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Weld Groove and its Effectiveness in SMAW

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Abstract: **This study investigates the most important welding process and effectiveness of weld joint it mainly focuses on the strength of the weld joint based on the different weld groove angle. The most noticed one is the there is large variation in the mechanical properties according to the change in the groove angle. The most difficult part is cutting of the exact angle of weld groove. Besides the welding process how to improve mechanical properties are studied based on the groove angle. The study is conducted by SMAW arc welding and by using 6013 electrodes.**

Keywords: **groove angle, weld strength**

1. Introduction

Welding is a common process for joining metals using a large variety of applications. Welding occurs in several locations, from outdoors settings on rural farms and construction sites to inside locations, such as factories and job shops. Welding processes are fairly simple to understand, and basic techniques can be learned quickly. Welding is the joining of metals at a molecular level. A weld is a homogeneous bond between two or more pieces of metal, where the strength of the welded joint exceeds the strength of the base pieces of metal. At the simplest level, welding involves the use of four components: the metals, a heat source, filler metal, and some kind of shield from the air. The metals are heated to their melting point while being shielded from the air, and then a filler metal is added to the heated area to produce a single piece of metal. It can be performed with or without filler metal and with or without pressure. There are several types of welding that are used today. Gas Metal Arc Welding (GMAW) or MIG, Gas Tungsten Arc Welding (GTAW) or TIG, Flux Core Arc Welding, and Stick Welding are the most common found types of welding.

Fusion welding can be defined as the melting together and coalescing of materials by means of heat, usually supplied by chemicals or electrical means. Filler metals may or may not be used and in solid state welding joining takes place without fusion, consequently, there is no liquid (molten) phase in the joint. The basic processes in this category are diffusion bond and cold, ultrasonic friction, resistance and explosion welding. Brazing uses filler metal and involve lower temperature than welding. Soldering uses similar filler metal (solder) and involves even lower temperature

2. Basics of welding

A. Fundamentals of welding

A welded joint is obtained when two clean surfaces are brought into contact with each other and either pressure or heat, or both are applied to obtain a bond. The tendency of atoms to bond is the fundamental basis of welding. The inter-diffusion direct transfer of stress between members eliminating gusset and splice plates necessary for bolted structures. Hence, the weight of the joint is minimum. In the case of tension members, the absence of holes improves the efficiency of the section. It involves less fabrication cost compared to other methods due to handling of fewer parts and elimination of operations like drilling, punching etc. and consequently less labor leading to economy. Welding offers air tight and water tight joining and hence is ideal for oil storage tanks, ships etc. Welded structures also have a neat appearance and enable the connection of complicated shapes. Welded structures are more rigid compared to structures with riveted and bolted connections. A truly continuous structure is formed by the process of fusing the members together. Generally welded joints are as strong as or stronger than the base metal, thereby placing no restriction on the joints. Stress concentration effect is also considerably less in a welded connection. Between the materials that are joined is the underlying principle in all welding processes. The diffusion may take place in the liquid, solid or mixed state. In welding the metallic materials are joined by the formation of metallic bonds and a perfect connection is formed. In practice however, it is very difficult to achieve a perfect joint; for, real surfaces are never smooth. When welding, contact is established only at a few points in the surface, joins irregular surfaces where atomic bonding occurs. Therefore, the strength attained will be only a fraction of the full strength. Also, the irregular surface may not be very clean, being contaminated with adsorbed moisture, oxide film, grease layer etc. In the welding of such surface removed for the bonding of the surface atoms to take place. This can be accomplished by applying either heat or pressure.

As pointed out earlier, any welding process needs some form of energy, often heat, to connect the two materials. The relative amount of heat and pressure required to join two materials may vary considerably between two extreme cases in which either heat or pressure alone is applied. When heat alone is applied to make the joint, pressure is used merely to keep the joining members together. Examples of such a process are Gas

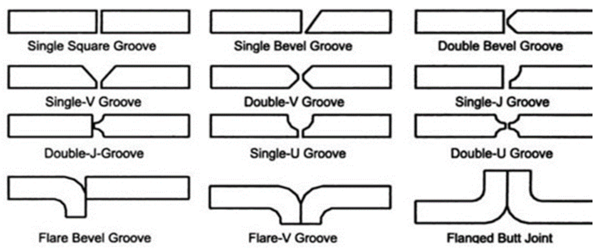
Tungsten Arc Welding (GTAW), Shielded Metal Arc Welding (SMAW), and Submerged Arc Welding (SAW) etc. On the other hand pressure alone is used to make the bonding by plastic deformation, examples being cold welding, roll welding, ultrasonic welding etc. There are other welding methods where both pressure and heat are employed, such as resistance welding, friction welding etc. A flame, an arc or resistance to an electric current, produces the required heat. Electric arc is by far the most popular source of heat used in commercial welding practice.

B. Welding process

In general, gas and arc welding are employed; but, almost all structural welding is arc welding. In gas welding a mixture of oxygen and some suitable gas is burned at the tip of a torch held in the welder's hand or by an automatic machine. Acetylene is the gas used in structural welding and the process is called oxyacetylene welding. The flame produced can be used both for cutting and welding of metals. Gas welding is a simple and inexpensive process. But, the process is slow compared to other means of welding. It is generally used for repair and maintenance work. The most common welding processes, especially for structural steel, use electric energy as the heat source produced by the electric arc.IS:816 in this process, the base metal and the welding rod are heated to the fusion temperature by an electric arc. The arc is a continuous spark formed when a large current at a low voltage is discharged between the electrode and the base metal through a thermally ionized gaseous column, called plasma. The resistance of the air or gas between the electrode and the objects being welded changes the electric energy into heat. A temperature of 33000 C to 55000 C is produced in the arc. The welding rod is connected to one terminal of the current source and the object to be welded to the other. In arc welding, fusion takes place by the flow of material from the welding rod across the arc without pressure being applied.

3. Different types of joints

By means of welding, it is possible to make continuous, load bearing joints between the members of a structure. A variety of joints is used in structural steel work and they can be classified into four basic configurations namely, Lap joint, Tee joint, Butt joint and Corner joint. For lap joints, the ends of two members are overlapped and for butt joints, the two members are placed end to end. The T- joints form a Tee and in Corner joints, the ends are joined like the letter L. Most common joints are made up of fillet weld or the butt (also calling groove) weld. Plug and slot welds are not generally used in structural steel work. Fillet welds are suitable for lap joints and Tee joints and groove welds for butt and corner joints. Butt welds can be of complete penetration or incomplete penetration depending upon whether the penetration is complete through the thickness partial. Generally, a description of welded joints requires an indication of the type of both the joint and the weld. Though fillet welds are weaker than butt welds, about 80% of the connections are made with fillet welds. The reason for the wider use of fillet welds is that in the case of fillet welds, when members are lapped over each other, large tolerances are allowed in erection. For butt welds, the members to be connected have to fit perfectly when they are lined up for welding.



A. Abbreviations and Acronyms

- GTAW-gas tungsten arc welding
- SMAW-shielded metal arc welding
- MIG-metal inert gas arc welding
- TIG-tungsten inert gas arc welding
- GMAW-gas metal arc welding
- SAW-submerged arc welding
- MM-millimeter
- BHN-Brinell hardness number
- HAZ-Heat affected zone

B. Material used

The material IS 2062 Grade B Mild Steel of the required dimension was purchased from the local market and the test specimen was prepared from it. The chemical composition of IS2062 Grade B mild steel by weight (wt %) is given as follow C-0.22, Mn1.50, Si-0.40, CE-0.41,P-0.045, S-0.045 and Fe.

C. Testing the weld joint

- *Tensile test:* Tensile properties of the weld joints namely yield and ultimate strength and ductility (% age elongation, % age reduction in area) can be obtained either in ambient condition or in special environment (low temperature, high temperature, corrosion etc.) depending upon the requirement of the application of tensile test which is usually conducted at constant strain rate (ranging from 0.0001 to 10000 mm/min).Tensile properties of the weld joint are obtained in two ways

a) Taking specimen from transverse direction of weld joint consisting base metal heat affected zone weld metal heat affected zone base metal and
b) All weld metal specimen as shown in fig.

- *Hardness Test:* Hardness is defined as resistance to indentation and is commonly used as a measure of resistance to abrasion or scratching. For the formation of a scratch or causing abrasion, a relative movement is required between two bodies and out of two one body must penetrate/indent into other body. Indentation is the penetration of a pointed object (harder) into other object (softer) under the external load. Resistance to the penetration of pointed object (indenter) into the softer one depends on the hardness of the sample on which load is applied through indenter.

All methods of hardness testing are based on the principle of applying the standard load through the indenter (a pointer object) and measured the penetration in terms of diameter/diagonal/depth of indentation (Fig.). High penetration of an indenter at a given standard load suggests low hardness. various methods of an indenter at a given standard load suggests low hardness. Various methods of hardness testing can be compared on the basis of following three criteria 1) type of indenter 2) magnitude of load and 3) measurement of indentation.

- *Bend test:* Bend test is one of the most important and commonly used destructive tests to determine the ductility and soundness (for the presence porosity, inclusion, penetration and other micro size internal weld discontinuities) of the weld joint can be done from face or root side depending upon the purpose that is whether face or root side of the weld is to be assessed. The root side bending can be performed using simple compressive/bending load and die of standard size for free and guided bending respectively. Moreover ,free bending can be face or root bending while guided bending is performed by placing the weld joint For bend test, the load increased until cracks start to appear on face or root of the weld for face and root bend test respectively and angle of bend at this stage is used as a measured of ductility of weld joint. Higher is bend angle (needed for crack initiation) greater is ductility of the weld Fracture surface of the joint from the face/root side due to bending reveals the presence of internal weld discontinuities.

D. Literature

R.A. Mohammed (2013) investigated the mechanical and metallurgical properties of mild steel using shielded metal arc welding process (SMAW) with weld metal, heat affected zone and parent metal. From the results, shielded metal arc welding (SMAW) of mild steel increased the strength of the welded joint in particular the heat affected hardness zone (HAZ), as revealed by lower impact strength, higher tensile strength and hardness values as compared with the parent and lower than the weld metal which is attributed to the fine ferrite matrix and fine pearlite distribution as compared to the parent metal. However, there was a loss of ductility at the welded joint resulting to brittleness of the material. The parent metal (un-welded specimen) had the highest toughness and is the most ductile as compared to the heat affected zone and the weld metal.[2]

S.H. Zoalfakar (2017) studied the effect of welding parameters on mechanical and microstructural properties of welded joints produced by shielded metal arc welding (SMAW) was analyzed. Different heat inputs (H) were applied to butt-welding joints by controlling current. The specimens were machined with different groove angles 40˚, 60˚, 80˚ and 100˚. In order to determine the effect of welding process on the local heat affected zone (HAZ) thermal cycle during welding, three different conditions were chosen, temperatures were recorded by using K-type thermocouples and a data acquisition system card of USB 6008, National Instrument type. The mechanical properties were evaluated by means of micro hardness and tensile tests at room temperature. Taguchi approach was applied to determine the most influential control factors which will yield better mechanical properties of the joints, where Taguchi's tools such as signal-to- noise ratio (S/N) have been used to observe the significant parameters and the optimal combination level of SMAW parameters. In this study, the effect of experimental parameters namely groove angle, C.E, heat input, and preheating on UTS, elongation and average hardness are investigated experimentally and statistically Taguchi technique and ANOVA. Specific findings of this research include the followings: The combined effect of both carbon equivalent and groove angle play an important role in improving tensile strength while keeping ductility at relatively high level. In this annealing is effect to reduce the hardening effect during and after welding via reducing crack susceptibility. The error between the experimental results at the optimum settings and the predicted values for UTS, elongation%, and average hardness lie within 2.1, 3.1, and 4% respectively [3].

R.P. Singh (2012) explained the effects of various welding parameters on penetration in mild steel having 5 mm thickness welded by shielded metal arc welding. The welding current, arc voltage and welding speed were chosen as variable parameters. The depths of penetration were measured for each specimen after the welding operations and the effects of these parameters on penetration were researched. Welding currents were chosen as 90 and 110 Ampere (A), arc voltages were chosen as 20, and 24Volt (V), the welding speeds were chosen as 40, and 80 mm/min and external magnetic field strengths were used as 60 and 80. It was observed that on increasing welding current, the depth of penetration increased. In addition, arc voltage is another important parameter for penetration. However, its effect is not as much as current. The highest penetration was observed for 110 A current, 24 V voltage, 80 Gauss magnetic field and 77 mm/min welding speed. The welding speed was kept constant with the help of a lathe machine. Using the experimental data a multi-layer feed forward artificial neural network with back propagation algorithm was modeled to predict the effects of welding input process parameters on weld bead geometry. A strong joint of mild steel is found to be produced in this work by using the SMAW technique. If amperage is increased, depth of penetration generally increases. If voltage of the arc is increased, depth of penetration decreases. If travel speed is increased, depth of penetration of weld decreases. If magnetic field is increased, depth of penetration of weld decreases. Artificial neural network based approaches can be used successfully for predicting the output parameters like weld width, reinforcement height and depth of penetration of weld [4].

Table 1
Dimensions of weld specimen

Weld specimen	Length	Width	Thickness
Tensile specimen	30mm	5mm	0.5mm
Bend test specimen	30mm	5mm	0.5mm
Hardness specimen	30mm	5mm	0.5mm

Table 2
Tabulated value of 50-degree groove specimen

S. no	Load (in kilo newton)	Deflection (in mm)
1	20	3
2	50	8
3	60	12
4	65	14
5	76	21

Table 3
Tabulated value of 60-degree groove specimen for tensile test

S. no.	Load (kilo newton's)	Deflection (mm)
1	20	5
2	50	10
3	62	15

Table 4
Tabulated value of 50-degree groove by leeb hardness test

S.no.	Parent metal 1 (BHN)	Haz-1 (BHN)	Weld portion (BHN)	Haz-2 (BHN)	Parent metal 2 (BHN)
1	105.43	129.48	287	131	132
2	111	114	275	135	121
3	104	113	120	150	123

Table 5
Tabulated value of 60-degree groove by leeb harness test

S.no.	Parent metal 1 (BHN)	Haz-1 (BHN)	Weld portion (BHN)	Haz-2 (BHN)	Parent metal 2 (BHN)
1	108	129	222	119	127
2	117	136	204	127	111
3	110	120	199	121	124

Table 6
Tabulated value of 50-degree groove by bend test

S.no.	Parent metal 1 (BHN)	Haz-1 (BHN)	Weld portion (BHN)	Haz-2 (BHN)	Parent metal 2 (BHN)
1	108	129	222	119	127
2	117	136	204	127	111
3	110	120	199	121	124

Table 7
Tabulated value of 60-degree groove by bend test

S.no.	Load (kilo newton's)	Deflection (mm)
1	8	94
2	11	96

Fig. 1. Failure in the tensile test


Fig. 2. Performing leeb hardness test


Fig. 3. Failure in the bend test

4. Conclusion

The joints fabricated by SMAW process exhibits high strength value. The strength exhibited by the 50-degree groove weld joint is higher than the 60-degree groove weld joint. One of the conclusion is that the hardness of the weld zone is greater than the hardness of the nonwelded zone that is parent metal. Hardness of the weld zone increases as the velocity of arc movement decreases and it decreases as the velocity of arc movement increases. This happens due to the metal flowing rate.

If our objective is to use the welded joint in the tensile stress conditions, then we must use 50-degree groove angle at 50-degree groove angle the tensile strength of the joint is very high. 50-degree groove angle is the optimum groove angle by increasing or decreasing the groove angle the tensile strength of the joint decreases. If our objective is to use the welded joint in the impact loading condition or compression load condition, then the 60-degree groove angle shows the high strength and it is found that the maximum compressive stress is withstand at the 48-degree groove angle.

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