Impact of Welding Current and Type of Joint Design on Tensile Properties of Welded Mild Steel Joint by using SMAW

Muhamad Faiq Bin Faizol, Khalil Bin Abd Razak

Faculty of Chemical Engineering, Universiti Teknologi MARA

Abstract— **Oil and gas today are being developed in many sectors. Upstream, midstream and downstream. So, throughout its development, one of the major department is facilities and in facilities, basically welding play an important role for its completion. So, welding is known as sculptural process that joins materials, usually metals or thermoplastics, by causing fusion, which is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In the heavy as well as small industries, welding is widely used by metal workers in the fabrication, maintenance and repair of parts and structures. Welding current is the most influencing parameter in welding process which controls the depth of fusion; the electrode feed rate and depth of penetration. The amount of heat developed during welding depends upon the current used for a given size of electrode and filler wires. It is therefore essential that a correct current is used to produce good quality of weld and reduce the distortion problems on the job.**

In this study, with the objective to determine the suitable welding current in order to produce the strongest mild steel joint from two separate metals, Mild Steel plates of 6mm were welded using different joint type using Shielded Metal Arc Welding process. Single V, Double V and Square. Welding current was varied in all the cases. 100A, 110A and 120A. Mechanical properties such as ultimate tensile strength, yield strength and percentage elongation were evaluated. Results indicated that the single V joint design does have the highest Ultimate Tensile Strength in comparison to other welding joints This is due to an optimum amount of heat feed rate is given.

***Keywords*—Shielded Metal Arc Welding (SMAW), Tensile Strength, Mild Steel, Welding Current, gas pipelines, oil pipelines, type of material.**

I. INTRODUCTION

In the heavy metal industries, welding is almost the essential part for the application in various sectors such as fabrication and maintenance. Somehow welding also have become the industries itself with various methods shown to join metals due to its convenient or fast work rate. A welded joint is obtained when two clean metal surfaces are made into contact with each other either by using pressure or heat or both to obtain these strong bonds. The fundamental of welding industries is the tendency of atoms to bond. In welding the metallic materials such as mild steel, carbon steel and stainless steel are joined by forming the strong metallic bonds. In basic, welding process needs some form of energy, usually heat to connect the two-metal materials structure such as pipe, joint, and plate. The amount of heat and pressure must be in good mix in order to connect the separate two metal materials. When heat is applied alone to connect the joint, somehow pressure is used merely to keep the joining members together. Examples welding process are Gas Tungsten Arc Welding (GTAW), Shielded Metal Arc Welding (SMAW), and Submerged Arc Welding (SAW).

As for the Oil and Gas Industries, welding activities are carrying out actively not only in the upstream but even in downstream facilities structure. Quality and safety factor is a major criterion to be concerned in this field because it will involve lives of the workers working around it. From this, the factor of safety in depends on the type and quality of materials used in build a strong structure such as scaffolding, piping, and frame buildings. Good quality materials with reasonable price that have good mechanical properties and the right technique of joining them will give the ability of the mild steel joints to withstand against high loading forces so that sure it will not collapse easily during and after it was built.

Normally, most of facilities in oil and gas industries will be used mild steel material. As the aged of these mild steels made facilities increased, some defects will happen and one of it is crack. To patch the crack, again welding process need to be done but at which parameter the welding process will be the best to hold the force. Because of that, mild steel that being used will be analysed by running the tensile test using Universal Testing Machine after the welding process between two parts of mild steel metal structure is joined. The parameter will be changed such as the welding current and joint design to see which parameter will achieve the best Ultimate Tensile Strength.

So, in this study, an experiment will be carry out in order to find the good mix of welding parameter and joint design that can yield strongest welded joint of mild steel. The welding current is the main component played here because its heat feed rate melting the base metal and electrode will gave the optimum fusion and well deposition between two separate metals.

II. METHODOLOGY

A. Material Selection

The chemical composition of mild steel specimen which used as base metal is shown in the Table 2.2

Material	C	Mn	Si	S	P
Mild Steel	0.14	0.76	0.28	0.013	0.010

Table 2.2: Mild Steel Plate Chemical Composition

E6013L electrodes were used to weld the specimen using SMAW process. Its chemical composition is as in the table below

Material	C	Mn	Si	S	P
E6013L	0.08	0.40	0.25	0.02	0.02

Table 2.3: Electrode Chemical Composition

B. *Joint Type Design*

These are several different types of weld joints that will be used in this study. Each joint is joined in a different way and has different strengths and uses, and thus it is important to use the right one for the right job. When two pieces of metal joined end to end a butt weld joint is used. Butt joints are frequently used when a smooth face is desired. Some applications that use butt joint are pressure vessels, piping and takes. For this study the decided butt joint is the square joint, the single 'V' and double 'V' joint.

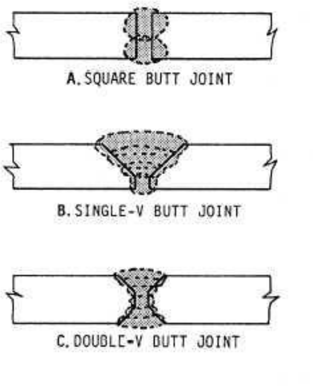

Figure 2.1: Joint Type Design

C. *Experimental Procedure*

Shielded Metal Arc Welding (SMAW) has been introduced in order to join two metals together. Using electric current either alternating or direct current forming electric arc between the electrode and the metal that needed to be join.

In this study, MMA/TIG Welding Machine with 400A capacity is setting up with fixed 22V all through the experiment. Then, Mild Steel alloy plate with the dimension of 150mm x 50mm x 6mm (Figure 2.1) were chosen as the main material sample for this study. First and foremost, these plates must be cleaned out from dirt, dust and other unwanted material before the edge joint preparation. The joints are prepared where the single V joint is made for bevel angle of 37°, double V edge for 45° and square butt joint plates were smoothed by its surfaces. Throughout all the preparations, the root gap of 1.5mm and root of 1mm was maintained. The mild steel plate is put on the welding table and to avoid undesired distortion to the minimal, the suitable size of stiffeners was provided at critical point when the welding is carried out. Then, only the welding tacking process joining the two plates is conducted.

After that, these joined plate is cutting according to its required dimensions using the power hacksaw. To conduct the experiment, 9 types of specimen were prepared with three different types of joint which is, single V joint, double V joint and square butt joint. The specimen is set to be manipulated according to the Table 2.1.

Then only the main part of this study will take place. All the 9 samples will be taken to the Universal Testing Machine in order to conduct the Tensile test. The value of tensile properties obtained would be the Ultimate Tensile Strength and the Yield Strength of each sample. Therefore, in the end of this experiment, we could find out the impact of different welding current and joint type design on tensile properties of Mild Steel metal specimens. The broken test sample will be shown in the Figure 2.4

Specimen code	Welding current (A)
1V	100
2V	110
3V	120
1D	100
2D	110
3D	120
1S	100
2S	110
3S	120

Table 2.1: Specimen Code Sample

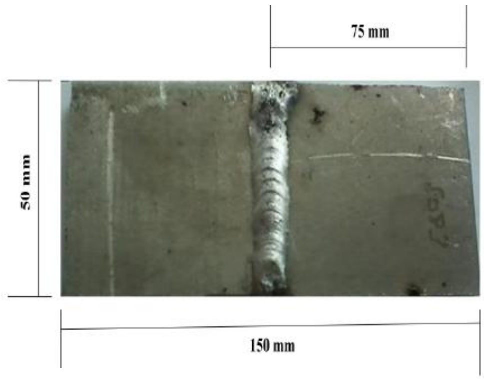

Figure 2.1: View of Single Butt Joint Welded Specimen

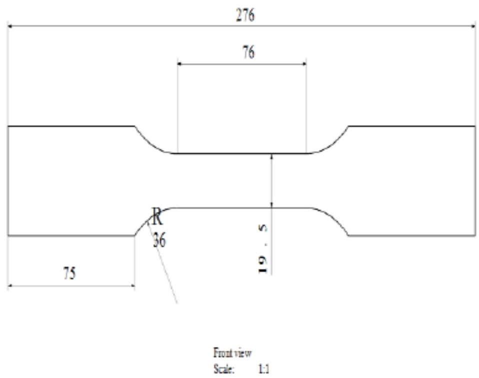

Figure 2.2: Specimen Sample Dimension

Figure 2.3: Shielded Metal Arc Welding

Figure 2.4: Broken Test Sample After Tensile Test

III. RESULTS AND DISCUSSION

The tensile properties of the welded mild steel joints were analyzed. They were tested to obtain the result in Table No. 3.1

Effect of Welding Current & Joint Design on Mild Steel Tensile Properties

Specimen Code	Joint Design	Voltage (volts)	Current (A)
1V	Single V	22	100
2V	Single V	22	110
3V	Single V	22	120
1D	Double V	22	100
2D	Double V	22	110
3D	Double V	22	120
1S	Square Butt	22	100
2S	Square Butt	22	110
3S	Square Butt	22	120

Table 3.1: Tested Sample Parameter

Specimen Code	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Percentage Elongation (%)
1V	302.11	418.64	18.60
2V	340.23	435.59	20.40
3V	327.11	427.11	19.91
1D	297.81	387.24	23.36
2D	296.62	386.26	25.42
3D	237.44	375.65	22.80
1S	284.93	394.15	24.10
2S	271.32	386.24	25.22
3S	225.64	377.44	23.13

Table 3.2: Welding Current Effect on Tensile Properties

Effect of Welding Current and Joint Design on Ultimate Tensile Strength

Based on the value obtained from Ultimate Tensile Strength (UTS) for joint type of single V at current of 100A, 110A, 120A, it's clearly be seen that with 110A of weldment resulted the maximum Ultimate Tensile Strength compared to the 100A and 120A. Comparatively the single V joint design, giving the highest value of ultimate tensile strength 435.59 Mpa.at 110A than those of double V joint design (ultimate tensile strength 387.74 MPa at 100A) and square butt joint design (ultimate tensile strength 394.15 MPa at 100 amp). From the above analysis it was observed that the single V joint has maximum tensile strength in compared to other joint design. Moreover, this ultimate tensile strength increases with the increase in welding current up until 110A which the optimum welding current in order to obtain the strongest single V joint because in further increasing of the welding current will only result to produce weaker joint. At 110A of single V joint, it means that the rate at which the amount of melted base metal , the melted welding electrode, dilution, the depth of penetration, depth of fusion and the deposition rates was just in a good mix amount at this value and optimum weldability can be achieved at joint design of single V for current 110 amp. However, we might be wondering that increasing the welding current beyond this optimum value increases the amount of wire feed rate and penetration will yield stronger mild steel joint than the previous one. But it is not true. At 110A, the welding current to make strongest mild steel joint is the best for single V joint.

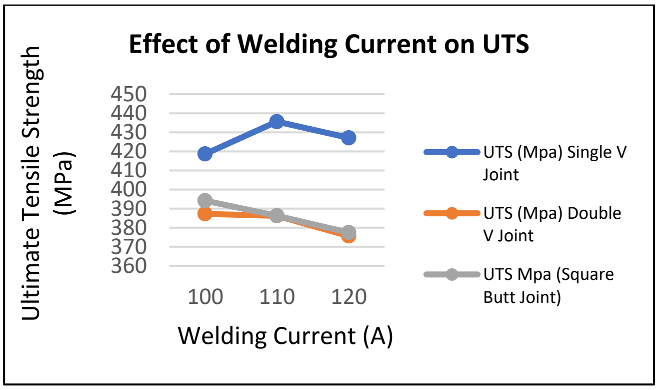

Figure 2.5: Graph of Effect of Welding Current on Ultimate Tensile Strength

Effect of Welding Current on Yield Strength

Based on the values of yield strength for joint type Single V at 100A, 110A, 120A, it is observed that 110A welding current also gave the highest value of yield strength compared to other joint type (Double V and Square Butt Joints) which have less amount of yield strength. This shows that again, at current 110A and single V joint, the Yield Strength is Maximum.

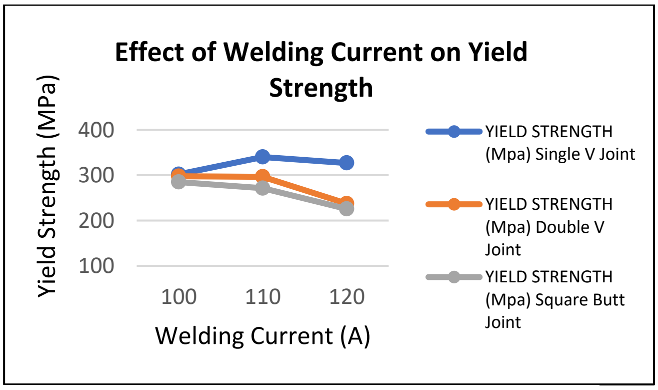

Figure 2.5: Graph of Effect of Welding Current on Yield Strength

IV. CONCLUSION

In conclusion of this experimental investigation, the impact of welding current and joint design type can be clearly seen at all the tested sample. Firstly, obviously the single V joint type will make the strongest joint among these three joint type and the square butt as well as double V joint will somehow making a weaker joint welded joint strength with little amount of difference of its Ultimate Tensile Strength and Yield Strength. This is due to a high intensity amount of melted electrode with the melted metal base produces good mix of deposition rate and fusion together. Meanwhile, as for the welding current, somehow it does not have a fixed trend such increasing current will depict increasing UTS. The graph shows that the value of the current affected the UTS and Yield Strength will produce different kind of result with no linear trend. But it does somehow shows the optimum current to be use for is 110A that will give a very large amount of Ultimate Tensile Strength and Yield Strength on the Single V joint. Hence it can be concluded that the ultimate tensile strength for single V joint was maximum and the strongest due to correct fusion between base and welding metal, suitable joint design and edge preparation for this type of material thickness. Moreover, it can be summarized that increasing the welding current, the UTS will increase too until it reaches to the optimum value. After further increasing beyond that, it will result in decreasing UTS.

V. References

[1] Inoue Hiroshige, Matsuhashi Ryo, Tadokoro Yutaka, Fukumoto Shigeo, Hashimoto Takeshi, Mizumoto Manabu and Nagasaki Hajime; Development of Welding Consumables for High-Corrosion Resistant Stainless Steel NSSC®260A for Chemical Cargo Tankers; January 2007; No.95; Nippon Steel Technical Report.

[2] Kane S. F., Farland A. L., Siewert T. A. and McCowan C. N.; Welding Consumable Development for a Cryogenic (4 K) Application; August 1999; Welding Journal; Pg 292-300.

[3] Sopousek Jiri, Foret Rudolf and Jan Vit; Simulation of Dissimilar Weld Joints of Steel

[4] Mitra U., Chai C. S. and Eagar T. W.; Slag Metal Reactions during Submerged Arc