CHAPTER 07 Conclusion and Future scope

7.1 Introduction

The current chapter discusses the conclusions related to the investigation of A-TIG, FB-TIG and FZ-TIG welding processes performed on 2205 DSS. Effect on metallurgical, mechanical properties of the welded joints and comparisons of A-TIG weld joint with its variants are also analyzed and concluded in this chapter. Furthermore, this chapter includes the scope for future work as observed after the completion of the present work objectives.

7.2 Conclusions

Based upon the investigation of 2205 DSS weld joint by A-TIG, FB-TIG and FZ-TIG welding processes following conclusions have been drawn.

- In A-TIG 2205 DSS weld metal, a maximum D/W ratio 0.87 is achieved at 185 amps weld current, 100 mm/min torch speed and SiO_2 flux. Which is 480 % higher compared to the D/W ratio (0.15) reported in (autogenous) TIG weld. Higher tensile strength is achieved in a few A-TIG welded joints this is due to the high D/W ratio and less formation of delta ferrite than TIG welded joint along with the formation of Widmannstetter structure with high miss-orientation of grain in A-TIG weld metal. Maximum hardness 362 HV is reported in TIG welded joint, which is quite higher than A-TIG all welded joint. Due to low heat input during the TIG welding.
- The higher-order mathematical model is developed using RSM for weld bead geometry and mechanical properties. The generated mathematical model is successfully used to predict the depth of penetration, bead width, tensile strength and microhardness for the given range of process variables in A-TIG welding. An optimized value of depth of penetration, bead width, tensile strength and microhardness are 6.13 mm, 8.05 mm, 777 MPa and 320 HV respectively. Which are obtained at 201.86 A welding current 140 mm/min torch speed and SiO2 flux. Experimental validation results show less than 4% error in all responses. A-TIG welding successfully increases the penetration capability along with mechanical

properties in 6mm thick 2205 DSS.

- In FB-TIG welding at 2 mm flux gap with SiO_2 flux, the highest penetration depth 5.9 mm and D/W ratio 0.74 is obtained. This is 310% more than the TIG weld D/W ratio (0.18) under the same welding conditions. By increases in heat input, the penetration and D/W ratio are increased due to a higher temperature gradient which enhances the reversal of Marangoni convection. A maximum D/W ratio 0.75 is achieved at 210 amps welding current. However, after the 210 amps, the current further increase the current 235 amps bead width increases which reduces the D/W ratio due to extra metal deposition is at the weld bead.
- In FB -TIG weld metal highest tensile strength 772 MPa is reported at 210 A current which is 10 % higher than TIG weld metal. This is attributed to the reduction in delta ferrite along with the growth of Widmanstätten austenite. However, maximum microhardness 367 HV is observed in TIG weld which is higher compared to all FB-TIG weldments due to reduction in grain size and excessive ferrite content in TIG weld metal. Though, with minimum heat input 160 amps welding current maximum microhardness 354 HV is obtained in FB-TIG welded joint this is only 3.5 % less than TIG welded joint.
- FB-TIG welding is capable enough to increase the penetration in 2205 DSS by overcoming the disadvantages of the A-TIG weld joint. However, under the same weld condition 2.5 % less penetration is observed compared to A-TIG welding.
- The highest D/W ratio 0.91 is obtained in the FZ-TIG weld joint with SiO_2 centre region flux and Cr_2O_3 side region flux. This is 18 % more than A-TIG and 23 % FB-TIG weld metal. However, at 8 mm thick plate reduction in penetration (6.1 mm) is reported. This is due to increase in heat dissipation area increases with the plate thickness. Due to a substantial increment in D/W ratio in FZ-TIG weld metal, negligible angular distortion is observed. Among all welding processes, maximum heat input 1.53 KJ/mm is reported in FZ-TIG welding which leads to lesser microhardness. In all A-TIG, FB-TIG and FZ-TIG weld metal microstructure formation of Widmanstätten austenite with high miss-orientation of grain is observed in ferrite matrix. However, the highest tensile strength 778 MPa is observed in FZ-TIG weld metal which is 2.3% higher than the A-TIG weld joint and 8% higher than FB-TIG weld joint. This attributed to a more balance structure of ferrite/austenite by forming larger laths of Widmanstätten austenite in a ferrite

matrix in the FZ-TIG weld joint. An almost similar reduction in electrode diameter is detected after A-TIG and FZ-TIG welding, Whereas, after FB-TIG welding negligible reduction in electrode diameter is observed. Therefore, a larger electrode diameter (3.2 mm) is more suitable to perform A-TIG and FZ-TIG welding to avoid electrode consumption. FZ-TIG weld bead appears with a thin layer of oxide file which is less compared to A-TIG weld bead. This is attributed to two different flux combinations having different physical and chemical properties.

7.3 Future Scope

From the systematic investigation of existing literature, some points are acknowledged and inferred that address the forthcoming research in A-TIG, FB-TIG and FZ-TIG welding.

- Various activated fluxes influence the weld quality differently. Proper selection of process parameters and fluxes is important for good weld bead and effective mechanical properties in A-TIG welding. The right combination of multi-component activated fluxes effect can be investigated on different stainless steel alloys with the adequate amount of shielding gas mixture to discover high weld penetration with the quality of the weld bead.
- The integrated approach of RSM and Jaya is much simpler to optimize process parameters. However, limited study has been reported with this integrated approach to optimize A-TIG process parameters for stainless steel alloys. This gives an opportunity for further research. Ample research has been reported on the influence of weld parameters on the microstructure and mechanical properties of austenitic and ferrite grades of stainless steel. However, researchers need to explore other stainless steel grades. Also, the improvement in mechanical properties is reported in TIG with electromagnetic stirring. This approach can be incorporated with A-TIG welding.
- A-TIG was successful in increasing the penetration to a great extent but a high amount of inclusion density was observed which is eliminated by the FB-TIG process. Arc constriction due to the insulation effect is a major contributing mechanism in FB-TIG welding which must be studied in detail. High penetration depth with good surface quality is observed in FZ-TIG welding with two flux combinations however, different flux combinations can be ascertained.