List of Tables

1.1	Parameters and properties of the research work	3
2.1	Availability of various elements from the earth crust.	38
2.2	Generally adopted nomenclature for various degree of aluminium purity	39
2.3	Solid solubility of various elements in aluminium.	39
2.4	The density of molten 99.996% aluminium.	39
2.5	Designation of wrought aluminium alloys.	41
2.6	Designation of cast aluminium alloys.	45
2.7	Thermal expansion of aluminium.	51
2.8	Mechanical properties of aluminium.	51
2.9	Similar work reported by different researchers	67
3.1	Process Parameters	71
4.1	Chemical composition of as supplied raw materials by Energy Dispersive Spectros (EDS)	copy 93
4.2	X-Ray diffraction values of as received commercially pure aluminium	95
4.3	X-Ray diffraction values of as received MnO_2 powder	95
4.4	Sieve analysis of MnO_2 powder.	96

4.5	Chemical compositions of various Al-Mg systems by spectroscopy (Element Recovery).) 7
4.6	X-Ray diffraction values of Al-3 wt % Mg sample)8
4.7	Chemical compositions of various $Al-MnO_2$ systems by spectroscopy (Element Recovery))7
4.8	X-Ray diffraction values of Al-2.5 wt % MnO_2 system in sequence A 10)9
4.9	X-Ray diffraction values of Al-2.5 wt % MnO_2 system in sequence B 11	0
4.10	Chemical compositions of various $Al - Mg - MnO_2$ systems by spectroscopy 11	7
4.11	X-Ray diffraction values of Al-1 wt % MnO_2 system in sequence A	9
4.12	X-Ray diffraction values of Al-2.5 wt % MnO_2 system in sequence A 12	20
4.13	X-Ray diffraction values of Al-4 wt % MnO_2 system in sequence A	21
4.14	X-Ray diffraction values of Al-1 wt % MnO_2 system in sequence B	22
4.15	X-Ray diffraction values of Al-2.5 wt % MnO_2 system in sequence B 12	23
4.16	X-Ray diffraction values of Al-4 wt % MnO_2 system in sequence B	24

List of Figures

1.1	Generalised flow sheet of present work methodology.	6
2.1	A classification of composite materials based on matrix materials.	9
2.2	A classification of composite materials based on reinforcement materials	10
2.3	Different types of fiber reinforced composites.	14
2.4	Laminar composite.	15
2.5	Sandwich panel.	16
2.6	Different composite manufacturing techniques.	18
2.7	Single action compaction of powder mix.	20
2.8	Sintering stages: (1) initiation of bonding at contact points; (2) formation of the necks; (3) reduction of pore size; and (4) development of the grain boundaries	21
2.9	Three particle model showing various diffusion mechanisms	21
2.10	Wettability phenomena.	24
2.11	(a) Large θ gives non-wetting condition and (b) small θ gives wetting condition	24
2.12	Wetting phenomena between two different grains during liquid phase sintering occurs when θ_A and θ_B approach zero.	25
2.13	Schematic diagram of spray deposition method.	30
2.14	Line diagram of stir casting.	31
2.15	Mechanical Stirring by impeller.	31

2.16	Schematic illustration of infiltration process.	32
2.17	Schematic illustrations of major infiltration processes: (a) spontaneous infiltration, (b) squeeze casting, (c) gas pressure infiltration, and (d) centrifugal infiltration	33
2.18	Schematic diagram of squeeze casting method	35
2.19	Classifications of the Squeeze Casting process	36
2.20	Direct and indirect squeeze casting: (a) Direct Squeeze Casting and (b) Indirect Squeeze Casting.	36
2.21	The principle aluminium alloys.	41
2.22	Phase diagram of aluminium silicon alloy.	46
2.23	Variation of properties with manganese amount.	48
2.24	Variation of yield strength with different elements.	49
2.25	Ex-situ composite and microstructures showing various phases in (a) $AA7075Al - SiC$ and (b) $AA7075Al - Al_2O_3$	53
2.26	In-situ composite and microstructures showing various generated phases	54
2.27	Case I: Addition of MO in molten aluminium	55
2.28	Case II: Addition of MC in molten aluminium.	55
2.29	Case III: Addition of MOC in molten aluminium	55
2.30	Applications of the Aluminium Metal Matrix Composites (AMMCs) in various fields.	59
3.1	The schematic diagram of the experiment set-up used.	72
3.2	Four blade turbine type stainless steel stirrer used in present work.	73
3.3	Metallic die used in present work.	73
3.4	(a) Raw CPA, (b) MnO_2 powder, (c) solid magnesium block and (d) fluxing powder and degassing tablet powder.	74
3.5	Placing and setting up the crucible filled with charge materials in the resistance heating furnace.	75

3.6	Resistance heating furnace before and after experimentation	75
3.7	Flow chart of experimental steps followed in phase I	76
3.8	Solidified AMMC in metallic die.	78
3.9	Checking final yield after solidification of the AMMC (weight measurement).	78
3.10	Manual sample cutting by hacksaw.	78
3.11	Preparation of hardness and microstructure samples.	79
3.12	Preparation of tensile specimens.	79
3.13	Flow chart of experimental steps followed in Sequence A of phase II	80
3.14	Flow chart of experimental steps followed in Sequence B of phase II	81
3.15	Flow chart of experimental steps followed in Sequence A of phase III	83
3.16	Flow chart of experimental steps followed in Sequence B of phase III	85
3.17	Measurement of density by Pycnometer.	87
3.18	Monsanto-20 tensile testing machine and its accessories.	88
3.19	Typical dimensions of the specimens for the tensile test.	89
3.20	Brinell hardness testing machine.	90
3.21	Scanning electron microscope.	91
3.22	X-ray diffraction machine.	92
4.1	Typical XRD pattern of (a) Commercially Pure Aluminium (CPA) and (b) MnO_2 powder in as received condition.	94
4.2	(a) Optical microstructure of Commercially Pure Aluminium (CPA) and (b) SEM image of MnO_2 powder at 100X.	95
4.3	Typical XRD pattern of Al-3 wt % Mg system	98
4.4	Variation of density in Al-Mg system.	99
4.5	Variation of ductility in Al-Mg system.	100

4.6	Variation of the hardness in Al-Mg system
4.7	Variation of the ultimate tensile strength in Al-Mg system
4.8	Optical Microstructure of (a) 0.05 wt % Mg, (b) 0.15 wt % Mg, (c) 0.5 wt % Mg, (d) 1 wt % Mg, (e) 1.5 wt % Mg, and (f) 2 wt % Mg of Al-Mg system at 100x magnification (Without Etching)
4.9	Optical Microstructure of (a) 3 wt % Mg, (b) 4 wt % Mg, (c) 5 wt % Mg, (d) 6 wt % Mg and (e) 7 wt % Mg of Al-Mg system at 100x magnification (Without Etching) 104
4.10	SEM images of (a) 0.05 wt % Mg, (b) 0.15 wt % Mg, (c) 0.5 wt % Mg, (d) 1 wt % Mg, (e) 1.5 wt % Mg, and (f) 2 wt % Mg of Al-Mg system at 500x magnification (Without Etching)
4.11	SEM images of (a) 3 wt % Mg, (b) 4 wt % Mg, (c) 5 wt % Mg, (d) 6 wt % Mg and (e) 7 wt % Mg of Al-Mg system at 500x magnification (Without Etching)
4.12	Manganese recovery in $Al - MnO_2$ system
4.13	Fe/Si ratio of $Al - MnO_2$ system
4.14	Typical XRD pattern of Al-2.5 wt % MnO_2 system in sequence A of $Al - MnO_2$ system. 109
4.15	Typical XRD pattern of $Al - 2.5wt\%MnO_2$ system in sequence B of $Al - MnO_2$ system
4.16	Variations of density in sequence A and sequence B of $Al - MnO_2$ system 111
4.17	Variations of ductility in sequence A and sequence B of $Al - MnO_2$ system 112
4.18	Variations of hardness in sequence A and sequence B of $Al - MnO_2$ system 112
4.19	Variations of ultimate tensile strength in sequence A and sequence B of $Al - MnO_2$ system
4.20	Sequence A Optical microstructure of (a) $0.5 \text{ wt } \% MnO_2$, (b) $1 \text{ wt } \% MnO_2$, (c) $1.5 \text{ wt } \% MnO_2$, (d) $2 \text{ wt } \% MnO_2$, (e) $2.5 \text{ wt } \% MnO_2$, (f) $3 \text{ wt } \% MnO_2$, (g) $3.5 \text{ wt } \% MnO_2$ and (h) $4 \text{ wt } \% MnO_2$ of $Al - MnO_2$ system at 100x magnification (Without Etching)

4.21	Sequence B Optical microstructure of (a) $0.5 \text{ wt } \% MnO_2$, (b) $1 \text{ wt } \% MnO_2$, (c) $1.5 \text{ wt } \% MnO_2$, (d) $2 \text{ wt } \% MnO_2$, (e) $2.5 \text{ wt } \% MnO_2$, (f) $3 \text{ wt } \% MnO_2$, (g) $3.5 \text{ wt } \% MnO_2$ and (h) $4 \text{ wt } \% MnO_2$ of $Al - MnO_2$ system at 100x magnification (Without Etching)
4.22	SEM images of 2.5 wt % MnO_2 in sequence A at (a) 100x and (b) 500x magnification (Without Etching)
4.23	SEM images of 2.5 wt % MnO_2 in sequence B at (a) 100x and (b) 500x magnification (Without Etching)
4.24	Mn recovery in sequence A and sequence B of $Al - 3wt\%Mg - MnO_2$ system 118
4.25	Fe/Si ratio of $Al - 3wt\%Mg - MnO_2$ system
4.26	Typical X-ray diffraction patterns of 1 wt % MnO_2 in sequence A of $Al - 3wt\%Mg - MnO_2$ system
4.27	Typical X-ray diffraction patterns of 2.5 wt % MnO_2 in sequence A of $Al-3wt$ % $Mg-MnO_2$ system
4.28	Typical X-ray diffraction patterns of 4 wt % MnO_2 in sequence A of $Al - 3wt\%Mg - MnO_2$ system
4.29	Typical X-ray diffraction patterns of 1 wt % MnO_2 in sequence B of $Al - 3wt\%Mg - MnO_2$ system
4.30	Typical X-ray diffraction patterns of 2.5 wt % MnO_2 in sequence B of $Al-3wt$ % $Mg-MnO_2$ system
4.31	Typical X-ray diffraction patterns of 4 wt % MnO_2 in sequence B of $Al - 3wt$ % $Mg - MnO_2$ system
4.32	Variations of density in sequence A and B of $Al - 3wt\%Mg - MnO_2$ system 125
4.33	Variations of ductility in sequence A and B of $Al - 3wt\%Mg - MnO_2$ system 125
4.34	Variations of hardness in sequence A and B of $Al - 3wt\%Mg - MnO_2$ system 126
4.35	Variations of ultimate tensile strength in sequence A and B of $Al - 3wt\%Mg - MnO_2$ system
4.36	Optical microstructure of (a) 1 wt % MnO_2 , (b) 2.5 wt % MnO_2 and (c) 4 wt % MnO_2 of $Al - 3wt\%Mg - MnO_2$ system at 100x in sequence A (Without Etching) 128

- 4.38 Optical microstructure of (a) 1 wt % MnO_2 , (b) 2.5 wt % MnO_2 and (c) 4 wt % MnO_2 of Al - 3wt% $Mg - MnO_2$ system at 100x in sequence B (Without Etching). 130