A review paper on effect of welding process parameters on material and properties of weld in submerged arc welding process

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Abstract: Submerged arc welding (SAW) is used commonly because of its specific characteristics like high deposition rate, high quality welds, ease of automation and low operator skill requirement. For achieving high productivity, best weld quality and good mechanical properties, the welding process parameters need to be optimized. During welding, a lot of heat is generated which is responsible for changes in mechanical properties and distortion. Parent material and heat affected zone (HAZ) experiences a rise in temperature due to conduction and also effected by convention and radiation. Due to uneven heating and cooling complex stresses and strains are produced which further produce distortion and residual stresses. In this review paper it was tried to consider different research papers containing the research and analysis made on input output parameters of submerged arc welding process. This paper also focused on analysis of some research papers containing heat input rate, cooling rate of weld, micro structure of weld and heat affected zone and their effect on the performance of the joint

Keywords: Process Parameters, Cooling rate, Submerged Arc Welding, Current, Microstructure, HAZ

Introduction:

Welding is a cost-effective and flexible method of fabricating large structures, but drawbacks such as residual stress, distortion and buckling must be overcome in order to optimize structural performance. Many metallic structures in industry are assembled through some kind of welding process which is composed of heating, melting and solidification using a heat source such as arc, laser, torch or electron beam. The highly localized transient heat and strongly non-linear temperature fields in both heating and cooling processes which cause non uniform thermal expansion and contraction, and thus result in plastic deformation in the weld and surrounding areas. As a result, residual stress, strain and distortion are permanently produced in the welded structures. High tensile residual stresses are known to promote fracture and fatigue, while compressive residual stresses may induce undesired, and often unpredictable, global or local buckling during or after the welding. It is particularly evident with large and thin panels, as used in the construction of automobile bodies and ships. These adversely affect the fabrication, assembly, and service life of the structures. Therefore, prediction and control of residual stresses and distortion from the welding process are extremely important in the ship building and automotive industry. The heat supplied during arc welding is responsible for the changes in the micro structures, and development of residual stresses and distortions.

Welding process parameters like electrode diameter, electrode travel speed, thickness of the work piece material, current and voltage greatly affect the temperature distribution patterns and hence residual stresses and distortions. A large number of models have been reported in the published literature to predict temperature distributions, residual stresses and distortions in the welded joints. The important process parameters which are required to be considered in any welding are: moving heat source, arc travel speed, heat input and temperature dependent material properties. Heat flow in welding. In all welding processes, heat is required to accomplish the joint. Depending upon heating and cooling, different micro-structure are obtained in weld bead and heat affected zone (HAZ). It produces different mechanical properties. To obtain welding of desire specifications it is essential to know the heat flow in welding. This is achieved by temperature distribution during welding so as to determine the cooling rates in different directions with respect to weld axis. Temperature distribution depends upon many factors: nature of welding process used, type of heat source employed, energy input per unit time, configuration of joint (linear or circular), type of joint (butt, fillet etc), physical property of metal being welded nature of surrounding medium (ordinary conditions or under water[1]. Welding process is a complicated transient process occurring in a structure. In welding transient heat flows from the heat source to the work piece and gets dissipated to the atmosphere due to convention and radiation. In work piece itself, heat flows because of conduction. Heat loss also occurs due to convention and radiation. The heat which flows into the work piece is responsible for the changes in mechanical properties and its micro-structure. It becomes very important to know about the heat flow in the work piece

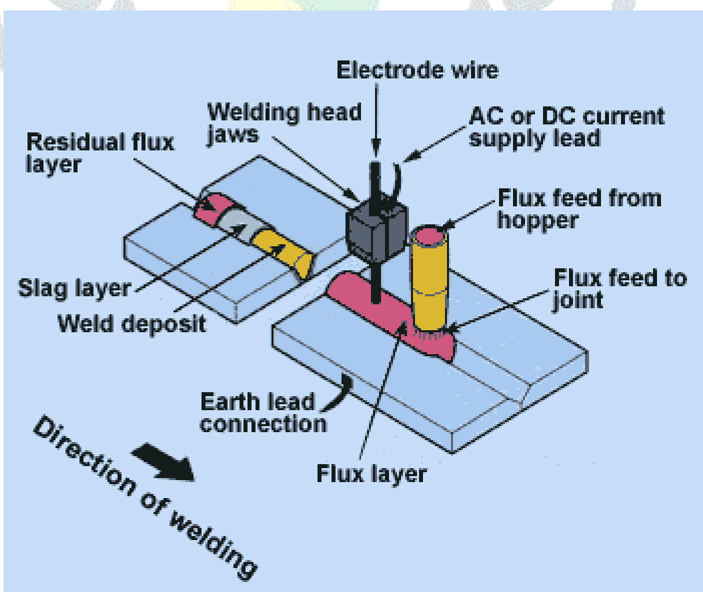

Fig1: Submerged Arc welding[1]

Distortion

Residual stresses and distortions are unavoidable in welding, and their effects on welded structures cannot be disregarded. Determining residual stresses and distortions is thus an important problem. However, accurate prediction of residual stresses and distortions induced by the welding process is extremely difficult because the thermal and mechanical behavior in welding include local high temperature, temperature dependence of material properties, and a moving heat source. Finite element simulation of the welding process is highly effective in predicting thermo-mechanical behavior.

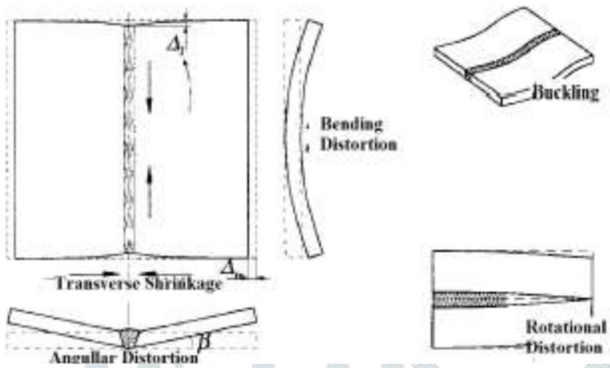

Fig 2 : Different types of distortion[1]

Basic Equipment

Essential equipment for SAW are:[2]

(a) Power source

(b) SAW head (welding gun)

(c) Flux handling

(d) Protective equipment

Application of SAW

Cover pressure vessel, line pipe, storage tank, heavy structural ships, railway wagon and coaches are some of the application of SAW.

Welding parameters

Different types of welding parameter are:

1) Electrode polarity

2)Welding current

3)Electrode diameter

4)Arc voltage

Distortion in welds Any unwanted physical change or departure from specification in fabricated structure or component as a consequence of welding is called welding distortion. After lot of experiment it has been found out that distortion not only complicates the fabrication but also affects the purpose for which it designed.

Also the cost of rectifying welding distortion by straightening distorted component may be more than actual welding. Distortion is always caused by non uniform expansion and contraction with respect to the base material during cooling and heating cycle of welding process. Before welding areas of plate are cold and during welding metal melts and tries to expand and after solidification it tries to contract which in result produces stresses and distortion. Thermal expansion and contraction is responsible for the welding distortion, if one restraint the body movement by restricting its degree of freedom then internal stresses will develop and it increases beyond the yield point of the material then plastic deformation occurs. Thus both material properties and welding procedure affect the distortion.[3,4,5]

Wen et al (2001) investigated the affect of process parameter on weldment geometry. ABAQUS software is used for predicting the distortion and analysis was done on line pipe. Distortion predicted with FEA matches with experimental values and FEA was used for selecting optimal parameter.[6]

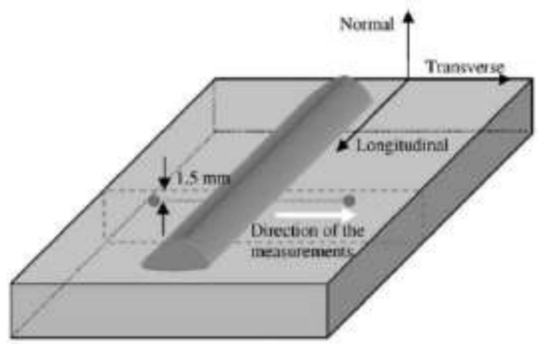

Fig3 : Direction of distortion measurement [3]

In another study by Chen et al thermal and thermo-mechanical analysis was performed on aluminium alloy by using FEA and friction stir welding. Stresses in longitudinal and lateral direction were simulated by using FEA and X-ray technique is used for measuring residual stresses and has been observed that simulation result using FEA and experimental value matches very closely.[7]

Muhammad and Qarni (2009) investigated the HAZ of low carbon steel pipejoints, ABAQUS software were used for three dimensional modeling and FEA analysis of HAZ around the circumferential joint. Value predicted with FEA by using finer mesh around the joint closely matches with experimental value[8]. The effect of thermal conductivity was investigated on residual stresses by FEA analysis, two dimensional model was generated using FEA and it has been observed that large tensile stresses are present near the weld line and temperature distribution is affected by thermal conductivity, and also observed that as thermal conductivity is increased residual stresses are highly affected and reduced to great extent [9]

References

[1]. Parmar, R. (2010). \Welding engineering and technology". Khanna Publishers.

[2] Miller (1993). Submerged Arc Welding guide".

[3] Goldak, J. (2009). Distortion and residual stress in welds: The next generation". Trends in Welding Research: Proceedings of the 7Th International Conference, page 45.

[4] Mahapatra, M., Datta, G., Pradhan, B., and Mandal, N. (2006). Three-dimensional finite element analysis to predict the e_ects of SAW process parameters on temperature distribution and angular distortions in single-pass butt joints with top and bottom reinforcements". International Journal of Pressure Vessels and Piping,83(10):721 { 729.

[5]Simion, C., Manu, C., Baset, S., and Millard, J. (2006). Distortions Generated by Welding Process Using ANSYS-FEA". Atomic Energy of Canada Limited.

[6]Wen, S., Hilton, P., and Farrugia, D. (2001). \Finite element modelling of a submerged arc welding process". Journal of Materials Processing Technology, 119(1-3):203-209.

[7] Chen, C. and Kovacevic, R. (2003). \Finite element modeling of friction stir weldingthermal and thermo-mechanical analysis". International Journal of Machine Tools and Manufacture, 43(13):1319-1326.

[8]Abid, M. and Qarni, M. J. (2009). \3D thermal finite element analysis of single pass girth welded low carbon steel pipe-flange joints". Turkish J Eng Env Sci, 33:1-13.

[9] Armentani, E., Esposito, R., and Sepe, R. (2007). \The effect of thermal properties and weld efficiency on residual stresses in welding". Journal of Achievements in Materials and Manufacturing Engineering, 20:319{322.