3D Visualization of Defects From Ultrasonic Pipe Testing

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Category
Manufacturing Functional Test

Products Used
LabVIEW 7.0
MIO DAQ
NI-6602 Counter
Enterprise Connectivity Toolset

The Challenge
UT DAQ & MES, Stats, 2048/in for 45 ft

A major multinational manufacturer of seamless steel pipe needed help enhancing their basic LabVIEW data acquisition application. In order to be of maximum benefit the application needed to interface to the steel mills Manufacturing Execution System (MES). Detailed wall thickness data from their ultrasonic test system needed to acquire 2048 data points over each inch of pipe over the entire forty five foot length and be available in a convenient form to all personnel throughout the plant immediately upon being acquired.

The Solution

Data Science Automation (DSA) was chosen to implement the requirements of this integrated system. Roundtable discussions were held that included production engineers, instrumentation engineers, quality control (QC) engineers, plant operations personnel and information systems (IS) personnel. As a result of the insight gained in these meetings three areas of application enhancement were identified:

1. Integrate access to the plant MES system to prevent redundant transcription of information available elsewhere.
2. Modify the data acquisition task to acquire the data using a rotary encoder as an external clock source.

3. Place summary statistical information in a database for multi-client access.
4. Prototype a three-dimensional visualization of each pipe's wall thickness data.

Item 1 was accomplished by having the IS personnel write a simple process that exposed only the information required by the QC operators of the ultrasonic test system. The information from this process identified the queue of test articles (and their associated characteristics) that had been pulled from the production line and routed to the ultrasonic test station. Each time the test system loaded a test article, the operator was presented with the Task Tally VI window shown in Figure 1. The Task Tally VI was designed to allow the operator to handle the typical exceptions to the standard operating procedures such as:

- Pipe information from the MES process was incorrect. Allow manual entry and deletion of MES information.
- Pipe information in the MES queue was in the wrong order.
- Pipe unable to be safely tested due to flaws that would damage the ultrasonic sensors.

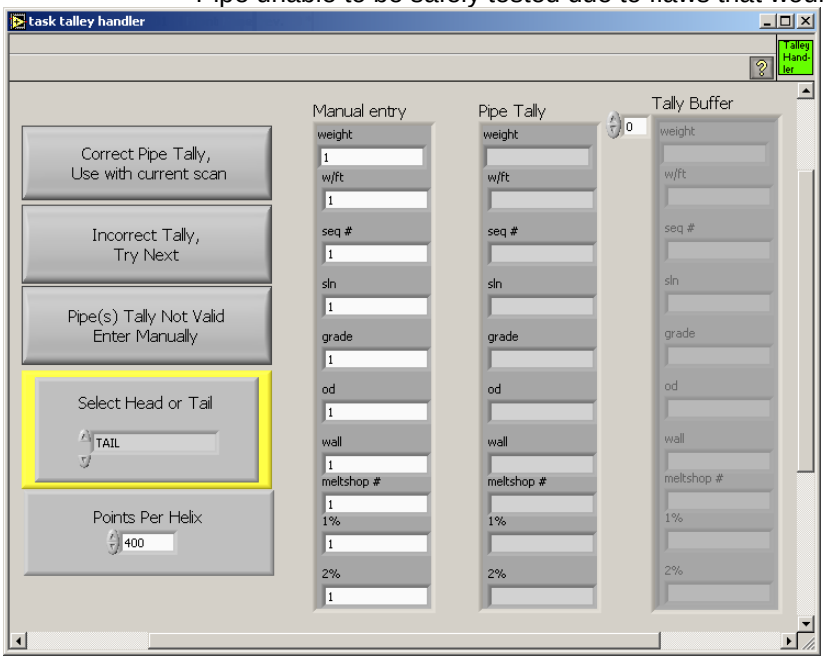

Figure 1. Task Tally Client

The ultrasonic testing process consisted of placing the pipe to be tested in the test fixture, rotating the pipe about its longitudinal axis, and moving the sensor end-to-end in a line along the outer surface of the pipe while the pipe rotated. This resulted in a helical path of the sensor relative to the pipe surface. In order to know the axial and circumferential position of the sensor, rotary and linear encoders were used. A complicating factor was the fact that the rotary encoder was not directly coupled to the rotational drive. Rather the rotary encoder was connected to a three inch diameter wheel that was held against the outer surface of the rotating pipe at a fixed axial location along the pipe. This resulted in the rotary encoder pulses being associated with the outer circumference of the pipe. But due to pipe non-uniformities, only the nominal circumference of the pipe was known. In order to determine the actual number of rotary counts per rotation of a particular pipe, the cyclic repetition of the non-uniformity was used by monitoring the ultrasonic sensor signal over several rotations while holding sensor at a fixed axial location while the pipe rotated. The nominal circumference of the pipe was used to ensemble average the rotations based upon the cyclic repetition of the non-uniform shape of the signal. This approach addressed Item 2 and resulted in the linear and polar plots shown in Figure 2.

The waveform data for each pipe was summarized in a database to address Item 3. The database allowed multi-client access to the trends of wall thickness statistics for the last thirty pipes tested. The LabVIEW executable that

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was developed to query the database and display the trends could be run on many computers concurrently throughout the steel mill. Figure 3 shows the user interface of the thirty pipe trender.

Finally, to address Item 4, a 3D visualization of the helical data was prototyped. Figure 4 shows the data from one of the test data sets. Both circumferential and axial non-uniformities are easily seen with this visualization.

Summary

By using some of the advanced enterprise connectivity tools and an in-depth understanding of the client's processes and systems, DSA developed a plant wide integrated application using LabVIEW that conveniently and immediately exposed critical quality data and trends to the production engineers and plant operations personnel to allow them to make adjustments to the steel mill manufacturing process. This information allowed significant improvements in the quality and uniformity of the seamless steel pipe across a broad range of diameters covering the client's entire product line.

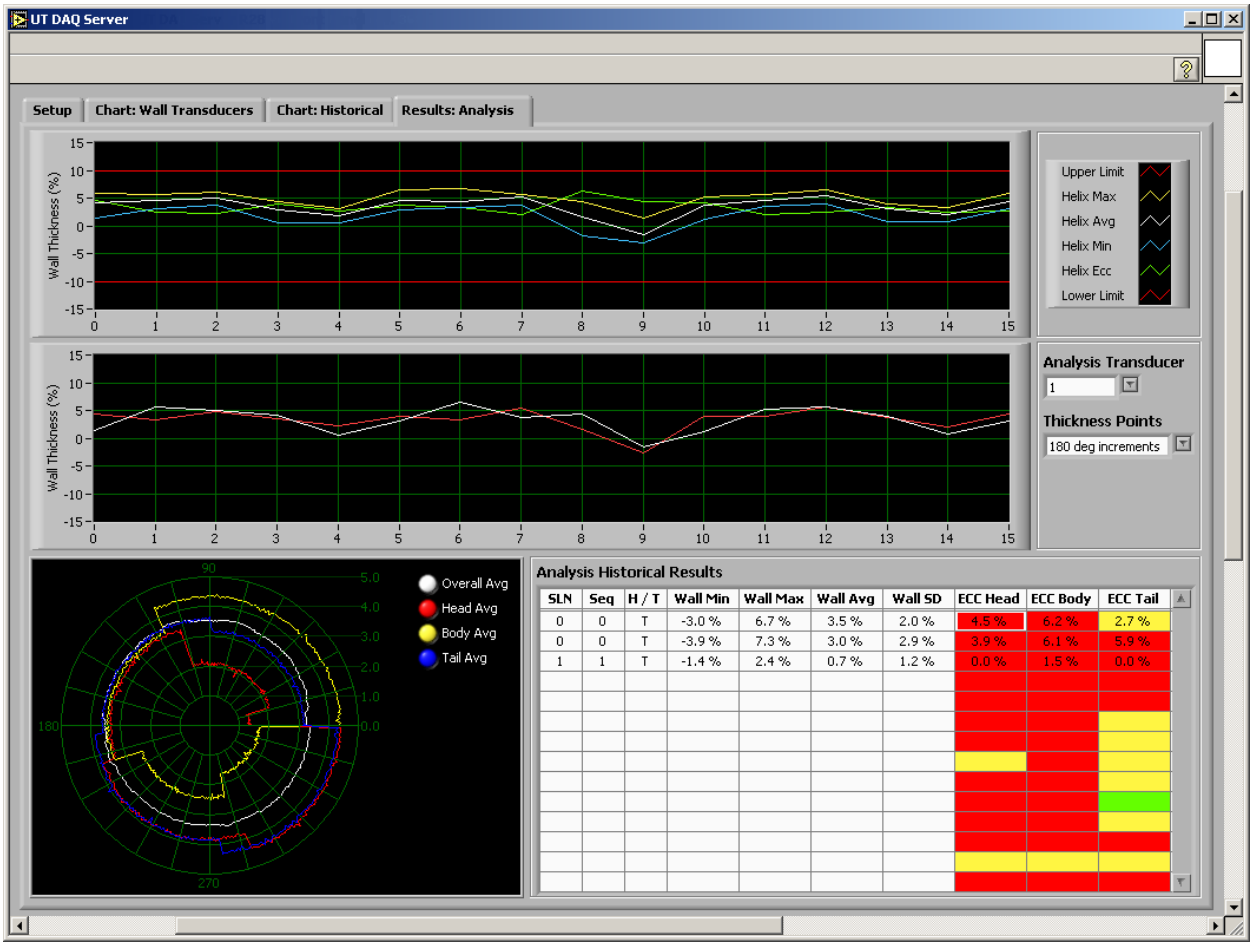

Figure 2. Linear and Polar Trends of Wall Thickness

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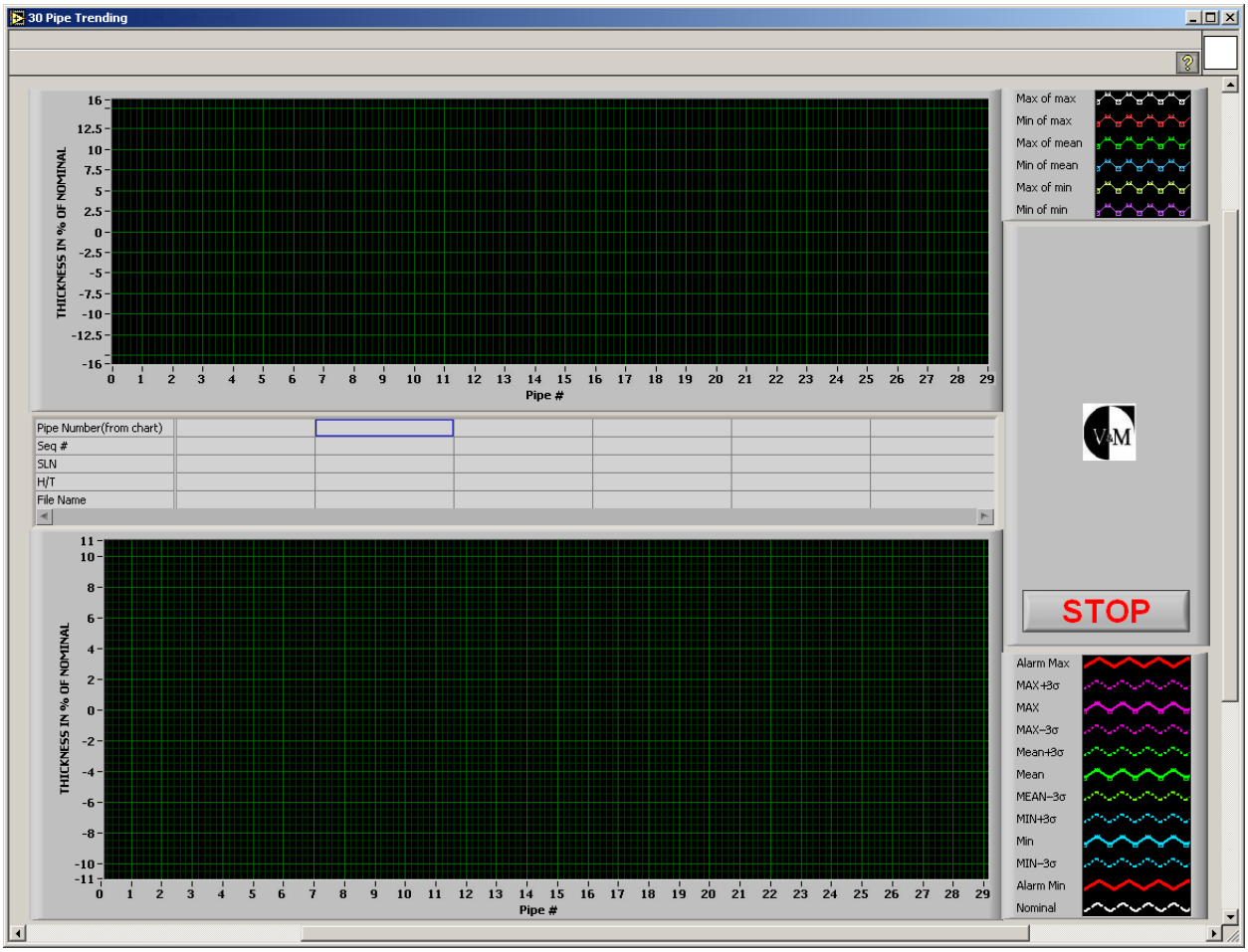

Figure 3. Trends of Summary Statistics for Last Thirty Pipes Tested

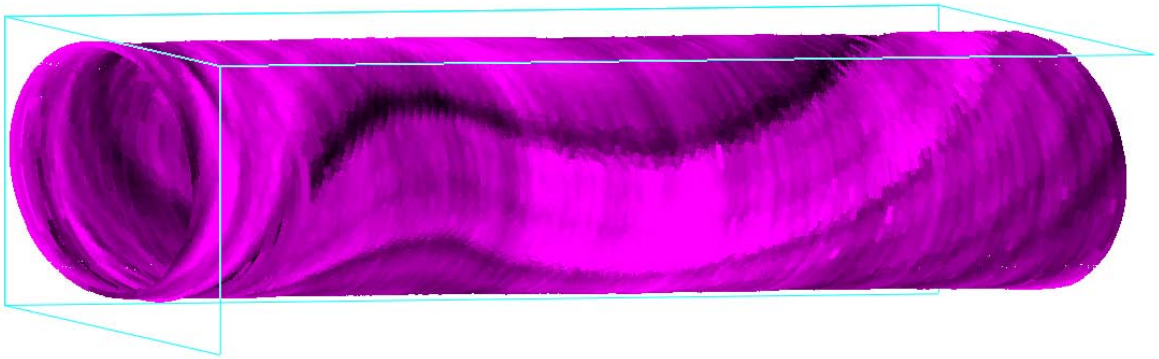

Figure 4. 3D Visualization of Circumferential and Axial Non-Uniformity of Wall Thickness

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