Chapter 4
Tribological Characteristics of Copper–Nano Carbon Crystalline Composites

K. Rajkumar
SSN College of Engineering, India

S. Aravindan
Indian Institute of Technology Delhi, India

ABSTRACT

In order to exploit the excellent properties, nano-particles can be used as reinforcement in the matrix of a metal. This chapter utilizes reinforcement of nano-particles through the innovative microwave processing technology for the fabrication of copper-crystalline carbon composites. In order to understand the friction and wear properties of microwave-sintered copper-CNT and copper-Nano Graphite (NG) composites, pin-on-disc wear experiments were carried out. High surface area of nano-graphite particles embedded in copper matrix exhibited high adherent carbonaceous tribo-layer at the contact surface. Copper-CNT and copper-nano graphite composites exhibited comparable tribological properties.

1. DEVELOPMENT OF MATERIALS FOR THE ELECTRICAL SLIDING CONTACTS

1.1 Electrical Sliding Contact

An electrical sliding contact is defined as the interface between the current carrying members of electrical devices that assures the continuity of electrical circuit like brushes for generators and motors. A brush functions as an electrical contact between a stationary and a moving electrical circuit. A brush is always a part of an electro mechanical system; it is a conductor of current in the electrical system and it is subjected to mechanical forces due to its contact with moving surface. The critical components in motors and generators are the sliding electrical contacts. In order to satisfy the electrical and mechanical requirements, the electrical sliding contact should be capable of adequately conductive with lubricating characteristics. When the electrical sliding brushes contact with the slip ring/commutator experiences wear due to the softer brush material. While sliding,

DOI: 10.4018/978-1-4666-7530-8.ch004

mechanical wear takes place due to the brush and counter body which leads to reduced life time of electrical sliding contact. Traditionally carbon and electro-graphite brushes were used for electrical sliding contact. These materials are well known for their elastic modulus and brittleness. The major drawbacks of carbon or graphite brush materials are low strength, brittleness and low thermal conductivity and these drawbacks can be alleviated by incorporating a metallic material. Introducing a metallic material like copper in the conventionally available carbon/graphite brush material, not only surpasses the drawbacks of conventional materials but also provides high current carrying capacity and low contact resistance. There is a tremendous opportunity available to develop a whole range of new class of high-performance electrical brush contacts using carbon nano-particles such as carbon nanotubes and graphite nano-particles. It can offer high electrical and thermal conductivity, mechanical strength, and anti-friction behavior.

1.2 Metal Matrix Composites (MMC)

A composite can be classified as any material having two or more distinct phases where one phase is termed as the matrix which is continuous and surrounds the other dispersed phase. As mentioned in the background section, metal matrix composites are inseparable from the high technology applications. There are no pure metals or their alloys possessing a combination of properties to satisfy the complete requirements of electrical sliding contact applications. It can be resolved by using advanced materials like copper based metal matrix composites. The properties of a composite as a whole is a function of the properties of the constituent phases, the relative volume amount of each constituent, and the geometry and orientation of the dispersed phase. Metal matrix composites combine the advantages of the metal matrix (copper) and reinforcement (CNT and nanographite) so that the required properties such as increased anti-wear and reduced friction can be achieved.

1.3 Copper Matrix

Copper and copper alloys constitute one of the major groups of commercial metals. They are widely used because of their excellent electrical and thermal conductivities, outstanding resistance to corrosion, ease of fabrication, and good strength and fatigue resistance. Melting point and thermal conductivity of copper is 1083°C and 388 W/m•K respectively. Copper is nonmagnetic and it has face centered cubic structure. Copper and its alloys are relatively good conductors of electricity and heat. However, alloying elements invariably decreases electrical conductivity of copper matrix.

1.4 Carbon Nanotube (CNT)

Iijima, (1991) discovered a new form of carbon crystalline material, called carbon nanotubes. A carbon nanotube is composed of a sheet of carbon atoms in a hexagonal matrix rolled up into a seamless tube. They can be categorized as single walled carbon nanotubes (SWCNT) or multi-wall carbon nanotubes (MWCNT). CNT has many unique chemical, mechanical, and electrical properties. Many researchers reported that the mechanical properties of carbon nanotubes exceed those of any previously existing materials. The theoretical and experimental results have shown that CNTs are having extremely high elastic modulus, greater than 1 TPa (the elastic modulus of diamond is 1.2 TPa) and the strength of CNT is 10–100 times higher than steel (Thostenson, Ren, & Chou, 2001). In addition to the exceptional mechanical properties, it also exhibits superior thermal and electrical properties. Therefore, CNTs are believed to be ideal reinforcement for making advanced high performance composites. CNT is thermally stable up to 2800°C in vacuum, it has thermal conductivity as high as diamond and the