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Simulation Study on the Effect of Crack Width on ECT Signal

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Abstract

Eddy current testing (ECT) is a widely used non-destructive inspection technique on pipeline. To develop a precise inspection method, the variations of the amplitude and phase of ECT signal should be investigated taking into account crack width. This paper describes 2D axial symmetric numerical analysis of ECT. The stimulation results show when the width of rectangular slot is constant, signal phase has obvious rules related to slot depth. But The ECT signals are seriously influenced by the slot width under the conditions of fixed slot depth. The effect of crack width and depth of pipeline is clarified. Understanding of respective signal characteristics would be useful for more reliable inspection.

Key words: defect width; phase; finite element analysis (FEA); eddy current testing (ECT)

1. Introduction

Eddy current testing (ECT) has become the most widely applied nondestructive inspection method for steam generator heat exchange tubes in nuclear power plant, the wheel hub of aircraft and so on [1-3]. The results show the phase of ECT signals has a significant reduction with the defect depth in aluminum, stainless steel pipe [4]. However, the defects of actual work piece vary widely, which are certainly

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different in depth and width of defect. Therefore, it is noteworthy that whether the crack width has influences on the amplitude or phase of detection signals and interferes with people distinguishing between internal and external wall defects.

At present, the quantitative evaluations of crack depth have been extensive studied with ECT method [5-6]. G.Cao [7] explained the diameter changes of via hole would cause the signal phase differences, amplitude and phase can be combined to reasonable evaluate the defect size, but they scarcely discuss the impact of signal on the change of crack width. Z.H.Huang [8] preliminarily simulated and analyzed the signal changes of steel pipeline defects caused by the depth and width, based on which the eddy current probe has been optimized. However, the results were still not perfect because the range of crack sizes is too small.

In this paper the Finite element analysis (FEA) model of inserted ECT is established. The defects of cracks are characterizes with rectangular slot, the impedance changes of eddy current coil are calculated. The phase and amplitude of signals changing with the crack depth are analyzed. It is expected to be helpful for ECT in the engineering practice.

2. ECT Model

Fig.1 shows the ECT model with inserted eddy current probe for stainless steel (Inconel690) pipe. Considering the symmetry of the model, three-dimensional solid model is replaced by the 2D axial symmetric model in this paper. The inside diameter D of tested pipeline is 20mm，the wall thicknesses H is 2 mm and the length L is 70 mm. The inside diameter d_1 of eddy current coil is 16 mm，the outside diameter d_2 of coil is 19 mm，the gap d between two coils is 1.5 mm. In order to use mesh flexibly, reduce the computation, save computing time and ensure the accuracy of simulation, a cylindrical ring of air is set in the free zone outside the pipeline model. The air layer thickness is 8mm. The rectangular slot width c is 0.02 ~ 20 mm and the depth h_1 is 0.2 ~ 1.7 mm. The relative permeability of tested pipeline is 1 and the conductivity is 1.03×10^6 S/m； The relative permeability of eddy current coil is 1 and the conductivity is 0.58×10^8 S/m. The eddy current coil turns N is 100 turns.

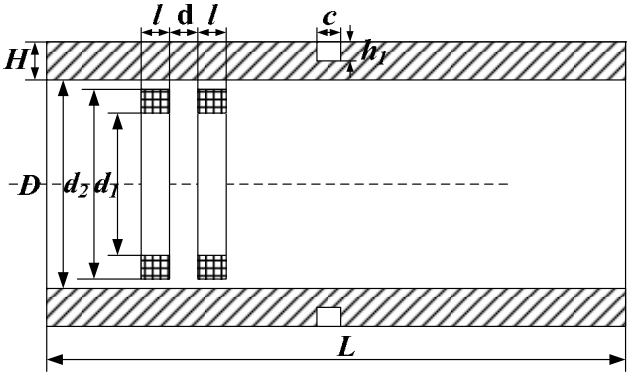

Fig. 1. FEA model