Inspection of As-Cast Steel Slabs Using EMAT Arrays

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1. Introduction

Online non-destructive assessment of internal slab quality is not currently possible, with internal defects only identified after casting by sulphur printing [1]. This work describes preliminary efforts to develop an industrially robust system for detecting internal vertical cracking and other defects.

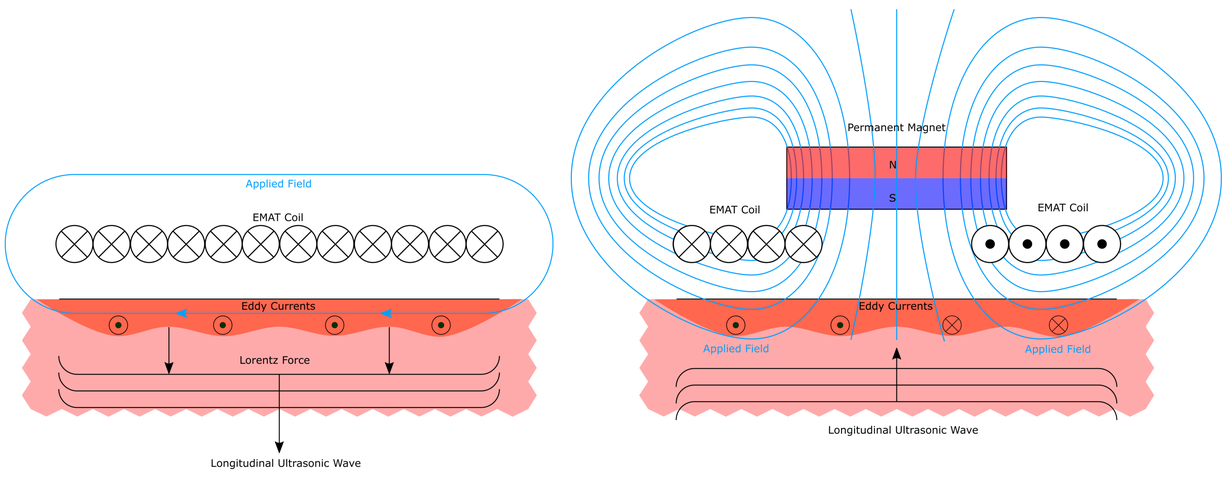

Figure 1: Schematic diagrams of a self-field EMAT generator (left) and detection EMAT (right).

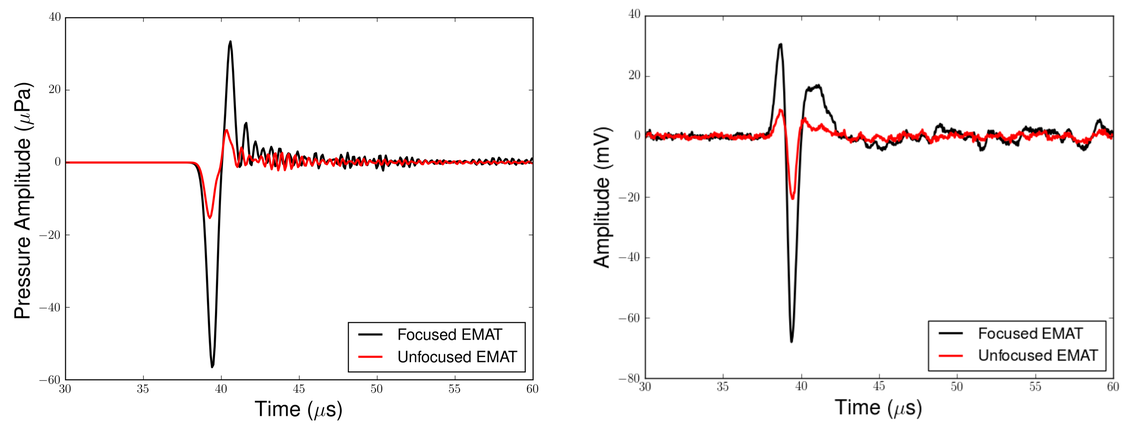

Figure 2: Simulated (left) and experimental (right) data demonstrating signal enhancement from phased array generation using EMATs.

Electromagnetic acoustic transducers (EMATs) are industrially-robust ultrasound sensors that have been demonstrated operating at casting temperatures [2, 3]. EMATs suffer from poor efficiency, and so ultrasonic inspection of coarse-grained cast steel at high temperatures is challenging. In this work, phased EMAT arrays have been developed to improve the signal-to-noise ratio of transmitted ultrasound pulses.

2. Internal Defect Detection

A 9 cm thick steel block with a 6 mm diameter side-drilled hole was used to develop an EMAT scanning system. An EMAT array was used to transmit ultrasound into the block and a detection EMAT was placed opposite. The generator-detector pair was scanned along the length of the block to produce an ultrasound B scan image.

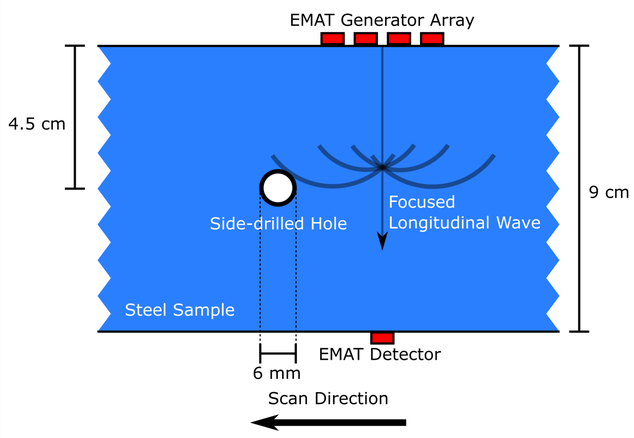

Figure 3: Schematic diagram of scanning experiment on a test block used to demonstrate the expected signal variation in a case where the defect geometry and position are well-known.

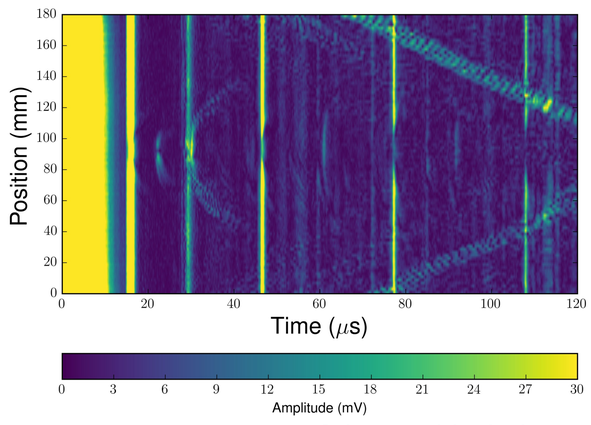

Figure 4: B scan image of the test block showing a defect indication at 90 mm.

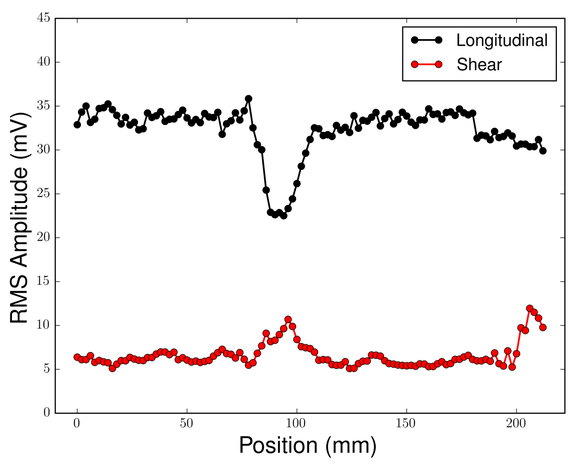

Figure 5: Amplitude variation of transmitted longitudinal and shear modes in the B scan.

3. As-Cast Cracked Samples

B scan data were recorded for 22.5 cm thick as-cast slab samples from Tata Steel's IJmuiden casting plant. One sample has been cut from a slab that is presumed to be defect-free, and two samples were cut from a severely defective slab showing visible vertical cracking. The cracks' orientation and rough surfaces prevent clean specular scattering of the incident ultrasound pulses. Instead, a defect's presence can be indicated by a drop in the transmitted signal amplitude and an increase in spurious signals corresponding to scattered longitudinal waves and mode-converted shear waves.

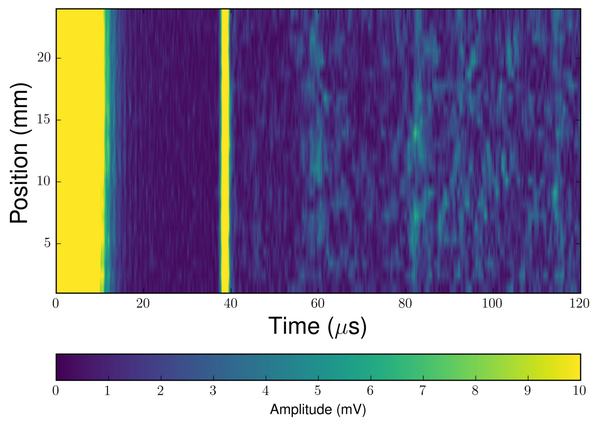

Figure 6: B scan image from a non-defective cast sample.

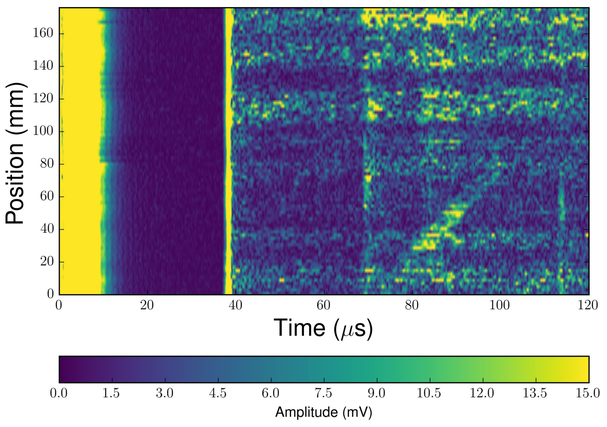

Figure 7: B scan image from a cast sample cut from a severely cracked slab.

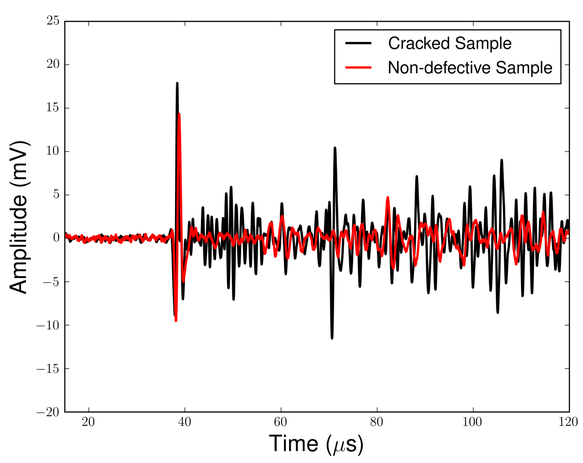

Figure 8: A comparison of amplitude data from the non defective sample from fig. 6. and from a defective region of fig. 7.

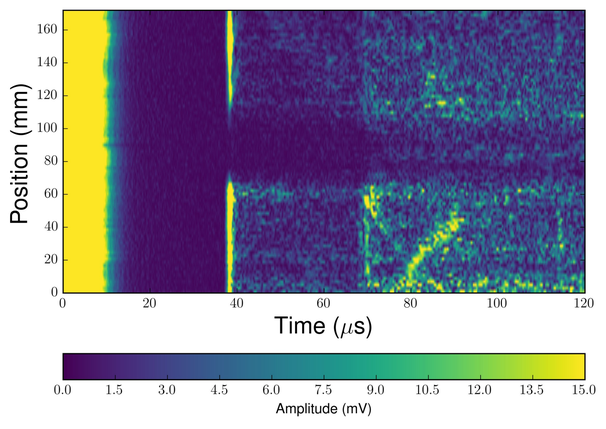

Figure 9: B scan image from a cast sample with a visible crack through the full cast thickness.

4. References

- [1] J. Sirgo *et al.*, Industry Applications Conference, 2006 41st IAS Annual Meeting. Conference Record of the IEEE **1**, 516 (2006).
- [2] I. Baillie, P. Griffith, and S. Dixon, Insight **49**, 87 (2007).
- [3] Y. Izuka and Y. Awajiya, Journal of Physics: Conference Series **520**, 012011 (2014).
- [4] C. Holmes, B. Drinkwater, and P. Wilcox, NDT&E Int. **38**, 701 (2005).