DEFECT ASSESSMENT USING CONFORMABLE ARRAY DATA

Quarterly Report
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Disclaimer

Abstract

This second quarterly report of the project presents the activity and conclusions reached to date. Specifically, the design parameters of the field eddy current array have been determined and the overall approach to data collection and analysis defined. The data acquisition, display, and assessment software has been completed. A preliminary hardware design was also completed and parts ordered to fabricate a breadboard circuit to validate the concept.

A review meeting was held at Southwest Research Institute.

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1. Introduction

Array design decisions include the following:

(a) The flexible array board will be approximately 15 inches square with the active coil section confined to a smaller section at the center of the board. The outer edges of the board will be used for switching and other circuitry.

(b) The diameter of the array coils will be approximately 7 to 10 mm.

Data acquisition strategy includes:

(a) The corrosion spots will be mapped by successive passes of the active section of the array board. Five sets of data will be acquired from each coil in the array, with the highest and lowest value being discarded and the remaining three measurements averaged. This will be repeated for each coil in the array in a sequential manner. The total corrosion image for the sector will be built from the individual coil data.

(b) Corrosion larger than the operational portion of the array board will be measured by using a grid technique. Uniquely identified areas in the grid will overlay a corroded area, and data collected for each area will be connected by the display and assessment software to form a composite image for the corroded area.

(c) Defect assessment will be invoked on the corrosion image by "boxing" selected areas on the color contour map.

2. Experimental

This project is a follow-on project from the Conformable Array for Mapping Corrosion Profiles, DOE Contract No. DE-FC26-02NT41644. Most of the experimental work was performed during the previous project, and the work in this project is to develop a prototype of the conformable array and the data acquisition software. Included in this work was a review of the literature on used eddy current methods for imaging and the evaluation criteria for assessing remaining strength in pipe.[1–4] The experimental work consists of component selection for the conformable array and working with the appropriate MATLAB modules to obtain the required functionality.

3. Results

Array—The design specifications for the array were completed in this reporting period. A conceptual image of the array is shown in Figure 1. As shown in the figure, the array will consist of 256 coils in a 16 by 16 square array. The 7- to 10-mm coils will be positioned very close to one another, producing a 160-mm (6.3-inch) square active coverage area. Note that the array consists of two portions, a rigid portion to carry the switching and other circuitry and a flexible portion that will conform to the pipe surface. A preliminary hardware design has been completed and parts are on order to build a breadboard circuit to validate the concept. Design and fabrication of the array hardware will be completed in the next reporting period.

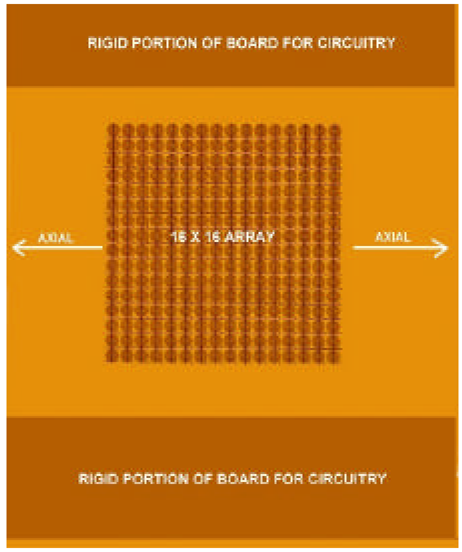

Figure 1. Conceptual image of the array

Data Acquisition—The data acquisition strategy and software development were completed in this reported period. The acquisition, display, and assessment software has been exercised on simulated corrosion data.

The acquisition technique was defined as follows: five data sets will be acquired from each coil, the highest and lowest values will be discarded, and the three remaining data set values will be averaged to produce the value for that coil measurement. This process will be repeated for each coil in succession. It was determined that taking five measurements at a time for each individual coil would be faster than taking single measurements for the coils in succession and repeating the process to obtain five measurements per coil.

Since many corroded areas will be larger than the 160-mm by 160-mm coverage area for the array, provision must be made for multiple scans to cover large corrosion areas. The proposed method to accomplish this is to use a thin, flexible, mylar underlayer against the pipe surface. The underlayer will be transparent with outline information printed on it. The outline will consist of 160-mm squares that are uniquely identified, e.g., A, B, C,….F. This example considers a situation where the six adjacent squares cover an approximately 320-mm (12.6-inch) by 480-mm (18.9-inch) pipe surface area. The underlayer will be securely attached to the pipe in a position that minimizes the number of outline squares that encompass the corrosion. The active array can then be moved from one designated square to the next with an identifying label input into the computer prior to data acquisition. This will make it easier to connect the data during analysis to present a single image of the entire corroded area.

The Pipe Corrosion program is available from the screen shown in Figure 2. The current version of the Pipe Corrosion program allows for the acquisition and analysis to be done quickly and efficiently. The program has five main functions. These are:

- ***Calibrate—***Used to calibrate the eddy current array to a piece of pipe with no surface defects.

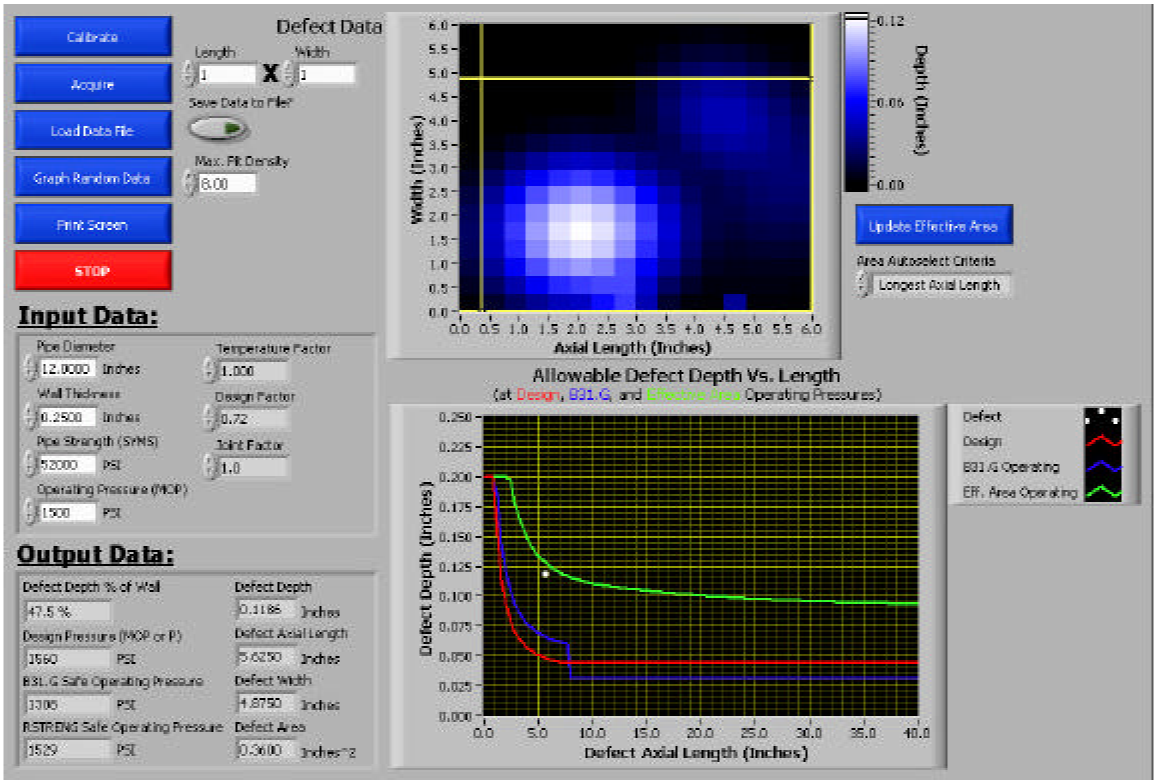

Figure 2. Pipe Corrosion Program display

- ***Acquire***—Allows the user to scan areas of corrosion on the pipe. It uses the length and width inputs to define the number of scans to be taken. For example, length and width equal to 1 corresponds to only using area A on the mylar sheet, while a length of 3 and a width of 2 would correspond to areas A through F. These data will be saved to a file, provided "Save Data to File" is enabled.

- ***Load Data File***—Loads corrosion data that were taken previously so the operator can perform analysis.

- ***Graph Random Data***—Creates a random corrosion image that can be used to demonstrate the software without using an array. It uses length and width exactly like acquire and also allows for the saving of data. In addition, it uses the input max pit density. This control sets a maximum limit on the number of random corrosion bits per 16×16 image.

- ***Print Screen***—Prints a copy of the panel on the default Windows printer.

The image will be displayed as a 2D color map in the defect data plot with the maximum depth being shown in white. At the same time, the program will examine the data using one of two options, Deepest Pit or Longest Axial Length, to select an effective area on which to perform the analysis. The analysis calculations use both ASME B31.G and RSTRENG methods.[5–6] These options are available from the control labeled Area Autoselect Criteria on the screen, and will display either the Deepest Pit or the Longest Axial Length. The user can select from the choices at a later time and update the effective area using the Update Effective Area button.

Once the effective area is computed, the program automatically fills in the Output Data table and the Defect Depth vs. Length plot. The Output Data calculations are performed using the numbers provided in the Input Data section and will be updated immediately if the user changes any of these Input parameters.

Future work includes enhancing the program with the addition of a series of warning and status messages informing the operator of the pipeline condition with the current data. For example, one message will inform the operator that the pipe is running in an unacceptable range if the operating pressure is above a safe level. These warning and status messages are intended to increase the utility of the array and the application.

4. Conclusion

The project activities are consistent with those laid out in the proposal. The system is still planned to be as shown in the artist concept presented in Figure 3.

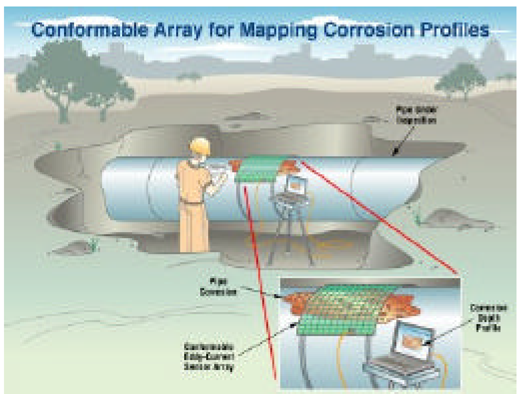

Figure 3. Artist concept image

The next quarter will see completion of the design of the flexible array board, acquisition of the data acquisition and analysis hardware, and completion of the software enhancement.

5. References

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3. A. Bugar and J. Moulder, “Use of Eddy Current Sensors for Controlling the Probe Lift-off Actively During Scans,” *Review of Progress in Quantitative Nondestructive Evaluation*, Vol. 13 (1994), D. Thompson and D. Chimenti, eds. pp. 1103–1110.

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6. Z662-99, “Oil and Gas Pipeline Systems.” Canadian Standards Association, 1999, pp. 179–187.