INVESTIGATION ON MECHANICAL PROPERTIES OF SMA WELDED CARBON STEEL JOINTS BY VARYING JOINT DESIGN AND GROOVE ANGLES

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ABSTRACT

This paper discussed about the experimental investigation of mechanical properties of SMAW welded carbon steel plates IS 2062 E350 having two different joints single V and double V groove and also varying the groove angles as 40°, 50°, 60°, and 70° by keeping constant current and voltage as constant. From the observed results, the double V groove joint with groove angle of 50° have maximum tensile strength than the other joints. The maximum toughness was achieved in the double V groove joint with 60° groove angle than 40°, 50° and 70°. In hardness double V groove joint with 50° groove angle is prior to all other groove angles. By comparing the results, double V groove joint with groove angle of 50° provides the satisfactory results from this investigation.

KEYWORDS: Groove angles, SMA, Tensile strength, Joint design & Carbon steels

INTRODUCTION

Welding is the process of joining of two or more, similar or dissimilar metals with the addition of heat or pressure and with or without the help of filler materials. Joining process is most widely used in fabrication industries to manufacture automobile parts, aircraft bodies, ship body construction etc., during joining process the corner of the metal plate is fused together and form a permanent joint. Unlike the rivets are semi-permanent joints. Weld geometry plays a vital role in attaining greater joint strength and provides extended life of the component. The metal plates can be joined by the various joint designs like lap, butt, corner and tee joints. Each type has different characteristics, unique strength and applications. The most appropriate method for joining of metals is Shielded Metal Arc Welding method, which is most convenient, effective, reasonable and suitable for complex joint designs. The shielded metal arc welding method makes a weld upto maximum thickness of 20mm plate and can operate in both AC and DC power supply. Depending upon the plate thickness the voltage and ampere can be varied. To understand the properties of materials, mechanical testing is to be carried out on metals such as tensile, hardness, and izod test etc. In this study, IS 2062 E350 is welded with various welded joints and groove angles using SMAW process and joints are evaluated by mechanical testing methods.
MATERIALS AND METHODS

Parent Metal

The parent metal for the welding is IS 2062 E350, which is mostly used for the industries like chemical, paper and pulp also used for the oil and gas industry, petrochemical industry, off Shore Company as well. Due to its high resisting property it is used for applications of seawater and marine. This type of hot rolled carbon steels are commonly used easily available. It has good tensile strength, easy to formability and weld ability, high mechanical strength and shear strength etc.

The chemical composition of the parent metal is shown in the table.

<table>
<thead>
<tr>
<th>Composition</th>
<th>C (Max)</th>
<th>Mn (Max)</th>
<th>P (Max)</th>
<th>S (Max)</th>
<th>Si (Max)</th>
<th>Nb+V+Ti (Max)</th>
<th>Carbon Equivalent (CE), Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 2062 E 250 BR</td>
<td>0.20</td>
<td>1.50</td>
<td>0.045</td>
<td>0.045</td>
<td>0.45</td>
<td>0.25</td>
<td>0.42</td>
</tr>
</tbody>
</table>

The base material has the tensile strength of 450-630 N/mm² yield strength 315-355 N/mm² and the elongation is upto max 22 %. This type of carbon steels can withstand its strength upto maximum temperature of 345°C. It is readily available in as rolled condition.

Weld Joints

There are various types of joints and groove angles are available for strengthening the joints of the parent metal. Butt, Tee, Single and double bevel, Single and double V groove, Single and double U groove, Single and double J groove, the groove angles may vary from 30° to 70°

In our present study, the weld joints such as single V and double V with the groove angles from 40° to 70° is selected to examine the strength of the welded joints.

Filler Metal

The selected filler metal is E7018. This type of filler metal is designed to improve deposition rates and provides smooth arc on the base material and give very less spatter with medium arc penetration. It can also be used in AC or DCEP power source. E7018 electrodes produce strong welds with high impact properties and it can be weld carbon steel, high-carbon, low-alloy or high strength steel base metals.
Welding Methods

For welding of carbon steel plate variety of welding methods can be employed. One of the best suitable methods is Shielded Metal Arc Welding (SMAW). It provides more mechanical strength to MS weld joints. In this work, to weld the plates SMAW process selected with the AC current.

Testing Methods

A weld must possess good mechanical strength such as tensile, hardness, toughness and compression. These properties can be evaluated by using mechanical testing methods such as tensile test using universal testing machine, hardness test using Rockwell and brinell hardness test. In this study the tensile, hardness and toughness tests are carried out in order to examine the strengths of the welded joints.

One of the important evaluations in the weld joints is metallographic examination. This type of test will give the results about microstructure of weld joints which will helps to understand the mechanical properties of welded joints. This can be done by optical microscope.

EXPERIMENTAL WORK

From the literature survey, the specimen is initially cleaned to remove the foreign particles present in the surface of the metal. The specimen has to be cut as per the dimensions (125 × 125 × 15 ) mm. The groove angles are made on the corners of the specimen. The selected groove angles are 40°, 50°, 60°, and 70°. There are 8 set of specimens are prepared for the study.

Welding Parameters

- Current, I = 100 A
- Voltage, V = 80 V
- Groove angles = 40°, 50°, 60°, and 70°
- Joint design = Single and Double V

Table 2: Chemical Composition of Filler Metal

<table>
<thead>
<tr>
<th>Composition</th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>E7018</td>
<td>0.07</td>
<td>0.87</td>
<td>0.015</td>
<td>0.011</td>
<td>0.61</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Figure 2: Shielded Metal Arc Welding
• Root gap = 2mm
• Bevel height = 3mm

![Diagram of single and double V grooves]

Figure 3: Single and Double V Groove

RESULTS AND DISCUSSIONS

Tensile Test: Single V Groove and Double V Groove

The specimen was prepared as per the dimensions and joints and the welding was carried out on the base metal. After welding the joints were ready for the examination of tensile strength. The welded metals were loaded in the UTM to observe the tensile strength. From the following graphical it is came to know that the double V groove joint with 50° groove angle have 510.20 MPa which is higher than the other groove angles of 40°, 60°, and 70°. This is might be because of less formation of internal stresses in the specimen than groove angle. The volume of groove in the specimen can also be considered. It is evident that when increasing the groove angle there might be a chance of decreasing the tensile strength.

![Graph of tensile strength for various groove angles]

Figure 4: Tensile Strength for Various Groove Angles
Investigation on Mechanical Properties of SMA Welded Carbon Steel Joints by Varying Joint Design and Groove Angles

Toughness Test (Izod): Single V Groove and Double V Groove

The impact energy for the welded specimen can be determined by both Charp and Izod test. It is used to measure the toughness of a weld joint. In this study Izod setup was preferred and joints were examined. From the observed readings it is came to know that the double V groove joint with groove angle of 60° has attained impact strength of 51.7 Joules. While comparing with groove angles, it has the maximum impact energy.

![Figure 5: Impact Strength for Various Groove Angles](image1)

Single and Double V Groove: Hardness Test (Brinell)

The Measuring of hardness values are more important to have better life for the welded joints otherwise it may leads to the failure of the structure. The figures 6 and 7 are represents the hardness values of both single and double V groove joints for 40°, 50°, 60°, and 70°. For finding the hardness, the welded joints were tested in the brinell hardness test which has the ball indenter. From the recorded values of hardness and by seeing both the joints, double V groove joint with 50° groove angle is prior to all other groove angles.

![Figure 6: Hardness Test for Single V Groove](image2)

![Figure 7: Hardness Test for Double V Groove](image3)
CONCLUSIONS

From all the observed results it may conclude that,

- The carbon steel IS2062 E 350 welded with E7018 filler metal by SMAW process, the double V groove joint with the with 50° groove angle have 510.20 MPa which is higher than the other groove angles. When increasing the groove angle the tensile strength of joint is getting reduced.

- By comparing single and double V groove joint for the impact energy, the double V groove joint with groove angle of 60° has attained impact strength of 51.7 Joules which is higher than 40°, 50° and 70° groove angles.

- On seeing the hardness values, double V groove joint with 50° groove angle is prior to all other groove angles and it provides satisfactory results.

- It is came to that the most suitable joint and groove angle for IS2062 E 350 is double V grove and 50° for attaining better strength in all aspects.

- There might be a chances for increasing the strength of welded joints, when it undergoes both preheat and post weld heat treatment process. In can future, it can be considered.

REFERENCES


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