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Analysis of the mechanisms relating to tire-road wear in relation to the emissions of fine particles

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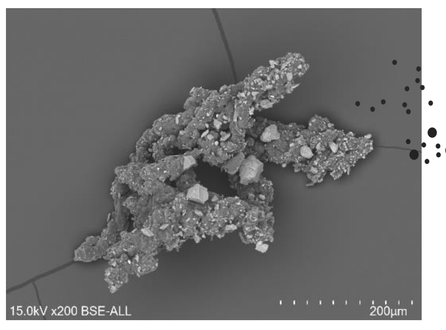
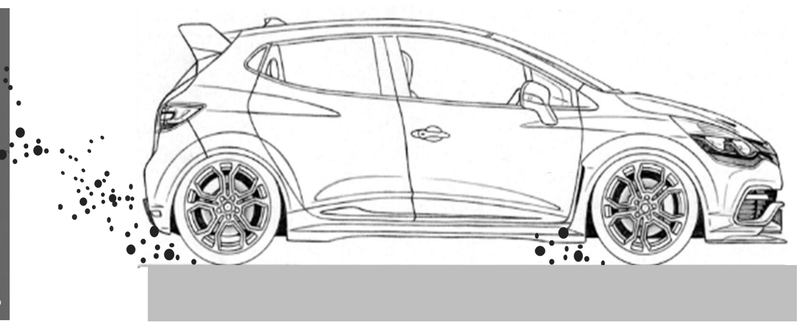
Introduction

Understanding of tire-road contact is pivotal for tire and road durability, road safety enhancement and health risk mitigation due to emissions [1].

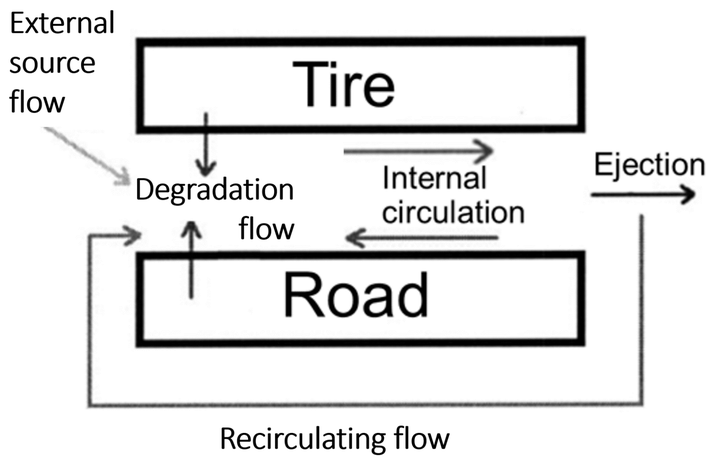
While numerous studies have explored particle characteristics from tire-road contact [2], a holistic grasp of wear mechanisms, particle dynamics, and surface evolution remains at an early stage [3].





Objectives

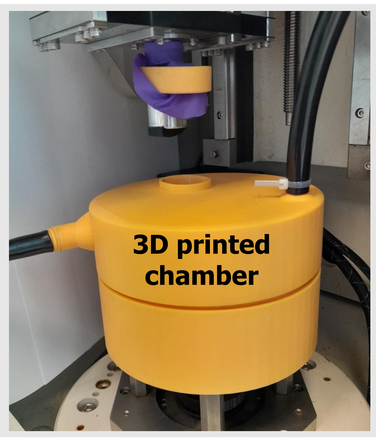
- Understanding the mechanism of wear debris generation.
- Develop a methodology to collect and characterize ejected particles.
- Understanding particles circulation process at the tire-road interface.



Methodologies

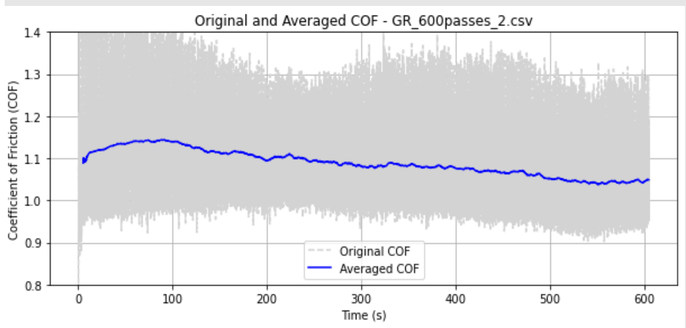
1 - Experiments

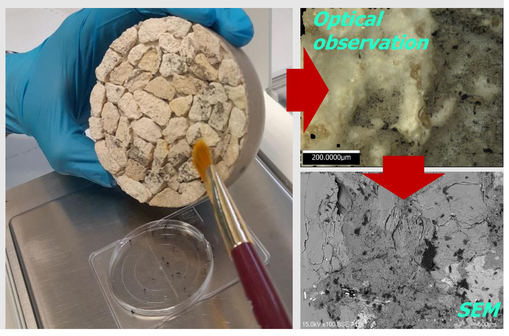
- Pin-on-disk tribometer with a isolated chamber.
- Test conditions simulated normal braking at 60 km/h (slip ratio G=0.01).
- Material variables: aggregate mosaic disks (limestone, granite) and normal/aged asphalt mixture pavement samples.



2 - Data collection

- Record friction coefficients during wear tests.
- Collect and weight wear particles with a soft brush.
- Measure disc and pin mass loss.
- Surface observation: camera images, 3D optical microscope, surface topography, SEM.





3 - Analysis and modelling

- Wear particles generated during wear tests are collected.
- SEM observation and composition analysis are conducted.
- Worn surface topography is measured using a 3D imaging device.
- Mass loss and mass of generated particles are quantified.

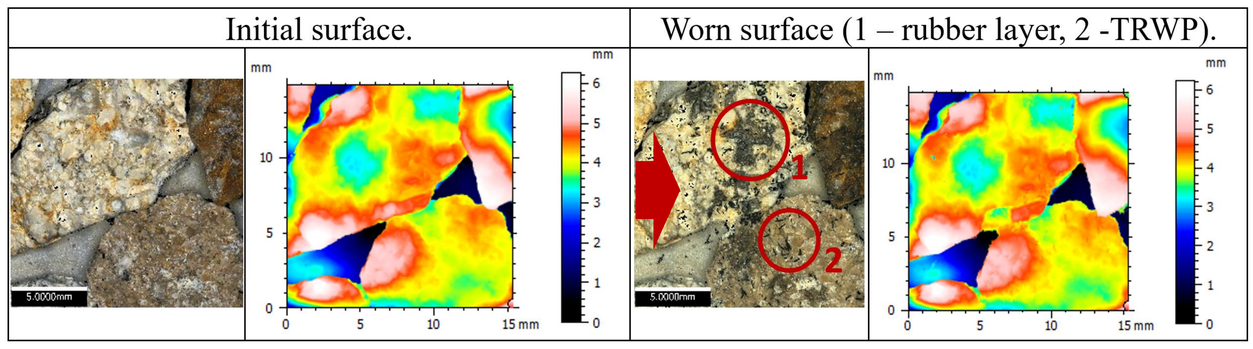
Model considers intricate composition of third body (TRWP + rubber layer)

$$\frac{dm}{dt} = Qd - Qe + c_1 \cdot h$$
$$\frac{dh}{dt} = c_2 \cdot h - c_3 \cdot m$$

m – mass of trapped particles,
h – rubber layer thickness,
Qd – degradation flow,
Qe – ejected flow,
c1, c2, c3 – unknown coefficients.

Results

- Wear particles generated using tribometer exhibit similar morphology to TRWP collected on-road.
- Individual effects of TRWP and deposited rubber layer on COF and texture have been observed.
- Different mass flow components have been defined to develop a model for particles ejection.



Conclusion

Results highlight the complex relationship between friction coefficient evolution and surface texture changes during wear tests. Modelling approach is implemented to account effect of the third body.

Bibliography

[1] R. W. Lowne, "The effect of road surface texture on tyre wear," Wear, vol. 15, no. 1, pp. 57–70, Jan. 1970
[2] N. Fillot, I. Iordanoff, and Y. Berthier, "Wear modeling and the third body concept," Wear, vol. 262, no. 7–8, pp. 949–957, Mar. 2007
[3] M.-T. Do and V. Cerezo, "Road surface texture and skid resistance," Surf. Topogr. Metrol. Prop., vol. 3, no. 4, Oct. 2015

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