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Local temperatures evaluation on the pin–disc interface using infrared metrology

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ABSTRACT

This paper presents the development of an infrared metrology to evaluate local temperatures in sliding contact. A pin-on-disc tribometer was adapted for this purpose. The originality of this metrology is the use of a pin comprising a transmissive infrared window and an optical fiber two-color pyrometer. Local temperatures are evaluated at the pin–disc interface thanks to the optical fiber inserted in the pin. The experimental local temperatures correlate well with the disc surface temperature calculated with an analytical solution found in the literature for a pin-on-disc frictional device. In addition, disc temperature at the exit from the contact area is measured by a monochromatic pyrometer. The monochromatic temperature is corrected by taking into account the emissivity obtained by two-color pyrometry. Results show that the difference between the local temperatures in the pin-disc contact area and the corrected temperature obtained by the monochromatic pyrometry at the exit from the contact area remains weak. Besides, a good correlation was found between the local contact temperature and the friction torque. Thus, the knowledge of the local contact temperature is necessary to determine the modification of the tribological behavior at the pin-on-disc interface.

1. Introduction

The temperature resulting from the frictional heating in sliding contacts can have important consequences on the tribological behavior of sliding components. In order to understand the thermal and mechanical phenomena, it is necessary to develop experimental techniques that evaluate the temperature of sliding components.

Thermal metrology in sliding contacts has been the subject of many studies [1–5]. One can in particular note infrared techniques such as pyrometry and thermography [6–12]. However, for most radiometric techniques, the difficulty lies in the knowledge of the surface emissivity [13–17], which depends on various factors, often time variant and depending on parameters such as the object temperature and its surface quality. Recently, a fiber optic two-color pyrometer with a short time response (8 μs) and a small measurement spot (2.4 mm) capable of measuring the brake disc surface temperature and emissivity has been developed [18]. Experiments carried out on a braking test bench were able to obtain the transient brake disc surface temperature and emissivity during braking [19]. However, this infrared technique provides the brake disc temperature at the exit from the contact area because of the difficulty to access the contact zone.

An application of this two-color technique allowing the evaluation of the local temperatures in a sliding contact is presented here. A pin-on-disc tribometer was adapted for this purpose. It is equipped with a pin comprising a Calcium Fluoride transmissive infrared window. The Calcium Fluoride infrared window was selected due to its high infrared transmittance and the fact that it has a small surface (only 4.7% of the total surface of the pin) in order to minimize its influence on the nature of the pin–disc contact. Local temperatures are evaluated at the pin-disc interface thanks to the optical fiber of the two-color pyrometer inserted in the pin. In addition, disc temperature at the exit from the contact area is estimated by a monochromatic pyrometer.

2. Experimental study

2.1. Braking tribometer

Tests were performed on a pin-on-disc braking tribometer developed to reproduce at reduced-scale the contact stress observed between disc and pad at full-scale during railway braking [20]. Fig. 1 shows the braking tribometer: general view (a), pin and disc view (b) and schematic drawing (c). A motor rotates the disc with an initial

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