ABSTRACT

An increasing demand of new materials for the various fields of engineering applications such as automotive, railways, marine and aerospace industries etc. Due to the wide range of applications, new materials require 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.

Therefore to fulfil this continuous demand of such materials up to a level, a low density copper metal is selected as matrix to develop its various hybrid composites with enhanced performances. In the present investigation, stir-casting technique is considered to be the most viable for developing the copper-based hybrid composites due to certain advantages, such as, easy to perform and very economical. The different ceramics reinforcing phases are used such as WC, Al_2O_3, ZrO_2, BN and B_4C particles due their high hardness, high chemical stability, high modulus, grain refining effect, better corrosion and wear resistance. There are broadly two categories of copper-based hybrid composites known as binary reinforced and tertiary reinforced hybrid composites are developed depending on the number of reinforcement into the copper metal matrix. The binary reinforced hybrid composites 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).

Subsequently, the developed copper-based hybrid composites have gone through various characterizations for its microstructural, physical, mechanical and tribological behaviors. The various characterizing and analytical tools such as X-ray diffraction (XRD), high-resolution X-ray diffraction (HRXRD), optical, scanning electron microscopy (SEM), energy dispersive analysis of X-ray (EDAX) and high-resolution scanning electron microscope (HR-SEM) have utilized for microstructural observations. The hardness, compressive strength and the tensile properties of developed hybrid composites have been measured. The electrical resistance has also been measured by four-probe technique. However, friction and wear tests were conducted according to ASTM G99-05 standard using a pin-on-disc tribometer against a counter face of EN31 steel hardened to 60-62 HRC at ambient temperature. The worn surfaces and wear debris of all the materials studied in the present investigation were examined under SEM and EDAX to explore the operative mechanisms of wear.

After various characterizations, it is observed that the developed copper-based hybrid composites have better mechanical and tribological properties as compared with copper matrix due to the uniform distribution and good wettability of the reinforcing phases in the copper matrix. Therefore, the developed copper-based hybrid composites can be successfully used for various engineering applications such as resistance welding electrodes, electrical contacts, shipping hulls, automotive, railways, marine and aerospace industries etc.

Keywords: Stir-casting, Metal matrix hybrid composites, physical properties, mechanical properties and tribological properties.