STUDY OF HEAT AFFECTED ZONE FOR SMAW PROCESS FOR LOW CARBON STEEL SPECIMEN WITH CONTROLLED PARAMETERS

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Abstract—Welding is a widely used process, in the fabrication industries. Different welding processes are used in the manufacturing of automobile bodies, construction industry, aviation industry, refineries, pipeline fabrication and general machine repair work. With considering importance of welding and its application, this present study helps to understand the effects of various controlling parameters on welding metallurgy. Since most of the welding methods are performed under high temperature conditions, sensitization of the material in its Heat Affected Zone, changes of microstructure in weld zone and different welding defects. HAZ is the most complicated region for any welding process and hence, it becomes very essential to control its effects up to some extent. In this present work, an attempt to evaluate and study heat affected zones for a Carbon Steel specimen by SMAW process and to improve the metallurgical properties by controlling parameters such as welding current, arc voltage and welding speed.

Keywords—SMAW, HAZ - Heat Affected Zone, Welding Current, Arc Voltage, Welding Speed, Microstructure.

I. INTRODUCTION

In manufacturing world, welding is considered as a core process. 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 pressure, filler material and flux. Welding methods are classified into Electric Arc, Gas, Resistance, Thermo-Chemical Reaction Welding (Thermite welding), and Radiant Energy Welding.

HAZ is the most crucial region in the welding process as it affects the microstructure and grain size of weld bead. Major factors for improving weld-bead quality are:

- Welding process
- Material selection
- Welding parameters

Welding thermal cycle has negative influence on the mechanical properties of Heat Affected Zones. In terms of material and energy consumption, every welding process is different from each other and thus has different environmental impact. Hence, it is important to analyze the effects caused while performing Shielded Metal Arc Welding process.

1.1. Shielded Metal Arc Welding

In SMAW, various process parameters collude in an intricate system and their correlations influence the bead geometry, bead quality, metallurgical characteristics, mechanical properties and most importantly the Heat Affected Zones of the material.

Shielded Metal Arc Welding (SMAW) phase change performs important functions on weld pool geometry and determines weld quality. Welding torch, which is move or not, has an important effect on the phase change of weld pool and the elements distributions, which affects the weld quality [5].

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The SMAW process is intermittent, because welding has to be interrupted from time to time to discard the unused stub and to place a fresh electrode into the holder and also, to de-slag the joint, i.e. to remove the layer of slag covering the weld. For higher productivity, semi-automatic or fully automatic welding processes are preferred.

1.2. Review on Material Selection

Low carbon steel is widely used for structural work, since 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 [10]. In addition, it exhibits better weldability phenomenon as compared to other categories of Carbon Steel.

II. WELDING PARAMETERS

In order to study heat-affected zone for SMAW for a Carbon Steel specimen following parameters are considered

- Welding current
- Welding speed
- Arc voltage

2.1. Welding Current

The welding variable that has the greatest effect on the degree of weld penetration is current (measured in amperage or amps). Quite simply, as welding current increases, weld penetration increases and as welding current decreases, weld penetration decreases. Figure illustrates this point with three welds made at different current levels and where all other variables constant.

2.2. Welding Speed

Fast the electrode travels down the joint affects how much time the arc energy has to transfer into the base plate at any particular point along the joint. As travel speed increases, the amount of time that the arc is over a particular point along the joint is less and the resulting level of penetration decreases. As travel speed decreases, the amount of time that the arc is over a particular point along the joint is greater and the resulting level of penetration increases as shown in figure.
2.3. Arc Voltage

Arc voltage affects the arc length. At the same wire feed speed, as voltage increases, the arc length gets longer and as voltage decreases, the arc length gets shorter. The length of the arc in turn determines the width and size of the arc cone. As arc length decreases, the arc cone becomes narrower and the arc is more focused. The result is a weld bead that is more narrow and ropy and the level of weld penetration may decrease very slightly. Conversely, as arc length increases, the arc cone becomes wider and the arc is broader. The result is a weld bead that is wider and flatter and the level of weld penetration may increase very slightly.

From above study, we have concluded that by varying welding current, penetration in weld bead is affected, by varying welding speed the penetration rate at particular position change with respect to intermediate phase and by varying arc voltage width of weld pool is affected.
III. RESULT AND CONCLUSION

The following table provides data obtained by using E-6013 electrode with a diameter of 3.15mm and carbon steel plate specimen of 6mm thickness.

| Sr. No. | Welding Voltage(V) | Welding Current (A) | Arc Time (sec) | Welding Speed (mm/min) | Heat Input (J/mm) |
|---------|--------------------|---------------------|----------------|------------------------|------------------|
| 1       | 30                 | 100                 | 27.15          | 256.2                  | 702.57           |
| 2       | 30                 | 100                 | 36.9           | 183.25                 | 982.4            |
| 3       | 30                 | 150                 | 36.2           | 207.18                 | 1303.52          |
| 4       | 30                 | 150                 | 41.2           | 172.03                 | 1569.47          |
| 5       | 30                 | 150                 | 47.8           | 141.92                 | 1904.30          |

Microstructure of Parent metal:

It shows the unaffected base metal structure away from the weld. The microstructure is a two-phase ferrite pearlite structure. Polygonal and equi-axed white grains of ferrite occupy 90% of volume while the rest dark phase is unresolved pearlite.

The following images shows the comparison of experimental specimen to the standard specimen.
Microstructure of HAZ & Parent metal boundary:

This part reveals coarse grain structure on one side and as cast structure on other side with transition effect.

**Figure 9a. Experimental specimen**  
**Figure 9b. Standard specimen**

Microstructure of HAZ:

As shown in standards, it is observed that the formation of fine martensitic structure is found, which is considered to be very hard and the experimental image shows, lesser formation of the same. Hence, the controlled parameters reduce the brittleness of the weld joint.

**Figure 10a. Experimental specimen**  
**Figure 10b. Standard specimen**

REFERENCES

[1] T. Vuherer, M. Dunder, L.J. Milovic, M. Zrilic, I. Samardzic “Microstructural investigation of the Heat Affected Zone of Simulated welded joint of P91 steel”, Conference: 8. INTERNATIONAL SCIENTIFIC-PROFESSIONAL CONFERENCE SBZ 2015 October 2015

[2] Alireza Sadeghi, Ahmad Moloodi, Masoud Golestanipour, Meysam Mahdavi Shahri “An investigation of abrasive wear and corrosion behavior of surface repair of gray cast iron by SMAW”, Journal of Materials Research and Technology Volume 6, Issue 1, January–March 2017, Pages 90-95.

[3] K.S. Sangwan, Christoph Hermann, Patricia Egede, Vikrant Bhakar, Jakob Singer “Life Cycle Assessment of Arc Welding and Gas Welding Processes”, Procedia CIRP Volume 48, 2016, Pages 62-67

[4] Ravindra Kumar, V.K. Tewari, Satya Prakash “Oxidation behavior of base metal, weld metal and HAZ regions of SMAW weldment in ASTM SA210 GrA1 steel”, Procedia Engineering Volume 75, 2014, Pages 103-107

[5] L.G. Tong, J.C. Gu, S.W. Yin, L. Wang, S.W. Bai “Impacts of torch moving on phase change and fluid flow in weld pool of SMAW”, International journal of Heat and Mass Transfer, Volume 100-Sep 1, 2016

[6] Vijayesh Rathi, Hunny “Analyzing the Effect of Parameters on SMAW Process”, International Journal of Emerging Research in Management &Technology ISSN: 2278-9359 (Volume-4, Issue-6)

[7] Andrés R. Galvis E, W. Hormaza “Characterization of failure modes for different welding processes of AISI/SAE 304 stainless steels” Engineering Failure Analysis, Volume 18, Issue 7, October 2011, Pages 1791- 1799

[8] B-W. Cha, S-J. Na “A study on the relationship between welding conditions and residual stress of resistance spot welded 304-type stainless steels” Journal of Manufacturing Systems, Volume 22, Issue 3, 2003, Pages 181- 189
[9] G Magudeeswaran’, V Balasubramaniarr’, G Madhusudhan ReddyZ’, T S Balasubramaniarr’ “Effect of Welding Processes and Consumables on Tensile and Impact Properties of High Strength Quenched and Tempered Steel Joints” Journal of Iron and Steel Research, International, August 19, 2007, Pages 87-94

[10] Jijin Xu, Ligong Chen, Chunzhen Ni “ Effect of vibratory weld conditioning on the residual stresses and distortion in multipass girth-butt welded pipe” International Journal of Pressure Vessels and Piping, Volume 84, Issue 5, May 2007, Pages 298-303

Jun Yan, Ming Gao, Xiaoyan Zeng “Study on microstructure and mechanical properties of 304 stainless steel joints by TIG, laser and laser-TIG hybrid welding” Optics and Lasers in Engineering, Volume 48, Issue 4, April 2010, Pages 512-517

[11] Subodh Kumar, A.S. Shahi “Effect of heat input on the microstructure and mechanical properties of gas tungsten arc welded AISI 304 stainless steel joints” Materials & Design, Volume 32, Accepted 7 February 2011, Pages 3617-3623

[12] Ajay N. Boob, Prof. G. K. Gattani “Study on Effect of Manual Metal Arc Welding Process Parameters on Width of Heat Affected Zone (Haz) For Ms 1005 Steel”, International Journal of Modern Engineering Research (IJMER) Vol. 3, Issue. 3, May.-June. 2013 pp-1493-1500