CHAPTER 1

INTRODUCTION

Novel materials are always needed for a variety of technical applications because of their numerous uses in sliding contact bearings, automotive sectors, carbon brushes in motors, bearing materials, and sliding contact between mating surfaces without lubrication. Copper metal matrix composites have become more demanding, and popular in recent years. A wide range of engineering applications make copper an exceptionally useful material for the above application. Because copper has outstanding corrosion resistance, high ductility, and great conductivity in both heat and electricity as a matrix material, it is used in many technological fields.

Metal matrix composites based on copper can be produced using a variety of reinforcements, such as graphite, graphene, molybdenum disulfide (MoS_2), carbon nanotube (CNT), etc. type of carbon called graphite gives the composite several advantages, including excellent self-lubricating capabilities, minimal friction, and great heat stability. The composite material's improved mechanical, thermal, and tribological (wear and friction) qualities result from combining copper and graphite. Applications for copper graphite composites include electrical engineering, where their superior conductivity is advantageous, and sliding electrical contacts and bearings, which are needed for good lubricating qualities. These composites' specially blended copper and graphite composition offers a balance of qualities appropriate for particular engineering applications. Graphite reinforcement in the copper matrix is commonly utilized in various applications such as brushes, electrical sliding contact, and bearing material (Bai et al., 2018; R & Rao, 2018; Wang et al., 2022).

Investigators have been experimenting with various combinations, both with and without solid lubricants, since the early days of composite material development to attain the intended tribological qualities. Therefore, other strategies such as surface modification (coatings) or the creation of self-lubricating composite materials have become practical means of effectively lubricating in such circumstances to reduce wear and friction. In order to minimize wear and friction between sliding surfaces, liquid lubricants are frequently used; nevertheless, because they are typically poisonous and do not biodegrade easily, they seriously harm the environment. Additionally, due to several restrictions, it is not always possible to utilize lubricants in every sliding circumstance. By developing self-lubricating composite materials, it is possible to eliminate the need for external lubricants. These materials can achieve low friction and wear at the contact surfaces without requiring external lubrication during sliding.

Investigators have also shown that incorporating secondary phase particles into copper graphite composites can improve the materials' mechanical strength and wear resistance.

According to several investigations, adding hard material to the base matrix to reinforce it can boost load-bearing capacity during sliding wear tests and improve thermal properties (Z.Q. et al., 2001; Murphy et al., 1992). Several studies have investigated the impact of secondary reinforcements in copper-graphite composites, including aluminum oxide (Al_2O_3), boron carbide(B_4C), Zirconium dioxide (ZrO_2), and silicon carbide (SiC). In contrast to their conventional copper-graphite counterparts, the hybrid reinforcements gradually enhanced the composites' mechanical and tribological properties. In contrast to their conventional copper-graphite composites, the hybrid reinforcements gradually enhanced the mechanical and tribological properties of the composites. New materials are needed to satisfy various requirements because of the broad range of applications, including good mechanical strength, high wear resistance, stable and high friction coefficient, raised thermal stability, high stiffness, good anti-seizure behaviour, and corrosion resistance. Any engineering system must have these three fundamental qualities: dependability, longevity, and efficiency. The engineering system's life, dependability, and efficiency may be impacted by the relative sliding motion between its links or components, which creates friction and wears down both parts by causing material loss. Wear, or the slow loss of material from rubbing surfaces due to mechanical action, typically the cause of machine failure rather than fracture.

A composite material is formed when two or more materials with distinct physical and chemical properties are mixed at a microscopic level, resulting in a combined material exhibiting different characteristics from its individual components. The production of composite materials is driven by the need to create materials that are stronger, lighter, or less expensive than traditional materials. The matrix is the continuous constituent material, while the reinforcements are the discontinuously dispersed constituents inside the matrix. The design possibilities are extraordinary because of the large range of available reinforcements and matrix materials (Rohatgi et al., 1995). The large range of matrix and reinforcements available has allowed for the development of hybrid composite materials, in which two or more ceramic elements are reinforced within a soft metal matrix. Because hybrid-reinforced composites have the combined effects of their reinforcing constituents, they exhibit behavior better than composites reinforced with single-phase particles (Ramesh et al., 2009). The qualities of the composite material are determined by the geometry and scales of the reinforcement phase, which can vary widely from micron to nanoscale.

Particle-reinforced Metal matrix composites (MMCs) have garnered particular interest because of their isotropic qualities, reduced cost, and ease of development. Various processing methods, including stir casting, spray deposition, and powder metallurgy, have developed discontinuously reinforced Metal matrix composites (MMCs). The basic principle of all these methods is the addition of reinforcements, either in powder or molten form, to the matrix materials. However, the primary challenges associated with the liquid metallurgical approach are the interfacial interactions between the reinforcements and the matrix and the inadequate bonding between the reinforcements and the matrix due to the reinforcements' surface contamination. It is commonly acknowledged that the size, volume fraction, and type of bonding at the matrix-reinforcement interfaces determine the characteristics of Metal matrix composites (MMCs).

The powder metallurgy (P/M) approach, a solid-state process, is considered the most suitable method to develop high-quality metal matrix composites (MMCs) compared to the other specified processing techniques. Powder metallurgy (P/M) is a well-known and tested processing method that has been utilized for the past 70 years to create high-quality products with a wide range of significant applications in electronics, aerospace, power tools, home appliances, and other industries. This is an efficient method to develop composites because of several benefits, including uniform distribution of reinforced particles that improves structural stability, dimensional control with an excellent surface finish, mitigation of reactions between the matrix and the reinforcement, and, consequently, improved bonding between the reinforcement particles and the matrix. The synthesis of materials that are challenging to process through other means is made possible by the versatility of the Powder metallurgy (P/M) approach.

The present investigation aims to develop copper-based hybrid metal matrix composites using the powder metallurgy (P/M) approach. copper composite can increase its wear resistance and hardness by mixing it with hard ceramic boron carbide (B_4C) and silicon carbide (SiC) particles and solid lubricant graphite (Gr). However, including chromium (Cr) in the matrix will enhance the bonding between the matrix and the reinforcements and increase the wettability between copper and ceramic support. This investigation aims to produce copper matrix composites using boron carbide (B_4C), silicon carbide (SiC), and carbon in the form of graphite through powder metallurgy. This work has addressed the development of copper chromium hybrid composites with boron carbide (B_4C), silicon carbide (SiC), and graphite reinforcement. Scanning electron microscopy (SEM) and X-ray diffraction analysis (XRD) analysis were used to investigate the morphology and microstructure of copper-chromium hybrid composites. Further mechanical, physical, and wear qualities were thoroughly studied to determine the effect of the reinforcements. The two different composites Cu-B_4C -Gr and Cu-SiC-Gr assigned as Cu-0Cr-0Gr-0B_4C (CU01/C1), Cu-2Cr-1.5Gr-1.5B_4C (CU02/C2), Cu2Cr-3Gr-3B_4C (CU03/C3), and Cu-2Cr-4.5Gr-4.5B_4C (CU04/C4), and Cu-0Cr-0Gr-0SiC (S1), Cu-2Cr-1.5 Gr-1.5SiC (S2), Cu-2Cr-3Gr-3SiC (S3), and Cu-2Cr-4.5Gr-4.5SiC (S4) respectively. The current study aims to determine which copper hybrid composites are best suited for a range of engineering applications, including sliding contact bearings, automotive sectors, carbon brushes in motors, bearing materials, and sliding contact between mating surfaces without lubrication.