Indonesian Journal of Maritime Technology (ISMATECH)
Vol. 2, Issue 1, June 2024
eISSN: 3025-518X
DOI: https://doi.org/10.35718/ismatech.v2i1.1055

Analysis of Shielded Metal Arc Welding (SMAW) with Current Variations Against Tensile Strength, Bending Strength, and Microstructure of API 5L X52

Qowi Matin[1], Ridhwan Haliq[1], Andi Idhil Ismail[1], Muchammad Jamil[1]

[1]Mechanical Engineering, Kalimantan Institute of Technology, Balikpapan, 76127, Indonesia

KEYWORDS
Welding Current
SMAW
Tensile Strength
Bending Strength
API 5L X52

ABSTRACT – This study aims to analyze the effect of current variations on the V seam with a seam angle of 37.5° on the testing of mechanical properties and the appropriate welding method as a connector for two API 5L X52 materials using the Shielded Metal Arc Welding (SMAW) welding method. The current variation used is (70, 100, 115 A) in Sample A, the current variation is (70, 120, 130 A) in Sample B, and the current variation is (70, 125, 130 A) in Sample C. After the welding process is carried out, the samples are then tested for tensile, bending, observing macro structures, and microstructures. The test results obtained the highest value of tensile testing on current variations (70, 125, 130 A) with a value of 715.4 MPa, while the lowest value on current variations (70, 100, 115 A) with a value of 596.66 MPa. The results of the bending test show that the highest value is obtained in the current variation (70, 125, 130 A) with a value of 1417.93 MPa, while the lowest value is obtained in the current variation (70, 100, 115 A) with a value of 1289.01 MPa. The results of metallographic testing showed that the microstructure data on variations in the welding current strength of (70, 100, 115 A), (70, 120, 130 A), and (70, 125, 130 A) resulted in a phase that composed of ferrite and pearlite. The microstructure formed is influenced by the magnitude of the welding current used. The results of macro-observations obtained porosity in the weld metal area.

*Corresponding Author | Andi Idhil Ismail | ✉ a.idhil@lecturer.itk.ac.id

INTRODUCTION

The construction field is growing rapidly along with technological advancements. One example is welding. Welding has a significant role in engineering and repairing metals. The welding process is the number one of the steps performed, such as the welding structure and welding specifications. Then, the factors that affect weld production are the tools and materials needed in the manufacturing process, manufacturing agenda, determination of the type of camp, selection of welding machine, selection of welder, selection of electrodes, and order of implementation [1].

API 5L X52 material is a material that is used for liquefied natural gas distribution pipelines Liquid Natural Gas (LNG) in offshore applications. API 5L X52 material has a high economic value and is also used in the chemical industry, especially in the distribution of gases produced from chemical reactions. This pipe is fabricated by hot rolling on the sheet and then cold rolling until the steel sheet can be produced. The fluid flow in the pipe will provide a large compressive force when feedback occurs. The reaction force caused by the baffle creates stress across the cross-section of the pipe. This can result in cracking and leakage of the weld joint. Therefore, it is necessary to conduct a welding process and selection of strong currents to produce good-quality welded joints [2].

Arc welding and gas arc welding (AW) are used as industrial welds. Shielded Metal Arc Welding (SMAW) is one kind of electrode arc welding. During welding, the base metal [3] and electrodes melt and fuse into the welding metal [4]. The role of electrodes is very important in the connection process between two materials to be welded in the SMAW welding process. Various sizes, types, and brands of electrodes are available for welding applications. Electrodes play an important role in welding as connectors for two materials. Electrodes are available in various sizes and types and sold under different brands. To obtain good welding results, the electrodes must be correctly adjusted based on the welded material [5]. As for maritime sector, this welding process has been widely applied in many studies. For example, this process was used in shipbuilding industry [6] [7].

Electrodes consist of certain materials with a certain composition. The materials used are classified as arc-reinforced materials. Deoxidizers, gas generators, slag generators, binders, and other alloying elements. These materials are carbonates, metal oxides, fluorides, iron filings, silicates, alloy steels, and organic substances [8]. The electrodes must be adjusted to the material to be combined to get optimal welding results [9]. Furthermore, welding variables such as current and voltage play an important role in determining the final quality of the welding material. This work aims to investigate the influence of welding current variation and voltage on the tensile strength, bending strength, and microstructure of API 5L X52 material after SMAW.

METHOD

Research on the effect of welding current variations on potency v with SMAW welding on the macrostructure, micro, bending strength, and tensile strength of API 5L X52 materials by conducting a literature study after that determining the parameters of welding current and preparation of API 5L X52 material.V bead shape was used with an angle of 37.5° as shown in Figure 1. The welding was carried out with current variations on specimen A (70, 115, 120 A), specimen B with variations (70, 120, 130 A) and specimen C with variations (70, 125, 130 A) with electrode type of E6010. Microstructure observation was performed after sample preparation using several mechanical polishing steps followed by acid etching. Tensile testing was carried out in accordance with ASTM E8 standards in a Tensilon UTM machine. Similarly, a bending test was performed in a similar machine. Nevertheless, the standard used according to ASME Section IX QW - 462.3.

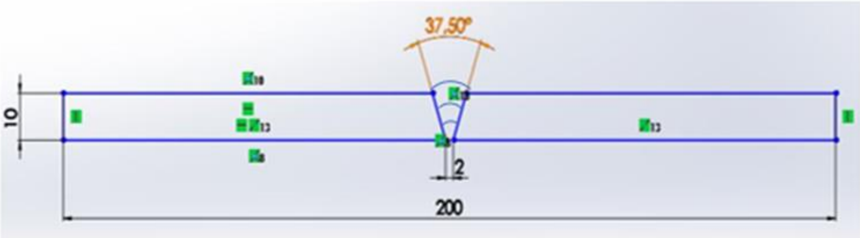

Figure 1. Sketch of welding specimen.

RESULTS AND DISCUSSION

Macrostructure Observation

This test aims to determine the effect of SMAW current variations on weld penetration in API 5L X52 material. Figure 2 shows the macrostructure of a welded specimen. The macro view looks at the boundary of weld metal and base metal. The part marked red is visible porosity. Porosity occurs due to hydrogen gas trapped during the welding process of API 5L X52 material [1].

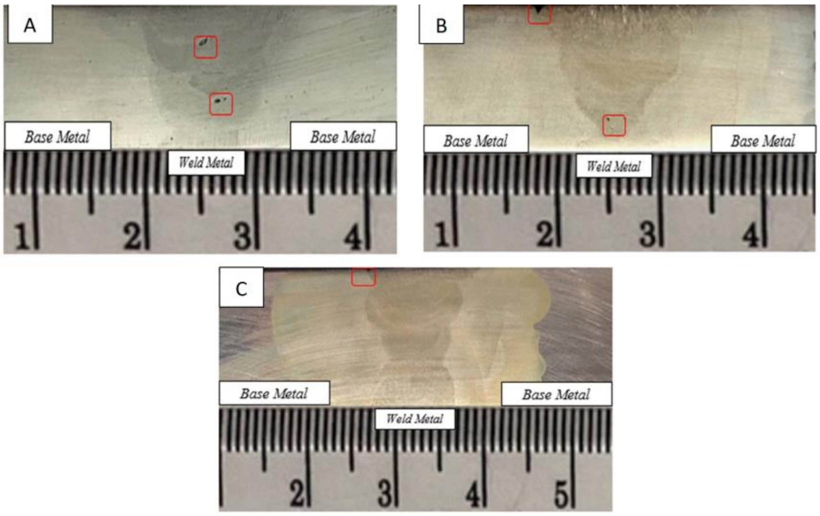

Figure 2. Macrostructure of variation (A) (70, 100, 115 A), variation (B) (70, 120, 130 A), and variation (C) (70, 125, 130 A).

Microstructure Observation

The material API 5L X52 observations microstructure were carried out to see the phase after welding. Microobservations on this research specimen were carried out in the weld metal area, base, and affected zone. Figure 3 shows the structure of Micro base metal after observation using an optical microscope. The base metal microstructure in the form of pearlite and ferrite pearlite has dark characteristics, and ferrite has light characteristics. The presence of pearlite and ferrite phases in the base metal shows that steel has ductile properties where there is no difference between micro photos in the base metal. Because the base metal is not affected by heat during welding, there is no change in structure [5].

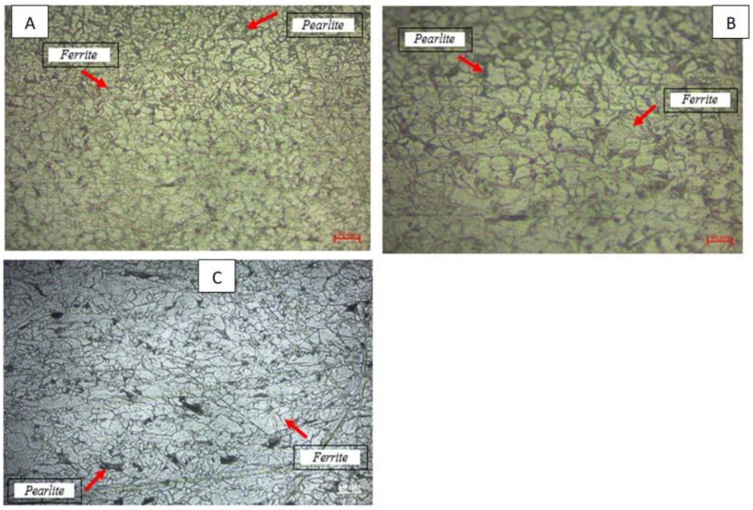

Figure 3. Microstructure of Base Metal variations (A) (70, 100, 115 A), variations (B) (70, 120, 130 A), and variations (C) (70, 125, 130 A).

Figure 4 shows a photo of the microstructure of the heat-affected zone after observation using an optical microscope. The ferrite phase dominates photos of microstructures in the heat-affected zone. This is due to the slow cooling speed due to heat in the weld metal area, which is getting bigger as the use of current increases. The heat generated by the weld metal is absorbed and distributed to the HAZ (thermal welding cycle), which will then be absorbed by the base metal so that cooling becomes faster [2].

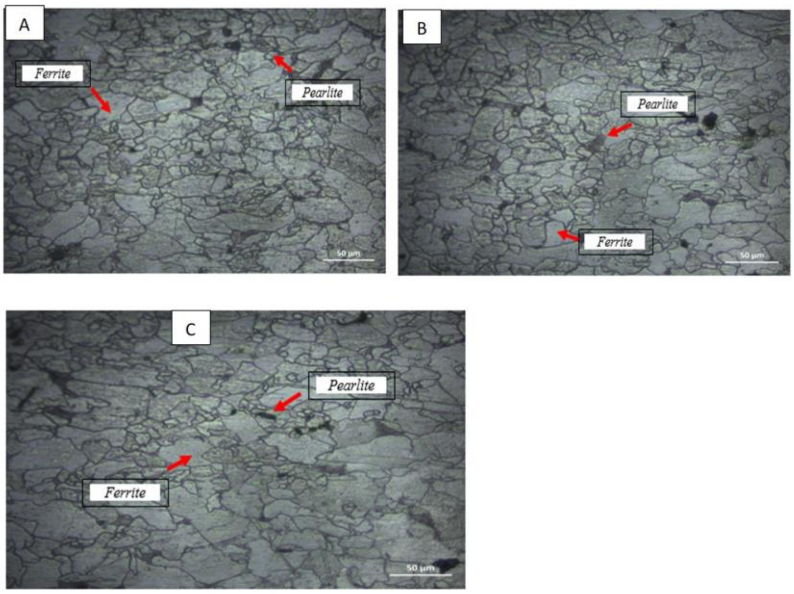

Figure 4. Microstructure of Heat Affected Zone current variation (A) (70, 100, 115 A), current variation (B) (70, 120, 130 A), and current variation (C) (70, 125, 130 A).

Figure 5 shows a photo of the microstructure of the weld metal after observation using an optical microscope. In this area, ferrite and pearlite are denser than the base metal and heat-affected zone, and ferrite dominates compared to pearlite. This is due to the rapid cooling rate until cooling reaches room temperature. In addition, the use of a larger current causes the heat generated to be greater so that the heat is absorbed by the heat-affected zone area, which will experience rapid cooling so that the distribution of heat received by the material will increase the pearlite phase in weld [10].

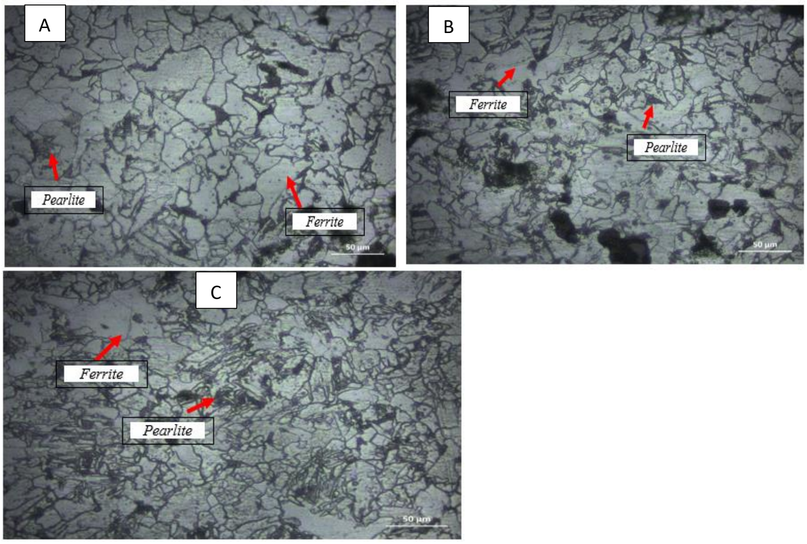

Figure 5. Microstructure of Weld Metal current variation (A) (70, 100, 115 A), current variation (B) (70, 120, 130 A), and current variation (C) (70, 125, 130 A).

Tensile Test Results

Figure 6 represents the tensile test result values of the three SMAW welding specimens. A comparison of the three welding specimens is shown in Figure 10. Based on Figure 10, specimen A with variations in welding current (70, 100, 115 A) obtained a value of 596.66 MPa. Specimen B, with a large variation in welding current (70, 120, 130 A) obtained a value of 633.84 MPa and experienced an increase in tensile strength of 5.87% from specimen A. Specimen C with a large variation in welding current (70, 125, 130 A) obtained a value of 715.40 MPa experienced an increase in tensile strength by 11.40% from specimen B, the tensile strength value from specimen A to specimen C increased tensile strength by 16.6%. The greatest tensile strength was obtained in specimen C with a current variation (70, 125, 130 A) of 715.40 MPa [11].

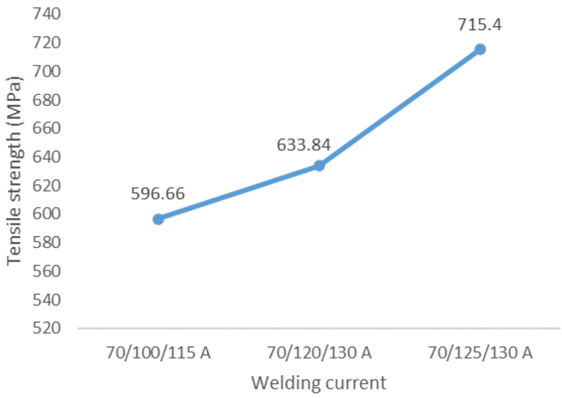

Figure 6. Comparison of tensile strength values of test specimens.

The fracture pattern of the tensile test results shown in Figure 7 is ductile fractures. One can see a ductile fracture pattern from the colour of the fault, which is grey and filamentous. The tensile testing results show that all fracture specimens occur in the weld metal area.

Figure 7. Tensile Test Results of current variation (A) (70, 100, 115 A), current variation (B) (70, 120, 130 A), and current variation (C) (70, 125, 130 A).

Bending Test Results

Table 1. Bending Test Data Results.

Welding current	Bending strength (MPa)
70, 100, 115 A	1289,01
70, 120, 130 A	1293,01
70, 125, 130 A	1417,93

Table 1 represents the values of bending test results from the three SMAW welding specimens with different current variations. The comparison of the value of the bending strength of the welding specimen is shown in Figure 8. Based on Table 1, a comparison of the bending strength values of each welding specimen is shown. It can be seen that the bending strength value of specimen A variations (70, 100, 115 A) is 1289.01 MPa, and specimen B variations (70, 120, 130 A) is 1293.01 MPa. the value of bending strength increases but not too far, this is due to the porosity formed when welding affects the value of bending strength. The results of the bending test obtained values for large variations of current (70, 125, 130 A) higher than specimens with current variations (70, 100, 115 A) and (70, 120, 130 A). This is because the higher heat input and faster cooling time make the microstructure finer and smoother, so the increased bending strengths have caused API 5L X52 specimens to be more resilient [11],[12].

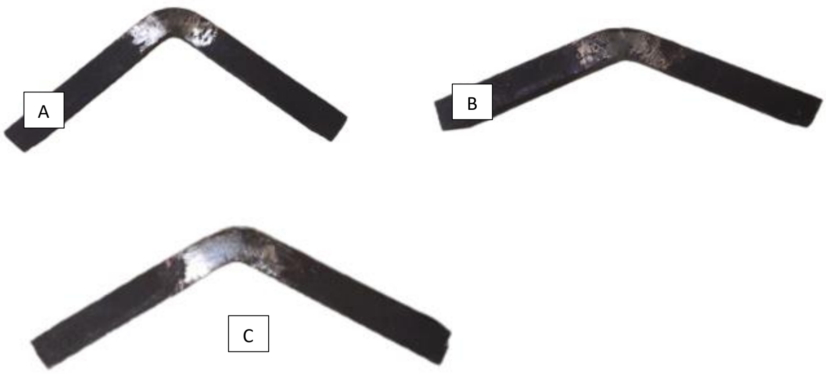

Figure 8. Bending test results specimens of current variation (A) (70, 100, 115 A), current variation (B) (70, 120, 130 A), and current variation (C) (70, 125, 130 A).

Based on Figure 8, all specimens from bending testing do not have open cracks. According to the 2015 edition of ASME Section IX, test specimens must not have cracks not exceeding 1/8 in (3 mm) after testing. Specimens with welding current variations (70, 100, 115 A), (70, 120, 130 A) and (70, 125, 130 A) do not have open cracks so specimens are declared accepted [7],[13].

CONCLUSION

After analysis of the study, the following conclusions were obtained. Increased current variations affect the microstructure produced in the weld metal and HAZ, while base metal does not change significantly. Current variations in the welding process affect the macrostructure produced in the weld metal area. The use of increased current variations affects the increased tensile strength produced. Specimen with variation (70, 100, 115 A) tensile strength value 596.66 MPa, the specimen with variation (70, 120, 130 A) tensile strength value 633.84 MPa, specimen with variation (70, 125, 130 A) tensile strength value 715.40 MPa. The use of increased current variations affects the bending strength produced is increasing. S specimen with variation (70, 100, 115 A) bending strength value is 1289.01 MPa, specimen with variation (70, 120, 130 A) bending strength value is 1293.01 MPa, specimen with variation (70, 125, 130 A) bending strength value is 1417.93 MPa.

ACKNOWLEDGEMENT

LPPM and LABTER ITK are acknowledged for the funding and facilities.

REFERENCES

[1] R. A. Primasta, “Strong influence of welding current and electrode type on tensile testing of SMAW welded connection results on ST 37 steel,” Universitas Nusantara Pgri KedirI, vol. 87, no. 1,2, pp. 149-200, 2017.
[2] F. Riyadi, “Analisa mechanical dan metalurgical baja karbon A36 dengan metode SMAW,” 2013.
[3] A. Asikin, Analysis of faults due to circumferential stress in gas pipeline welded joints. Diponegoro University, 2009.
[4] M. Fernanda, Analysis of strong variation of welding current combination of SMAW and FCAW p noV-groove potency against microstructure and hardness of API 5L X52 material. Kalimantan Institute of Technology, 2019.
[5] S. D. Anggraeni, “Comparative study of SMAW welding process pthere are terrestrial and underwater environments against the resistance of bending weld joint material A36 test,” ITS Eng. J., vol. 5, no. 2, 2016.
[6] M. U. Pawara, Alamsyah, M. Syarif, F. Mahmuddin, And Harifuddin. “Effect Of Post Weld Heat Treatment On Tensile Strength Of Astm A36 Welded Joints: Application On Hull Vessel Material,”Int.J.Mar.Eng.Innov.Res.,Vol.8,No.1,Pp.5665,2023,Doi:Http://Dx.Doi.Org/10.12962/J25481479.V8i1.16312.
[7] Alamsyah, F. . Indah Sari, A. M. N. . Arifuddin, M. U. . Pawara, A. A. Mubarak, and Hijriah, “Experimental Test of Tensile Strength of Barge Deck Plate Welded Joints”, Int. J. Metacen., vol. 2, no. 2, pp. 9-17, Dec. 2022.
[8] A. Syahrani, “Current variation against tensile strength and bending p no SM490 welding results,” Mech. J., vol. 4, no. 2, p. 393402, 2013.
[9] A. A. Soleh, “Analysis of the strong influence of current on micro structure, hardness, tensile strength in low carbon steel with SMAW welding using electrode type E7016,” Exact Scholar Sci. J., vol. 1, no. 2, pp. 29-35, 2017.
[10] R. Balaka, “Analysis of the effect of welding current at electrode angle 70 on hardness properties and microstructure of low carbon steel using jig welding,” Sci. J. Mech. Eng. Stud., vol. 2, no. 2, pp. 50-55, 2016.
[11] A. Syahrani, “Current variation against tensile strength and bending p no SM490 welding results,” Mech. J., vol. 4, no. 2, p. 393402, 2013.
[12] R. J. Ramadhan, The influence of current variations and types of electro and welding on the microstructure and hardness of Bisclad 600 welding results using the SMAW method. Sepuluh Nopember Institute of Technology, 2018.
[13] M. R. Sugestian, “Analysis of the strength of SMAW vertical horizontal down hand welded joints on jis 3131sphc steel plate and stainless steel 201 with piles transfer application in thermoforming machines (stacking unit),” Thesis J., 2019.