MICRO-SCALE ABRASION MECHANISMS DURING SCRATCH TESTING OF THERMALLY SPRAYED IRON COATINGS

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Thermally sprayed coatings (TSC) applied in engine cylinder bores can reduce weight and improve the tribological behavior. Machining (e.g. honing) these coating layers is still a challenge, due to the material characteristics. Abrasion phenomena are important in the understanding of machining operations. This work aims to study the influence of multiple parallel or angled scratches conducted in TSC and base the discussions on the abrasion mechanisms, microstructure and mechanical properties. Scratches were analyzed both experimentally and with simulations using the Finite Element Method (FEM). Borders formation influences in the abrasion process and subsurface conditions.
Keywords (from 3 to 5 max): Coated bores, thermal sprayed coatings, tribological contact, abrasive process.

1. Introduction

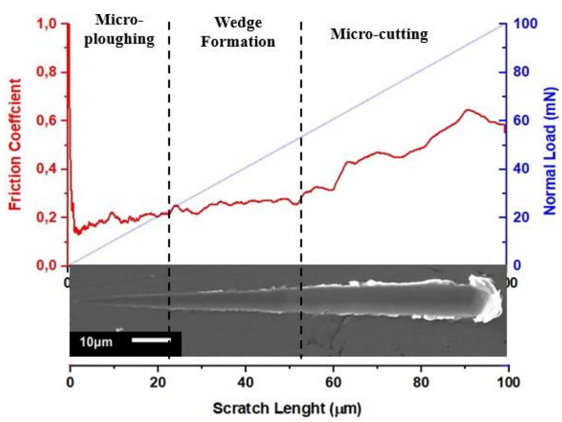
The application of TSC in engine cylinder bores is an option to reduce weight and to improve the tribological behavior of internal combustion engines [1]. Machining of thermal-sprayed layers presents several unanswered questions. In order to better understand honing operations, it is important to study the process in a more fundamental condition. Various machining studies of the inhomogeneous bore material and simulations on different scales are needed to gather an understanding of ideal cutting parameters that promote a functional surface. Therefore, this work aims to relate the affected zone effect by the material remove process with the abrasion mechanisms.

2. Methods

Commercial iron-based thermal spray coatings sample were analyzed. Hardness and elastic modulus were measured by instrumented indentation using Berkovich tip. Scratch tests were carried out in a TI-950 tribo-indenter from Bruker Inc. using a cono-spherical diamond tip with radius of 5 µm. Initially, the scratches were conducted with increasing normal loads, from 0 to 100 mN, to observe the loads that promote each abrasion mechanism (micro-ploughing, wedge formation or micro-cutting). Secondly, the scratches were conducted at constant load for the normal loads 10 mN, 25 mN, 50 mN e 75 mN, in parallel or angled pattern. Abrasion mechanisms were characterized by scanning electron microscopy (SEM) and atomic force microscopy (AFM). The experimental condition was reproduced in a numerical model prepared using the Finite Element Method (FEM) with Abaqus/Explicit® 2018. The tribosystem was modelled assuming that the abrasive particle was rigid, with a 5 µm tip radius, and the workpiece (coating) presented an elastic-plastic behavior. The coating mechanical properties were considered based on the literature [2] following the Johnson-Cook constitutive behavior and failure model.

2.1. Results

Fig. 1 shows the result of a scratch with load varying from 0 to 100 mN. Three different regions were identified along the scratch. In the first region, the material predominantly presented plastic deformation, corresponding to the micro-ploughing mechanism. The second region represents a transition between the first mechanism ant the last one, being commonly defined as wedge formation. Lastly, chip formation was observed in the last region, corresponding to a micro-cutting mechanism. Knowing transition borders of abrasion regimes will help to optimize the complex abrasive process at honing where grooves in cross hatch pattern structure represent essential aspects of the finished tribological contact. Exceeded burrs at the presence of exceeded contact pressure cause unwelcomed asperities. Flat or steep cutting angles are decisive for these burrs and wedges as well as subsurface conditions and stresses.



3. Figure 1: Coating behaviour varying the load from 0 to 100 mN during the scratching process.References

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