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Technical Report

Accelerated wear testing for evaluating the life characteristics of copper–graphite tribological composite

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ABSTRACT

Sliding wear is a key determinant of the performance of electrical sliding contacts used in electrical machines. The behavior of the contact in sliding couple is controlled by the mutual metal transfer, friction and wear. Product life and reliability of sliding contacts are dictated by wear phenomenon. The present paper focuses on evaluation of tribological performance of copper–graphite composites using reliability theory. These composites are made up of a high electrical and thermal conductivity matrix with a solid lubricant reinforcement, making it most suitable for sliding contacts. Traditional life tests under normal operating condition would be a time consuming process due to a very long expected life of the composite. Hence, accelerated wear testing was carried out for evaluating the life characteristics. Analysis was then performed on the times-to-failure data and reliability models were developed. Life-stress relationship based on the inverse power law-Weibull model was used to make reliability predictions at normal usage level.

1. Introduction

The functioning of many mechanical and electromechanical components/systems gets affected by friction and wear. For such components/systems, the friction and wear mechanisms should be studied thoroughly in order to address the tribological issues. In electrical motor/generator industries, there is a high demand for electrical sliding contacts like electric brushes. Severe friction and wear conditions are experienced by the brushes since there is a relative movement between the brush and slip ring/commutator [1,2]. In electrical machines, the electrical sliding contact usually consists of carbon and electrographite brushes. These materials do not last long due to the generation of carbon dust when wear process commences [3]. As these brushes fall in the category of non-repairable components, they are expected to be replaced at regular intervals according to a preventive replacement schedule. Since this adds to the life cycle cost of the equipment, it is desirable to have a material with improved properties with respect to self lubrication, wear resistance, good conductivity and resistance to arcing [4,5].

It was found from the literature that microwave sintered copper–graphite composites possess the properties suitable for electrical sliding contact applications [6,7]. The present study proposes to use and evaluate the tribological performance of copper–graphite composite, processed through microwave sintering, as a potential material for electrical sliding contact. Due to a very long expected life of the composites, carrying out the traditional life tests under normal operating conditions would be time consuming. Hence, accelerated wear testing was carried out for evaluating the life characteristics, within a shorter duration. Reliability assessment was done based on life-stress relationship using inverse power law-Weibull model.

2. Accelerated life testing (ALT)

2.1. The concept

In conventional life data analysis, the life data of a test sample operating under normal (or usage) condition is analyzed in order to quantify the life characteristics of the product and make reliability predictions. However, due to time or budget constraints, it may be necessary to obtain test results more quickly than the normal operating condition. This can be achieved using quantitative accelerated life tests (QALT) to capture life data of the product under accelerated stress conditions. The QALT approach is to use life data obtained under accelerated conditions and estimate the probability density function (*pdf*) for the product under normal usage condition, which can then be further used to do a variety of reliability analysis [8,9].

To accelerate the time-to-failure for the products under test, two approaches viz. usage rate acceleration and operating stress acceleration can be employed [10,11]. Usage rate acceleration is appropriate for products that do not operate continuously under

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