# Abstract

In the present era of industrialization, the need for energy demands is increasing at a very fast rate. This calls for the increased load on power plants to produce the required amount of energy economically and efficiently. Supercritical power plants offer improved efficiency by consuming less coal and emits lower $CO_2$. Power plant fabrication and maintenance is a challenging process due to the extreme service environments. Different components and structural establishments require the use of dissimilar metal welds for enhanced integrity and performance. The motivation behind this work was to develop shielded metal arc welding electrode coatings to ensure enhanced performance and minimize the problem of high-temperature failure. Shielded metal arc welding (SMAW) is a widely used welding process in weld fabrication, repair and maintenance. The information about welding consumables presently used is classified and limited in the public domain.

The objective of this thesis is to design and develop highly basic electrode coatings to fabricate P22/P91 and P91/SS304L dissimilar joints for power plant applications. Mineral system $CaO$-$CaF_2$-$SiO_2$-$Al_2O_3$ was used to formulate coating compositions by extreme vertices mixture design approach. The developed coatings were experimentally characterized to investigate the physicochemical, thermophysical and wettability properties. The statistical regression analysis has been used to quantify the effect of coating ingredients on these properties. Multipass bead on plate experimentations was performed using developed electrodes. The qualitative and quantitative examination of beads were carried out to assess the suitability of laboratory-developed electrodes**.**

The best performing electrode coatings were then used to fabricate dissimilar P22/P91 and P91/SS304L welds after being extruded on ER90S-B3 and Inconel-82 core wires respectively. The fabricated welds were characterized by mechanical and microstructural behavior. A comparison was also drawn between laboratory developed and commercially available electrodes used for these joints. The developed electrodes had better performance and showed enhanced properties as compared to commercially available electrode. Impact strength improved by 19% and 24% for P22/P91 and P91/SS304L welds respectively. Tensile strength for both the laboratory developed electrode joints remains comparable to the commercially developed electrode joint**.** High-temperature performance is the intended application for the above-mentioned joints. The base materials P22, P91 and SS304 along with welds P22/P91 and P91/SS304L were investigated for hot corrosion resistance. They were subjected to molten salt environments of alkali sulphates, alkali chlorides and vanadium pentoxide at high temperatures. The welds fabricated with laboratory-developed electrodes exhibited higher corrosion resistance as compared to commercial electrode fabricated welds under all conditions**.**

The results obtained from this work indicate successful development of SMAW electrode coating designed explicitly for P22/P91 and P91/SS304L weld for application in USC power plants. The developed electrodes have better mechanical properties, high-temperature corrosion resistance as compared to commercially available electrode and acceptable microstructural stability.