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Preface

The 2nd ICIEVE 2017, the International Conference on Innovation in Engineering and Vocational Education, held on October 25-26, 2017 at Aryaduta Hotel, Manado, North, Sulawesi, Indonesia, is hosted by Universitas Pendidikan Indonesia (Indonesia), Universitas Negeri Manado (Indonesia), and Rajamangala University of Technology Thanyaburi (Thailand).

The conference was a platform for scientists, scholars, engineers, industrial professionals, and researchers to exchange, share, and discuss their innovation, experiences, research works and problem solving techniques in all issues in engineering and vocational education.

The participants of ICIEVE 2017 were from around the world with a variety of background, including academics, industry, and even well-known enterprise. In general, there were 140 papers discussing such various topics as engineering and technology innovation (mechanical engineering, chemical engineering, civil engineering, etc.), engineering education (basic science in engineering education, engineering education reforms, new technologies in education, etc.), and vocational education and training (industry-driven training programs and collaborations, lifelong learning – reskilling and upskilling, government and policy, etc.).

We would like to thank all of those who helped and supported ICIEVE 2017. Each individual and institution's support was very important for the success of this conference. Specifically, we would like to acknowledge the advisory board, scientific committee, and organizing committee for their valuable advice, help, suggestions, and support in the organization and helpful peer-reviewing process of the papers. This year, we would like to express our deepest gratitude for all the co-hosts of ICIEVE 2017, UNIMA, Indonesia, and Rajamangala University of Technology Thanyaburi, Thailand for the collaboration. We would also extend our best gratitude to keynote speakers for their valuable contribution for sharing ideas and knowledge in the ICIEVE 2017.

We sincerely hope that ICIEVE 2017 will be a forum for excellent discussions for improving the quality of research and development in relation to innovation in engineering and vocational education. We also hope that this forum will put forward new ideas and promote collaborative researches among participants. We believe that the proceedings can serve as an important research source of reference and the knowledge. Indeed, the proceedings will lead to not only scientific and engineering progress but also other new products and processes for better science and technology in vocational education.

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Characteristics from Recycled of Zinc Anode used as a Corrosion Preventing Material on Board Ship

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Abstract. The objective of this research is to obtain the values of chemical composition, electrochemical potential and electrochemical efficiency. Methods used were experiment with physical tests conducted in metallurgical laboratory and DNV-RP-B401 cathode protection design DNV (Det Norske Veritas) standard. The results showed that the composition of chemical as Zinc (Zn), Aluminium, Cadmium, Plumbumb, Copper and Indium is suitable of standard. The values of electrochemical potential and electrochemical efficiency were respectively. However it can be concluded that the normal meaning of recycled zinc anode with increasing melting temperature can produce zinc anode better than original zinc anode and can be used as cathode protection on board ships. This research can assist in the management of used zinc anode waste, the supply of zinc anodes for consumers at relatively low prices, and recommendations of using zinc anodes for the prevention of corrosion on board ship.

1. Introduction

Corrosion is a degradation of a substance or its nature due to its interaction with the environment. The corrosion mechanism is very damaging to materials and equipment in the industrial structure [1]. Corrosion is assumed to be the result of three sequential processes: degradation of the paint layer, pitting point formation, and pitting point progress. Corrosion rate can be identified quantitatively. Modeling probabilistic corrosion by analyzing existing data collected from plate thickness measurements. Data is verified by comparing the approximate behavior of corrosion and dispersion progress with actual data [2].

The corrosion rate of the sacrificial anodes of Al-Zn-In-Mg-Ti in sea water is higher than that of sea mud [3]. Many types of corrosion such as pitting corrosion is a material failure mechanism of a component that occurs due to an aggressive environmental influence, this is indicated by the presence of chloride and sulphide that accelerate the corrosion process above 50-55^{0}C [4].

Steel is a metal that is widely used in marine ship structures that are strongly influenced by moisture and atmospheric ocean temperatures resulting in extremely vulnerable corrosion. So it is necessary to prevent by using sacrificial anode to reduce the corrosion rate. The marine environment is a corrosive environment which is as a factor that greatly affects metal degradation. Corrosion can occur continuously if there is no corrosion precaution on the metal [5]. Treatment needs to be done to minimize corrosion. There are several methods to protect material against corrosion commonly known as cathodic

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protection method (CP) and cathodic prevention (CPrev) [6]. Voltage generated by the anode can function as an antifouling on the hull of the ship [7].

Generally the conventional anode used as a sacrificial anode on board is the Aluminum-Zinc-Indium (Al-Zn-In) alloy. This type of alloy has high efficiency and high potential protection in the seawater environment [8]. Various types of sacrificial anodes such as Al-Zn-In-Mg-Ti have the same relative dissolution. Several factors affecting corrosion rates are conductivity and dissolved oxygen in seawater [3]. When electrochemical testing is applied, sampling for testing shall be carried out for each heat produced, and has to be standardized. Unless agreed by others, the testing shall be carried out according to the procedure in standard and the following acceptance criteria shall apply for Zinc based anodes electrochemical capacity: minimum 780 Ah/kg, closed circuit potential: $\leq$ -1.00 V [9].

Zinc is a type of metal widely used as a sacrificial anode to protect iron from rust as well as aluminum and magnesium. The working principle of the anode is metals such as zinc, aluminum, and magnesium, because it is more reactive to the carat element and has a lower oxidation point than the iron so that when mounted on other metals such as iron, it first reacts to the rust and neutralize the rust before attacking the iron. Anode can work because it is made of zinc, aluminium, and magnesium metal which is more active against corrosion than iron so that if installed adjacent to the arrangement based on the correct calculation, then the rust will go to the anode first. Due to its inherent nature, after a certain period the anode should be replaced to ensure maximum protection. The zinc anode work will increase naturally to a maximum level to protect the hull from corrosion caused by the high salinity content of seawater present in the ocean waters [10]. Recycling used products from metal to be used again has been done in many western countries [11]. Recycling allows the recovery of metal parts, reducing the resource requirements of the natural environment. Recycling will save natural resources, reduce pollute, and save energy [12].

2. Methods

The method used in this research is experimental method that goes through several stages: conducting test of making zinc anode by recycling used zinc anode; laboratory testing of recycled zinc anode product to obtain value of chemical composition, electrochemical potential value and electrochemical efficiency value. Tools and materials such as: Furnace, Brander, Cast/Mattress, Thermometer, Scales, Iron strip, Rubber gasket, Zinc anode, Calliper, Camera, ATK, Grinder, Epoxy, and Scissors/cutter.

Data was obtained in the form of quantitative data from laboratory test results include chemical composition, electrochemical potential value (V), and electrochemical efficiency value (Ah/kg) analyzed and compared with DNV standard.

3. Results and Discussion

This research started with the manufacture of zinc anode products using a zinc anode material. There are several stages on how to recycle, among others:

3.1. Preparing materials to be recycled (zinc anode) used

This material is obtained from zinc disposal waste from vessels that is docking. In accordance with the provisions of SOLAS and the provisions of the Classification Bureau of the vessel, which performs the annual dock, must perform zinc anode replacement.

3.2. Preparing the smelting equipment (furnaces, steel pans, fuel, scoop, tongs and other equipment)

This equipment must be available before starting the smelting work to make the smelting work process runs smoothly and safely.

3.3. Set up printing equipment

Mattress used for this research is sand casting, by sprinkling the powder on the mattress and then fill in the sand and solidify it by adjusting the shape of the mat. The compacting is done evenly to get the desired result

3.4. Melting Process

The melting of the material is carried out on a steel skillet above the furnace by directing the combustion directly on the material to be melted. Fuel used by LPG gas. The heated material melts at a temperature of 609 ° C in approximately 30 minutes and then stirs well and separates the dirt that floats on the surface of the already melted material.

3.5. Pouring

Pouring is done with a careful heart, by inserting the liquid material in the sand casting hole. The material liquid is put into the cast until it is full.

3.6. Opening the cast

After the material is put into the cast, the ingredients will be cooled for about 5 minutes, then the cast can be dismantled to retrieve the printed zinc anode results.

3.7. Finishing

The end of the zinc anode recycling casting work is to do the finishing including checking and smoothing.

Zinc anode testing was conducted in corrosion laboratory and material failure of Ten November Institute of Technology Surabaya. The tests were performed using DNV ((Det Norske Verity) standard to test the material characteristics [9].

3.8. Testing the chemical composition that is contained in the zinc anode.

The compositions tested include Zn (Zinc), Al (Aluminium), In (Indium), Cd (Cadmium), Fe (Iron / Ferro), Cu (Copper), Pb (Led / Plumbumb).

From the tests performed, the results are as listed in the table below.

Table 1. Comparison between DNV standard compositions with laboratory test results

Chemical Composition	Result (%Wt) Std DNV	Result (%Wt) Lab
Zn	rem	99.300
Al	0.10-0.50	0.333
In	na	0.002
Cd	≤0.07	0.029
Fe	≤ 0.005	< 0.002
Cu	≤0.005	0.021
Pb	≤0.006	0.015

Table 1 illustrates that the Zn composition of the tested product is 99.300% Wt and this proves the Zinc compound is excellent. Aluminium Composition 0.333% Wt is in the range between 0.10-0.50% Wt indicating under normal conditions. Indium composition is not specified on the standard while the results of the lab test are 0.002% Wt. Standard Composition Cadmium ≤ 0.07% Wt is 0.029% Wt in accordance with the provisions. Copper Composition Standard ≤ 0.005% Wt turns out in the laboratory test 0.021% Wt as well as the standard value of Plumbumb composition ≤ 0.006% Wt on laboratory test 0.015% Wt. Of the eight chemical compositions, Copper has a difference of 0.016% Wt and Plumbumb 0.009% Wt. Since both are the last compositions of relatively small values in Zinc Anode material, they are still categorized as normal.

3.9. Potential Electrochemical Testing and Electrochemical Efficiency

The results of testing the characteristics of Electrochemical Potential and Electrochemical Efficiency are as in Table 6.

Table 2. Comparison of Potential Electrochemical and Electrochemical Efficiency between DNV standard and Laboratory test results

Characteristics	DNV Standard	Test in Lab
Electrochemical Potential (V)	≤ -1.00	-1.07
Electrochemical Efficiency (Ah/kg)	780	842

Referring to the DNV standard that the required potential electrochemical quantity is ≤ -1.00, while the test result shows -1.07, it means that the electrochemical potential in the recycled zinc anode is adequate (or qualified). Similarly, electrochemical efficiency at a minimum standard is 780 whereas in a recycled zinc anode shows 842, it can be defined that it is adequate with the required standard.

4. Conclusions

Process for the zinc anode by recycling zinc anode former takes approximately 30 minutes and a melting temperature of 609 ° C to obtain a higher percentage of remaining zinc 99.30%. The results of laboratory tests on the chemical composition performed in the laboratory of corrosion and material failure Institute of Technology (ITS) Surabaya, is normal, which means that the recycled zinc anode can be used as protection / cathode protection in preventing corrosion on ships.

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