CHAPTER VIII

CONCLUSIONS AND FUTURE RESEARCH

8.1 Conclusions

The primary objective of this dissertation is to develop mathematical models for improving the weld bead quality using GTAW process, for stellite 6 hard facing ASTM - A105 grade valve seat rings.

1. The mathematical models were developed using response surface methodology and three factor five level design matrix is effectively used.

2. Mathematical models were developed for the following responses like percentage dilution (D), penetration (P), reinforcement (R) and bead width (W). The responses were related with process parameters, welding current (I), feed rate (F) and welding speed (S). The coded values were used in the models and validated by conformity tests and ANN technique.

3. The experimental results indicate:
   - Dilution (D) and penetration (P) decrease while reinforcement (R) increases slightly with the increase of feed rate (F).
   - P increases with the increase in I but it decreases with the increase in the welding speed, S.
   - The welding current (I) and filler rod feed rate (F) have significant effect on reinforcement (R) and bead width (W).
   - The Filler rod feed rate (F) and welding speed have significant effect on reinforcement (R) and bead width (W).
ANN results agree very well with the experimental values. Therefore ANN technique can be applied for hardfacing using GTAW process.

4. The process parameters were optimized using MATLAB6.1 Software for minimum dilution of 8% to ensure improved weld quality.

5. The optimum values 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 bead parameters corresponding to the optimum values are:
   
   Penetration, P = 0.2192 mm
   Reinforcement, R = 2.6064 mm
   Bead Width, W = 11.2393 mm

   The results obtained using optimized process parameters for hardfacing of stellite 6 on wear, corrosion and microstructure 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.

6. The influence of the testing 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:
• Wear increases when the normal load, sliding velocity and track radius increase.

• 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 condition predicted using MATLAB 6.1 software are:

Wear, \( W = 10.359 \, \mu m \).

The corresponding normal load, \( P = 30 \, N \).

Sliding Velocity, \( S = 437.5 \, \text{rpm} \)

Track radius, \( R = 40 \, \text{mm} \)

The optimum wear using GA technique is 10.217 \( \mu m \).

The corresponding normal load, \( P = 30 \, N \).

Sliding Velocity, \( S = 435 \, \text{rpm} \)

Track radius, \( R = 40 \, \text{mm} \)

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

7. The microstructure using color metallography confirms the objective of this research.

The large idiomorphic primary carbide crystal of \( M_7C_3 \) type found in the microstructure proves the best wear resistance.
A dendritic structure of cobalt rich solid solution matrix with surrounding eutectic carbides of tungsten and chromium proves the high corrosion resistance.

8. The less $I_{corr}$ in the pitting corrosion test indicates the high corrosion resistance.

8.2 Suggestions for Future Research Work

This study was aimed to my knowledge to assess the Effects of Weld Quality of Stellite 6 deposited on Valve Seat Rings by developing mathematical models.

This study has focused the benefit of using optimum parameters like welding current, feed rate and welding speed for improving wear resistance and corrosion resistance.

The study can be extended to assess the productivity and cost saving to the industry.

Future research studies need to investigate the different alloys or processes which can be employed for depositing hardfaced layers.

Additional parameters like torch angle, diameter of filler rod etc. can be included for Future research work.

Since the wear experiments have been carried out at ambient temperature, the wear behaviour at elevated temperatures can be examined.

The deposit composition analysis can be carried out to relate the deposit layer properties with the variation of content of each element.
The corrosion behaviour of the hardfaced layer can be examined at various temperatures and corrosion environments.