Quarterly Report – Public Page

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Technical Status

GTI has developed a two sensor, ultrasonic inspection technique for butt fusion joints. A "model" was developed wherein a modest number of independent parameters are required to assess butt fusion quality. Dependent values are determined by testing against only good joints. No flawed joint sections are used to determine the dependent parameters. The number of joints required to determine the parameters is small. To date, the technique has correctly classified all of the joints tested.

There are four important advantages to the technique:

- Discrimination decisions can be made automatically without the operator viewing the waveform. This minimizes operator expertise which was a major downfall of previous ultrasonic testing techniques of ASTM D 1598 and the UltraMc®. It should be a major advantage over phased array ultrasonic equipment requiring a highly trained operator.

- The independent parameters are few in number, which facilitates portability across materials and pipe geometries.

- A small number of good joints are required to determine the dependent parameters.

- The potential exists for a very inexpensive, "standard/non-standard" joint inspection system.

This same approach is being applied to develop the analytical approaches and sensor scanning patterns for inspecting non-EF socket and saddle fusion joints. As in the other tasks, the goal is techniques that require minimal ultrasonic expertise by the operator.

As part of the measurement program, ultrasonic measurements were made on socket tees and socket couplings that were donated to GTI by a utility. These fittings had failed in the field and included a leak through the fusion interface between the socket tee and pipe, a tee with a pipe misaligned at a 5^{o} angle, and a cracked fitting. All of these samples were on orange MDPE 2306 2-inch diameter pipe.

Photograph of tee showing location of leak

Photograph of socket tee and angled pipe

Measurements on good fusion areas of the socket tee joints show strong reflections from the interior pipe wall as would be expected if the joint is not flawed. GTI also detected small amounts of reflection from the heat affected zone (HAZ). The HAZ is created because the heating process changes the PE density and velocity of sound slightly. The size of the HAZ provides information on the quality of the joint: too large and the material has been over heated, too small and the joint will not be strong enough.

Ultrasonic measurements on the leg of the socket tee with a leak show lack of fusion along a narrow channel parallel to the pipe axis. The location of the channel agrees with the position marked as the leak. The waveforms have a peak in amplitude at the time corresponding to the round trip travel time between the sensor and the socket tee/pipe interface. The amount of reflection from the interior pipe wall is reduced as would be expected because wave energy has been lost at the fusion interface.

Measurements were taken around the circumference of the socket tee with the misaligned pipe. The waveforms show reflection from the fusion interface indicating poor fusion quality and a reduction in amplitude from the reflections from the pipe interior surface. There is variation in the time of arrival of the reflections from the inner pipe wall due to the different path lengths caused by the slanted pipe. Similarly, ultrasonic measurements were made on the leg of a tee with a cracked socket tee. Those ultrasonic measurements showed that the crack sloped toward the body of the tee as the crack went deeper into the fitting.

A discrimination model analogous to the butt fusion model was made for the socket fusion tee. Independent parameters were selected and the corresponding dependent parameters determined. This model is easy to adapt to other socket fusion tee sizes and materials. It can also be adapted to socket couplings. So far, differentiation among flaws using the model is good. Two scanning sensor patterns for the cylindrical geometry of the socket fusion tees and coupling are possible. The choice would be made in a follow-on phase of the project based on the ease of developing a mechanical device.

GTI is also using the techniques developed for butt fusion inspection to develop analysis methods and scanning patterns to test the quality of electrofusion (EF) fittings. In previous quarters, GTI identified critical flaw types, purchased pipe and fittings, and had joints with a range of intentional flaws made from 4-inch diameter PE 2406 and EF couplings. Although, differences were detected among some flaw types, the results were not as robust as expected. Work is proceeding to improve the discrimination of good fusions from bad fusions.

Results and Conclusions:

Results from the co-funded project are very promising and are being transferred to this PHMSA project. The co-funded project developed a method of analyzing the ultrasonic waveforms from butt fusion joints that requires only a modest number of independent parameters. Dependent parameters are determined from measurements of good joints. This approach has the advantages of requiring minimal operator expertise and being implementable with inexpensive hardware. GTI is successfully applying these techniques to non-EF socket couplings and socket couplings. The sensor scan patterns for these fusion joints will be straight forward to implement because of the cylindrical geometry of the fittings.

Plans for Future Activity:

- Continue development of techniques to inspect socket tee and socket couplings
- Continue development of classification algorithms for the 4-inch diameter EF coupling joints
- Continue ultrasonic measurements on and analysis of the 4-inch diameter EF saddle joints
- Begin ultrasonic measurements on and analysis of the non-EF socket and saddle fittings