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ANALYSIS OF THE INFLUENCE OF BACKHAND AND FOREHAND WELDING DIRECTIONS ON MECHANICAL PROPERTIES USING THE SMAW METHOD

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Abstract
The use of metal materials to support human life continues to grow along with the rapid development of science and technology. This greatly influences the technology to process it into a ready-to-use product. Among the production techniques used to make a product is the welding process. Welding is a method of joining that is widely used in steel building construction and machine construction. Another connection method used on metal joints is bolts and rivets. Welding technology, besides being able to be used to join and cut metal, can also be used to fill holes in castings, make hard coatings on tools, thicken worn parts, and other kinds of repairs.
AISI 1037 is a carbon steel with a carbon content of around 0.37%, which is classified as Medium Carbon Steel. The tensile strength of AISI 1037 is 650 MPa with a yield stress of 350 MPa. A test has been carried out on AISI 1037 with the welding method, where the welding method used is the 1G and 1 F welding process. With this method compared to the mechanical properties of the welding results, the seam used is seam V with an E 6013 electrode with a diameter of 2.6mm. The welding process refers to the AWS D1.1 standard with the SMAW welding type with a plate thickness of 5mm.

Keywords: *SMAW, AISI 1037, E 6013 electrode, AWS D1.1 standard with the SMAW*

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Introduction

Welding is a metal joining technique by melting some of the base metal with or without pressure and with or without additional metal and produces a continuous connection. Classification of welding processes According to AWS (American Welding Society) The process of joining by welding is divided into 3 parts, namely:

a. Melting welding (fusion welding) Melt welding is carried out at temperatures above the melting point of the metal and heating from a heat source is applied for the purpose of melting the metal. At the time of liquefaction also occurs mixing of molten metal between each parent metal and parent metal and filler metal.

b.These welding processes are used to obtain metal joints performed at temperatures below the melting point of the metal being welded. Often these processes are called pressure welding or diffusion bonding. Pressure is applied to optimize surface contact and produce plastic deformation on each surface and to remove the oxide layer.

c. Brazing & Soldering In the brazing/soldering process the base metal does not melt, only the filler metal or additional metal. To heat the base metal and melt the filler metal, various heat sources are used, for example, a flame originating from oxy-acetylene welding. Electrode Wrapped Electric Arc Welding (Shielded Metal Arc Welding) The method of welding that is often used in practice and includes qualifications for electric arc welding is covered electric arc welding. In this welding used metal electrode wire wrapped with flux. In the picture below it can be seen clearly that an electric arc is formed between the base metal and the tip of the electrode. Due to the heat from this electric arc, the base metal and the tip of the electrode

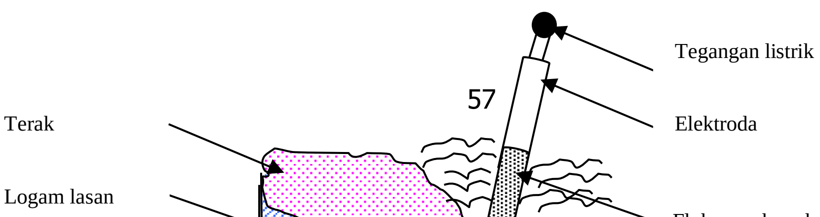


Figure 1. Wrapped Electrode Arc Welding

The process of removing metal from the electrode occurs when the tip of the electrode melts and forms grains that are carried by the electric arc current that occurs. When a large electric current is used, the molten metal grains that are carried become finer, conversely when a small current is used, the grains become larger. Selection of Welding Parameters Selection of welding parameters greatly affects the strength of the welded joint.

Therefore the selection of welding parameters must be considered. The welding parameters are:
1. Arc voltage The high and low voltage of the electric arc depends on the length of the arc required and the type of electrode used. A long bow is not good, because its stability is easily disrupted so that the resulting weld metal surface uneven.
2. Welding current The magnitude of the welding current depends on the material and size of the weld, the geometry of the joint, the welding position, the type of electrode and the diameter of the electrode core.
3. Welding speed Welding speed depends on the type of electrode, the diameter of the electrode core, the material being welded, the geometry of the joint and the accuracy of the connection. Welding speed is directly proportional to the welding current, so fast welding requires a high welding current.
4. Electrical polarity For electric arc welding covered electrodes can be used straight polarity and reverse polarity. Straight polarity is usually used for materials that are thick and have high thermal conductivity. Reverse polarity is used to weld thin metals. Electrodes Electrodes are fillers for electric arc welding, the electrodes used in the SMAW process have many differences both in the composition of the welding wire and the type of flux. The standard diameter of the electrode (welding wire diameter) varies from 230 mm to 455 mm. The welding electrode is not only metal but also protected or covered with flux. At the time of welding this flux also melts and mixes with liquid metal originating from the base metal and welding wire.

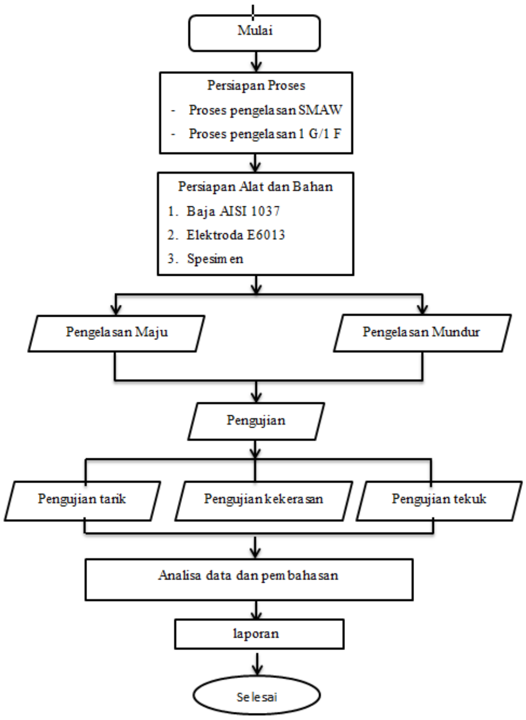
The flux that is made to cover the welding wire has several functions, including:
1. Producing gas (CO_2) originating from flux combustion, which serves to protect electric arcs and weld metal pooling from the atmospheric environment.
2. Binds O_2 gas which is dissolved in metal liquid.
3. Slag/slag forming, which protects the frozen weld metal from oxidation and helps form the weld bead.

4. Alloying elements that provide certain improved properties of the weld metal. 5. Increasing welding productivity (eg in fluxes containing iron filings). American Welding Science (AWS) has created a classification system to identify and classify various welding electrodes. All SMAW process carbon and alloy steel electrodes are written starting with the letter E which indicates the electrode and followed by a 4-digit number (AWS E XXXX). The first two digits are the tensile strength of the weld metal (all weld metal) in units of ksi. The third digit indicates the welding position and the fourth digit represents the type of flux covering the electrode.

Table 1. SMAW Electrode Classification System for Carbon Steel and Low Alloy Steel Materials

Klasifikasi AWS	Kekuatan Tarik Minimum		Kekuatan Luluh Minimum		Elongasi Minimum
	MPa	Ksi	MPa	ksi	(%)
E60XX	430 – 460	62 – 67	340 – 380	50 – 55	17 – 22
E70XX	480 – 500	70 – 72	390 – 420	57 – 60	17 – 25
E80XX	550	80	460 – 550	67 – 80	16 – 24
E90XX	620	90	530 – 620	77 – 90	14 – 24
E100XX	690	100	600	87	13 – 20
E110XX	760	110	670 – 760	97 – 110	15 – 20
E120XX	830	120	740 - 830	107 - 120	14 - 18

Research Method



Specimen preparation In this research process, the basic material used was AISI 1037 plate with a thickness of 5 mm, the shape of the material is shown in the figure below.

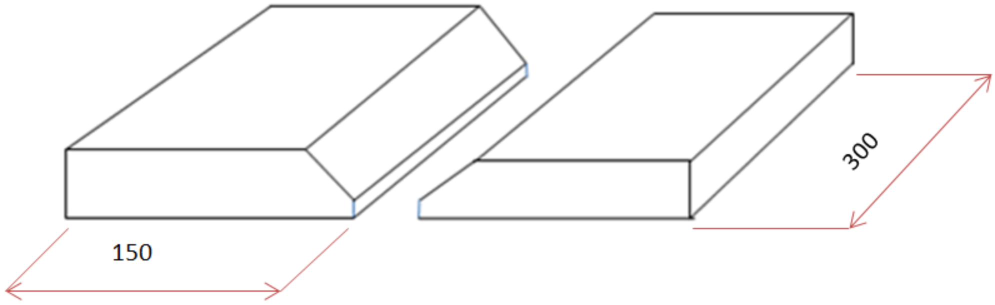


Figure 2. Pictures of pieces of welding connection types

Specimen joining process procedure After cutting the material, then the process of making welded seams is carried out, followed by the SMAW method of joining. The sequence of how the SMAW equipment works is as follows:

- Placement of workpieces that have undergone a surface cleaning process.
- Using safety equipment in the form of gloves, leather jackets and eye protection helmets.
- Inserting the tip of the electrode in the electrode holder.
- Adjustment of the welding machine with current as needed, then the machine is turned on.
- Grasp the electrode holder with one hand and ignite the arc by scraping the tip of the electrode

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onto the workpiece.
• During the welding process, you must always keep an eye on the welding metal liquid.

Welding Parameters In this study the type of welding used was SMAW welding with the following specifications:
• Standard : AWS D1.1
• Welding process: Manual
• Type of welding machine : ESAB, Electric driven
• Current type : DCEP • Electrodes : E 6013
• Electrode Diameter : 2.6 mm • Base Metal : AISI 1037
• Plate thickness : 5 mm • Current: 90-160 Amperes
• Voltage: 22-35 Volts
• Welding position : 1 F / 1G

Figure 3. Welding Machine Image

Results and Discussion

Tensile Test
Destructive testing to determine the strength of the material using a tensile testing machine

Figure 4. Specimen to be tested for tensile

In the tensile test, the specimen is given a continuous one-axis tensile force that increases continuously, at the same time observations are made regarding the increase in length experienced by the test object, until the material breaks.

Bending Test

This Bending test aims to determine the magnitude of the flexural strength of the specimen. The test is carried out by applying a bending load slowly until the specimen reaches its fatigue point. The manufacture of bending test specimens refers to the ASTM E23-02 standard for bending testing as shown below:

Figure 5. Bending Test Specimens (ASTM E23-02)

After carrying out tensile, bending and hardness tests, the following data is obtained: Data and Discussion of Tensile Test Results

Parameter Uji	Rumus	Hasil Uji		Ket.
No Identitas		1	2	
Tebal awal, T (mm)	T_0	4,78	4,78	1= Maju
Lebar awal, W (mm)	W_0	26,56	26,56	2=Mundur
Luas Penampang awal A_o(mm^2)	$A_0 = T_0.W_0$	127,05	127,05	
Beban Tarik Maksimum, F_{max} (kgf atau N)	F_{max}	3880	3880	
Kuat Tarik,σ_B (kgf/mm^2 atau N/mm^2)	$\sigma_B = F_{max}/A_0$	30,53	30,53	
Lokasi Patahan		las	las	

The final cross-sectional area after the withdrawal process for forward specimens = 122.10 mm^2 The final cross-sectional area after the withdrawal process for the backward specimen = 124.15 mm^2

$$RA = \frac{A1 - A0}{A0} x100\%$$

$$RA\ maju = \frac{127,05 - 122,10}{122,10} x100\%$$

$$= 4,05\%$$

$$RA\ mundur = \frac{127,05 - 124,15}{124,15} x100\%$$

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= 2,33%

Initial length of gage length = 40 mm The final length of the gage length for the forward process = 46 mm The final length of the gage length for the reverse process = 44 mm
Calculating Extension (e) backwards , e=(L1 x xLo)/Lo x100% =(44-40)/40 x100%
= 10 %
Calculating Extension (e) forward , e=(L1 x xLo)/Lo x100% =(46-40)/40 x100%
= 15 %

Data and Discussion of Bending Test Results

Parameter Uji	Rumus	Hasil Uji		Ket.
No Identitas		1	2	
Tebal awal, (mm)	D	4,78	4,78	1= Maju
Lebar awal, (mm)	B	20	20	2=Mundur
Panjang span (mm)	L	150	150	
Beban Tekan Maksimum, F_{max} (kgf atau N)	F_{max}	1375	1300	
Kekuatan Bending ,σ_b (kgf/mm^2 atau N/mm^2)	$\sigma b = \frac{3pl}{2bd^2}$	3236,14	2039,74	
Lokasi Patahan		las	las	

Data and Discussion of Hard Test Results Base Metal Initial Hardness
Data The hardness test on the base metal before the welding process is carried out using the Vikers method

Table Material Initial Hardness (HV) Data

Material	**1**	**2**	**3**	**4**	**5**	**Rata - rata**
AISI 1037	143	143	143	143	143	143

Final Hardness Data The test was carried out using the Vickers method

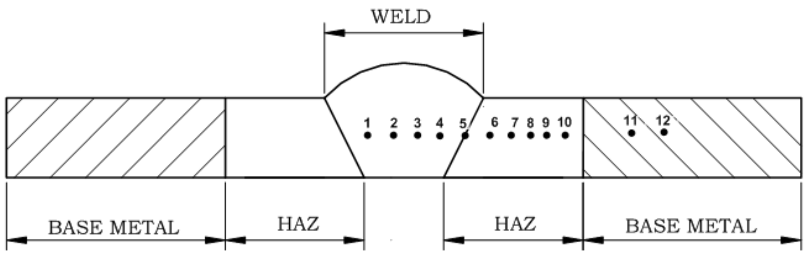

Table .AISI 1037 Vickers Hardness Testing Results

No	Materrial Pengujian	Weld Metal					HAZ					Base Metal	
		1	2	3	4	5	6	7	8	9	10	11	12
1	AISI 1037 (Maju)	140	140	139	139	140	149	149	149	150	150	143	143
2	AISI 1037 (Mundur)	139	139	139	139	140	149	148	148	149	150	143	143

Conclusion

AISI 1037 is a carbon steel with a carbon content of around 0.37%, which is classified as Medium Carbon Steel. The tensile strength of AISI 1037 is 650 MPa with a yield stress of 350 MPa. A test has been carried out on AISI 1037 with the welding method, where the welding method used is the 1G and 1 F welding process. With this method compared to the mechanical properties of the welding results, the seam used is seam V with an E 6013 electrode with a diameter of 2.6mm. The welding process refers to the AWS D1.
1 standard with the SMAW welding type with a plate thickness of 5mm. The mechanical tests carried out are tensile testing, hardness testing and bending testing with the aim of seeing the mechanical properties that occur in the weld area. After welding, the test results are obtained as follows:
2. Tensile strength (σt) for the forward welding process = 30.53 N/mm2
3. Tensile strength (σt) backward welding process = 30.53 N/mm2
4. Bending strength (σb) advanced welding process = 3236.14 N/mm2
5. Bending strength (σb) advanced welding process = 3236.14 N/mm2
6. The hardness price of the advanced welding process for weld metal is 139.6 HB
7. The hardness price of the advanced welding process for HAZ 149.6 HB
8. The hardness value of the reverse welding process for weld metal is 139.2 HB
9. Hardness price of backward welding process for HAZ 148.8 HB

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