Evaluation of Hardness of Butt Joint Weld at Different Groove Angles at Varying Amperage (SMAW)

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Abstract:- This study investigates the mechanical properties of the mild steel after performing the welding operation by SMAW process. Two specimen of 50^0 and 65^0 groove angle configurations were prepared and welded at different current and voltages for this purpose. Various tests like tensile strength test, hardness test, and bending test were performed and the results for the welded joint were noted. The results obtained from the welded zone, HAZ (heat affected zone), and unaffected base metal zone (BM) were compared with each other. The results showed that the tensile strength increases linearly with the increase in groove angle. So the tensile strength for 65^0 groove angle is more than that of 50^0. But the hardness values of this welded joint were so great than the other joint. While the 50° groove angle welded joint has the least tensile strength, and also the hardness values were low. So after checking all the mechanical properties of these two types of welded joints, the joint with groove angle of 65^0 was confirmed to be the optimum value in the SMAW process and also this angle is suggested to be used in industries.

Keywords – SMAW, BM, Groove Angle.

I. INTRODUCTION

Welding is the process of joining two or more metals by heating them at suitable temperature with or without using the filler material. The basic needs for welding are filler rod , metals to be weld, electrode, welding torch , power supply .

Welding is usually used for metals and thermoplastics. Among different process of welding, Arc welding is best suitable for light weight materials. Arc welding is a fusion welding process which uses an electric arc to produce the heat required for melting the metal to produce weld. In this process a consumable electrode which is coated with flux is used to produce an arc. Arc welding is usually Gas Tungsten Arc Welding(GTAW), Gas Metal Arc Welding(GMAW), shielded Metal Arc Welding(SMAW), Flux Cored Arc Welding(FCAW).

In Shielded Metal Arc Welding due to the presence of flux on the electrode the electric arc is produced and that arc acts as a shield to avoid atmosphere gas.In Shielded metal arc welding ,the arc is produced by the form of consumable electrode and metal piece. In this we can use flux coated .Due tothis flux coating layer it acts as a shield to protect from atmospheric gases . So it is named as shielded arc welding. The electrode often used as E6027 and E7024.

The depth of fusion or penetration of weld is effected due to the current. If we use more current the penetration increases. At the same time if we decreases the current the penetration is less. Another phenomenon used to classify the joining processes is based on the composition of the joint. According to this, all the joining processes can be grouped into three categories, which are, (1) autogenous, (2) homogenous, and (3) heterogenous. In all the autogenous processes no filler metal is consumed during joining. All the types of Solid phase welding like friction welding, electron beam welding, laser welding etc., and also resistance welding comes under this category. In the homogenous joining processes, the filler metal is used. The filler material used to provide the joint is similar to the parent metals to be joined. Electric Arc Welding, Gas Welding and the Thermit Welding belong to this category. For the heterogenous processes the filler metal's material is different from the parent material. Examples of this category are Soldering and Brazing. There is a special case for heterogenous process, like the two materials which are almost insoluble in each other can also be joined. For example, consider Iron and Silver. The joining of these two materials can be achieved by using a filler metal of third type but which s soluble in both the parent materials.

We know that the atomic bonding forces between two metallic atoms decreases very rapidly if the interatomic distance increase. That is, the bonding force almost reduces to zero. In contrast, if we reduce the interatomic distance to a very small value, then the force increases sharply to attain a very large value. Thus, if we put all the effort to bring two metallic surfaces together such that only the grain boundaries are the barriers for the atoms of two metals, then the two bodies will adhere with a very large force, resulting in the process called as Welding. Welding process is a fabrication process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the workpieces and adding a filler material to form a pool of molten material (the weld puddle) that cools to become a strong joint, but sometimes pressure is used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which

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involve melting a lower-melting-point material between the workpieces to form a bond between them, without melting the workpieces. Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding can be done many different environments, including open air, underwater and in space. Regardless of location, however, welding remains dangerous, and precautions must be taken to avoid burns, electric shock, poisonous fumes, and overexposure to ultraviolet light.

II. LITERATURE REVIEW

Rouhollah Mohsen Pezeshkian had investigated the mechanical and micro structural properties of the P460N steel after the steel parts are joined by Shielded metal arc welding process (SMAW). P460N alloy steels come from the fine grain normalized steel family. This type of alloys are widely used in petroleum industries, chemical industries, power plants and also for the production of heat exchangers, gas cans, LPG bottles and in other fields. In his study, he had prepared three specimen with the groove angles of 60°,45°,75° and joined them using SMAW process. And then he had performed some tests like Tensile strength test, grain size test, and metallographic test on the welded joint metal, heat affected zone (HAZ), and Base metal (BM). Then he compared all the test results. And then he concluded that the yield stress in welded specimen cross-section done by SMAW process with the groove angles of 45° and 75° is less than that of the base metal (P460N steel). In SMAW method with groove angle of 60° yield stress in welded portion is more than that of base metal which is acceptable from engineering and standard point of view. And after performing the metallographic test on the three specimen he concluded that the grain size of the weld metal and the HAZ in the specimen with groove angle of 60° is much closer to the base metal compared to all other sizes. From this prospective, the 60° groove angle is evaluated as the proper groove angle [1].

Saiedeh Safaiepour studied the mechanical properties and metallurgical properties on the weld joint made by SMAW process. In his study he took five specimen with the groove angles of 45°,60°,65°,70°,75° and joined them using the SMAW process. He then performed the tensile strength test, impact strength test, bending test, and the grain size test on all the five specimen. He studied that the impact energy results in HAZ were different so that HAZ areas in the specimen with 45°,60° and 65° groove angles have less impact energy compared to base metal. But in the specimen with 70° and 75° groove angle, impact energy was more in base metal. This increase can be due to the formation of intermetallic compounds that are formed by high entered heat energy created by welding conditions in these regions. By performing tensile strength test, he studied that the tensile strength in all the cases for all the welded metals is more than that of the base metal. But the yield stress in the groove angles of 45°, 65°, 70°, 75° is less than that of the parent metal. Whereas, for the groove angle of 60° the yield stress in welded metal is more than that of the base metal. Since, the base of engineering plan is yield stress he preferred 60° angle rather than 75° angle [2].

Bekir Cevich explained that the quality of the welded joints depends on many factors such as welding current, voltage, welding speed, shielding gas type, and the welding position. One of the main factors in the welding position is the Groove design. This is because different stresses (tensile, compressive, bending.) can occur on the welded joints. For this reason, while designing welded constructions, it is important to join them with the most appropriate groove configuration by considering the stresses the welded joints can be exposed to. In his study he explained the effect of groove configuration on the mechanical and metallurgical properties of S275 structural steel joined by SMAW process. S275 structural steels are widely used as structural steel tubes, construction pipes, foundation pipes, piling tube sheet, and profiles especially in structural engineering. Then he performed the tensile, hardness and bending tests to determine the mechanical properties of the SMAW joint for different grooves. As a result of his microstructure studies, it is seen that different structures such as ferrite, widmansttaten ferrite, and acicular ferrite were formed in the weld metal and coarse-grained region. He observed that the hardness of the weld metal was higher than HAZ and the base metal in all the joints. He found that the bending strength of the welded samples were lower than that of the base metal. The lowest bending strength was obtained in the joint made with V-type welding configuration. In bending test results, it was observed that fractures occured in all the weld samples. In all of them the fracture occured mainly near to the base metal-weld metal transition zone [3].

III. METHODOLOGY

➢ SELECTION OF MATERIAL

- *Base Metal Pieces*

Mild steel plates of sizes 150x50x5 mm^3 were selected as base material because this material is widely used for the engineering applications in the industries. Mild steel has the excellent weld ability. The metal is mostly used for the fabrications work and building of structures. This metal is also widely used in constructional field, automobile field etc., due to its excellent weld ability.

Element	%
Carbon	0.20
Manganeese	1.60
Sulphur	0.045
Phosphorous	0.045
Silicon	0.45

Table 1:-Chemical composition of base material

Electrode Material

A flux coated consumable electrode is used for the SMAW because it acts as shield to avoid atmosphere gases and oxidation on the weld pool. It also acts as cleaning agent by avoiding or removing impurities from the weld pool. Generally flux is made from calcium carbonate, magnesium carbonate, calcium fluoride , silicate materials and few other shielding compounds. The basic electrode used in SMAW are E6010, E6011, E6013, E7018, E7024.

Filler Rod Material

The flux rod material is usually made of steel and stainless

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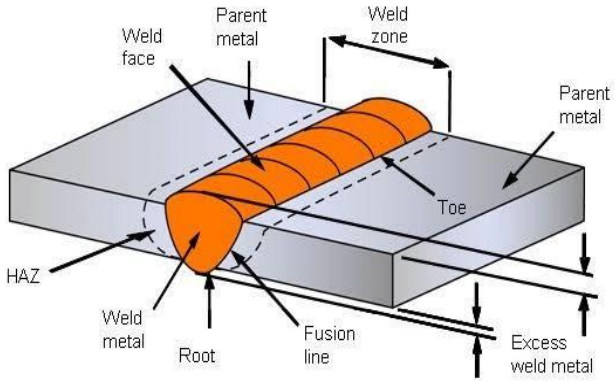
steel. ER308 and ER3082 are common welding rods.

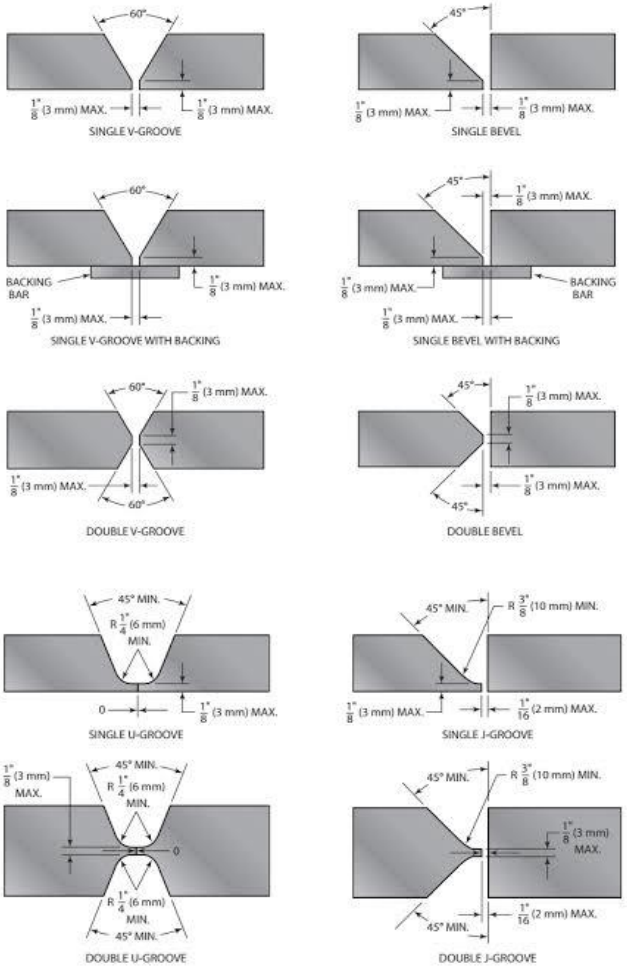
- SELECTION OF JOINTS

The important aspect of welding include the joint selection. Among all joints(Butt joint, Lap joint, Tee joint ,Edge joint). Butt joint is used to weld. In butt joint the two metals are placed side by side to do weld. It is easy to weld at different angles.



- SELECTION OF GROOVE ANGLES

The major stop to be considered to do world is that selecting groove angles. This groove angle effects the mechanical properties of weld. Generally we use weld grooves like Single V, Double V, Single U, Double U, Single Bevel, Double Bevel, Single J, Double J for the weld. But we choose single v groove angle because of its less completely during making the groove. The groove angle for single v is 50^0 and 65^0 was chosen by us to do weld.



SELECTION OF CURRENT

The current effects upon the penetration of the weld is the current increses the depth of weld also increses at same time is the current decreses the depth of weld also decreses.

Size	Dia Length	2.0	2.5	3.2	4.0	5.0
		250	350	350	400	400
Current range	F	30-60	50-90	90-140	120-170	160-230
	V,OH	30-60	50-90	90-140	100-160	120-200

WELDING PROCEDURE

The welding process is done using Shielded Metal Arc Welding process. The DC rectifier manufactured by MEMCO industries having welding current rating of 450Amps with 60% rated duty cycle was used as a power source for the welding process. The butt weld was made in following steps.

Step1: In this step a supporting plate was taken and a notch was made exactly near the groove. The notch was made by grinding it on a fixed grinding machine.

Step2: Here the E6013 electrode was taken and tack welds were kept on each side of the steel plate. Then tack welds were allowed to cool for a while. The tack welds being made are shown in the figure below.

Step 3: The supporting member was also attached such that the notch on the supporting one was exactly above the groove. Then this joint was also allowed to cool.

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Step 4: Following the third step, three welding passes were made. The first one is called the Root pass (pass1), the second one as the hot pass (pass2) and the third one as the capping pass (pass3).

This is the joint after completing the entire process.

The welding parameters used for different passes is shown in the table below.

Pass no.	Size of the electrode used	Current used (Amps)
Root pass	3.15mm	90A
Hot pass	3.15mm	100A
Capping pass	3.15mm	100A

Welding parameters for different passes

IV. TESTING AND RESULTS

To know the weld defects and mechanical properties of weld can be determined by testing basically testing can be done by breaking or without breaking material.

A.Non- Destructive Testing

This process can be done without breaking the welded material. In this process the weld defects can be evaluated. Basically non-destructive testing are Liquid penetration test, Visual inspection test, Magnetic particle test, Radiograpy test, Ultrasonic test, Eddy current test, Leak test. We preferred Liquid penetration test. The basic requirements of LPT are penetrant removal, developer, dye penetrant.

Steps included in LPT are:

Pre cleaning: This can be done by using cotton waste or brush.

Appilication of penetrant: The dye penetrant can be sprayed on the weld pool and wait for some time. This time is known as dwell time.

Penetrant removal: By using penetrant removar we can remove the penetrant from the work piece.

Applying of Developer: Developer can be sprayed on the work piece and dwell time can acts under observation.

Observation: Some weld defects can be evaluated on the work piece.

Post cleaning: During this process developer is removed and work piece can be cleaned.

The weld defects such as spatter, porosity, slag inclusion, lack of penetration, lack of fusion can be observed and evaluated.

B. Destructive Testing:

In this process the work piece can be break to know the mechanical properties such as Tensile strength, Hardness and Bending stress.

Hardness Test:

In hardness test we can use Brinnel Hardness Testing machine during this process we need to consider three zones on the work piece those zones are Base Metal Zone, Heat Affected Zone, Weld Pool. The work piece is placed on the hardness testing machine the load is applied on the work piece in varies zones that is HAZ, Weld pool, Base metal zone observe the readings from the hardness testing machine of two work pieces of angle 50^0 and 65^0.

The various observation shown below.

Brinnel Hardness Testing

S.No	Weld metal zone	HAZ zone	Base metal
1	95	91	84
2	91	86	83
3	93	86	84

Table: hardness test reading for 50^0

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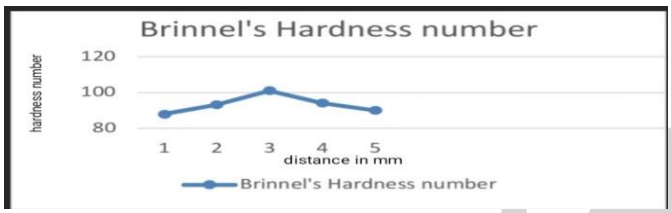
S.No	Weld metal zone	HAZ zone	Base metal
1	101	93	88
2	103	94	90
3	102	95	89

Table: hardness test reading for 65^0

For 50° angle the hardness test results are as follows

For 65° angle the hardness test results are as follows



From this it has been concluded that the hardness value of weld zone is higher than any other zone. From the hardness test results it has been concluded that the hardness of the weld 65° angle is greater than the other which is not very advisable. And the lowest hardness values were found in 50°angle which is also not recommended. So the optimum values were found in 65° groove angle.

Specimen after breaking

Length	Thickness	Load	Deflection	Elongation	Tensile
190mm	6mm	25kN	25 mm	205mm	433.3N\mm

Tensile test values of mild steel plates.

Tensile test:

In tensile test the work piece is placed between two fixtures of Universal testing machine (UTM) and Gradual load (pull force) is applied on both sides. Thus the material reaches its yield strength and starts breaking. From this test we can evaluate the strength of two work pieces of angle 50^0 and 65^0 after calculation of elongation we can conclude that the work piece having 65^0 as more tensile strength as compared to 50^0. So we prefer 65^0 is work piece is best suitable for industrial application. For 50° groove angle the load was increased gradually and the changes in dimensions are noted. Thus the maximum load applied was 59 kN where the fracture was observed. The load is applied till the failure is observed. Initially, the deformation was not observed till 50 kN. Thereafter, the steady deformation is observed. The deformation observed was of 13mm when the fracture has occurred. The results are as follows.

V. CONCLUSION

We need to used SMAW process for bulk production because of its less complexity and shielded production and also we preferred v groove butt joint to do the weld. From the above observation the work piece with 65^0 is best suitable for industrial application due to its salient futures. The tensile strength for 65^0 work piece is more hat of 50^0 work piece and also the hardness is also better in 65^0 as compared to 50^0 work piece these observation can be done by using universal testing machine and brinnel hardness testing. In hardness we found that hardness is more at weld pool as compared to heat affect zone and base metal zone.

REFERENCES

[1] R. A. Mohammed, M. Abdul Wahab, E. T. Dauda "Properties evaluation of shielded metal arc welded mild steel material," International Journal ofInnovative Research in Science, Engineering and Technology, Volume 2, August 2013.

[2] Rajeev Ranjan "Parametric optimization of shielded metal arc welding processes by using factorial design approach," International Journal of Scientific and Research Publications, Volume 4, September 2014.

[3] Bekir cevich analysis of welding groove configurations on the strength of S275 structural steel welded by SMAW.

[4] Causes for Weld Defects. IIW Doc. XII-B-046-83.International Institute of Welding, 1983.

[5] R.P. Singh, R.C. Gupta and S.C. Sarkar "The Effect of Process Parameters on Penetration in Shielded Metal Arc Welding under Magnetic Field using Artificial Neural Networks," International Journal of Application or Innovation in Engineering & Management (IJAIEM) (Volume-1), December 2012.

[6] Houldcroft, P.T. Welding process Technology, Cambridge University Press, London,1977.

[7] Roulallah mohsen pezekian,payman shayanfar, groove angle nfluence on mechanical and metallurgical properties of SMAW joint.

[8] Saiedeh Safaiepour, experimental study of shielded metal arc welding parameter on weld strength for AISI 1020

[9] Ling, fu, huang groove configurations of a flux cored arc welding.

[10] Kaya, kahraman, durgutlu, gulench investigations of mechanical properties of different thicknesses of the grade A ship plates joined by submerged arc welding.

[11] Tejpal singh, arivinder singh, sumit saini effect of groove design on mechanical properties of SMAW joint.

[12] Chennakesava reddy, balram naik an experimental investigation of SMAW on stainless steel.

 DOI : 10.35291/2454-9150.2021.0611