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AN INVESTIGATION OF ULTRASONIC DATA ANALYSIS
USING A MULTICHANNEL ANALYZER OR
EQUIVALENT CIRCUITRY

J. D. Elkins
R. D. Sachs
L. A. Austin

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
OAK RIDGE Y-12 PLANT

operated for the **ATOMIC ENERGY COMMISSION** *under* **U. S. GOVERNMENT Contract W-7405 eng 26**

**UNION
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OAK RIDGE Y-12 PLANT
P. O. Box Y
OAK RIDGE, TENNESSEE 37830

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Nuclear Division

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ABSTRACT

A study of simulated weldment flaws by a multichannel pulse height analyzer showed that the flaws assume separate characteristic locations among the 400 memory channels of the analyzer. A digital computer may be used in conjunction with the analyzer to completely process the ultrasonic information.

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SUMMARY

A multichannel pulse height analyzer was used to study the characteristics of reflected ultrasonic signals and particularly reflections from simulated weldment flaws. The study demonstrated that simulated flaws of different dimensions occupied separate characteristic locations among the 400 memory channels within the multichannel analyzer. This demonstration confirmed the expectation that a digital computer may be used to completely process the ultrasonic information.

A potential savings in the form of reduced manpower combined with improved test results of greater reliability, reproducibility, and accuracy may be realized if ultrasonic inspection data can be analyzed automatically.

INTRODUCTION

Presently, the Nondestructive Testing Laboratory at the Oak Ridge Y-12 Plant^(a) employs a widely used ultrasonic technique for evaluating weld joints. Basically, this technique involves directing a beam of high-frequency sound energy from a transducer into a material and observing the reflected energy as the beam encounters weldment flaw interfaces. Figure 1 is an illustration of a typical inspection scheme. A Sperry Reflectoscope is used to amplify the reflected pulses and to produce a visual display which enables inspection personnel to establish desirable setup conditions. Output from the Sperry instrument also provides signals to give a graphic representation of flaws on wet paper (c-scan) and strip-chart (analog) recordings. An analysis of the data is possible by observing the correlation that exists between the signal amplitude and the known flaw size. This analysis is usually accomplished by reviewing the data manually and comparing the results with predetermined criteria, a task which requires from one to two hours. Figure 2 shows the apparatus associated with an ultrasonic inspection.

Figure 1. ULTRASONIC INSPECTION OF ELECTRON-BEAM WELD PENETRATION.

(a) Operated for the US Atomic Energy Commission by the Union Carbide Corporation-Nuclear Division.

127946

Figure 2. APPARATUS USED FOR AN ULTRASONIC INSPECTION.

INVESTIGATION OF THE ANALYTICAL METHOD

ANALYZER TECHNIQUE

The purpose of this study was to learn if the present system could be modified to include a multichannel analyzer and determine the usefulness of the data acquired in this manner. A 400-channel Hewlett Packard instrument was selected because it was available on a short-term loan basis. One typical application of this instrument is in gamma-ray spectroscopy where it often serves as an intermediate link to a final computer analysis of complex radiation spectra.^(b)

The Sperry Reflectoscope output was found to be eight volts negative at the baseline and zero volts for a saturated signal amplitude. These values proved to be compatible with the 2 volts/100-channel range of the analyzer. The analyzer was equipped with a display scope to observe the pulse distributions and a Friden printer to give a readout of the number of pulses stored in each channel. Figure 3 presents a block diagram of the ultrasonic system modified to include the 400-channel analyzer.

Figure 3. ULTRASONIC MULTICHANNEL ANALYZER SYSTEM.

(b) Euler, B.; "Pulse Height Analyzers: Computer-Compatible Output for Both Stationary and Mobile Systems", Nuclear Instruments and Methods, 63, pp 29 - 38 (1968).

SPURIOUS BACKGROUND SIGNALS

During the initial setup of the instrumentation, spurious low-level signals contributed unwanted counts throughout many of the information channels. However, suitable discriminator levels were found so that the signals could be omitted completely or confined within the first eighty channels. The latter alternative was chosen because it was felt the signals possibly resulted from fine structural characteristics of the material under investigation. Also, enough channels were left free to separate the range of signals arising from known Elox slot flaws of 2, 5, and 10 mils in size. Unfortunately, the loan time of the instrumentation precluded a detailed investigation into the origin of the low-level signals. Figure 4 is a photograph of the background that was acquired by scanning an area free of any flaws. An inspection of a weld joint completely free of flaws would be expected to produce a similar result.

Figure 4. PHOTOGRAPH OF THE BACKGROUND PATTERN ACQUIRED BY SCANNING AN AREA FREE OF FLAWS.

FLAW RESOLUTION

Flaws within materials provide a barrier to the transmission of sound energy. Boundary conditions, of course, assume various geometries; but, as a general rule, the energy reflected back along the incident beam path is primarily a function of the cross-sectional area of the flaw. Using flaws of known size and fixed geometry and orientation, voltage pulses proportional to flaw sizes can be produced. In order to study the capability of a multichannel analyzer

to resolve flaws of various sizes, a test piece was used that contained Elox slots of 2, 5, and 10-mil depths. An example of the results from these slots is presented in Figure 5. The 2-mil slot registered counts in a relatively narrow band of channels near Channel 220; counts from the 5 and 10-mil slots were also observed to fall into characteristic channel groupings.

Figure 5. MULTICHANNEL ANALYZER SCANS OF ELOX SLOTS FROM A TEST PIECE.

An investigation was conducted to determine if the counts registered per unit time was a function of flaw size. This determination was achieved by using a single flaw and adjusting the reflectoscope gain. When a 60 percent signal was counted for three minutes, 116,117 counts were registered for that channel group; with the same signal reduced to 20 percent of its maximum amplitude, 118,222 counts were acquired in three minutes. Thus, any error arising from a pulse amplitude-count rate relationship appears to introduce an error of less than two percent.

TYPICAL DATA COLLECTION

Data were acquired from a weld joint by allowing the beam to scan the entire weld length and then indexing to a new position until all the weld was scanned.

The effective beam diameter at its focal point was about 30 mils and each index step amounted to about 14 mils. This setup established an overlap; that is, data were acquired more than once for each flaw. Consequently, the number of counts per beam pass had to be determined by producing two isolated flaws of different sizes and then determining the counts generated as the beam completely traversed each. One flaw closely simulated the signal of a 10-mil-deep Elox slot; the second flaw produced a signal approximately equal to that of a 5-mil-deep Elox slot. When the beam was allowed to traverse each flaw at 1.24 inches/sec in 14-mil index increments, 48 counts were accumulated for the larger flaw and 12 counts resulted for the smaller flaw.

The total count in each instance was arrived at by summing the counts from the channels contributing to the peak, thus:

$$\text{Number of 10-Mil or Greater Flaws} = \frac{x (\text{counts})}{48 (\text{counts/flaw})}, \text{ and}$$

$$\text{Number of 5-Mil Flaws} = \frac{x (\text{counts})}{12 (\text{counts/flaw})}.$$

When typical weld joints on two parts were inspected, the analyzer data indicated the existence of 101 flaws that were equal to or greater than the 10-mil Elox slot, and 78 flaws equivalent to a 5-mil Elox slot. On a separate part there were 64 flaws equal to or greater than a 10-mil slot and 43 flaws equivalent to a 5-mil slot. Figure 6 gives photographs of the data collections from the two inspected weld joints. Although the 5-mil peak is not apparent in the Figure 6 photographs, the counts in the 5-mil amplitude channels were obtained from the Friden printout of counts per channel. This analysis demonstrates only rather crudely what can be done. The numbers quoted were based on meager statistical evidence, but a more extensive study of system characteristics should produce accurate results.

DESCRIPTION OF AN AUTOMATED SYSTEM

Ultrasonic inspection data can be put into digitized form such that quicker and easier interpretations are possible. Going one step further, the information can be digitized and fed into a computer that is preprogrammed to perform a comparative analysis and printout a record of the results. A fully automated analysis system eliminates the need of a multichannel analyzer and substitutes in its place an analog-to-digital converter (ADC). The ADC can supply signals into a digital computer. In essence, the computer replaces the multichannel analyzer and not only provided information storage, but also gives the capability to make decisions regarding the information. An additional desirable

Figure 6. MULTICHANNEL ANALYZER SCANS OF TWO INSPECTED WELD JOINTS.

feature of a completely automated system may be to provide a means of correlating flaws to part locations. This service may be provided by using an encoding device which can indicate a part location relative to a known starting point. Figure 7 provides a block diagram showing the components of such a system.

Figure 7. COMPONENTS OF A COMPUTER-ULTRASONIC SYSTEM.

Presently, plans are being made to incorporate a PDP-81 computer for analysis of ultrasonic inspection data.

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