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The Influence of Current Strength and Electrode Type on the Corrosion Rate of Low Carbon Steel in SMAW Welding

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INTISARI

Kapal dominan menggunakan bahan kayu dan mengandalkan angin sebagai penggerak utamanya. Kapal kayu dahulu mempunyai satu kekurangan yang terlihat jelas, yaitu tidak dapat bergerak tanpa adanya bantuan angin dan layar. Hal itu tidak dapat memenuhi kebutuhan manusia yang semakin membutuhkan kecepatan dan keefisienan. Karenanya, dengan semakin majunya teknologi dan pengetahuan penggunaan kayu untuk kapal pun mulai ditinggalkan dan mulai menggunakan logam sebagai gantinya dan menggunakan mesin penggerak. Adapun tempat yang akan di tempati menelti yakni di worshop teknik mesin yang akan di laksanakan selama 3 bulan. Berdasarkan hasil pengujian yang telah dilakukan terhadap keseluruhan data yang diperoleh, maka dapat disimpulkan bahwa: (1). Kuat arus elektroda berpengaruh signifikan terhadap laju korosi pada pengelasan SMAW, (2). Kuat arus 100 A merupakan laju korosi terbesar dimana laju korosi yang diperoleh adalah 0,08508 mm/y dengan elektroda E 6013 dan 0,08061 mm/y dengan elektroda E 7016, (3). Kuat arus 120 A merupakan laju korosi sedang yaitu 0,07508 mm/y dengan elektroda E 6013 dan 0,06880 mm/y dengan elektroda E 7016, (4). Kuat arus 140 A merupakan laju korosi terkecil dimana laju korosi yang dihasilkan 0,06428 mm/y dengan elektroda E 6013 dan 0,05881 mm/y dengan elektroda E 7016.

Kata Kunci: Kuat Arus, Elektroda, Laju Korosi, Baja Karbon, Pengelas, dan SMAW.

ABSTRACT

Wooden ships predominantly relied on wood materials and wind as their primary means of propulsion. However, wooden ships had one significant drawback: they could not *move without the assistance of wind and sails. This limitation could not meet the increasing human demand for speed and efficiency. Therefore, as technology and knowledge advanced, the use of wood for ships began to be abandoned in favor of metal and engine-powered systems. The research will be conducted in a mechanical engineering workshop and will last for three months. Based on the results of tests conducted on the data obtained, the following conclusions can be drawn: The electrode current significantly affects the corrosion rate in SMAW welding, A current of 100 A produces the highest corrosion rate, with a corrosion rate of 0.08508 mm/y using the E 6013 electrode and 0.08061 mm/y using the E 7016 electrode, A current of 120 A produces a moderate corrosion rate, with a corrosion rate of 0.07508 mm/y using the E 6013 electrode and 0.06880 mm/y using the E 7016 electrode, A current of 140 A produces the lowest corrosion rate, with a corrosion rate of 0.06428 mm/y using the E 6013 electrode and 0.05881 mm/y using the E 7016 electrode.*

Keywords: Current Strength, Electrode, Corrosion Rate, Carbon Steel, Welder, and SMAW

1. INTRODUCTION

Sea transport, particularly ships, plays a very important role because the Earth is mostly covered by oceans, and due to their large size, ships can transport goods and people on a large scale. With the technology and knowledge of the past, ships predominantly used wood and relied on wind as their main source of propulsion. Wooden ships had one clear disadvantage: they could not move without the help of wind and sails. This could not meet the growing demand for speed and efficiency. Therefore, with the advancement of technology and knowledge, the use of wood for ships was gradually abandoned in favor of metals, which were then equipped with engines for propulsion. Ships made of metal are obviously better in terms of strength, but almost all metals have a major enemy: corrosion.

Corrosion is one of the causes of the deterioration of the quality of metal materials due to a chemical reaction between the metal and substances in its environment, forming undesirable compounds. Metal materials face various environments during the manufacturing, transportation, storage, and daily operations. To address this, ships are usually coated with ship paint and fitted with sacrificial anodes. However, corrosion cannot be completely stopped. It can only be controlled or slowed down to delay the degradation process. Therefore, repairs are routinely carried out on ships every few years.

Generally, welding is used to make repairs involving metals, and ships are no exception. Welding is a process of joining two or more pieces of metal into a single connection using heat. This heat is needed to melt the part of the metal to be joined, with an electrode serving as filler material (Saiful 2018). Welding is widely used in construction because it is economical, easy to implement, and can withstand high strength. In practice, however, there are still shortcomings in welding, one of which is that the welding process makes the metal more vulnerable to corrosion. Corrosion is detrimental because it can reduce the strength of a construction and shorten its lifespan, potentially rendering it ineffective sooner than planned. However, this has not deterred the use of welding for handling tasks related to the construction of various structures.

To reduce the rate of corrosion, the author attempts to conduct research by varying the welding current and the type of electrode in SMAW welding, using one of the plates commonly used in ship repair and construction, namely Low Carbon Steel Plate. Therefore, the author will examine the influence of welding current and electrode type on the corrosion rate of Low Carbon Steel plates in SMAW welding.

Based on the background above, the author formulates the following problems: How does the welding current affect the corrosion rate in SMAW welding? And how does the type of electrode affect the corrosion rate in SMAW welding? The objective of this research is to understand the influence of welding current and electrode type on the corrosion rate in SMAW welding, and to determine the impact of electrode type on the corrosion rate in SMAW welding. The benefits to be gained from this research include enhancing the author's knowledge in the fields of welding, corrosion, and engineering materials, as well as providing literature for similar studies, particularly in the field of welding.

The electrode is a filler material or additive material used to form the weld metal deposit, which serves to fill the gap in the joint. The electrode material consists of a core wire and a coating (Suwahyo & Sidiq, 2019). This wire is made to ensure that the hardness and ductility of the weld metal formed are as desired. The core wire is coated with a wrapping material composed of various substances, including silicon, manganese, potassium, iron powder, phosphorus, and others, mixed in specific proportions to form the coating.

Welding is widely used by metalworkers in fabrication, maintenance, and the repair of parts and structures. Although there are many methods for joining metals, welding is one of the easiest and fastest methods. The term "welding" refers to the process of joining metals by heating them to their melting point, causing the molten metal to flow together. This can range from simple steel brackets to nuclear reactors. The primary purpose of welding is to create a strong bond between materials to form a larger and functional structure or component. The welding process is used in various industries, including manufacturing, construction, automotive, and others. Currently, there are many welding processes available. This list is published by the American Welding Society (AWS), which shows the official abbreviations for each process. For example, RSW stands for resistance spot welding. Shielded Metal Arc Welding (SMAW) is a welding process where the metal is melted by heating it with an electric arc formed between a covered metal electrode and the metal being joined. The main difference between various welding processes is the method in which heat is generated to melt the metal (Hamdani et al., 2023).

The welding machine plays an important role in the welding process. This can be proven by the fact that if the welding machine experiences a malfunction, the welding process will be disrupted. A good SMAW welding machine will produce a stable current for both low and high amperage, making it easier to adjust the current (Boentarto, 2019). Additionally, a good welding machine will be durable if used for extended periods. This is because a quality welding machine is usually equipped with a cooling system (cooler) in the form of fans or coolant liquids that function to cool the transformer coils, allowing the machine to work for hours without stopping.

Corrosion is the deterioration of metal quality due to electrochemical reactions with its environment, which is directly exposed to the open air, commonly referred to as atmospheric corrosion. Atmospheric corrosion is greatly influenced by topographical and climatic conditions or the environment. Factors such as temperature, humidity, and the chemical content in the air significantly determine the rate of corrosion (Affandi et al., 2020).

Carbon steel is widely used in infrastructure construction because it has good mechanical properties. Carbon steel, or plain carbon steel, is commonly used for various applications due to its relatively low cost. One type of carbon steel is low-carbon steel, which contains about 0.05-0.25% carbon, making it easy to forge and ductile. Low-carbon steel has relatively low tensile strength but high ductility, weldability, and machinability. Another advantage of low-carbon steel is that it is inexpensive and easy to shape, with surface hardness being able to be increased through carburizing. However, carbon steel materials are not produced with corrosion resistance in mind, but the use of this steel is often applied in corrosive environments (Royani, 2021).

2. RESEARCH METHODS

This research was conducted in a mechanical engineering workshop and will be carried out over a period of 3 months. The tools used include cutting tools, calipers, scales, 3 containers for immersion, grinders to form the weld bead on low carbon steel plates, welding machines, and safety equipment. The materials used include low carbon steel plates, electrodes E6013, E7016, with a diameter of 3.2mm, and seawater. In this study, experiments were conducted on the welding process using 3 types of electrodes (E7018, E6013, E7016) with 3 different welding currents: 100 A, 120 A, and 140 A. A total of 18 experiments were conducted. Then, the corrosion rate for each current and electrode was calculated using the formula: $CR = \frac{W.T}{D.A.T}$

Where:

CR = Corrosion rate (mm/y)

W = Weight loss (g)

D = Density (g/cm^3)

T = Time (hours)

Z = Surface area of the material (cm^2)

K = Constant (8.76×10^7)

3. RESULTS AND DISCUSSION

The results of weighing the specimen's mass before and after immersion for 30 days, along with the weight loss of the specimens, are presented in Table 1.

Table 1. Mass of 18 specimens before and after immersion.

Number	Trial Number	Initial Mass (g)	Final Mass (g)	Mass loss (g)
1	Current of 100 A Electrode E 6013			
	1	227,90	227,54	0,36
	2	228,17	227,80	0,37
	3	228,39	228,00	0,39
2	Current of 120 A Electrode E 6013			
	1	228,56	228,22	0,34
	2	228.89	228,57	0,32
	3	228,18	227,85	0,33
3	Current of 140 A Electrode E 6013			
	1	229,16	228,86	0,30
	2	229,41	229,14	0,27
	3	228,94	228,66	0,28
4	Current of 100 A Electrode E 7016			
	1	228,13	227,78	0,35
	2	227,69	227,33	0,36
	3	227,91	227,56	0,35
5	Current of A Elektrode E 7016			
	1	228,98	228,67	0,31

	2	229,29	229,01	0,28
	3	229,45	229,13	0,32
6	Current of A Elektrode E 7016			
	1	229,96	229,72	0,24
	2	230,11	229,85	0,26
	3	229,49	229,22	0,27

Sumber: Hasil Pengujian Spesimen

To determine the Mass Loss Value for each experimental segment by subtracting the initial mass from the final mass, as per the following formula:

$$\text{Mass Loss} = \text{Initial Mass} - \text{Final Mas}$$

The results of the corrosion rate calculation are obtained by averaging the data in Table 2. The average corrosion rate.

Table 2. The average corrosion rate.

Number	Current	Type of electrode	Average CR (mm/y)
1	100 A	E 6013	0,08508
		E 7016	0,08061
2	120 A	E 6013	0,07508
		E 7016	0,06880
3	140 A	E 6013	0,06428
		E 7016	0,05881

Sumber: Hasil Analisis Rata - Rata Laju Korosi

From Table 2, the average corrosion rate shows that the highest corrosion rate occurs at a current of 100A with Electrode Type E 6013 (0.08508 mm/y) and E 7016 (0.08061 mm/y). The second highest corrosion rate is at 120A with Electrode Type E 6013 (0.07508 mm/y) and E 7016 (0.06880 mm/y), while the smallest corrosion rate occurs at 140A with Electrode Type E 6013 and E 7016, with a corrosion rate of (0.06428 mm/y) for E 6013 and (0.05881 mm/y) for E 7016.

To facilitate the assessment of the corrosion rate, the average corrosion rate is presented in the form of Graph 1 below.

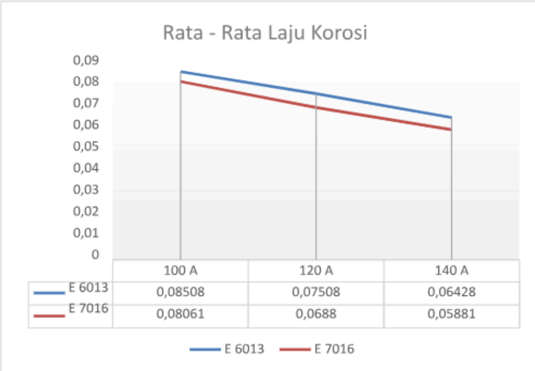

Figure 1. Graph Average Corrosion Rate

From Figure 1, the Average Corrosion Rate shows that as the current increases, the corrosion rate decreases, and as the current decreases, the corrosion rate increases.

Based on the results of the tests conducted, it was found that the type of electrode does not significantly affect the corrosion rate in SMAW welding, although there are slight differences in the corrosion rates. At 100A, the corrosion rate for Electrode Type E 6013 is slightly higher by 0.00447 mm/y compared to Electrode Type E 7016. At 120A, the corrosion rate for Electrode Type E 6013 is slightly higher by 0.00628 mm/y compared to Electrode Type E 7016, and at 140A, the corrosion rate for Electrode Type E 6013 is slightly higher by 0.00547 mm/y compared to Electrode Type E 7016. This is due to the fact that Electrode E 7016 contains slightly more Manganese (Mn) than Electrode E 6013.

Based on the results of the tests conducted, the corrosion rate for SMAW welding at 100A is obtained as follows: the CR (mm/y) for Electrode Type E 6013 is 0.08508 mm/y and for E 7016 is 0.08061 mm/y. At 120A, the CR (mm/y) for Electrode Type E 6013 is 0.07508 mm/y and for E 7016 is 0.06880 mm/y. At 140A, the corrosion rate for Electrode Type E 6013 is 0.06428 mm/y and for E 7016 is 0.05881 mm/y. This indicates that the current strength of the electrode affects the corrosion rate in SMAW welding. In other words, the lower the current used, the higher the corrosion rate, and the higher the current used, the lower the corrosion rate.

4. CONCLUSION

Based on the results of the tests conducted on the overall data obtained, the following conclusions can be drawn:

a. The current strength of the electrode significantly affects the corrosion rate in SMAW welding. A current of 100A results in the highest corrosion rate, where the corrosion rate obtained is 0.08508 mm/y with Electrode E 6013 and 0.08061 mm/y with Electrode E 7016. At 120A, the corrosion rate is moderate, with a corrosion rate of 0.07508 mm/y for Electrode E 6013 and 0.06880 mm/y for Electrode E 7016. At 140A, the smallest corrosion rate is observed, with a corrosion rate of 0.06428 mm/y for Electrode E 6013 and 0.05881 mm/y for Electrode E 7016.
b. The type of electrode does not significantly affect the corrosion rate in SMAW welding, although there are small differences in the corrosion rates. This can be seen at 100A, where the corrosion rate of Electrode E 6013 is slightly higher by 0.00447 mm/y compared to Electrode E 7016. At 120A, the corrosion rate of Electrode E 6013 is slightly higher by 0.00628 mm/y compared to Electrode E 7016, and at 140A, the difference is similarly small.

5. REFERENCE

Affandi, A., Huzni, S., Siregar, A. M., Siregar, C. A., Nasution, A. R., Tanjung, I., & Fonna, S. (2020). Analisa Korosi Atmosferik Baja Karbon Rendah Di Kecamatan Medan Belawan. *Multitek Indonesia*, *14*(2), 80–88. https://doi.org/10.24269/mtkind.v14i2.2841

Boentarto. (2019). *Bengkel Teknik Las Listrik*. Aneka.

Hamdani, Aswinur, Ismi, A. S., Rusman, & Jupriadi. (2023). *Standar Pengelasan Konstruksi*. CV. Andi Offset.

Royani, A. (2021). Pengaruh Suhu Terhadap Laju Korosi Baja Karbon Rendah Dalam Media Air Laut. *Jurnal Simetrik*, *10*(2), 344–349. https://doi.org/10.31959/js.v10i2.493

Suwahyo, & Sidiq, N. M. (2019). *Mengelas Dengan Las Busur Listrik Manual*. Insania.