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CORROSION STUDY OF SS316L IN ENVIRONMENT SULPHUR ACID USING WEIGHT LOSS METHOD

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Abstract *-- Application of SS 316 metal is commonly used as a building material in the chemical industry. This material is commonly used because it has good mechanical properties, corrosion resistant, but in reality, the SS 316 L metal can corrosive its acid environment, making it easy to solve the problem. corrosion. Therefore, this study is aimed to study SS316L corrosion level in H_2SO_4 acid by using weight loss method with 1 day, 3 days and 5 days immersion in H_2SO_4 environment with concentration 0,1 M, 0,3 M and 0,5 M The results showed that the corrosion rate increased with increasing concentration of H_2SO_4 and yield up to 5 days with average corrosion rate (CR) 2.729078 x 10-6 mpy. Morphological damage SS 316 L is demonstrated by SEM (Electron Microscope Scanning) there is a pitting corrosion on the metal surface*

Keywords*: SS316L; Corrosion; Corrosion rate; Weight loss*

INTRODUCTION

Stainless Steel (SS) 316 L, is a corrosion-resistant alloy, widely used in chemical, fertilizer, food and beverage industries (Raharjo et al., 2015; Morena et al., 2015; Frangini and Zaza, 2011) and one of them is used as a material on bipolar plates in PEM fuel cell, with composition (16,2% Cr; 10,3% Ni; 2,06 % Mo; 0,033 %P; 0,021% C; 1,48% Mn; 0,43% Si; 0,43% Cu; balance Fe) (Shanmugham and Rajendran, 2015). Metal corrosion mechanism in an acidic environment, oxidation reaction (Yang et al., 2011):

$$M \rightarrow M^{n+} + ne^- \quad (1)$$

where M is a metal element, Mn + is a metal ion and e is a free electron which is soluble in acid solution, whereas a reduced reaction can occur;

$$O_2 + 4H^+ + 4e \rightarrow H_2O \quad (2)$$

where M is a metal element, Mn + is a metal ion and e is a free electron which is soluble in acid solution, whereas a reduced reaction can occur.

One reason is that most metals are always associated with open air where humidity and pollutant contents may affect metal leakages. Factors such as temperature, humidity and chemical content in the air determine the degree of corrosion (Bandriyana et al., 2014). Meanwhile, metal composition, metallurgical structure, and metallurgical processes also accelerate corrosion. Corrosion is a difficult metal problem, dangerous and very expensive if not treated. Generally, corrosion is a metal deterioration due to a reaction between metals and the surrounding environments. The important types of corrosion are uniform, galvanic, crack, current-assisted, intragranular and high-temperature corrosions (Priyandoko, 2017; Azar et al., 2010; Fontana, 1998). Corrosion results from a low pH effect of water in which H^+ ions react with electrons in cathodes. The factors that can cause corrosive metals are pH, oxygen content, air, metal and temperature (Raharjo et al., 2015; Vadivelan et al., 2015). Corrosion prevention in a metal can be done in several ways, such as cathodic protection, coating and can use also use inhibitor. Inhibitor use green is the new trend in corrosion control (Sutharssan et al., 2017; Abu-Dalo et. al., 2012). SS 316 L metal application is commonly Corrosion used as a building material in the chemical industry, material is commonly used because it has good mechanical properties, corrosion resistant, but in reality, SS 316 L metal can corrosive its acid environment, making it easy to solve the problem (Yang et al., 2011).

Therefore, this study is aimed to study SS316L corrosion level in H2SO4 acid by using weight loss method with 1 day, 3 days and 5 days immersion in H_2SO_4 environment with concentration 0,1 M, 0,3 M and 0,5 M The results showed that the corrosion rate increased with increasing concentration of H_2SO_4 and yield up to 5 days with average corrosion rate (CR) 2.729078 x 10-6 mpy. Morphological damage SS 316 L is demonstrated by Electron Microscope Scanning (SEM) there is a pitting corrosion on the metal surface.

The SS 316 L metal application is commonly used as a building material in the chemical industry, this material is commonly used because it has good mechanical properties, corrosion resistant, but in reality, the SS 316 L metal can corrosive its acid environment, making it easy to solve the problem (Antunes et al., 2010; Feng et al., 2011). Therefore, this study is aimed to study SS316L corrosion level in H_2SO_4 acid by using weight loss method with 1 day, 3 days and 5 days immersion in H_2SO_4 environment with concentration 0,1 M, 0,3 M and 0,5 M The results showed that the corrosion rate increased with increasing concentration of H2SO4 and yield up to 5 days with average corrosion rate (CR) 2.729078 x 10-6 mpy. Morphological damage SS 316 L is demonstrated by SEM (Electron Microscope Scanning) there is a pitting corrosion on the metal surface.

METHOD

The method used in this research is, by weight loss method from SS316L test sample with surface size 1cmx1cm immersed in H_2SO_4 acid solution with concentration 0.1M; 0.3M and 0.35M in immersion time 1 day, 3hari and 5 days, then weighing the initial weight and after immersion to get the value of weight loss, the corrosion rate can be calculated by the following equation (Sumarji, 2012; Ornelasari, 2015).

$$\text{Corrosion rate (CR)} = (K \cdot W) / (A \cdot T \cdot D) \quad (3)$$

where:
K = costanta corrosion rate (5,44 x 10^{-2})
T = immersion time (hour)
W = weight loss (gr)
D = Dencity (g/cm^3)
A = surface area (cm^2)

The morphology and surface of 316L stainless steel specimens were examined after polishing and after explore to 0.5 M Sulphur acid (H_2SO_4) using scanning electron microscopy (SM).

RESULTS AND DISCUSSION

Weight Loss Method

Based on the result of research of SS316 L metal after soaking in an environment of sulfuric acid (H_2SO_4) with concentration 0,1 M, 0,3 M and 0.5 M at soaking for 5 days have highest average weight loss equal to 0,0062 gram, 0,0052 gram, and 0.0160 gram. Based on the calculation of the average value of corrosion rate is increasing along with the increase of the concentration of sulfuric acid (H_2SO_4), for more details can be seen the difference of weight loss at different concentration of H_2SO_4, as seen in Fig. 1.

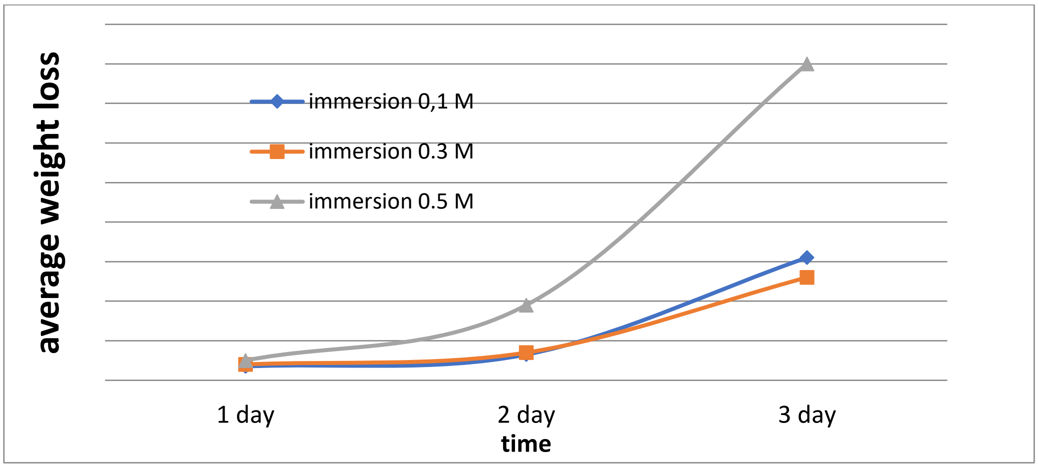

Figure 1. Graphs Weight loss of SS 316 L in H_2SO_4 environment against immersion time

The result of corrosion rate analysis (CR) using SS 316 L method in H_2SO_4 environment showed increasing of H_2SO_4 concentration and the longer the immersion was obtained, the corrosion rate value was increasing, the biggest value was at the concentration of 0.5 M H_2SO_4 and the immersion time for 5 days 2.729078 x 10^{-6} mpy as shown in Fig. 2. This happens because the SS316L metal has been oxidized and corrosion due to the presence of a corrosive acid solution.

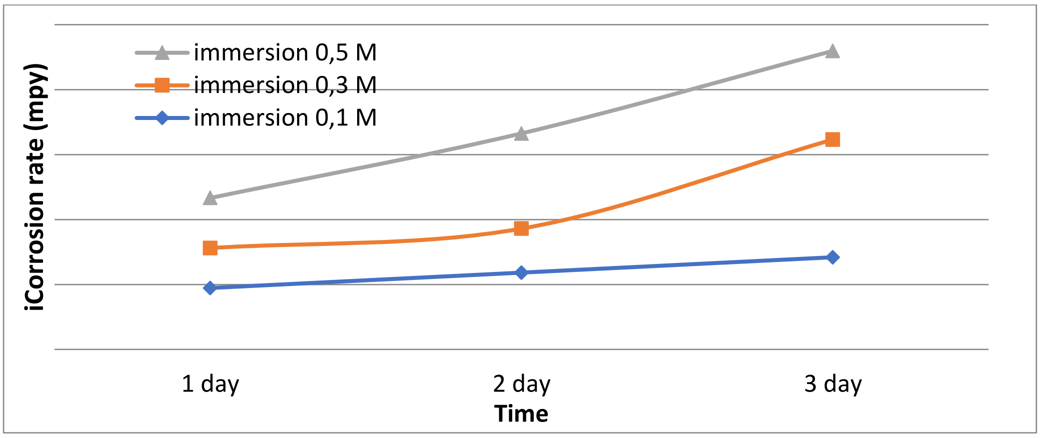

Figure 2. Graph SS 316 L corrosion rate in the H_2SO_4 environment against immersion time

To see the surface morphology of the SS 316L test material before soaking and after soaking 5 days (120 hours) it is seen that the immersion test material as shown in Fig. 3, shows that the surface has not yet detected corrosion damage which looks subtler than the test material after immersion.

Metallic surfaces in certain locales are damaged by passive layers in the form of pitting holes in certain areas that have been oxidized in advance of the possibility of this occurring because locally in the initiation of damage or defects of the metal, so that the local first suffered damage due to the environment H_2SO_4 is corrosive, whereas in certain local locale is still passive as able to see in Fig. 4.

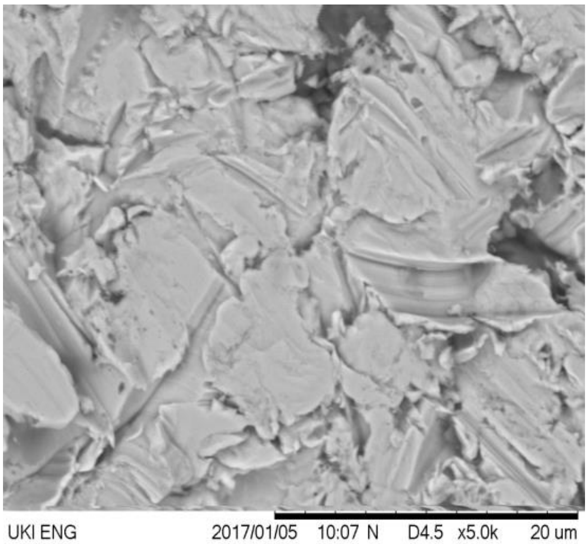

Figure 3. Photo SEM surface morphology SS136L without immersion 0.5 M H_2SO_4

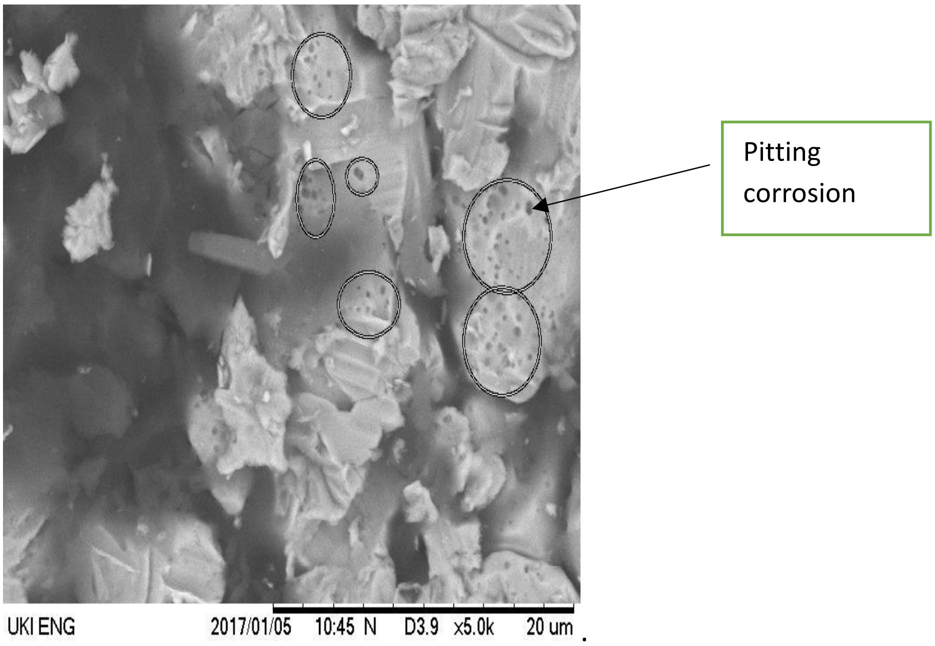

Figure 4. SEM photo, surface morphology of SS316L, with immersion of 5 days in 0.5 M H_2SO_4

CONCLUSION

Result of analysis of SS316L using weight loss method and SEM (Scanning Electron Microscope) got the value of corrosion rate (CR) SS316L after immersion with sulfuric acid (H_2SO_4) with concentration 0.1 M, 0.3 M and 0.5 M which has the biggest corrosion is 1.055319 x 10-6 mpy and immersion time for 5 days with a concentration of 0.5 M. while for the smallest corrosion rate of 1.41844 x 10-7 mpy, the longer the immersion time will get the value of corrosion rate is increasing. Using the SEM device with 5000x magnification can see the surface morphology of the SS316L test material immersion value of corrosion that will occur will be marked by the presence of local blasting corrosion of the metal surface, it indicates that the local defect on the metal surface will be the first corrosion and corrosion to rise with an increase sulfuric acid concentration.

REFERENCES

Abu-Dalo, M.A., Othman, A.A. and Al-Rawashdeh, N.A.F. (2012). Exudate Gum from Acacia Trees as Green Corrosion Inhibitor. *International Journal of Electrochemical Science*. 7;9303-9324.

Antunes, R.A., Oliveira, M.C.L., Ett, G. and Ett, V. (2010), Corrosion of metal bipolar plates for PEM fuel cells: A review. *International Journal of Hydrogen Energy*. 35 (8) : 3632–3647. http://dx.doi.org/10.1016/j.ijhydene.2010.01.059

Azar, V., Hashemi, B. and Rezaeeyazdi, M. (2010). The Effect Of Shot Peening on FatiGue And Corrosion Behavior Of 316L Stainless Steel in Ringer's Solution. *Surface and Coatings Technology.* 204(21), 3546-3551. http://dx.doi.org/10.1016/j.surfcoat.2010.04.015

Bandriyana, B., Prajitono, D. and Dimyati, A. (2014). Effect of Copper Addition on High Temperature Oxidation of Zirconium Alloy ZrNbMoGe for Advanced Reactor Fuel Cladding Material, *Advanced Material Research.* 896, 617-620. http://dx.doi.org/10.4028/www.scientific.net/AMR.896.617

Feng, K., Wu, G., Li, G., Cai, X., and Chu, P.K. (2011). Corrosion behavior of SS316L in simulated and accelerated PEMFC environments. *International Journal of Hydrogen Energy.* 36(20), 13032-130042. http://dx.doi.org/10.1016/j.ijhydene.2011.07.058

Fontana, M. G, (1998). Corrosion *Engineering* 3rd Ed. Singapore: McGraw-Hill Book Company.

Frangini, S. and Zaza, F. (2011). Anti Corrosion Methods for Fuel Cell Metal Bipolar Plates: A Review of Recent Patent Literature. *Recent Patents on Corrosion Science.* 1 (2), 93–107. http://dx.doi.org/10.2174/2210683911101020093

Morena, N. G., Molina, M.C., Gervasio, D., and Robles, J.F. N. (2015) . Approaches to polymer electrolyte membrane fuel cells (PEMFCs) and their cost. *Renewable and Sustainable Energy Reviews.* 52, 897–906. http://dx.doi.org/10.1016/j.rser.2015.07.157

Ornelasari, R. (2015). Analisa laju Korosi Pada Stainless Steel 304 menggunakan Metode ASTM G31-72 pada Media Air Nira Aren. *Jurnal Teknik Mesin* 1(1), 112-117.

Priyandoko, G. (2018). Non-Destructive Leak Detection in Galvanized Iron Pipe using Nonlinear Acoustic Modulation Method. SINERGI. 22(1), 19-23. http://dx.doi.org/10.22441/sinergi.2018.1.004

Raharjo, R., Widodo, T.W., Wardhana, B.S & Wahyutama, S. (2015). Tingkat Kekerasan Permukaan Stainless Steel 316L. Akibat Tekanan. *Proceeding Seminar Nasional Tahunan Teknik Mesin XIV (SNTTM XIV),* Banjarmasin, Indonesia.

Shanmugham, C. and Rajendran, N. (2015). Corrosion Resistance of Poly p-phenylenediamine conducting polymer coated 316LSS bipolar plates for Proton Exchange Membrane Fuel Cells. *Progress in Organic Coatings*. 89;. 42-49. http://dx.doi.org/10.1016/j.porgcoat.2015.07.023

Sumarji, S. (2012), Evaluasi Korosi Baja karbon Rendah ASTM A36 Pada Lingkungan Atmosferik di Kabupaten Jember, *Jurnal ROTOR.* 5(1); 44-51.

Sutharssan, T., Montalvao, D., Chen, Y.K., Wang, W., Pisac, C. & Elemara, H. (2017). A review on prognostics and health monitoring of proton exchange membrane fuel cell. *Renewal and Sustainable Energy Reviews.* 75 ; 440–450. http://doi.org/10.1016/j.rser.2016.11.009

Vadivelan, R.M, Kumar, S.N. and Balaji, R. (2015). A Review on Corrosion of Metallic Bi-Polar Plates for Proton Exchange Membrane (PEM) Fuel Cells. *IOSR Journal of Mathematics (IOSR-JM).* 11(6)V6, 83–99.

Yang, Y., Guo, L., & Liu, H. (2011). Corrosion Characteristics of SS316L as bipolar plate material in PeMFC cathode environments with different acidities. *International Journal of Hydrogen Energy.* 36(2);1654-1663. http://dx.doi.org/10.1016/j.ijhydene.2010.10.067