THE PROBLEM STUDIED

The objectives of the research were:

1) To develop methods based on a new approach to probability to determine the uncertainty in the factor of safety for engineering devices, structures and materials relative to strength and imposed stress;

2) To develop probability methods capable of analyzing strength/stress problems in three physical dimensions.

The approach we used is based on very recent work in engineering probability using differential geometry and the principle of indifference to determine conditional probability models for the purpose of analyzing data. This approach has already been successfully used to determine the probability for the state of multi-axial stress on an isotropic material, given observed strains (stresses) with respect to a specified plane.

The short term significance of this research is that many uncertainty problems involving stress and strength now solved in only two physical dimensions were solved in three dimensions. The long term potential significance of this work is that it could result in the upgrading of best engineering practice in civil and mechanical engineering design.

B. SUMMARY OF THE MOST IMPORTANT RESULTS

In the paper "An Engineering Basis for Statistical Lifetime Models with an Application to Tribology", familiar engineering knowledge was used to derive lifetime probability distribution models. Engineering curves related to the failure mechanism are used to determine the model parameters. Taking an application from tribology, we model the lifetimes of a collection of cutting tools, based on measurements of their deterioration through time. The use of related engineering curves is contrasted with the more common technique of fitting the parameters of a statistical hazard function.

In the paper ``Predicting Imbalance in Rotors", probability models for predicting dynamic imbalance of rotors were derived. Several sources of imbalance were considered. It was shown that wider tolerances in the orientation of a rotor lead to more than proportionately worse imbalance. It was shown that the expected dynamic imbalance of a cylinder is proportional to the square root of the feed rate of the cutting tool over the speed. Such models show how various parameters in the manufacturing process affect the distribution of imbalance.

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Yu Hayakawa, part of her Ph.D. thesis was published as

"The Construction of New Bivariate Exponential Distributions from a Bayesian Perspective" Journal of the
American Statistical Association, (1994) pp. 1044-1049.

Suneung Ahn, Thesis in progress. Should finish October 1995.

Scientific Personnel Supported by this Project

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Ro Cooke
Ji Huang
John Shortle
Pei Tsai

Report of Inventions (By Title Only):

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List of Manuscripts Submitted or Published under ARO Sponsorship

ARO Sponsored Technical Reports and Papers
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Max Mendel

"A Fatigue Life Model for Crack Propagation Under a Variable-Amplitude Load." Mechanics Research Communications Vol. 22, No.1., pp. 95-101 (with Ahn, S.) [1994].

"Operational Parameters in Bayesian Models." TEST, Journal of the Spanish Statistical Society, vol. 3, n. 2, December 1994, pages 195-206.

"The Geometry of Bayesian Inference." (with J. Shortle), Bayesian Statistics 5, Bernardo, Dawid, Smith, (eds.), [1994].

"Deriving Probability Models for Stress Analysis." Probabilistic Structural Mechanics: Advances in Structural Reliability Methods, P.D. Spanos (ed.), Springer-Verlag, 1994 (with Ahn, S. and Chick, S).

"Deriving Accelerated Lifetime Models from Engineering Curves with and Application to Tribology." Proceedings of the 40th Annual Technical Meeting and Exposition of the IES, Chicago,1994. (with Chick,S).

"Deriving Fatigue Life Models from the Physical Failure Mechanism." Proceedings of the AIAA Conference, Hilton Head, 1994, (with Ahn, S).

"An Engineering Basis for Statistical Lifetime Models with an Application to Tribology." Submitted to IEEE Transactions on Reliability (with Chick, S.)

``Predicting Imbalance in Rotors." Submitted to Probabilistic Engineering Mechanics. (with J. Shortle)

R. E. Barlow

"A Bayesian Approach to the Analysis of Reliability Data Bases" in the book Recent Advances in Life-Testing and Reliability, edited by N. Balakrishnan, pp. 43-50, CRC Press (1995), Boca Raton, Fl.

"Foundational Issues Concerning the Analysis of Censored Data", (with Peisung Tsai) Lifetime Data Analysis, Vol. 1, No. 1, pp. 27-34, 1995.

``The Operational-Bayesian Approach." (with Max Mendel), In P. Freedman and A.F.M. Smith, editors, Aspects of Uncertainty: A Tribute to D.V. Lindley. John Wiley, 1994.

``Similarity as a Probabilistic Characteristic of Aging" (with Max Mendel), Reliability and Decision Making, Chapman \& Hall Ltd., London, England, [1993].

``The Operational Bayesian Approach In Reliability Theory," (with Max Mendel), Resenhas IME-USP, Vol. 1, #1, 46-56, [1993].

"De Finetti-type Representations for Life Distributions" (with Max Mendel), Journal of the American Statistical Association, vol. 87, n. 420, December 1992, pages 1116-1122.