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A NEW STOCHASTIC MODEL FOR PARTICULATE MATTER AND DEBRIS EMITTED BY DIESEL ENGINES

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ABSTRACT

Emissions from diesel engines can be reliably estimated by precise and cheap diagnosis of wear condition at a low cost and reduced equipment stops. This paper proposes a new stochastic model to predict the evolution of the wear in a diesel engine without interrupting its operation. A Markov Chain was developed based on a new debris analysis dataset. The debris were collected in the exhaust pipe of the engine through an innovative device built in the Tribology Laboratory of UFRN. The morphology and chemicals compounds of the debris collected by the device were analyzed using Scanning Electrons Microscope (SEM) and Energy Dispersive Spectroscopy (EDS), respectively. The identified mechanisms were: spalling, tribo-corrosion, high temperature damage and delamination. Spalling and tribo-corrosion states presented a higher probability with an aperiodic and positive recurrence behavior. After the period of tests, the Markov chain converged to an equilibrium probability distribution.

Keywords: particulate matter, debris, Markov chain, predictive maintenance, tribology.

INTRODUCTION

Wear debris analysis consist to diagnose the current condition of machines and to be able to predict any future wear states and problems (Tonggang, Jian, Xiaohang, and Zhiyi, 2012). This technique determinate wear mechanisms acting in machine through the concentration, morphology and chemical composition of wear particles (Kumar, Shankar Mukherjee, and Mohan Misra, 2013). For optimize wear debris analysis mathematical models, Markov chain for example, are able to provide accurate condition based predictions of failure probability (Giorgio, Guida, and Pulcini, 2010).

This paper brings a new application of the wear debris analysis, the debris are collated of the exhausted pipe of a diesel engine at twenty-hours intervals and their characteristics were used for building a Markov chain.

RESULTS AND CONCLUSIONS

The relation between the type of debris, morphology and wear mechanisms are shown in Figure 1. This classification is based on (Kumar *et al*., 2013).

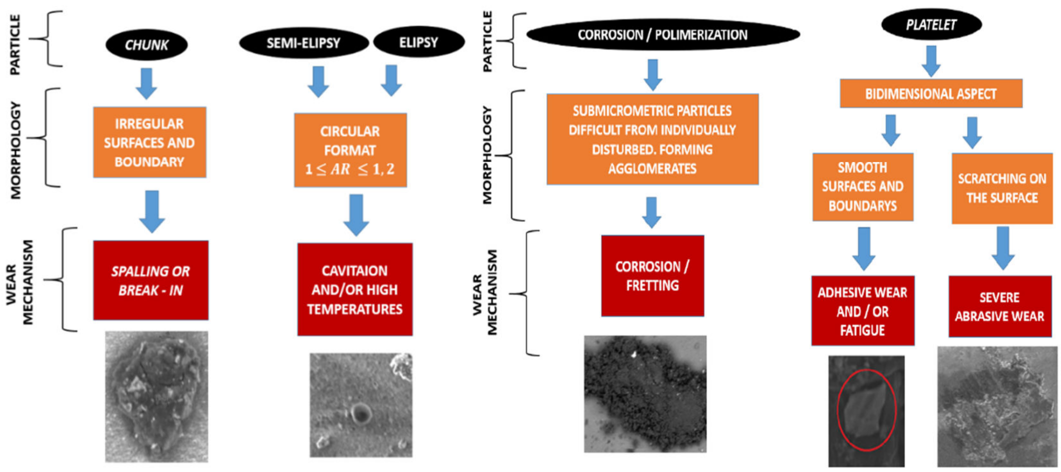

Fig. 1 - Wear debris classification.

After accounting for the concentration of each type of debris in the SEM images and verifying how these values vary in each step of time, the transition probabilities of each state were established and the graph shown in Figure 2 was set up.

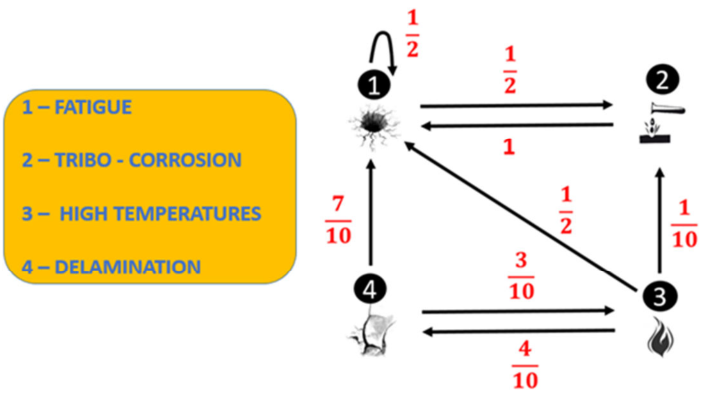

Fig. 2 - Wear debris classification.

The analysis of the states showed a predominance of fatigue damage, which was to be expected since the engine is probably still in the running-in state. In this sense, it is necessary for a long-term planning the calculation of the equilibrium distribution of this chain and the time necessary to enter this condition. For future work, more fault wheel wear mechanisms can be added to the chain and to calculate the transition probabilities in the steady state.

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