Differential Hall-sensor Pulsed Eddy Current Probe for the Detection of Wall thinning in an Insulated Stainless Steel Pipe

D. G. Park [a*], Chandra. S. Angani [a,b], C. G. Kim [b], Y. M. Cheong [a]
[a]*Nuclear Materials Research Division, Korea Atomic Energy Research Institue., Daejeon, south korea, 305-600*
[b]*Materials science and engineering Dept., Chungnam National Universit, Daejeon, south korea, 305-764*
[*]*Corresponding author: dgpark@kaeri.re.kr*

1. Introduction

The local wall thinning is one of the most important factors to limit the life-extension of large structures, such as the pipe lines in the NPPs [1]. The pipelines are covered with a thermal insulator for low thermal loss. The PEC testing is the promising technological approach to the NDT, and it has been principally developed for the measurement of surface flaws, subsurface flaws and corrosion [2]. In the pulsed eddy current (PEC) technique, the excitation coil is driven by repeated pulses. According to the skin - depth relationship multiple frequency components penetrate to different depths, hence the PEC technique has the potential for bringing up deeper information about the tested sample. Because of the potential advantages of the PEC, prevalent investigations on this technique have been done [3]. In the present study a differential probe which is used in the Pulsed Eddy Current (PEC) system has been fabricated for the detection of wall thinning of insulated pipelines in a nuclear power plant (NPP). This technique can be used as a potential tool to detect the corrosion or the wall thinning of the pipelines without removing the insulation.

2. The PEC system

The PEC system consists of a wave form generator, a pulse amplifier, a differential probe having excitation coil with two hall sensors, a differential amplifier, a digital oscilloscope and a computer with data acquisition. The rectangular wave form is fed to pulse amplifier to drive the excitation coil. The net field which is the sum of the incident field and the field reflected due to the induced eddy currents can be detected by the two hall-sensors sensors. For the data acquisition, the probe output is interfaced to the computer through a 10MHz analog to digital conversion PCI card.

2.1 Differential probe design

The PEC probe basically consists of an exciting coil and a detecting sensor. The detecting sensor in the probe detects not only the magnetic fields of the induced eddy currents, but also field due to excitation coil, usually the excitation fields are very large, hence the small perturbed eddy current fields due to flaws and geometric changes may easily be masked. The effect of excitation fields can be reduced by differential probes [4]. Hence a differential probe has been proposed in this study, the probe consists of an excitation copper coil is wound on a cylindrical ferrite core, two hall-sensors (H1 and H2) are placed at the inner side top and bottom axial center of the excitation probe as shown in Fig. 1. The calibration sample is a stainless steel of thickness variation from 1mm to 5mm and a plastic plate is attached on the flat side of the sample to simulate the thermal insulation of the pipelines.

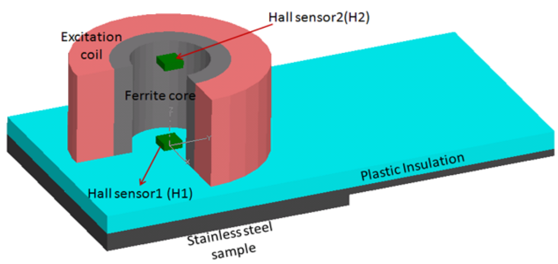

Fig. 1. Design of the differential PEC probe and tested sample.

3. Experimental results

The exciting coil is driven by a pulse having 500μs width and 500mA current. When we bring the probe proximity to conducting plate, the steep exciting pulse induces eddy currents and its associated magnetic field dissipates exponentially to approach its steady state. The induced eddy currents flow in the opposite direction to the currents which are flowing in exciting coil, hence when the probe is placed on the conducting plate, the detected field rises slowly to the maximum peak value [5]. When the probe is placed on the 3mm or 5mm thicknesses of the sample the responses of individual hall-sensors as well as the differential signal (V_{diff} = H2 – H1) are shown in Fig. 2. The detected pulse response from the H1 rises slower than the H2 because of the effect of the induced eddy currents are more on H1 than H2. The shape of the detected differential pulse is of interest to interpret the results;

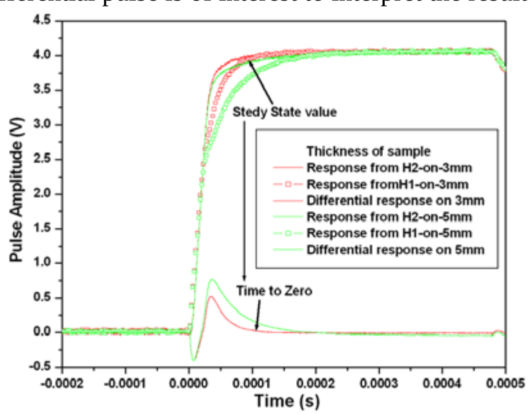

Fig. 2. Response from the individual hall sensors H1 and H2 in the probe and differential signal when the probe is placed

on 3mm and 5mm of the sample thickness.

the important characteristics of the pulse such as the peak value is utilized to investigate the variation in the thickness of the sample. The area under the differential

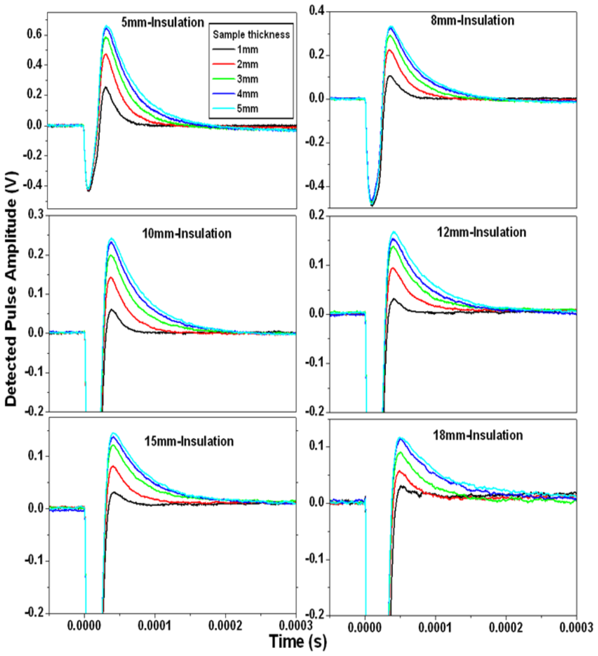

Fig. 3. The differential PEC probe response on the tested sample at different thickness of insulation.

pulse depends on time to zero (when the two hall sensor responses reach their steady value then differential signal is zero). As shown in the Fig. 2, the responses from the H1 and H2 on the 5mm thick sample raise more slowly than the response from the 3mm sample, and hence there is increase in the detected differential pulse peak value as well as the area of the pulse. Figure 3 shows the results which are measured at 5, 8, 10, 12, 15, 18mm of insulations on the tested sample. As the thickness of the sample increases the peak value of the pulse is increased. The detected pulse amplitude versus sample thickness at different thickness of insulation results which are obtained from Fig. 3 are shown in Fig. 4.

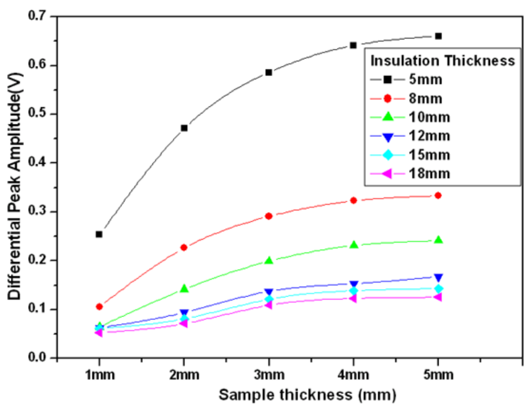

Fig. 4. The peak value of the detected pulse as a function of sample thickness at different insulation lift-off.

3. Conclusions

A differential probe which is used in PEC system has been fabricated for the detection of wall thinning in an insulated stainless steel pipe. The wall thinning of calibration sample under different thickness of insulation has been investigated using the discriminating feature of the detected pulse which is the pulse amplitude. The results show the PEC has the potential to detect the wall thinning in the insulated pipelines.

Acknowledgement

This work was developed by the research project on the development of advanced diagnostic technique for micro-material degradation and damages, as a part of long-term nuclear R&D program supported by the ministry of education science and technology (MEST), Korea.

REFERENCES

[1] J. Woon jun, J. Hwang, Quantitative Nondestructive Evaluation of the rack on the Austenite Stainless Steel using the Induced eddy current and hall sensor array Instrumentation and measurement technology Conf. Poland IMTC, May. 2007.
[2] J. C. Mouldar, J. A. Bieber, Scanning Pulsed Eddy Current Instrument for Non Destructive inspection of aging of aircraft, Proc. SPIE, Vol.2945, pp. 2-13. 1996..
[3] M. A. Robers, R. Scottini, Pulsed eddy current in corrosion detection, NDT.net The e-Journal of Nondest. Testing, Vol.7, Oct. 2002.
[4] Y. K. Shin, D. M. Choi, Signal characteristics of differential-pulsed eddy current sensors in the evaluation of plate thickness, NDT&E Int., Vol. 42 pp. 215-221, 2009.
[5] C. Chi. Tai, characterization of coatings on magnetic material using the swept frequency eddy current method, , Review of science instruments, Vol. 67,pp. 3965, 1996.