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The current strength welding analysis of electrode E6013 and E7016 type CS32 steel to the flows on microstructure and hardness

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Abstract. The research on the effect of welding current strength on microstructure and hardness on CS32 type steel with electrode wire E6013 and E7016 has been carried out. This research uses CS 32 type concrete reinforced steel or low iron alloy steel treated with variations of electric current 90, 100, and 125 Ampere using reverse polarity DC SMAW welding with E7016 and E6013 electrode wire with a diameter of 3.2 mm and 20 cm long, and V with a 50 ° angle. The results of microstructural characterization showed that the metal base area in the form of ferrite (white) and pearlite (black) phase, and the HAZ region Widmanstatten phase (ferrite, pearlite and bainite) and the central weld area were bainite, ferrite fascia, and elastic phases with granules smooth. The results of this study indicate that the hardness value of welding CS32 type iron is reached at 271 HV, in the HAZ region of 100 Ampere electric current, the shape of the Widmanstatten phase structure (ferrite, pearlite, and bainite).

1. Introduction

The infrastructure development on bridges, buildings and construction work cannot be separated from welding because it has an important role in metal engineering and repair. The construction of metal construction in the era of globalization involves a lot of welding elements, especially in the field of design because welding joints are one of the most widely used joints making, requires equipment technically, methods, processes and skills. Others : steel frame, pressure vessels, aircraft construction, shipping, bridges, pipelines, and means of transportation.

One that requires welding time, to get good results included balance of voltages and amperes. This has a great effect on the heat input that occurs in addition to speed and welding expertise. One of the factors that influence the welding process is the input of heat to the material to be welded, because it greatly affects the microstructure, hardness, impact strength, and cooling rate. Before the welding process takes place, it is necessary to measure the chemical composition of the parent metal directly, because the hardness, cooling rate and composition result in microstructure and toughness of the welding results.

Problems with welding results also occur in several industries, for example in the Indonesian railroad industry. The railroad car undergoes a change in shape or slight deviation between the thin plate wall and the frame on the carriage door. To minimize the change in shape of welding results has become an important research subject in welding. Because of changes in shape severe ones can cause undesirable effects on manufacturing costs because additional work or repairs need to be done. Previous research focused a lot on the effect of welding speed, stress and welding methods to improve the mechanical properties of welds, and microstructure. Low carbon steel can be welded by encased arc welding electrodes, soak arc welding and MIG welding (noble gas metal welding). Low carbon steel is commonly used for thin plates and general construction. [1] Welding electrodes in SMAW welding can affect the weld results. One of the electrodes that can or often is used is E7016. Other electrodes can use DC- and DC + currents. The use of current ranges from 115-165 Ampere .With these current intervals, the resulting welding will be different. [4] The strength of weld results is influenced by arc voltage, current size, welding speed, magnitude of penetration and electrical polarity. Determination of the amount of current in connecting metals using arc welding affects the efficiency of work and welding materials. Problems that arise in the welding process with a large influence of welding current on microstructure, hardness and tensile strength of low carbon steel from SMAW welding the effect of welding current on microstructure and hardness on CS32 type steel concrete with E6013 and E7016 electrode wires.

2. Research Method

Material used: - CS32 concrete type, 32 mm diameter -Write the E6013 and E 7018 type electrodes with a diameter of 3.2 mm. Equipment used: - Complete welding equipment of E6013 and E7016 electrode wires - Complete metallographic equipment - optical microscope -Hardness Test Hardness Vickers scale.

Procedure

Welded joints are made on cylindrical type CS32 steel, diameter 32 mm in size Concrete iron is prepared V type of open, gap for concrete iron is 2 mm, root height is 2 mm and angle of displacement is 50 °, at both ends to be welded with root pass 1 – 2.
The workpiece is welded by welding SMAW with electrode wire types E6013 and E 7018 with a diameter of 3.2mm. Electric current strength with variations: 90, 100, and 125Amper.
The working principle of SMAW welding is that when the electrode tip is brought close to the workpiece there is electric heat (electric arc) which makes the workpiece between the workpiece and the end of wrapped electrode melts together. The electrode itself is a wire / metal wrapped in flux. At the electrode it functions as a bow stabilizer and also as a bow and also as a slag source which will protect the new weld from contamination of the outside air.

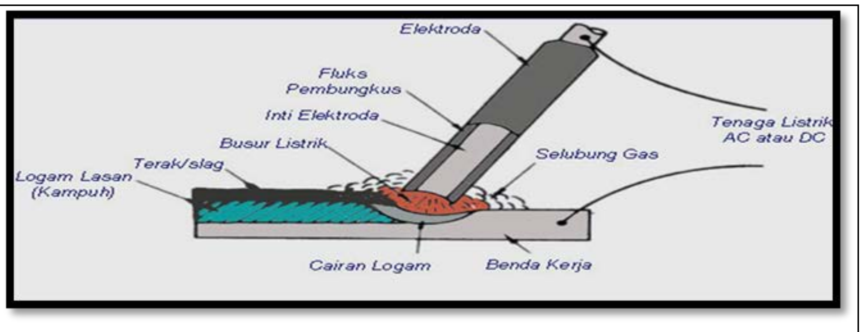

Figure 1. Scheme of welder SMAW process

Figure 2. Sample of result welder

Morphological observations (microstructure) were carried out using an optical microscope, previously prepared by metallographic processes. To get the morphology of the parent metal area, the HAZ region, and the central weld area. The hardness test was carried out by Vickers test with a load of 500 GRF to obtain a hard distribution on the parent metal region, the HAZ region, and the central weld area.

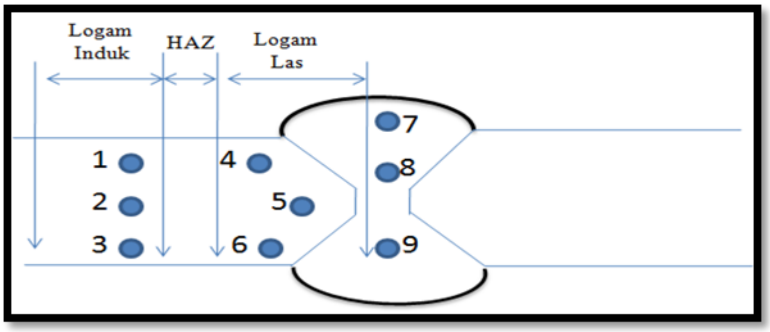

Figure 3. Investigation point of specimen type CS32 steel

3. Results and Discussion

a. Analysis of Microstructure

Photographs of microstructure on welding samples with E7016 and E6013 welding wires, with 50A tapered 50 ° current can be seen in Figures 4 and 5.

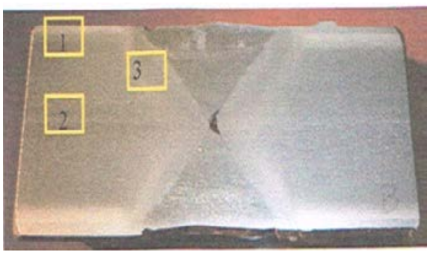

Figure 4. Samples CS 32 type concrete iron after E7016 welding

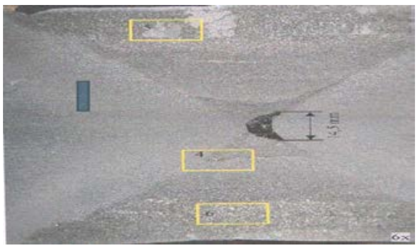

Figure 5. Samples CS 32 type concrete iron after E6013 welding

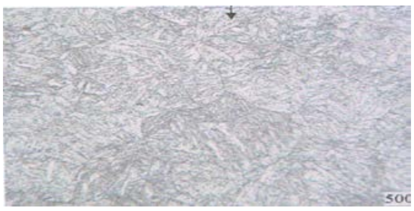

Figure 6. Micrograph basic material in the form of ferrite (white) and pearlite (black). E7016

Figure 7. Micrograph basic material in the form of ferrite (white) and pearlite (black). E6013

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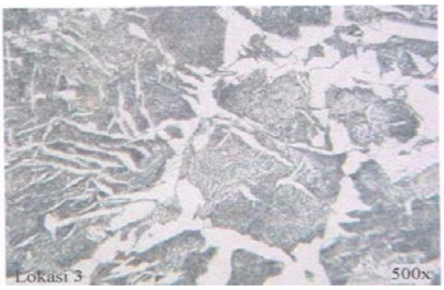

Figure 8. Micrograph HAZ region in the form of Widmanstatten (ferrite, pearlite and bainite). E7016

Figure 9. Micrograph HAZ region in the form of Widmanstatten (ferrite, pearlite and bainite). E6013

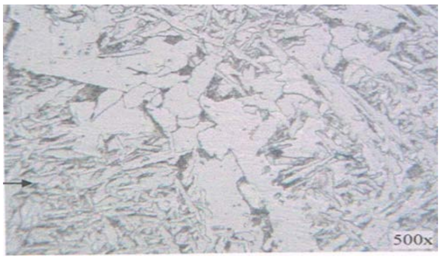

Figure 10. Micrograph of welding material in the form of bainite and fine granular ferlite. E7016

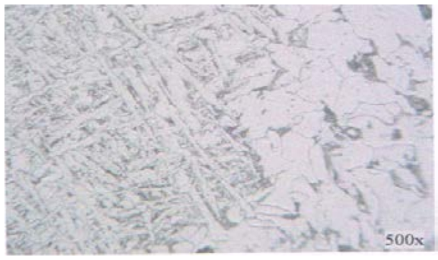

Figure 11. Micrograph of welding material in the form of bainite and fine granular ferlite. E6013

The microstructure results from the welding of CS32 type concrete iron can be classified into 3 zones, namely: the parent metal region, the HAZ region, and the central weld area can be seen in Figures 6 to 11. Based on Figures 6 and 7, it can be seen that the microstructure of the parent metal has a longitudinal grain structure which corresponds to the ferrite phase and pearlite phase. Furthermore, Figures 8 and 9 showed the microstructure in the HAZ region, which is finer than the Widmanstatten phase (ferrite, pearlite and bainite). This occurs due to recrystallization of the grain after the welding process. Likewise, Figures 10 and 11 show very clear boundaries between the HAZ region and the central weld area. Where coarse grains in the central area of the weld are due to grain growth at a certain temperature and tend to show the bainite phase structure.

b. Analysis of Hardness

Table 1. Result of Hardness Test Method Vickers (HV)

Point	Zone	Electrode Type Specimen E7016			Electrode Type Specimen E6013		
		Current 90 A	Current 100 A	Current 125 A	Current 90 A	Current 100 A	Current 125 A
1	Metal of Basic	175	167,5	169	176, 5	173,5	170,5
2		159	162,5	176,5	159,5	223	175
3		167	167,5	173,5	169	175	167,5
	Average	**167**	**165,8**	**173**	**168,4**	**190,5**	**171**
4	HAZ	183	199	271	201,5	186	179,5
5		181	170,5	181	170,5	204	175
6		176.5	179,5	212	190	201,5	192
	Average	**180,1**	**183**	**221,3**	**187,3**	**196,8**	**182,1**
7	Metal of weld	146	188	220,5	141,8	134	143
8		172	157	179,5	146	130	135
9		188	173,5	183	141,8	148	148
	Average	**168,6**	**172,8**	**194,3**	**143,2**	**137,3**	**142**

From Table 1, it can be seen that the comparison of the values of violence on the 3 variations of electric current shows the average hardness of the BM region (points 1–3), the HAZ region (point 4-6), and WM (point 7-9) the highest at electric current 125 A and E 7016 which is the hardness value of 271 HV, and the lowest in electric currents of 100A and E6013, namely the hardness of 130 HV Thus the increase in electric current will tend to increase the value of material hardness. Testing the hardness value has a relationship with tensile strength and toughness in welding with variations in heat input.

According to researcher [5] stated that an increase in the number of AF would increase the toughness of weld metal. This is in accordance with the results of the microstructure and the results of the impact test that at the 756 J / mm heat input volume AF fraction is the most compared to other heat inputs so that the material toughness increases. Thus it can be stated that the 756 J / mm heat input has the best level of toughness because it has the most AF structure compared to other heat inputs. Also in the tensile strength test that is the tensile strength of the welded joints carried out by the transversal direction tensile test and horizontal direction showing the tensile strength of the welded joints with variations in heat input tend to have the same value which is around 480 ± 7 MPa. This is because the tensile test fault occurs in the parent metal region (BM), not in weld metal or HAZ

4. Conclusion

Based on calculations and analysis conclusions can be taken as follows:

1. The results of microstructural observations indicate that the metal base area is in the form of phase ferrite (white) and pearlite (black), and the HAZ region Widmanstatten phase (ferrite, pearlite and bainite) as well as the central weld area, the bainite, ferrite, and elastic phases are visible with fine granules.

2. The highest hardness value is located in the HAZ area of the Widmanstatten phase structure (ferrite phase, pearlite phase, and bainite phase) shows 221.3 HV, at the input of electric current 100 Ampere.

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