ABSTRACT

Welding of thin austenitic stainless steel are commonly employed in variety of industries ranging from pulp and paper to critical industries such as chemical, petrochemical, aviation and nuclear industries. Generally, gas tungsten arc welding process is commonly used for the welding of thin stainless steel sheets. But the process introduces defects and features such as inconsistent penetration, burn through, undercut welds and distortions etc., due to excessive heat input which are not acceptable for certain critical industrial applications. The recently developed pulsed current GTAW process was found to solve such problems in welding of thin stainless steel sheets. But pulsed GTAW process inspite of its advantages such as low heat input, less distortion, consistent penetration, prevention of hot cracking etc still does not find successful applications due to the complexity involved in current pulsing and its influence on the weld. Hence, considerable research works have been carried out in this aspect but with little success. Based on earlier work, it was observed that no consistent results were reported with regard to welding of thin austentic stainless steel by pulsed GTAW process. The most important aspect of consistent penetration and bead geometry has to be studied and effectively controlled within the optimum range for better economy and to ensure the desired mechanical and corrosion resistance properties of the weld.

A detailed study has been carried out on welding of thin stainless steel sheets to establish mathematical models for pulsed GTAW process relating controllable welding process parameters to weld bead dimensions using response surface methodology in order to select accurately the process parameters and procedure. Using the mathematical model, prediction of weld bead dimensions were carried out. Optimization of pulsed GTAW process parameters were carried out for achieving optimum bead dimensions using Quasi Newton numerical optimization technique. The quality of weld and their suitability for service were evaluated by conducting metallurgical as well as corrosion studies.

Trail runs were conducted to evolve the design matrix based on central composite rotatable design. Experiments were conducted based on design matrix and mathematical models were developed to study the effects of process parameters such as pulsed current, pulse current duration and welding speed on weld bead dimensions in austenitic stainless steel.
steel weld. Response surface methodology was employed to study the linear, quadratic and two way interaction effects of process parameters on bead dimensions. Conformity tests were conducted to find the accuracy of the model. The measured bead dimensions from the conformity tests samples were in close agreement with the bead dimensions predicted by the model.

Metallurgical aspect of the weld such as microhardness, delta ferrite content as well as microstructure including delta ferrite morphology were studied to evaluate its suitability for service. Microhardness survey was carried out across different zones of the weld to correlate microstructure and microhardness and to achieve high degree of confidence in predicting microstructure of the weld. Color metallographic technique was employed to assess the microstructure of the weld resulted from different modes of solidification. Delta ferrite content model was developed to study the effects of pulsed GTAW process parameters on delta ferrite content of the austentic stainless steel weld. The delta ferrite model was used to predict the delta ferrite content of the weld of a given heat with high accuracy.

Evaluation of corrosion resistance of the weld was carried out in the final phase of investigation. Electrochemical pitting corrosion studies were carried out using potentiodynamic anodic polarization technique. Mathematical model correlating corrosion resistance parameters such as corrosion potential, pitting potential and protection potential with pulsed GTAW process parameters were developed. Using these models, the pitting corrosion resistance of the welds were evaluated. Intergranular corrosion resistance of the welds was also studied using double EPR test. A mathematical model correlating $I_p / I_a$ ratio obtained from the test with the welding process parameters were developed. The models developed were applied to predict the corrosion resistance parameters with reasonable accuracy. Using the developed models, the pitting corrosion and the intergranular corrosion resistance of the weld were studied. Weld obtained from optimized PGTAW process parameters conditions was found to have good pitting and intergranular corrosion resistance.