Application of through transmission technique to pipe condition assessment

Vincent Shen, Yuwu Yu, Ankit Vajpayee and Dave Russell
Russell NDE Systems Inc.

1. Summary

Russell NDE Systems Inc.'s (RNSI) proprietary TT (through transmission) is capable of detection and sizing of local and general wall loss in ferromagnetic tubes and pipes. Probes based on this new technique can detect various defects in pipes with thick insulation layer.

2. Introduction

Although we have so many conventional and standard NDE techniques available, there are always demands for developing specialized inspection techniques that meet the unique needs of asset owners. Many NDE techniques are applicable only when the system is shut down so that easy access to the components is available. However, in some applications, the components need to be inspected while still in service. This basically rules out many available NDE techniques and requires special NDE solutions. RNSI is positioned to provide such very specialized NDE techniques.

Recently RNSI developed a through transmission technique intended to inspect a live pipe with thick insulation. The line could have been inspected by conventional NDE techniques, such as RFT. However, the inspection may require a system shutdown in order to have access to pipe ID. TT technique is the recommended inspection technique for in-service pipes with thick insulations. Such technique requires neither system shutdown nor insulation removal.

This paper presents results of experimental study of the TT technique and its feasibility as an effective NDE technique for tubes and pipes.

3. Experiments

As the first step toward development of final TT products, TT technique are lab tested on carbon steel tubes and pipes in order to verify its feasibility as an effective NDE technique.

A 5 -channel TT probe is shown in Figure 1 (to be replaced by a probe w/ hidden exciter/detector coils). The tube with wall thickness of 0.120" has OD grooves simulating short general wall loss, and OD FBHs (flat bottom holes) simulating pitting defects. A R&D prototype 16-channel TT probe was made for 6" pipes with wall thickness of 0.28", as shown in Figure 2. All coils are mounted on an 8" PVC pipe, which simulates 1" thick insulation layers. Simulated defects in the 6" pipe include OD FBHs of varying depth.

TT probes are connected to a Ferroscope 308 instrument and the Ferroscope is connected to a computer for instrument control and data acquisition. Just like any other NDE techniques, instrument settings can be optimized so that high defect sensitivity is achieved for each probe at given pipe/tube wall thickness. The probe can be designed so that half of the pipe circumference is inspected per scan. Two scans cover the entire circumference.

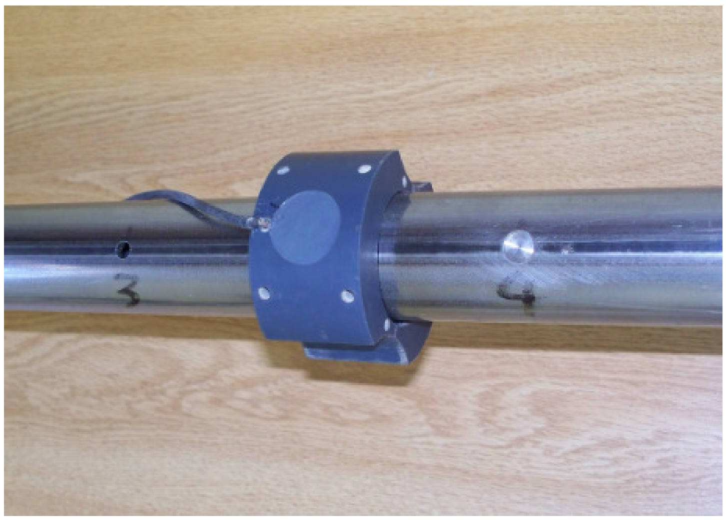

Figure 1. A 5-channel TT probe for testing a ϕ1.75" carbon steel tube.

Figure 2. A 16-channel prototype TT probe for testing 6" carbon steel pipe.

4. Results and Discussion

4.1 TT application to tubes

Both local and general wall losses detected by the 5-channel TT probe are shown in Fig. 3. There is phase separation among these defects at the test frequency of 51 Hz. Signal phase can be used for measuring defect depth. The magnetic permeability variation is not evident at 51 Hz. However, minor wall thickness variations along the tube length due to manufacturing process can be noticed from the data in strip charts. The detector array of the probe covers about 150° out of 360° tube circumference, almost half of the circumference. The detectors have a liftoff of 0.1". In summary, the TT technique can detect and size local and general ID or OD wall loss. It has high sensitivity to minor wall loss when detector liftoff is small. TT probe sensitivity appears compatible with RFT probes and advantageous to ETC in view of probe liftoff effect. Although no experimental data is available yet, the TT probe is expected to maintain high sensitivity at increased liftoff, as shown in the next section, "4.2 TT application to pipes."

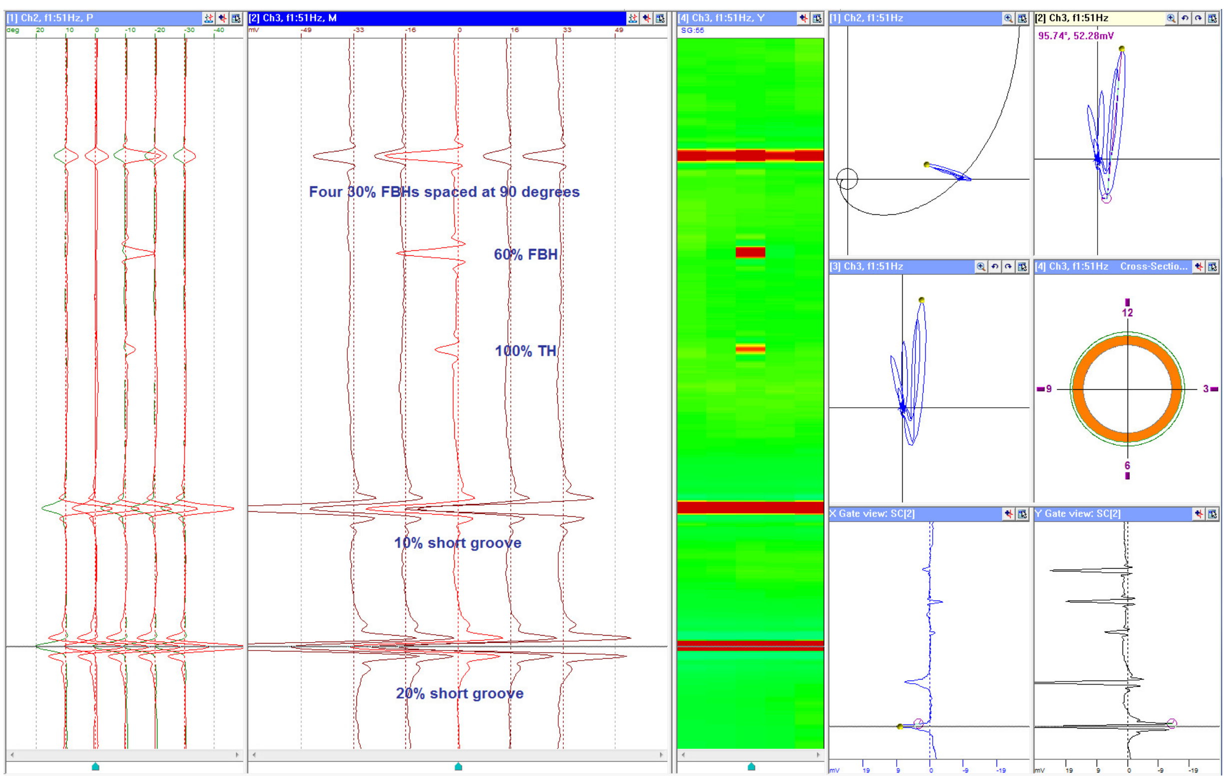

Figure 3. TT signal for machined defects in ϕ1.75" CS tube: strip chart and voltage plane display.

The experimental results from a sample tube illustrate the physical principle underlying the TT technique: magnetic field propagates through the pipe wall twice: from exciter coil to tube ID and then from ID to tube OD. Any wall thickness change (wall loss or gain) in the path of the magnetic field will cause signal change in both amplitude and phase. Detectors in a TT probe can detect the above changes related to wall thickness changes due to manufacturing and natural corrosion. Magnetic field pattern for a TT probe can be more quantitatively illustrated from finite element analysis (FEA) of the TT phenomenon, the work of which will be part of ongoing TT research and development.

4.2 TT application to pipes

TT signal from machined defects in a 6" carbon steel pipe is shown in Fig. 4. At 1" detector liftoff, the probe can detect small through holes (THs – ϕ1/2" and ϕ1/4") and shallow FBHs (20% deep) in addition to large and deep defects. Signal phase spread among these defects is noticed and can be used as a measure of defect depth. Signal magnitude may be used as an indication of volumetric material loss when proper calibration is available.

The pipe clearly shows magnetic permeability variation due to residual stress. The pipe also shows general wall thickness variation along the pipe length probably from manufacturing tolerance. Once again, the TT probe demonstrates its high sensitivity to local and general wall thickness variations, including manufacturing tolerance.

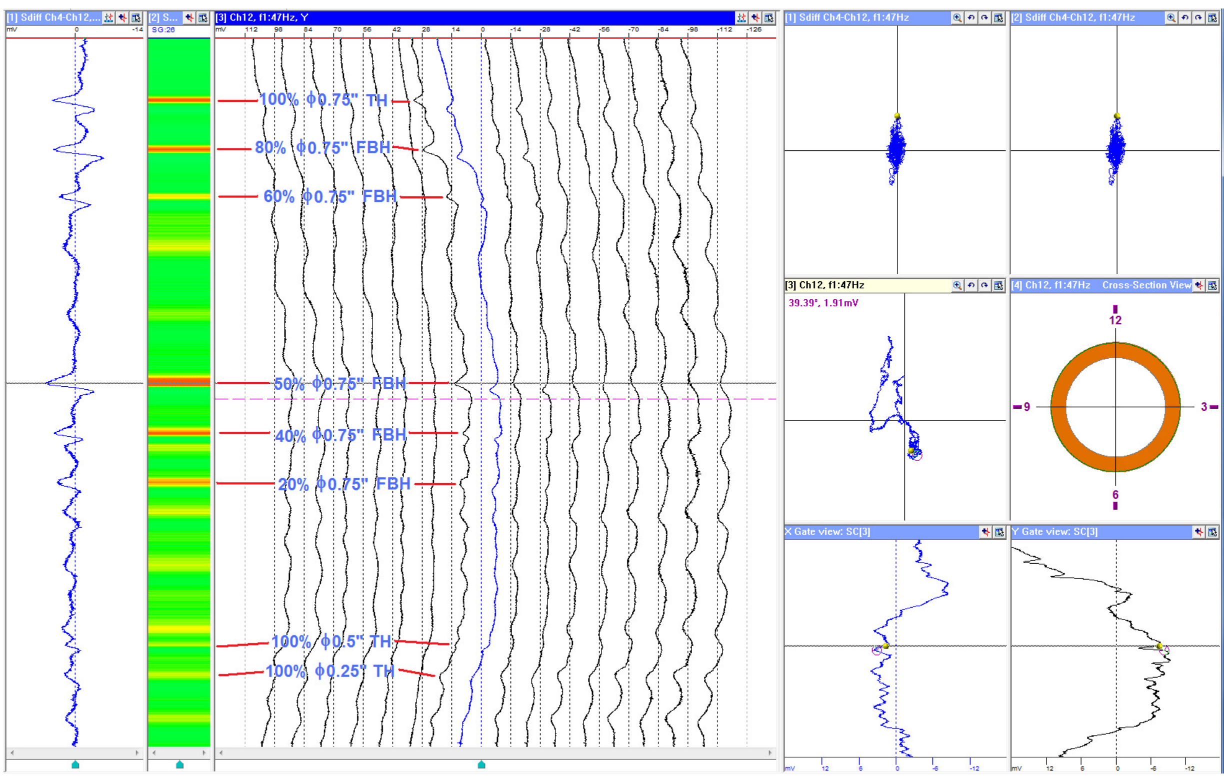

Figure 4. TT signal for machined defects in 6" CS pipe: strip chart and voltage plane display. Probe liftoff is 1".

Lab tests will be followed by field demonstration in order to verify the TT technique. At least two field demonstrations are being planned: one for 10" carbon steel pipes with 2" thick insulation layer; one for 24" cast iron pipes without any insulation.

5. Conclusion

Application of TT technique has been lab demonstrated to be feasible for tube and pipe inspection. The technique shows high sensitivity to local and general wall loss as well as wall thickness variations from manufacturing tolerance.

6. Acknowledgments

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