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Application of the Guided Wave Technique to the Heat Exchanger Tube in NPP

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1. Introduction

The heat exchanger tube is examined by the method of eddy current test(ECT) to identify the integrity of the nuclear power plant. Because ECT probe is moved through the tube inside to identify flaws, the ECT probe should be exchanged periodically due to the wear of probe surface in order to remove the noise form the ECT signal. Moreover, it is impossible to examine the tube by ECT method because the ECT probe can not move through the inside due to the deformation such as dent. Recently, the theory of guided wave was established and the equipment applying the theory has been actively developed so as to overcome the limitation of ECT method for the tube inspection of heater exchanger in nuclear power plant.

The object of this study is to know the application of the guided wave technique to heat exchanger tube in NPP.

2. Methods and Results

2.1 Application Technology and Instruments

Guided waves refer to elastic waves in ultrasonic and sonic frequencies that propagate in a bounded medium (such as pipe, plate, rod and so on) parallel to the plane of its boundary. The waves termed "guided" because it travels along the medium guided by the geometric boundaries of the wave. The velocity of the guided waves varies significantly with wave frequency and the geometry of the medium.

The magnetostrictive sensor developed by the Southwest Research Institute is a sensor that generates and detects guided waves electromagnetically in the material under non-destructive testing.

The magnetostrictive sensor is directly operable on structure made of ferrous materials and of non-ferrous materials by bounding a thin nickel to the structure under testing.

A schematic diagram of the magnetostrictive sensor and associated instruments (MsSR 2020D) for the generation and detection of guided waves is illustrated in Figure 1. The sensor is configured to apply a time varying magnetic field to the structure be under test and to pick up magnetic induction changes in the material caused by the guided wave.

2.2 Torsional Guided Wave Mode

The guided wave mode is controlled by the relative alignment between the direct current bias magnetic field and the time varying magnetic field produced by the magnetostrictive sensor.

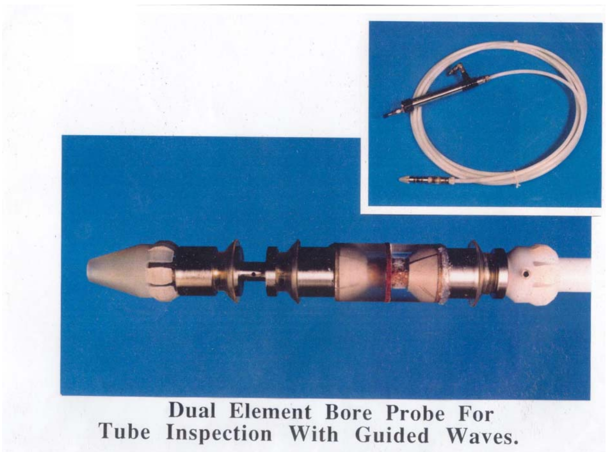

Figure1 Guided Wave Probe to Inspect of S/G Tube in NPP

For torsional guided wave mode in tube, the alignment is perpendicular. The guided wave propagate in the direction parallel to the direction of time varying magnetic field produced by the magnetostrictive sensor

The fundamental torsional guided wave mode is not dispersed and does not interact with liquid inside the tube. The disadvantage of the torsional guided wave magnetostrictive sensor is the requirement for direct physical access to the tube surface for bonding of the thin ferromagnetic layer. [1]

The velocity of torsional guided wave is 3,100 m/s in heat exchanger tube material.

2.3 Mode Analysis

To show the magnetostrictive sensor system (MsSR 2020) capability, the artificial flaws placed at the twelve locations along the heat exchanger tube in Figure 2.

The tube made of Titanium Gr. 2 was 24 mm outside diameter with 0.7 mm wall and was 3 m long.

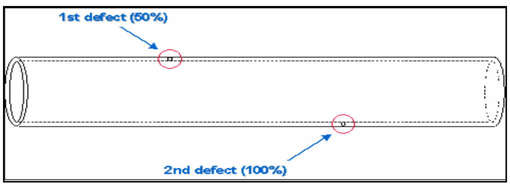

Figure 2. Artificial Flawed Heat exchanger tube

The data were acquired with the magnetostrictive sensor positioned at the tube left end in figure 2.

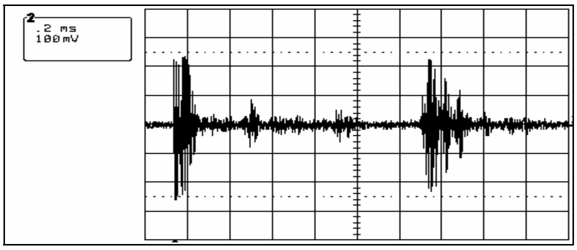

Figure 3. 128 kHz Torsional Mode guided wave data obtained from heat exchanger tube specimen

The data in figure 3 demonstrate the guided wave's ability to inspect the entire heat exchanger tube circumference from a single sensor location.

The guided waves are very useful for inspecting heat exchanger tube for various shape and depth flaws.

3. Conclusion

The ECT method for heat exchanger tube inspection is very tedious work and takes about four weeks during the overhaul in NPP. The cost and time of heat exchanger tube inspection is continuously required to be decreased without reducing integrity of the heat exchanger tube.

Guided wave technique using magnetostrictive sensor is possible quickly and economically for inspecting heat exchanger tube with 18 m long for defects from a single test location. But this experiment was conducted the outer of the heat exchanger tube. In site use, it is recommended that in-core type magnetostrictive sensor and examination procedure be developed to inspect the heat exchanger tube.

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