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ANALYSIS OF SMAW IN DIFFERENT MATERIALS WITH ELECTRODE VARIATIONS

Dede Ardi Rajab[1], Lapi Artitana[2], Agus Suprayitno[3]
[1,2]Mechanical Engginering STT Wastukancana Purwaakarta
[3]dedeardirajab@wastukancana.ac.id , Lapiartitana83@wastukancana.ac.id , asuprayitno@wastukancana.ac.id

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ABSTRACT

Welding is a technique for joining metals by melting part of the parent metal and filler metal with or without additional metal and producing a continuous connection. One type of welding that is often used is SMAW welding (Shield Metal Arc Welding). In SMAW welding, the influence of the electrode strength or amperage used plays an important role in welding, because it influences the results of the joint strength during welding. Therefore, the current setting must be appropriate to the material and choosing the right welding parameters will also improve the quality of the welding results. This research was conducted to determine the mechanical properties of tensile testing and the microstructure of the influence of the different electrodes and amperes that will be used. In this research, current variations of 70 A, 80 A, and 90 A were used and the types of electrodes used were E6013, E309-16 and E7018. The research results obtained from the tensile test had an optimum value for the E7018 electrode, 90 A with a tensile strength of 41 .60 kg/mm. The tensile test results for E7018 obtained an average tensile value of 33.19 kg/mm. The tensile test result value of E6013, 80 ampere has a value of 36.55 kg/mm, after being averaged the tensile strength of E6013 is 35.36 kg/mm, the tensile test result of E309, 80 A has a value of 38.15 kg/mm after being averaged got a tensile test value of 36.20 kg/mm.

Corresponding Author:

Lapi Artitana
Mechanical Engineering STT Wastukancana Purwakarta
West Java, Indonesia
Email: Lapiartitana83@wastukancana.ac.id

1. BACKGROUND

Welding methods, as well as those that occur in other fields, are experiencing progress driven by increased science and technology based on the definition of Deutsche Industrie Norman (DIN). Welded joints are metallurgical bonds in metal or metal alloy joints that are carried out in a melted or liquid state.(Yassyir Maulana, 2016), after the welding process required treatment to reduce residual stress and improve its mechanical properties.(Mesin et al., 2020), Welding of dissimilar metals (Dissimilar Metal Welding) is a development of modern welding technology as a result of the need for joining materials that have different metal types..(Amanda, Prasetyo et al., 2011), Carbon steel is an alloy of carbon iron in which the element carbon determines its properties, while the other alloying elements normally contained in it occur due to the manufacturing process. The properties of ordinary carbon steel are determined by the proportion of carbon and the microstructure.(Arifin et al., 2017). In more detail, it can be seen that the welding method must also be planned, inspection methods, welding materials and the type of welding used, based on the functions and parts designed.

Based on the background above, there has been no research that examines the properties and mechanics for SMAW welding of low carbon steel ST 37 with Stainless Steel SS304 Stainless Steel, so the research that the authors took was "Analysis of Shield Metal Arc Welding on Different Materials Based on Electrode Variations"

to obtain the resulting parameters for the value of the strength / ductility of a material with different welding currents using the Tensile test. Finding out the toughness point of the material using different current variations through microstructure testing. Based on the research objectives above, the benefits of this research are to obtain and provide information and data for readers from the results of different welding voltages to increase knowledge and reference for readers or advanced researchers to develop more modern technology.

2. METHOD

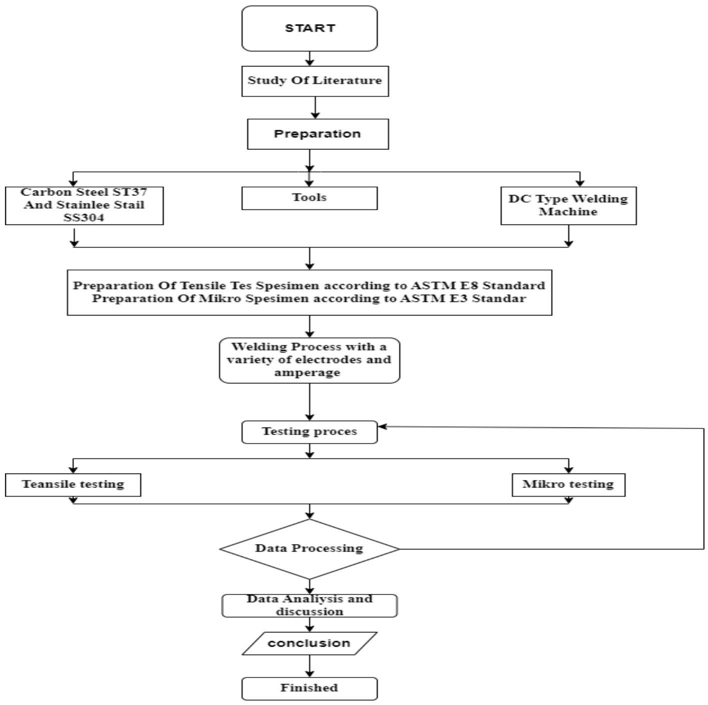


Figure 1 Research Flowchart.

This research used experimental methods carried out at the Stt Wastukancana Purwakarta laboratory as a test for tensile strength, while metallographic testing was carried out at the Bandung State Polytechnic. Testing using carbon steel ST37 and Stainless Steel SS304 using SMAW welding with a variety of electrodes (E7018, E6013, and E309) using current (70,80,90 A)

Carbon steel is a type of alloy steel consisting of iron (Fe) and carbon (C) elements where iron is the basic element and carbon is the main alloying element..(Yassyir Maulana, 2016)

Table 1 Carbon Steel Classification.

steel type	minimum breaking voltage (MPa)	melting stress (MPa)	minimum stretch (%)
BJ 34	340	210	22
BJ 37	370	240	20
BJ 41	410	250	18
BJ 50	500	290	16
BJ 55	550	410	13

Stainless steel or stainless steel is an alloy steel that has properties of resistance to oxidation and corrosion (rust).(Setiawan & Sungkono, 2017)

Table 2 Classification of Stainless Steel.

AISI Type	C %	Cr %	Ni %	Other dalam %
201	0,15	16 – 18	3,5 – 5,5	N. 0,25 ; Mn. 5,5 – 7,5 ;
202	0,15	17 – 19	4,0 – 6,0	P. 0,06
301	0,15	16 – 18	6,0 – 8,0	N. 0,25 ; Mn. 7,5 – 10 ;
302	0,15	17 – 19	8,0 – 10,0	P. 0,06
304	0,08	18 – 20	8,0 – 12,0	-
304 L	0,03	18 – 20	8,0 – 12,0	-
308	0,08	19 – 21	10,0 – 12,0	-

SMAW welding (Shield Metal Arc Welding) which is also called Electric Arc Welding is a welding process that uses heat to melt the base material or base metal and electrodes (filler material) (Azwinur et al., 2017)

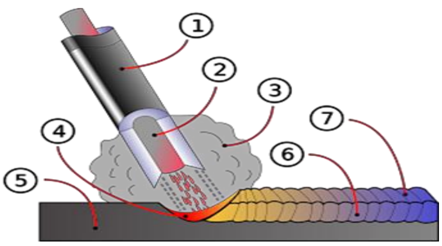


Figure 2 SMAW welding

In electric arc welding, the energy source comes from electricity which is converted into heat energy. This heat energy is actually the result of the collaboration of welding current, welding voltage and welding speed. The quality of the welding results is influenced by heat energy which means it is influenced by three parameters, namely welding current, welding voltage and welding speed. The relationship between the three parameters produces welding energy which is often called heat input.(Romdhoni et al., 2019)

Tensile strength is one of the most important and dominant mechanical properties in a construction design and manufacturing process. Each material or material has different properties (hardness, flexibility, etc.). To be able to determine the mechanical properties of a material, a test is needed, one of the most frequently performed tests is the tensile test.(Kurniawan et al., 2018)

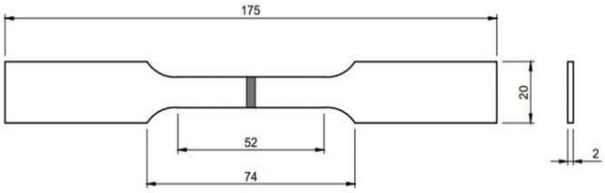


Figure 3 Tensile Test Specimens.

The formula for knowing the value of the tensile test results is as follows:

Stress = Voltage

$$\sigma = \frac{F}{A} \quad (1)$$

σ = Voltage

F = Force/Load

A = Cross-sectional area

elongation

$$\varepsilon = \frac{l1 - lo}{lo} \times 100\%$$

$$\frac{\Delta l}{lo} \times 100\% \quad (2)$$

ε = elongation

L1 = Final Length

Lo = Initial Length

Metallography is the science of metal that studies the characteristics and structure of a metal on a micro scale using a light microscope. The basic principles of metallography were first laid out by Henry Clifton Sorby (1826–1908). Metallography is grouped into two types, namely macrography and micrography.(M et al., 2016)

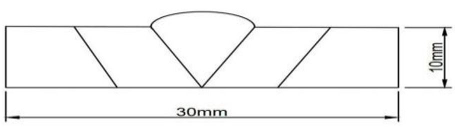


Figure 4 Metallographic Specimens

3. RESULTS AND DISCUSSION

Manufacture of alloy steel specimens, namely Carbon Steel ST37 with Stainlees Steel 304 by dissimilar connection and welding with Metal Arc Welding Shield Welding (SMAW) and different electrodes (E6013, E309-16 and E7018) using current variations, the currents used for testing are 70A, 80A and 90A which will be tested at the Stt Wastukancana Laboratory, Purwakarta. Specimen testing consists of Tensile Testing and Microstructure testing in order to obtain appropriate results in the test. Tensile testing is carried out to determine the strength of a material against tensile loads. By carrying out a tensile test, it will be known the maximum stress, strain and modulus of elasticity of the specimen being tested. The specimens tested have the shape and size according to the ASTM E8 standard

Figure 5 Specimens Before testing

Figure 6 Specimens E7018 (70,80,90 A).

Figure 7 Specimens E6013 (70,80,90A)

Figure 8 Specimens E309 (70,80,90a).

Table 3 E7018 Tensile Test Results.

No	**Sample code**	**Dimensions of the cross-section of the test object**		**Area (mm^2)**	**Length Measure Gauge length**	**Max Load (kg)**	**Tensile strength (kg/mm^2)**	**Yield strength (kg/mm^2)**	**Elongation**
		Wide	**Thick**						
1	E7018 (70A)	10	2	20	52	625,597	31,28	120	0,3
2	E7018 (80 A)	10	2	20	52	534,031	26,70	140	0,3
3	E7018 (90 A)	10	2	20	52	832,006	41,60	100	0,6
MAX						832,006	41,60	140	0,6
MIN						534,031	26,70	100	0,3
AVERAGE						663,878	33,19	120	0,4

Table 4 E6013 Tensile Test Results.

No	**Sampel code**	**Dimensions of the cross-section of the test object**		**Area (mm^2)**	**Length Measure Gauge length**	**Maks Load (kg)**	**Tensile strength (kg/mm^2)**	**Yield strength (kg/mm^2)**	**Elongation**
		Wide	Thick						
1	E6013 (70 A)	10	2	20	52	695,575	34,78	150	0,3
2	E6013 (80 A)	10	2	20	52	730,972	36,55	150	0,3
3	E6013 (90 A)	10	2	20	52	695,075	34,75	150	0,6
MAX						730,972	36,55	150	0,6
MIN						695,075	34,75	150	0,3
AVERAGE						707,207	35,36	150	0,4

Table 5 E309 Tensile Test Results.

No	**Sampel code**	**Dimensions of the cross-section of the test object**		**Area (mm^2)**	**Length Measure Gauge length**	**Maks load (kg)**	**Tensile strength (kg/mm^2)**	**Yield strength (kg/mm^2)**	**Elongation**
		Wide	Thrick						
1	E309 (70 A)	10	2	20	52	704,565	35,23	200	0,3
2	E309 (80 A)	10	2	20	52	763,018	38,15	200	0,6
3	E309 (90 A)	10	2	20	52	704,531	35,23	150	0,6
MAX						763,018	38,15	200	0,6
MIN						704,531	35,23	150	0,3
AVERAGE						724,038	36,20	183	0,5

Table 6 Maximum load average data

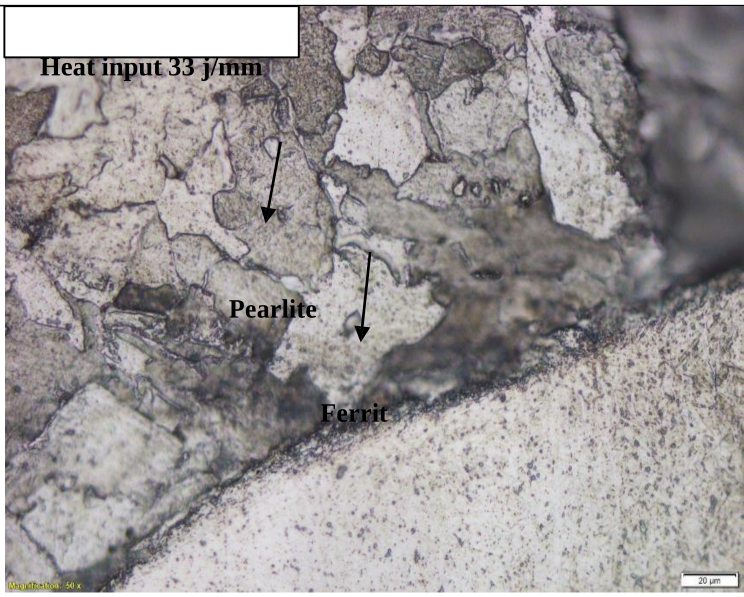
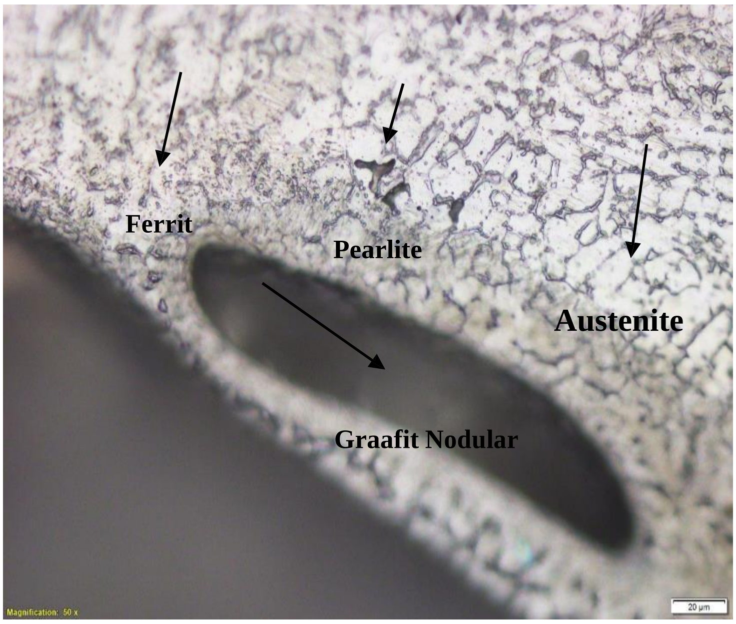
Electrode Type	Maks load (Kg)	Burden Average (N)
E7018 Arus 70,80,90	625,597	663,878
	534,031	
	832,006	
E6013 Arus 70,80,90	695,575	707,207
	730,972	
	695,075	
E309 Arus 70,80,90	704,565	724,038
	763,018	
	704,531	

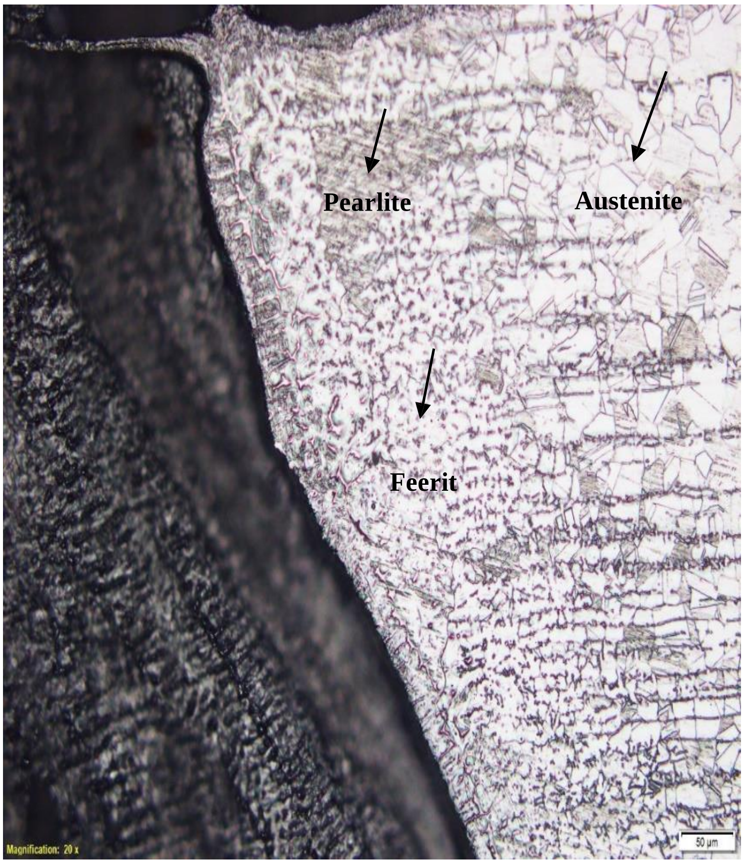
Table 7 Data Average maximum tensile strength.

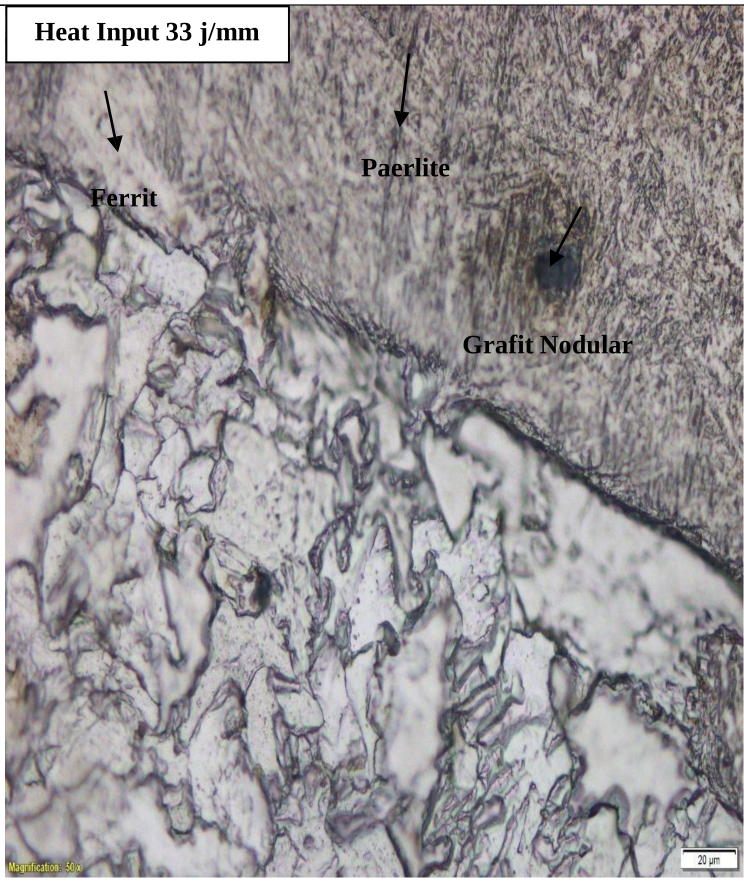
Electrode Type	Maximum Tensile Strength (Kg/mm^2)	Tensile Strength Average (kg/mm^2)
E7018 Arus 70,80,90	31,28	33,19
	26,70	
	41,60	
E6013 Arus 70,80,90	34,78	35,36
	36,55	
	34,75	
E309 Arus 70,80,90	35,23	36,20
	38,15	
	35,23	

Microstructure testing aims to determine the structure contained in the research specimen in the form of microphotos. Each specimen has a different structure depending on the type of treatment given. The microstructure in the results of this study was taken using an optical microscope. Form a micro-section with a magnification of 5 to 100 times at the Wm/Haz position

Table 8 Micro test results.

<table>
<tr><th>Specimen Code</th><th>MICRO STRUCTURE</th><th>Area</th></tr>
<tr><td rowspan="2">E7018 (80)</td><td>
</td><td>(WM-Haz Steel) 50x</td></tr>
<tr><td>
</td><td>(WM-Haz Stainlees steel) 50x</td></tr>
</table>

<table>
<tr>
<td rowspan="2">E7018
(90A)</td>
<td>
</td>
<td>(Wm-Haz Steel)
20x</td>
</tr>
<tr>
<td>
</td>
<td>(Wm-Haz
Stainlees Steel)
20x</td>
</tr>
</table>

<table>
<tr>
<td>E6013
(80A)</td>
<td>
</td>
<td>(Wm-Haz Steel)
50x</td>
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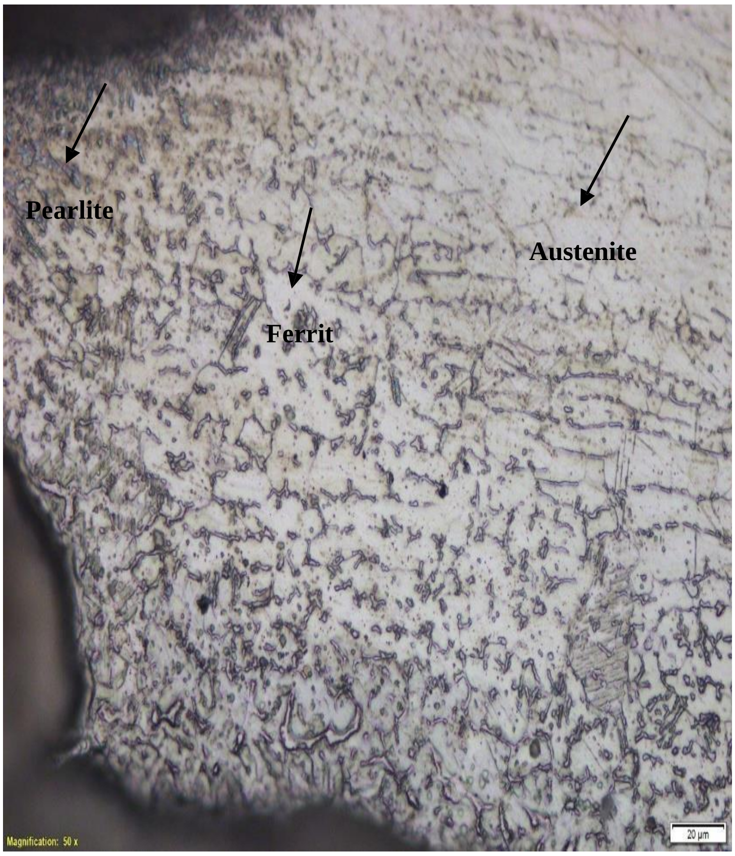
<tr>
<td></td>
<td>
</td>
<td>(Wm-Haz
Stainlees Steel)
50x</td>
</tr>
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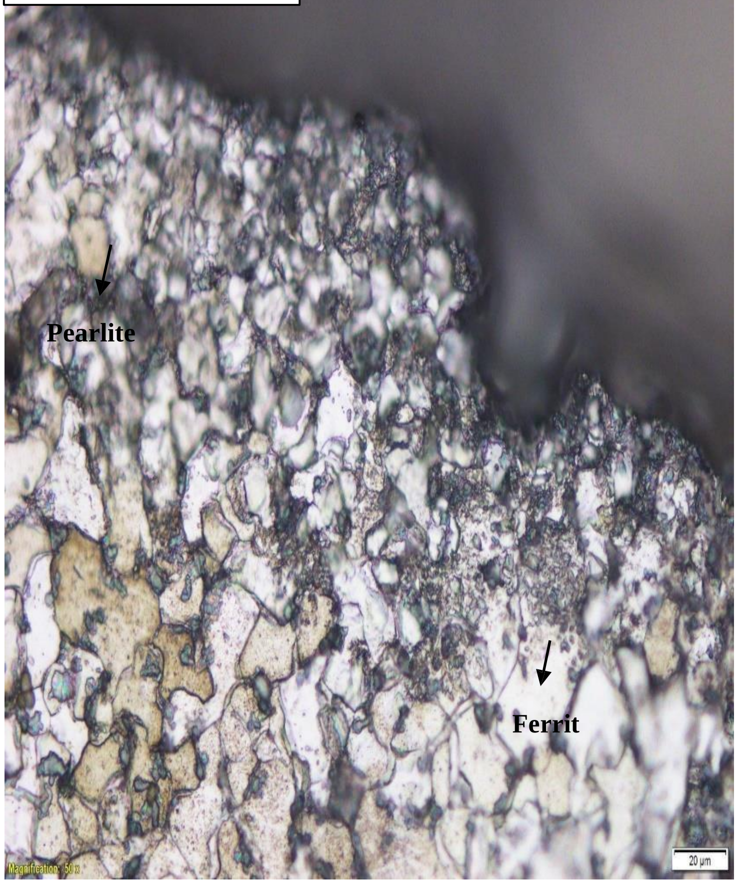
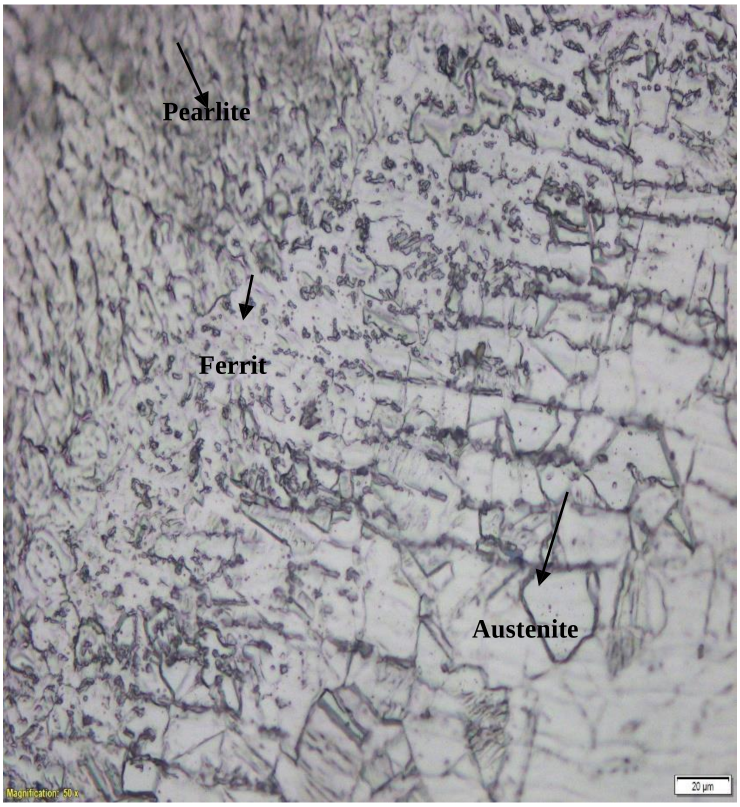
<table>
<tr>
<td>E309
(80A)</td>
<td>Heat Input 33 j/mm



</td>
<td>(Wm-Haz Steel)
50x

(Wm-Haz
Stainlees Steel)
50x</td>
</tr>
</table>

In metallographic testing to look for this microstructure, the images attached are the Wm and Haz areas based on the existing drawings, it can be seen that in the Wm and Haz regions in carbon steel there are (ferrite and pearlite) and in Haz and Wm Stainlees Steel there are (Austenite, ferrite and Pearlite).

CONCLUSION

Based on the results of research and analysis that has been carried out on low carbon steel and stainless steel with welding processes using different electrodes and current variations, the following conclusions can be drawn:

1. Tensile test of E7018, 70 A, 80A , 90 A obtained very much different tensile strength values, the very high tensile strength values were at 90 A while the lowest values were at 80 A, while for the tensile test specimens E6013 and E309 (70, 80.90 A) has its highest rating at 80 Amperes.

   The physical properties of the E7018 80 Ampere electrode are more Peralite, less Ferrite and Austenite and masternit in the welding results, resulting in brittleness of the material during the tensile test

   Properties of the E7018 90 Amperes Electrode Greater Ferrite, Pearlite and Austenite in welding results, resulting in stronger material when tested in tensile

   The properties of the E6013 80 Amperes electrode are larger in ferrite and pearlite and smaller in Austenite, resulting in a stronger material in the tensile test

   Properties of the E309 80 Amperes Electrode. Larger ferrite and austenite and smaller pearlite results in a stronger material in the tensile test.
2. The microstructure consists of Ferrite, Pearlite, Austenite. Tenacity that is superior to the three different electrodes and amperes is found in the E7018 electrode, 90 amperes due to ferrite, pearlite and austenite which are larger so as to get high tensile strength

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