ABSTRACT

In the present study, while considering several applications in the fields of sliding contact bearings, electronics, automotive, thermal management, heat exchangers, aircraft, rail transportation, and sliding contact between mating surfaces without lubrication, novel materials are always needed for a wide range of technical applications.

In the past few years, copper metal matrix composites have become more demanding and popular from an engineering and technological point of view. Copper is an incredibly valuable material for the application above due to its wide variety of engineering applications. Copper is employed in numerous technological domains because of its exceptional resistance to corrosion, excellent ductility, and great conductivity of heat and electricity when used as a matrix material.

To consider the ongoing demand for these materials, low-density copper metal is chosen as the matrix for the development of various copper-based hybrid metal matrix composites with improved performance. For this scientific and technical purpose, the powder metallurgy technique is considered the most suitable for developing copper-based hybrid metal matrix composites in the current investigation. This technique offers several advantages, including higher precision in forming the product and homogeneous distribution of particles. Additionally, it utilizes lower temperatures compared to other processing methods. The selection of hard ceramics reinforcing phases, such as (B_4C) and (SiC) particles, is supported by their ability to refine grain, their hardness, chemical stability, specific strength, good corrosion and wear resistance, and the presence of solid lubricant (Gr), which enhances wear resistance qualities. Adding chromium (Cr) to the matrix will improve the bonding between the matrix and the reinforcements and boost the wettability between copper and ceramic reinforcement. This investigation aims to make copper matrix composites by utilizing B4C,

SiC, and graphite in the form of carbon reinforced through the powder metallurgy technique. 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), Cu-2Cr-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, have been developed by powder metallurgy technique.

Following several characterizations, it is found that the produced hybrid metal matrix composites based on copper have superior mechanical and tribological characteristics than copper matrix because of uniform dispersion and high wettability of the reinforcing Phases found in the matrix of copper. Therefore, a variety of engineering applications, including sliding contact bearings, the automotive and electronic industries, heat exchangers, thermal management, aerospace, and rail transportation, as well as sliding contact between mating surfaces without lubrication, can successfully use the developed copper-based hybrid metal matrix composites.

The copper-based hybrid metal matrix composites have undergone many characterizations to investigate their microstructural, physical, mechanical, wear, and friction characteristics. The microstructural observations have been conducted using a range of characterizing and analytical techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), high-resolution transmission electron microscopy (HRTEM), energy dispersive analysis of X-ray (EDAX), and high-resolution scanning electron microscope (HR-SEM). The effect of the reinforcements was analysed by conducting a detailed investigation of the hardness, compressive strength, density, porosity, friction, and wear characteristics. Parametric analysis is crucial in the research of metal matrix composite materials since it allows for the examination of different behaviours exhibited by these materials during their evolution. Friction and wear tests were performed in accordance with the ASTM G99-05 standard. A pin-on-disc tribometer was used, with the pin rubbing against a counter face made from EN31 steel that had been hardened to a hardness of 62 HRC. The tests were completed at ambient temperature. An evaluation of the deteriorated materials deteriorated surface was carried out during the wear test. The deteriorated surface of all the composites analyzed in the present study was evaluated using a scanning electron microscope (SEM) equipped with energy-dispersive X-ray spectroscopy (EDS) equipment. The purpose was to investigate the mechanisms of wear. In order to further scientifically and technically understand wear mechanisms, the deteriorated surfaces of the specimens were examined using a Scanning Probe Microscope (SPM).