UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF THE OXIDATION METALS BY USING EDDY CURRENT WITH INTERNET OF THINGS (IOT)

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

ENGKU AMIRULHISHAM BIN ENGKU SENUSI
B071710298
951117015067

FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING TECHNOLOGY

2020

UNIVERSITI TEKNIKAL MALAYSIA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: DEVELOPMENT OF THE OXIDATION METALS BY USING EDDY CURRENT WITH INTERNET OF THINGS (IOT)

Sesi Pengajian: 2020

Saya **ENGKU AMIRULHISHAM BIN ENGKU SENUSI** mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (X)

5.

☐	SULIT*	Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972.
☐	TERHAD*	Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.
☒	TIDAK TERHAD	

Yang benar,

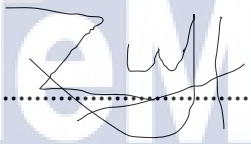
.....

ENGKU AMIRULHISHAM BIN ENGKU SENUSI

Alamat Tetap:
NO 04-01 BLOK N1,
JALAN CAMAR 13,
TAMAN PERLING,
81200 JOHOR BAHRU,
JOHOR

Tarikh:

Disahkan oleh penyelia:



.....

ZULHAIRI BIN OTHMAN

Cop Rasmi Penyelia

ZULHAIRI BIN OTHMAN
Pensyarah
Fakulti Teknologi Kejuruteraan
Universiti Teknikal Malaysia Melaka

Tarikh:

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini

DECLARATION

I hereby, declared this report entitled DEVELOPMENT OF THE OXIDATION METALS BY USING EDDY CURRENT WITH INTERNET OF THINGS (IOT) is the results of my own research except as cited in references.

Signature: ……

Author : ENGKU AMIRULHISHAM BIN ENGKU SENUSI

Date:

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 : ZULHAIRI BIN OTHMAN

ABSTRACT

The eddy current widely uses for industries such as Oil and Gas industries, Nuclear Plant, Automation and Aeronautics. Encouragement for using Internet of Things (IoT) simplifies the human task to achieve the mission for all day long. The combination of eddy current and IoT should be ease to human, but there are some problems to encounter. However, to encounter this problem, it is difficult to monitoring metal installation that has more than five years involving oxidation metal that may lead to catastrophic failure. The objective of this project is to develop an eddy current to detect the oxidation of metal by using an android application that able to monitor and collect the potential data to alert the personal computer or smartphone. By making own eddy current sensor and combine with Arduino Uno as microcontroller input and output of the system be equipped with WIFI internet to transmit and receive from a personal computer that can always be monitored. Observation for oxidation metal is necessary to make sure the eddy current can function as need. The data from the input microcontroller will send the alert to the observer the condition of oxidation metal. The project is user friendly and able to improve industrial structure that involves the base metal to the environment.

ABSTRAK

Eddy Current digunakan secara meluas dalam industry minyak dan gas, loji nuclear , automasi dan aeronautic. Galakan penggunaan Internet kepada benda atau dikenali sebagai (IoT) memudahkan manusia dalam menguruskan tugas dan menyelesaikan masalah dalam seharian. Gabungan Eddy Current dan IoT memudahkan manusia tetapi ada masalah yang perlu dihadapi dan diselesaikan. Walaubagaimanapun , untuk menghadapi masalah ini, pemantauan pada pemasangan besi agak sukar apabila pemasangannya melebihi lebih lima tahun termasuk pada logam yang terhakis disebabkan oksida menyebabkan malapetaka yang besar. Objektifnya adalah menghasilkan Eddy Current untuk mengesan oksida pada besi menggunakan aplikasi Android yang membolehkan untuk dipantau dan mengambil data yang berpotensi untuk memberitahu pengguna melalui komputer persendirian atau telefon pintar. Bagi menghasilkan Eddy Current dan gabungan NodeMCU sebagai mikrokawalan masukkan dan keluaran pada system mestilah dipasang melalui internet WIFI dengan menerima dan menghantar dari komputer persendirian yang membolehkan sentiasa diawasi. Pemantauan pada besi oksida adalah perlu bagi membolehkan Eddy Current berfungsi dengan baik. Data daripada masukkan mikrokawalan mestilah dihantar dan memberi amaran kepada pemantau terhadap besi oksida. Projek yang dihasilkan adalah mesra pengguna dan boleh meningkatkan struktur industri yang yang melibatkan logam atas pada persekitaran.

DEDICATION

To my beloved parents,

Engku Senusi Bin Engku Mansor and Norsah Binti Sharom ,

My Supervisor Sir Zulhairi Bin Othman

and all my fellow friends

ACKNOWLEDGEMENTS

First and foremost, praise and thanks to Allah SWT for his showers and blessings throughout research work to complete successfully

Seconds I would like to express deep and sincere gratitude to research supervisor Sir Zulhairi Bin Othman, for giving to do the opportunity to do research and providing invaluable guidance throughout this research.

Next, I am incredibly grateful to parents for their love, prayers, caring, and sacrifices for educating and preparing for the future. Also, I express to siblings for support and valuable prayers.

Besides that, I would say to thanks to my friends and research colleagues, for their constant encouragement .moreover don't forget to lecturers gives lectures in class and laboratory from the first year until now give more information and teach a better way to solve the problem in engineering courses .Finally, thanks to my supporters which involve directly and indirectly during complete my research from starting until the end of this project.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AE ..... *Acoustic Emission*
CUI ..... *Corrosion Under Insulation*
DAQ ..... *Data Acquistation*
ECT ..... *Eddy Current Testing*
EIS ..... *Electrochemical Impedance Spectroscopy*
EP ..... *Electrophoteric Painting*
ETREE ..... *Extended Truncated Region Eigenfunction Expansion*
GFM ..... *Gradient-field Measurement*
GMR ..... *Giant Magneto Resistive*
GPEC ..... *GFM based PEC*
IoT ..... *Internet of Things*
MFL ..... *Magnetic Flux Leakage*
NDE ..... *Non - Destructive Evaluation*
NDT ..... *Non - destructive Techniques*
PCA ..... *Principal Component Analysis*
PEC ..... *Pulse Eddy Current*
PMEC ..... *Pulse - Modulation Eddy Current*
PMFL ..... *Pulse Magnetic Flux Leakage*
PMR ..... *Pulse Magnetic Resistance*
RFEC ..... *Remote Field Eddy Current*
SSIM ..... *Structural Similarity Index*
WTD ..... *Wall Thinning Defects*

CHAPTER 1 : INTRODUCTION

1.1 Introduction / Background

Eddy current is known as Foucault's currents, means eddy are loops of electrical current induced within conductors by changing magnetic field. It was discovered by Francois Arago the 25th Prime Minister of France in the late of 17th until mid of 18th also known as a mathematician, physicist and astronomer. In the meantime, Michael Faraday observed and called as rotatory magnetism in 1824 and known as Faraday Laws nowadays. Heinrich Lenz says that magnetic flux caused current flow due to the direction of induced current flow in an object in 1834. Differing opinions Leon Foucault discovered eddy current induced in the metal become heated when the force required for rotation of copper disc rotating between the poles of a magnet in 1855. Nevertheless, there is always a need to find the solution for eddy current to detect the oxide metal depends on the environment and usage of eddy current may affect during penetration testing.

Besides, the corrosion is the threat for base metal to oxidize the thickness on the surface. One of the reasons of corrosion is high pH solution of an anodic solution, and hydrogen-based mechanism may occur stress on the surface of the steel (Javidi & Bahalaou Horeh, 2014). The situation shows on how the chemical reaction to ionizing the particle on the surface of the steel which may have the equation of the chemistry usage that may result to catastrophic on the steel which can crack the surface. The direct methods to know the fracture parameter measurement is crack propagations parameters and it occurs to the stress intensity factor from this method shows that the crack length is measure indirectly from the displacement of the specimen. Seconds is fracture toughness to determine fracture toughness to defined size and shapes, but at the same time, it often becomes difficult or impossible to detect the accuracy. For indirect methods which is crack propagations parameters is microscopic cracks present obtained to static or dynamic strength measurement of the metal. Second, fracture toughness is indirect determinations by estimate the power function that's only valid for slow velocity range, but only power function is use (Lycett & Hughes, 2018).

Besides that, there are several types of an eddy current to detect the metal problems usually cause of crack of metal and oxidation on metal. One of them is the eddy current testing can identify and respond to abnormalities of steel (Mun & Kim, 2014). Different types and design of probes may affect the ways of electromagnetic to find defects on the steel. Each of them may have advantages to solve the problems, but in the meantime, it needs to reduce cost and more efficient without make complex circuit. The usage of non-destructive techniques has been used before for the researches to find defects on the surface of the steel (Grosso et al., 2018),(He et al., 2014), (Alamin et al., 2012). Most techniques for non-destructive techniques (NDT) are electromagnetic based on eddy current techniques for inspections of conductive materials that usually based on the base metal. This technique is based on interaction

magnetic field sources and teat material and inspecting crack detection. Most of them are conductive materials, either ferromagnetic or non- ferromagnetic. This method does not need direct physical contact between the sensor and steel(García-Martín et al., 2011).

Moreover, there are three principles of probes for tracking the cracking corrosion on the surface of the steel. The impedance probes, Transmitter/Receiver (T/R) probes and Transmitter/ Transmitter (T/T) probes are less suitable to detect defects on steel. According to research (Obrutsky et al., 1996), T/R eddy current probe displaced transmit and receive coils. It has its advantages over impedance probes which can improve the signal-to-noise ratio, have a definite directional purpose, permitting probe optimization or axial crack detection. The application for this probe is to increase the scope and maximizing defect signal on an area of the surface steel.

Furthermore, impedance probes may suitable because of the voltage drop varies depth and length of defects increase if compare with T/T probe and T/R probe(Mun & Kim, 2014). to be seen, The magnetic field impedance probe has to lean towards the defects increase with its existence, but in the meantime, if the strength signals changes, the impedance of the receiver will fluctuate. By using impedance, the probe can easily detect the defects because impedance varies in proportion to the length if compare to T/R probe change impedance are not change the depth of defects.

As in this case of impedance probe and T/R probe has its advantages as the researches prove the way how does probes to do the operation to defects occur on the surface steel. In this work, to investigate different types of the probe, design and operation have to design impedance probe with enhanced depth of defect can be detected for steel corrosion can be avoided.

1.2 Problem Statement

Primary metal always exposes to water and air that bring to corrosion. The oxidation metal brings to catastrophic to the environment if it does not change the metal maybe it will cause leakage of water or oil during transferring from place to another place. These failures occur when the usage of the metal such as pipeline usually use more than five years, and metal does not cover with epoxy coating potential to reduce corrosion occur. As a result, eddy current testing to do pipeline inspection to observe and collect data of the waveform whether the pipeline can be used for a long time or need to replace with a new one if need.

Besides, because periodic inspection means that the observer does not have to go down the field and to ensure the system is running smoothly without interruption, additional IoT is applied. If the oxidation of the pipeline occurs during the system run, the observer may prepare maintenance or spare part shortly before the catastrophic incident occurs.

1.3 Objectives

The aim of this project would be to concentrate on some of the problems listed below.

i. To study the oxidation metal occur when it expose to chemical reaction and environment
ii. To develop eddy current sensor to analyze oxidation on the metallic materials
iii. To notify the observer when the metal has reach to oxidation phase

1.4 Expected Outcomes

By the end of this project, an electronic system which is eddy current sensor use to identify the metal object when the metal has reached to oxidation phase. The eddy current combine with other circuits such as collects oscillator to give suitable frequency and to identify the voltage drops when it reaches to oxidation surface. To communicate the observer, the IoT is used to notify with apps when the metal has reached its oxidation phase before metal reach to crack phase

1.5 Project Scope

The Eddy current uses to test iron metal when it is oxidized and has no oxidation phase. The data will send to NodeMCU controller to collect the measurement from the eddy current sensor. Notify the observer about the oxidation phase metal of the surface iron metal by sending the data to the device such as smartphone or computer

CHAPTER 2 : LITERATURE REVIEW

2.1 Eddy Current

The base metal is a metal that easily to oxidizing or corroding when reacts to hydrochloric acid to the hydrogen form, for example, iron, nickel, lead and zinc. As an industry such as oil and gas, aeronautics, automation, plumbing and so on the importance to do an inspection when the metal that usually use more than a decade to make sure that there are not in catastrophic damage happen when some processing and working is on its way. Therefore to solve the issues before catastrophic will happen, preparation must be on its way by examining the condition of the metal either need to replace or repair the condition because of corroding makes the surface of the metals corrosive that may be unable to repair and awful condition. Eddy current testing use to determine the condition of the metal surface by knowing the voltage reading or the wave. Although eddy current is the most suitable method to use because it can detect the parts of corrosive without touching or open the metal surface because of electromagnetic fields that generate into the probe. The IoT nowadays, the inspection or maintenance workers do not need to go down to the field checking the metal, when the time comes the analogue from probe eddy current will send the signals to controller to notify the inspection or maintenance workers to change when it needs.

2.2 Method for Eddy Current due to Incubation Corrosion

2.2.1 Incubation Period of Corrosion Stress Cracking For Low Carbon

According to by (Butusova & Mishakin, 2019) monitoring the surface of the metal is essential when it pressures up to 12 MPa, and it will last longer for twenty years or more. In the incubation stage, the metals take to 80 until 90 per cent of the whole life that may appear to crack on surface metal. The capability for eddy current to do a rapid contactless diagnostic of surface metal will depend on the frequency and electric signals which are electromagnetic properties of the material. Besides, eddy current able to monitor but unable to microstructural changes at incubation stages in figure1.

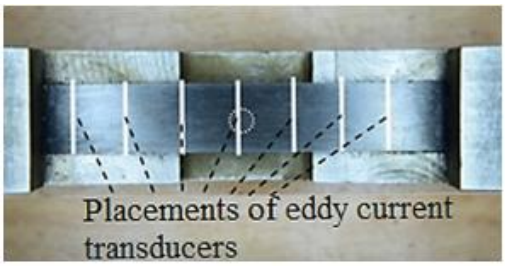


Figure 1 : Placement eddy current to monitor by using making lines

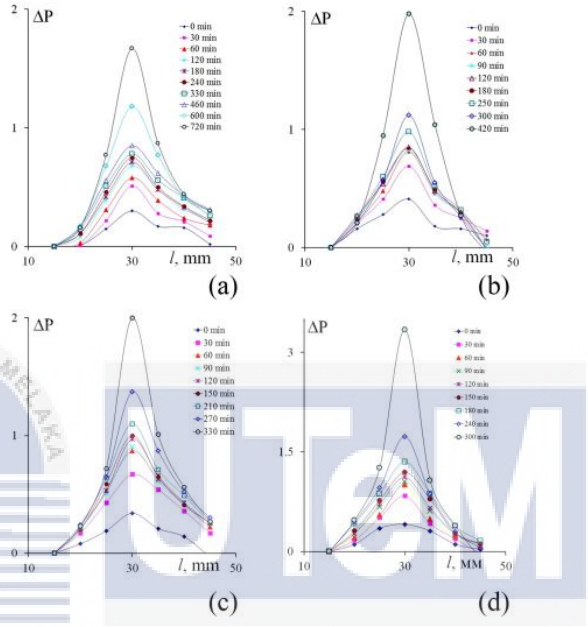


Figure 2 : Exposure metal of different times due different correspond curves

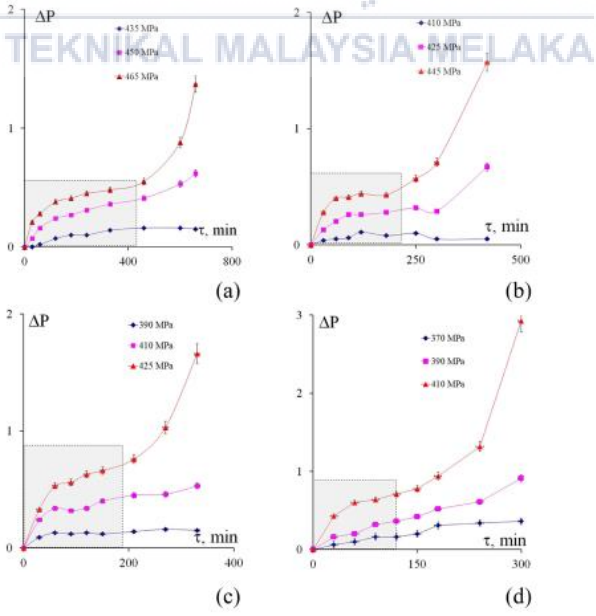


Figure 3 : Error! No text of specified style in document.

The graph shows that metal has stress values when metal exposes to nitrate solution, which is the longer times that it needs to dissolve the metal in figure2. The incubation stage in the grey area and at the end of this stage, microcracks will appear in figure3.

From this research, eddy current use to monitoring the second stage which is the middle of pressure given from the graphs in incubation stage which this stage has to happen of microcracks which are lastly from macrocracks is about 5mm in figure 4.

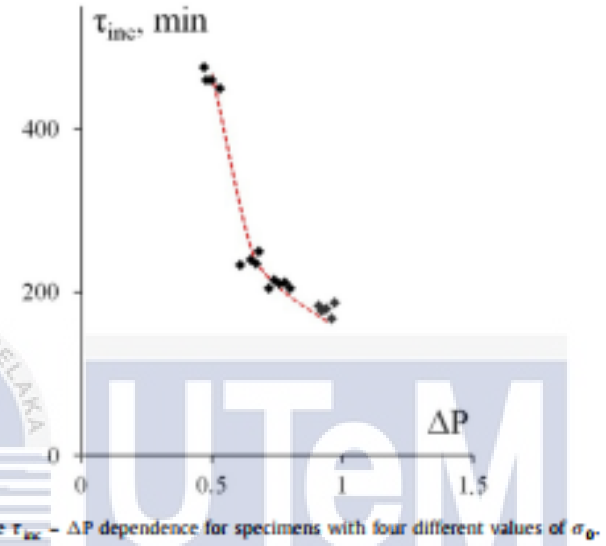


Figure 4 : The graph shows 4 different values that lead to 5mm cracks

2.2.2 Inspection Of Coatings For Storage Tanks By Using Eddy Current

The detectability of eddy current technique to evaluate coating storage is apply to against corrosion..(Grosso et al., 2018) . In addition, coating is currently considered to be the best option to avoid corrosion, which is usually used for industrial or home use due to exposure to heat and rain. The coating is typically used for steel tanks, pipes, heat exchangers and structural components.

In addition, blister coating, lack of adhesion and undercoating can contribute to corrosion. From this article shows that Non-Destructive Techniques (NDT)s is subject to visual assessment in which detection of interlayer and undercoating. Thus this method allows to inspect the coating , ensure the efficiency of coating, and monitor coating performance.

First, the relationship between the main magnetic field and the components tested is a variation of eddy current testing. The presence of discontinuities observed by adjusting the impedance of the coil modifies by measuring the induced magnetic field but, at the same time, the traditional eddy current method has its drawbacks due to the single frequency excitation coil.

Therefore , Eddy Current Testing (ECT) and samples use to running the experiment of coating based on carbon steel surface which painted with Electrophoretic Painting (EP) with different thickness and iron thickness based on figure5.

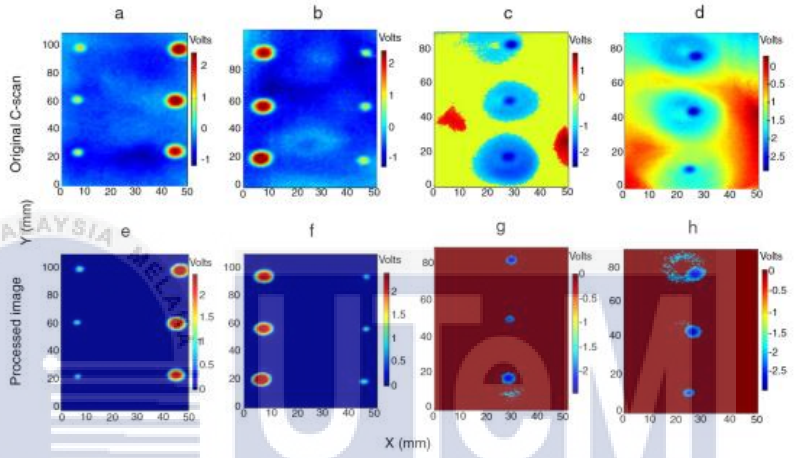


Figure 5 : By using image processing C-Scan map with different layer EP for sample A, sample B, sample C, and sample D

Image processing is analyzed to highlight corrosion and to remove false detection and to enable distinction after processing. Signal calibration can cause defects that lead to positive and negative values. From this defect detection, samples A and B have a resistance value of 2.5V for larger diameter and 1.5V for smaller diameter for defect based on Figure 6. A negative value does not respond to any defects. They are using a multi-level threshold to eliminate the effect of thickness variation and improve the detectability of defects. For the C and D samples, negative resistance is shown, and the false defect is shown and, using the C scan method, corrosion can be detected on the carbon steel surface in Figure 5.

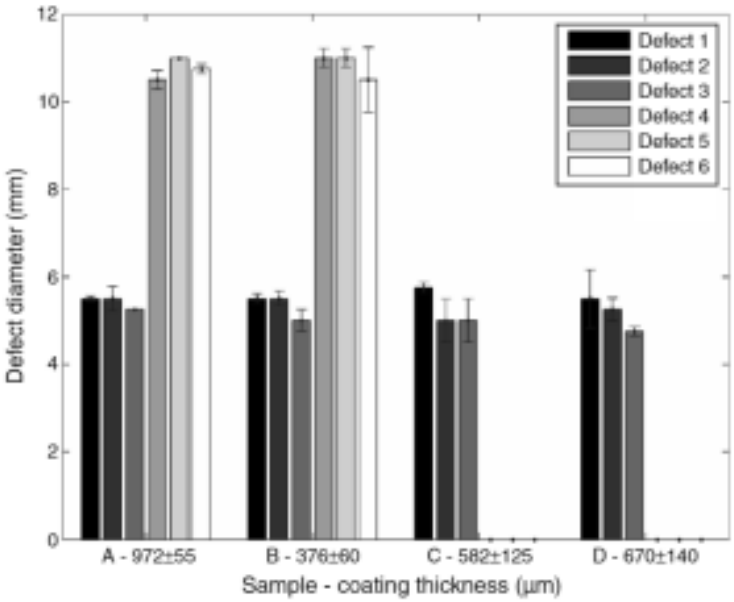


Figure 6 : Coating thickness for sample A, sample B , sample C and sample D by using C-scan map.

2.2.3 Corrosion Inspection Using Pulsed Eddy Current

From this article (Silva et al., 2014), Pulse Eddy Current (PEC) technique is used to create repetitive pulses in short time duration. PEC has several advantage which is greater depth penetration, wealth of information about defects and robustness compare to conventional technique of single frequency.

Besides that, corrosion under insulation (CUI) is an electrochemical process that happens when humidity and oxygen occur in a range of -4 degree Celsius to 175 degree Celsius. Others than that, present of chlorides and sulfides increase the corrosive water.

Furthermore, the Fourier transform of square pulse contains different frequency component which depends on frequency. The feature has its limitation, which is PEC testing to generate eddy current in metal and the magnetic field generated to detect by the solid-state sensor and the detection of discontinuities difficult. However, to overcome this limit, the arrangement with one sensor is used to subtract a reference signal acquired outside the inspection area in figure 7.