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Analysis of Smaw Welding Results on AISI 304 Stainless Steel with Variations in Current and Electrode Diameter

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ABSTRACT

Construction using metal at the present time involves many elements, especially the field of welding engineering for welded joints is one of making connections that technically requires a high skill for welding, in order to obtain a connection with good quality. This study aims to determine the effect of variations in flow and the electrode on the distribution of hardness and microstructure in welding Stainless Steel AISI 304 seam type used is a double hem V with an angle 45. In this study used current and electrode diameter different, current used is 85 A, 95 A, 105 A, 115 A and the diameter of the electrode used is 2.6 mm and 3.2 mm, the type of weld used is Shielded Metal Arc welding (SMAW). Tests used in the form of micro hardness testing and photo. Based on the research results obtained hardness values were highest at 3. 2 mm electrodes with a current 85 A (85.86 HRB). It should be used in these premises welding electrode diameter of 3.2 mm and a flow of 85 A, because it has the highest hardness value than when using an electrode diameter of 2.6 mm. For testing photo that the greater the flow and diameter are used in welding will be more and more also the occurrence of porosity.

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1. INTRODUCTION

Welding in the construction field is very widely used, including bridge construction, shipping, the body industry, etc(Maulana, 2017). In addition to welding construction, it can also be used to weld metal defects in metal casting results, thickening the wear (Bachtiar, 2016). In simple terms it can be interpreted that welding is a process of joining two metals to the point of recrystallization of the metal either using added materials or not and using heat energy as a liquefaction of the material being welded (Saputra & Syarief, 2014). The definition of welding according to Widharto (2003) is one way to connect solid objects by melting them through heating (Anggaretno et al., 2012). Based on the definition of the Deutche Industrie Normen (DIN) welding is a metallurgical bond at the connection of a metal or metal alloy which is carried out in a melted or liquid state (F. Putri, 2009) (Saputra & Syarief, 2014). Wiryosumarto and Okumura (2004) stated that welding is the local joining of several metal rods using heat energy (Maghfiroh et al., 2020). The joining of two metals into one is done by heating or melting (Hamid, 2016), where the two ends of the metal to be joined are melted or melted with an arc flame or heat obtained from an electric arc (burning gas) so that the two ends or metal planes are strong mass fields and are not easily separated (Bhirawa, 2021). At least there are currently about 40 types of welding (Bachtiar, 2016). Of all these types of welding, only two are the most popular in Indonesia, namely welding using an electric arc (Shielded

metal arc welding / SMAW) and carbide welding (Oxy acetylene welding / OAW) (Helanianto et al., 2020). Until now, there are many classification methods used in the welding field, this is because there is no agreement in this regard (Maukar, 2019). Conventionally, these classification methods can be divided into two parts, namely: (Kosasih et al., 2020): (1) Based on the welding method, (2) Based on the energy used.

Welding based on the classification of working methods can be divided into three groups, namely liquid welding, press welding and desoldering. Liquid welding is a welding method in which the object to be joined is heated until it melts with a heat energy source. The most widely used welding methods are liquid arc welding (electric arc welding) and gas. There are 4 types of electric arc welding, namely arc welding with wrapped electrodes, gas arc welding (TIG, MIG, CO2 arc welding), arc welding without gas, and submerged arc welding. Types of wrapped arc welding electrodes, one of which is SMAW welding (Shielding Metal Arc Welding).

DC current welding machine can be used in two ways, namely straight polarity and reverse polarity. A straight polarity DC welding machine (DC-) is used when the melting point of the parent material is high and the capacity is large, the electrode holder is connected to the negative pole and the base metal is connected to the positive pole, while the reverse polarity DC welding machine (DC+) is used when the melting point of the material is low mains and small capacity, the electrode holder is connected to the positive pole and the base metal is connected to the negative pole. The choice when using DC of negative or positive polarity is primarily determined by the electrode used. Some SMAW electrodes are designed to be used only DC- or DC+. Other electrodes can use both DC- and DC+. The E7018 electrode can be used on reverse polarity DC (DC+). This welding uses E7018 electrodes with a diameter of 3.2 mm, so the current used ranges from 115-165 Amperes. With this current interval, the welding produced will be different (Soetardjo, 1997). Not all metals have good weldability. Materials that have good weldability include low alloy steels.

These steels can be welded by enveloped electrode arc welding, submerged arc welding and MIG welding (noble gas metal welding) (Soleh et al., 2017). Low alloy steels are commonly used for thin plates and general construction (Sobirin et al., 2019). In ferritic stainless steel produces low toughness after welding. This is because the microstructure in the HAZ which is close to the weld metal undergoes roughening or excessive grain growth that can trigger cracks especially if welding thick plates (>25 mm) (Tristanta, 2007). For this reason, in the welding process, it is necessary to pay attention to several welding process parameters related to the quality of the weld such as voltage and current used, welding speed, use of appropriate electrodes, and so on (Rozy, 2021). One of the most important mechanical properties in welding is hardness (Syahrani et al., 2017). Based on the above background, this research takes the title: "Analysis of SMAW Welding Results on Stainlees Steel 304 With Variations in Current and Electrode Diameter" (Tarigan, 2016).

The specific objectives of this study are: (1) To determine the effect of variations in current and electrode diameter on hardness with AISI 304 Stainless Steel material on SMAW welding results. (2) To determine the effect of variations in current and electrode diameter on the microstructure of AISI 304 Stainless Steel material on SMAW welding results. (3) To determine the quality of welded joints with AISI 304 Stainless Steel material on SMAW welding results.

2. RESEARCH METHOD

The research method is a method used in research, so that the implementation and results of research can be justified scientifically (Zaluchu, 2020). This study uses an experimental method, which is a way to find a causal relationship between two influential factors (JaeDun, 2011). Experiments were carried out in the laboratory to obtain data on the effect of welding currents and electrodes on hardness and metallography in SMAW welding with AISI 304 Stainless Steel as the test material (Yustiasih Purwaningrum, 2021).

2.1 Research Steps

The method of the steps carried out in this research are as follows: (1) Literature Study, the literature study is carried out by studying the appropriate literature, so as to facilitate the research process and research data analysis (AE Putri, 2019). (2) Welding Process, to carry out the welding process in this research, there are several stages that must be carried out, namely: (1) Preparation of tools, (2) Determination of Ampere Meters (3) Welding Process, the steps taken in the welding process are : (4) Prepare the DC SMAW welding machine according to the reverse polarity installation. (5) Preparing the workpiece to be welded on the welding table (Azwinur et al., 2017). (6) Welding position using horizontal or underhand welding position and zigzag pattern electrode movement (Noya & Hadi, 2019). (7) Welding position using the welding position above the head and electrode movement pattern C (8) The seam used is an open V seam, with an angle of 450, with a gap width of ±5 mm. (9) Prepare the electrodes according to the current and plate thickness, in this study selected electrodes of type E308L and type of electrodes E309L (10) Adjusting the ampere meter used to measure the current that has been determined, then one of the clamps is clamped on the cable used to clamp electrode (Pradana, 2018). The welding machine is turned on and the electrodes are scratched until they light up. Ampere meter is set to a predetermined number (Umartono & Latif, 2019). Next, the welding of the specimens was started. (3) Research methods, analysis and discussion are carried out on the results of the tests carried out. The test results analyzed are as follows (Imron, 2019): (1) Hardness Test, (2) Micro Photo.

3. RESULTS AND DISCUSSIONS

3.1. Introduction

This chapter will discuss the results of the tests carried out on the specimens, after carrying out the stages as in the research methodology, the test values are obtained.

3.2. Test Result

The test results in this study include the results: (1) Hardness Test (Hardness test), (2) Metalography (micro photo).

3.3. Hardness Test Results

Hardness testing of Aisi 304 stainless steel specimens uses the Rockwell Hardness Test method, how to test hardness using an Equatip Hardness Tester, the test results are directly printed on the monitor, the sample is measured up to five times and the average is taken.

Table 1. Hardness value (HRB) with electrode E 308L diameter 2.6 mm

Sampel	Nilai Kekerasan (HRB)					Kekerasan Rata-rata (HRB)
	Titik 1	Titik 2	Titik 3	Titik 4	Titik 5	
I/26	82,33	84,58	82,96	85,15	84,49	83,90
II/26	84,94	78,76	86,26	85,17	87,79	84,58
III/26	83,27	81,93	87,85	81,88	84,85	83,96
IV/26	82,05	82,32	82,18	83,78	84,22	82,91

From the table above, it can be seen that the hardness value (HRB) with an E308L electrode with a diameter of 2.6 mm is the highest average hardness value for a specimen with a current of 95 A is 84.58 HRB while the lowest average hardness value is a specimen with a current of 115. A is 82.91 HRB.

Figure 2. Graph of the average hardness value (HRB) with an E 308L electrode with a diameter of 3.2 mm

From the graph above, it can be seen that the hardness value with the E 308L electrode with a diameter of 3.2 mm is the highest average hardness value for a specimen with a current of 85 A is 85.86 HRB while the lowest average hardness value for a specimen with a current of 115 A is 81.18 HRB.

3.4. Microstructure Observation Results

Observations of the microstructure were carried out to determine the microstructure and grain size so as to determine the changes and phenomena that occurred in the welds.

Table 2. Specimen specifications

Spesimen	Pembesaran (X)	Arus	Diameter
I	200	85	26
II	200	95	26
III	200	105	26
IV	200	115	26
V	200	85	32
VI	200	95	32
VII	200	105	32
VIII	200	115	32

Figure 4. Microphotographs with E 308L electrodes with a diameter of 2.6 mm and a current of 85 A

The results showed that the specimens used in SMAW welding experiments using Stainless Steel Aisi 304 with E308L electrodes with a diameter of 2.6 mm with a current variation of 85 A, will produce microstructures in the form of ferrite (light areas) and pearlite (dark areas), microstructures ferrite is more dominant than ferlite microstructure. Black spots are a form of of shrinkage of the weld meat which is called porosity. In the picture the porosity contained in the specimen is quite small.

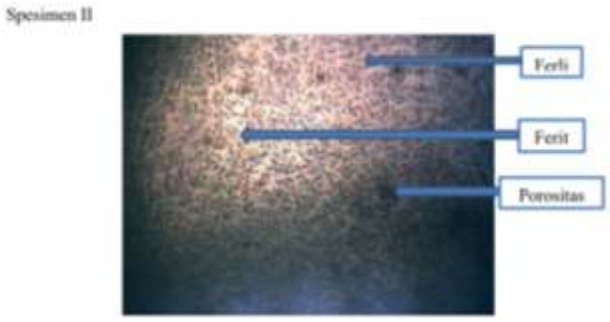

Figure 5. Microphotographs with E 308L electrodes with a diameter of 2.6 mm and a current of 95 A

The results showed that the specimens used in SMAW welding experiments using Stainless Steel Aisi 304 with E308L electrodes with a diameter of 2.6 mm with a current variation of 95 A, will produce microstructures in the form of ferrite (light areas) and pearlite (dark areas). The felrite and ferrite grains are larger and the guides are more homogeneous. Black spots are
This form of shrinkage of the weld is called porosity. In the figure the porosity contained in the specimen is quite large, this is because the greater the current used for welding, the more porosity will be.

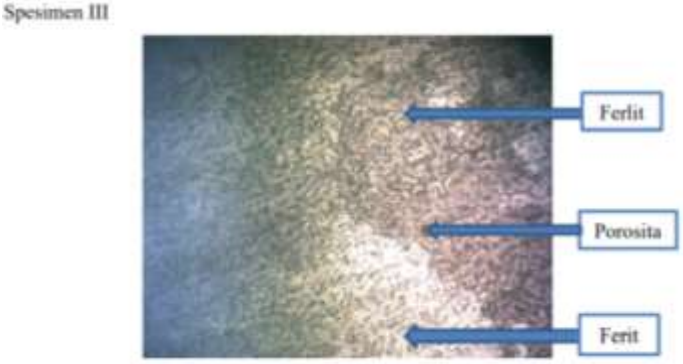

Figure 6. Results of micro-photographs with E 308L electrodes with a diameter of 2.6 mm and a current of 105 A

The results showed that the specimens used in SMAW welding experiments using Stainless Steel Aisi 304 with E308L electrodes with a diameter of 2.6 mm with a current variation of 105 A, will produce microstructures in the form of ferrite (light areas) and pearlite (dark areas). The felrite and ferrite grains are larger and the guides are more homogeneous. Black spots are a form of shrinkage of the weld known as porosity. On picture. The porosity contained in the specimen is classified as more, this is because the greater the current used for welding, the greater the porosity.

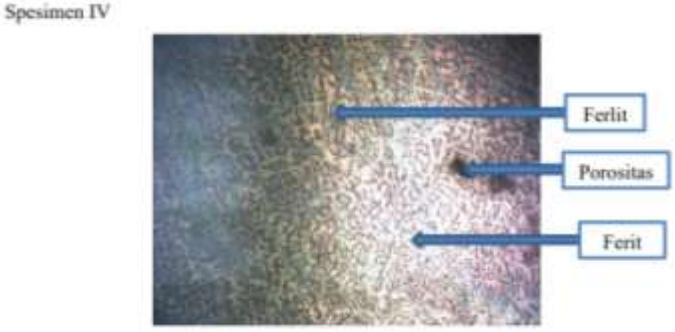

Figure 5. Microphotographs with E 308L electrodes with a diameter of 2.6 mm and a current of 115 A

The results showed that the specimens used in SMAW welding experiments using Stainless Steel Aisi 304 with E308L electrodes with a diameter of 2.6 mm with a current variation of 115 A, will produce microstructures in the form of ferrite (light areas) and pearlite (dark areas). The felrite and ferrite grains are larger and the guides are more homogeneous. Black spots are a form of shrinkage of the weld known as porosity. On picture. The porosity contained in the specimen is classified as more, this is because the greater the current used for welding, the greater the porosity.

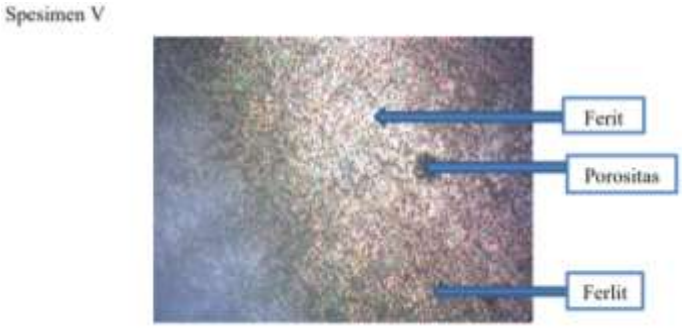

Figure 6. Microphotographs with E 308L electrodes with a diameter of 3.2 mm and a current of 85 A

The results showed that the specimens used in the experiment on SMAW welding using Aisi 304 Stainless Steel with E308L electrode with a diameter of 3.2 mm with a current variation of 85 A, will produce a structure. The microstructure is ferrite (light area) and pearlite (dark area). Felrite and ferrite granules larger and the guides are more homogeneous. Black spots are a form of shrinkage of the weld known as porosity. In the figure, the porosity contained in the specimen is classified as more, this is because the greater the current used for welding, the greater the porosity.

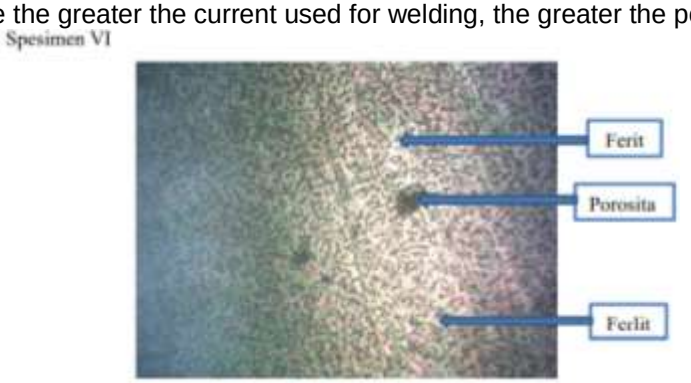

Figure 7. Microphotographs with E 308L electrodes with a diameter of 3.2 mm and a current of 95 A

The results showed that the specimens used in SMAW welding experiments using Stainless Steel Aisi 304 with E308L electrodes with a diameter of 3.2 mm with a current variation of 95 A, will produce microstructures in the form of ferrite (light areas) and pearlite (dark areas). The felrite and ferrite grains are larger and the guides are more homogeneous. Black spots are. This form of shrinkage of the weld is called porosity. In this figure, the porosity contained in the specimen is classified as more. This is because the greater the current used for welding, the greater the porosity.

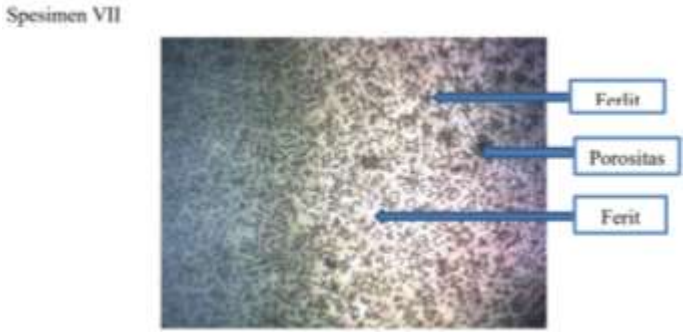

Figure 8. Microphotographs with E 308L electrodes with a diameter of 3.2 mm and a current of 105 A

The results showed that the specimens used in the SMAW welding experiment using Stainless Steel Aisi 304 with E308L electrodes with a diameter of 3.2 mm with a current variation of 105 A, will produce microstructures in the form of ferrite (light areas) and pearlite (dark areas). The felrite and ferrite grains are larger and the guides are more homogeneous. Black spots are a form of shrinkage of the weld known as porosity. On picture. The porosity contained in the specimen is classified as more, this is because the greater the current used for welding, the greater the porosity.

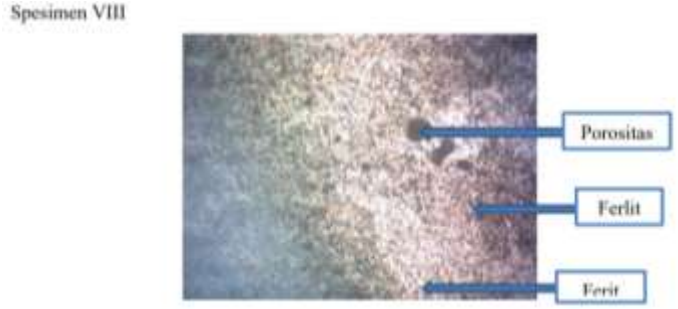

Figure 9. Results of micro-photos with E 308L electrodes with a diameter of 3.2 mm and a current of 115 A

The results showed that the specimens used in SMAW welding experiments using Stainless Steel Aisi 304 with E308L electrodes with a diameter of 3.2 mm with a current of 115 A, will produce microstructures in the form of ferrite (light areas) and pearlite (dark areas). The felrite and ferrite grains are larger and the guides are more homogeneous. Black spots are a form of shrinkage of the weld known as porosity. On picture. The porosity contained in the specimen is classified as larger and more numerous, this is because the greater the current used for welding, the greater the porosity.

4. CONCLUSION

Conclusions are: (a) The variation of the current and the diameter of the electrode used when welding the specimen can affect the HRB value. From the results of the hardness test, the hardness value for the Aisi 304 Stainless Steel specimen with the E 308L electrode with a diameter of 2.6 mm, current 85 A,95 A,105 A, 115 A, the highest hardness value is 95 A (84.58 HRB), while at the electrode diameter of 3.2 mm with a current equal to diameter 2.6 mm, the highest hardness value is with a current of 85 A (85.86 HRB), so it should be used in this welding with an electrode diameter of 3.2 mm with a current of 85 A, because it has the highest hardness value compared to when using an electrode. diameter 26mm (b) Variations in current and electrode diameter used during welding can affect the results of micro-photographs. From the results of photo micro testing, the greater the current and diameter used, the more porosity will occur. Suggestions are (a) To obtain better results, research tools should be adequate and damaged tools repaired or replaced

with new ones so that the accuracy of the test results is maximized and accurate. (b) It is advisable to preheat the electrode before welding to remove the hydrogen present in the flux, because hydrogen will cause poor quality welds. (c) Be more careful in the welding process.

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