Cracking the corrosion code

PPSA members THOMAS BEUKER of the ROSEN Technology and Research Center (RTRC) in Germany, BRYCE BROWN of ROSEN USA and MOHAMMED JAARAH of ROSEN Saudi Arabia, describe the results of a survey into the use of Electro-Magnetic Accoustic Transducer technology to help combat stress corrosion cracking.

Recognised as a major integrity threat since the 1970s, the phenomenon of Stress Corrosion Cracking (SCC) forms an important part of integrity management programmes worldwide. Whereas SCC has conventionally been detected with liquid coupled ultrasonic technology, advances made in recent years in ultrasonic systems based on an Electro-Magnetic Acoustic Transducer (EMAT) mean that this technology now has the potential to be established as a preferable alternative. Dispensing entirely with the need for a liquid coupling means EMAT is a highly cost-effective inspection method for gas pipelines in particular. This article presents a summary of the field tests conducted to establish the suitability of high-resolution EMAT technology in assessing SCC and similar threats in pipelines.

Test approach and nature of EMAT

The process of qualifying an inspection technology for a specific type of defect is typically based on three criteria: sensitivity to sub-critical flaws (refer to Figure 1), depth and length sizing accuracy, and defect characterisation capability. ROSEN used these criteria in a test series conducted to initiate the qualification process for EMAT as an inspection technology suitable for crack detection and assessment in gas pipelines.

Inspection tools incorporating EMAT technology usually consist of two measurement units to achieve complete coverage of the internal pipeline surface and a sufficient number of sensors to support high-resolution analysis of cracks and crack colonies (see Figure 2). Since EMAT-based inspection tools provide a detailed view of the dimensions and distribution of the detected anomalies both around the circumference and along the pipeline axis, they greatly facilitate the subsequent evaluation process.

Sensitivity

The sensitivity threshold for individual cracks accepted throughout the pipeline industry is 30 mm (1.18") in length and 1 mm (0.039") in depth. A combination of artificial and natural crack-like indications was studied following inspection with the EMAT tool. The minimum dimension detected with EMAT technology was found to be 20 mm (0.79") in length and 0.65 mm (0.026") in depth with a probability of detection (POD) of 92 percent. The analysis conducted proves conclusively that the sensitivity of EMAT is comparable to more established inspection technologies and notably that the target for detecting subcritical flaws is met.

Depth and length sizing capabilities

A depth-sizing model based on electromagnetic acoustic inspection was developed by ROSEN as part of the test project. This model incorporated a quantitative multi-parameter process whereby various parameters derived from the datasets, e.g. amplitude and frequency content of the different wave modes, were correlated to the depth of a crack indication. This model was then applied to artificial crack-like flaws as well as natural cracks and SCC. The accuracy levels achieved in these tests was found to be +/- 0.64 mm (0.025") with a confidence level of 90 percent. This result is comparable to that of widely accepted crack evaluation processes based on other inspection technologies. Beside the depth of a crack, its length is an essential parameter for integrity assessment. A threshold criterion is used on the signal amplitude to determine the length of a flaw. Sizing results for artificial defects of different length are shown below; even for short defects, a stable length sizing can be achieved. However, due to the physical size of the applied shear wave, short features result in a slightly larger scattering of the length measurement.

Defect characterisation and coating assessment

Over and above the criteria of sensitivity, depth and length sizing, the ROSEN

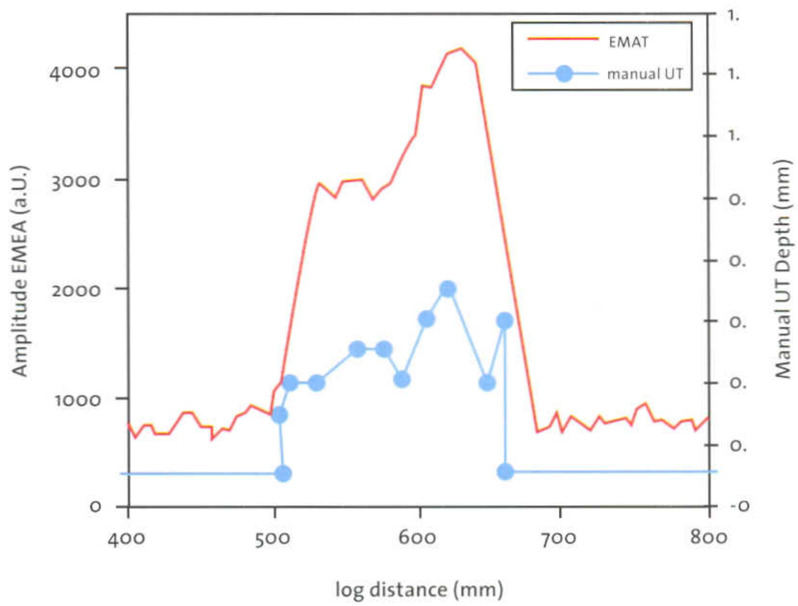

Figure 1: Sensitivity of EMAT technology. The graph correlates a manual UT depth profile with the profile of the integrated EMAT amplitude. This example is taken from an excavation campaign following an EMAT inspection survey.

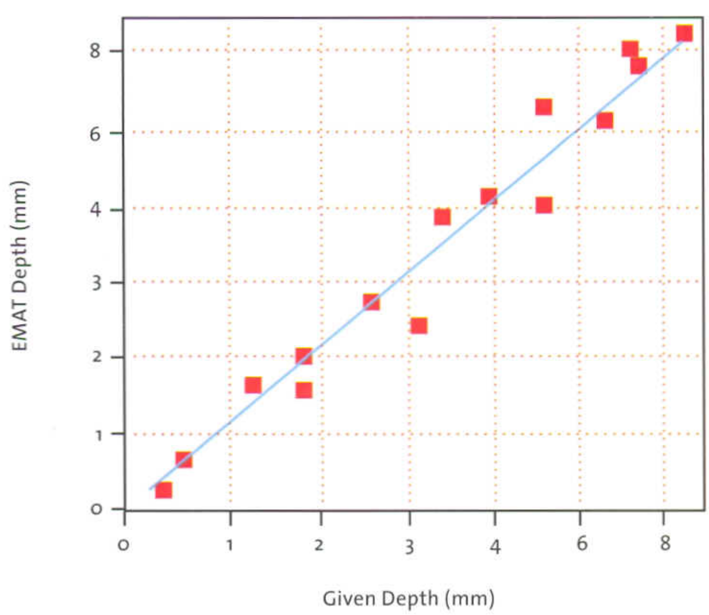

Figure 2: Application of the EMAT sizing to a population of artificial flaws in a 16" test joint.

test programme also investigated the ability of EMAT to characterise different types of defects. Since both risk assessment and corrective measures directly depend on the types of defects present in a pipeline, their reliable identification plays a vital part in asset integrity management. Adopting a multi-parameter correlation model (MPC) taking into account the distribution of the responses to a particular feature type, EMAT was applied to a sample set of 315 crack-type and non-crack-type defects. Field verification subsequently revealed that the probability of identification (POI) for these flaws was as high as 91 percent.

Apart from direct defect characterisation, the ability to identify pipeline-coating types is helpful, since some coating types are more prone to stress corrosion cracking (SCC) than others. Additional information on the condition of the coating is also directly relevant to crack-type defects, since coating disbondment is demonstrably a precursor of SCC. The tests revealed that the EMAT inspection system is capable of providing dependable information on both coating type and condition. Identified on the basis of changes in transmission amplitude received through multiple signal channels, the precise position and even lateral dimensions of disbonded areas are reported.

Conclusion

For the purpose of initiating the qualification process for EMAT as an adequate inspection method for crack detection in gas pipelines, ROSEN conducted a series of empirical tests. These tests confirmed the high sensitivity of EMAT even to sub-critical flaws and its excellent depth and length sizing capabilities, which are on a par with well-established technologies. In addition, EMAT accurately characterised defects and furnished precise and dependable information on the type and condition of pipeline coating encountered. In sum, the sensitivity and accuracy of EMAT inspection systems are the basis for a subsequent application of integrity management programs. This has been described as exemplary using the API 579 assessment standard. ■