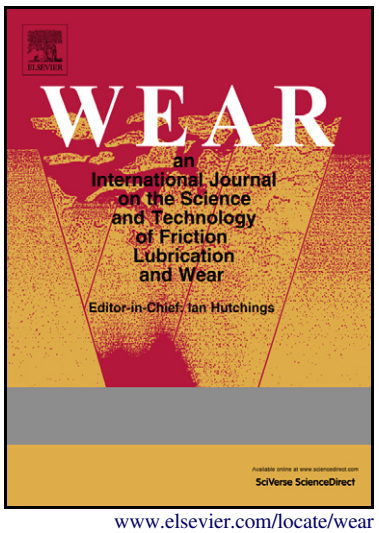

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Experimental and analytical thermal study of PTFE composite sliding against high carbon steel as a function of the surface roughness, sliding velocity and applied load

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Abstract

This study investigates the contact temperatures caused by frictional heating of sliding parallel pairs. In this case the materials studied are a PTFE composite in contact with a high carbon steel plate. These materials are commonly used for industrial applications, in particular as the main contacting components within a scroll expander system. The expected contact temperature values are important to be quantified in order to predict failure mechanisms associated with excessive thermal effects caused by sliding friction. A rational and coherent interpretation of the thermal effects on the actual tribological contact is presented.

Contact temperatures are monitored continuously using a high-precision infrared thermal imaging technique with a systematic variation in surface roughness of the high carbon steel material. These surface temperatures are investigated as a function of the friction coefficient, the sliding velocity and the applied load while the most influential parameter for the temperature rise is determined. Analytical results using conventional mathematical methodology are also produced. The analytical and experimental findings are then compared indicating interesting correlations within the macro- and micro- surface temperature regimes and the experimental conditions. Microscopic observations show that thermal effects can seriously affect fibers durability while transfer films formed across the steel counterpart can be beneficial for the operation of scroll systems under specific roughness and test conditions.

Keywords: flash temperature; roughness; dry sliding wear; PTFE composite; steel; calcium aluminosilicate; frictional heat; asperities; scroll expander

1. Introduction

Scroll expander systems are widely used in mechanical applications characterised by dry or lubricated sliding conditions. Typical industrial examples are micro combined heat and power systems, electrical generators and air-conditioners. Within these applications, scroll devices are utilized and face wear and cavitation. Tzanakis et al [1-2] has identified the main wear and cavitation mechanisms responsible for the severe damage of the tip seal and the steel plate of a specific scroll expander. Apart from cavitation and sliding wear, frictional heating can also play an important role on the tribological behaviour of a scroll expander system.

Frictional heating may cause surface temperatures to reach the melting or softening temperature of polymer materials resulting in a change in friction and wear rates [3-4]. Flash temperatures are generated which are considerably in excess of the bulk and the average temperature of the apparent contact area. This rise of the surface temperature can influence the surface geometry leading to severe local wear and lubrication breakdown. The ability to predict and measure the surface temperatures of the actual contacting bodies is important in order to prevent the failure mechanisms of various tribological components like tip seals. A