ABSTRACT

Hardfacing is one of the surfacing methods and widely employed in valve manufacturing industries to deposit stellite-6, a cobalt base alloy on low carbon steel valve seat rings to enhance special properties like wear, corrosion resistance etc. Gas Tungsten Arc Welding (GTAW) process is used in valve industries for hardfacing smaller size valves. The quality of the hardfaced deposits depends on dilution. The control of dilution will improve the metallurgical and mechanical properties of hardfaced deposits. Mathematical models were developed to study the effects of GTAW process parameters on dilution and other important bead parameters viz., penetration, reinforcement and bead width. Models were tested for their adequacy by regression methods and further validated by ANN. The direct and interaction effects are presented in the graphical form using which not only the prediction of geometry but also the controlling of weld bead quality by selecting appropriate process parameter values are possible.

Results from experimental research indicate:

- Dilution (D), bead width (W) and penetration (P) decrease while reinforcement (R) increases with increase in feed rate (F).

- ANN results agree very well with the experimental values. Therefore ANN technique can be applied for modeling GTA hardfacing process.
The process parameters were optimized using MATLAB 6.1 Software for obtaining minimum dilution of 8% to ensure improved weld quality.

The optimum values of GTAW process parameters are:

- Welding current, \( I \) = 215.95 Amps
- Wire Feed rate, \( F \) = 26.77 cm/min
- Welding speed, \( S \) = 13.92 cm/min

The results obtained using optimized process parameters for hardfacing of stellite 6 implies that the wear is minimum, corrosion resistance of the deposit is high and has better metallurgical properties.

The sensitivity analysis of process parameters indicates that the welding current has significant effect on all bead parameters.

The influence of the process parameters such as normal load, \( P \), track radius, \( R \), and sliding velocity, \( S \) on wear were studied. Mathematical model for wear was developed using three factor three level Box-Behnken design matrix. The results of the wear test indicate:

- The rate of increase in wear with the increase in normal load is predominant.
- The wear is found to be minimum when all the three factor values lie between levels 1 and 2.

The optimum wear conditions predicted using MATLAB 6.1 software are:

- Wear, \( W \) = 10.359 \( \mu \)m.
- Sliding Velocity, \( S \) = 437.5 rpm
- Track radius, \( R \) = 40 mm
The optimum wear using GA technique is 10.217 μm.

The sensitivity analysis of wear model shows that the wear is more in the high normal load region.

The microstructure of hardfaced layer using color metallography confirms that the stellite overlay deposited has high wear and corrosion resistance.

Presence of the large primary crystal of $M_7C_3$ type found in the microstructure revealed that the hardfaced valve seat rings had better wear resistance.

Presence of a dendritic structure of cobalt rich solid solution matrix with surrounding eutectic carbides of tungsten and chromium indicated that the hardfaced valve seat rings had good corrosion resistance.

Lower values of $I_{corr}$ obtained from the pitting corrosion test indicated the hardfaced valve seat rings had good pitting corrosion resistance.