Evolution of sintered metallic brake pad under effect of thermomechanical stresses

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Abstract

The evolution of brake pad material caused by brake loads is a key concern in tribology. However, the effect of brake loads on the microstructural evolution, has so far not been intensively investigated in literature. This challenging issue resulted from the complexity of brake loads, which combined mechanical, thermal, physicochemical loadings etc.. In this study, we propose an experimental approach where physics is decoupled but inspired by the braking sequence. Two experimental approaches of thermal gradient test and hot-compression test are carried out to highlight the effects of thermal (temperature gradient) and mechanical (compression) solicitation. The evolution of brake pad material is characterized by Scanning Electron Microscopy (SEM) coupling with Energy-dispersive X-ray Spectroscopy (EDS). Sequentially, the obtained results are discussed by associating with the strain fields collected by a compressive test equipped with a Digital Image Correlation (DIC).

Methodology

Overview

Completed braking sequence → Simplified braking sequence *(excluding friction)* → Thermal solicitation / Thermal-mechanical solicitation / Mechanical solicitation

- ✓ ***Decoupling the complexity of braking stress***
- ✓ ***Understanding the effect of each solicitation on the evolution of material (microstructure and mechanical properties)***
- ✓ ***Understanding the link between the evolution of microstructure and mechanical behavior under braking stress***

Methodology

Thermal solicitation (température gradient)

Characterization before the experiment → Simplified solicitation experiments → Characterization after the experiment

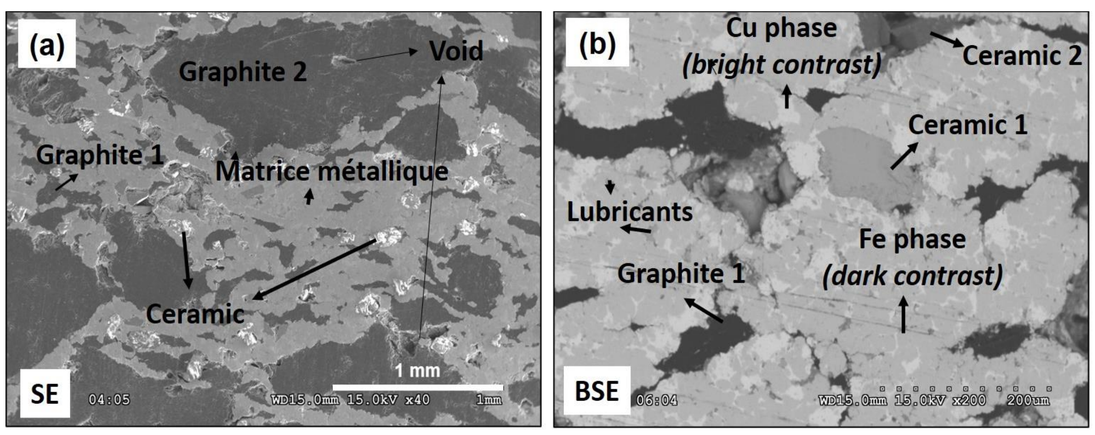
Thermal-mechanical solicitation (gradient température + compression)

Friction material

Compositions of friction material

Main components	Mass (%)	Particle size
Metallic matrix	70	Fe and Cu powder: < 100µm
Graphite 1	20	100-600µm
Graphite 2		400-1100µm
Ceramic 1	10	100-300µm
Ceramic 2		

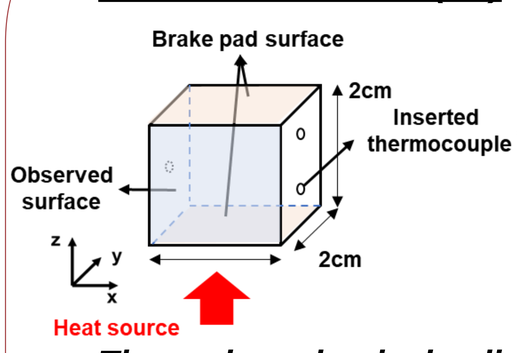
Microstructure of virgin friction material (RM)

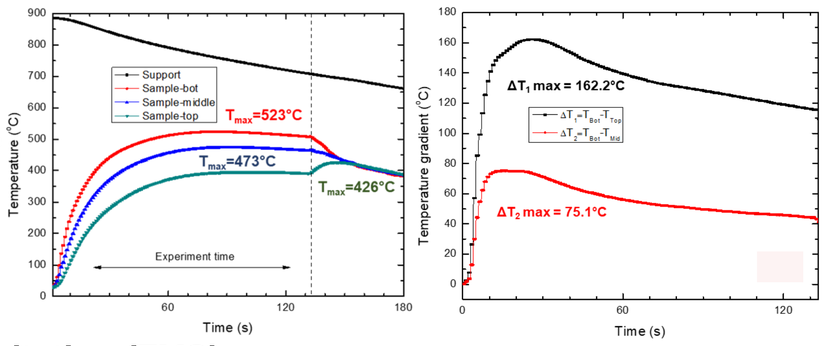


Microstructure of simplified semi-metallic brake-pad material. a)Secondary electrons image at low resolution, b)Backscattered-electrons at higher resolution

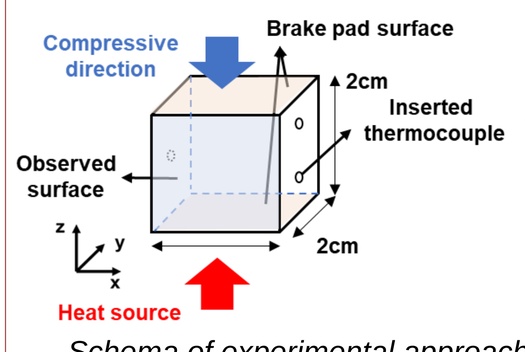
Experimental setup

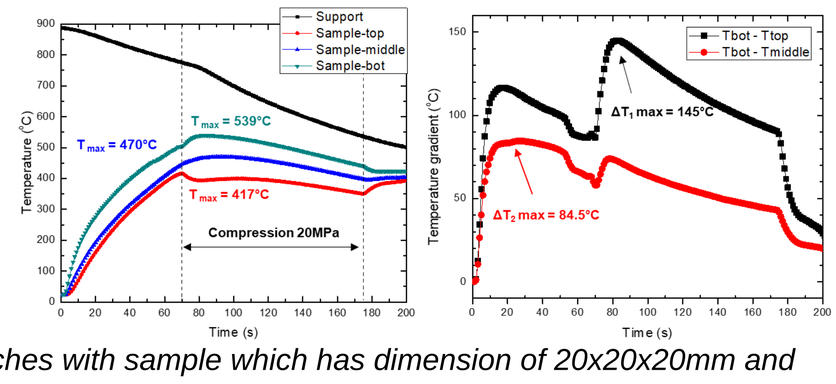
Thermal solicitation (TS)





Thermal-mechanical solicitation (TMS)

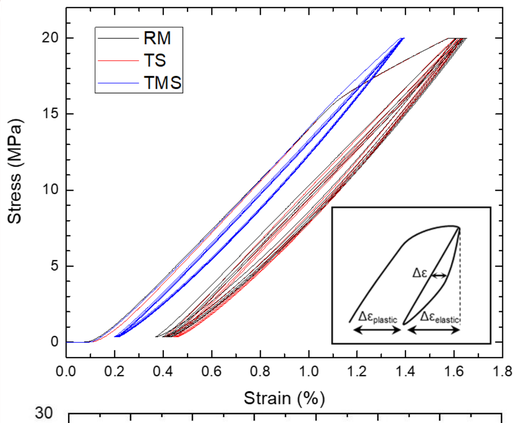


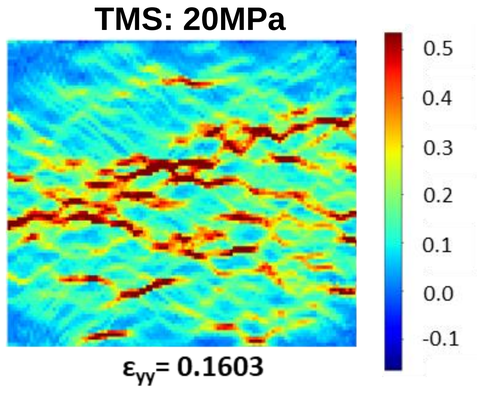


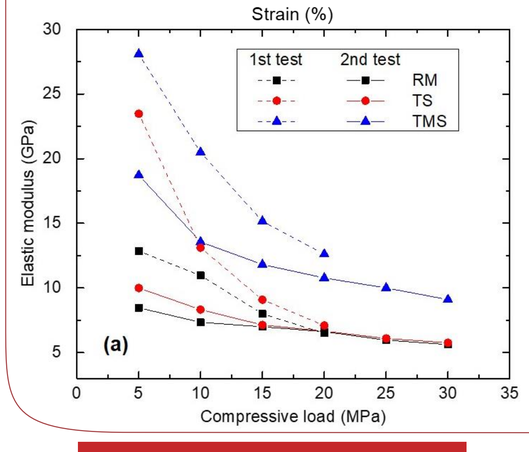
Schema of experimental approaches with sample which has dimension of 20x20x20mm and temperature gradient measured by inserted thermocouples, 3 different signals correspond to different position on sample (top, middle, bottom)

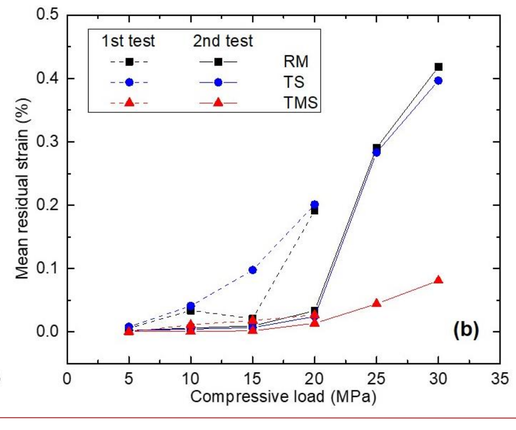
Results

Evolution of the mechanical properties

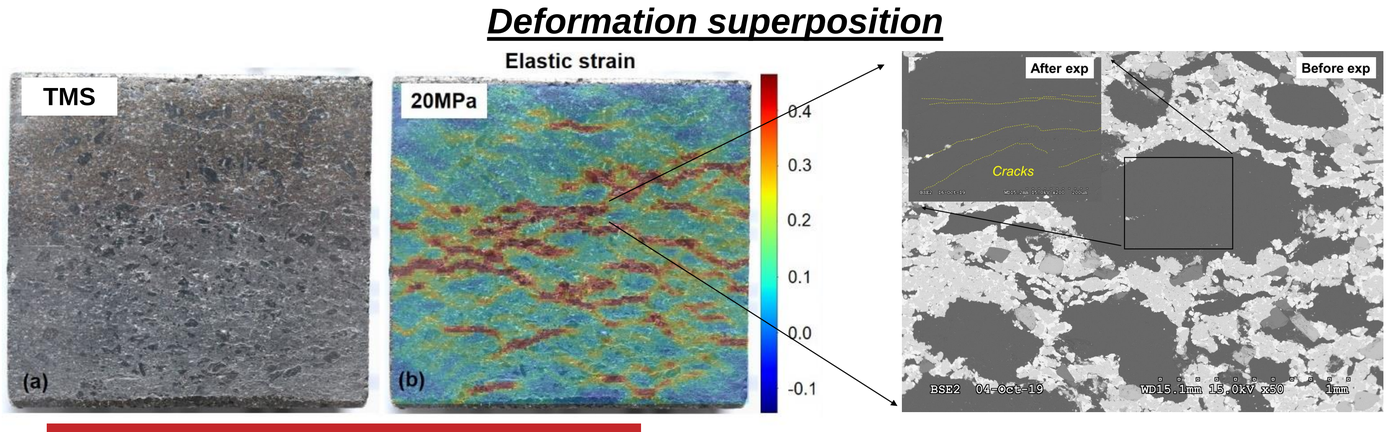








Deformation superposition



Conclusions and perspectives

- ➢ ***Thermal and mechanical solicitation don't have separate effect on the mechanical properties of friction material***
- ➢ ***Evolution of mechanical behavior is due the combination thermo-mechanical solicitation which increases the stiffness of friction material***
- ➢ ***Strains concentrate in the middle layer and coincide with the alignment of graphite inclusions which correspond to the defects observed in graphite 2***
- ➢ ***Localize the microstructure characterization (metallic matrix) for investigating the evolution of material due to thermochemical solicitation***

Acknowledgments

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