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Short Communication

Carbon fiber knitted fabric reinforced copper composite for sliding contact material

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ABSTRACT

A novel carbon fiber knitted fabric reinforced copper (C/C–Cu) composite was fabricated by a pressureless infiltration technique. The microstructure of the composite was characterized by scanning electron microscopy, X-ray diffraction and energy dispersive spectroscopy. The mechanical, electrical and tribological properties of the C/C–Cu composite were compared with those of a carbon/copper contact strip. The experimental results showed that the C/C–Cu composite formed an interpenetrating network structure. It exhibited a high bending strength of 186 MPa, excellent impact strength of 4.7 J/cm^2 and a particularly low electrical resistivity of 0.58 μΩ m, giving it advantages over the C/Cu strip in terms of both mechanical and electrical properties. Friction and wear experiments were conducted for the C/C–Cu composite and the C/Cu strip on a hemisphere pin-on-block apparatus, using cooper pins against polished specimens in dry sliding conditions. It was found that the C/C–Cu composite exhibited greater wear resistance than the C/Cu strip and did less damage to the copper pin.

1. Introduction

Carbon/copper composites are known for their high electrical conductivity and good wear resistance. These properties lead to its application in electrical contact devices, such as electrical brushes, pantograph contact strips, and heat [1–3]. In general, powder metallurgy is utilized to manufacture carbon/copper composites, but this has a number of disadvantages. It is difficult to prepare a carbon/copper composite with good interface bonding since liquid copper does not wet carbon, resulting in poor mechanical properties [4,5]. Moreover, it is also very difficult to attain a uniform quality in the production of components via the powder metallurgy process due to a major density difference between carbon and copper.

As early as 1958, Beech suggested that one way of improving mechanical properties would be to design a composite with an interpenetrating network of a metal in the matrix [6]. It was suggested that a composite with an interpenetrating network structure would exhibit high strength and wear resistance as well as thermal shock resistance. Several metal-impregnated carbon materials with improved strength have been produced by infiltration of a molten metal into a porous carbon preform under pressure [7,8]. However, the shape and size limitations on the component produced make this pressure infiltration technology less attractive.

In the present study, an attempt has been made to prepare a novel C/C–Cu composite with interpenetrating network structure by pressureless infiltration technique. The most significant problem encountered in the infiltration process was that the wettability of molten Cu on carbon material is poor [9,10]. Since it has been reported that Ti addition can effectively reduce the contact angle between liquid Cu and graphite or vitreous carbon [11,12], we try to fabricate the C/C–Cu composite by the spontaneous infiltration of molten Cu alloy containing Ti into C/C preform with interconnection pore. The microstructure of the composite is characterized. The mechanical, electrical and tribological properties of C/C–Cu composite were compared with those of a carbon/copper contact strip for pantograph electric railway vehicle. The purpose of the comparison was to provide information on the further application of the C/C–Cu composite.

2. Experimental procedure

2.1. Materials and specimens

Needled integrated needled carbon fiber felts were used to fabricate porous C/C preform by chemical vapor infiltration (CVI) of carbon. The felts were fabricated by needling the stack of alternating layers of unidirectional non-woven carbon cloth and carbon felt made from chopped fibers. The felts were densified into C/C preform by CVI in $C_3H_6 + N_2$ atmosphere. A porous C/C preform (3 cm × 3 cm × 10 cm) with a porosity of 20% was embedded in the powder of mixed copper (99.5% powder, −100 mesh) and addition agent titanium (99.0% powder, −20 + 100 mesh) in the crucible. They were placed in the furnace under a vacuum of 10^{-2} Pa and heated at a rate of 20 °C/min, up to 1300 °C. The samples were held at this temperature for 10 min before the furnace was switched off and cooled to room temperature. The C/C–Cu composites were obtained as the molten copper solidified in the C/C preforms. The C/Cu specimen for comparison came from a contact

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