

ANALYSIS OF MULTIMODAL EXPERIMENTAL DATA FOR PHYSICAL UNDERSTANDING OF EMISSIONS MECHANISMS DURING BRAKING EVENTS

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KEYWORDS

Friction; Surface topography; Wear; Physical mechanisms

ABSTRACT

Most ground transportation vehicles depend on braking systems with sliding contacts between rotating and stationary parts. In such scenarios, the emission of fine particles and high-intensity noise, commonly known as squeal [1], can present human health risks based on the size, number and composition of particles or the noise's intensity, frequency and occurrences. While numerous studies focus on particle noise emissions, considering factors such as friction pair materials and loading conditions [2, 3], only a few address the physical source mechanisms of these emissions. This aspect is considered complex due to intricate physical processes in a closed system that cannot be directly observed [4]. The parameters determining occurrences of brake emissions remain uncertain due to the complexity of the involved phenomena.

It is proposed here to provide elements of identification for mechanisms responsible for brake particle and squeal occurrences, thanks to a multimodal operando instrumentation associated with a discrete follow-up of surfaces. To carry out these measurements, a laboratory device of a pin-on-disc type is used, with a car disc equipped with a pin of material extracted from a brake pad. Numerous sensors are introduced, continuous measurements of forces, displacements, accelerations, and temperatures, combined with measurements of noise emission.

Surface conditions are observed between each sequence of braking through optical measurements and profilometry. Particle emission is analyzed using an Engine Exhaust Particle Sizer (EEPS) Spectrometer and an Optical Particle Sizer (OPS) device, providing a comprehensive measurement range from 0.3 nm to 10 µm. This coupled approach offers detailed insights into the emitted particles during the experiments.

Thermo-mechanical phenomena and tribological behavior of the contact are investigated to establish a link between contact conditions and brake emissions. In particular, the use of machine learning methods enabled the systematic study of the large amounts of data in order to identify relations between the different measured quantities. The results show significant correlations and highlighted the crucial role of temperature in phenomena associated with braking systems. This, together with the surface monitoring, makes it possible to describe the tribological scenario which associates emissions with the evolution mechanisms of the interface and the materials. This is a key point for the identification of the source mechanisms of brake emissions, highlighting points of action for their reduction during braking events.

This work is conducted within the Franco-German project PI-CUBE, "Physics-informed Artificial Intelligence for Cutting Brake Emissions from Electric Vehicles" Program IA FR-DE – Type 2 RD BMBF-MESRI.

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