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The Effect of Material Heat Treatment on Hardness and Corrosion Rate in 319 as Aluminum Alloy

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----------***ABSTRACT***----------
The hardness value for the 319 as cast aluminum alloy with an average value of 45.2 HRB and the average hardness value for the 319 aluminum alloy treated with 63.6 HRB there is an increase in the hardness value of 71%, the corrosion rate for the 319 as aluminum alloy is as big as 0.1655 mpy while for aluminum heat treatment alloy has a corrosion rate of 0.0226 mpy, there is an increase in corrosion resistance of 7.3% so that the corrosion resistance of the 319 aluminum alloy heat treated is better than the corrosion resistance of the 319 as aluminum alloy, thus heat treatment on material has a positive effect on the value of hardness and corrosion rate of the material.
KEYWORDS: *Scrap, Hardness, Heat treatment, Corrosion rate*

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I. BACKGROUND

Aluminum is a lightweight metal that has good corrosion resistance. This material is used in a broad field not only for household appliances but also used for industrial purposes, for example for the aircraft industry, ship industry, automobile components, regulator components and other constructions. Apart from these properties aluminum is also cheap and easy to obtain, so the use of aluminum as a base material from time to time is increasing. As a result of the increase in the use of aluminum as a base material so that the amount of aluminum that is not used anymore has increased so that a new problem arises, namely the accumulation of waste. Therefore, an effort is needed to recycle the aluminum waste so that it can be utilized again into a new product. Most small metal casting companies do not use pure aluminum, but use scrap or reject material from previous casting materials. So that this affects the results and quality of the goods produced. Therefore, the strength and composition of aluminum alloy must be tested properly. In the manufacture of components the ship must have the technical specifications of the user. Some ship components are determined by the user, in addition to the technical specifications must also meet the standard. Standardization must be fulfilled in order to achieve safety and comfort for both passengers and the ship itself. Hardness is one of the material mechanical properties that shows the strength of the material. Good mechanical properties and material resistance to corrosion are very important to know in order to produce a quality and quality vessel component. This research was conducted to find out how much the effect of heat treatment material on the value of hardness and corrosion rate of the material.

II. METHODOLOGY

The method used in this research is descriptive and experimental methods so that data can be obtained regarding the effect of heat treatment on the hardness and corrosion rate of the material

Determination of Aluminum Alloy Test Materials

The aluminum alloy to be used in this study is an alloy with the target chemical composition approaching alloy 319, from mechanical properties this alloy has considerable tensile strength which is equal to 27 ksi or 186,158 N/mm2 for as cast and 36 ksi or 248,211 N/mm2 for T6, besides good mechanical properties, materials that are more environmentally friendly are also needed.
The alternative material that is more environmentally friendly is obtained from scrap aluminum alloy, because this material is quite abundant in Indonesia.

The data on the chemical composition of each scrap can be obtained from the results of tests conducted by researchers on various types of scrap with abundant market availability, so that the chemical composition data is accurate so that the simulation results approach or match the real composition in the range the percentage required by the existing standard, then the scrap that will be used in the research after being sampled to test the chemical composition is made into ingots which have clear chemical composition.

Figure 1. Ingot scrap

To calculate what percentage of scrap will be used from various types of scrap, the chemical composition of each scrap must be recorded in advance and what aluminum alloy will be used. To make it easier to determine the chemical composition of each aluminum scrap and the chemical composition data of each scrap is accurate, the researchers made the aluminum scrap scrap into an ingot that is ready to be used to make the desired aluminum alloy.

Scrap Type	Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Ni	Pb	Sn	Al
Elbow	0.482	0.442	0.134	0.076	0.500	0.134	0.016	0.011	0.007	0.044	0.005	98.1
Hanger	0.533	0.216	0.042	0.004	0.498	0.007	0.004	0.001	0.002	0.0005	0.002	98.6
Piston	13.277	0.409	1.456	0.107	1.034	0.048	0.072	0.022	1.020	0.012	0.015	82.5
Plate	0.162	0.479	0.106	0.072	0.025	0.080	0.009	0.004	0.004	0.008	0.003	99
Engine Block	10.812	0.733	1.728	0.255	0.197	0.689	0.035	0.027	0.199	0.063	0.017	85.2
Gear	10.254	0.941	2.236	0.203	0.082	0.791	0.034	0.038	0.072	0.061	0.023	85.2
Wheels	7.112	0.444	0.169	0.045	0.318	0.433	0.094	0.010	0.014	0.060	0.005	91.2
Aircraft Scrap	0.139	0.216	0.046	0.639	4.345	0.011	0.015	0.113	0.004	0.0002	0.000	94.4

Table 1. Data on the composition of aluminum scrap chemical from the test results

Casting of Test Material

After the raw material is made into ingots, it is then weighed according to the results of calculations that have been done using a calculation simulation process, then casting the test material. The casting process begins with heating kowi around 10 to 15 minutes so that the temperature reaches 200-300°C as shown in figure 2.

Then the weighed ingredients are inserted into the kowi little by little, after the raw material has been seen to melt everything then stirred to make sure all the material has melted all, when the liquid has reached 680°C input into the Degasser tablet 850 HS liquid with Nitrogen base material that functions to bind hydrogen gas, tablet degasser dipped in liquid and bubbles will emerge air from inside the liquid, this treatment takes about 10 minutes.

Figure 2. Degasser administration in cast fluids

After the process of giving the tablet degasser to the liquid manure will float and then discarded from the liquid, after making sure the liquid is clean from the dirt sprinkle the fluk covering as much as 0.5 to 1% of the weight of the liquid and leave for 2 minutes, after finishing giving fluk covering and temperature the liquid has reached 701°C then the liquid pouring process is carried out into the mold.

Figure 3. Pouring liquid into the mold

***Heat Treatment* Material**

To improve the physical and mechanical properties of the material by changing the microstructure of the material, heat treatment was carried out, in this study the heat treatment was carried out using the T6 Solution Heat Treatment method, the sample was heated at 504°C for 12 hours; then dipped (quenching) into hot water (66-100°C); then Aging at 154°C for 2-5 hours.

Figure 4. Furnace for heat treatment

Material Testing

Chemical Composition Test

This test aims to determine the percentage content of alloy elements contained in the test object. Tests were carried out using spectrotest-ARL 3460 test equipment that works automatically, testing was carried out by firing on the surface of the test sample which had been smoothed with argon gas emissions so that the elemental elements contained in the test sample were obtained.

Material Hardness Test

Material hardness test is the most effective test to test the hardness of a material, because by this test we can easily know the picture of the mechanical properties of a material. Even though measurements are only carried out at a certain point or area, the value of hardness is sufficiently valid to state the strength of a material. By conducting a hard test, the material can be easily classified as a ductile or brittle material. In this study the test was carried out by the Rockwel method.

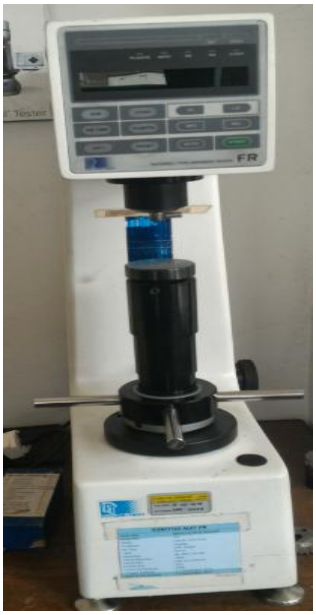

Figure 5. Rockwell FR-Ie Future-Tech Corp hardness testing machine

Material Corrosion Test

Corrosion testing will be carried out in this study using the polarization method because it does not require a long time to get the results of the corrosion rate. The equipment used in the form of grinding paper (grinding paper), polarizing flask where linear polarization cells are placed with three electrodes, a potentiostat, a voltmeter and a computer system.

Samples that have been cut with a diameter of 1 cm with a thickness of 20 mm are weighed and sanded with grinding paper with hardness of 40, 80, 320, 500, 1000 and 1200 then the sample is washed with acetone until clean, attaching the working electrode to the electrode holder. The clean sample is input into the polarizing flask that has been filled with sea water as the medium which has been placed working electrodes, auxiliary electrodes, and reference electrodes.

Incorporating polarization parameters such as density, scan rate and potential limits in the M 342 software made by Princeton Applied Research's EG & G Research, the polarization potential testing procedure refers to ASTM G5.

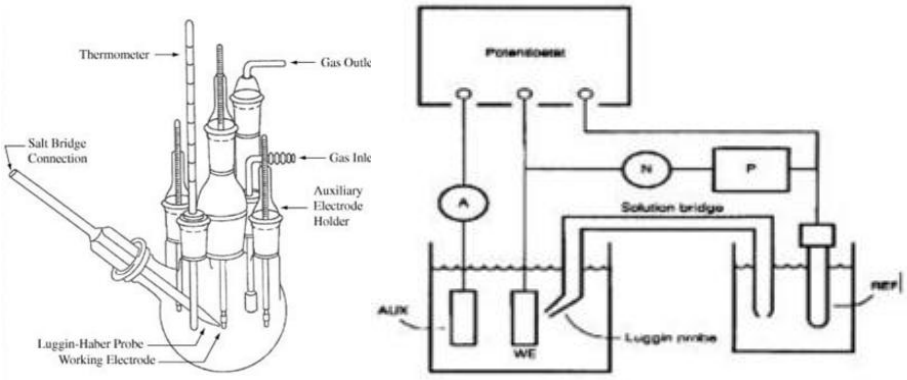

Figure 6. Polarization and polarization cell series circuit scheme (ASTM G5)

III. RESULTS AND DISCUSSION

Casting Alloy Chemical Composition Test

The purpose of this test is to determine the chemical composition of elements of alloy material, in general for the macro composition of alloy casting results of the 319 approach using scrap material consisting of 71.4% scrap, 14.4% AlC_{u10} and 0.7% ingot Zn has met the required standards, such as Si elements in the chemical composition of the test results of 6.17% are still in the range required by the standard composition of 5.5-6.5%, for Fe elements in the real composition of 0.824% while in the composition standard 1% there is a deficiency of 0.176%, the Cu element in the composition of the test results of 3.97% is still in the standard composition range of 3-4%, the Mn element in the composition of the test results is 0.121% while in the standard composition 0.50% there is a deficiency of 0.379% of the composition of the results, the element of Mg in the composition of the test results is 0.17% while in the standard composition 0.10%, for the element of Zn the composition of the results is 1.26% while the composition of the standard is 1.0%.

Element	Alloy	Si	Fe	Cu	Mn	Mg	Zn	Al
%	Standard	5.5 – 6.5	1.0	3.0 – 4.0	0.50	0.10	1.0	Residual
%	Test Result	6.17	0.824	3.97	0.12	0.17	1.26	Residual

Table 2. Standard chemical composition and results of testing 319 aluminum alloys

Aluminum Alloy Hardness Test

Material hardness testing is the most effective test to test the hardness of a material, because with this test we can easily find out the picture of the mechanical properties of a material. Even though measurements are only carried out at a certain point or area, the value of violence is sufficiently valid to state the strength of a material. By conducting a hard test, the material can be easily classified as a ductile or brittle material, testing of the material is carried out with two

considerations, namely to determine the characteristics of a new material and see the quality to ensure a material has certain quality specifications.

Testing of violence in this study was carried out in the mechanical test lab of the Manufacturing Polytechnic of Bandung using Rockwell FR-1e hardness test equipment with a capacity of 60,100 and 150 kgf. Rockwell method hardness testing uses an indenter in the form of a hardened steel ball or can also use an indenter in the form of a diamond cone, the load or force used for emphasis varies depending on the metal being tested. The hardness value is based on the depth of indentation that occurs. The hardness value of this study uses a B scale written with HRB because the material or metal tested is relatively soft and uses a steel ball with a diameter of 1.6 mm with a load of 100 kilograms.

From the test results on the 319 as aluminum alloy and the heat treatment results obtained as in the table and graph below:

Alloy Name	Testing					
	1	2	3	4	5	Average
319 as cast	46.1 HRB	44.5 HRB	45.0 HRB	46.0 HRB	44.2 HRB	45.2 HRB
319 HT	60 HRB	62.7 HRB	62.0 HRB	66.0 HRB	67.0 HRB	63.6 HRB

Table 3. Hardness of aluminum alloy and heat treatment hardness test results

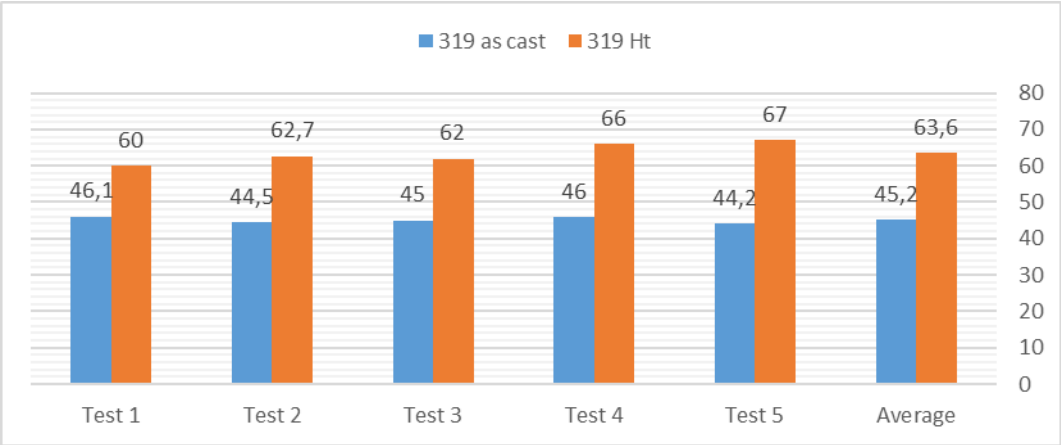

Figure 7. Hardness of aluminum alloy and heat treatment hardness test results

From the table and graph above can be seen the effect of heat treatment on the hardness of 319 aluminum alloy material is very significant increase in the level of hardness, from 5 times the tests carried out on 319 as aluminum aluminum alloy obtained an average hardness level of 45.2 HRB and for aluminum alloy get heat treatment or heat treatment the average level of hardness from 5 times the test is 63.6 HRB so that if the average increase in material hardness level is 71%.

Corrosion Test of Aluminum Alloy Material

Corrosion test was carried out on 319 as aluminum alloy material with alumnium 319 alloy which has been heat treated, so that a comparison of corrosion resistance between aluminum as cast alloy material and aluminum alloy material from heat treatment will be obtained, corrosion tests carried out at the Nuclear Technology and Industry Center (PTBIN)-BATAN Puspitek Serpong using the potentiodynamic polarization method, the tool used was a Model 273 Potensiotate / Galvanostat equipped with a computer with M342 software made by Princeton Applied Research by EG&G Research.

This corrosion test is carried out to determine how much influence heat treatment material has on its corrosion rate.

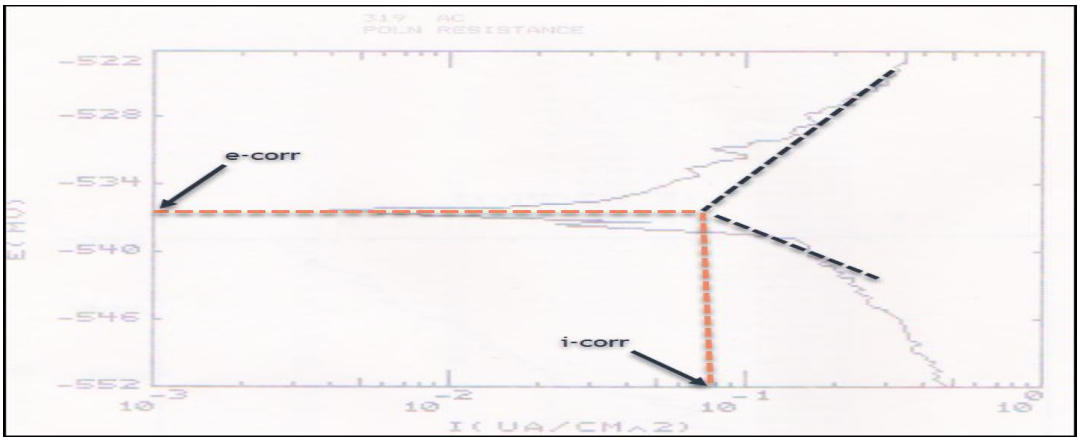

Figure 8. Polarization curve of 319 aluminum alloy as cast with seawater media

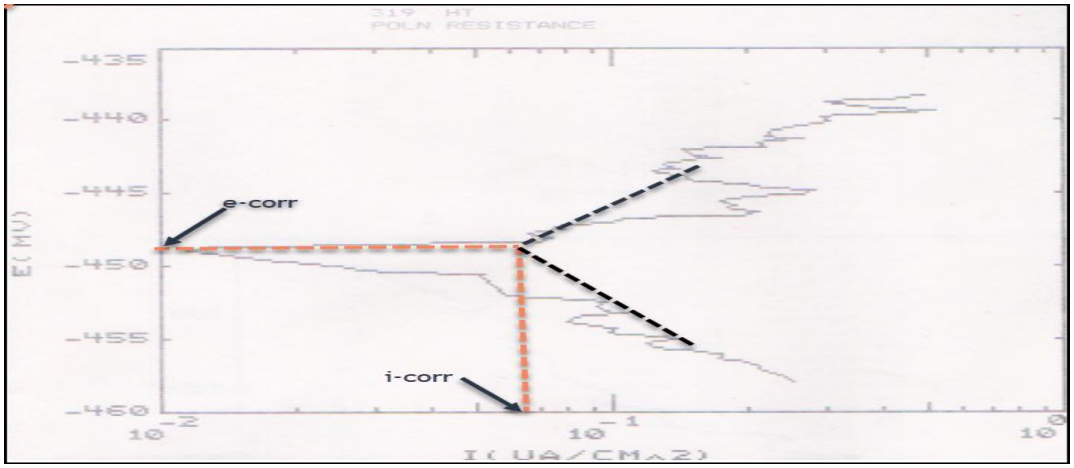

Figure 9. Polarization curve of 319 aluminum alloy heat treatment with sea water media

Figure 8 shows the results of polarization of 319 as cast aluminum alloys with seawater media, corrosion potential or e-corr on the polarization curve of the 319 aluminum alloy as more negative than the polarization curve of the 319 heat treatment aluminum alloy sample in Figure 9, meaning corrosion reaction when the equilibrium point is more active on the 319 as cast aluminum alloy polarization curve compared with the 319 heat treatment aluminum alloy with the more active corrosion reaction when at equilibrium the corrosion resistance of the 319 as cast alloy is worse than the 319 heat treatment aluminum alloy which shows less active corrosion reaction at the point of equilibrium.

The reactivity between the anodic and cathodic side shows that the density of anodic and cathodic currents on the aluminum alloy polarization curve 319 is greater than that of the 319 heat treatment aluminum polarization curve. compared to the polarization curve of 319 aluminum alloy heat treatment.

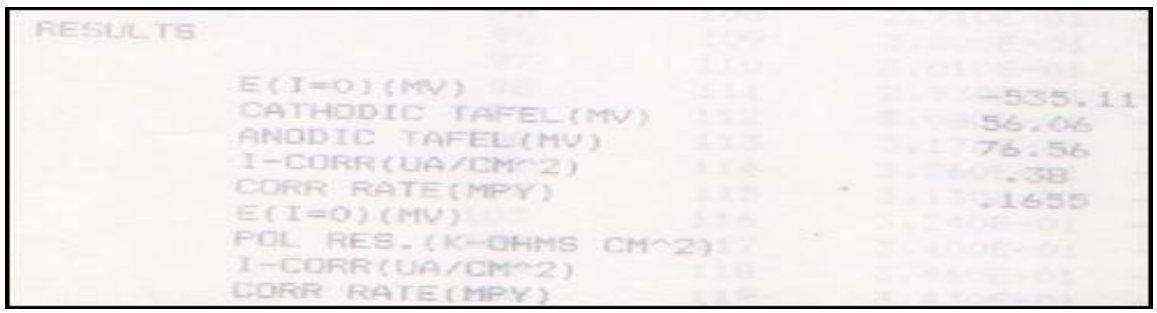

Figure 10. Corrosion test results of the 319 aluminum alloy as cast

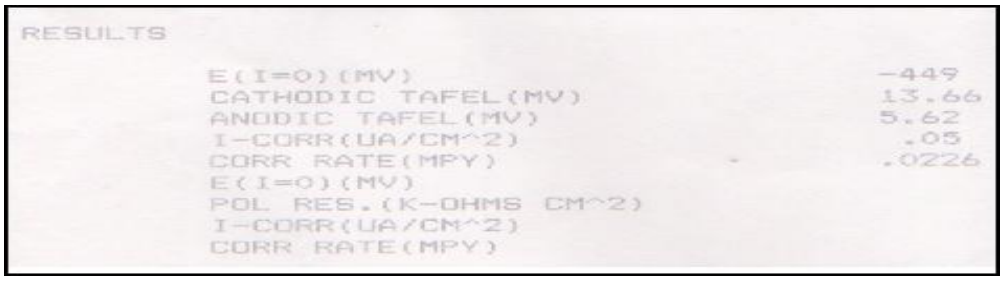

Figure 11. 319 heat treatment aluminum alloy corrosion test results

Figures 10 and 11 show the results of corrosion tests carried out on 319 as cast aluminum alloys and heat treatments, corrosion or i-corr current densities for 319 as cast aluminum alloys of current density of 0.38 µ / cm2 and for alloys of 0.05 µ / cm2 with the greater corrosion current density, the greater the corrosion rate so that the greater the corrosion current density, the resistance to corrosion material decreases, from the image of the corrosion test results of aluminum alloy as cast with aluminum alloy heat treatment, the corrosion rate for 319 as cast aluminum alloy is 0.1655 mpy while for aluminum heat treatmnet alloy has a corrosion rate of 0.0226 mpy, so the corrosion resistance of the 319 aluminum alloy heat treated is better than the corrosion resistance of the 319 aluminum alloy cast, thus heat material treatment has a positive effect on the corrosion rate of the material.

IV. CONCLUSION

1. The macro composition of alloy casting 319 approach uses scrap material consisting of 71.4% scrap, 14.4% AlC_{u10} and 0.7% Zn ingots that meet the required standards with a chemical composition of 6.17% Si, 0.824% Fe, 3.97% Cu, 0.12% Mn, 0.17% Mg, 1.26% Zn and the rest Al.
2. The average hardness test for 319 as cast aluminum alloy is 45.2 HRB and for 319 heat treatment aluminum alloy is 63.6 HRB.
3. The corrosion rate for 319 as cast aluminum alloy is 0.1655 mpy while for aluminum heat treatmnet alloy has a corrosion rate of 0.0226 mpy, so the corrosion resistance of the 319 aluminum alloy heat treated is better than the corrosion resistance of the 319 as aluminum alloy.
4. There is a significant effect on the value of material hardness heat treated by 71% and for increasing corrosion resistance by 7.3%.

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