A HIGHLY INTERACTIVE SYSTEM FOR PROCESSING LARGE VOLUMES OF ULTRASONIC TESTING DATA

H. L. Grothues, R. H. Peterson, D. R. Hamlin, K. S. Pickens
Southwest Research Institute
San Antonio, Texas

INTRODUCTION

Automated ultrasonic testing (UT) of big structures poses particular problems related directly to economics and productivity. Generally, UT examinations on these large structures are performed with multiple channels to reduce scan time and collect data from various orientations. The amount of resulting data also is quite large. Traditional approaches have relied on up-front gating and signal thresholding to reduce the amount of data recorded. This has been a practical approach, as the capability of data processing and recording devices has also been limited. Even with the incorporation of computer technology, most systems performing UT of large structures still operate on this same data acquisition principle. General purpose computer configurations lack the performance to provide any substantial improvement in data analysis. Computer resources have been focused on number crunching, data summary, and data comparison using general criteria such as signal amplitude and sound path location. In practice, examiners use this type of system to identify areas of concern and then perform "re-looks" while observing the instrument A-scan display. Years of experience are then applied in interactive analysis of the A-scans for final resolution. For the particular area of concern, as much additional information as possible is collected (e.g., different angles and orientations) to provide information crucial to the final disposition. If the system collected the proper data and was capable of presenting these data in a meaningful format, this manual "re-look" procedure would not be necessary.

DISCUSSION

The Enhanced Data Acquisition System (EDAS) is designed for automated multichannel UT of large components. Its goals are to

- Provide rapid disposition of indications
- Be usable in low signal-to-noise ratios
- Require less stringent calibration requirements
- Increase productivity of the UT crew

In addition, EDAS must be able to quickly collect the proper type of data in sufficient quantity to present easy-to-interpret displays.
The EDAS philosophy is based on using the best probes for the particular examination rather than attempting sophisticated enhancements to less than adequate data. Along with that, the system provides features directed toward typical problems encountered in the UT of large components: multi-channel operation to reduce examination time, realtime display of test data to confirm proper UT system operation during the examination, development of compressed images in realtime to assist in methodical data evaluation, high-speed interaction to enable searches of data to help correlation of results, and a mechanism for annotating and linking different sets of results for analysis and reporting.

To achieve productivity, EDAS is composed of two subsystems: one dedicated to data acquisition and one to data analysis. Data transfer between the subsystems is via high-density laser disk. Separation of acquisition and analysis activities permits data acquisition to occur on subsequent components while data analysis is being performed. EDAS uses the basic ultrasonic C-, B- and A-scan displays as well as side and end views of the material volume as data analysis tools. Since data evaluation is based on visual image analysis, the system must record full waveforms at close intervals. For EDAS, waveform length can vary from 256 to 4096 points, and typically are collected at a scan interval of 0.05 inch. The power of image analysis is that even an inexperienced analyst can detect the predictable pattern of a reflector in an ultrasonic B-scan. In the B-scan image all A-scans are of value in data analysis. Since this is the case, waveforms are continually recorded based on position—no amplitude thresholding is employed.

ACQUISITION SUBSYSTEM

EDAS is a multichannel system composed of a replication of independent channels, as shown in Figure 1. Each channel functions under the control of a channel processor—a microprocessor responsible for data acquisition, generation of data for realtime display, generation of data for 3-view display, and general housekeeping tasks. Each channel interfaces with a high-speed signal averager and a commercially available UT instrument. System interface with the scanner mechanism is accomplished through a position processor responsible for triggering data acquisition, recording position location, and ensuring scan constraints are met. Data flow from each of the channels and the position processor is orchestrated by a command processor responsible for passing data to the realtime display and storage of all data on the laser disk. The data acquisition system provides functions for: diagnostics, calibration, parameter entry, 3-view display, realtime display, and A-scan/B-scan presentation.

In the process of acquiring data, the channel processor is responsible for developing summary displays to be used in data analysis. These displays (termed 3-view) are developed in realtime and written to disk as part of the examination record. The information is for immediate use at the data analysis subsystem. The purpose of the 3-view display is to assist the analyst in locating relevant areas and to provide a logical framework for the analysis process. It assists in reducing the amount of information to be reviewed.

To cope with the speed and volume of information being recorded by the system, EDAS provides a realtime color display for the examiner. This display enables simple review of UT data for all channels during each scan and permits comparison of data patterns between successive scans and between different channels. The realtime display also provides the operator with confidence that the system is performing as expected.
To provide further detail, the acquisition subsystem makes available a combination B-scan/A-scan presentation for localized use by the examiners in performing interactive operation and investigation in resolving anomalies observed during the examination. The data acquisition subsystem is not intended to be used for data analysis activities.

Operation of the data acquisition subsystem is through a high-performance color graphics workstation incorporating a window-based mouse-driven user interface. All system functions are displayed as push-buttons on the graphics display in front of the operator. Selection is made by "pointing and pressing" with the mouse—making the system easy to use and not restricting operation through a series of hierarchical menus or complicated commands. The basic acquisition configuration is capable of supporting up to seven channels simultaneously at a scan speed of 6 inches per second.

ANALYSIS SUBSYSTEM

The analysis subsystem consists of a high-performance color graphics workstation, a color hardcopy unit, and a laser disk drive. It can be located separately from the acquisition subsystem, since it operates independently of it. In performing data analysis, EDAS provides a highly interactive, response-oriented environment for the operator. The system uses a series of command display screens and data display windows. User interface with the analysis subsystem is very similar to that of the acquisition subsystem with controls displayed of the graphic screen as push-buttons and operator selection accomplished through "pointing and pressing" with the mouse. This type of operator interface enables freestyle application of the system. The operator is free to use the system in the manner best suited to his or her methods. System response is near realtime for any operator command. Since the system is highly interactive, this enables the operator to perform analysis and recall at will with no observable penalty for repeating steps. The powerful multitasking system and window-based user interface enables selection and simultaneous arrangement of displays to assist the analyst in understanding the data.
Generally speaking, the operator would start analysis with the 3-view summary display generated from the entire set of scan data during the examination. The 3-view display, illustrated in Figure 2, is a volumetric projection (top, side, and end views) of the peak signal data acquired from the inspected volume. A 3-view display is produced for each channel. All three views are properly aligned in a single image so that positional correlation can be made. The image is scaled in coordinates of the component, with signal amplitude mapped to a color scale adjustable by the analyst. The analyst uses this image to identify indications where more detailed information is required for proper disposition. Areas of interest are defined directly from this image through use of a box-type cursor which appears on each of the views simultaneously. The size of the box cursor is adjustable for each of the three coordinate axes, and its location is controlled through manipulation of the mouse. For the volume specified by the cursor boundaries, corresponding 3-view images for other channels and basic B-scan and A-scan data can be retrieved through push-button selection by the analyst.

EDAS handles all coordinate transformations between channels as well as coordinate determination between images automatically—the operator is free to concentrate on interpretation of the data. In particular, EDAS offers powerful enhancements in data analysis by providing proper images for scan-to-scan and channel-to-channel correlations at a speed which is in direct response to the analyst's request. The process is much like switching between color slides in a projector, but with the additional capability for the analyst to retain and arrange multiple images on the display as desired. Throughout this process, the analyst can: sequence through B-scans for a selected channel, review successive A-scans for echo dynamics and predictable sound-path variations, and switch to corresponding images for other channels. In each of these images, the analyst may identify indications and electronically mark them on the image. The EDAS software keeps track of these operator notations and the references to the corresponding data. Where the analyst determines correlation of data from different ultrasonic channels, these data are logically linked and recorded for retrieval and reporting purposes.

![Fig. 2. Acquisition subsystem block diagram](image-url)
The analysis subsystem software provides a dynamic capability that permits the operator to interactively control the display of recorded A-scans so that waveform dynamics can be observed and evaluated. This permits experienced examiners who are unfamiliar with image interpretation to bridge the gap between traditional A-scans and image analysis, thus taking advantage of their full range of experience.

EDAS is not limited to image display; it offers capabilities to extract quantitative information from the images so that complete analysis and reporting can be performed. The ability to efficiently handle enormous amounts of data in a nonpredefined manner makes EDAS a realistic tool for experienced ultrasonic examiners.

SUMMARY

EDAS is designed for use with both conventional and multibeam UT techniques. The power of the system is in its ability to efficiently handle large volumes of ultrasonic data in a highly responsive, interactive manner. Keith Pickens, in a companion paper, discusses the development of image processing and artificial intelligence applications that are potential enhancements to the system.

DISCUSSION

Mr. Green: I know it's not your work, so maybe it's an unfair question but why are you doing these experiments? You don't have a problem with (inaudible)?

Mr. Peterson: This work was a more fundamental study of the interactions between hydrogen and defects. In terms of applications, the positron annihilation technique has promise as a nondestructive method of evaluating hydrogen embrittlement in steels.

Mr. Green: And gives you the basic fundamentals of what you can do and can't do?

Mr. Peterson: Correct.

Mr. Jeff Eberhard, G.E.: Can you say a little bit more about the experimental configuration, how the positrons get in, and all that kind of stuff?

Mr. Peterson: Two different radioactive isotopes were used in this work, one of which was sodium-22. That source consisted of sodium-22 chloride deposited in a narrow trench on a lucite block. The source is placed on one side of the sample. A gamma ray detector is placed on the other side of the sample to detect the annihilation photons. The signals from the detector are fed into a multi-channel analyzer and then into a computer system. The resultant peak consists of the number of counts as a function of energy. The peak is centered about 511 keV, which is the energy that the annihilation photons would have if the electron in the annihilation event was stationary. As the changes in the spectra produced by defects are very subtle, computer analysis is required to extract meaningful parameters from the raw data.

Mr. R. Green: Are there restrictions or some restriction on the thickness of the specimen?
Mr. Peterson: Yes, mainly on the lower end. The sample should be thick enough to effectively stop all of the positrons. This minimizes the background contribution from positrons annihilating in the detector.

Mr. Ron Smith, Harwell: You are going about the very small changes you need to measure with the positron system. Could you say why you use the R parameter rather than, say, an S parameter, which is the peak width parameter?

Mr. Peterson: S, P or P/W parameters give an indication of the number of positrons annihilating in defect traps. The R parameter analysis considers both the peak and wing portions of the spectra in order to detect changes in the predominant positron trap.

From the Floor: You mentioned the proton screening of the dislocation. What does that mean?

Mr. Peterson: Hydrogen (protons) and positrons are both attracted to defects where the crystal structure is relaxed. A proton at a dislocation will repel any positrons since they both have positive charge. Consequently, the positrons will be more likely to annihilate in the matrix.