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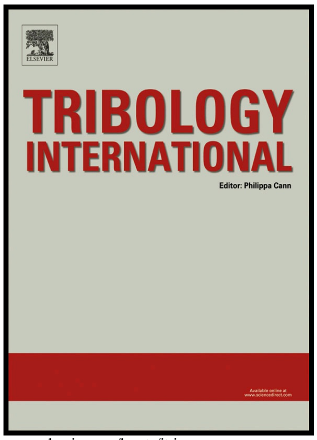


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P.D. Neis, N.F. Ferreira, G. Fekete, L.T. Matozo, D. Masotti

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# Towards a better understanding of the structures existing on the surface of brake pads

P. D. Neis[a*], N.F. Ferreira[a], G. Fekete[b], L. T. Matozo[c], D. Masotti[c]

[a]Federal University of Rio Grande do Sul, Laboratory of Tribology, Brazil
[b]Savaria Institute of Technology, Department of Mechanical Engineering, Hungary
[c]Fras-le S.A., Research and Development Department, Brazil

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[*]Corresponding author: Tel.: +55 513308 4219; fax: +55 513308 3355. patric.neis79@gmail.com (P. D. Neis)

## Abstract

In the present investigation, optical microscopy, confocal laser scanning microscopy (CLSM), microindentation and image segmentation were employed to investigate the different structures existing on the worn surface of a non asbestos organic (NAO) and a low metallic (LM) brake pad. The following structures were identified on the surfaces of the studied pads: (i) deformable and non-deformable primary plateaus, (ii) secondary contact plateaus formed with and without the support from the structural components of the pad (the primary plateaus), and (iii) the "elastic highlands". This last structure stays in a high position on the pad's surface topography and responded very flexible to applied loads. Finally, correlation between friction and the structures found on the pads' surfaces is discussed throughout this paper.

Keywords

Brake pad; Image segmentation; Contact plateaus.



## 1. Introduction

The sliding of a brake pad against a grey cast iron rotor is very different from most tribological systems. When worn against the rotor, the complex structure and very inhomogeneous composition of the pads results in a particular surface structure, with large (and relatively flat) contact plateaus rising a few micrometers above the rest of the surface, as reported in the literature [1-3]. The contact plateaus are also known as "contact patches", "hard patches" or simply "patches", as shown in some publications, e.g. Ostermeyer [4], EL-Tayeb and Liew [5], Ostermeyer and Wilkening [6], Wilkening et al. [7], Ostermeyer and Müller [8].

The contact plateau is subdivided into two categories, the primary plateaus and secondary plateaus [2, 9]. The primary plateaus consist of wear resistant ingredients of the brake pad (metal fibers, structural components and others abrasive particles), which protrude from the surface. In a second stage, these protruding hard phases may form nucleation sites for the growth of secondary plateaus [3, 9]. Occasionally, wear debris flowing through the channels formed between the contacting pad and disc become jammed and pile up against the primary plateaus. Then, these wear debris are compacted by the normal and frictional loads against the mechanically stable primary plateaus [2, 9]. The mechanism of formation and growth of the secondary plateaus is a gradual process, since it requires normal pressure, shear forces and the friction heat [2]. According to Ostermeyer and Wilkening [6], a contact plateau might be destroyed when its size becomes too large. Third body abrasion by wear debris transported through the contact is an important process which leads to the contact plateaus destruction. Ostermeyer [4] described the growth and destruction of the contact patches as a continuous and dynamic process during braking.

On the other hand, the surface surrounding the primary and secondary contact plateaus, which is known as "lowlands" (also called "voids" by Bian and Wu [10]), has been often described as irregular and rough by the literature, e.g. Eriksson and Jacobson [2], Eriksson et al. [3]. It consists of less wear resistant pad constituents, such as polymeric resins, fillers, and friction modifiers. The lowlands are mechanically weak and worn mainly through three-body abrasion. Some particles resulting from the wear of the lowlands may take part in the formation and growth of the secondary contact plateaus [9].

The scientific literature [3, 9, 11] has shown that the size, amount and composition of the plateaus have a crucial influence on the friction behavior of the pad. According to Eriksson [9], it is because in brakes, as for all dry sliding systems, the real friction force is transmitted via the area of real contact, which is confined within a limited number of contact plateaus. The morphology of the contact plateaus seems to be also related to brake noise, as reported in [3, 12].

The dynamic of the hard patches formation and destruction has been used by many researchers as a base to build up new computational models for friction and wear of brake materials. In these models, the strength of inter-particle