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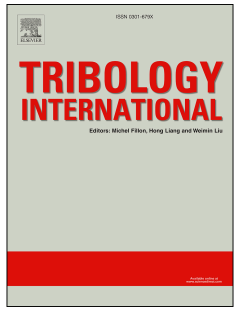

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Oil Distribution and Oil Film Thickness within the Piston Ring-Liner Contact Measured by Laser-induced Fluorescence in a Reciprocating Model Test under Starved Lubrication Conditions

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Abstract:

For a better understanding of the most important parameters and boundary conditions for scuffing initiation in the piston ring versus cylinder liner contact at fired top dead center of internal combustion engines, oil distribution measurements were performed by means of laser-induced fluorescence (LIF) on a reciprocating test rig. The 2D LIF measurements showed the change of the oil distribution in and around the contact area and verified that the oil available in the contact during the test decreased gradually over time until scuffing was initiated. For an improved quantification and increased detection limit of the oil film thickness within the contact, a sheet-of-light method was implemented, which enables evaluation of oil film thicknesses below 0.05 µm and by which it was possible to study oil film thicknesses in the range of the surface roughness level of the counterparts. The decrease of the oil supply at the leading edge of the contact area just before scuffing initiation and the corresponding very low oil film thickness below the roughness level of the surfaces was quantitatively evaluated and proved that oil starvation was an important parameter for scuffing between piston ring and cylinder liner.

1. Introduction

The continuous development of internal combustion engines for reduced fuel consumption entailed a huge number of investigations and attempts to further improve fuel economy. As the piston ring pack contributes about 25% of the friction losses of the combustion engine (1), there is large potential of optimization. Friction measurements with floating single-cylinder engines and simulation have broadened the knowledge of the processes in the piston assembly (2) (3). Furthermore, the piston ring versus liner contact is one of the most heavily loaded contacts in the power unit of an internal combustion engine. This is the reason for the strong interest in developing low-friction ring coatings, cylinder liner finishing, and low viscosity lubricants while maintaining high wear resistance of these components to ensure excellent functionality and high quality standards concerning friction, wear, and scuffing were performed. For preselection of new materials, lubricants, and coatings with high wear resistance and low friction losses, a huge number of model tests have been developed (4), (5), (6), (7). Often, the transferability of the test results is proved by a comparison of the wear mechanisms on the contact surfaces. To do this, wear phenomena on the surface of samples from fired engine tests were compared with those from model tests (8).

Wide discrepancies in the chosen parameters make model tests complex and difficult to compare. There are investigations that compare reciprocating and rotating test methods with different results depending on the test method (9), (10). The common understanding is that test parameters should be as close as possible to the real contact situation in the engine.