
Abstract

Carbon/Carbon (C/C) composite materials are employed in many high-performance braking applications, such as aeronautical braking, in which light weight and thermal resistance represent crucial requirements. Because of the growing interest in this class of materials, a large amount of research works investigated their tribological response. A complex behavior, characterized by the existence of different frictional regimes in function of the main contact parameters (temperature, pressure, sliding velocity etc.), has been highlighted. Despite the amount of works focused on this topic, only few research groups investigated the relationship between the frictional response of C/C materials and the occurrence of unstable friction-induced vibrations (FIV) of the mechanical system, pointing out a fundamental role played by the interface rheology on the frictional behaviors leading to the occurrence of dynamic contact instabilities.

In this framework, this Ph.D. thesis investigates the role of the third body (i.e. the interface layer formed by wear and external particles) on the tribological and dynamic response of C/C frictional systems. To this purpose, a new experimental method for the evaluation of the third body rheological role is developed, adopting an indirect approach. The ultrasonic cleaning technique is applied to remove the third body layer from a contact pair, allowing to perform tests on the same material samples both in presence and in absence of the interface layer. The comparison between the measured behaviors evidences a predominant role of the third body in controlling the overall frictional response of the system, especially at high temperature conditions. The reintroduction in the contact of an external third body is also investigated, using the cleaned samples, obtained after real brake conditions and after removal of their natural third body, as substrates. The validation of this procedure opens the way to the test of artificially introduced third body specimens. Complementary SEM observations have been performed to characterize the third body layer observed on the frictional surfaces of C/C materials conditioned during service life. Morphological families of the third body in agreement with the existent literature have been identified, and a particular focus has been placed on the heterogeneous contaminants observed in the carbonaceous third body. These observations driven the development of the artificial third body specimens, intended to reproduce as better as possible the morphology of the natural third body, controlling the presence and the morphology of the heterogeneous contaminants. Using this methodology, the role of the third body and of its characteristics, such as morphology and chemical composition, on the frictional and dynamic response of C/C has been analyzed. The effect of selected third body contaminants is investigated, revealing a strong sensitivity of the C/C frictional response on the contaminant nature, even in presence of a low fraction of heterogeneous elements in the third body layer. Each type of contaminant is characterized in terms of its effect on the mean frictional values and on the friction-velocity relationship, aspects both fundamentals to evaluate their impact on the occurrence of unstable friction-induced vibrations. Rheological scenarios are then proposed to explain the measured tribological response, clarifying the frictional behaviors that lead to the occurrence of an unstable dynamic response of the system.

This PhD work has been performed in the frame of an international collaboration between the Mechanical and Aerospace engineering department (DIMA) of the Sapienza University of Rome (Rome, Italy), the Contact and Structure Mechanics Laboratory (LaMCoS) of the INSA Lyon (Villeurbanne, France) and the company Safran Landing Systems (Villeurbanne, France).

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