STUDY OF THE INFLUENCE OF CONDUCTIVE DEFECT CHARACTERISTICS ON EDDY CURRENT DIFFERENTIAL PROBE SIGNAL

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Abstract *– Nowadays, numerical modelling has become an interesting tool for determining impedance variations due to various conductive flaws in eddy current non-destructive evaluation systems. These kinds of defects, rarely treated in the published works, are taken into consideration in the modelling while introducing them as electrically conductive volumes with a finite electric resistivity. This step is very important since it permits to improve qualitatively several models developed so far by many authors whose consider the defect as loss of material only. However, in several applications, the defect can occur with a finite resistivity such as impurity, small burns and micro-solder. On the other hand, even though the defect appears with a loss of materials, some polluting materials can fill the affected region. Indeed, the volume of the initial defect will be completely or partially occupied by these conducting pollutant materials. This paper deals with the effect of physical and geometrical characteristics of such kind of defects on the differential sensor response. Furthermore, the necessity of taking the defect electric conductivity (as an important parameter) into account will be explained, in order to develop a reliable and accurate inverse method allowing a full characterization of conductive defects.*

Keywords: *Eddy Current, Differential Sensor, Conductive Defect.*

1. Introduction

The eddy current technique is one of the preferred Non Destructive Testing (NDT) methods for the inspection of deployed metallic components [1]. It is a fast and effective method of defect detection in metal rods and plates caused by corrosion or stress [2]. Eddy Current Testing (ECT) requires an excitation coil to induce currents within the sample conductive material. In the presence of a defect, these currents are perturbed and thus, the produced magnetic field is also perturbed. Eddy current sensor is used for detecting this perturbed field. These field perturbations are then processed to infer on the defect presence and its physical and geometrical characteristics. Until now, the majority of the published scientific works in the literature treating eddy current testing have elaborated the detection and the characterization of defect existing in the material as a loss of material. However, other defects can appear without loss of material; one can state as examples the small inclusions, small burns and micro-solders, [3].

In fact, even though the defect appears with a loss of materials, some polluting materials can fill and occupy the affected region. Indeed, the volume of the initial defect will be completely or partially occupied by these conducting pollutants materials; that can be the sit of induced currents. Therefore, if this phenomenon is not taken into consideration in the modeling of these systems, the results with this assumption will be affected. In this article, the effect of this parameter on the signature of the defect will be made into evidence. In other words, the effect of physical and geometrical parameters of this kind of defects such as its depth, width and electric conductivity on a differential probe signal will be studied. The advantage of differential coils is being able to detect very small discontinuities and permits to eliminate temperature and lift-off variation effects, [11].

2. Eddy current testing through Maxwell equations

Maxwell's equations describe the physical model used for electromagnetic EC problems solved with the finite element method (FEM) that allows determining the response of sensor eddy current. The magnetic vector potential, electric and magnetic field or the pointing vectors are the most quantities widely used to solve the field equations, [2]. Quasi-stationary Maxwell equations are given hereafter:

$$\nabla \times \vec{H} = \vec{J}_s \quad (1)$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \quad (2)$$

$$\nabla . \vec{D} = 0 \quad (3)$$

$$\nabla . \vec{B} = 0 \quad (4)$$