Improper fit and its consequences on weld joint

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Abstract **This study investigates the mechanical properties of the mild steel after performing the welding operation by SMAW process. Two specimens of 30°, and 60° groove angle configurations were prepared and welded 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 60° groove angle is more than the other two. But the hardness values of this welded joint were so great than the other two joints. While the 60° groove angle welded joint has the least tensile strength, and also the hardness values were low. So, after checking all the mechanical properties of the three types of welded joints, the joint with groove angle of 60° was confirmed to be the optimum value in the SMAW process and also this angle is suggested to be used in industries.**

Keywords — Base Metal, Groove angle, Heat Affected Zone, Hardness, Tensile Strength, Welding,

I. INTRODUCTION

The welding is a process of joining two or more, similar or dissimilar metals by heating them to a suitable temperature with or without the application of the pressure, filler material and flux. Welding is a method of repairing metal structures by joining the pieces of metals or plastic through various fusion processes [1]. Generally, heat is important to weld the materials. Welding equipment's can utilize open flames, electric arc or laser light [2]. In the 19th century, major breakthroughs in welding were made. The use of open flames (acetylene) was an important milestone in the history of welding since open flames allowed the manufacture of intricate metal tools and equipment's. The term joining is generally used for welding, brazing, soldering, and adhesive bonding, which form a permanent joint between the parts. The term assembly usually refers to mechanical methods of fastening parts together. Some of these methods allow for easy disassembly, while others do not. We begin our coverage of the joining and assembly processes with welding [3]. For the development of the new technique, operation, process or methodology it is very important to make detail study on the existing techniques, methodology and to understand the same for elimination of problem concerned with them. This study can be helpful for improving the weld strength of metal, also reduced in cost of welding. In this paper detailed discussion is carried out on the various mechanical tests like bending test, tensile test and Brinell's hardness test done on the improper fit with v groove angle of 60° [3].

II. EXPERIMENTAL PROCEDURE

Selection of material

Mild steel plates of sizes 150x50x5 mm3 were selected as base material because this material is widely used for the engineering applications in the industries. Mild steel has the excellent weldability. The metal is mostly used for the fabrications work and Mild steel plate of 150x50x5mm3 building of structures [4]. This metal is also widely used in constructional field, automobile field etc., due to its excellent weldability. The chemical composition of steel has been given in table below.

Table1:

Chemical composition of steel

element	%
Carbon	0.20
Manganese	1.60
Sulphur	0.045
Phosphorus	0.045
silicon	0.45

Mild steel plate of 150x50x5mm3

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Selection and preparation of Weld groove

Selection and preparation of weld groove is an important step in the fabrication of a welded joint. Selection of a correct joint design of a welded member leads to perform within load service, corrosive resistant atmosphere and safety. The weld joint which we use to join the welded members should have the required load bearing capacity when the Element % Carbon 0.20 Manganese 1.60 Sulphur 0.045 Phosphorous 0.045 Silicon 0.4531load is applied in any direction. This should have good surface finish to make a sound weld joint [5]. It should be designed in such a way that it will produce minimum distortion and residual stresses in the weldment as well as it should be economical. Since the distortions and residual stresses are main causes for the failure of weld joints. Based on thickness and width of the base plate 60°,60° groove angles were selected. Then the two specimens were bevelled to their quired angles with a hand grinding machine. In this procedure the mild steel plates were held fixedly in the bench vice [6]. Then the grinding wheel was allowed to bevel the edges of the plates to the required angles. The grinding procedure is shown below:

Grinding operation

Then all the plates were bevelled to required angles in the similar manner. The spatters formed on surfaces of the steel plates are also removed to make a smooth surface. The complete groove after beveling to angle of 60^0 is shown below;

v-groove

Welding Procedure

The welding process is done using shielded 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 specifications of the power source is given in the table below:

Table 2:

Make	
Maximum current capacity	450Amperes
Duty cycle	60%
Cooling	Air-cooled
Output current	DC

The welding electrode used was E6013 having size of 3.15mm. this electrode was selected because it has matching properties with the base metal and can be used in any position. the electrode E6018 was used in this process since they are only used to join thick plates [6]. Then the butt weld was made in the following steps:

Step 1: 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.

Step 2: Here the E6013 electrode was taken and tack welds were kept on each side of the steel plate. Then the tack welds were allowed to cool for a while.

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

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) [6][7].

Supporting member for the weld joint

Welding process

III. TESTS CONDUCTED

The testing was carried out physically on various testing machines such as universal testing machine and Rockwell

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hardness testing machine. The tests performed were tensile test, bending test and hardness test.

Hardness test

The hardness test is conducted for the specimen by using Rockwell hardness testing machine for 60°v- groove angle. One test is for 60° v- groove angle with open root gap is conducted. The test is conducted at different places on the surfaces of the specimen like parent1, HAZ1(heat affected zone), weld bead, parent2, HAZ2. The values for the test are noted in the tabular column. The test shows that the strength of weld joint is increased from parent1 to weld bead, and decreased from the weld bead to parent2 [5][8].

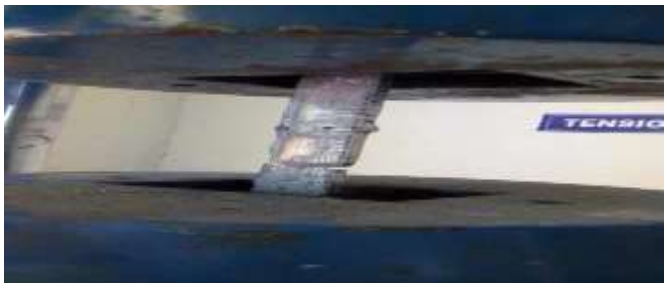
Tensile test

Hardness test

After welding process

Chipping process

For 60° groove angle the load was increased gradually and the changes in dimensions are noted. Thus, the maximum load applied was 90kN for open root gap weld joint where the fracture was observed. The load is applied till the failure is observed. Initially, the deformation was not observed till 78kN. Thereafter, the steady deformation is observed. The deformation observed was of 20mm when the fracture has occurred [5][8].



Tensile test

Bending test

The bending test was also done on the universal testing machine. The required set up for the bending test was done. And then the plate was subjected to bending. At some point of application of load the most of the welded joints would be fractured. But in few cases, the specimen bends without any fracture. Then the elongation and the load at which complete bend took place or the fracture occurred were noted. And this process was also repeated for all the specimen of all the angles [8]. The bending setup used in universal testing machine is shown in the below figure.

Bending test

IV. RESULTS Hardness test result

For 60° angle with root gap the hardness test results are given by the table and graph below.

Table 3;

From this it has been concluded that the hardness value of weld zone is higher than any other zone.

For 60° angle with root gap the hardness test results are given by the table and graph below.

Sno	Parent1	HAZ1	weld	HAZ2	Parent2
1	107	124	126	108	113
2	114	117	144	107	97
3	102	113	143	110	102

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For 60° angle without root gap the hardness test results are given by the table and graph below.

sno	P1	HAZ1	weld	HAZ2	P2
1	99	114	128	123	119
2	107	97	119	125	105
3	102	101	121	115	94

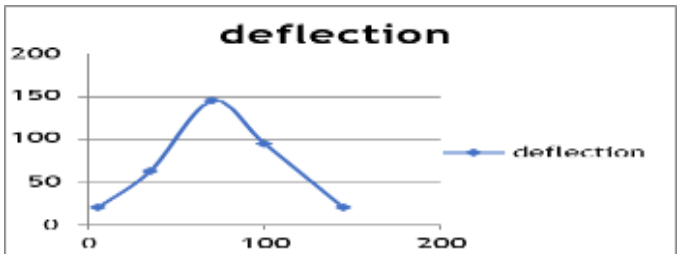
From this it has been concluded that the hardness value of weld zone is higher than any other zone.

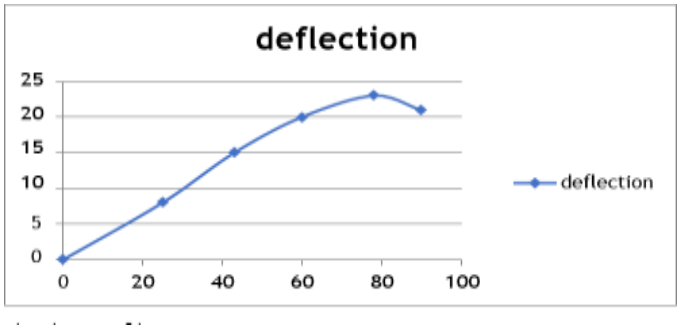
Tensile test result

The testing specimen was kept in universal testing machine and the tensile test was conducted for all the three specimens. The loads and the deformation for all the groove angles were noted and are as follows.

SNO	distance	hardness
1	5	20
2	35	63
3	70	145
4	100	95
5	145	20

S.no	Load	Deflection
1	0	0
2	25	8
3	43	15
4	60	20
5	78	23
6	90	21



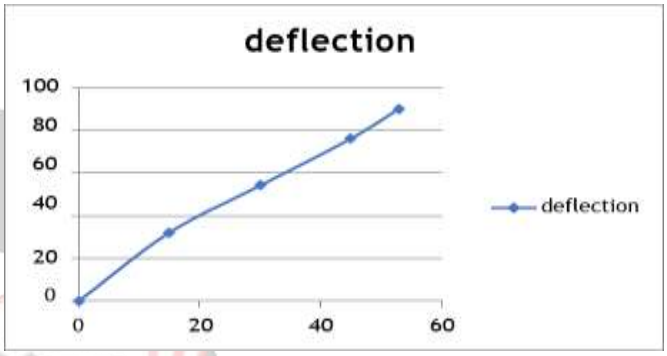


Bending test result

The bending test is conducted by UTM machine. The maximum load applied is 53KN. At that point weld joint undergoes deformation.

S.NO	LOAD	DEFLECTION
1	0	0
2	15	32
3	30	54
4	45	76
5	53	90

From the graph we can see that maximum deflection is about 90mm and if further is deflected then the specimen breaks into two pieces.



The graph shows that the bending of the weld joint which is occurred by deformation and at some limit the weld joint breaks into parts.

V. CONCLUSION

The groove angle configuration is the most essential part of the welded joint. The tensile strength increases linearly with the groove design. So, the 60° groove angle has the highest tensile strength than the 60° and 60° angles. But the hardness results show that the 60° groove angle has more hardness values than the other two which is not at all desirable. Since, the increase in hardness values decrease the ductility and increases the brittleness. So, after analyzing all the results, we found that the tensile strength in 60° is the least while the hardness values are permeable. So, to obtain the optimum values of hardness and tensile and all other mechanical properties the standard groove angle is 60°.

Thus, the groove angle configuration of 60° is the best value for any type of operation used in industries.

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