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A Review Paper On Effect Of Varying Welding Heat Inputs On Microstructure, Mechanical Properties And Corrosion Behaviors Of Ferritic Stainless Steel & Mild Steel

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ABSTRACT: *This paper focuses on analysis of varying welding heat inputs on material properties by different authors. The influence of welding process parameters such as welding current, travel speed and voltage on material properties has been identified .ferritic Stainless Steel is a new grade of steel produced by Steel Authority Of India Limited.The use of FSS has been increased noticeably in building up of railway wagons, which were priorly built by Mild Steels. Ferritic Stainless Steel's amazing strength-to-weight ratio makes wagons lighter by 40 per cent yet, keeps them strong enough to take on 12 per cent more payload. As a result, trains travel faster, consume less fuel and increase efficiencies. This review tries to conclude the effects of variation in heat input on mechanical properties as well as microstructural properties of the welds.*

Keywords: *Bead on plate, FSS, heat inputs, SMAW*

I. INTRODUCTION

Welding, the fusing of the surfaces of two workpieces to form one, is a precise, reliable, cost-effective, and "high-tech" method for joining materials. No other technique is as widely used by manufacturers to join metals and alloys efficiently and to add value to their products. Most of the familiar objects in modern society, from buildings and bridges, to vehicles, computers, and medical devices, could not be produced without the use of welding. Welding goes well beyond the bounds of its simple description. Welding today is applied to a wide variety of materials and products, using such advanced technologies as lasers and plasma arcs. The future of welding holds even greater promise as methods are devised for joining dissimilar and non-metallic materials, and for creating products of innovative shapes and designs.

1.1Heat inputs:

Fundamental to the study of welding is the study of heat-flow. In welding, the application of a heat source is called energy input. It is defined as the quantity of energy introduced per unit length of weld from a traveling heat source. The energy input (heat input) is expressed in joules per meter or millimeter. This important measure is calculated as the ratio of total input power in Watts to its velocity:

$$H = fEI/V$$

Where:
f= heat transfer efficiency
E=volts
I=amperes
V =Travel velocity of heat source (mm/sec)

1.2Shielded Metal Arc Welding:

Shielded metal arc welding (SMAW) is a manual arc welding process that uses a consumable electrode coated in flux to lay the weld. An electric current, in the form of either alternating current or direct current from a welding power supply, is used to form an electric arc between the electrode and the metals to be joined. As the weld is laid, the flux coating of the electrode disintegrates, giving off vapors that serve as a shielding gas and providing a layer of slag, both of which protect the weld area from atmospheric contamination. Because of the versatility of the process and the simplicity of its equipment and operation, shielded metal arc welding is one of the world's most popular welding processes. It dominates other welding processes in the maintenance and repair industry.

1.3Bead on plate welding:

A bead weld or weld bead is the result of a welding pass that deposits filler material. Welding is a process that combines multiple pieces of metal by heating and softening them. With bead welding, a filler material is inserted in the space between the two materials. When the metal filler material cools, a strong bond is formed between the two surfaces.

1.4Ferritic Stainless Steel:

Ferritic stainless steel (FSS) with 12 wt% Cr developed to feel the gap between stainless steels and the rust prone carbon steels has been attracted as low cost utility stainless steels. They are now commonly used in the coal mining industry for bulk transport of coal and gold, for cane and beet sugar processing equipment, road and rail transport, power generation, petrochemical, pulp and paper industries etc. In fact, the use of these steels in the past few years has been increased markedly with their successful applications in passenger vehicles, coaches, buses, trucks, freight and passenger wagons.

1.5Mild Steel:

Mild steel is the least expensive of all steel and the most common steel used. Used in nearly every type of product created from steel, it is weldable, very hard and, although it easily rusts, very durable. Containing a maximum of 0.29% carbon, this type of steel is able to be magnetized and used in almost any project that requires a vast amount of metal. Its structural strength prevents it from being used to create load-bearing girders and structural beams.

II. LITERATURE REVIEW

M V Venkatesan, N Murugan, B M Prasad, A Manickavasagam [1] discussed the influence of flux cored arc welding (FCAW) process parameters such as welding current, travel speed, voltage and C02 shielding gas flow rate on bowing distortion of 409M ferritic stainless steel sheets of 2 mm in thickness. The bowing distortions of the welded plates were measured using a simple device called profile tracer. An experimental regression equation was developed to predict the bowing distortion and with this equation, it is easy to select optimized process parameters to achieve minimum bowing distortion. It is revealed that the FCAW process parameters have significant influence on bead profile and the bowing distortion.

E. Taban, E. Deleu, A. Dhooge, E. Kaluc [2] presented microstructural and toughness properties and mechanical properties of gas metal arc welded 6 mm thick modified X2CrNi12 stainless steel with two different heat inputs. According to results, grain size has dominant effect on impact toughness. Grain coarsening has no adverse influence either on tensile properties or on bend properties but the heat affected zone impact toughness for sub-zero temperatures generally decreases and this depends on the amount of grain coarsened microstructures and eventual precipitates present.

P. Kanjilal, T.K. Pal, S.K. Majumdar [3] developed a rotatable designs based on statistical experiments for mixtures to predict the combined effect of flux mixture and welding parameters on submerged arc weld metal chemical composition and mechanical properties. Bead-on-plate weld deposits on low carbon steelplates were made at different flux composition and welding parameter combinations. The results show that flux mixture related variables based onindividual flux ingredients and welding parameters have individual as well as interaction effects on responses, viz. weld metal chemical composition and mechanical properties.

P.K. Palani, N. Murugan [4] investigated the effect of cladding parameters such as welding current, welding speed,
and nozzle-to-plate distance on the weld bead geometry. The experiments were conducted for 317L flux cored stainless steel wire of size 1.2 mm diameter with IS:2062 structural steel as a base plate. Sensitivity analysis was performed to identify the process parameters exerting the most influence on the bead geometry and to know the parameters that must be most carefully controlled. Studies reveal that a change in process parameters affects the bead width, dilution, area of penetration, and coefficient of internal shape more strongly than it affects the penetration, reinforcement, and coefficient of external shape.

V.M. S´anchez-Cabrera, C. Rubio-Gonz´alez [5] performed welding with two alternative ways, preheating the welded parts and using similar filler material or using an austenitic stainless steel filler metal without preheating. This research work consists in identifying and comparing, for these two alternatives, the effect on microstructure, fracture toughness and fatigue crack growth rate of the welded joint. On the first alternative, using a GMAWwelding process and similar filler metal, the variable is preheating temperature, with the purpose of minimizing internal residual stresses and the level of diffusible hydrogen. On the second alternative, also using a GMAW welding process and austenitic stainless steel filler metal (greater hydrogen solubility), the variable is hydrogen concentration in the argon shielding gas with the purpose of diffusing hydrogen to the heat affected zone. The results indicate how the thermal cycle, different hydrogen levels and hydrogen trapping sites affect the mechanical properties.

A K Lakshminarayanan , V Balasubramanian [6] investigated The microstructure analysis and mechanical properties evaluation of laser beam welded AISI 409M ferritic stainless steel joints. Single pass autogeneous welds free of volumetric defects were produced at a welding speed of 3000 mm/min. The joints were subjected to optical microscope, scanning electron fractography , microhardness , transverse and longitudinal tensile, bend and charpy impact toughness testing. The coarse ferrite grains in the base metal were changed into dendritic grains as a result of rapid solidification of laser beam welds. Tensile testing indicates overmatching of the weld metal is relative to the base metal. The joints also exhibited acceptable impact toughness and bend strength properties.

M. Mukherjee and T.K. Pal [7] described The effect of heat input on martensite formation and impact properties of gas metal arc welded modified ferritic stainless steel (409M) sheets (as received) with thickness of 4 mm. The welded joints were prepared under three heat input conditions, i:e: 0.4, 0.5 and 0.6 kJ/mm using two different austenitic filler wires (308L and 316L) and shielding gas composition of Ar + 5% CO2. The welded joints were evaluated by microstructure and charpy impact toughness. The dependence of weld metal microstructure on heat input and filler wires were determined by dilution calculation, Cr/Ni ratio, stacking fault energy (SFE), optical microscopy (OM) and transmission electron microscopy (TEM). It was observed that the microstructure as well as impact property of weld metal was significantly affected by the heat input and filler wire. Weld metals prepared by high heat input exhibited higher amount of martensite laths and toughness compared with those prepared by medium and low heat inputs, which was true for both the filler wires. Furthermore, 308L weld metals in general provided higher amount of martensite laths and toughness than 316L weld metals.

Jerzy Nowacki, Paweł Rybicki [8] determined The influence of the heat input submerged arc welding (SAW) of duplex steel UNS S31803 on kind and quantity of welded butt joints defects. Analysis of welding heat input influence on mechanical properties of test joints using heat input from 2.5 to 4.0 kJ/mm. For analysis of welding heat input influence on creation of welding imperfections, there were executed welding of sheet of thickness 10–32mm using two ranges of the welding heat input: up to 2.5 and up to 3 kJ/mm. It was shown that submerged arc welding of duplex steel with the heat input from 2.5 up to 4.0 kJ/mm has no negative influence on mechanical properties of the joints. Experiment showed, that welding with heat input up to 3.0 kJ/mm reduces welding defects of joints, e.g. slags, lack of a joint penetration for plates of thickness of 10–23 mm, as well as sticks, cracks, and the thoroughly decrease of other defects existence. Usage of larger welding heat input provides the best joints quality.

M Yousefieh, M Shamanian, A Saatchi [9] studied the effect of heat input variations on the microstructure and corrosion resistance of a DSS UNS S32760 in artificial sea water media. The corrosion resistance in 3. 5% of NaCl solution was evaluated by potentiostatic polarization tests at room temperature. It is found that the presence of sigma phase and Cr_2 N decreases the corrosion potential. The specimen with heat input of approximately 0.95 kJ/mm have the best corrosion characteristics, which is the result for the lack of deleterious phases such as sigma and Cr_2N and balanced ferrite-austenite proportion.

Huaibei Zheng, Xiaoning, Laizhu Jiang, Baosen Wang, Zhenyu Liu, Guodong Wang [10] investigated the corresponding microstructures in HTHAZ with different chemical compositions and heat inputs through thermal simulation tests. There are several primary conclusions: (1) When ferrite factor (FF) is above 9.0, the microstructure in HTHAZ is fully ferrite or a small amount of martensite net likely distributing along delta ferrite grain boundaries. On the other hand, if FF is below 9.0, the martensite content increases with the decreasing of FF. (2) Heat input influences the microstructure of high FF steel in HTHAZ. The martensite content and its distribution of low FF steel are not sensitive to heat inputs, but the grain size grows up with the increase of heat inputs. (3) The coarse Ti-rich particles in low FF steels containing Ti can promote intragranular austenite formation inside delta ferrite resulting in packet morphology of martensite.

M.O.H. Amuda [11] investigated the effects by producing the welds on a 1.5mm thick plate of 16 wt% Cr FSS conforming to AISI 430 commercial grade,using TIG torch in argon environment at a heat flux between 1008W to 1584W and speed between 2.5mm/s and 3.5mm/s. The width of the sensitization zone increases with increasing the heat input. The depth of the sensitization zone in the thickness direction is insignificant and it is generally within one half of a millimetre. The use of heat input greater than 432J/mm increases the development of sensitized regions. This level of heat input corresponds to heat fluxes in the range 1008-1296W and welding speed between 3mm/s and 3.5mm/s. Under this condition the average cooling time is about 10s. Most grain attack is restricted to the ferrite-ferrite grain boundaries. The ferrite martensite boundaries do not show visible attack. This indicates that welding condition that promotes the formation of martensite in the HAZ is ideal for the presentation of sensitization.

J. Pekkarinen [12] focused to determine empirically, which microstructural changes occur in ferritic and duplex stainless steel when heat input is controlled by welding parameters. They concluded that microstructure of ferritic stainless steel grade 1.4003 is fully martensitic in all welding parameters combination used. Hardness of martensite structure is dependent on heat input, increasing heat input decreasing the hardness. In duplex stainless steels microstructure is very much dependent on cooling rate. Ferrite content is decreasing with increasing heat input and the microstructure is however dependant also on composition and therefore the suitable welding parameters must be adjusted for each steel grade separately.

Bipin Kumar Srivastav, S.P. Tewari [13] studied the effect of arc welding parameters on quality of welds and concluded that several process control parameters in SAW influence bead geometry, microstructure as well as weld chemistry .Their combined effect is reflected on the mechanical properties of the weld in terms of the weld quality as well as joint performance . The selection of the suitable process parameters are the primary means by which acceptable heat affected zone properties ,optimized bead geometry and minimum residual stresses are created. The mechanical properties of the weld are influenced by the composition of the base metal and to a large extent by the weld bead geometry and shape relationship as well. It observed that with increase in electrode stick out, hardness of the weldment increases, yield strength and impact value decreases, ultimate tensile strength of the joint initially decreases but thereafter increases provided welding current and voltage arc kept at a constant level. The function of the flux ingredients such as Cao, MgO, CaF2 and Al_2O_3 in submerged arc welding studied and concluded that among the flux ingredients, MgO appears to be important on its own in influencing the mechanical properties.

Eslam Ranjbamode [14] studied the microstructural characteristics of tungsten inert gas (TIG) welded AISI 409 ferritic stainless steel and effect of the welding parameters on grain size local mis-orientation and low angle grain boundaries was investigated. It concluded that the welding plastic strain is an increasing factor for local misorientation and low angle grain boundaries. It shows that the final state of strain is the result of the competition between welding plastic strains and stress relieving from recrystallization.

M.O.H Amuda and S. Mridha [15] reports the microstructural features of FSS welds produced under different heat input rates along with the governing parameters of welding like travel speed, welding current and material properties and investigated that irrespective of the welding condition, the primary solidification structure changed from a predominentely ferritic structure to a matrix interspersed with increasing fraction of inter dendritic martensite in the weld metal grain boundary martensite in the heat affected zone. This implies that below the critical welding current value, the mechanical properties of ferritic steel weld might be influenced by both welding current and speed.

III. CONCLUSION

1. Excessive welding speed can exacerbate sensitization during low heat input welding.
2. Welding conditions that promotes the formation of martensite in the HAZ can be ideal for the prevention of sensitization.
3. Variation in heat input resulted in significant changes in the mechanical properties of the weld.

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