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The Analysis of the Crevice Corrosion Rate of AISI 1020 Steel Due to Speed Flow of Seawater

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ABSTRACT--*Crevice corrosion is local corrosion that usually occurs between similar metal joints in a closed section of the gap or on cracks within the metal surface. The specimens used in this study were AISI 1020 ring-shaped steel with a thickness of 2 mm, a hole diameter of 8 mm, and a surface diameter of 23 mm of 24 specimens. The purpose of this study is to determine the extent of seawater fluid flow velocity to the AISI 1020 carbon steel crevice corrosion rate. The process of crevice corrosi on rate testing is carried out by dipping the test method into the seawater environment which is given temperature treatment and seawater fluid flow velocity, with time for 5 hours, 10 hours, 15 hours, and 20 hours periodically. The test results the rate of crevice corrosion is strongly influenced by the temperature and flow velocity of the fluid passing through it and the largest corrosion rate is 0.109 mpy at 30℃ temperature conditions with a testing time of 20 hours and a flow speed of 2.05602 m/s.*

Keywords—*analysis, crevice, corrosion, speed flow, seawater*

I. INTRODUCTION

Corrosion problems have been discovered since the early use of metals in human civilization (Callister, 2000). In many cases corrosion is inevitable but we can try to control it. Many types of corrosion that can occur in an environment, especially for industries located on the beach (Fontana, 1987). These types of corrosion indicate the importance of controlling corrosion in an environment.

Pattireuw, 2013, conducted a study to determine the corrosion that occurs in carbon steel and copper alloy materials. Weight loss due to corrosion is closely related to time, in other words, the more the time of dyeing the greater the weight loss that occurs. the results of corrosion rate testing carried out within 3 hours, obtained an average value for specimen I in carbon steel and copper alloys in a solution of seawater is 1,350 mils/year and 0.015 mils/year. Whereas the sulfuric acid solution is 1,400 mils/year and 1,306 mils/year

Rahmaniati. et al., 2011, conducted a study to study the effect of time on microbiological corrosion which was applied to API 5L Grade B carbon steel material. The environmental media used in this study was formation water from the injection system of an oil and gas company in Indonesia. The corrosion rate calculated by the weight loss method shows that the value continues to decrease with the addition of time where the three-day period has the largest corrosion rate of 5,080 mpy and the smallest corrosion rate occurs in the fifteen-day immersion period with a value of 1,874 mpy.

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Sasono, 2010, conducted a study to determine the effectiveness of the use of aluminium alloy sacrificial anodes as cathodic protection of hull plates and determine the need for sacrificial anodes to slow the rate of corrosion of hull plates in seawater media. Test specimens for laboratory experiments were AISI E 2512 steel plates, three different types of aluminium alloy sacrificial anode products (product A, Al = 86.118%, product B Al = 85.097% and product C Al = 97.665%) and using seawater media. Corrosion test results in the laboratory can prove that among the three aluminium alloy sacrificial anodes installed on the steel plate of the AISI E 2512 ship, the one that has the most optimal performance is the aluminium alloy sacrificial anode product C, with the average corrosion rate on the lowest steel plate of 0,065 mm/year.

This research is motivated by previous research that research on corrosion especially in crevice corrosion but with different variations or parameters. Most of the damage to building construction equipment and structures is caused by corrosion processes that occur in the environment.

II. MATERIALS AND METHODS

The ASTM G78 method is a standard guideline for testing crevice corrosion in iron alloys and nickel stainless alloys in seawater and other aqueous environments containing chlorides. The ASTM G78 guidelines contain information on procedures for conducting crevice corrosion tests and identifying any factors that can influence crevice corrosion.

The procedure in ASTM G78 can also be used to identify conditions that are most likely to cause crevice corrosion and provide a basis for assessing the relative resistance of various alloys to crevice corrosion under certain conditions. The corrosion rate is the speed of decline or the speed at which material quality decreases with time. The weight-loss method is a calculation of the rate of corrosion by measuring the lack of weight due to corrosion that occurs. This method uses a research period to get the amount of weight loss due to corrosion that occurs. To get the amount of weight loss due to corrosion used the following formula:

Corrosion Rate (CR), $$CR = \frac{534.W}{D.A.T} \qquad (1)$$

The crevice corrosion test was carried out based on the ASTM G 31-72 standard (standard recommended the practice for laboratory immersion corrosion testing of metal) for 20 hours with intervals of 5 hours, 10 hours, 15 hours and 20 hours. The specimens observed were AISI 1020 steel. The test specimen used for this test was a ring which had a flat surface area based on the surface area to be calculated theoretically, in the form of a metal sphere measured by a thickness of 2 mm, a hole diameter of 8 mm, and a surface diameter of 23 mm of 24 specimens. The specimens to be used, as shown in Figure 1.

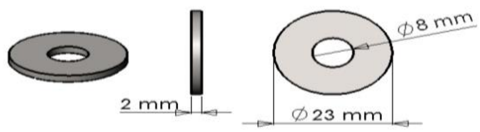

Figure 1: The dimension of test specimen

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Furthermore, the specimen is marked so that the identity of the specimen is identified according to each test time between 5 hours, 10 hours, 15 hours, and 20 hours periodically, so there was no error during the data processing. In this case the marking of sequential specimens in alphabetical order, according to the crush of rubber gasket of the same type by the length of each test time that has been determined.

Weighed specimens, then merged by combining them into one bond between AISI 1020 steel specimens with rubber gaskets, fastened using bolts with a diameter of 6.5 mm and nuts with a hole diameter of 7 mm, as shown in Figure 2.

Figure 2: Merging Specimens

The electrolyte solution used in this test is seawater that complies with ASTM D1141-98 standards (standard practice for the preparation of substitute ocean water). Seawater used in seawater taken from the coast of the West Hagu Village of Kec. Banda Sakti, Lhokseumawe, with a NaCl level of 2.8% was tested using a salt content test (refractometer).

In this test, the container used is made of stainless steel. The temperature of the fluid test in the container ranges from 30 ℃ with a constant flow rate of fluid in seawater. The tool used in this test is designed in Figure 3.

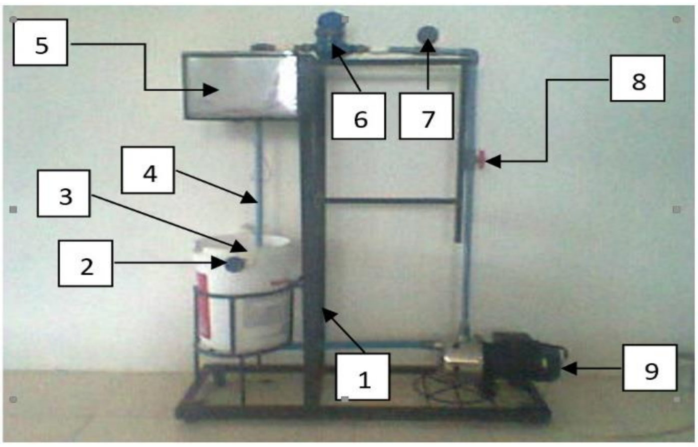

Figure 3: Corrosion Rate Test Equipment

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In the immersion step, specimens that have been merged are then immersed in a stainless steel container containing seawater with the state of the seawater flowing using a circulatory system tool, through one component of the tool namely a PVC pipe. The first immersion is done in 5 hours. Then the specimens that have been tested, cleaned and took the results of the test data, after that the second immersion was carried out with 10 hours, the third immersion with 15 hours, and the fourth immersion with 20 hours with the same steps as in the first immersion step. During the dyeing process, it is observed and records the phenomenon of corrosion that occurs in the steel in solution.

III. RESULTS AND DISCUSSION

The influence of the environment, especially seawater with 2.8% NaCl levels is very dangerous to the corrosion rate of metals that are susceptible to corrosion. Electrochemical processes play a major role in corrosion. There are four components of corrosion in cells, namely the presence of anode, cathode, electrolyte, and the presence of an electric current between the anode and the cathode.

In the immersion test, the condition of seawater is varied by being given a temperature treatment of 30 ℃ and the presence of seawater fluid flowing. With the variety of treatment, it will be seen the extent of the influence of fluid flow on the rate of metal corrosion which has been merged into one bond between AISI 1020 steel material with rubber gaskets, from each test time between 5 hours, 10 hours, 15 hours, and 20 hourly periodically into a stainless steel container filled with seawater that is given a temperature with the condition of the state of seawater that is flowed using a circulation system tool.

Theoretically, it is necessary to calculate the average flow rate of fluid flow. The purpose of calculating the fluid flow velocity is to predict the corrosion rate of AISI 1020 steel. From the results of calculations and data retrieval, the flowrate Q = 2.08275 m^3/s is obtained, and the fluid flow velocity U = 2.05602 m/s. So to find out whether the fluid flow is laminar or turbulent flow, we can assume by following the Reynold equation. From the calculation of Reynold's number, the value obtained is Re = 78132.77 so it can be assumed that the flow used at the time of the study is turbulent.

Comparison of the average corrosion rate of specimens with test time for 5 hours, 10 hours, 15 hours, and 20 hours periodically in a stainless steel container with crushed rubber gaskets of the same type can be seen in Figure 4 the following corrosion rate graph.

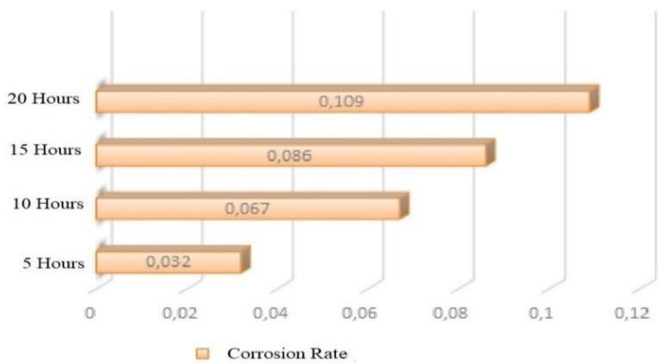

Figure 4: Average Values of Gap Corrosion Rates

From Figure 4. It can be seen an increase in the corrosion rate between the testing time of 5 hours and 10 hours. An increase in the average corrosion rate that occurs by 0.035 Mpy or an increase of more than 100% shows the magnitude of the corrosion reaction that occurs in the rubber gap and the amount of Cl-trapped by turbulent flow which also increases O_2 levels in the fluid. Oxygen is a strong oxidizer so that it will increase the corrosion potential of metals in aqueous (fluid) environment containing dissolved oxygen (Roberge, 2007).

By comparison of the same test time between 10 hours and 15 hours, it was seen that the corrosion growth occurred was lower around 0.019 Mpy. Furthermore, the average corrosion rate that occurs at the time of testing 15 hours to 20 hours also shows a comparison value of 0.023 Mpy. The phenomenon of decreasing the corrosion rate with a variety of testing time up to 20 hours shows the influence of high temperatures causes a decrease in the level of O_2 dissolved in the fluid (Roberge, 2007). Besides, saturated fluids that continue to circulate for 20 hours are also analysed as a cause of decreased corrosion rate.

IV. CONCLUSIONS

From the results of research that has been done related to the analysis of the crevice corrosion rate of AISI 1020 steel due to the speed flow of seawater, it can be concluded that the rate of crevice corrosion is strongly influenced by the temperature and flow velocity of the fluid passing through it. Significant corrosion rates occur when Oxygen (O_2) is available in a large enough gap and seawater fluid containing salt (NaCl 2.8%) is a corrosive solution. With the results of this study, it is hoped that we can map and predict the corrosion that will occur if using metal materials in a coastal or marine environment.

V. ACKNOWLEDGMENTS

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