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Investigation on the Micro-Structure and Mechanical Properties of Heat Affected Zone for SMAW in IS-2062

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Abstract:
There are multiple methods of joining different materials and welding is one such method used by a majority of fabricators in the manufacturing sector. Shielded Metal Arc Welding (SMAW), also known as Stick welding, is one of the most popular arc welding methods that make use of a metallic consumable electrode to produce the weld. The most effective feature of this technique is its intense heat source. SMAW has simple and highly portable equipment and, therefore it is suitable for all welding positions. With this experiment, we will be differentiating between the varying effects of controlling parameters over the heat affected zone (HAZ) due to SMAW for a low carbon steel specimen. Properties such as hardness, brittleness and tensile strength in the HAZ of IS-2062 and its relation with the micro-structural changes caused due to heat input have been a focus of this work.

Key words: SMAW, HAZ, IS-2062, Welding Current, Hardness, Tensile Strength

I. INTRODUCTION

In welding, melting of the parent metal occurs due to high heat generation and a filler material is used to join the metal forming a molten weld pool. On cooling, it forms a joint and the welded portion becomes stronger than the parent metal. Welding thermal cycle, generally, has a negative influence on the mechanical properties of HAZ, hence, the analysis and study of HAZ is of prime importance. The factors for improving weld-bead quality can be majorly classified by material selection and welding parameters. Their combined effect is reflected on the mechanical properties of the weld in terms of weld quality as well as joint performance. Thus, it can be understood that several process control parameters in SMAW welding is influenced on bead geometry, microstructure as well as weld chemistry.

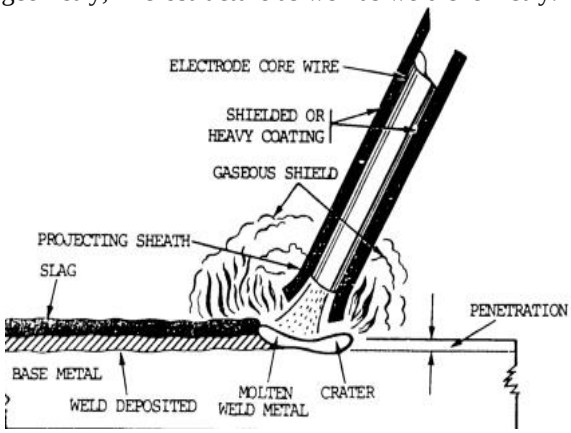

Figure.1. Shielded Metal Arc Welding

II. MATERIAL SELECTION

Low-carbon steels are widely used for structural work, as it is more likely to retain its ductility when overheated than other metals. Even if we try to quench it in water too quickly, it manages to survive the shock of the sudden chill. It can also be derived that low carbon steels, those having less than 0.25% carbon, display good weld ability, meaning that they can be generally welded without special precautions using most of the processes available. While working on a small budget, low carbon steel proves to be the best. It is an ideal material that keeps project cost as low as possible. The high level of demand makes mild steel a widely produced material and therefore a very affordable material. Ferritic steels, such as IS-2062 (with 0.25% C approx), provide strength and structural integrity for the systems as well as excellent resistance to high temperature, pressure water or steam.

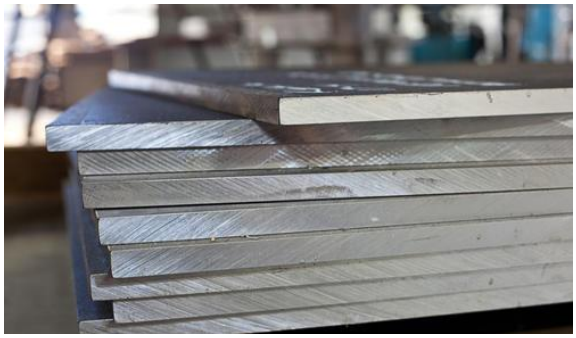

Figure.2. IS-2062 plates

One of the most beneficial properties of IS-2062 is that it can be bent, cut and twisted to create the desired shape easier than other extractions of low carbon steel. It is one of the reasons why IS-2062 is popular in many industries from the manufacture of household items to structural applications to home improvement projects. Working with IS-2062 is, therefore, easier and is used for manufacturing auto parts, pipelines and fences for homes and businesses.

III. WELDING PARAMETERS

The principal parameters considered for welding are welding current, arc voltage, electrode diameter and travel speed. Also, joint position can greatly affect finished weld quality for which selecting the right electrode size is really important. Based on parent metal and fusion with it, electrode selection is carried out. It should be made sure that the joint position and electrode matches well with the metal, not causing any burn through. Heat input is the most significant factor for controlling width of the HAZ. The increase in amount of heat input increases the width of HAZ. As welding speed increases, the width of HAZ decreases, therefore, proper control on welding speed is another important parameter for controlling the HAZ. Welding Speed is defined as the rate of travel of the electrode along the seam or the rate of travel of the work under the electrode along the seam.
Travel Speed = Travel of electrode/arc time (mm/min)
Heat input rate or arc energy = V×I×60 /v (J/mm)
Where, V= arc voltage (volts)
I = welding current (Ampere)
v = speed of welding (mm/min)

IV. EXPERIMENTAL PROCEDURE

A. Welding equipments

- SMAW machine
- Welding torch
- E-7018 electrode
- IS-2062 specimen (200x100x6 mm)

B. Methodology

An experiment of SMAW was performed using E-7018 electrode of 3.4mm diameter using below mentioned values of current for each test coupon:

Table .1. Parameters for SMAW

Sr. No.	Current (A)	Voltage (V)	Time (min)	Travel Speed (mm/min)	Heat Input (J/min)
1.	75	22	1.40	123.7	838.3
2.	80	25	1.40	122.4	1317.6
3.	85	32	1.40	120	1734

C. Test coupons for SMAW:

Figure.3. SC-1 (75A)

Figure.4. SC-2 (80A)

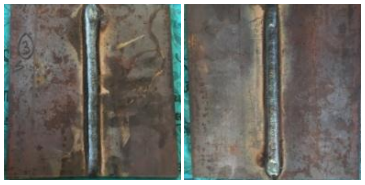

Figure.5. SC-3 (85A)

V.RESULT

a) The following given microstructures have been obtained from Met-Heat Engineers laboratory:

Figure.6. HAZ of SC-1 (75A)

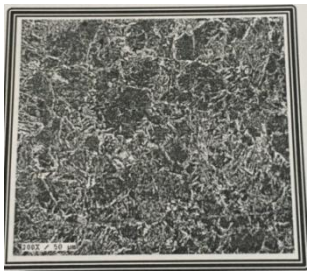

Figure.7. HAZ of SC-2 (80A)

Figure.8. HAZ of SC-3 (85A)

b) Fig. 11 shows the results obtained for hardness test on the three test coupons as per Vickers Hardness HV-10 (ASTM E-384:2011A)

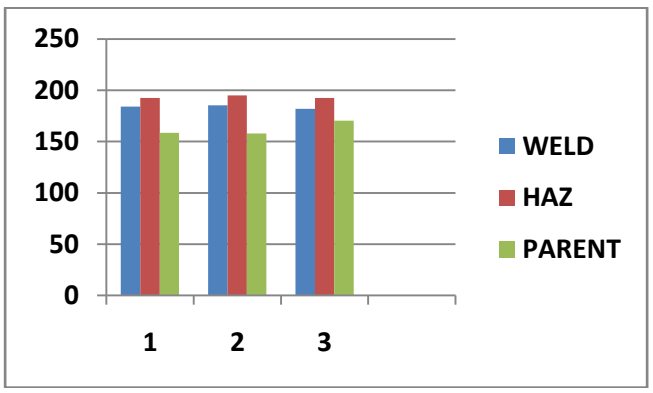

Figure.9. Vickers Hardness test

Fig. 12 shows the results obtained for tensile test on the three test coupons as per tensile test (ASME Sec-9: 2017)

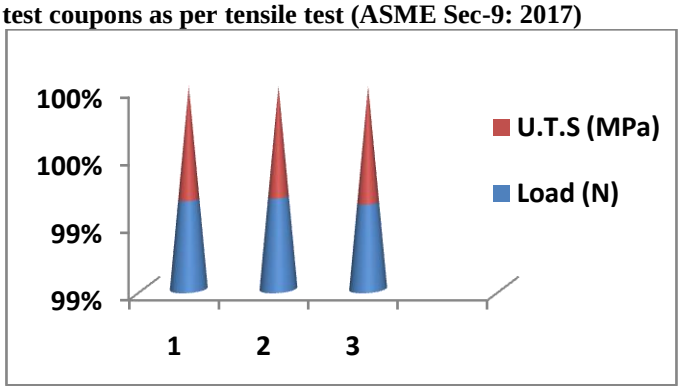

Figure.10. Tensile test

VI.CONCLUSION

- 85A current gave a columnar structure of bainitic plates in the HAZ, indicating a coarse weldment. But, the test coupon was fractured at the weldment and hence, this range of current would not be considered desirable.
- The test coupon with 80A current had some proportions of pearlitic structure as well as non-uniform ferrite platelets with relatively lesser values of tensile strength.
- At 75A, HAZ showed a coarse bainitic structure, thus, indicating more desirable properties such as decrease in hardness, increase in ductility and higher value of ultimate tensile strength**.**
- Hence, we can conclude that 75A current when applied to a 6mm thick plate of IS-2062 would give excellent properties of hardness as well as display good impact and tensile characteristics.

VII.APPLICATIONS

The applications of SMAW can be generally found in some of the below mentioned areas:

- Oil & gas industry
- Pressure channels
- Chemical plants
- Heat exchangers
- Condenser tubes
- Sheet metal industry
- Infrastructure repair
- Marine structures
- Aerospace industry

VIII. FUTURE SCOPE

Shielded Metal Arc Welding serves as the most effective method for providing structural integrity, giving more efficient designs at the same time minimizing the amount of welding. With this project, we aim at quality and productivity of a welded component which is one of the most essential tasks in the manufacturing sector. We have made an attempt to study heat affected zones for low carbon steel, IS-2062, using SMAW for a defined dimensional specimen which thus, opens up the possibilities of discovering various other phenomena for other categories of welding so as to improve the metallurgical properties by controlling parameters.

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