CHAPTER 1

INTRODUCTION

There is a constant requirement of novel materials for various engineering applications such as automotive, railways, marine and aerospace industries etc. Due to the wide range of applications, new materials are required to meet miscellaneous demands such as good mechanical strength, high resistance to wear, stable and high friction coefficient, elevated thermal stability, high stiffness, good anti-seizure behavior and resistance to corrosion. It is very complicated to attain such properties in monolithic form or solo material. Therefore, composite materials have been tailored to meet these combinations of properties for a wide range of engineering applications (Tjong, 2013; Rino et al., 2012).

Composite materials are developed by combining the two or more chemically dissimilar materials at a microscopic level. Composite materials display quite different physical, mechanical and tribological behaviors than the behaviors of the constituents due to their synergistic effect. The continuous constituent material is called matrix and the other discontinuously dispersed constituents in the matrix are called reinforcements. The design potentials are unbelievable due to availability of reinforcements and matrix in the wide range (Rohatgi et al., 1995). Such availability of wide variety of matrix and reinforcements explored the possibility of hybrid composite materials where two or more ceramic particles are reinforced in a soft metal matrix. Hybrid reinforced composites show improved behavior as compared to composites reinforced with single phase particles because it has the joint effects of its reinforcing constituents (Ramesh et al., 2009; Riaz et al., 2009).

The materials which are embedded with hard ceramic reinforcements generally known as discontinuously reinforced metal matrix composites (DMMCs) i.e. the reinforcements are embedded into materials. Thus, Metal matrix composites merge the toughness and ductility of the matrix with good modulus and strength of ceramic reinforcements, leading to a higher compression and shear strength along with the potential to retain its good properties at higher working temperature. It has been extensively investigated that the good physical, tribological and mechanical properties such as high specific modulus, strength, good wear resistance and thermal stability) can be achieved in metal matrix composites. Metal matrix composites are employed in marine, automotive, aerospace industries including other structural applications. The applications of composites have been increased during last few decades as a result of the accessibility of comparatively economical reinforcing phase and expansion of various processing techniques which produce the materials with repeatability of the properties. The groups of DMMCs include the composites which are reinforced with particles, whisker or short fiber.

Therefore, the metal matrix composites reinforced with particles (pMMCs) are of special attention due to its simplicity of production, lower expenditure, and isotropic properties. Conventionally, pMMCs have been developed by numerous processing routes such as mechanical alloying (MA), spray deposition, powder metallurgy and several casting processes, i.e. compo-casting, rheo-casting, and squeeze casting. The processing techniques are classified on the basis of incorporation of ceramic reinforcements into the matrix that may be in powder or molten state. It is well known that the reinforcement's size and its volume fraction as well as bonding nature with matrix always play the vital role to control the properties of metal matrix composites. An optimum set of properties can be observed when fine and thermally stable ceramic particles are homogeneously distributed in the matrix.

During the past decades, several processing techniques have been discovered to develop the particles-reinforced metal matrix hybrid composites (pMMCs) because of its potential for extensive applications. Many scientist and researchers have been elucidated the synthesis of particle reinforced hybrid composites (pMMCs) in which the ceramic particles are reinforced externally in molten metal matrix using stir-casting technique. In stir-casting technique, pMMCs with a broad range of matrix materials such as copper, titanium, aluminum, iron and nickel, and reinforcing phase like- nitrides, carbides, oxides, borides and their mixtures have been developed. The developed pMMCs exhibit excellent physical, mechanical and tribological properties as compared with metal matrix. Commercial application of this processing (stir-casting) technique needs an understanding of numerous key processing parameters.

Copper is an essential engineering material extensively used in its pure form and pure copper is the most significant material for the electrical industry. It has good electrical conductivity and corrosion resistance and is easy to manufacture. It has adequate tensile strength and the requisite and joining and soldering uniqueness. However, copper alloys and its composites are used significantly in mechanical engineering industries. Copper-based hybrid composites are specifically developed using stir-casting technique to fulfill these requisite purposes, by utilizing the different ceramic reinforcements in copper metal matrix. Copper alloys are generally used in the wrought forms of bar for good strength conductors, rod for spot welding electrodes, discs for aircraft brake and forged wheels for seam welding. Cast alloys find applications in electrode holders and electrical extinction equipment where the more intricate shape needed and so, uneconomical for machining.

Alloying technique to enhance strength of copper has the demerit of losing its electrical and thermal conductivities since solute atoms act as scattering centers for electrons and phonons. So it may not be recommended for alloying approach to enhance strength and performance of copper alloys. Hard ceramics reinforcement which has no solubility in copper is not expected to adversely affect the electrical or thermal conductivity. Therefore, development of copper-based composites using stir-casting technique can be a favourable approach to enhance strength and performance. So, copper-based composites have been promising materials for applications where strength and wear resistance are important along with electrical and thermal conductivities.

The objective of the present investigation is to develop binary and tertiary reinforced copper composites which are designated as Cu-2Cr-1WC-1ZrO_2 (Hybrid composite-1 (HC-1)), Cu-2Cr-1WC-1Al_2O_3 (HC-2), Cu-2Cr-1WC-2ZrO_2 (HC-3) and Cu-2Cr-1WC-2Al_2O_3 (HC-4). Whereas, tertiary reinforced hybrid composites are designated as Cu-2Cr-1.5WC-1BN-0B_4C (HC-5), Cu-2Cr-1.5WC-1BN-0.5B_4C (HC-6), Cu-2Cr-1.5WC-1BN-1B_4C (HC-7) and Cu-2Cr-1.5WC-1BN-1.5B_4C (HC-8) using stir-casting technique. In this process, the different ceramics reinforcing phases are added externally in the copper matrix and chromium is added to increase the wetability of the reinforcements. The developed copper hybrid composites are characterized through various techniques and explored its physical, mechanical and tribological behaviors. In the current investigation, the copper hybrid composites are developed with the goal to discover their best for various engineering applications such as shipping hulls, resistance welding electrodes, railways contacts, electrical contacts, copper tube-plumbing and fire sprinklers.