STUDIES ON AUSTENITIC WELDED LINERS OVER MILD STEEL CORROSION RESISTANT CONTAINMENT APPLICATIONS IN NUCLEAR FACILITIES

ABSTRACT

This thesis discusses the results of a systematic investigation on the influence of the thickness of the austenitic steel liner over mild steel on the chemical, mechanical and microstructural properties of the dissimilar metals welded joints. Hot cells, radioactive effluent storage tanks, reactor vaults are lined with stainless steel (AISI 304/304-L) over mild steel (IS-226) grid work embedded on reinforced cement concrete (R.C.C) structure, flush with the concrete surfaces, using ER-309 filler wire for root passes E-308-L electrode for subsequent filling passes. Sample welds simulating the above lining have been made with square groove joints having wider root gaps (3-19mm) with AISI-304-L stainless steel sheets/plates (thickness 1.6, 3.0, 6.0, 8.0 and 16.0 mm) on 6.0 mm thick mild steel back-up strips.

The welds were tested by non-destructive testing (NDT) techniques like dye penetrant and radiography tests to identify and reveal the surface and internal defects if any, before cutting and specimen preparation. The welds have been examined and evaluated in as welded condition.
for dilution (chemical analysis of chromium, nickel, carbon, nitrogen and sulphur, layer wise), intergranular corrosion due to sensitisation as per ASTM-262-practice (E), mechanical properties as per ASME and ASTM codes and specifications, delta ferrite content and its distribution based on magnetic (magna gauge) measurements and chemical compositions (Schaeffler and Delong constitutional diagrams and Seferian equation). Metallographic examinations have also been carried out for studying the interfacial microstructure in these mild steel/stainless steel dissimilar welds. In addition to the above metallographic examination, microhardness measurements have also been carried out along the mild steel/stainless steel weld interface to study the phases present.

It has been observed that as the liner thickness increases there is a decrease in the dilution effect. In 0.6mm liner throughout the weld cross section chromium and nickel percentages are well below 18 and 8 respectively inspite of using type 25/12 filler wire for root passes. In 3.0mm liner also top surface weld composition lies near the border of 18% and 8% with respect to chromium and nickel respectively.

Delta ferrite measurements from magna gauge shows higher percentage of delta ferrite in the roots and top
surfaces of the weld metal. Although delta ferrites estimated from Schaeffler and Delong constitutional diagrams and from Seferian equation show generally upward trend from the root to the face. Magna gauge gives misleading results in the root passes due to other magnetic phases such as martensite present there. However at the surface there has been some general agreement in the results obtained by the four methods.

Total loss of corrosion resistance in the case of 1.6mm liner weld metal is observed due to higher percentage of martensite as well as sensitisation effects. Further reduced chromium and nickel contents would have also contributed for this observation. Other liner thicknesses 3-0, 6-0, 8-0, and 16.0 mm passed the corrosion tests. Presence of martensite has also been confirmed by the micro-hardness measurements carried out.

Transverse tension tests on full thickness samples showed that the weld metal is stronger than the base metal. As the liner thickness increases, there is increase in tensile strength as well. Root and face bend tests have not yielded any striking results. Shear tests specimen generally failed in the mild steel side of the weld interface and shear strength obtained are generally in the same order as tensile strengths. Ductility of the
joint improves as liner thickness increases in view of lesser dilution in such cases and the weld metal is able to retain its original properties.

Sensitisation in the root runs was observed it was most predominant in 6.0 and 8.0 mm liners. As distance increases from the interface sensitisation effect reduces. The ferrite morphology raised from isolated particles in the root to a continuous network near the top of the welds.