UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF EDDY CURRENT SENSOR TO DETECT CRACK ON METAL

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours.

by

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I hereby, declared this report entitled DEVELOPMENT OF EDDY CURRENT SENSOR TO DETECT CRACK ON METAL is the results of my own research except as cited in references.

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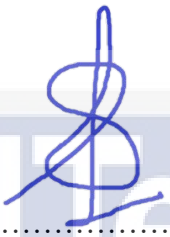
APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Industrial Electronics) with Honours. The member of the supervisory is as follow:

Signature:  .....

Supervisor : TS. WAN NORHISYAM BIN ABD RASHID

ABSTRAK

Pada masa kini, kaedah Non-destructive (NDT) terkenal di kalangan sektor perindustrian yang terdiri daripada kelemahan pengesanan bahan yang memerlukan induktor elektromagnetik untuk membuat medan magnet dan melakukan ujian arus eddy. Digunakan secara meluas oleh industri aeroangkasa dan perkhidmatan pembuatan yang memerlukan pemeriksaan logam yang berkaitan dengan masalah keselamatan. Oleh kerana pengujian semasa eddy lebih sedikit kos berbanding dengan NDT lain, ia akan mempunyai peluang lebih tinggi untuk menembusi pemasaran industri yang melibatkan pemeriksaan atau analisis logam yang memerlukan peralatan yang tinggi. Oleh itu, simulasi adalah untuk mengkaji kajian yang berkaitan yang terdiri daripada kerja pengujian arus eddy sebagai sensor untuk mengesan keretakan pada logam atau sebarang kekurangan. COMSOL Multiphysics adalah kunci utama kejayaan simulasi dalam ujian arus eddy yang menerapkan semua faktor teori yang mempengaruhi kajian arus eddy.

ABSTRACT

Nowadays, the Non-destructive method (NDT) is famous among the industrial sector which consists of make detection flaws of any substance which required an electromagnetic inductor to create a magnetic field and perform an eddy current testing. Widely used by the aerospace industry and manufacturing service that requires the inspection of metal which related to safety problems. Since eddy current testing less cost compare to other NDT, it will have higher chances to penetrate the industry marketing which involves inspection or analyzed metal flaws that required a high level of equipment. So, the simulation was to study the related study which consists of eddy current testing work as a sensor to detect crack on metal or any flaws. COMSOL Multiphysics was the major keys to the success of simulation in eddy current testing which applies all the theoretical factors that affect the study of eddy current.

DEDICATION

This thesis is dedicated to:

My beloved parent

Mazzlan Bin Che Ahmad

My generous supervisor

TS. Wan Norhisyam Bin Abd Rashid

And

My beloved sibling and friends

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NDT	Non-Destructive Testing
NDE	Non-Destructive Eddy
WAAM	Wire Arc Addicting Manufacturing
CAM	Computer-Aided Manufacturing

CHAPTER 1

INTRODUCTION

1.1 Project Background

Today, non-destructive techniques are popular in the industrial sector and in which to measure the properties of a material without damaging. One of the most popular non-destructive techniques is eddy current, radiography, ultrasonic and penetrating tests. With limited ability to identify the flaw in metal, this will be the biggest problem when measuring or determining the metal subsurface to check whether it is in good condition.

Eddy currents that flow through the present is like a circular pattern into the conductor. It was generated by modifying magnetic fields and radiating parallel to the direction of the magnetic field through closed loops. This is because when the metal passes through the magnetic field, the eddy current is generated by the magnetic field or by the direction diffused in the conductor. The effect of the eddy current is equal to the output of the magnetic field, the circuit area, and the strength of the magnetic field and inversely proportional to the resistance of the conductor.

1.2 Problem Statement

The flaw or fracture that occurs on the metal is a human concern in the examination of the metal component, even when the fault is not visible by the skilled eye of the user and must be examined by a procedure involving the appliance to identify the defect.

The biggest issue of the project is the weakness of the human ability to detect a metal flaw. A 3-D metal block model was built in the COMSOL module to determine the disruption effects of flaws on eddy currents, that indicates that the fracture disruption impact on eddy current is minimized by the current loop when the crack is propagated. Thus, it is difficult to determine the type of core or winding using COMSOL. Last but not least, unable to determine circular eddy current.

1.3 Research Objective

The main aim of this project is to:

a) Detecting a metal crack or defect on metal block using eddy current testing sensor technique using COMSOL Multiphysiscs simulation.

b) Study heat power losses occur in metal block in COMSOL Multiphysics.

c) Determine the generating circular of eddy current in metal block in COMSOL Multiphysisc simulation.

1.4 Scope of Research

The scope of this research are as follows:

- Differentiate various types of crack in metal block.
- Power dissipation for each types of crack .
- Circular pattern of eddy current that oriented perpendicular to the direction of magnetic field.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will review the analysis in different zones of the recently constructed design. Literature overviews were provided from publications such as informative articles, papers, and various sources. Scriptures for this task have been categorized into three key topics: simulation of eddy current, coil construction effects, and form of non-destructive metal crack test.

2.2 Crack Detection using Non-destructive testing (NDT) technique

The varieties of tool for evaluating products and materials and non-destructive methods are an essential factor for many application scenarios. The Non-Destructive Evaluation (NDE) or Non-Destructive Testing (NDT) field requires analyzing and classifying damage to the structure and overall design of components without removing or modifying the metals(Papaelias et al., 2008). In certain terms, NDT refers to the method used to measure process in addition or materials for evaluation or detection of defects and flaws according to other requirements without altering the original qualities or damage the product being tested. NDT techniques provide a cost-effective method of a sample for high tendency or could be added to the whole material for examination in a research.

2.2.1 Eddy current

Eddy current is a circular electrical current generated by a magnetic field change within the conductor. This concept explains the fundamental electrical law of Faraday when a coil is applied with a time of varying current, which has brought about a near-magnetic, secondary current generated in the magnetic field(Rifai et al., 2016). Thus, the current flows in the sample parallel to the coil, but in the reverse direction of the eddy current in the sample, which contrasts with the main magnetic field. From this point on, the presence of flaws in the sample would interrupt the flow of eddy current, reduce the active response and reactivity of the sample.

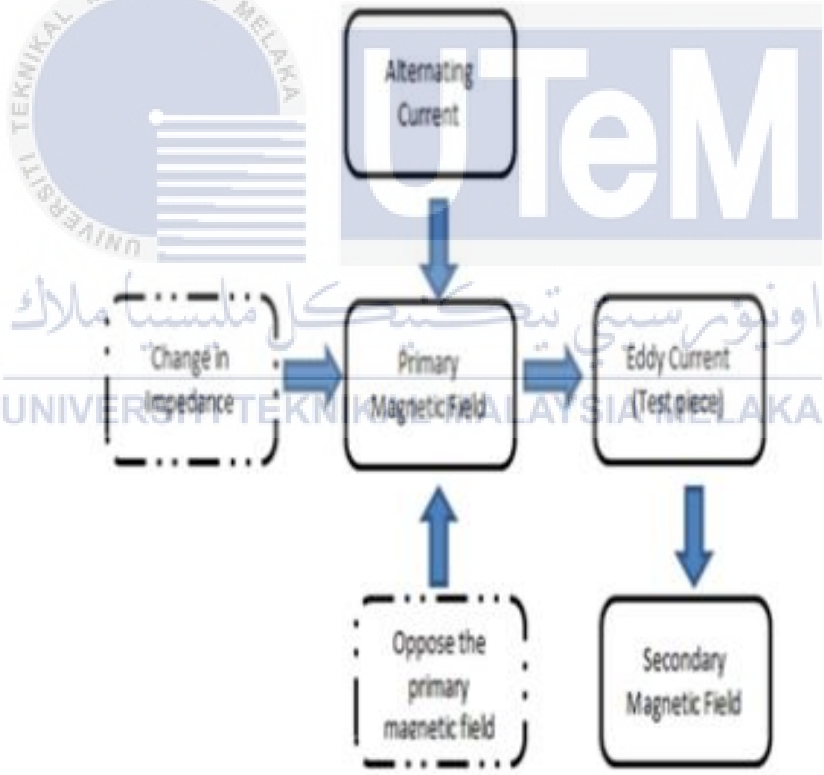

Figure 2. 1:Diagram of principle of eddy current testing

Notice that the flaws must be directly cross with the current eddy line to noticed, and the flaws lies parallel to the current eddy line does not create any conversion or

transformation in secondary magnetic field. Prevention of depth fracture in materials is a major priority for eddy currents. Identification relies not only on the responsiveness of the magnetometer but also on engagement among both fracture and eddy current in the structures evaluated. (Hamia et al., 2014).

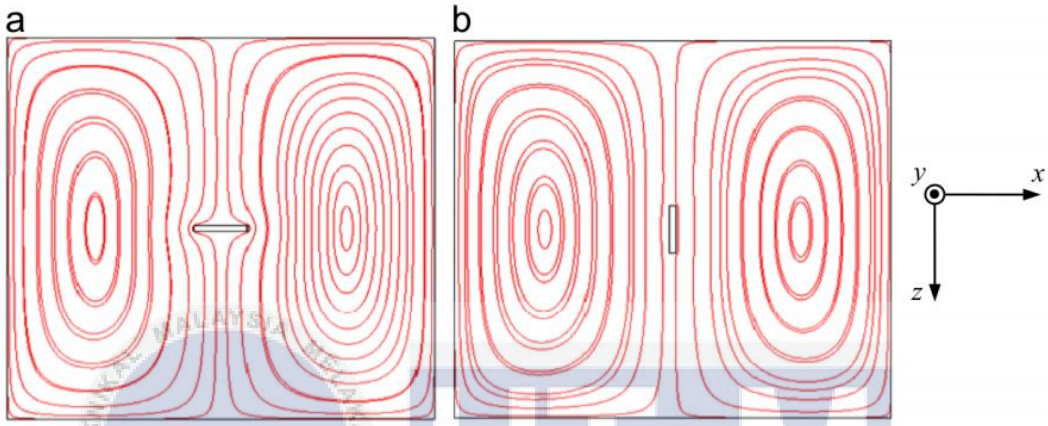

Figure 2. 2:The flow of eddy current at a) x-axis and b) z-axis

As shown in the figure above, the non-destructive test on eddy current has a favorable direction for crack detection. Also, the inducer is a guide to trigger a current parallel to the crack length, as an example in Figure 1.2, an aluminum sample where a single wire creates the eddy flow of current as an inducer that is oriented along the z-axis. When the eddy current is applied directly to the subject, a significant pattern disturbance appears on the crack. However, when the disruption is parallel to the eddy current direction, a small flow disturbance occurs, and the detection of the defect is reduced.

2.2.1.1 Penetration Depth

The caused eddy current amount gradually decreases from the top to the bottom of the material. The standard depth for the eddy current check is the depth of the material

surface where the eddy-current tension on the surface of the article has fallen to 37% of its original value. (Damhuji Rifai1, 2016).Based on the intensity of testing, as well as the criteria of the sample material such as electrical conductivity and permeability. The depth of penetration is defined as: (Damhuji Rifai1, 2016) :

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}$$

Where σ is the conductivity of a conductor, μ is the permeability of conductor and f is the frequency. The amplitude of the induced eddy current gradually decreases in the metal surface. The amplitude of the fields in the conductor at depth along the x-axis is expressed as (Damhuji Rifai1, 2016) :

$$J(x) = J_s X e^{-x/\delta}$$

The normal penetration depth of the skin is defined as the depth where the density of the eddy current is around 36.8 per cent of its surface value (Damhuji Rifai1, 2016). Since the inspection of embedded defects involves greater penetration depth of eddy currents, the selection of the excitation frequency is critical. Detecting a deeper defect necessitates lower level of excitation.