LIST OF FIGURES

	FIGURE	Page No.
Chapter 1	Metal Matrix Composite (MMC)-An Introduction	1
1.1	Conventional Powder Metallurgy process	8
1.2	Electroplating / Electroforming process	10
1.3	Schematic of stir casting process. (1) Stirrer spindle, (2) Sliding mechanism with impeller position control unit, (3) Electric motor (4) Sprue, (5) Crucible, (6) Electric furnace, (7) Impeller, (8) Argon gas inlet, and (9) Thermocouple.	10 r,
1.4	Direct and indirect squeeze casting.	12
1.5	Spray Deposition process	13
1.6	Ultra-hard and wear-resistant component manufactured from Fe/TiC MMCs	14
Chapter 2	Literature Review: Processing, Structural, Mechanical and Electrochemical Behavior of Metal Matrix Composites	16
2.1	SEM micrographs of Al and Al ₂ O ₃ powders (a) Al, (b) Al ₂ O ₃ - 3μ (c) Al ₂ O ₃ - 12μ m and (d) Al ₂ O ₃ - 48μ m.	m, 23
2.2	Effect of sintering time on microstructure of composites at 600 °C (a) 45,(b) 60 and (c) 90 min.	C 24
2.3	Effect of sintering temperature on microstructure of composi after sintering for 45 min (a) 500, (b) 550 and (c) 600°C.	tes 25
2.4	Micrographs of powders of: (a) Ni– coated SiC, (b) Ni–coated Al ₂ O ₃	29
2.5	Microstructures of: (a) Cu– 20% coated SiC, (b) Cu–20% SiC, (cu– 20% coated Al_2O_3 , and (d) Cu–20% Al_2O_3 composites.	c) 29
2.6	The effect of sliding distance on the weight loss of the investigate alloys (a) 3 N, (b) 5 N and (c) 20 N	ed 32
2.7	SEM micrographs of the worn surfaces of the investigated alloys	33
2.8	XRD patterns of samples (a) sintered block, (b) magnesium matr composite	ix 34
2.9	SEM photograph of samples (a) sintered blocks, (b) magnesium matrix composite	35
2.10	SEM micrographs of Mg matrix composite (transverse direction) reinforced with SiC of size: (a) 15, (b) 20, (c) 25, (d) 38 and (e) 5 um	36 50
2.11	SEM of (a) Worn surface of the alloy showing oxide formation (I Worn surface of the alloy with oxides agglomeration	b) 37
2.12	Typical SEM micrographs of (a) Mg and (b) Mg–6SiC surfaces obtained after immersion in 1M NaCl for 5 min	40

2.13	SEM image of the microstructure of $Al_2O_3 + X$ % Fe composites showing the distribution of the Fe Al ₂ O ₄ spinel	41
2 14	SFM of worn surfaces at sliding velocity of 1.26m/s and load of	43
2.11	20N (a) Iron-sintered at 100 mm/s. (b) Iron–3wt.% SiC sintered at	15
	100 mm/s	
2.15	SEM micrographs of corroded surfaces before and after anodic	45
	polarization curve tests in 3.5% NaCl solution: (a) original surface	
	morphology of composite A; (b) corroded surfaces morphology of	
	composite A	
Chapter 4	Synthesis and Characterization Methods	50
4.1	Schematic Layout of Pin on Disc Wear and Friction Testing	69
	Machine	
4.2	Standard potentiodynamic anodic polarization plot of 430 stainless	80
	steel	
4.3	Excitation waveform for Tafel plots	81
4.4	Experimentally measured Tafel plot	82
4.5	Schematic Diagram showing the Corrosion Cell	83
Chapter 5	Sintering and Hardness Behavior of Fe-Al ₂ O ₃ Metal Matrix	85
	Nanocomposites	
5.1	XRD patterns of the specimens (a) 5AFe900(2) (b) 5AFe1000(2)	87
	and (c) 5AFe1100(2)	
5.2	XRD patterns of the specimens (a) 10AFe900(1) (b) 10AFe1000(1)	88
	and (c) 10AFe1100(1)	
5.3	XRD patterns of the specimens (a) 10AFe900(2) (b) 10AFe1000(2)	89
	and (c)10AFe1100(2)	
5.4	XRD patterns of the specimens (a) 20AFe900(1) (b) 20AFe1000(1)	90
	and (c) 20AFe1100(1)	
5.5	XRD patterns of the specimens (a) 20AFe900(2) (b) 20AFe1000(2)	91
	and (c) 20AFe1100(2)	
5.6	XRD patterns of the specimens (a) 20AFe900(3) (b) 20AFe1000(3)	92
	and (c) 20AFe1100(3)	0.0
5.7	XRD patterns of the specimens (a) $30AFe900(1)$ (b) $30AFe1000(1)$	93
5.0	and (c) $30AFe1100(1)$	0.4
5.8	XRD patterns of the specimens (a) $30AFe900(2)$ (b) $30AFe1000(2)$	94
5.0	and (c) $30AFe1100(2)$	05
5.9	ARD patterns of the specimens (a) $30AFe900(3)$ (b) $30AFe1000(3)$	95
5 10	and (c) $30AFe1100(3)$ SEM image at 250V of (c) Eq Douvdor (b) A1 O. Douvdor	07
J.10	SERVI image at 250A of (a) Fe Powder (b) Al_2O_3 Powder SEM image of ball milled newsdar at 200X of (c) Eq. 59(-A1-O(l))	9/ 00
3.11	SERVE image of ball infined powder at 200A of (a) Fe-5% AI_2O_3 (b) Fe 10% AI_2O_2 (c) Fe 20% AI_2O_2 (d) Fe 20% AI_2O_3	98
5 1 2	$\Gamma = 1070 \text{ Al}_2 \text{ O}_3 (\text{C}) \Gamma = -2070 \text{ Al}_2 \text{ O}_3 (\text{C}) \Gamma = -5070 \text{ Al}_2 \text{ O}_3$ SEM of 5 A Eq000(3) at (a) 5000 V and (b) 15000 V respectively.	100
3.12	SLIVE OF SATCHOUS at (a) SUUVA and (b) ISUUVA respectively	100

	SEW of SAFe1000(5) at (a) 5000 \times and (b) 15000 \times respectively	100
5.14	SEM of 5AFe1100(1) at (a) 5000X and (b) 15000X respectively	100
5.15	SEM of 10AFe900(1) at (a) 5000X and (b) 20000X respectively	101
5.16	SEM of 10AFe900(2) at (a) 5000X and (b) 20000X respectively	101
5.17	SEM of 10AFe1100(1) at (a) 5000X and (b) 20000X respectively	101
5.18	SEM of 20AFe900(1) at (a) 5000X and (b) 20000X respectively	102
5.19	SEM of 20AFe900(2) at (a) 5000X and (b) 20000X respectively	102
5.20	SEM of 20AFe900(3) at (a) 5000X and (b) 20000X respectively	102
5.21	SEM of 20AFe1000(1) at (a) 5000X and (b) 20000X respectively	103
5.22	SEM of 20AFe1000(2) at (a) 5000X and (b) 20000X respectively	103
5.23	SEM of 20AFe1000(3) at (a) 5000X and (b) 20000X respectively	103
5.24	SEM of 20AFe1100(1) at (a) 5000X and (b) 20000X respectively	104
5.25	SEM of 20AFe1100(2) at (a) 5000X and (b) 20000X respectively	104
5.26	SEM of 20AFe1100(3) at (a) 5000X and (b) 20000X respectively	104
5.27	Density vs. % Al ₂ O ₃ plots for the various specimens	108
5.28	Hardness vs. % Al ₂ O ₃ for the specimens sintered at 900°C	112
5.29	Hardness vs. % Al ₂ O ₃ for the specimens sintered at 1000°C	113
5.30	Hardness vs. % Al_2O_3 for the specimens sintered at 1100°C	114
Chapter 6	Wear and Deformation Characteristics of Fe-Al ₂ O ₃	116
	Metal Matrix Nanocomposites	
61	Wear Rate vs. Load for specimens sintered at 900°C	118
6.2	Wear Rate vs. Load for specimens sintered at 1000°C	119
0.2	ven rate vs. Doud for specificity sintered at 1000 C	11/
6.3	Wear Rate vs. Load for specimens sintered at 1100°C	120
6.3 6.4	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c)	120 122
6.3 6.4	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load	120 122
6.3 6.4 6.5	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c)	120 122 123
6.3 6.4 6.5	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load	120 122 123
6.3 6.4 6.5 6.6	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c)	120 122 123 125
6.36.46.56.6	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load	120 122 123 125
6.3 6.4 6.5 6.6 6.7	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c)	120 122 123 125 126
6.36.46.56.66.7	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load	120 122 123 125 126
 6.3 6.4 6.5 6.6 6.7 6.8 	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c)	 120 122 123 125 126 127
 6.3 6.4 6.5 6.6 6.7 6.8 	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load	 120 122 123 125 126 127
 6.3 6.4 6.5 6.6 6.7 6.8 6.9 	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c)	120 122 123 125 126 127 132
$ \begin{array}{c} 6.3 \\ 6.4 \\ 6.5 \\ 6.6 \\ 6.7 \\ 6.8 \\ 6.9 \\ 6.10 \\ \end{array} $	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load Wear Rate vs. Load for specimens sintered for 1h Wear Rate vs. Load for specimens sintered for 2h	120 122 123 125 126 127 132 133
$ \begin{array}{c} 6.3 \\ 6.4 \\ 6.5 \\ 6.6 \\ 6.7 \\ 6.8 \\ 6.9 \\ 6.10 \\ 6.11 \\ \end{array} $	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load Wear Rate vs. Load for specimens sintered for 1h Wear Rate vs. Load for specimens sintered for 2h Wear Rate vs. Load for specimens sintered for 3h	120 122 123 125 126 127 132 133 134
$ \begin{array}{c} 6.3 \\ 6.4 \\ 6.5 \\ 6.6 \\ 6.7 \\ 6.8 \\ 6.9 \\ 6.10 \\ 6.11 \\ 6.12 \\ \end{array} $	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load Wear Rate vs. Load for specimens sintered for 1h Wear Rate vs. Load for specimens sintered for 3h Frictional Force vs. Load for specimens sintered for 1h	120 122 123 125 126 127 132 133 134 135
$ \begin{array}{c} 6.3\\ 6.4\\ 6.5\\ 6.6\\ 6.7\\ 6.8\\ 6.9\\ 6.10\\ 6.11\\ 6.12\\ 6.13\\ \end{array} $	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load Wear Rate vs. Load for specimens sintered for 1h Wear Rate vs. Load for specimens sintered for 3h Frictional Force vs. Load for specimens sintered for 1h Frictional Force vs. Load for specimens sintered for 2h	120 122 123 125 126 127 132 133 134 135 137
$\begin{array}{c} 6.3 \\ 6.4 \\ 6.5 \\ 6.6 \\ 6.7 \\ 6.8 \\ 6.9 \\ 6.10 \\ 6.11 \\ 6.12 \\ 6.13 \\ 6.14 \end{array}$	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load Wear Rate vs. Load for specimens sintered for 1h Wear Rate vs. Load for specimens sintered for 3h Frictional Force vs. Load for specimens sintered for 2h Frictional Force vs. Load for specimens sintered for 3h	120 122 123 125 126 127 132 133 134 135 137 137
$\begin{array}{c} 6.3 \\ 6.4 \\ 6.5 \\ 6.6 \\ 6.7 \\ 6.8 \\ 6.9 \\ 6.10 \\ 6.11 \\ 6.12 \\ 6.13 \\ 6.14 \\ 6.15 \end{array}$	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load Wear Rate vs. Load for specimens sintered for 1h Wear Rate vs. Load for specimens sintered for 3h Frictional Force vs. Load for specimens sintered for 1h Frictional Force vs. Load for specimens sintered for 2h Frictional Force vs. Load for specimens sintered for 3h SEM micrographs of specimens sintered for 3h	120 122 123 125 126 127 132 133 134 135 137 137
$\begin{array}{c} 6.3 \\ 6.4 \\ 6.5 \\ 6.6 \\ 6.7 \\ 6.8 \\ 6.9 \\ 6.10 \\ 6.11 \\ 6.12 \\ 6.13 \\ 6.14 \\ 6.15 \end{array}$	Wear Rate vs. Load for specimens sintered at 1100°C SEM micrograph of 5AFe900(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe900(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1000(3) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(1) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load SEM micrograph of 5AFe1100(2) (a) 200X (b) 5000X and (c) 10000X magnification after measurement at 2 Kg load Wear Rate vs. Load for specimens sintered for 1h Wear Rate vs. Load for specimens sintered for 3h Frictional Force vs. Load for specimens sintered for 1h Frictional Force vs. Load for specimens sintered for 3h SEM micrographs of specimens sintered for 3h	120 122 123 125 126 127 132 133 134 135 137 137 139

6.16	SEM micrographs of specimen 10AFe900(2) at (a) 200X (b) 500X and (c) 10000X magnification after measurement at 2.0	140
	Kg load	
6.17	SEM micrographs of specimen 10AFe900(3) at (a) 200X (b) 500X and (c) 10000X magnification after measurement at 2.0 Kg load	141
6.18	SEM micrographs of specimen 10AFe1000(3) at (a) 200X (b) 500X and (c) 10000X magnification after measurement at 2.0 Kg load	143
6.19	SEM micrographs of specimen 10AFe1100(1) at (a) 200X (b) 500X and (c) 10000X magnification after measurement at 2.0 Kg load	144
6.20	X-Ray diffraction pattern of representative nanocomposite specimen	148
6.21	(a) % Increase in specimen diameter for dry, solid lubricant and liquid lubricant conditions with different h/d ratios (b) % decrease in specimen height for dry, solid lubricating and liquid lubricating conditions with different h/d ratios	149
6.22	Undeformed Fe-Al ₂ O ₃ nanocomposite specimens (a) $h/d<1$ and (b) $h/d>1$	150
6.23	Deformed Fe-Al ₂ O ₃ nanocomposite specimens tested under different interfacial conditions (a) $h/d < 1$ and (b) $h/d > 1$	150
6.24	Bulge Profile of specimens having (a) $h/d<1$ (b) $h/d=1$ and (c) $h/d>1$ tested under dry condition (All Dimensions are in mm)	151
6.25	Bulge Profile of specimens having (a) h/d<1 (b) h/d=1 and (c) h/d>1 tested under solid lubricating condition (All Dimensions are in mm)	152
6.26	Bulge Profile of specimens having (a) h/d<1 (b) h/d=1 and (c) h/d>1 tested under liquid lubricating condition (All Dimensions are in mm)	153
6.27	Density vs. different h/d ratio specimens showing Green, Sintered and Deformed Conditions	155
6.28	% Densification vs. h/d Ratios for Dry, Solid Lubricating and Liquid Lubricating Conditions	156
6.29	Hardness vs. h/d Ratios for before and after deformation conditions	157
6.30	Scanning Electron Micrograph of etched surface of specimen 5AFe1100(1) at (a) 100X (b) 500X (c) 2000X and (d) 5000X magnifications respectively	159
6.32	Scanning Electron Micrograph of non-etched surface of specimen 5AFe1100(1) at (a) 1000X (b) 2000 X (c) 5000X and (d) 10000X magnifications respectively	161
6.33	EDAX and Compositional Analysis of non-etched surface of specimen 5AFe1100(1) (a) Full Frame (b) At a point and (c) On a particle	162

- 6.34 SEM of deformed specimen with h/d<1 in dry state at (a) 100X (b) 164 500X (c) 2000 X (d) 5000X (e) 10000X and (f) 15000X
- 6.35 SEM of deformed specimen with h/d<1 in solid lubricating 165 (Graphite Powder) at (a) 100X (b) 500X (c) 2000 X (d) 5000X (e) 10000X and (f) 15000X
- 6.36 SEM of deformed specimen with h/d<1 in liquid lubricating (Oil) 166 at (a) 100X (b) 500X (c) 2000 X (d) 5000X (e) 10000X and (f) 15000X
- 6.37 SEM of deformed specimen with h/d=1 in dry state at (a) 100X (b) 169 500X (c) 2000 X (d) 5000X (e) 10000X and (f) 30000X
- 6.38 SEM of deformed specimen with h/d=1 in solid lubricating 170 (Graphite Powder) state at (a) 100X (b) 500X (c) 2000 X (d) 5000X (e) 10000X and (f) 30000X
- 6.39 SEM of deformed specimen with h/d>1 in dry state at (a) 100X (b) 172
 500X (c) 1000 X (d) 5000X (e) 10000X and (f) 15000X
- 6.40 SEM of deformed specimen with h/d>1 in solid lubricating 173 (Graphite Powder) state at (a) 100X (b) 500X (c) 1000 X (d) 5000X (e) 10000X and (f) 15000X

Chapter 7 Studies on Structural and Mechanical Characterization of CoO 179 and CeO₂ Doped Fe-Al₂O₃ Metal Matrix Nanocomposites

- 7.1 XRD plot of (a) 10AFe0.5Co1100(1) (b) 10AFe1.0Co1100(1) (c) 180 Pure Fe+0.5% CoO
- 7.2 SEM micrograph of 10AFe0.5Co1100(1) (a) 1000X magnification 181 of the test specimen (b) 2500X magnification of circle portion in (a) (c) 5000X magnification of circle portion in (b) and (d) 15000X magnification of circled portion in (c); the current micrograph also shows nanosize particles
- 7.3 SEM micrograph of 10AFe1.0Co1100(1) (a) 1000X magnification 182 of the test specimen (b) 2500X magnification of circle portion in (a) (c) 5000X magnification of circle portion in (b) and (d) 15000X magnification of circled portion in (c); the current micrograph also shows nanosize particles
- 7.4 SEM micrograph of Pure Fe + 0.5% CoO (a) 1000X magnification 183 of the test specimen (b) 2500X magnification of circle portion in (a) (c) 5000X magnification of circle portion in (b) and (d) 15000X magnification of circled portion in (c); the current micrograph also shows nanosize particles
- 7.5 Wear Rate vs. Load plot for specimen (a) 10AFe0.5Co1100(1) (b) 186
 10AFe1.0Co1100(1) and (c) Pure Fe+0.5% CoO
- 7.6 SEM of specimen 10AFe0.5Co1100(1) after wear test (a) 500X (b) 188 5000X and (c) 20000X
- 7.7 SEM of specimen 10AFe1.0Co1100(1) after wear test (a) 500X (b) 189 5000X and (c) 20000X

7.8	SEM of specimen Pure Fe+0.5% CoO after wear test (a) 500X (b)	190
79	XRD pattern of specimen (a) 10AFe0 5Ce1100(1)	192
1.9	(b) $10AFe1 0Ce1100(1)$ and (c) Pure Fe+0 5% CeO ₂	172
7 10	SEM of 10AFe0 5Ce1100(1) at (a) 200X (b) 1000X (c) 5000X and	194
/.10	(d) 10000X respectively	171
7.11	SEM of 10AFe1.0Ce1100(1) at (a) 200X (b) 1000X (c) 5000X and	195
	(d) 10000X respectively	
7.12	SEM of Pure Fe+0.5% CeO ₂ at (a) 200X (b) 1000X (c) 5000X and	196
	(b) 10000X respectively	
7.13	Full frame microscopic investigation of specimen	197
	10AFe0.5Ce1100(1) (a) SEM image (b) full frame EDAX (c)	
	elemental profile	
7.14	Regional microscopic investigation of specimen	198
	10AFe0.5Ce1100(1) (a) SEM image (b) full frame EDAX (c)	
	elemental profile	
7.15	Full frame microscopic investigation of specimen	199
	10AFe1.0Ce1100(1) (a) SEM image (b) full frame EDAX (c)	
	elemental profile	
7.16	Regional microscopic investigation of specimen	200
	10AFe1.0Ce1100(1) (a) SEM image (b) full frame EDAX (c)	
	elemental profile	
7.17	Full frame microscopic investigation of specimen Pure Fe+0.5%	201
	CeO_2 (a) SEM image (b) full frame EDAX (c) elemental profile	
7.18	Regional microscopic investigation of specimen Pure Fe+0.5%	202
	CeO_2 (a) SEM image (b) full frame EDAX (c) elemental profile	
7.19	Wear Rate vs. Load Plots (a) 10AFe0.5Ce1100(1) (b)	205
	10AFe1.0Ce1100(1) and (c) Pure Fe+ $0.5%$ CeO ₂	
7.20	SEM of worn specimen 10AFe0.5Ce1100(1) after wear test (a)	206
	200X (b) 2500X and (c) 10000X	
7.21	SEM of worn specimen 10AFe1.0Ce1100(1) after wear test (a)	207
	200X (b) 2500X and (c) 10000X	• • • •
7.22	SEM of specimen Pure Iron doped with 0.5% CeO ₂ after wear test	208
	(a) 200X (b) 2500X and (c) 10000X	
Chapter 8	Studies on Structural and Mechanical Characterization of	211
	Fe-Al ₂ O ₃ -ZrO ₂ Hybrid Metal Matrix Nanocomposites	
8.1	XRD plots of specimens (a) 2.5Zr2.5AFe900(1) (b)	213
	2.5Zr2.5AFe900(2) and (c) 2.5Zr2.5AFe900(3)	
8.2	XRD plots of specimen (a) 2.5Zr2.5AFe1000(1) (b)	214
	2.5Zr2.5AFe1000(2) and (c) 2.5Zr2.5AFe1000(3)	
8.3	XRD plots of specimen (a) 2.5Zr2.5AFe1100(1) (b)	215
	2.5Zr2.5AFe1100(2) and (c) 2.5Zr2.5AFe1100(3)	

8.4	SEM micrograph of specimen $2.5Zr2.5AFe900(1)$ at (a) 1000X (b) 5000X (c) 10000X and (d) 25000X respectively.	216
8.5	SEM micrograph of specimen $2.5Zr2.5AFe900(2)$ at (a) 1000X (b)	217
8.6	5000X (c) $10000X$ and (d) $25000X$ respectively SEM micrograph of specimen 2.5Zr2.5AFe900(3) at (a) $1000X$ (b)	218
8.7	SEM micrograph of specimen 2.5Zr2.5AFe1000(1) at (a) 1000X (b) 5000X (c) 10000X and (d) 25000X respectively	220
8.8	Full Frame EDS and elemental profile of specimen 2 57r2 5 A Fe1000(1) at (a) 5000X and (b) 25000X respectively	221
8.9	SEM micrograph of specimen $2.5Zr2.5AFe1100(1)$ at (a) 1000X (b) 5000X (c) 10000X and (d) 25000X respectively	222
8.10	Full Frame EDS and elemental profile of specimen 2 57r2 5AFe1100(1) at (a) 5000X and (b) 25000X respectively	223
8.11	SEM micrograph of specimen $2.5Zr2.5AFe1100(2)$ at (a) 1000X (b) 5000X (c) 10000X and (d) 25000X respectively	224
8.12	Full Frame EDS and elemental profile of specimen 2.57r2.5AFe1100(2) at (a) 5000X and (b) 25000X respectively	225
8.13	SEM micrograph of specimen $2.5Zr2.5AFe1100(3)$ at (a) 1000X (b) 5000X (c) 10000X and (d) 25000X respectively	226
8.14	Full Frame EDS and elemental profile of specimen 2 57r2 5AFe1100(3) at (a) 5000X and (b) 25000X respectively	227
8.15	Density vs. Sintering Temperature plot of various 2.5Zr2.5AFe	229
8.16	Hardness vs. Sintering Temperature plot of various 2.5Zr2.5AFe	230
8.17	Wear Rate vs. Load plot for specimen sintered at 1000°C	232
8.18	Wear Rate vs. Load plot for specimen sintered at 1100°C	233
8.19	Worn SEM micrograph of specimen 2.5Zr2.5AFe1000(1) at (a) 500X (b) 2000X (c) 5000X and (d) 25000X respectively	234
8.20	Worn SEM micrograph of specimen 2.5Zr2.5AFe1100(1) at (a) 500X (b) 2000X (c) 5000X and (d) 25000X respectively	235
8.21	Worn SEM micrograph of specimen 2.5Zr2.5AFe1100(2) at (a) 500X (b) 2000X (c) 5000X and (d) 25000X respectively	236
8.22	XRD plots of specimen (a) 3.5Zr1.5AFe900(1) (b) 3.5Zr1.5AFe900(2) and (c) 3.5Zr1.5AFe900(3)	238
8.23	XRD plots of specimen (a) $3.5Zr1.5AFe1000(1)$ (b) 3.5Zr1.5AFe1000(2) and (a) $3.5Zr1.5AFe1000(3)$	239
8.24	XRD plots of specimen (a) $3.5Zr1.5AFe1100(1)$ (b) 3.5Zr1.5AFe1100(2) and (c) $3.5Zr1.5AFe1100(3)$	240
8.25	SEM micrograph of specimen 3.5Zr1.5AFe900(1) at (a) 500X (b) 1000X (c) 5000X and (d) 20000X respectively	241

8.26	SEM micrograph of specimen 3.5Zr1.5AFe900(2) at (a) 500X (b) 1000X (c) 5000X and (d) 20000X respectively	242
8.27	SEM micrograph of specimen $3.5Zr1.5AFe900(3)$ at (a) $500X$ (b) $1000X$ (c) $5000X$ and (d) $20000X$ respectively.	243
8.28	SEM micrograph of specimen 3.5Zr1.5AFe1000(1) at (a) 500X (b) 1000X (c) 5000X and (d) 20000X respectively	244
8.29	SEM micrograph of specimen 3.5Zr1.5AFe1100(1) at (a) 500X (b) 1000X (c) 5000X and (d) 20000X respectively	246
8.30	SEM micrograph of specimen 3.5Zr1.5AFe1100(2) at (a) 500X (b) 1000X (c) 5000X and (d) 20000X respectively	247
8.31	SEM micrograph of specimen 3.5Zr1.5AFe1100(3) at (a) 500X (b) 1000X (c) 5000X and (d) 25000X respectively	248
8.32	Density vs. Sintering Temperature plot of various 3.5Zr1.5AFe specimens	249
8.33	Hardness vs. Sintering Temperature plot of various 3.5Zr1.5AFe specimens	250
8.34	Wear Rate vs. Load plots for specimen sintered at 1000°C	252
8.35	Wear Rate vs. Load plots for specimen sintered at 1100°C	253
8.36	Microstructure of worn specimen 3.5Zr1.5AFe1000(1) after 2.0 Kg load at (a) 500X (b) 1000X and (c) 2000 X magnification respectively	255
8.37	Microstructure of worn specimen 3.5Zr1.5AFe1000(2) after 2.0 Kg load at (a) 500X (b) 1000X and (c) 2000X magnification respectively	256
8.38	Microstructure of worn specimen 3.5Zr1.5AFe1100(2) after 2.0 Kg load at (a) 500X (b) 1000X and (c) 2000X magnification respectively	257
8.39	Microstructure of worn specimen 3.5Zr1.5AFe1100(3) after 2.0 Kg load at (a) 500X (b) 1000X and (c) 2000X magnification respectively	258
Chapter 9	Corrosion Behavior of Fe-Al ₂ O ₃ Metal Matrix Nanocomposites	261
9.1	Tafel plots of the specimens 5AFe900(1), 5AFe1000(1) and 5AFe1100(1) sintered for 1h at different temperatures	262
9.2	Tafel plots of the specimens 5AFe1100(1), 5AFe1100(2) and 5AFe1100(3) sintered at same temperature for different times of sintering	263
9.3	Corrosion Rate vs. Sintering Temperature of Fe-5% Al ₂ O ₃ nanocomposite specimens	265
9.4	Corrosion Rate vs. Sintering Time of Fe-5% Al ₂ O ₃ nanocomposite specimens	266
9.5	XRD plots of Specimens (a) 5AFe1000(3) and (b) 5AFe1100(1)	267
9.6	SEM of specimen 5AFe1000(3) (a) 3000X and (b) 10000X magnification after corrosion in 1N HCl	268

9.7	SEM of specimen 5AFe1100(1) (a) 3000X and (b) 10000X	268
9.8	Tafel polarization plots of specimens 10AFe900(2), 10AFe1000(2) and 10AFe1100(2) sintered for 2h at different	271
9.9	sintering temperatures Tafel polarization plots of specimens 10AFe1000(1), 10AFe1000(2) and 10AFe1000(3) sintered at 1000°C for	272
9.10	different sintering times Tafel polarization plots of specimens 10AFe1100(1), 10AFe1100(2) and 10AFe1100(3) sintered at 1100°C for different sintering times	273
9.11	E_{corr} , I_{corr} and Corrosion Rate vs. Sintering Temperature plot for different sintering time intervals	273
9.12	XRD plots of specimen 10AFe900(1) and 10AFe900(2) after corrosion in 1N HCl solution	277
9.13	XRD plots of specimen 10AFe1000(1) and 10AFe1100(2) after corrosion in 1N HCl solution	277
9.14	SEM of specimen 10AFe900(1) at (a) 500X (b) 2000X (c) 5000 X and (d) 15000 X magnifications after corrosion in 1N HCl	279
9.15	SEM of specimen 10AFe900(2) at (a) 500X (b) 2000X (c) 5000X and (d) 15000 X magnifications after corrosion in 1N	280
9.16	SEM of specimen 10AFe1000(1) at (a) 500X (b) 2000X (c) 5000 X and (d) 15000 X magnifications after corrosion in 1N	281
9.17	SEM of specimen 10AFe1100(2) at (a) 500X (b) 2000X (c) 5000 X and (d) 15000 X magnifications after corrosion in 1N	283
9.18	Tafel Polarization plots of cobalt oxide doped specimens	285
9.19	XRD pattern of corroded surfaces of (a) Pure Fe (b) 10AFe0.5Co1100(1) (c) 10AFe1.0Co1100(1) and (d) Pure Fo+0.5% CoO specimens respectively.	287
9.20	SEM micrograph of Pure Iron specimen after corrosion in 1N HCl at (a) 1000X (b) 2000X and (c) 5000X magnification	288
9.21	SEM and EDAX of different regions (a, b, and c) for pure iron	289
9.22	SEM of the specimen 10AFe0.5Co1100(1) after corrosion in 1N HCl at (a) 1000X (b) 2000X and (c) 5000X magnification respectively	291

9.23	SEM and EDAX of different regions (a, b, c and d) of the specimen 10AFe0.5Co1100(1) after corrosion in 1N HCl at 2000X magnification	292
9.24	SEM of the specimen 10AFe1.0Co1100(1) after corrosion in 1N HCl at (a) 1000X (b) 2000X (c) 5000X and (d) 20000X	293
	magnification respectively	204
9.25	SEM and EDAX of full frame view for specimen	294
	10AFe1.0Co1100(1) after corrosion in 1N HCl at 2000X	
0.00	magnification at 20000X magnification	205
9.26	SEM and EDAX of full frame of the specimen	295
	10AFe1.0Co1100(1) showing nano size particles after corrosion	
0.27	IN IN HUI SEM and EDAY of different regions (a, b, and c) for superiment	207
9.27	SEM and EDAX of different regions (a, b, and c) for specimen	297
	magnification	
0.28	SEM of pure iron specimen with 0.5% CoO offer correction in	200
9.28	1N LICI at (a) 1000X (b) 2000X (a) 5000X and (d) 50000X	298
	IN HCI at (a) $1000X$ (b) $2000X$ (c) $5000X$ and (d) $50000X$	
0.20	SEM and EDAX of full frame of muse incer an environ with 0.5%	200
9.29	SEM and EDAX of full frame of pure from specimen with 0.5%	299
0.20	CoO after corrosion in TN HCI at 5000X magnification	201
9.30	latel Polarization plots of cerium oxide doped specimens	301
9.31	XRD pattern of corroded surfaces of	304
	(a) 10AFe0.5Ce1100(1) (b) 10AFe1.0Ce1100(1) and (c) Pure	
	Fe+0.5% CeO ₂ specimens respectively	•••
9.32	SEM of specimen Pure Fe+ 0.5% CeO ₂ after corrosion in 1N	305
	HCl at (a) 100X (b) 500X (c) 1000X and (d) 4000X	
	magnification respectively	• • •
9.33	SEM of specimen 10AFe0.5Ce1100(1) after corrosion in 1N	306
	HCl at (a) 100X (b) 500X and (c) 1000X magnification	
	respectively	
9.34	SEM of specimen 10AFe1.0Ce1100(1) after corrosion in 1N HCl at (a) 100X (b) 1000X and (c) 4000X magnification respectively	307