CONTENTS

ACKNOWLEDGEMENT ..... **xi**

LIST OF FIGURES ..... **xix**

LIST OF TABLES ..... **xxv**

LIST OF SYMBOLS ..... **xxvii**

PREFACE ..... **xxix**

CHAPTER 1 ..... **1**

INTRODUCTION AND LITERATURE REVIEW **1**

1.1 INTRODUCTION 1

1.2 METAL MATRIX COMPOSITE: AN OVERVIEW 3

1.2.2 Polymer matrix composite 4

1.2.3 Ceramic matrix composite 5

1.2.4 Metal matrix composite 5

1.3 FABRICATION TECHNIQUES OF MMCS 7

1.3.1 Liquid state techniques 7

1.3.2 Solid state techniques 9

1.4 POWDER METALLURGY, PROCESSING, AND DEVELOPMENT 10

1.4.1 Different powder production techniques 11

1.4.2 Synthesis of MMC by Powder Metallurgy 14

1.5 COPPER (Cu) BASED METAL MATRIX COMPOSITES 16

1.6 MOTIVATION FOR THE THESIS 19

1.7 COPPER – GRAPHITE (Cu-Gr) COMPOSITES 20

1.7.1 EFFECT OF VARIOUS PARAMETERS ON Cu-Gr COMPOSITES.....22

1.8 WEAR 24

1.8.1 Type of Wear.....26

1.8.2 Friction and its laws.....27

1.8.3 Operating conditions affecting wear.....28

1.8.4 Tribological Properties of Cu-Gr and of Cu-Gr hybrid composite.....29

1.9 TIC AS A REINFORCEMENT.....33

1.10 RESEARCH GAP IN THE LITERATURE 38

1.11 OBJECTIVES OF PRESENT STUDY.....39

CHAPTER 2 41

EXPERIMENTAL DETAILS 41

2.1 INTRODUCTION.....41

2.2 MATERIALS AND METHODS.....41

2.2.1 Preparation of the Copper-Graphite-TiC composite.....42

2.3 X-RAY DIFFRACTOMETER FOR PHASE ANALYSIS 44

2.4 DENSITY AND POROSITY 44

2.5 MICROSTRUCTURAL CHARACTERIZATION.....45

2.5.1 Optical Microscope (OM) 45

2.5.2 Scanning Electron Microscope (SEM) 46

2.6 MECHANICAL CHARACTERIZATION 46

2.6.1 Hardness 46

2.6.2 Compressive strength 46

2.7 TRIBOLOGICAL MESEAUREMENT AND WORN SURFACES STUDY 47

2.7.1 Wear and Friction 47

2.7.2 Surface topography 49

2.8 STATISTICAL MODELLING USING RESPONSE SURFACE METHODOLOG……49

CHAPTER 3 53

MORPHOLOGY AND MECHANICAL PROPERTIES OF COPPER-GRAPHITE-TiC COMPOSITES 53

3.1 INTRODUCTION 53

3.2 EFFECT OF SINTERING ON COPPER-GRAPHITE COMPOSITE 53

3.2.1 Density of copper- graphite composite 53

3.2.1 Hardness of copper- graphite composite 54

3.3 X-RAY DIFFRACTION (XRD) ANALYSIS 55

3.4 DENSITY AND POROSITY CALCULATION 56

3.5 OPTICAL MICROSCOPY 57

3.6 SCANNING ELECTRON MICROSCOPY 59

3.7 MECHANICAL PROPERTIES 64

3.8 CONCLUSIONS 66

CHAPTER 4 67

TRIBOLOGICAL PERFORMANCE OF COPPER-GRAPHITE-TIC COMPOSITES IN DRY SLIDING CONDITIONS 67

4.1 INTRODUCTION.....67

4.2 WEAR & FRICTION BEHAVIOR UNDER DRY SLIDING.....67

4.2.1 Influence of sliding distance.....67

4.2.2 Influence of sliding velocity.....71

4.2.3 Influence of load.....78

4.2.4 Influence of TiC content.....82

4.3 CONCLUSIONS.....92

CHAPTER 5.....93

TRIBOLOGICAL PERFORMANCE OF COPPER-GRAPHITE-TIC COMPOSITES IN LUBRICATING SLIDING CONDITIONS 93

5.1 INTRODUCTION.....93

5.2 WEAR & FRICTION BEHAVIOR UNDER LUBRICATING SLIDING.....93

5.2.1 Influence of sliding distance.....93

5.2.2 Influence of sliding velocity.....97

5.2.3 Influence of load.....101

5.2.4 Influence of TiC content.....106

5.3 CONCLUSIONS.....113

CHAPTER 6.....115

STATISTICAL MODELLING OF TRIBOLOGICAL PARAMETERS USING RESPONSE SURFACE METHODOLOGY.....115

6.1 INTRODUCTION 115

6.2 STATISTICAL MODELLING OF WEAR RATE AND COF IN DRY SLIDING CONDITION 116

6.2.1 Central composite design (CCD) 116

6.2.2 Quadratic model and analysis of variance 117

6.2.3 Regression equation for wear rate and COF 121

6.2.4 Validation of model and optimization of tribological parameters 130

6.3 STATISTICAL MODELLING OF WEAR RATE AND COF IN LUBRICATING SLIDING CONDITION 132

6.3.1 Central composite design (CCD) 132

6.3.2 Quadratic model and analysis of variance 134

6.3.3 Regression equation for wear rate and COF 137

6.3.4 Validation of model and optimization of tribological parameters 145

6.4 CONCLUSIONS 147

CHAPTER 7 149

MAJOR CONCLUSIONS 149

SUGGESTIONS FOR FUTURE WORK 151

REFERENCES 153