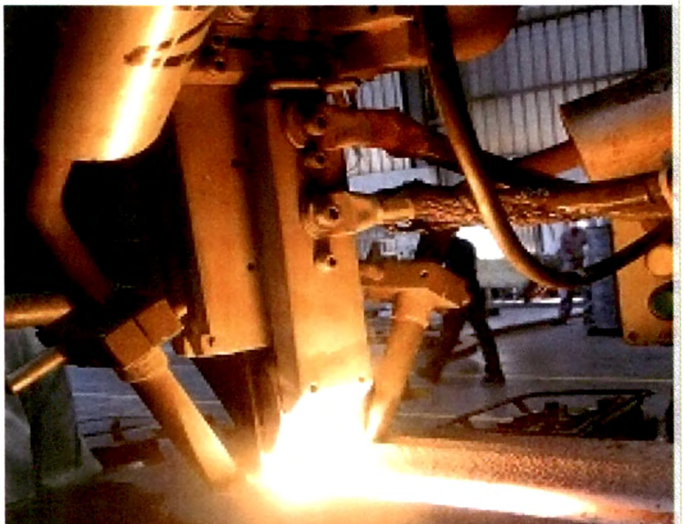
CHAPTER-1

INTRODCTION



Introduction

Large pressure vessels are used in hydrogen containing environments, for example, in the petroleum industry in hydro-cracking, hydrodesulphurization and catalytic reforming processes as well as in the chemical and coal conversion industries [1]. All hydro processing reactors made of low carbon low alloy steel or Cr-Mo steel which require internal protection of the reactor vessel walls experience electrochemical corrosion such as pitting corrosion, inter-granular corrosion, stress corrosion cracking & hydrogen disbonding. Due to their excellent mechanical properties with good corrosion resistance and heat resistance, corrosion resistant alloys such as austenitic stainless steel and nickel based alloys are very suitable for the cladding of such pressure vessels in the petrochemical industries. The two most productive systems for surfacing the large components which are subjected to corrosion or wear are submerged arc and electro-slag cladding, using a strip electrode. Both processes are characterized by a high deposition rate, low dilution and high deposit quality. Both these processes are suitable for surfacing flat and curved objects such as heat exchanger tube sheets and pressure vessels. Submerged arc welding (SAW) is most frequently used but, if higher productivity and restricted dilution rates are required, electro-slag welding (ESW) is recommended [2]. In electro-slag strip cladding process, strip electrodes which are made up of different grade of austenitic stainless steel such as 304. 304 L, 347,309L, 309LNb, 316L, 317L are used as a cladding metal.

In addition to operational stresses, reactor vessel experience thermal stresses during manufacturing and service, because of the different thermal conductivities and expansion coefficients of stainless steel and low carbon low alloy steel [3]. Weld overlay are generally subjected to the Post-weld heat treatment (PWHT), at 690^0C for prolong period of time to decrease residual stress levels & improve the ductility. However, during PWHT, carbon diffuses from the low steel to the austenitic weld overlay generating a decarburised layer in the low alloy steel adjacent to the interface and a carbon-enriched layer in the nearby weld overlay. Most of the carbon in the carbon-enriched zone precipitates as carbides, thereby decreasing the dissolved Cr concentration in the matrix. The formation of these inter-metallic compounds during PWHT may affect the pitting corrosion & IGC susceptibility of weld overlay.

To improve the resistance against IGC susceptibility as well as pitting corrosion of reactor vessel the 309L & 309 L Nb austenitic stainless steel are used as strip cladding material in ESSC process. The niobium form NbC preferentially to that of chromium carbide to reduce the free carbon in the alloy to a level below which chromium carbides do not precipitate in grain boundaries, thus avoiding depletion of the region of chromium and avoiding inter-granular corrosion. Researcher Mr. *Abdel Salam Hamd has* investigated that the corrosion behavior of austenitic stainless steel specimens containing different amount of Nb alloying element using the polarization study in 3.5 % NaCl solution which shows that the formation of Nb rich protective oxide film shifts the current to more noble one and consequently, reducing the number of pits formation [4]. During ESSC process it was found that the welding speed has a considerable influence on bead geometry, ferrite content, dilution & micro-structural changes of the weld overlay. If welding speed is decreased during process, overlay with low dilution is formed but at the same time acquiring an unacceptable high content of ferrite & course grain structure. This lead to increase in susceptibility towards IGC. Whereas, higher welding speed would produce an overlay with finer grain structure due to faster cooling rates in the fusion region. That may lead to the inhibition of the formation of planar grain boundaries and hence decrease in susceptibility towards IGC.

Thus, an attempt has been made to attain a clear understanding of general corrosion behaviour of the austenitic stainless steel strip cladded weld overlay at different locations (clad, interface & base metal) in diffident corrosive environments and also to investigate the pitting & sensitization behaviour in welded as well as after post weld heat treated condition of weld overlays at different locations. The ESSC process was adopted to develop 309L & 309 L Nb cladded weld overlays with varying welding speed from 160 to 200 mm / min. at fixed range of voltage & current. Further, it was subjected to PWHT at 690^0C for 24 hr of exposure time to study its effect on various micro-structural changes, degree of sensitization and pitting susceptibly for the both weld overlays.

In the present work, the micro-structural change of both the weld overlay was observed by optical microscopy method with the help of Neophot-2 microscope while inter-metallic compound as well as the elemental analysis was carried out by SEM & EDAX technique. The ferrite content was measured by Fischer Ferrite- scope MP 30 and hardness value was determined by Vicker hardness testing with the help of vickers pyramid hardness testing method using Wilson Wolpert Micro Vickers – 401MVD Instrument for both types of weld overlays. The potentiodynamic testing was carried out to study passivation and to find out corrosion rate of both the weld overlays in 0.1 N HCl, 0.1 N HNO_3, 0.1 N H_2SO_4 & 3.5 % NaCl solution as per ASTM G-5 standard using Potentiostat Gammry Reference 600. The pitting behaviour were studied by cyclic polarization scan in 6 % $FeCl_3$ Solution as per as per ASTM Standard G-61 & IGC susceptibly was determine in term of degree of sensitization by EPR testing in 0.5 N H_2SO_4 & 0.01 M NaCl solution for both the weld overlays before and after the post weld heat treatment (PWHT) at different locations mainly at clad & interface region using Potentiostat Gammry Reference 600.

The results of this research shows that 309L cladded weld overlay exhibit better corrosion resistance in 0.1N HNO_3 & 0.1N HCl solutions while 309L Nb cladded weld overlay exhibit better corrosion resistance in 0.1 N H_2SO_4 & 3.5 % NaCl solutions at all welding speeds. With increase in the welding speed finer microstructure obtained having less ferrite content , higher hardness & comparatively improved pitting & IGC resistance mainly for 309L Nb cladded weld overlay developed at 180mm /min welding speed. After PWHT, at interface region of both weld overlays, there is diffusion of carbon atom from base metal region adjacent interface in the form of iron carbide which increase the hardness value at interfaced as compared to clad or base metal. Next to this layer on the clad metal side it formed Type II boundary of austenite phase which is approximately parallel to the dark-etching layer. Further also into the weld metal on the left of the Type II boundary - austenitic weld metal structure containing ferrite in the substructure boundaries which is refer as type I boundaries. After PWHT 309 L Nb cladded weld overlay exhibit good pitting & IGC resistance at 180 mm/min welding speed at cladded region while the interface region both at 180 & 200mm/min welding speed.