CHAPTER-11

CONCLUSIONS AND SCOPE FOR FURTHER WORK

11.1 Conclusions

The following conclusions could be drawn from the present investigations

1. The proposed models are adequate to predict the weld geometrical parameters with a confidence level of 95%.
2. The two level full factorial designs have been found to be effective tools for quantifying the main and interaction effect of the welding variables on weld bead geometry.
3. The developed model can be effectively used to predict the weld bead geometry in the submerged arc welding within the range of parameters used.
4. Penetration increases significantly with voltage, current and wire feed rate and decreases with welding speed and nozzle to plate distance.
5. Reinforcement height increases with current, nozzle to plate distance and wire feed rate and decreases with voltage and welding speed.
6. Weld width rapidly increases with voltage, slowly increases with current and wire feed rate and decreases with welding speed and nozzle to plate distance.
7. The following results have been obtained by multiple regression analysis:
   - The larger values of correlation coefficients ($R_p=.999$, $R_{rh}=.999$, $R_{ww}=.999$) between observed value and predicted value of penetration, reinforcement height and weld width indicate a strong relationship.
The value of coefficient of multiple determination ($R_p^2=0.999$, $R_{rh}^2=0.998$, $R_{ww}^2=0.998$) indicates that 99.9%, 99.8% and 99.8% of total variation in Penetration, Reinforcement Height and Weld Width are explained by the five independent variables.

The estimated equations for the prediction are:

- **PENETRATION**
  \[ P = 5.503 + 1.414*V + 1.291*I + 0.508*F - 0.491*S - 0.258*VF - 0.229*VI + 0.221*FS + 0.135*VC - 0.423*C + 0.620*VI + 0.948*VF - 0.221*FC + 0.266*SC \]

- **REINFORCEMENT HEIGHT**
  \[ RH = 3.663 - 0.395*V + 0.915*I + 0.342*F - 0.414*S + 0.725*C - 0.195*VI - 0.132*VF + 0.191*VS - 0.166*VC - 0.104*IS + 0.330*IC - 0.302*FS - 0.083*FC + 0.134*SC \]

- **WELD WIDTH**
  \[ WW = 15.612 + 2.146*V + 0.681*I + 0.549*F - 1.896*S - 0.927*C + 0.760*VI + 0.620*VF - 0.448*VS + 0.377*VC - 0.252*IS - 0.271*IC - 0.144*FS + 0.330*FC - 0.233*SC \]

- The predictor is making significant contribution to the model as the value in the column labelled “sig” in Table 7.15-7.17 (Pp 89) is less than 0.05 (level of significance).
- The regression model as whole is significant as indicated by F-test.
- VIF (variance inflation factors) values for the models developed and the tolerance statistics indicate that there is no collinearity within the experimental data and the models are valid.
- Cross-validation test full-fills the validity of the models developed.

The assumption of regression is met. Thus, we can say that the models proposed for a sample can be accurately applied to the population of interest.
8. ANFIS (Adaptive Neuro-Fuzzy Inference System) model has been found to give minimum error as compared to ANN (Artificial Neural Network) and MRA (Multiple Regression Analysis) method.

**11.2 Scope for Further Work**

There is a lot of scope for further work on this topic. Some examples of the works which can be carried out on similar lines are given below:

- The work could be extended to welding processes other than SAW like TIG, MIG/MAG and Laser Beam Welding.
- The work on SAW can be extended by choosing the input process parameters other than what have been considered in this work.
- Regarding the responses, study can be carried out to investigate the effects of input parameters on the bead shape factor.
- Work can also be done on other materials and of different thicknesses.