Minimum level of dilution is necessary for controlling the alloy content of the weld metal needed to bring about the necessary surface modifications and mechanical properties which is the major limitation with the conventional processes which has the adverse effects on the productivity and quality of deposited material.

Submerged arc welding (SAW) is one of the most widely used welding processes globally. However, in welding applications, such as welding of sheet metal, surfacing or when it is desirable to minimize or closely control the arc force and heat input, the use of submerged arc welding process becomes impractical. The problem occurs because for any combination of filler wire and power supply, the welding current, the electrode stick out and the deposition rate cannot be individually varied without affecting the other variables. Since the existing processes have their limitations, a new process by the name of ‘advanced submerged arc welding’ developed by Prof. Sunil Pandey in the Welding Laboratory of the Indian Institute of Technology Delhi for controlling weld dilution, has been investigated in this research work. By providing independent and balanced control of these variables, the new process i.e, Advanced Submerged Arc welding (ASAW) provides an extremely versatile and flexible system.

With the help of advanced SAW process the variation in heat input achieved using single wire having an effect on bead reinforcement, bead width, penetration depth, contact angle, heat affected zone(HAZ) size, deposition area, penetration area and total molten area were analyzed. The level of dilution and different melting efficiencies were calculated and their variation with heat input was analyzed based on the acquired measurements.

Three sets of thirty two runs of experiments were conducted according to the random run suggested by two-level fractional factorial design. For determining their main and interactions effects on various weld bead geometry responses five direct welding parameters were selected. Relationship between bead geometry and shape relationship and dilution control were also studied. The experimentation was designed by using
rotatable central composite design (CCD) and accordingly a design matrix was formed. Experiments were performed according to the design matrix and the responses corresponding to each run were recorded. The correlations between the process parameters and important responses from the cladding point of view were developed by using response surface methodology (RSM). Single and multiple response optimization of the process parameters was then carried out using desirability approach in order to achieve the optimum dilution.

The relationship with respect to welding current behavior in advanced submerged arc welding was compared with the conventional submerged arc welding process. The preheating of filler wire during the advanced submerged arc welding process resulted in reduction in overall welding current. The Volt–Ampere transients were recorded to evaluate the behaviour of metal transfer during welding and to analyze the effect of preheating of filler wire. Simultaneously the temperatures were recorded using Adams software and the effect of cooling rate and the heat transfer rate were compared with the submerged arc welding process.

In the longitudinal and transverse direction micro hardness testing was carried out within the weld bead, heat affected zone and the base material region. Microstructures of weld metal, Heat affected zone and the base metal in different zones were analyzed. The effect of preheating on phase distribution and different phases in weld metal were observed.

At the optimum dilution level conditions multipass multilayer cladded plates were prepared for evaluating their quality in terms of mechanical and metallurgical performance such as microstructures, microhardness, elements retention, and ferrite content. By performing the bend tests the integrity of the stainless steel clad layer on mild steel base was checked.

Major findings of the research work are as follows:

1. The methodical research has proven the technological advantage of the newly design and developed advanced submerged arc welding process over the conventional arc welding processes in terms of major reduction in
the weld metal dilution, sound and desired weld metal properties and exceptional economical advantage. It was possible to quantify the main and interaction effects of process parameters on the cladding responses and in turn the quality.

2. Due to its low dilution capabilities the ASAW process can be used to clad thin plates.

3. Hardness and ferrite content in the first clad layer itself was found satisfactory thus reducing the need for multilayer cladding.