LIST OF FIGURES

No.	Title	Page No.
Fig. 2.1	Classification based on the matrix used	6
Fig. 2.2	Classification of the processing routes to develop MMCs	8
Fig 2.3	Various stages of powder metallurgy process	11
Fig. 2.4	Schematic diagram of high energy ball milling	12
Fig. 2.5	Relationship of green density and compacting pressure	13
Fig. 2.6	A schematic diagram of sintering	14
Fig. 2.7	Microstructure showing the dispersion of TiC in Cu matrix	25
Fig. 3.1	Process flow chart of the composite preparation and its characterization	47
Fig. 3.2	Schematic diagram of the compaction press	49
Fig. 3.3	Schematic diagram of the furnace used in the present investigation	50
Fig. 3.4	Schematic diagram of the pin on disk testing rig	55
Fig. 4.1	(a) The morphology and (b) X-ray diffraction pattern of as-received Cu powder	56
Fig. 4.2	(a) The morphology and (b) X-ray diffraction pattern of Ni powder	57
Fig. 4.3	(a) The morphology and (b) X-ray diffraction pattern of TiC powder	57
Fig. 4.4	The SEM morphology of (a) Cu4Ni, (b) Cu4Ni-2TiC, (c) Cu4Ni-4TiC, (d) Cu4Ni-6TiC and (e) Cu4Ni-8TiC composite powders milled for 6 h	58
Fig. 4.5	Particle size distribution of (a) Cu4Ni, (b) Cu4Ni-2TiC, (c) Cu4Ni-4TiC, (d) Cu4Ni-6TiC and (e) Cu4Ni-8TiC composite powder milled for 6 h	59

Fig. 4.6	The morphology of Cu4Ni-4TiC composite powder after (a) 0 h, (b) 2 h, (c) 4 h and (d) 6 h of milling	60
Fig. 4.7	Particle size distribution of Cu4Ni-4TiC composite powders as a function of the milling times (a) 0 h, (b) 2 h, (c) 4 h and (d) 6 h	61
Fig. 4.8	The EDS spectra of Cu4Ni-4TiC composite powder milled for 6 h	61
Fig.4.9	XRD patterns of Cu4Ni–x wt. % TiC composite powders after 6 h MA	62
Fig. 4.10	XRD patterns of Cu4Ni–4TiC composite powders after 0, 2, 4 and 6 h of MA	63
Fig. 4.11	Compressibility curves of Cu4Ni-4TiC composite powder at different compaction pressure	65
Fig. 4.12	Compressibility curve of experimental data of Cu4Ni-4TiC composite powder fitted by (a) Panelli and Ambrosio Filho, (b) Heckel and (c) Ge's compaction equations	67
Fig. 4.13	Optical micrographs of sintered materials after 2 h milling showing microstructure of (a) Cu4Ni, (b) Cu4Ni-2TiC, (c) Cu4Ni-4TiC, (d) Cu4Ni-6TiC and (e) Cu4Ni-8TiC	69
Fig. 4.14	SEM micrographs of (a) Cu4Ni matrix alloy, (b) Cu4Ni-2TiC, (c) Cu4Ni-4TiC, (d) Cu4Ni-6TiC and (e) Cu4Ni-8TiC	70
Fig. 4.15	EDS analyses of (a) Cu4Ni alloy, (b) Cu4Ni-4TiC and (c) Cu4Ni-8TiC.	71
Fig. 4.16	HR-SEM micrograph of (a) Cu4Ni, (b) Cu4Ni-4TiC, (c) Cu4Ni-8TiC and (d) EDS analysis of Cu4Ni-4TiC composite	72
Fig. 4.17	XRD patterns of Cu4Ni–x wt. % TiC (x = 0, 2, 4, 6 and 8) composites sintered at 850°C	73

Fig. 4.18	Micro-hardness of Cu4Ni-4TiC composite with milling time	75
Fig. 4.19	Variation of micro-hardness of composites with TiC content	76
Fig. 4.20	Variation of electrical resistivity with TiC content	76
Fig. 5.1	Variation of coefficient of friction with sliding distance at normal load of (a) 5 N, (b) 10 N, (c) 15 N and (d) 20 N at a constant speed of 1.25 m/s	86
Fig. 5.2	Variation of coefficient of friction with sliding distance at normal load of (a) 5 N and (d) 20 N at a constant speed of 1 m/s	87
Fig. 5.3	Variation of coefficient of friction with sliding distance at normal load of (a) 5 N and (d) 20 N at a constant speed of 0.75 m/s	87
Fig. 5.4	Variation of average coefficient of friction with normal load	88
Fig. 5.5	Variation of average coefficient of friction with sliding speed at normal load of (a) 5 N and (b) 20 N	89
Fig. 5.6	The variation of the average coefficient of friction with hardness under 5 N and 20 N for Cu4Ni, Cu4Ni-2TiC,Cu4Ni-4TiC,Cu4Ni-6TiC, and Cu4Ni-8TiCcomposites	90
Fig. 5.7	Variation of coefficient of friction with TiC reinforcement at normal load of 5 N,10 N, 15 N and 20 N for a constant sliding speed of 1.25 m/s	91
Fig. 5.8	Variation of cumulative volume loss with sliding distance at normal load of (a) 5 N, (b)10 N, (c) 15 N and (d) 20 N for a constant sliding speed of 1.25 m/s	92

Fig. 5.9 Variation of cumulative volume loss with sliding distance at normal load of (a) 5 N and (d) 20 N for a constant sliding speed of 1 m/s 93

Fig. 5.10 Variation of cumulative volume loss with sliding distance at normal load of (a) 5 N and (d) 20 N for a constant sliding speed of 0.75 m/s 93

Fig. 5.11 Variation of wear rate with normal load 94

Fig. 5.12 Variation of wear rate with sliding speed at normal load of (a) 5 N and (b) 20 N 95

Fig. 5.13 Variation of wear coefficient with TiC reinforcement at constant sliding speed of 1.25 m/s 96

Fig. 5.14 Variation of wear rate with TiC reinforcement at normal load of 5, 10, 15 and 20 N for a constant sliding speed of 1.25 m/s 96

Fig. 5.15 SEM micrographs of worn surface of (a) Cu4Ni matrix alloy, (b) Cu4Ni-4TiC and (c) Cu4Ni-8TiC composite at load of 5 N and sliding speed of 1.25 m/s 97

Fig. 5.16 SEM micrographs of worn surface of (a) Cu4Ni matrix alloy, (b) Cu4Ni-4TiC and (c) Cu4Ni-8TiC composite at load of 10 N and sliding speed of 1.25 m/s. 98

Fig. 5.17 SEM micrographs of worn surface of (a) Cu4Ni matrix alloy, (b) Cu4Ni-4TiC and (c) Cu4Ni-8TiC composite at load of 15 N and sliding speed of 1.25 m/s 99

Fig.5.18 SEM micrographs of worn surface of (a) Cu4Ni matrix alloy, (b) Cu4Ni-4TiC and (c) Cu4Ni-8TiC composite at load of 20 N and sliding speed of 1.25 m/s 100

Fig.5.19	EDS of worn surface of (a) Cu4Ni matrix alloy, (b) Cu4Ni-2TiC (c) Cu4Ni- 4TiC, (d) Cu4Ni-6TiC, and (d) Cu4Ni-8TiC composite at load of 20 N and sliding speed of 1.25 m/s.	101
Fig.5.20	SEM micrograph of worn surface of (a) Cu4Ni, (b) Cu4Ni-4TiC and (c) Cu4Ni-8TiC composite at sliding speed of 0.75 m/s and at load of 5 N	102
Fig.5.21	SEM micrograph of worn surface of (a) Cu4Ni, (b) Cu4Ni-4TiC (c) Cu4Ni-8TiC composite at sliding speed of 0.75 m/s and at load of 20 N	103
Fig.5.22	SEM micrograph of worn surface of (a) Cu4Ni, (b) Cu4Ni-4TiCand (c) Cu4Ni-8TiC composite at sliding speed of 1 m/s and at load of 5 N	104
Fig.5.23	SEM micrograph of worn surface of (a) Cu4Ni, (b) Cu4Ni-4TiC and (c) Cu4Ni-8TiC composite at sliding speed of 1 m/s and at load of 20 N	105
Fig.5.24	SEM micrographs of wear debris of (a) Cu4Ni matrix alloy and (b) Cu4Ni- 4TiC	105
Fig. 6.1	Face centered, central composite design	114
Fig. 6.2	(a) Measured and predicted values of the volume loss; and (b) measured and predicted values of the coefficient of friction	122
Fig. 6.3	Surface plots and contour plots of the combined effects of wt.% of TiC and sliding distance on volume loss of composites	124
Fig. 6.4	Surface plots and contour plots of the combined effects of the wt.% TiC and load on volume loss of composites	124
Fig. 6.5	Surface plots and contour plots of the combined effects of the load and sliding distance on volume loss of composites	125

Fig. 6.6 Surface plots and contour plots of the combined effects of the wt.% of TiC and sliding distance on coefficient of friction of composites 125

Fig. 6.7 Surface plots and contour plots of the combined effects of the the wt.% TiC and load on coefficient of friction of composites 126

Fig. 6.8 Surface plots and contour plots of the combined effects of the load and sliding distance on coefficient of friction of composites 126

Fig. 6.9 Optimal conditions of process variables on the responses of composites 127