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

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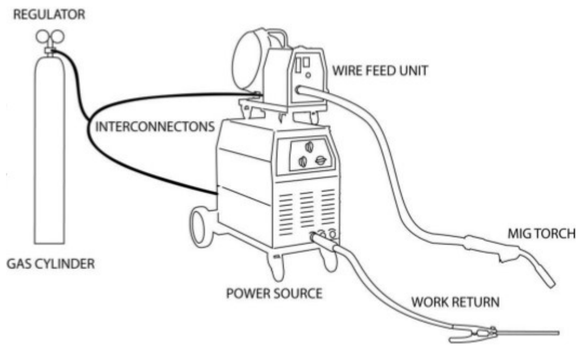
ABSTRACT

There are various categories of joining processes and welding is one such method used by a majority of fabricators in the manufacturing sector. Gas Metal Arc Welding (GMAW), popularly known as Metal Inert Gas (MIG) Welding, is one of the most traditional arc welding methods that make use of a consumable electrode to produce the weld. The most effective feature of GMAW is its intense heat source. Since, this method does not involve any use of flux, there are less chances of slag entrapment and high quality welds can be produced at a faster rate. With this experiment, we will be differentiating between the varying effects of controlling parameters over the heat affected zone (HAZ) due to GMAW 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.

Keywords: GMAW, 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 section 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.



Figuer 1. Gas 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. Heat exchanger tubes in power boilers and waste heat recovery systems are typically made of ferritic steels with lesser proportions of carbon in them. 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.

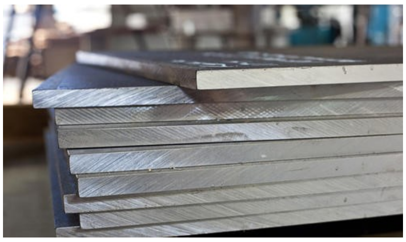


Figure 2. IS-2062 plates

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. The bead geometry parameters such as bead width, bead height, penetration etc., are the secondary factors that influence the properties of the welded joints. Based on parent metal and fusion with it, electrode selection is then 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 = $V \times I \times 60 / v$ (J/mm)

Where, V= arc voltage (volts)

I = welding current (Ampere)

v = speed of welding (mm/min)

IV. EXPERIMENTAL PROCEDURE

A. Welding equipments:

- GMAW machine
- Welding torch
- Argon, carbon dioxide gases
- ER70S-6 filler wire
- IS-2062 specimen (200x100x6 mm)

B. Methodology:

An experiment of GMAW was performed using ER70S-6 filler of 2.4mm diameter using below mentioned values of current for each test coupon:

Table 1. Parameters for GMAW

Sr. No.	Current (A)	Voltage (V)	Time (min)	Travel Speed (mm/min)	Heat Input (J/min)
1.	160	22	1.42	117.6	1795.3
2.	190	21	1.22	146.3	1635.9
3.	210	21	0.48	250	1058.4

C. Test coupons for GMAW:

Figure 3. MC-1 (160A)

Figure 4. MC-2 (190A)

Figure 5. MC-3 (210A)

V. RESULT

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

Figure 6. HAZ of MC-1 (160A)

Figure 7. HAZ of MC-2 (190A)

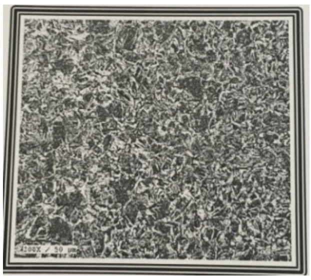


Figure 8. HAZ of MC-3 (210A)

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

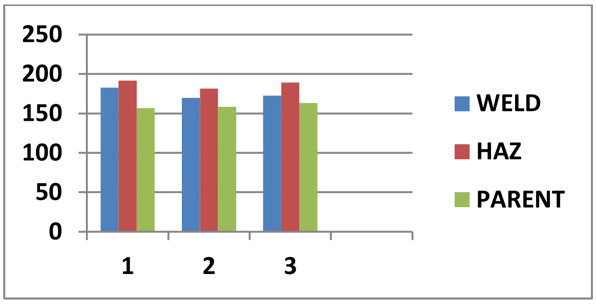


Figure 9. Vickers Hardness test

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

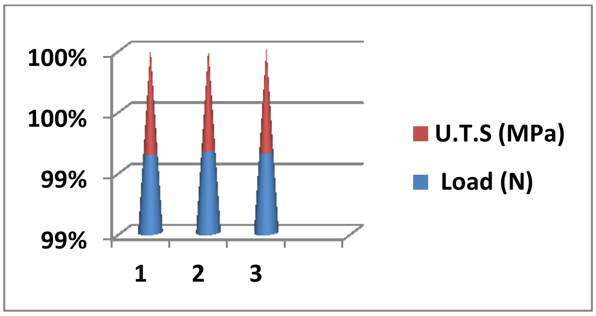


Figure 10. Tensile test

VI. CONCLUSION

- While, 210A 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.
- At 190A current, we observe homogeneous bainitic structure with relatively lesser amount of hardness and higher tensile strength in the weld metal.
- The test coupon with 160A current had, relatively, the highest amount of pearlitic structure and small non-uniform ferrite platelets; thus, making it less desirable for good tensile characteristics.
- Hence, we can conclude that 190A 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 GMAW can be generally found in some of the below mentioned areas:

- Reactor vessels
- Pressure channels
- Fuel claddings
- Heat exchangers
- Condenser tubes
- Sheet metal industry
- Infrastructure repair
- Marine structures
- Aerospace industry

VIII. FUTURE SCOPE

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. There is a gigantic growth in the market because welding serves as the most effective method for providing structural integrity, while being compared to alternative materials such as plastics, composites and other advanced engineering materials. We have made an attempt to study heat affected zones for low carbon steel, IS-2062, using Gas Metal Arc Welding (GMAW) 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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