

List of Figure

Figure 1.1 Preparation and coating of flux paste	4
Figure 1.2 A schematic diagram of FB-TIG welding	5
Figure 1.3 A schematic diagram of FZ- TIG welding	6
Figure 2.1 Keyhole mode (Ahmadi & Ebrahimi, 2015)	11
Figure 2.2 Schematic of arc constriction due to negative ions in the Activated TIG process (Howse & Lucas, 2000)	12
Figure 2.3 (a) Marangoni convection (B) Reversal Marangoni convection	14
Figure 2.4 Marangoni force in (a)TIG welding (b) Reverse Marangoni force in A-TIG welding	15
Figure 2.5(a) Electromagnetic force (b) Buoyancy force (c) Aerodynamic drag force.....	16
Figure 2.6 Disparity in weld metal geometry (a) penetration depth, (b) weld bead width with current, in 304LN stainless steel welds (Vidyarthi & Dwivedi, 2016).....	18
Figure 2.7 Torch speed effect on weld penetration with changing weld current (Tseng & Chuang, 2012).....	19
Figure 2.8 Effect of various oxide flux on arc voltage (Tseng & Hsu, 2011)	20
Figure 2.9 Arc voltage waveforms with (a) SiO ₂ and (b) TiO ₂ flux (Li, Wang, Zou, & Wu, 2007)	21
Figure 2.10 Effect on weld D/W ratio with an arc length of different steel casts; each mark signify a different steel (Chakravarthy, Agilan, & Neethu, 2019).....	22
Figure 2.11 Effect of coating density on penetration D/W ratio with different flux (Ahmadi & Ebrahimi, 2015)	25
Figure 2.12(a) Base metal 316L SS (b) Weld metal without flux (Tseng & Chen, 2012)	32
Figure 2.13Weld metal formed with TiO ₂ flux (d) Weld metal formed with SiO ₂ flux (Tseng & Chen, 2012).....	32
Figure 2.14 Hot cracking in 316 L (a) with TIG weld (b) with A-TIG weld (Tseng, Chen, & Chen, 2012).....	33
Figure 2.15 AISI 430 Weld metal microstructure after (a) TIG and (b) A-TIG welding (Ramkumar, et al., 2015)	34
Figure 2.16 Charpy toughness test specimen fracture surface (a)A-TIG (b) A- TIG weld after PWHT (Vidyarthi, Dwivedi, & Vasudevan, 2017).....	35
Figure 3.1 A-TIG/FB-TIG/FZ/TIG welding (a) setup and (b) fixture.....	40

Figure 3.2 (a) welding torch angle change (b) Stirrer for mixing flux and carrier solvent	41
Figure 3.3 Selected single component Oxide fluxes.....	43
Figure 3.4 Ellingham diagram represent the various oxide metals relative stability (Mitchell, 2004)	45
Figure 3.5 Welded joint location for microstructure, microhardness, tensile and impact specimen extraction for testing plates.....	47
Figure 3.6 Dimension of the tensile test specimen	48
Figure 3.7 Charpy V-notch impact test prepared specimen.....	49
Figure 3.8 Dimension of Charpy V-notch impact test specimen.....	49
Figure 3.9 Flowchart for layout of Experiments.....	50
Figure 4.1 Flux applied in A-TIG welding	52
Figure 4.2 Welding current: 120 A, Torch speed 200 mm/min.....	53
Figure 4.3 Welding current: 250 A, Torch speed 80 mm/min.....	53
Figure 4.4 Welding current: 185 A, Torch speed 120 mm/min.....	54
Figure 4.5 A-TIG welded specimen as per design matrix	57
Figure 4.6 Macrostructure of A-TIG 2205 DSS weld metal	58
Figure 4.7 Macrostructure of TIG 2205 DSS weld metal.....	59
Figure 4.8(a) Parent metal microstructure (b) TIG weld metal microstructure of 2205 DSS	59
Figure 4.9 A-TIG, 2205 DSS weld metal at (a)185 amps current and 100 mm/min torch speed SiO ₂ flux (b)160A current, 140 mm/min torch speed, TiO ₂ flux.....	60
Figure 4.10 Failed tensile test specimen of A-TIG 2205 Duplex stainless steel weld	61
Figure 4.11 Schematics illustration of predicted values and experimental values agreement of depth of penetration	65
Figure 4.12 Schematics illustration of predicted values and experimental values agreement of bead width.....	67
Figure 4.13 Schematics illustration of predicted values and experimental values agreement of tensile strength	68
Figure 4.14 Schematics illustration of predicted values and experimental values agreement of microhardness	70
Figure 4.15 Illustration (a) effect of the current and torch speed on DOP (b) effect of the torch speed and flux on DOP (c) effect of the current and flux on DOP.....	71
Figure 4.16 Illustration (a) effect of the current and torch speed on BW (b) effect of the torch speed and flux on BW (c) effect of the current and flux on BW.....	72
Figure 4.17 Illustration (a) effect of the current and torch speed on tensile strength (b) effect of	

the torch speed and flux on tensile strength (c) effect of the current and flux on tensile strength	73
Figure 4.18 Illustration (a) effect of the current and torch speed on tensile strength (b) effect of the torch speed and flux on tensile strength (c) effect of the current and flux on tensile strength	75
Figure 4.19 Macrostructure of A-TIG weld metal observed in the confirmatory experiment.	78
Figure 4.20 Charpy impact test (a) set up and (b) fractured impact test specimen.....	79
Figure 5.1 A-TIG weld surface	81
Figure 5.2 Flux applied in Flux Bounded TIG welding	82
Figure 5.3 Flux bounded TIG weld bead geometry at varying the gap 2 to 7 mm with SiO ₂ flux	84
Figure 5.4 TIG weld bead geometry (D/W ratio: 0.18)	84
Figure 5.5 Influence of flux gap (with SiO ₂ flux) on weld bead geometry of FB-TIG 2205 DSS weld.....	85
Figure 5.6 Influence of different fluxes at 2 mm flux gap on weld bead geometry in FB-TIG 2205 DSS welds.....	85
Figure 5.7 Influence of heat input (welding current) on FB-TIG 2205DSS weld bead geometry	87
Figure 5.8 Microstructure of (a)2205 DSS base material (b) TIG weld metal	88
Figure 5.9 Microstructure at (a) minimum heat input 160 A current (1.14 KJ/mm).....	89
Figure 5.10 Influence of heat input on mechanical properties of FB-TIG DSS weldments....	90
Figure 5.11 Microhardness of TIG (at 185 A current) and FB-TIG weld joint at different heat input	91
Figure 6.1 Macrostructure of A-TIG weld metal (D/W: 0.77) and FB-TIG weld metal (D/W: 0.74)	93
Figure 6.2 Flux applied in FZ –TIG welding.....	95
Figure 6.3 Macrostructure of FZ-TIG 2205 DSS weldments	96
Figure 6.4 A-TIG, FB-TIG and FZ-TIG flux applied surface	98
Figure 6.5 Comparison of the macrostructure of TIG and its variants	98
Figure 6.6 Comparison of weld bead geometry of the TIG welding variant.....	99
Figure 6.7 The macrostructure of FZ-TIG weld joint in 8 mm thick 2205DSS plate	99
Figure 6.8 Optical microscopic image of (a) base metal (b)A-TIG (c) FB-TIG and (d) FZ-TIG welded samples	101
Figure 6.9 Measurement of angular distortion.....	102

Figure 6.10 Effect of D/W ratio on angular distortion..... 102
Figure 6.11 Effect of welding process on Mechanical Properties103
Figure 6.12 Electrode tip appearance after A-TIG, FB-TIG and FZ-TIG welding 104
Figure 6.13 Weld bead appearance of A-TIG, FB-TIG and FZ-TIG weld joint 105