CHAPTER 1

INTRODUCTION

Composite materials are important engineering materials due to their outstanding mechanical properties. Aluminum metal matrix composite (Al MMC) materials are one of the widely known composites because of their superior properties such as high strength, hardness, stiffness, and wear and corrosion resistances. By introducing a hard reinforced phase either in particulate or fiber form, the modulus and wear resistance of aluminum composites could be considerably improved [Ibrahim, (1991), Clyne, (1993), Lloyd , (1994)]. Silicon carbide particle (SiCp) reinforced aluminum-based MMCs are among the most common MMC and commercially available ones due to their economical production [Bedir (2004)]. Moreover, Wilson et al. (1996) investigated the high temperature dry sliding wear performance of different aluminum alloy composites. The authors concluded that addition of reinforced ceramic particles improves the wear resistance of the composite at higher temperature compared to pure alloy, SiC being more effective than Al_2O_3.

Al MMCs are used for Space Shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs and a variety of other applications. A prolonged diversion is seen in years ago in metal matrix composite, generally light metal based, which have discovered their applications in numerous industry branches, among others in the airship industry, car, and deadly implements ones, and in addition to electrical building and hardware, and so forth. Aluminum alloys are extensively used in aerospace and automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to conventional metals and alloys. Aluminum makes a defensive covering oxide being subsequently exceedingly consumption and safe also. Aluminum is an admirable electricity and heat conductor. Taya et.al, (1989) stated that the matrix can be selected on the basis of oxidation and corrosion resistance or other properties.

Aluminum is recyclable with low vitality for re-casting. It was reported that the energy consumed when aluminum is recycled is only about 5% of that required in the primary production of aluminum [John et al.,, (1993)].

Composite materials with aluminum metal matrix are produced by liquid state processing (stir casting, infiltration, squeeze casting etc.), semisolid processing and powder metallurgical methods. .The significant favorable factor of stir casting process is its appropriateness to large scale manufacturing. Compared with other production techniques, stir casting procedure costs are as low as low as 1/3rd to 1/10th for large scale manufacturing of metal matrix composites [Maruyama et al., (1998), Surappa et al., (1981)]. The importance of enhanced energy efficiency in current decades reflects the effects of increased gasoline and oil costs to the consumer and graduated government-mandated fuel-efficiency standards for automobile and truck manufacturers. Environmental concerns, global competitiveness and raw material concerns reinforce the incentives to reduce fuel consumption while preserving product performance and cost objectives. The most cost-effective means of addressing these challenges has been the submission of lightweight materials in existing and projected automotive design. The use of cast aluminum alloys in automotive structural applications is growing rapidly because of the need to reduce weight. One very crucial issue to consider in the selection of the matrix alloy composition involves the natural dichotomy between the wet ability of the reinforcement and excessive reactivity with it [McKimpson et al., (1989)].

Commercial aluminum alloys were selected by researchers for MMCs because they offer good mechanical properties, easily available and many of them are suitable for heat treatment. The common series of aluminum alloys are 1000 (Pure aluminum), 2000 (Al-Cu), 3000(Al-Mn), 4000 (Al-Si), 5000 (Al-Mg), 6000 (Al-Si-Mg), 7000 (Al-Zn-Mg) and 8000 (Al-Li).

From a material point of view, when compared to polymer matrix composites, the advantages of MMCs lie in their retention of strength and stiffness at elevated temperature, good abrasion and creep resistance properties. Most MMCs are still in the development stage or the early stages of production and are not so widely established as polymer matrix composites. The major complication in processing MMCs is achieving a homogeneous distribution of reinforcement in the matrix as it has a strong impact on the properties and the quality of the material [Naher, et al., (2005)]. Aluminium metal matrixes reinforced with particulate filler material (ceramic) have their isotropic properties and comparatively low costs are attracting researchers worldwide [Kala et al.,, (2014)].

A bird’s eye-view of the literature surveyed:

Iseki, et al. (1984)	Formation of Al_4C_3 and Si due to reaction SiCp with liquid aluminum is reported in this research.
Kamat et al., (1989)	The mechanical properties of Al2024/ Al_2O_3 composite was observed and concluded yield and ultimate tensile

	strength of the composite increased with increase in volume fraction of Al_2O_3 particles.
Kumar et al., (2008)	Fabrications of Al-7Si alloy composite reinforced with in situ TiB_2 were done and investigated it's mechanical and wear behavior in this research work. The authors observed that the increase in values of the hardness, ultimate tensile strength, the yield strength and the young modulus were observed with increase in weight percentage of TiB_2. Also the coefficient of friction and wear rate decreased with addition of TiB_2 compared to pure alloy.
David. et al., (2013)	The mechanical properties of stir cast (SiC + Fly Ash) reinforced aluminum (6061) hybrid composite were studied in this research. The author has revealed that the macro hardness and tensile strength of the composite increased with increase in wt. percent of the SiC particles.
Ashok et al, (2012).	The authors investigated the mechanical behavior of stir cast Al (6061) matrix composite reinforced with Al-N particles and concluded that ultimate tensile strength and yield strength of the composite was better than pure alloy. The author revealed that micro hardness and macro hardness of the composite increased with increase in percentage of Al-N into the alloy matrix.
Jinfeng et al., (2008)	The authors investigated the machining ability of SiC/Gr/Al composite and observed that tensile strength and elastic modulus of the composite was enhanced compared to pure matrix and it improved with increase in volume fraction of graphite.

Veeresh Kumar et.al., (2010)	The authors scrutinize the base matrix and the reinforcing phase of AA 6061, AA 7075 and particles of Al2O3 and SiC of size 20 µm. It can be observed that the densities of composites are higher than that of their base matrix, further the density increases with increased percentage of filler content in the composites. It can be observed that the tensile strength of the composites is higher than that of their base matrix also it can be observed that the increase in the filler content contributes in increasing the tensile strength of the composite. In microstructure studies it can be observed that, the distributions of reinforcements in the respective matrix are fairly uniform.
Nrip.Jit et. al. (2009) and Mohammad.B.N et. al. (2007)	Mechanical properties and homogeneity are depends on reinforced particulate size, weight percentage and processing methods.
Virgil Geaman (2009)	Virgil, emphasized his work on the range of duralumin alloys and determined the fact that alloying is enlarging the possibilities of precipitation hardening.
Manoj et al.(2009)	Manoj et al., concluded that with the increase in the weight percentage of SiC, increases the hardness and impact strength, also the study suggest that homogenous dispersion of SiC particles in the Al matrix shows an increasing trend in mechanical properties.
Balasivanandha et. al., (2006)	Stirring speed and stirring time influence the distribution of SiC in metal matrix and hardness of MMC.
Aqida et.al., (2004)	Aqida et.al., concluded that at a high speed porosity of MMC were increased drastically after certain limit of stirring speed also at low speed clustering of metal alloy and non homogenous micrographs are observed.
Karthikeyan et. al., (1999)	The authors concluded that Material removal rate of electro discharge machining decreases with an increase in the percent volume of SiC (25 µ size constant) in LM 25 aluminum alloy matrix, whereas the TWR and the surface roughness increase with an increase in the volume of SiC.

Balasubramaniam et. al., (2014)	The researchers concentrated on multiobjective optimization of machining parameters during the electrical discharge machining (EDM) of aluminum (Al 6061)-silicon carbide (SiC) metal matrix composites (MMC). The process parameters considered were current, pulse on-time, dielectric flushing pressure, and SiC particles. A copper rod was used as an electrode. An Al-SiC MMC with Al 6061 as matrix and SiC particles having three different sizes (i.e., 15, 25, and 40 μm) were used as work pieces. It was found that the material removal rate increases with increasing peak current, pulse on-time, flushing pressure, and particle size.

If we consider the Campbell concept of critical velocity (pouring speed) for aluminum casting, it should be less than 5 cm/s. Once these values are exceeded, the surface of the metal will behave in a turbulent fashion, i.e. there is a real risk that the surface will break up into waves and droplets, causing the oxide film defects [John et al., (1996)]. Turner research suggested 90 mm pouring height is suitable to prevent air entrainment in aluminum casting [Turner (1965)]. Din et.al, (1996) concluded based on rigorous experiments that 100 mm pouring height is appropriate for aluminum alloy casting and effective in prevention of damage of mould and entrainment of air in casting. Campbell (2004) concluded that pouring time should be 10 second for typical aluminum casting to prevent oxidation of molten metal and air entrainment in casting. Still rare literatures available on pouring speed of aluminum composite casting, so pouring speed is considered as one of the prime parameter in this research.

Aluminum alloy is utilized due to high weight to strength ratio and hence better fuel economy would be provided to the automobile and aircraft. The SiC reinforced particles in MMCs uncover higher quality than the relating base material. Subsequently, they are frequently utilized as a part of numerous commonsense applications, for example, brake rotors, suspension arms, lodgings, sections, and so on. Every one of these components is working for the most part at different working conditions where varieties of temperature, stacking sorts, and strains are observed. Along these lines, the associate of the constitutive conduct of MMCs is of incredible significance for a precise procedure outline. It must be watched nonetheless, that it is exceptionally troublesome or even unfeasible to figure an all inclusive solid law which covers no less than one sort of a metallic composite (e.g. aluminum-based composites). Such inconveniences show up because of an assortment of various reinforcement shapes and distributions, volume portions and molecule shapes which come about because of various methods for material fabrication.

The aim of present work is to optimize the process parameters for production of metal matrix composite so that the cost and the time of production can be minimized and maximize the mechanical properties, machining ability and wear resistant capacity of metal matrix composites. It is of crucial importance to understand the effect of different process parameters affecting the microstructure and consequently mechanical properties of the alloys.

The previous studies show that Al6061 alloy metal matrix composite has better mechanical properties than Al6063 and Al 7072 composites [Chennakesava et al., (20101)]. The work of U. S. Bureau of Standards on Duralumin shows that the addition of 4% Cu in aluminum the precipitation hardening and aging phenomena in alloy material are achieved. And also precipitation hardening prevents dislocation at molecular level itself and aging may enhance the yield strength of alloy material up to 200%. The addition of copper improves strength; it also makes these alloys susceptible to corrosion. Present work emphasized on the effect of different process parameters on Al6061-4% Cu-SiC_P MMCs on mechanical properties (hardness and impact strength), machining ability and wear resistant capacity. The other process parameters are stirring speed and pouring temperature effect. For these parameters optimization of different mechanical properties of MMCs are investigated under following three titles:

i) Effect of Pouring Speed on Mechanical Properties and Machining Properties.

ii) Effect of Stirring Speed And Pouring Temperature on Mechanical Properties and Machining Properties.

iii) Effect of Stirring Speed And Pouring Temperature on Wear Rate Of Al6061-Cu-Si_{cp} Metal Matrix Composites.