Volume: 2 **Issue:** XI **Month of publication:** November 2014

DOI:

ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

A Review on Performance Improvement in the Weldment Regions of Chromium Manganese Stainless Steels (AISI 202 SS)

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Abstract: AISI 304 stainless steel is widely used in forming applications because of its superior formability. The high nickel price in recent years prompted an investigation into the feasibility of replacing AISI 304 with AISI 202 in applications requiring comparable mechanical properties. AISI 202 stainless steel is similar to 304 but susceptible to stress corrosion cracking / intergranular corrosion and reduction in pitting corrosion resistance especially after welding. So the properties such as stress corrosion cracking, pitting corrosion must be improved in the weldment areas. Flux coating in the weldment areas can improve the above mentioned properties to a greater extent.
Keywords: GTA Welding, AISI 202 SS, Corrosion resistance, Flux coating

I. INTRODUCTION

Stainless steels are an important class of engineering materials that have been used widely in a variety of industries and environments due to their high corrosion and oxidation resistance. Nickel (Ni) prices have been relatively high worldwide over the last couple of years. This has led to a situation in which, the cost of Ni plays a significant role in the total cost of stainless steel (SS) production. As a result, there has been increased interest in low-nickel or no-nickel grades of stainless steel having properties similar to AISI-304 Stainless steel. The AISI-200 series SS is a well-known example of low-Ni stainless steel alloyed with manganese (Mn) and the other alloying elements like nitrogen (N) and copper (Cu). In order to stabilize austenite phase, manganese acts as a substitute of nickel. These low-nickel stainless steels are economical than 300- series and are popularly known as chrome-manganese stainless steel. Its current contribution in total stainless steel production is more than 10%. Low nickel Cr–Mn SSs are used in various applications like home accessories, home appliances, light poles, construction, outdoor installation *etc.* where high corrosion resistance is not required. In some applications welding of the materials is important. Welding is one of the most widely used processes to fabricate stainless steel structures. The welding processes have been used in different applications such as pipelines, automotive exhaust gas systems, chemical industrial equipment repairs. However, welding often has potent effects on the microstructure and hence is expected to have strong influence on the mechanical and corrosion properties of the welded samples. Some of the problems associated with welding in the austenitic stainless steels are sensitization of the weld heat affected zone, hot cracking of weld metal and decrease in corrosion resistance.

A. Gas Tungsten Arc Welding (GTAW)

The welding of automotive exhaust gas systems, stainless steel pipes, repairing of chemical industries equipments, etc. are done with the help of Gas Tungsten Arc Welding (GTAW or commonly known as TIG). It uses a non-consumable tungsten electrode and an inert gas for arc shielding. Generally Argon is used as a shielding gas in the process and an electric arc is formed between the base metal and tungsten electrode. In order to obtain a good weld pool geometry it is important to select weld pool process parameters. The most important welding parameters are welding current, gas flow rate and welding speed which must be maintained in a particular range in order to achieve acceptable weld bead.

Filler metals for welding stainless steels are produced as coated electrodes, solid and metal core wire and flux core wire The filler material for austenitic stainless steels should match or exceed the alloy content of the base metal. If a filler material of the correct match is not available, filler with higher alloy content normally should be used. If maximum strength properties and corrosion resistance are required for the application, a filler metal of matching or similar composition to the base metal should be used.

II. LITERATURE REVIEW

A. Effect of Gta Welding On Stainless Steels

G.R. Mirshekari et al., Microstructure and corrosion behavior of multipass gas tungsten arc welded 304L stainless steel The microstructure, hardness and corrosion resistance evolutions of the weldments were investigated during single pass and multipass (double and triple pass) GTAW process of 304L SS. The important results can be summarized as follows: All welds were essentially austenitic with the presence of a small amount of d-ferrite. The microstructure of the welds was dendritic. In addition, the content of d-ferrite in the weld zone was maximum for the triple pass welded specimen and decreased in double pass and single pass welded specimens respectively. The hardness values from the weld zone towards the base metal increased in all weldments while the maximum values obtained for three passes welded specimen due to the increase in the d-ferrite content and grain refinement. Potentiodynamic polarization curves and immersion tests revealed that as the number of passes increased, the corrosion resistance also increased. Additionally, three passes welded specimen possessed the highest corrosion resistance compared with the other welded specimens.

Sahil Bharwal et al., [2014] investigated the weldability issue of AISI 202 SS (Stainless Steel) Grade with GTAW Process Compared to AISI 304 SS Grade. They used gas tungsten arc welding (GTAW) process to weld AISI 202 SS grade. GTAW process benefits the welded joint with maximum strength and better deposition rate. The results obtained after welding of AISI 202 are comparable to AISI 304 type satisfying the requirement of prescribed properties of welded joints. Hence 202 type SS can be used instead of 304 type SS for some applications.

Wichan Chuaiphana et al., [2011] studied the effect of welding speed on the microstructure, mechanical and corrosion behavior of weldment AISI 201 stainless steel sheet produced by a gas tungsten arc welding. The following conclusions can be drawn.(1) The welding speed increases, the width of face and root weld reduced because of the low heat input in the weld pool. Significant grain coarsening is found in the HAZs of all the joints is also observed that the extent of grain coarsening decreases with welding speed increase.(2) It is found that maximum tensile strength and ductility are possessed by the weld joints made using welding speed3.5 mm/s (high speed).(3) The welding speed increases, the pitting corrosion potential of weld metal also increases, due to small dendrite sizes and lessinter-dendritic spacing in the fusion zone.(4) The hardness of the weld metal is lower than that of base metal by all the joints and it is also observed that the hardness values of weld metals increase with welding speed increase. Based upon the present study it is recommended that welding speed 3.5 mm/s (high speed) should be preferred when welding AISI 201 stainless steel using GTAW process because of the reason that besides giving good mechanical properties (tensile strength and hardness), high corrosion resistance, the size of the weld bead and the extent of grain coarsening obtained in these weld joints are less.

Rui F. Martins et al., (2011) assessed the local replacement of the current material used in a gas turbine exhaust system, AISI 316L, by a new and cheaper (due to the lower Ni content) ultrahigh-strength austenitic stainless steel (Cr-Mn steel). The new material is slightly less pitting corrosion resistant and has higher ferritic content than the AISI 316L SS grade type. Nevertheless, static and cyclic yield strength values obtained at 24ºC, 350ºC or 500ºC for Cr-Mn austenitic stainless steel shown to be higher than the observed for AISI 316L, which is important to obtain high thermal shock resistance.

Himanshu Vashishtha et al., (2014) studied the welding behaviour of Low Nickel Chrome-Manganese Stainless Steel. Optical micrograph of solution annealed sample was cross checked by schaeffler diagram and it was concluded that steel consist of phases like austenite (in small amount), ferrite and martensite. Width of heat affected zone increases with increase in heat inputs. Accordingly considerable alterations in grain size (grain coarsening) were found and cause HAZ growth. Maximum tensile strength possessed by low heat input welded joint due to smaller dendrites and low spacing. Most of the fracture takes place in a ductile manner for low, medium and high heat inputs. Micro hardness varies from centre of the weld to the base metal in an increasing manner, some different trends were also found in hardness profile because of PMZ formation (hardness is very high at partially un-melted region).

From the above mentioned informations from various journals it is seen that the chromium manganese stainless steel (AISI 202 SS) acts as a replacement for 300 series stainless steels especially for the type AISI 304 SS where high corrosion resistance is not required, but in some applications the corrosion resistance for the material is important mainly in the weldment regions of the material. Chromium Manganese stainless steel (AISI 202 SS) have less pitting corrosion resistance and corrosion resistance which may affect its applications. So it is important to find a solution to improve the properties of the material in the weldment regions.

III. FLUX COATING

Surface engineering is a valuable tool for conserving both surface and bulk properties. Modification of surface properties by films or coatings is used in industrial applications. This is an area of interest to numerous fields. Surface engineering includes a diversity of technologies that alter the chemistry and properties of just a thin surface layer of the substrate by cladding processes which produce thick coatings, laser processing, thermal spraying, cold spraying, liquid deposition methods, anodizing, chemical and physical vapour deposition, and other such processes. From various experiments it is proved that the flux coating on any material increases some material properties such as hardness values, corrosion resistance,etc..

A. Literature Review On Effect Of Various Coatings On Stainless Steels

Tae Jun Park et al., [2011] studied the effect of Al–Si coating layer on the penetration and microstructures of ferritic stainless steel. Commercial 409L ferritic stainless steels and Al–8 wt% Si alloy-coated 409L ferritic stainless steels were subjected to gas tungsten arc welding and the effect of the coated layer on the penetration properties and microstructure were investigated. Full penetration was obtained with a welding current greater than 90A and a welding speed lower than 0.52 m/min. At the full penetration condition, the bead width of Al–8 wt% Si alloy coated 409L ferritic stainless steels was narrower than that of commercial 409L ferritic stainless steels. The average hardness values for bare 409L and coated 409L are similar. In all

ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

conditions, the hardness values for the case of coated 409L were higher compared to bare 409L, the hardness values of the welding zone was higher than that in the base metal, and especially the hardness in the welding zone of coated 409L exhibited higher values. However, the maximum hardness of Al–8 wt% Si alloy-coated 409L ferritic stainless steels was relatively high due to the formation of oxides such as Al2O3 and SiO2 that originated from the dissolved elements from the coating layer.

S. Frangini et al., [2011] developed a novel conversion coating process to meet the stability requirements of stainless steel hardware in the demanding MCFC fuel cell environments. The process applies a perovskite-based coating by exploiting spontaneous oxidizing reactions of the metallic surface with La2O3 in eutectic alkali carbonate mixtures. By using well controlled synthesis procedures, conversion coating layers covering the entire metallic surface with a uniform and compact structure could be obtained. The as-formed coatings with a surface morphology of agglomerated crystallite particles consisted of a thin (<5 lm) LaFeO3 perovskite layer grown over a thicker (>5 lm) LiFeO2-rich layer. Test coupons of 316L stainless steel with the perovskite conversion coating were analyzed for corrosion protection and interfacial resistivity properties. It was found that the conversion coating is highly conductive while showing excellent long-term corrosion stability in simulated MCFC environments. These results suggested that perovskite coatings formed by molten salt conversion reactions could be particularly attractive to confer optimal protection and electrical continuity to MCFC current collectors.

GAO Jun-guo et al., [2012] prepared Al2O3/Au nano-laminated composite coatings by means of magnetron sputtering. The coating was compact and comprised of nano-laminated Al2O3 and Au layers. High temperature cyclic oxidation test was employed to investigate the oxidation resistance of the composite coatings. The results revealed that the applied Al2O3/Au nano-laminated composite coatings improved the oxidation and spallation resistance of the stainless steel substrate significantly. The mechanism accounting for oxidation resistance was related with the suppression of inward oxygen diffusion and selective oxidation of Cr in the substrate. The mechanism accounting for spallation resistance was attributed to the relaxation of thermal stress by the nano-laminated structure.

M. Habibi et al., [2014] investigated on the structural properties and corrosion inhibition of W coatings on stainless steel AISI 304 using PF device. Tungsten thin films are deposited on SS-304 substrates using 35 shots of a low energy Mather type focus device on substrates positioned at different distances from the tip of the anode. The results of different analysis show formation of W films, with the one at 8 cm distance from the tip of the anode showing highest resistance to corrosion in a 1 M H2SO4 environment.

Jifu Zhang, et al., [2013] found that Erosion of sink rolls by molten zinc is one of the most prominent and persistent problems occurring in hot-dip galvanizing industry. MoB–CoCr as an alternative to WC–12Co for stainless steel protective coating resistance to molten zinc was deposited by high velocity oxygen fuel (HVOF). Microstructure and mechanical characterization of the coatings were carried out by SEM, XRD and micro-hardness test. Resistance to thermal shock and molten zinc corrosion of the coatings were also conducted. Results showed that MoB–CoCr coating exhibited a better resistance property to thermal shock than that of WC–12Co. At the same time, the corrosion test showed that lifetime of samples with MoB–CoCr coatings in molten zinc appeared to be longer than that of WC coating. The corrosion resistance of MoB–CoCr coating may be ascribed to non-wettability of MoB–CoCr in molten zinc, which can delay the molten zinc penetration into substrates along the micro-cracks of the coating.

Xiaoxu Ma et al., [2012] prepared a 7-layer (Al_2O_3–Y_2O_3)/Pt micro-laminated coating on 316L stainless steel alloy by magnetron sputtering. High-temperature cyclic oxidation and hot corrosion tests were adopted to investigate the high-temperature corrosion resistance of the coating. It is revealed that the (Al_2O_3–Y_2O_3)/Pt micro-laminated coating which effectively suppressed the inward diffusion of oxygen and corrosive fused salt to an extremely low level can significantly improve the high-temperature corrosion resistance of alloy substrate. The great mechanical properties of such coating were attributed to the brittle/ductile laminated composite structure by means of multilayer toughening and release mechanisms. A novel 7-layer (Al_2O_3–Y_2O_3)/Pt micro-laminated composite coating was prepared. The laminated coating exhibits excellent oxidation and spallation resistance. The micro-laminated coating provides excellent hot corrosion resistance at 900 °C. The brittle/ductile laminated structure enhances the coating's fracture toughness. The high-temperature corrosion rate of 316L stainless steel is extremely low.

K. Spencer, M.-X. Zhang [2011], studied Porosity in type 316 L stainless steel cold spray coatings from two different aspects. The first is to examine, for a given level of porosity, the effect of coating thickness on corrosion behaviour. Beyond a critical coating thickness the substrate is no longer attacked in polarisation tests, which has implications for coatings that contain some porosity (including some thermal spray coatings). The second aspect examined is to approximate the stainless steel particles as non-deforming, and apply the powder metallurgy practice of mixing particle size distributions to improve coating density. The results show that coatings sprayed using mixed particle size distributions can have similar properties to those sprayed using fine particles alone, but without the processing difficulties of fine particles such as inconsistent powder feeding or nozzle fouling.

IV. CONCLUSION

Thus from the above experiments it is seen that a layer of flux coating on the surface of stainless steels improves material properties such as hardness value, oxidation resistance, corrosion resistance etc.. Implementation of flux coating in the weldment regions of AISI 202 Stainless steels will show better results compared to that without coating and so that we can increase the use of 202 stainless steel for some more applications resulting in low cost.

ISSN: 2321-9653
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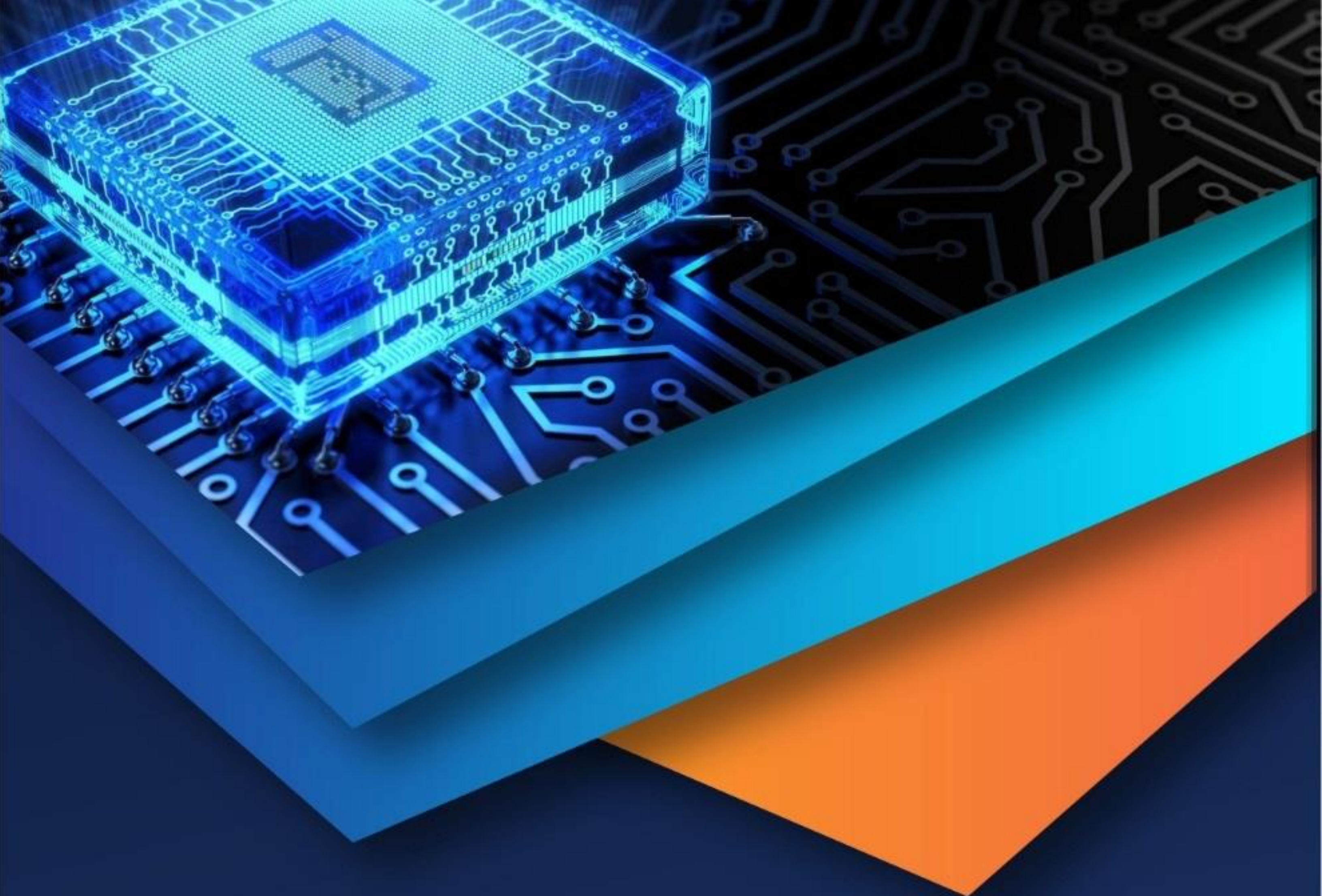

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