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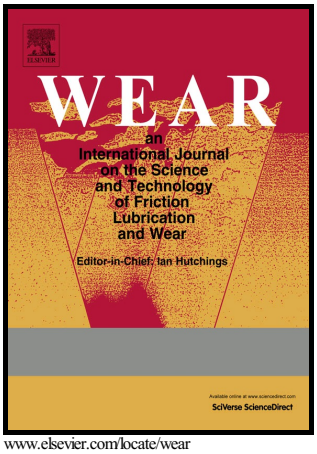

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Abstract

Copper-graphite composites in reciprocating sliding against copper are investigated with regards to friction, wear and contact resistance. The tribological and electrical evaluation is complemented with surface analysis. It is shown that the presence of graphite in the composite greatly reduces the coefficient of friction and wear. However, the amount of graphite is not critical and only has a minor influence on friction and wear. It is observed that the coefficient of friction is slightly lower, while the wear rate is slightly higher, in pure mechanical tests than in tests with current. The contact resistance is greatly reduced by an increase in the copper content in the composite. Chemical analysis of the tribofilm that forms on the copper surface shows that it consists of graphite as well as Cu_2O. It is shown that the mating couple with the highest amount of oxide in the tribofilm also has the lowest contact resistance. Hence, it is concluded that oxides are not necessarily detrimental for the contact resistance as long as there is unoxidized copper available. Novel cross-section techniques and images of the tribofilm contribute to a deeper understanding of how sliding electrical contact surfaces are affected by current and sliding motion.

Keywords: Tribofilm, electrical contact, copper-graphite, contact resistance, friction

1. Introduction

Continuously sliding electrical contacts are found, for example, where current or signals are transferred between one stationary and one rotating component. As such, they are tribological systems where friction and wear influence the performance. Carbon and graphite brushes are used for power transfer in everything from large generators to household appliances. Adding a metal, such as copper, will lower the resistivity and increase the current carrying capabilities [1].
Such metal-graphite composite materials are used to transfer power and signals in e.g. slip-ring assemblies and in locomotive pantograph strips for current collection. A satisfactory transfer of current, with low losses and low noise levels, are generally prioritized. Still, there is a lot to gain from improving also the tribological properties. In this paper, we present results on copper-graphite composite materials sliding against copper. Friction, wear and contact resistance are measured and special attention is paid to the contacting surfaces after testing, looking for material transfer, surface modifications and formation of tribofilms. Although the relationship between contact resistance and copper content in composite is rather straightforward, the correlation to friction and wear is more complicated.

Both friction and wear benefit from small real contact areas, which can for example be achieved with hard materials. Although increasing the hardness usually has an impact on the friction and wear, it is important to remember that these parameters are not intrinsic to a specific material.
For example, it is not necessarily the hardness of the materials that you start out with that makes a difference, but rather the tribofilm that is formed on the surfaces during sliding. It will be influenced by the specific circumstances during sliding, surrounding atmosphere, normal load etc. and its