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The degraded surface layer of a tyre tread: characterization and simulation

Kévin Daigne[1,2*], Guilhem Mollon[2], Nicolas Fillot[2], Sylvie Descartes[2]
Romain Jeanneret-Dit-Grosjean[1], Frederic Biesse[1]

[1] Manufacture Française des Pneumatiques Michelin, France
[2] LaMCoS, Univ. Lyon, INSA-Lyon, CNRS UMR5259, F-69621, France
*Corresponding author: kevin.daigne@insa-lyon.fr

This study will focus on the migration of minerals inside a rubber mix, in the perspective of understanding tyre wear. Indeed, this migration inside the degraded part of the rubber is well known, however, the corresponding mechanisms are still rather misunderstood. The goal here, is to explain with a multibody meshfree approach, how mineral grains captured on the road can migrate through the top layer of the rubber mix, and to find some key parameters which control this mechanism. Moreover, the study of the mechanical behaviour of this new composite will be useful for a future wear model.

Keywords: tribology, tyre, wear, meshfree

1. Introduction

Understanding the wear mechanisms of the tyre tread is a central issue regarding tyre performance, but is also pivotal in an environmental perspective. This topic is at the crossroads of several fields including tribology, surface engineering, granular physics and material science. Tyre wear particles are composed of an intimate mixture of rubber mix from the tyre tread, and minerals from the road [1, 2]. These facts have led Michelin to carry out several studies, in order to observe the effect of some parameters (minerals, road, rubber) on the wear rate. Moreover, SEM (Scanning Electron Microscopy) pictures have shown that the top layer of the rubber mix, is also composed of these minerals. This layer, which contains minerals and rubber mix, is called the degraded surface layer. The goal here, is to find how minerals can migrate into the rubber mix, and affect the surface properties.

2. Methods

To get a closer look at the *in situ* behaviour of these minerals inside the contact, a Multibody Meshfree Approach implemented in a custom-developed code, MELODY [3], will be used.

Figure 1: Numerical model of the formation of the degraded surface layer

Concerning the rubber mix, the bulk is considered as elastic and FEM (Finite Element Method) will be used due to the low deformation, and because it is supposed that minerals will not reach this zone (continuum medium cannot simulate migration).

The top layer of rubber mix is considered as a packing of a large number of cohesive and deformable bodies, in order to allow the migration of minerals between the interstices of each body. Moreover, as large deformation might be expected, a meshless method is used (with Moving Least Squares shape functions).

Finally, the abrasive surface and minerals are considered as rigid, because their stiffness is much higher than rubber mix, and thus, their deformations are negligible.

3. Discussion

Minerals seem to migrate inside the rubber mix material according to several steps. The first step, which can be the longest, is the initiation of the displacement of one mineral. Indeed, the initial structure of minerals is hard to break. This initiation can be of two types. The first one, is the mineral which directly penetrate inside the rubber, due to important stress localization exerted by the abrasive surface on the mineral. This form can occur rapidly, but is hard to predict. The second one, which occurs more often, is the rubber particles which, one by one, will occupy the void space between minerals, and step by step, will break the structure and initiate the displacement of minerals. The second step is the migration of minerals within the top layer, which is relatively linear and driven by the relative displacement of each rubber particles. Minerals migrate towards the bulk. The third and last step, it is when minerals reach a zone where these relative displacements are lower (far from the surface), and the minerals tend to stay at a fix position.

4. References

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