UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON CORROSION RATE OF THE ZINC ANODE FROM OUTBOARD BOAT ENGINE AROUND STRAITS OF MALACCA

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTEM) for the Bachelor Degree of Engineering Technology (Automotive Technology)

By

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DECLARATION

I hereby, declared this report entitled "**Study on corrosion rate of the zinc anode from outboard boat engine around straits of Malacca**" is the results of my own research except as cited in references.

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Date : 8/12/2016

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirement for the Degree of Engineering Technology (Automotive Technology) with Honour. The member of the supervisory is as follow:

……..

(Project Supervisor)

DR NONA MERRY MERPATI MITAN

APPROVAL

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(Project Co-supervisor)

EN KHAIRIL AMRI BIN KAMARUZZAMAN

DEDICATION

Dedicated to my father SYAHRIFUL BIN SYARIF and my mother NOOR AINI BINTI HASSAN. To my supervisor DR NONA MERRY MERPATI MITAN and my Co-supervisor EN KHAIRIL AMRI BIN KAMARUZZAMAN, all lecturers and friends of their help and motivate on me.

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I also want to express my appreciation to my parents that always support all the times and to my supervisor because of sharing the experiences, expertise, guidance and knowledges while I was doing this task. Thank you also goes for consistent guidance during generating of ideas to complete this report. All the suggestions that have been given can be translated easily into the content of this report to achieve the objective of this study

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Abstrak

Kakisan adalah degradasi bahan yang boleh diperhatikan bergantung kepada alam sekitar. Kakisan menjadi satu masalah yang serius disebabkan oleh perubahan sifat pada anod zink. Anod zink telah digunakan dalam projek ini dengan memasang kepada bot nelayan di Balai Nelayan, Kampong Sempang Pantai, Merlimau. Sifat mekanik zink anod dari selat Melaka menjadi tumpuan utama untuk mengkaji kakisan untuk anod zink. kajian kinetik kadar kakisan anod zink di dalam air laut segar sebenar akan dimasukkan ke dalam projek ini untuk mengetahui ketahanan bahan untuk keselamatan dan pencegahan penyelenggaraan enjin bot. Kemudian, anod zink akan menjalani beberapa ujian untuk mengetahui perubahan sifat-sifat dan struktur. alam sekitar juga menjadi faktor untuk kakisan anod zink. Terdapat faktor beberapa yang dibincangkan dan ditentukan. Keputusan bagi ujian zink anod menunjukkan bahawa anod zink yang digunakan telah berubah sifat-sifat mekanikal dan mikrostruktur. Keputusan ini dapat apabila anod zink yang digunakan dibandingkan dengan anod zink baru yang telah melalui ujian yang sama. Akhir sekali, objektif untuk kajian kadar kakisan anod zink pada enjin bot sangkut sekitar Selat Melaka telah dicapai dan berjaya. Kadar kakisan telah ditentukan bahawa $k = 3{,}272 \times 10^{-6}$ (gram / cm2. jam) untuk zink anod Suzuki 30 hp dan $k = 6.01 \times 10^{-4}$ (gram / cm2. jam) untuk zink anod Yamaha 40 hp dan akhir sekali untuk $k = 1.997 \times 10^{-4}$ (gram / cm2. jam) untuk zink anod Yamaha 60 hp.

Abstract

Corrosion is the degradation of material that can be observed depend on the environment. Corrosion become a serious problem due to the changing of the material properties on the zinc anode. The zinc anode were used in this project by attach it to the fisherman boat at *Balai Nelayan, Kampong Sempang Pantai, Merlimau*. The mechanical properties of zinc anode from strait Malacca be the main focus to study the corrosion for zinc anode. Kinetic study of corrosion rate of the zinc anode in real fresh sea water will be included in this project in order to know the durability of materials for the safety and preventive boat engine maintenance. Then, the zinc anode will be going through few testing to know the changes of the properties and structure. The surrounding environment also be a factor for the corrosion of zinc anode. There are a few factor that discussed and determined. The result for the zinc anode testing shows that the used zinc anode has been changed the mechanical properties and the microstructure. This result get when the used zinc anode was compared to the new zinc anode that has been going through the same testing. Lastly, the objective for study the corrosion rate of zinc anode on outboard boat engine around straits of Malacca was accomplished and succeeded. The corrosion rate value was determined that is k =3.272 $\times 10^{-6}$ (gram/cm2.hour) for zinc anode Suzuki 30 hp and k = 6.01 $\times 10^{-4}$ (gram/cm^2. hour) for zinc anode Yamaha 40 hp and lastly k = 1.997 $\times 10^{-4}$ (gram/cm^2. hour) for zinc anode Yamaha 60 hp.

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LIST OF ABBREVIATIONS

Cp	Cathodic Protection
Sa	Sacrificial Anode
Zn	Zinc
SACP	Sacrificial Anode Cathodic Protection
ASTM	American Standard Testing Method
FTK	Faculty of Engineering Technology

CHAPTER 1

INTRODUCTION

1.1 Background

Corrosion is the natural effect in global life, which make fine metal become deposited metal. This happens because of the reaction occur between metal and its surrounding environment that make the degradation of the material. Corrosion is the result from few phenomenon's such as galvanic or an electrolytic corrosion. Corrosion occurs usually at more reactive metal (more negative electrochemical potential) such as zinc. Since Malaysia has a tropical marine environment, which gives impact to the corrosion to the environment, in particular of the zinc anode for the fishing boat in Malaysia.

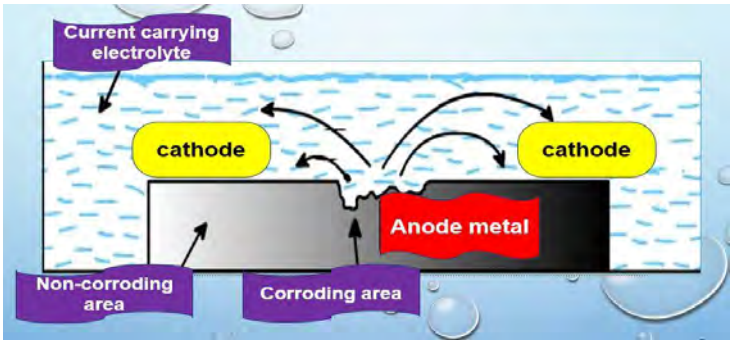

Figure 1.1: Corrosion mechanism reaction schematic diagram

From the observation and survey, many fisherman in Malaysia complains about the price of the zinc anode because it is expensive of the price. However, it is become increasingly difficult to ignore the zinc anode because it helps to protect the boat engine and also can help to stabilise in controlling the boat. For boat engine in the marine environment, zinc anode act as sacrificial metal was used in order to prevent

the corrosion deposited attacking the parts of the engine because this always occurs at zinc anode where the metal oxidized.

This zinc anode corrodes because of few factors such as humidity, salinity, temperature, and reaction with other metal. Other than that, it also occurs because of the movement or wave of the sea water that produced changes current of charge with the zinc anode also be known as an electrochemical process. Therefore, the expected result from this project by research and observe the fishing engine boat to collect the data and see the corrosion rate at the zinc anode.

1.2 Problem Statement

From observation and survey in fields, there are a few type of fisherman outlook that gives impact to the corrosion of zinc anode. The fisherman does not have a proper maintenance schedule in particular replacement of zinc anode regularly for years as shown in Fig. 1.3. As a sacrificial metal, zinc anode is used as an indicator to protect and prevent the boat engine from corrosion. This zinc anode will corrode in short time and need to change or make maintenance. Furthermore, several of fisherman that's own a boat regular use of boat for fishing but lack of engine cleaning after use their engine and this automatically will affect to the corrosion occur on the boat engine. Besides, boats are parked in the open area without cover or shade condition at the boat parking area as shown in Fig. 1.2. Therefore, the zinc anode will reach it efficient limit for the function and this will affect the boat engine performance.

Figure 1.2: Boat parking area

Figure 1.3: Maintenance making

1.3 Objectives

a) To determine the corrosion rate of zinc anode by investigation the thickness and crack of the zinc anode by using eddy current and ultrasonic apparatus respectively.
b) To calculate the corrosion rate of the used zinc anode.
c) To investigate the mechanical properties of zinc anode (hardness test, impact test and surface) prior to and after corrosion.

1.4 Scope

Zinc anode has main function is to prevent the outboard boat engine from corrosion process occur by attaching it to the engine. The zinc anode also have high voltage resistance for the safety of fisherman and the outboard boat engine. It act as the grounding part for the lightning shock with flow the high voltage of the lightning shock attack to the earth, so it prevent the lightning attack the fisherman or outboard boat engine. The corrosion of the zinc anode is from the reaction of sea water to the environment factors such as temperature and humidity. This study focuses on the corrosion rate of the zinc anode on outboard engine. The corrosion rate will be determined by reduction of the mass and the thickness.

Then, eddy-current and ultrasonic apparatus will be used for the non-destructive test before the zinc anode is cut. Then zinc anode will be cut into pieces for making some test and it will be going through a few testing such as hardness test, impact-test, and inverted microscope, then the changes of the zinc anode properties can be determined by the surface testing. The corroded zinc anode that has been used in 4 years, 2 years 6months and 1 year 6 months will be tested to get the initial data. Lastly, new zinc anode are attach to the same outboard boat engine and extensively observation on expose of the new zinc anode be made also the result will be discussed.

1.5 Limitation

This project have the limitation on the design and type of zinc anode are used. The zinc anode used are only for three different type of engine with different capacity of engine horsepower (hp). The three outboard boat engine are:

a) Suzuki 30 hp outboard boat engine
b) Yamaha 40 hp outboard boat engine
c) Yamaha 60 hp outboard boat engine

Then, the research only limit to that area of the fisherman go and boat parking area. The time and weather also effect this research because they only go out to the sea happening sunny day and lastly several fisherman only go out to the sea approximately around 4 to 6 hours and not even go if raining heavily.

CHAPTER 2

LITERATURE REVIEWS

2.1 Sea water

Sea is the most various part of the earth that have different characteristic and properties. This characteristic and properties are effecting the surrounding environment in both positive and negative way in living world. Sea have different level in density, temperature and salinity (Dean, 2000). Corrosion by sea water is an aqueous corrosion that involve electrochemical process (French, 1997). Then, the sea water have different level of acidity or alkalinity (pH) that become the factor in the changes metals and alloys specific electrical potential (corrosion potential) (Mccafferty, 2009)

2.1.1 Sea water resistivity

The sea water resistivity, ρ (ohm·m), is a function of the seawater salinity and temperature. For the sea water, the salinity does not vary significantly for the temperature is the main factor and the relationship between resistivity and temperature at a salinity of 30 to 40 ‰ (parts per thousand) (Amiruddin, 2011). In the estuaries area and the enclosed bays, the salinity will vary significantly to each other. It is recommended with depth the design of the cathodic protection that the measurements reflecting the annual mean value and the variation of resistivity (Cp) systems in such locations is based on resistivity (Rousseau et al., 2009). The resistivity of marine sediments is higher compared to seawater resistivity by a factor ranging from about 2 for very soft clays to approximately 5 for sand. (Reba, 2014). For the calculation of anode resistance in seawater and marine sediments, the highest factor shall be assumed for calculation of the resistance of any buried anodes are sediment

data for the location are available respectively, and independent of depth and the temperature regions (annual average) surface water temperature 7 to 12°C), resistivity's of 0.30 and 1.3 ohm.m are recommended as reasonably conservative estimates (Kim et al., 2006). Slightly seasonal variations in temperature the lower values were to be documented by actual measurements and also take in account.

2.1.2 Sea surface

From observation of the sea surface discloses a variety of features describe as the wedges, cusps, waves, turbulence, and spray, the masses of falling water breaking events. Any of these might contribute to the electromagnetic waves scattering that responsible for the sea clutter (Dean, 2000). The wave spectrum, which says little about the details of these features basic oceanographic descriptor of the sea surface is contains a great deal of information about the sea surface in general and, however, is central to the application of the Bragg scattering hypothesis. Accordingly, some spectral characterization of the sea surface can tutorial material describing included in this section, along with wave breaking is a brief discussion of surface events other surface effects thought to contribute to the production of sea spikes (Revie, 2011).

The capillary and gravity are basically two types of surface wave that depend on surface tension or the gravity. The surface fine structure then the transition between one and the other takes place at a wavelength of about 2 cm smaller of capillary waves supply, so that the gravity waves make up the larger and most visible surface structures (Ropelewski, 2011). Not mean that the wind is a particularly indicator of what the wave structure beneath Sea water waves to their own origin in the wind. The wind must blow for a sufficient time (duration)for the equilibrium state are in order to arouse the surface, over a sufficient distance (fetch) (Tidblad,& Kucera, 2001). Sea is that part of the wave structure directly produced by these winds. For waves propagate in the absence of local wind, the local wave motion due to waves arriving from far away so even, there can be significant, perhaps from a distant storm.

Since the surface over which the waves travel acts as a low-pass filter, the swell components often take the form of long-crested low-frequency sinusoids waves, and (Fallis, 2013).

2.2 Coastal and Estuarine

There are very few are not manifest environments that are left on our planet where human impacts in some form. Result in some artificialness to many environments from human activities bring changes which these activities will bring change which is to an area's, such as the creation of new habitat or increased environmental stability, while in many cases the environment suffers. However, environment are affected by unnatural conditions an environment whether change is beneficial or not, the natural processes which operate in that, once altered, ceases to be natural (Melchers, 2014).

Degree of impact in which human impacts have led to a whole range of coasts and estuaries are typical environments that considerable variation in their changes with it and every coast is typically a highly populated area. In addition, taking advantage of the beaches and attractive scenery by many peoples go to the coast as a place to spend their leisure time then; indeed, some people may associate the coast purely with such activities. Also, taking estuaries are seen as places to develop industrial or port sites is advantage of abundant water supplies, transport links, and sheltered areas for loading and unloading ships at coasts. As a result, the coastal zone (generally taken to refer to the area of land which is defined in many ways by different researchers) experiences influenced by the sea, and vice versa, and thus including areas of land and sea affected by coastal activities and intense pressure and demands from various sectors of the community. The degradation of environment are change occur if this not take care and the pressure has the potential to cause (French, 1997).

Historically, It has all been traditional to carry out these modifications with humans changes also seen as the central focus of the 'development tree'; that is, are seen in the light of benefits to humans (humanist approach). However, this set of 'benefits' can be seen as impacts on the environment if we becomes less appealing from a non-humanist perspective this substitute environment. Harmful for habitats an environment is good for tourism can be point of view, for example Coastal defences, while necessary for infrastructure protection, and in the transfer of an erosion problem elsewhere along the coast produce significant impacts on coastal sediment budgets. The coast has the potential to be environmentally damaging logical result of this argument is that any activity which occurs along it (Melchers, 2014).

2.3 Corrosion

Corrosion is an electrochemical process. At the different specific level of sea water acidity and alkalinity (pH), zinc anode have its own corrosion potential. The other example of the corrosion in the sea water are pitting attack in stagnant sea water may be as much a problem as impingement and the erosion or cavitation attack at the high velocities (Llindley & Higgins, 2008).

Corrosion has the main effect to the cost of repair and renovation in most of the society issues that regard to human safety, and the conservation of materials also. There are many factors that effect to the corrosion occurs in the daily life. The most effect factor is surrounding environments such as humidity and temperature (Benedetti et al., 2009). Corrosion will destroys many metal elements by convert them into oxides that effect the global. Therefore, the kinetic corrosion can be investigated and observe through corrosion rate, changes of the surface, and the changes of the metal properties like microstructure (Crundwell, 2010).

Corrosion for the metal surface due to the reaction also can be notified as damage with the environment all around. The process for the mechanical reaction of the properties to be prevent are include (Mccafferty, 2009):

a) Proper selection of material and design.
b) The direct contact of material with the environment are coating, painting and oiling/greasing.
c) Corrosion inhibitors usage.
d) Cathodic protection and anodic protection

Corrosion also have the process of deterioration when exposed to an aqueous environment (water). In the chemical corrosion, metal components are chemically unstable in requires energy to convert oxides into pure metals. An oxide in the presence of water either, underwater or in the atmosphere make the metal will react and return to its natural state. Steel will degrade (oxidize) back to rust and due to their relative stability only copper and the precious metals (gold, silver, platinum) exist as metals in nature because they does not oxidise and rust. (Melchers, 2014).

2.4 Sacrifice anode

Metal in the sea water react with the sea water and create the sea as electrolyte. In normal situation, the metal will start to react and corrosion process will occur also with the degradation. The corrosion can be avoid by adding the zinc as a sacrifice anode. Sacrificial anode usually attached to the structure that want to be prevent from the corrosion. To prevent the damage of the corroded part, the resistance must be lowered between both elements.

Zinc has -0.76 Volts of the standard and the iron has -0.44 Volts. Because of this different value of the standard potential, the zinc will corrode first then the iron that make the zinc is sacrifice anode.