ABSTRACT

Cladding is a surfacing process in which corrosion and wear resistant material is deposited onto a carbon or low alloy steel base metal. Metal Cladding is considered to be the best option for corrosion and wear protection. It is widely employed for fabrication and in the repair of valves and valve components for use in oil, chemical and other innumerable industries. Due to certain limitations such as deterioration of geometrical, mechanical, and metallurgical properties, better cladding procedure has to be established. The present investigation addresses those problems, thereby providing an effective solution to overcome those limitations.

In the present investigation, 410 L stainless steel was deposited on carbon steel designated as ASTM: A105 valve seat rings, using Plasma Transferred Arc (PTA) cladding process. Five factors, five levels Central Composite Rotatable Design was selected for conducting the experiments. The experiments were carried out as per design matrix by laying a single circular bead on valve seat rings. Regression models were developed to study the influence of significant PTA process cladding parameters such as welding current, welding speed, powder feed rate, plasma gas flow rate and oscillation frequency on the geometrical, mechanical and metallurgical properties of the clad valve seat rings.
Based on the investigation, it was found that welding current, welding speed, powder feed rate and plasma gas flow rate significantly influenced the clad bead geometry of the cladded valve seat rings. The regression models developed for the prediction of clad bead geometry revealed that the interaction effects of PTA process parameters played a major role in determining the clad bead geometry parameters and percent dilution.

The influence of PTA process parameters on the macrohardness of the clad valve seat rings was analyzed in the present investigation. The results indicated that the macrohardness increased with increase in welding speed and powder feed rate. The study also revealed that the interaction effect between welding speed and powder feed rate had significant influence in determining the value of macrohardness on the surface of the clad bead geometry.

Heat input had a significant role in determining the mechanical and metallurgical properties of the clad valve seat rings. The microstructure analysis and microhardness survey corresponding to low, medium and high heat input conditions of the clad specimen were studied. The microstructure and microhardness distribution of various zones such as Overlay, Fusion Zone (FZ), Heat Affected Zone (HAZ) and unaffected Base Metal (BM) were analyzed. The microhardness survey revealed that the hardness values of clad layer were higher than that of the substrate. The microhardness profiles were in good agreement with the corresponding microstructures. The microstructural analysis of the clad layer indicated the presence shows
the formation of that martensite. The presence of martensite in clad layer provided better wear and corrosion resistance.

The present investigation also focused on exploring the influence of wear testing parameters (applied load and sliding velocity) and PTA heat input on the wear rate of the clad layer. Three factor, three level, 15 runs Box-Behnken design was selected for conducting the experiments on claded specimens. Regression analysis was used for modelling the wear rate of the clad specimens. The result indicated that the wear rate increased with increase in PTA heat input, applied load and sliding velocity. The study also revealed that the interaction effect of applied load and sliding velocity had significant influence on wear rate of the clad specimens.

Test specimens were sliced from the clad material. Four test specimens with low (8730 J/mm), medium (10470 J/mm), high (12220 J/mm) and optimum (10890 J/mm) weld heat inputs were chosen for conducting the corrosion test experiment. The test was conducted for all specimens and the polarization curves were recorded. The test results show that the linear polarization resistance (LPR), corrosion rate and polarization scan used to evaluate pitting susceptibility. It was also observed that the tested surface was entirely free from formation of pits. Those results indicated that the clad stainless steel 410L alloy at the given testing conditions was not susceptible to pitting.