PREFACE

The demand of lightweight and high strength materials is increasing in automotive, aerospace and transportation applications due to strict environmental regulations and high fuel prices. The global need is to have fuel-efficient vehicles for energy conservation. There is a wide range of components such as cylinder blocks, cylinder liners, pistons, brake drums, connecting rods, etc., where we need materials with higher mechanical and tribological properties. But the conventional materials do not fulfil such requirements, composites can be tailored to provide combination of required properties with suitable choice of matrix and reinforcement. Apart from the monolithic composites, hybrid composites can be developed to meet the specific properties.

Hybrid composites are fabricated using two or more reinforcing material into metal matrix, offering more flexibility and reliability for engineering components. Properties of hybrid composite can be easily controlled by taking a suitable combination and composition of reinforcement particles. Hybrid composites have better properties than mono composites because they combine the advantages of more than one constituent reinforcement.

Al based composites can be produced by either exsitu process or insitu process. In exsitu process externally synthesized particulates added into the matrix, whereas in insitu process particulate are synthesized in matrix during fabrication. However, insitu technique have several advantages over exsitu technique such as homogeneous distribution of particulates, thermodynamically stable phase, good interfacial bonding with the matrix. Stir casting and cooling slope casting process can be the potential fabrication methods of composites due to its simplicity, low operation cost and near net shape forming capabilities.

The present investigation involves the synthesis of A356-Mg_2Si-TiB_2 hybrid composites with fixed 10wt.% of Mg_2Si and varying wt.% of TiB_2 reinforcement with 0, 1, 3 and 5 wt.% by stir casting and cooling slope (CS) casting route. The stir and CS cast hybrid composites were characterized for microstructural and consequent mechanical and tribological properties. Present thesis has been given in 8 chapters:

Chapter 1: This chapter provides an overview of the problem, as well as the scope and objectives of the investigations.

Chapter 2: This chapter presents literature reviews on the advancement of Al alloys and composites for automotive applications and their advantages and disadvantages, how Al based hybrid composites could be an alternative material for such applications. It describes various types of composites, metal matrix composites (MMCs), their advantages, applications, and fabrication methods with various matrices and reinforcements. It also describes insitu Mg_2Si reinforced composites, the growth morphology of the Mg_2Si reinforcements, different processing for refinement and modification of Mg_2Si reinforcement. Subsequently, presents the state of the knowledge about the microstructural, mechanical and tribological properties of various Al based hybrid composites.

Chapter 3: This chapter elaborates on the experimental techniques and instruments used to characterize the composites. The fabrication of A356-Mg_2Si-TiB_2 hybrid composite by stir casting and CS casting techniques with varying TiB_2 content. The hybrid composites have been characterized by X-ray diffraction, optical and scanning electron microscopy. Subsequently, the hardness, tensile and tribological properties have been evaluated.

Chapter 4: It deals with the microstructural characterization and mechanical properties of the hybrid composite with varying TiB_2 particles fabricated by stir casting and CS casting routes have been presented. It comprises XRD analysis data and interpretation for phase identification. It reveals three phases, Al, Mg_2Si and TiB_2, are present in the hybrid composites. Microstructural characteristics were studied using an optical microscope and scanning electron microscope. It shows that refinement of primary and eutectic Mg_2Si phase on the incorporation of TiB_2 particles as it acts as heterogeneous nuclei for the Mg_2Si phase. Applying the CS casting further improve the refinement and modification of phase morphology of the Mg_2Si and matrix phase owing to shearing action of the cooling slope and fragmentation of dendrites. CS casting technique also improve the distribution of Mg_2Si and TiB_2 particles in the hybrid composites. Mechanical test results indicate improvement in strength parameters such as ultimate tensile strength (UTS) and ductility with increased wt.% of TiB_2 particles. The behaviour of tensile fracture has been explained based on characteristics in fractography.

Chapter 5: This chapter includes the tribological behaviour of stir cast hybrid composites in dry sliding conditions. It was found that wear rate increases with increasing load and sliding distance. Increasing TiB_2 content in hybrid composites wear rate decreases while coefficient of friction increases and hybrid composite having 5 wt.% TiB_2 particles shows the minimum wear rate. The worn surfaces were examined using SEM attached with EDS and AFM. At low applied load and sliding distance mild/oxidative wear mode is dominant whereas at high applied load and sliding distance delamination is dominant wear mechanism. AFM analysis indicate that increasing TiB_2 content in hybrid composite surface roughness of worn surfaces decreases.

Chapter 6: This chapter presents the tribological behaviour of CS cast hybrid composites. Tribological properties of CS cast hybrid composites examined under varying applied load, sliding distance, sliding velocity, and varying wt.% of TiB_2. It has been found that CS cast hybrid composite have better wear resistance properties as compare to the stir cast hybrid composites. However, it was interesting to note that applying CS casting process, COF values also decreased even with an increase in TiB_2 content up to 3 wt.% of TiB_2. It could be due to higher matrix and Mg2Si phase refinement and better dispersion of reinforcements in the CS cast hybrid composites. Worn surfaces have been inspected using SEM and AFM and observed that abrasive wear is dominant wear mechanism at low applied load and sliding distance while plastic deformation and delamination is the dominant wear mechanism at higher load and sliding distance. AFM analysis reveals that lower surface roughness values even at higher load and sliding distance.

Chapter 7 This chapter presents the statistical modelling and optimization of tribological parameters of stir cast and CS cast hybrid composites using Response Surface Methodology (RSM). Design expert 13 software was used to optimize the response (wear rate and COF). Central composite design (CCD) is used to design the experiment. For analysis of wear rate and COF, quadratic model is suggested from fit summary as the R^2 value very close to 1. Analysis of variance (ANOVA) is used to check the significance, and p-value less than 0.05 and lack of fit insignificant specifies the adequacy of the developed model. Contour and surface plot for RSM is given to see the behaviour of wear rate and COF with varying input parameters and obtained results are in agreement with experimental results. Predicted and experimental values of wear rate and COF are found to be very close in the confirmatory test, also confirms that this model can be adequate for prediction of wear rate and COF.

Chapter 8: It includes the conclusions drawn from the current investigation as well as recommendations for the future scope.