ISOMAse
International Society of Ocean, Mechanical and Aerospace Scientists and Engineers

Journal of Ocean, Mechanical and Aerospace
-Science and Engineering-
30th November 2022. Vol.66 No.3

November 30, 2022

Analysis of Current and Electrode Types on Welding Defects in ASTM A36 Mild Steel

Herisiswanto [a], Yohanes [a,*] and Khoirul Hafisuddin [a]

[a)] *Mechanical Engineering Department, Faculty of Engineering, Universitas Riau, Indonesia*

*Corresponding author: yohanes@lecturer.unri.ac.id

Paper History

Received: 12-July-2022
Received in revised form: 23-August-2022
Accepted: 30-November-2022

ABSTRACT

The purpose of this study is to analyze the welding defects that occurring in the SMAW (Shielded Metal Arc Welding) process. This study used experimental method to investigate the various types of electrodes and welding current. The welding process in this study used ASTM A36 low carbon steel with specimen dimensions of 8 mm thick, 80 mm wide, and 100 mm long. The welding process was carried out in an underhand position (1G) using a V-seam layer with a SMAW welding machine, which a sliding adaptive two axis system with speed control. The types of electrodes used were E6013 and E7018 electrodes with a diameter of 3.2 mm. The current variations used 90 A, 105 A and 120 A. The test methods used the Penetrant Test, Visual Test (Non Destructive Test) and Tensile Test (Destructive Test). The results of this study were: 1) the welding defects that often occurring at the E6013 electrode due to undercut and at the E7018 electrode caused by the porosity, 2) at a current of 120 A the occurrence of welding defects was minimal, and 3) the tensile strength of E7018 was greater than E6013.

KEYWORDS: *Current, Electrode, SMAW, Welding Defects.*

1.0 INTRODUCTION

The SMAW (Shielded Metal Arc Welding) is a metal joining process by melting the parent metal using heat energy [1]-[3]. The SMAW welding has its own advantages, including the amount of current as a heat source that can be varied, easy to use in various welding positions and penetration and the width of the melting electrode can be adjusted [4]-[7]. The strength of the welding results is affected by the type of electrode, variations in electric current [8]-[10]. The determining factor that becomes an indicator of welding results is that a clean material surface and producing the stronger weld joint. The surface oxidation in welding joint must be removed because it can be trapped in the frozen metal and cause welding defects [11-12].

In the SMAW welding process, welding defects such as undercut, porosity and distortion are often found. Possible cause is the use of improper welding electric current. To reduce the problem of welding defects, it can be done by selecting the welding electric current used based on the size of the electrode diameter. Information on the electric current on the electrode has a variety of limits, starting from the lowest limit to the highest limit. So, it is necessary to choose an alternative electric current for the optimal welding process. The impact of variations in the choice of electric current during the welding process would affect the quality of welding [13]-[17].

The SMAW has been developed become SMAW welding with a sliding adaptive two axis system with speed control [18-19]. The advantage of the speed control system is that the welding speed can adjust to the conditions during the welding process both on the Y axis and on the X axis, so that the optimal welding speed and angle can be determined automatically. However, it cannot be denied that the risk of defects occurring during the welding process may occurred. This is certainly affect the strength and quality of the weld. According to [18], there were several specimens that failed or were not feasible, specimens that were said to have failed in the visual test were due to welding defects and imperfect welding. Similarly, [19] also said that there were welding defects in welding deposits such as over spatter defects and welding deposits that had non-optimal penetration and welding widths that did not match the reference used so that some specimens could not be used or failed. Therefore, it is necessary to conduct a study of welding defects with variations in current strength and the type of electrode used for the SMAW sliding adaptive two axis system with speed control [18-19]. The purpose of this study is to analyze the welding defects that occur in SMAW process with a sliding adaptive two axis system with speed control at various current and types of electrodes. The specimen results were conducted the visual testing, penetrant and tensile testing. So that the causes and solution to reduce the occurrence of defects in welding results can be known.

ISOMAse
International Society of Ocean, Mechanical and Aerospace Scientists and Engineers
Journal of Ocean, Mechanical and Aerospace
-Science and Engineering-
30th November 2022. Vol.66 No.3

November 30, 2022

2.0 METHODOLOGY

This study is used the experimental method to analyze the welding defects that occur in SMAW process with a sliding adaptive two axis system with speed control at various current and types of electrodes. In this study, the variations of the current were used 90 A, 105 A, and 120 A. Meanwhile, the types of electrodes used were E6013 and E7018. The material and dimensions of the specimen were 8 mm thick, 80 mm wide, and 100 mm long (Figure 1) and the type of material used low carbon steel with ASTM A 36 standards. The type of welding current of AC and V seam with an angle of 60° position 1G (Figure 1). The types of electrodes used E6013 and E7018 with an electrode angle of 70°.

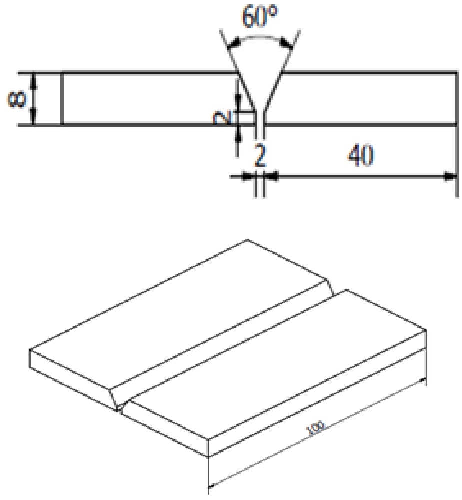

Figure 1: The dimension of specimen

The SMAW welding machine and two axis adaptive sliding system with speed control was used to conduct the study. The machine specification was 1000 mm in length, 500 mm in width and 1000 mm in height. Using a power supply component with a voltage of 24v and a current of 10A, an arduino uno and a servo motor with a current of 2.8A, the welding speed was regulated using speed control. The two-axis adaptive sliding machine with speed control is shown in Figure 2.

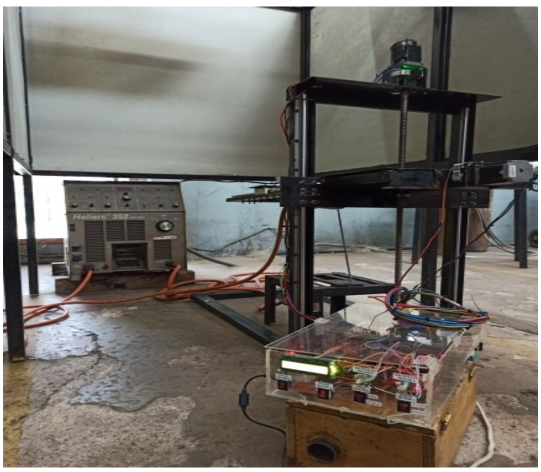

Figure 2: Two axis adaptive sliding machine with speed control

Then, the results of welding specimen were tested to determine the type of defects that occur from the test object. The tests in this study namely destructive test and non-destructive test the material. Non-destructive testing was carried out by visual testing and penetrant testing. The results obtained from non-destructive testing were to determine the type of defect and the size of the defect found in the welding results. Meanwhile, the destructive test was carried out by means of a tensile test to obtain the results of the tensile strength of the welding results and to find out the strength value and the location of the break in a welded joint occurring.

The stages in testing procedure to the work carried out in this research were as follows:

a. Preparation of work materials and tools, materials that need to be prepared are: (1) specimen 18 specimens of mild steel with ASTM A 36 standards and a size of 100 mm x 80 mm x 8 mm. Then making V seams with an angle of 60° and a root of 2 mm. (2) electrodes with the brands ESAB AWS E6013 and ESAB AWS E7018 were 3.2 mm in diameter. And (3) Liquid penetrant, used to see the defects that exist in the specimen after welding. The preparation of the tools in the research were: (1) a testing tool consisting of (a) a sliding adaptive two axis machine with speed control and (b) welding machine. (2) research measuring instruments used the caliper and arc, and (3) testing aids, namely grinders, milling machines and tensile testing tools.
b. The welding process, the welding process in this study was carried out with the 1G position on the SMAW welding machine with a sliding adaptive two axis system with speed control. Some preparations were done such as: (1) preparation on the SMAW welding machine, setting the type of AC current to be used and adjusting the welding current to 90 A, 105 A and 120 A, (2) preparing a sliding adaptive two axis with speed tool control by setting the X and Y axes.
c. Specimen testing, the test was carried out 3 times in each specimen. There were types of tests in this study, namely: (1) testing without damaging the specimen (non-destructive test), which consists of visual testing and penetrant testing, and (2) testing damaging the specimen (destructive test), which was a tensile test. The test standard for tensile test specimens refers to JIS Z 2201 No.7, which can be seen in Figure 3.

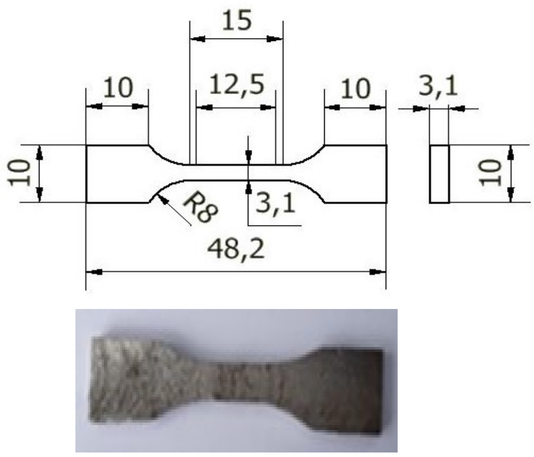

Figure 3: Tensile test specimen

JOMAse | Received: 12-July-2022 | Accepted: 30-November-2022 | [(66) 3: 110-115]
Published by International Society of Ocean, Mechanical and Aerospace Scientists and Engineers, www.isomase.org., ISSN: 2354-7065 & e-ISSN: 2527-6085

ISOMAse
International Society of Ocean, Mechanical and Aerospace Scientists and Engineers
Journal of Ocean, Mechanical and Aerospace
-Science and Engineering-
30th November 2022. Vol.66 No.3

3.0 RESULTS AND DISCUSSION

3.1 Visual Test

The results of measurements and visual tests using the E6013 electrode can be seen in Table 1. The method of analysis was carried out in this visual test by looking at the size of the weld results in the form of the dimensions of the length and width of the defects in the weld deposit.

Table 1: Welding test data of E6013 electrodes, measurement of length, width and type of defects on visual inspection

Current (A)	Spe-cimen	Length (mm)	Width (mm)			Type of Defect
			1	2	3	
90	1	33.90	8.20	4.90	4.75	Undercuts, Incomplete Penetration, Over Spatter
	2	46.75	8.75	6.90	9.25	Undercuts, Incomplete Penetration, Over Spatter
	3	82,20	8.50	9.95	5.90	Undercut, Incomplete Fusion
105	1	53.75	6	11.25	9.50	Undercut, Incomplete Fusion
	2	64.25	10	10.25	6.90	Incomplete Fusion
	3	77.70	13.25	11.10	9.90	Incomplete Fusion
120	1	87.20	7.85	11.75	9.90	-
	2	90.25	11.50	11.85	9.75	-
	3	91.40	13.6	10.90	10	Undercut

Testing the specimen using ASTM A36 steel plate with a thickness of 8 mm with a current of 90 A with a speed of 4.05 mm/s on specimen 1, 5.96 mm/s on specimen 2 and 3.95 mm/s on specimen 3. The specimen used a V seam with a corner angle of 60°. The welding result for current 90 A, there were undercut, incomplete fusion and over spatter defects. Welding results at a current of 90 A can be seen in Figure 4.


Figure 4: Welding results using the E6013 electrode at 90 A

Testing the specimen using ASTM A36 steel plate with a thickness of 8 mm with a current of 105 A with a speed of 3.80 mm/s on specimen 1, 3.86 mm/s on specimen 2 and 4.35 mm/s on specimen 3. The welding result for V seam with a corner angle of 60°. The welding result for current of 105 A there was an incomplete fusion defect. Welding results at a current of 105 A can be seen in Figure 5.

Testing the specimen using ASTM A36 steel plate with a thickness of 8 mm with a current of 120 A with a speed of 4.83 mm/s on specimen 1, 4.09 mm/s on specimen 2 and 4.12 mm/s on specimen 3. The welding result for V seam with a corner angle of 60°. The welding result for current of 120 A, only 1 specimen had a defect, namely an undercut defect. Welding results at a current of 120 A can be seen in Figure 6.


Figure 5: Welding results using the E6013 electrode at 105 A


Figure 6: Welding results using the E6013 electrode at 120 A

The results of measurements and visual tests using the E7018 electrode can be seen in Table 2. Testing the specimen using ASTM A 36 steel plate with a thickness of 8 mm with a current of 90 A with a speed of 5.97 mm/s on specimen 1, 4.15 mm/s on specimen 2 and 6.01 mm/s on specimen 3. Using a V seam with a corner angle of 60°.

Table 2: Welding test data of E7018 electrodes, measurement of length, width and type of defects on visual inspection

Current (A)	Spe-cimen	Length (mm)	Width(mm)			Type of Defect
			1	2	3	
90	1	95.00	11.10	7.75	7.20	Undercut, Porosity, Incomplete Fusion
	2	90.00	7.90	7.45	6.65	Undercut, Incomplete Fusion
	3	90.00	6.80	9.65	5.70	Undercut, Incomplete Fusion
105	1	90.00	9.50	11.75	11.10	Porosity
	2	95.00	9.00	10.90	10,10	Porosity
	3	90.00	9.30	9.25	9.35	Incomplete fusion
120	1	80,50	11.20	10.85	9.45	Undercut
	2	90.00	9.40	9.75	9.10	Undercut
	3	85	11.15	10.25	9.80	Undercut, Porosity

From the results of welding using electric current of 90 A, there were several defects, namely undercut, incomplete fusion, and porosity. The welding results at a current of 90 A can be seen in Figure 7.

Testing the specimen using ASTM A36 steel plate with a thickness of 8 mm with a current of 105 A with a speed of 4.35 mm/s on specimen 1, 5.98 mm/s on specimen 2 and 5.99 mm/s on specimen 3. Using a V seam with a corner angle of 60°. From the results of welding with a current of 105 A, there were several defects, namely incomplete fusion, and porosity. The results of welding at current of 90 A can be seen in Figure 8.

JOMAse | Received: 12-July-2022 | Accepted: 30-November-2022 | [(66) 3: 110-115]
Published by International Society of Ocean, Mechanical and Aerospace Scientists and Engineers, www.isomase.org., ISSN: 2354-7065 & e-ISSN: 2527-6085

Figure 7: Welding results using the E7018 electrode at 90 A

Figure 8: Welding results using the E7018 electrode at 105 A

Testing the specimen using ASTM A36 steel plate with a thickness of 8 mm with a current of 120 A with a speed of 3.25 mm/s on specimen 1, 4.07 mm/s on specimen 2 and 4.01 mm/s on specimen 3. Using a V seam with a corner angle of 60°. From the results of welding using a current of 120 A, there were some undercut and porosity defects. Welding results at a current of 120 A can be seen in Figure 9.

Figure 9: Welding results using the E7018 electrode at 120 A

3.2 Penetrant Test

The results of the penetrant measurement and testing using the E6013 electrode can be seen in Table 3. The results of the penetrant measurement and testing using the E7018 electrode can be seen in Table 4.

Table 3: Test results for welding defects using penetrant liquid using E6013 electrodes

Current (A)	Specimen	Defect Size (mm)	Type of Defect
90	1	66,20	Incomplete Penetration, Incomplete Fusion
	2	62.60	Incomplete Fusion, Over Spatter
	3	16.60	Incomplete Fusion
105	1	49.15	Undercut, Incomplete Fusion
	2	44.15	Incomplete Fusion, Over Spatter, Undercut
	3	10.95	Undercut
120	1	9.15	Incomplete Penetration
	2	-	-
	3	-	-

Table 4: Test results for welding defects using penetrant liquid using E7018 electrodes

Current (A)	Specimen	Defect Size (mm)	Type of defect
90	1	46.25	Porosity, Undercut
	2	4.60	Incomplete Fusion, Porosity
	3	10.25	Incomplete Fusion
105	1	11.10	Porosity
	2	8.90	Undercut, Porosity
	3	7.20	Hot crack
120	1	-	-
	2	-	-
	3	7,10	Porosity

3.3 Tensile Test

The results of the tensile test using the E6013 and E7018 electrodes can be seen in Table 5.

Table 5: Value of tensile test results on E 6013 and E7018 electrodes

Specimen	Area (mm^2)	Max. Force (N)	0.2% YS (N/mm^2)	Yield Strength (N/mm^2)	Tensile Strength (Mpa)	Elongation (%)
E 6013 B	10,973	5,125.3	119.94	119.94	467.09	67.93
E 6013 X	10,679	3,247.9	175.03	175.03	304.09	67.93
E 7018 B	10,800	5,955.1	230.21	217.35	551.39	67.93
E 7018 X	11,109	4,671.8	319.80	319.80	420.55	67.93

3.4 Discussion

Based on the results of the study, obtained several types of defects that occur in visual and penetrant testing, namely as follows:

a) Undercut defects, namely defects on the surface of the weld in the form of an overdraft. Undercut itself is caused by the travel speed (welding speed) is too low, the electrode position is not right, and the arc length is too high.
b) Incomplete fusion defects, namely imperfections in the joining process between the welding metal and the base metal usually occur on side of weld seam, the cause of the electrode distance during welding is too high.
c) Over spatter defects, namely defects in the form of welding sparks found on the edges and on the weld deposit, over spatter itself occurs due to electrode conditions that are too far apart in the welding process and also moist electrode conditions and too high current.
d) Defects, the small holes in the weld deposit, which usually occur for several reasons, are caused by trapped air entering the weld deposit and the presence of dirt on the specimen.

The results of the tensile test using the E6013 and E7018 electrodes can be illustrated by the graph of Figure 7. It can be seen in Figure 7 the highest tensile strength lies in the welding connection using the E7018+ electrode with a current of 120 A with a value of 551.39 MPa and a welding speed of 4.01 mm/s.

JOMAse | Received: 12-July-2022 | Accepted: 30-November-2022 | [(66) 3: 110-115]
Published by International Society of Ocean, Mechanical and Aerospace Scientists and Engineers, www.isomase.org., ISSN: 2354-7065 & e-ISSN: 2527-6085

The lowest tensile strength lies in the weld joint with the E6013 electrode - a current of 90 A with a value of 304.09 Mpa. The tensile strength results on E7018+ are greater than those of E6013+ due to the few defects that occur in welding deposits and the advantages possessed by the E7018 type of electrode so as to produce optimal deposits on the specimen. In line with the results of the research by Shomad and Mushfi [20], based on data from the test results, the E6013 electrode variation group has the smallest toughness compared to the E7018 electrode variation group and raw materials. It is evident from the data obtained from the tensile and hardness tests that the E6013 electrode variation group has the smallest toughness value.

Based on the results of the data obtained, the type of electrode is very influential on the welding results, especially in welding using the E7018 electrode. The E7018 electrode has a tensile strength of 70,000 Psi and the content in the E7018 electrode is an iron powder coating which is useful for increasing welding efficiency and contains low hydrogen so that it affects the cooling process of the weld metal. Welding on the E7018 electrode requires a higher current and low hydrogen which will affect the cooling process of the weld metal. The cooling process of the weld metal will be faster so that the weld metal will become harder and stronger for the connection. Meanwhile, the tensile strength of the E6013 electrode is 60,000 Psi and the content of the E6013 electrode is high sodium titania. The advantage is that the weld area is free from slag infiltration and oxidation effects.

The affects of tensile strength value of the E6013 electrode are lower than the E7018 due to the electrode membrane for the E7018 type of iron powder containing low hydrogen less than 5%, so that the weld deposit can be free of porosity.

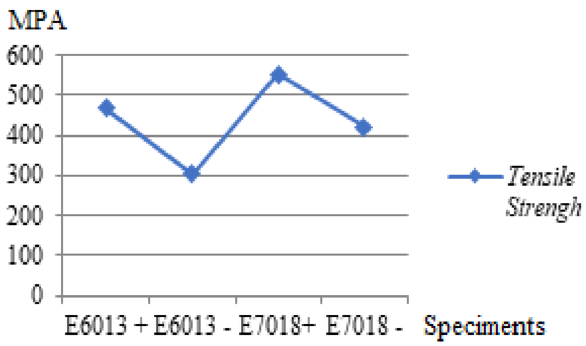

Figure 7: The results of the tensile test using the E6013 and E7018 electrodes

Comparing to the E6013 type of rutile-coated electrode, the penetration process is moderate, the flux and liquid metal would be difficult to see, therefore the porosity level is become higher. Sub-sequence, the possibility of slag trapped in the weld metal would be higher. From the test results, welding test specimens with variations of different types of electrodes should have relatively the same strength, but the large enough difference is possible for defects, especially on the seam that is not fully filled. So that, its strength is low. This is because in the joint area occurred the concentration of stress on the weld [21-22]. So that the mechanical properties change such as ductile properties change to brittle, thus during the tensile test the joint area easily to break.

4.0 CONCLUSION

The results of the welding defect test using a visual test and a penetrant test on the type of electrode E6013: (a) 90 A, welding defects of undercut type, incomplete fusion, incomplete penetration and over spatter were found, (b) 105 A, undercut, incomplete fusion, and incomplete penetration welding defects were found, and (c) 120 A, incomplete fusion and undercut welding defects were found. In addition to the types of defects mentioned above, all test specimens were declared to be affected by undercut and incomplete fusion welding defects. This was caused by high currents and inaccurate electrode positions and distances on the seams. To reduce the occurrence of defects during welding, it is better to do the initial setting of the electrode position and the distance according to the diameter of the electrode. It can be concluded that the optimum current for welding is at a current of 120 A because at a current of 120 A minimal welding defects are found.

The results of the welding defect test using a visual test and a penetrant test on the type of electrode 7018: (a) 90 A, welding defects of porosity, incomplete fusion and undercut types were found, (b) 105 A, a slight porosity and hot crack were found, and (c) 120 A, porosity and undercut welding defects were found. In addition to the types of defects mentioned above, all test objects were declared exposed to undercut and porosity welding defects. This was caused by the long distance between the electrodes and the wet electrodes. To reduce this type of defect, the electrode distance is adjusted to the size of the electrode diameter and the electrode should be stored at room temperature and in a closed condition. It can be concluded that of the three currents used, none of them did not experience welding defects. However, the least welding defects encountered were at a current of 120 A.

REFERENCES

[1] Anis, M. & Winarto (2011). Effect of plate thickness and weld position on distortion and residual stress of welded Ssructural steel, *Materials Science Forum,* 689, 296-301. 10.4028/www.scientific.net/MSF.689.296.

[2] Gery, D., Long, H. & Maropoulos, P. (2005). Effects of welding speed, energy input and heat source distribution on temperature variations in butt joint welding, *Journal of Materials Processing Technology,* 167, 393-401. 10.1016/j.jmatprotec.2005.06.018.

[3] Saraev, Y.N., Lunev, A.G., Semenchuk, V.M. et al. (2020). Heat and mass transfer kinetics in arc welding process, *Russia Physic Journal*, 62, 1573-1579. doi: 10.1007/s11182-020-01878-y.

[4] Nusbir, Y. & Sianipar, A. (2018). Experimental effect of angle variation and speed welding filler using vertical adaptive sliding system in SMAW welding, *Journal of Ocean, Mechanical and Aerospace -Science and Engineering-*, 59(1), 1-5.

[5] Sumardiyanto, D. & Susilowati, S.E. (2019). Effect of welding parameters on mechanical properties of low carbon steel API 5L shielded metal arc welds, *American Journal of Materials Science*, 9(1), 15-21. doi: 10.5923/j.materials.20190901.03.

[6] Kumar, S. & Singh, R. (2019). Investigation of tensile properties of shielded metal arc weldments of AISI 1018

mild steel with preheating process, *Materials Today: Proceedings*, 26. 10.1016/j.matpr.2019.10.167.
[7] Tong, L.G., Wang, L. & Yin, S.W. (2015). Influences of deposited metal material parameters on weld pool geometry during shield metal arc welding, *International Journal Heat Mass Transfer,* 90(2), 968-978.
[8] Zhang, X., Yao F, Ren Z, Yu H. (2018). Effect of Welding Current on Weld Formation, Microstructure, and Mechanical Properties in Resistance Spot Welding of CR590T/340Y Galvanized Dual Phase Steel, *Materials (Basel)*. 11(11):2310. doi: 10.3390/ma11112310. PMID: 30453641; PMCID: PMC6265945.
[9] Liu, X., Lan, S. & Ni, J. (2015). Electrically assisted friction stir welding for joining Al 6061 to TRIP 780 steel, *Journal of Materials Processing Technology*, 219, 112-123.
[10] Jasman, J., Irzal, I. & Pebrian, P. (2018). Effect of strong welding flow on the violence of low carbon steel results of SMAW welding with electrodes 7018, *Teknomekanik*, 1(1), 24-31.
[11] Mandal, N.R. (2017). *Welding defects*. In Ship Construction and Welding (pp. 283-292). Springer, Singapore.
[12] Kah, P., Rajan, R., Martikainen, J. & Suoranta, R. (2015). Investigation of weld defects in friction-stir welding and fusion welding of aluminium alloys, *International Journal of Mechanical and Materials Engineering*, 10(1), 1-10.
[13] Pratomo, M.A., Jasman, J., Erizon, N. & Fernanda, Y. (2020). The variation effect of electric current toward tensile strength on low carbon steel welding with electrode E7018, *Teknomekanik*, 3(1), 9-16.
[14] Haider, S.F., Quazi, M.M., Bhatti, J., Bashir, M.N. & Ali, I. (2019). Effect of shielded metal arc welding (smaw) parameters on mechanical properties of low-carbon, mild and stainless-steel welded joints: A review, *Journal of Advances in Technology and Engineering Research*, 5(5), 191-198.
[15] Yadav, A.K., Kumar, A., Singh, C.P.N., Singh, A.K. & Nand, M.S. (2020). Studies on impact of welding parameters on angular distortion and mechanical properties of structural steel welded by SMAW, International Research Journal Modern Engineering Technology Science, 2(5), 445-459.
[16] Gowthaman, P.S., Muthukumaran, P., Gowthaman, J. & Arun, C. (2017). Review on mechanical characteristics of 304 stainless steel using SMAW welding, MASK International Journal Science Technology, 2(2), 33-37.
[17] Chen, X., Liu, Y., Chen, H., Liu, J., Yan, Y. & Zhai, J. (2022). Effect of welding current and welding time on nugget size in RSW, *In ICETIS 2022; 7th International Conference on Electronic Technology and Information Science* (pp. 1-4).
[18] Yohanes, Y. & Harahap, M. (2018). Effects of electrode velocity variations and selection of electric current against quality welding results mild steel on SMAW welding, *Journal of Ocean, Mechanical and Aerospace -Science and Engineering-,* 57(1), 12-16.
[19] Sihombing, S.M. 2021. *Effect of Electrode Angle Variation and Reverse Polarity Current Strength on Shielded Metal Arc Welding Results*. Thesis. Riau University.
[20] Shomad, M.A. & Mushfi, S.M. (2017). Analisis pengaruh variasi elektroda las e6013 dan e7018 terhadap kekuatan tarik dan kekerasan pada bahan baja ss 400, *Dinamika Teknik Mesin*, 7(2). 10.29303/d.v7i2.156.
[21] Srinivasan, S., Sundarababu, J. & Lakshmipathi, A.R. (2018). Experimentation and comparative study of E6013 and E7018 weldments using shielded metal arc welding, *Proceedings of the Institution of Mechanical Engineers Part G Journal of Aerospace Engineering*, 8, 169-174.
[22] Nassar, A.A., Lefta, R.M. & Abdulsada, M.J. (2018). Experimental study of the effect of welding electrode types on tensile properties of low carbon steel AISI1010, *Kufa Journal of Engineering*, 9(42018.9113.

Published by International Society of Ocean, Mechanical and Aerospace Scientists and Engineers, www.isomase.org., ISSN: 2354-7065 & e-ISSN: 2527-6085