Detection of the sub surface Cracks in a Stainless Steel Plate using Pulsed Eddy Current

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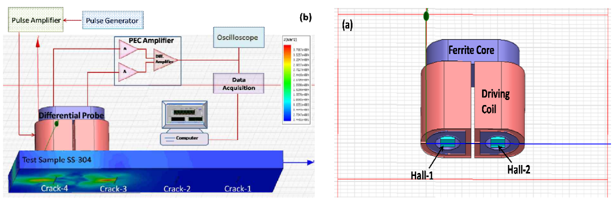
1. Introduction

The PEC testing is one of the most effective methods, which has been demonstrated to be capable of tackling different inspection tasks, such as sub-surface defect detection in complex structures [1-3]. Unlike conventional ECT the PEC uses pulse of electric current through the excitation coil. Because of many advantages of PEC over the conventional eddy current method, such as low power consumption due to the short pulse excitation, this method more is economical than other NDT methods. Because of broad band nature a pulse PEC has the capability to penetrate different depths in a conductive material and provides the depth information of the defects [4, 5]. In the present study a double-D differential probe has been developed in order to detect the subsurface defects in the stainless plate [6]. The double-D probe has self difference characteristics; hence reference signal is no longer needed. The paper is arranged as follows; firstly the experimental setup, probe design and testing sample were given in section 2. The experimental results with scanning of test specimen and signal processing were included in section 3. Finally, section 4 followed by conclusions.

2. Experimental Setup and PEC Probe

The PEC system has an arbitrary waveform generator, a power amplifier to amplify the pulse and drive the excitation coil in the PEC probe, a differential PEC amplifier, and a data acquisition system as shown in Figure.1 To simulate the cracks in steel pipe, small EDM cracks having the width of 0.2mm and length of 20mm at different depths 1, 1.5, 2, 2.5mm (crack1, 2, 3, 4 respectively) from the sample surface (probe position) were machined one side of the sample. During the PEC measurements the probe has been place on the opposite side of crack surface to detect the sub-surface defects in the tested sample.



3. Results and Feature Extraction

As shown in Figure.1 the PEC probe has two excitation coils are wounded opposite to each other on a ferrite core and are connected electrically in series. The excitation coil has been driven by a 2A, 2.5ms pulse with 50Hz repetition rate. When the probe is driven by a pulse, field detected by the Hall-sensor 1 (Hall-1) and the Hall-sensor 2 (Hall-2) and the difference signal were shown in Figure. 2, here the response from both sensors is almost same.

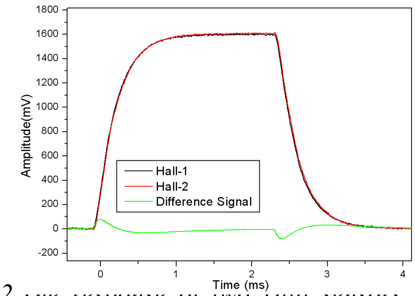


Figure 2.The response of two Hall sensors and their corresponding difference pulse when the probe is excited by a pulse width of 2.5 ms

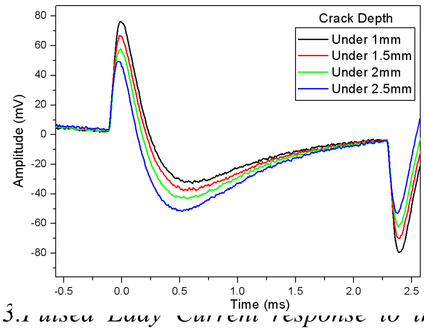


Figure 3.Pulsed Eddy Current response to the crack depending on the depth

As the sensors detects the sum of excitation field and induced eddy current filed, technically we can understand that, because of the differential arrangement of two sensors the excitation field is nullified, hence only the induced eddy current fields were detected. If the probe placed on the sample in such a position that one of the Hall-sensor comes above the crack and other sensor on defect free position. Then the detected differential pulse is of interest to interpret the results, the important characteristic is the peak value of the pulse. As shown in figure. 3, the detected pulse amplitude is decreased with increasing the crack depth, because if the crack is nearer to the surface of the sample (higher volume of crack or higher metal loss) that means there is large difference of conductive area present under the two Hall-sensors hence the differential pulse amplitude is high, but if the crack is far from the sensor (lower volume of crack or lower metal loss) then the conductive area present under the two sensors is almost same so the difference pulse is peak is less. There are several signal processing methods can be applied to analysis the PEC signal [7], here in the present study the Fourier transform of the pulse has been devised. The results shows that the FFT of the PEC response for the crack nearer to the surface has the small value of lower frequency component but dominates in the higher frequency region, and response for the crack at larger depth has dominant response in lower frequency range.

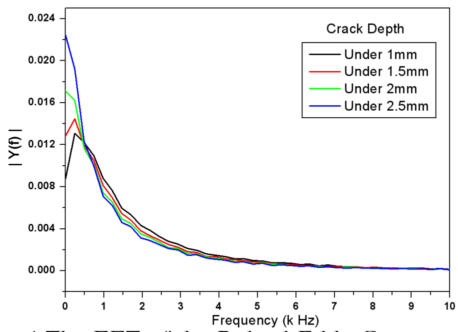
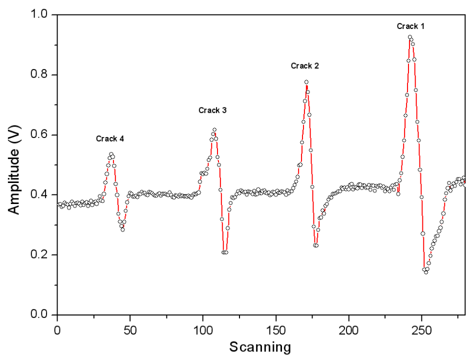


Figure 4.The FFT of the Pulsed Eddy Current response to the crack depending on the depth

Since the detected pulse consists of a broad frequency spectrum, it contains the important depth information, physically, the field is weakened as it travels deeper in to the highly dispersive material [8]. In other way because of broad band nature of the PEC, the greater amount frequencies in a pulse return the affluent information at many depths of test sample; according to skin depth relation lower frequency components can penetrate more depth in to the sample, the test sample acts like a frequency filter [9]. Figure 5 shows the scanning results of tested sample, during the scan the probe has been placed on the defect free side of the sample, the measurement feature for the scanning test is the peak amplitude of the detected pulse



4. Conclusions

The non-destructive evaluation (NDE) method to detect the sub surface crack using PEC under the thick stainless plate has been devised. A differential probe which is used in PEC system has been fabricated for the detection of sub-surface cracks in stainless steel type SS304 pipe. The EDM notch of length 25, width 0.2 and depth 1 to 2.5 mm from the probe surface were detected using specially designed double-D differential PEC probe. The amplitude of the signal induced by crack is decreasing as the distance from the probe to crack increases. The time domain features of detected pulse such as pulse amplitude was used to detect the cracks. The signal processing techniques such as Fourier transform for the detected pulse was derived to analyze and understand the PEC results. These parameters are well described the sub-surface crack. The scanning results were successfully displayed on the computer monitor. The results show the proposed differential PEC technique has the potential to detect the minute subsurface cracks in pipelines.

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