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THE IMPACT STRENGTH AND CORROSION RATE OF THE GTAW WELDING TECHNIQUE ON AA5083 MATERIAL

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Abstract

The 5xx series of Aluminium has strong corrosion resistance, excellent weldability, and good cold workability and also medium strength. This series is being utilized extensively in marine building applications for the construction of Oil tankers, pressure vessels, offshore, ships and other vessels. The purpose of this study is to verify and to ascertain how the welding process affects the corrosion rate and impact strength of 5083 Aluminium. In this experiment, four AA 5083 specimens were warmed to chosen variations of 50°C, 100°C, 150°C, 200°C, and 250°C. The amount of energy absorbed during the fracture process was then determined by subjecting the welding results to a Charpy impact test with varying loads. The best specimen was tested for corrosion rate using the Corrosion Tester 3-Electrode device after comparing impact toughness. According to the study's findings, the specimen with a 250°C preheating step had the maximum impact toughness (0.415) and corrosion rate (0.11353 mmPy).

Keywords: *AA 5083, Corrosion Tester 3-Electrode Device, Corrosion Rate, Impact Strength.*

1. INTRODUCTION

In line with the rapid development of technology, the selection of materials to meet the needs of the manufacturing industry is increasingly varied. Nearly 8% of the weight of the Earth's crust is made up of aluminum, making it one of the most common metal elements on the planet [1]. Aluminum is widely used in the manufacturing industry due to its lightweight nature and can be easily combined with other elements (alloying) to regulate carekteristic properties such as mechanical properties, engine-capable properties (machineabillity), corrosion resistance, heat conductivity and electricity [1-3].

Aluminum 5083 is widely used in the field of marine transportation, such as the hull on the vessels of the steamer goods use this material is very effective because it is 20% lighter than the steel frame and has weldable properties [4]. The use of GTAW welds in non ferrous is an appropriate welding method, because excessive heat spread in the workpiece is reduced by the addition of inert protective gases as well as cooling gases [5-6].

Welding is the technique of joining two separate metallic components together by applying pressure and heat. There are currently more than 30 different types of welding techniques that use things like gas, electricity, and laser beams. The building sector has begun to include the efficiency of welding operations [7].Because it is 20% lighter than a steel frame

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and has weldable qualities, aluminum 5083 is frequently utilized in the maritime transportation industry for things like ship hulls on ships items [8-9]. The inclusion of an inert protective gas that also serves as a cooling gas reduces the workpiece's excessive heat dispersion, making GTAW welding suitable for non-ferrous materials Grimsmo et al [10]. However, there is uneven heating between the welding metal, the in-duct metal, and the HAZ region during the welding process, which results in coarsening of the granules and residual stress. These acidification differences can then cause changes in mechanical properties, crystal structure, and deformation. In order to limit the temperature and porosity caused by welding, protective gases must be added Mohanavel *et al.*, [11]. Helium, Argon, Carbon Dioxide, and Nitrogen are some of the gases that can be employed in the protective gas approach. However, nitrogen protection gas was utilized in this investigation because it had various advantageous effects on the GTAW welding of aluminum 5083. Because nitrogen has a lower specific gravity than oxygen, using nitrogen protective gas during GTAW welding on aluminum 5083 can minimize the porosity of the welded product and avoid oxygen entrapment Kunigita *et al.*, [12].

On the other hand, the corrosion rate is a crucial assessment to establish how quickly corrosion spreads. Two specimens were joined together using ASTM 262, according to a prior investigation by Kumar *et al.* [13], and then dissolved in a solution of $CuSO_4$ and H_2SO_4. Ahmad *et al.* [14] used 3.5% NaCl solution in a research that was comparable to this one because of its widespread use and high tendency for corrosion.

According to certain texts, pre-treatment work must be done before the welding procedure is carried out. According to Montaya *et al.*, [15] pre-treatment with saltwater improves corrosion resistance because the phases are reinforced. But that experimental finding didn't focus on the passive layer. As the amount of heat input during welding increases, an inevitable increase in HAZ changes is noted by Ambade *et al.* [16]. This is impacted by increasing welding duration as well as temperature. As a result of a number of factors that have previously been addressed, it was necessary to analyze the impact and corrosion rate effect of the welding procedure by exposing it to an acidic solution.

2. EXPERIMENTAL METHOD

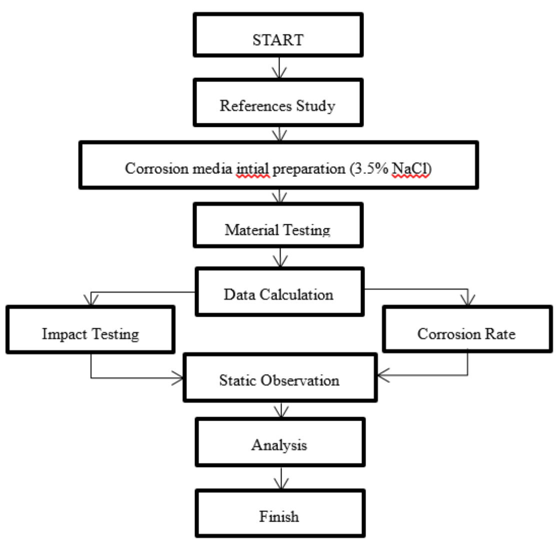

Figure 1. Flowchart

The real experiment investigation was chosen for this study employing a number of processes. Testing, observation, and direct inquiry into the chosen things were the first stages. Experimental study involves treating a subject, measuring the results, and repeating tthe process [19]. The test sample, AA5083, was subjected to a chemical-based solution containing 3.5 percent sodium chloride. The next step was to use a 3-Electrode Potential Corrosion Tester to measure the rate of corrosion. Figure 1 shows the entire experimental plan for this investigation.

2.1. Welding Treatment

An Al-(4-5.5%)Mg alloy with a V-seam, 3 mm aluminum plate AA 5083, was the material employed in this investigation. MIG welding was used to join two aluminum plates AA5083 with dimensions of 300 mm in length and 300 mm in breadth. The combination of process parameters is very important because it can only produce defect-free welding. Various defects that may arise during the welding process. One of these defects is caused by trapped air and preheating [28].

In this case, heat is the main cause of defects in GTAW welding, especially in aluminum, and the distribution of heat due to welding will cause porosity which will affect changes in mechanical properties. Porosity occurs when there is trapped air, porosity including surface defects that occur due to the presence of air trapped in the weld area, then as a result of which pores are formed that will result in a decrease in the mechanical properties of the material and will also corrode the weld area. This defect can be eliminated by controlling protective gases in the process, but it can also be done by preheating the material to be welded.

The initial material for the manufacture of this specimen is cut using an oxy acetylene cutter then continued to make a single V 45^o camp and spruced up using hand grinder tools [18]. This welding process uses the current strength that has been determined in GTAW welding. Using an argon shielding gas, 100 amps of current, 20 volts of voltage, a feed wire speed of 9 mm/s, and a welding speed of 10 mm/s (Ar). Throughout the welding process, heat is provided and then cooled. Static thermal tension (STT) was a method of reducing distortion. The GTAW welding locations are shown below. Figure 2 depicts the STT's organizational structure.

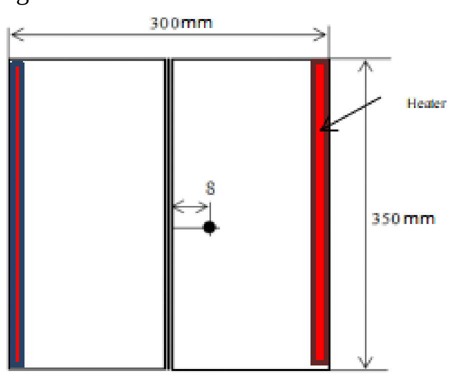

Figure 2. STT welding scheme

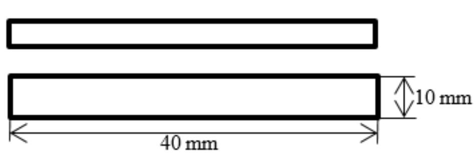

Figure 3. Corrosion specimen

In the picture up top, the research plan is shown. The welding area went through a preliminary heating or preheating operation. The preheating temperature variation for the electrical heater surrounding the weld (the red region) was set at 50°C, 100 °C, 150°C, 200 °C and 250°C. As a result of internal tensions and a possibility of cracking, the preheating procedure was designed to reduce the temperature differential.

2.2. Corrosion Rate

The material test of corrosion is frequently used to identify material flaws in the form of the specimen's corrosion rate value, which is displayed after treatment. Following that, rubbing paper with a size range of 500, 800, 1000, 1500, 2000, 3000 and 5000 is used to smooth the surface in accordance with the standards of impact test specimens with dimensions of length 40mm, breadth 10mm, and thickness 5mm. Make sure the specimen is entirely smooth (flat and glossy). If not, repeat the process, beginning with autosol and finishing with fine sandpaper. Following that, the sample components that had not yet undergone corrosion testing were coated with nodrop and tested using the three electrode cell technique.

$$CR = 3.27\ icorr\ \left(\frac{e}{d}\right) \qquad (1)$$

CR : corrosion rate (mmPY)

icorr : corrosion current speed (mA)

e : equivalent weight

d : metal density of coupon (g/cm^3)

According to ASTM E8 standards, tensile test specimens were prepared by cutting and rounding the specimens to the desired thickness for the test. Using a potential tester for 3-Electrode corrosion, the corrosion rate test was conducted. Test specimens for corrosion according to ASTM E8 are shown in Figure 3.

2.3. Impact Test

Material testing is a method used to test the strength of a material by providing a large force load. Impact testing according to, aims to determine the ability of the specimen to absorb the given energy . Impact testing is one of the processes of measuring the fragility properties of materials [20]. The tenacity or toughness of a material that cannot be detected by other tests, if two materials will have the same similar properties but if tested with an impact test it will be different. Impact testing is carried out to determine the strength of the material against shock resistance, such as the fragility caused by heat treatment or the fragility properties of the casting product (Casting) and the influence of the shape of the product. Impact testing is a response to shock loads or sudden loads. This test is carried out on a testing machine designed to have a pendulum with a certain weight that swings from a height to provide shock loads.

In this test there are two kinds of testing methods, namely the "Izod" method and the "Charpy" method which differ according to the direction of loading the test material and the position of the test material. In charpy and Izod standard tests, it was designed and used to measure impact energy known as notch toughness. Rod-shaped charpy specimens with a cross-section of oblong latitudes with V notches by machining processes [21].

Impact testing is a test used to identify a material's characteristics under dynamic loads. It is clear from this test that a material's strength attributes may either be described as clay-like or ductile and brittle. tenacity at an all-time high. Where the test material is higher, the material has an uneven fracture plane and appears fibrous. However, the outcome of the fracture seems beautiful and bright if the material is fragile. The transition temperature of a material, which reveals a change in the kind of fracture of a material when tested at different temperatures, is information from impact testing, when tested at various temperatures, it will be evident that the material is brittle at low temperatures and ductile at high temperatures [22]. Brittle cracking may be observed in conidial ductile material using ASTM E23 as indicated in Figure 4, by calculating the energy absorbed per unit transverse area of the test specimen.

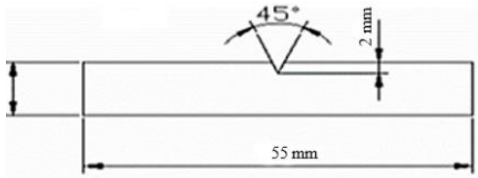

Figure 4. Impact test

$$K = \frac{W}{Ao} \quad (2)$$

k = Impact Value (kg.m/mm^2)

W = attempts to break objects (kg.m)

Ao = Cross-Sectional Area (mm^2)

3. RESULT AND ANALYSIS

Results of the data gathering were carried out. in the Brawijaya University and Gajah Mada University, with variable temperature changes of 50 °C, 100 °C, 150 °C, 200 °C, and 250 °C. These calculations were made using the experimental data.

Table 1. Result of Impact Test

No.	Cos α	Cos β	T (ºC)	G (kg)	λ (M)	Ao (mm)	FRACTURE FORM
1	153º	140º	50 ºC	150	1	40	Ductile
2	153º	139º	100 ºC	150	1	40	Ductile
3	153º	135º	150 ºC	150	1	40	Ductile
4	153º	137º	200 ºC	150	1	40	Ductile
5	153º	141º	250 ºC	150	1	40	Ductile

Table 2. Result of corrosion test

No.	SPESIMEN	T (ºC)	Solution	Ecorr (mV)	Icorr (μA)	Cathodic Beta (mV)	Anodic Beta (mV)
1	AA 5083	50 ºC	NaCl 3,5%	-0.9371 mV	3.42 x 10^{-5}	0.17296	0.11848
2	AA 5083	100 ºC	NaCl 3,5%	-0.9448 mV	3.42 x 10^{-5}	10.919	0.15325
3	AA 5083	150 ºC	NaCl 3,5%	-0.8297 mV	3.42 x 10^{-5}	10.919	0.51255

4	AA 5083	200 ºC	NaCl 3,5%	-0.9834 mV	3.42 x 10^{-5}	0.03678	0.027721
5	AA 5083	250 ºC	NaCl 3,5%	-0.9904 mV	3.42 x 10^{-5}	0.20497	0.12538

Table 3: Impact Value Calculation Result

No.	TEMPERATURE	W (kg.m)	A_o (mm²)	K (kg.m.mm^{-2})
1	50 ºC	**2700**	40	0.3439
2	100 ºC	**1950**	40	0.3122
3	150 ºC	**2100**	40	0.4103
4	200 ºC	**2450**	40	0.4152
5	250 ºC	**2450**	40	0.4061

3.1. Results of Impact Testing Using the Charpy Method

As previously shown in Tables 1 and 3, the hammer mass (W) and swing end angle (Cos) had an impact on the test specimen's ability to absorb energy during impact testing.

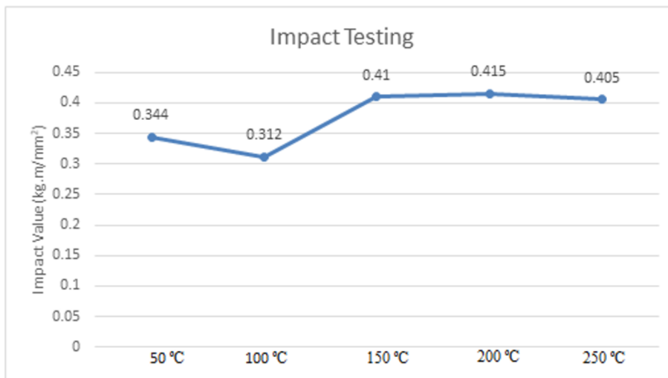

Figure 6. Impact of temperature variations

Therefore, it is clear that the impact test with a temperature of 200 °C produces the biggest impact price, which is 0.415 kg m / mm², followed by the impact test with a temperature fluctuation of 100 °C, which produces the smallest impact test value, which is 0.312 kg m / mm2. Based on the results of the impact test, this research is also backed up by the findings of earlier studies, which demonstrated that using nitrogen as a cooling gas during the GTAW welding process will lessen the specimen's toughness. This is unquestionably connected to the specimen's hardness and microstructure [13]. This was determined using a method that gives the researcher's estimated value for the work required by br. The more energy the specimen absorbs, the more of an impact this W factor has (K). This is corroborated by [17] regarding the specimen's temperature, which has a strong impact on the spread of cracks, and [29] regarding the effect of the tig weld's temperature with a temperature range of 50°C and 250°C, both of which state that the higher the welding temperature, the higher the toughness in taking a sudden load, and the opposite is true with a lower temperature. However, the hardness will naturally diminish at a certain temperature. According to [27], the severe impact caused by low temperature fracture propagation happens more quickly than plastic deformation does. As a result of plastic deformation occurring prior to cracks at higher temperatures, more energy is required for fractures.

3.2. Corrosion Rate

Obtained corrosion rate values from each specimen where the Al5083 specimen with Temperature variation 50 ºC has the largest corrosion rate, which is 0.41477mm / year, the Al5083 specimen with Temperature variation of 250 ºC has a corrosion rate of 0.25634 mm / year, the Al5083 specimen with Temperature variation of 150 oC has a corrosion rate of 0.38338 mm / year, Al5083 specimens with Temperature variation of 100 oC have a corrosion rate of 0.38511 mm / year, and the lowest corrosion rate value is found in the Al5083 specimen with a Temperature variation of 200 ºC which is 0.11353 mm / year. Based on the test data above, it can be known that the magnitude of the corrosion rate is affected by the speed of the nitrogen cooling gas. Where the faster the cooling gas rate, the smaller the corrosion rate that occurs in the Al5083 specimen. The magnitude of the corrosion rate is also influenced by the hardness of the specimen, which is influenced by nitrogen as the cooling gas of the welding process. Nitrogen cooling gas is likely to make specimens harder Aravinda *et al.*, [28].

The process of oxidizing a metal in a solution, which releases electrons to create positively charged metal ions, is often the first step in corrosion that takes place in a solution. Due to the decreased H+ and H_2O ions, the solution will function as a cathode under these circumstances, and the most frequent reactions to occur are the release of H_2 (Reaction 3), and the reduction of O_2 (Reaction 4). When the metal is continually dissolved into the solution, a reaction on its surface occurs, which further leads to attrition Tahir & Yapic [29].

Table 4. Result Of Corrosion rate

NO	SPECIMEN	SOLUTION	T (ºC)	Icorr (µA)	CORROSION RATE (mmPY)
1	AA 5083	NaCl 3,5%	50 ºC	3.42×10^{-5}	0.41477
2	AA 5083	NaCl 3,5%	100 ºC	3.42×10^{-5}	0.38511
3	AA 5083	NaCl 3,5%	150 ºC	3.42×10^{-5}	0.38338
4	AA 5083	NaCl 3,5%	200 ºC	3.42×10^{-5}	0.11353
5	AA 5083	NaCl 3,5%	250 ºC	3.42×10^{-5}	0.25634

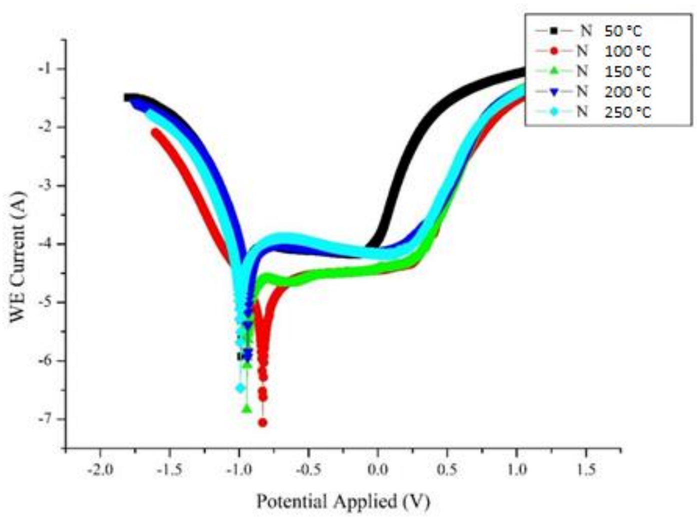

Figure 7. Corrosion Rate

Figure 7 depicts a graph created using the Versa Studio program following corrosion testing using a potentiodynamic polarization approach. According to the polarization graph in Figure 7, the speciment had an Icorr value of 3.42 x 10-5 A, an Ecorr value of -0.9834 mV, and a corrosion rate of 0.25634 mmPY in a 3.5 percent NaCl solution, as stated in Table.

Corrosion will occur more often the higher the corrosion current density (Icorr) produced. The NaCl's conductivity The high conductivity of the solution, which results in a strong corrosion current between the anode and the cathode, increased the rate of corrosion of the AA5083 material and was consistent with experimental data from Ahmad *et al.*, which had an impact on the increased corrosion rate of the AA5083 welding results. [14]. In the concentration of corrosive media affects the rate of corrosion depending on the type of media. It can be seen that the high value of the corrosion rate at a concentration of 3.5% NaCl. This is due to the passivation that occurs in the tested specimen [28] pasivation is an event where corroded aluminum will form a protective layer of oxidation results that cause the corrosion rate to decrease this is supported Wahyudianto [29] in his research on the influence of FSW welding on AA5083 in the NaCl medium 3.5% whose results have similarities, namely mpy values are influenced by the increasing value of corrosion current (Icorr) then the more High MPY values and Mpy values are also influenced by NaCl levels and also the influence of welding methods similar to research Ilman et al, [27].

4. CONCLUSION

The findings of GTAW welding on Aluminum AA5083 at 3.5 percent NaCl at 0.11353 mmPY and the value of the impact strength on temperature changes have revealed that the more the temperature variation utilized, the higher the impact value is also big, which is 0.415 (m/mm2) with temperature variations.

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