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Shear Wave EMAT Thickness Measurements of Low Carbon Steel at 450˚C without Cooling

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Ensuring reliability of components operating at high temperature, such as pipelines and boilers, within a variety of industries is of importance in the asset management process, and is implemented via regular inspections and condition monitoring. Performing online inspections without the need for plant shutdown is highly desirable. Development of portable or permanently installed high temperature ultrasonic sensors without sample surface preparation remains a key challenge. There are examples of high temperature piezoelectric sensors operating without cooling, but these usually require welding or brazing. Actively cooled electromagnetic acoustic transducers (EMATs) have previously been used for thickness measurements and defect detection to over 1000 ˚C. High temperature EMAT operation requires active cooling for permanent magnet EMATs [1] or a large electromagnet [2], limiting their use in some industrial settings. Low carbon steel pipelines operating at elevated temperatures often develop a magnetostrictive oxide surface coating (magnetite), which greatly improves EMAT efficiency below the Curie point of the magnetite (~560 ˚C), and we are able to take advantage of this if we can indefinitely operate an EMAT at elevated temperature. In this work, a high temperature shear wave EMAT utilizing a proprietary high field, high Curie point, permanent magnet has been developed to generate ultrasonic thickness measurements on magnetite coated steel at temperatures up to 450 ˚C, without active cooling. Exploiting the high efficiency possible on magnetite coated surfaces, relatively high signal-to-noise ratios, in the region of 25 dB for single shot data, have been measured at 450 ˚C using this technique, despite increased ultrasound attenuation and reduced magnet field strength at elevated temperatures.

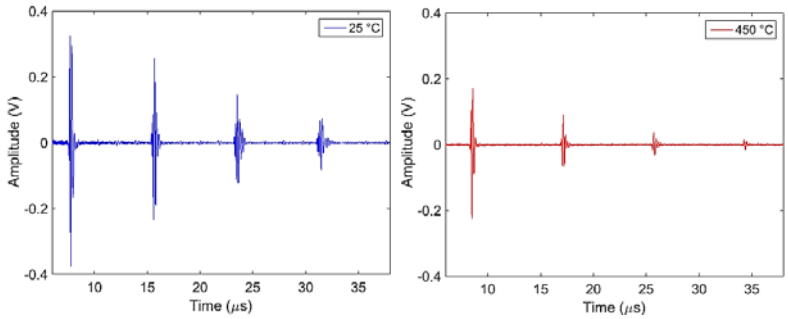

Figure 1. Ultrasonic A-scans with four consecutive back-wall echoes on a magnetite coated 12 mm thick steel sample at 25 ˚C (left) and 450 ˚C (right) with 512 averages

Acknowledgement:

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References:

1. Burrows, Susan E., Y. Fan, and S. Dixon. "High temperature thickness measurements of stainless steel and low carbon steel using electromagnetic acoustic transducers." *NDT & E International* 68 (2014): 73-77.
2. Hernandez-Valle, Francisco, and S. Dixon. "Pulsed electromagnet EMAT for ultrasonic measurements at elevated temperatures." *Insight-Non-Destructive Testing and Condition Monitoring* 53.2 (2011): 96-99.