Tribology issues in low-friction engine surface finishing

M. El Mansori[1,*], S. Mezghani[2], l. Sabri[3]

[1)] MSMP Laboratory, Arts et Métiers ParisTech, 2 cours des Arts et Métiers - F-13617 Aix en Provence, France.
[2)] MSMP Laboratory, Arts et Métiers ParisTech, LMPF - EA 4106, Rue Saint Dominique, BP 508, 51006 Châlons-en-Champagne, Cedex, France.
[3)] RENAULT S.A.S., Direction de la Mécanique/Direction de l'Ingénierie Process, Rueil Malmaison (Paris), France.

[*]Corresponding e-mail: mohamed.elmansori@ensam.eu

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ABSTRACT – Reducing the energy wasted to combat friction in internal combustion engines should help reduce consumption of fossil fuels. In the total engine friction equation, there are three major sources of friction loss: piston and rings, the valve train and the crankshaft and engine bearings. The tribo-system of piston/rings/cylinder is the undisputed first source, claiming about a 50% share. Second major source of friction loss is crankshaft and engine bearings, where the friction loss rises proportionally with RPM. Manufacturers are hence searching for low friction surface finishing processes that enable engine builders to achieve the tough emissions standards looming on the horizon. For example, in the case of the piston/rings/cylinder tribo-system, the major issue is to hone the cylinder liner sizes down to the millionths. The cylinder liner surface is in fact the "original" micro-scale structured surface; designed with a deterministic pattern of high aspect ratio features and anisotropy of surface properties. It comprises alternating flat plateaus (bearing regions) and deep valleys for lubricant, transportation. To manufacture such a tribo-functional surface, abrasive honing process is the choice for mass production.

For the crankshafts finishes, rotating assemblies ride on a thin wedge of oil having thickness of only 1.3 µm in some cases. Moreover, to reduce friction as much as possible, oil itself is much less viscous as well, so it is especially important to achieve proper surface finish on all crank journals. Belt polishing or micro-polishing is technically the most advanced way to achieve surface finish on cranks. The main goal of polishing any crankshaft is to create "peak-free" surface to handle load without changing the size of their ground parts.

The objective of this keynote paper is to show how tribology can be used to control low-friction surface design based on the premise that an intimate connection exists between the abrasive wear mechanisms prevailing during finishing and the multi-scale induced-modification on the produced surfaces. The implementation of this multiscale approach within a mass production environment allows to correlate the tribo-functional performance of the intolerance designed surface and the manufacturing process of its generation. The various applications of this multiscale approach also demonstrate that the process signature should respond in a predictable fashion to change its functional performance with respect to the durability and energy consumption footprint of Internal Combustion Engines.

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