1.11.20. DEVELOPMENTS IN LONG RANGE ULTRASONIC TESTING FOR PIPES USING GUIDED WAVES FOR ENHANCED DETECTION AND EVALUATION OF METAL LOSS DEFECTS

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Guided wave ultrasonic testing has become an established technology for the rapid screening of pipes and pipelines for in-service degradation, in particular for corrosion. As applications have become more widespread, the expectation of owners and operators of pipes for the performance and the level of information provided by guided wave tests has increased. In particular, there is a need to provide quantitative information so that the output of the tests may be used as an input to fitness for service assessments for pipes and pipelines. This paper describes developments taking place at TWI and its affiliates to enhance the capabilities of long range UT using guided waves in the *Teletest*® system for the benefit of the pipeline and process industries.

A characteristic of systems for monitoring pipes and other constructions for time-dependent degradation using ultrasonic guided waves is a large number of individual transducers required for the transmitting and receiving arrays. This requirement arises from the need to generate specific wave modes, the low frequencies (in ultrasonics terms) which tend to require large arrays and the need to cover large areas of the surface of the component. Consequently, the cost, size and weight of the transducers tend to be large. To address these factors Macro Fiber Composite (MFC) transducers have been developed for guided wave applications. These allow sensor systems to be built with a lower profile, lighter weight, and easier deployment than previous systems. Performance is at least equivalent to, and in some cases is better than existing transducer arrays.

A significant limitation of the use of ultrasonic guided waves for long range pipeline inspection is the amount of attenuation and scattering of the ultrasonic energy caused, predominantly, by external coatings applied to provide protection from corrosion. (Internal coatings or deposits may also produce the same effects.) This progressive dissipation of the transmitted energy leads to shorter test range and may prevent a meaningful test being carried out at all. Further, it reduces the sensitivity of the test for detection of small defects because the background base line 'noise' is significantly increased. This factor is the greatest and most intractable problem limiting the further development of guided wave testing for coated pipelines. Mathematical and numerical finite element models have been developed to describe the physical distribution of the wave across the thickness for a plain and coated-plates at different frequencies. Experimental results were in good agreement with the prediction of the model. These results have been used to select enhanced test parameters which enable the test range to be increased on coated pipes.

The additional information available for the analysis of guided wave signals resulting from the use of multi-channel array transducers allows post-processing of the received signals to produce area maps of the responses, enabling the technician to gain a better understanding of the sources of these responses and to provide a more accurate interpretation of the condition of the pipe under examination.

Using the guided wave tool as a phased array by applying appropriate phase delays/amplitude factors to each element allows a physical focus of the ultrasonic energy to be produced. The focusing technique allows a concentration of energy in the pipe wall at a specific angle for a given distance from the transducer. Numerical modelling was used to investigate the properties of the focus under different conditions. This enabled a semi-quantitative classification scheme to be developed based on both response amplitude and dimensional information from the focused test Application of this classification to the results from field tests on a variety of known defects gave an accurate prediction of relative defect severity, thereby providing pipeline operators with the information to make confident decisions about the continuing fitness for service of their pipelines.

Recent advancements within TWI's Core Research Programme have shown that it is possible to use the output from the guided wave test to determine the size of defects detected, so that such information may be input to standard methods of determining fitness for service. Figure 1 shows the accuracy of experimental results.

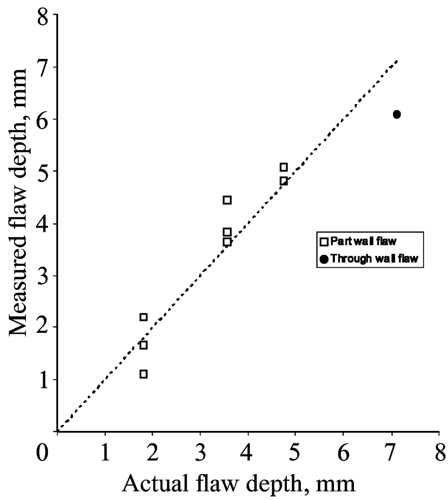

Fig. 1. Comparison of actual vs. measured flaw depth