# ABSTRACT

Duplex Stainless Steel (DSS) has equal amounts of ferrite and austenite, which makes them very resistant to chloride corrosion. The equal proportion of ferrite and austenite, changes with increased heating during welding. There will be a loss in the imperative characteristics of DSS, and the amount of loss can be minimized by employing appropriate welding methodologies. To achieve the desired ferrite/austenite balance and hence the properties of the duplex stainless steel, a specific range of heat input between 0.5 kJ/mm and 2.5 kJ/mm is required. The heat input can be controlled by using different metal transfer modes in the place of constant current (CC) mode of metal transfer. The modes of metal transfer, such as pulsed current (PC) and surface tension transfer (STT) modes of metal transfer, are the best methods for controlling the weld heat input instead of the typically used constant current (CC) mode. The present study aimed to learn about the effects of the CC, PC and STT modes of FCAW on the microstructure, mechanical, and corrosion properties of the duplex stainless steel joints.

In the present work, an investigation was conducted to optimize PC-FCAW and STT-FCAW process parameters for ferrite content in 2205 Duplex stainless steel joints. The metallurgical, mechanical and corrosion properties of the flux cored arc welded CC, PC and STT mode specimens were evaluated. Ferrite content in the weld metal zone of the DSS joints was measured using Ferritescope. Scanning Electron Microscope (SEM) analysis was performed to identify the ferrite and austenite phases in the FCAW DSS welded specimens. EDAX analysis was carried out to determine the material composition at the three points of interest in the flux cored arc welded specimens. An EBSD analysis was performed to discriminate between the dissimilar phases by equating the inter-planar angles taken from the diffraction pattern.

The mechanical properties have been evaluated using hardness, tensile, and impact tests. The tensile test was performed to obtain the ultimate tensile strength, yield strength, total elongation, and notch tensile strength of the welded specimens fabricated by the three welding modes. An impact test was carried out to evaluate the impact toughness of the specimens under the three FCAW conditions; CC, PC, and STT modes. The fracture morphology for identifying the type of failure for tensile and impact test samples was investigated using scanning electron microscopy (SEM).

The optimized process parameters of the PC-FCAW process are found to be 210 A and 140 A for peak and base currents, respectively, at 100 Hz and 80% for pulsed frequency and pulse on-time with a heat input of 1.37 kJ/mm. It was also found that the optimized process parameters of the STT-FCAW process were found to be 85 A and 200 A for background and peak current, and 5 and 4.8 m/min for tail out and wire feed rate, correspondingly with 1.52 kJ/mm heat input. The heat input of the CC mode of the FCAW is 1.52 kJ/mm, which is quite high. The heat inputs for all three modes of metal transfer used in this work are maintained below 2.5 kJ/mm, which is the maximum acceptable and permissible heat input to joint DSS 2205 plates. The ferrite content of the CC, PC and STT joints is 58.3 percent, 54.5 per cent, and 47.4 per cent, respectively, which is within the permitted range of 30-60 per cent ferrite content.

The high heat input of the CC mode produced elongated needle-shaped austenite in a fine ferrite matrix. The PC joint has a medium-sized fusion zone, and the STT joints have a smaller fusion zone. The STT joint has good mechanical strength due to the smaller average grain size produced by STT mode than the PC and CC modes. The Nishiyama-Wassermann orientation relationship favoured between austenite and ferrite resulted in improved overall weld metal mechanical properties.

The weld metal zone has less hardness than HAZ and BM, regardless of metal transfer mode. The CC joint has the highest hardness in the weld metal and fusion zones, but it has a lower hardness in HTHAZ and LTHAZ than the STT joint. The CC joint had better tensile strength than the PC and STT joints, but the difference was small due to the lower heat input, optimal ferrite content, and fine microstructure of the PC and STT joints. The Notch Strength ratio (NSR) was greater than unity for all joints, indicating that the weld metal is notch ductile. The STT joint exhibited superior impact toughness than the CC joint, PC joint, and base metal at room temperature. The fracture morphology for identifying type of qualifying ductile failure for smooth, notch tensile, and impact test samples was investigated using scanning electron microscopy (SEM).The PC joint has a corrosion rate that is 48.88% higher than the CC joint. The STT joint exhibits superior corrosion resistance, with a corrosion rate of 64.5 percent and 30.5 per cent lower than the PC and CC joints, respectively. The use of PC and STT metal transfer modes with flux-cored wire to join DSS 2205 plates resulted in a better ferrite-austenite balance in the weld metal zone. This resulted in better metallurgical properties without forming any undesired phases due to controlled and lower heat input. Hence, the PC FCAW and STT FCAW modes of metal transfer can be used to join DSS 2205 instead of the CC mode of metal transfer.