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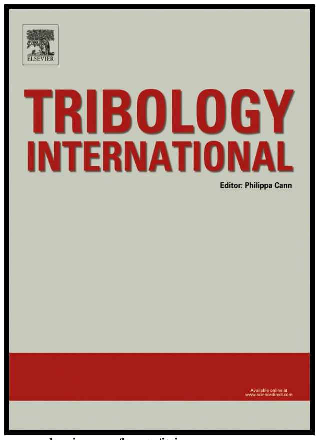

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Lubricant film thickness and friction force measurements in a laser surface textured reciprocating line contact simulating the piston ring – liner pairing

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Abstract

Applying surface texture to piston liners may provide an effective means of controlling friction and hence improving engine efficiency. However, little is understood about the mechanisms by which pockets affect friction, primarily because of a lack of reliable experimental measurements. To address this, the influence of surface texture on film thickness and friction force was measured simultaneously in a convergent-divergent bearing, under conditions that closely replicate an automotive piston ring-liner conjunction. Film thicknesses were measured using a modified version of the ultra-thin film optical interferometry approach, enabling film thicknesses <50 nanometres to be measured under transient, mixed lubrication conditions. This involved using the out-of-contact curvature of the specimens in place of a spacer layer and analysing multiple interference fringes to avoid fringe ambiguity. Tests were performed on both a textured sample (with features oriented normal to the direction of sliding) and a non-textured reference sample, while angular velocity, applied normal load and lubricant temperature were controlled in order to study the effect of varying lubrication regime (as typically occurs in service). Results showed that the presence of surface pockets consistently enhances fluid film thickness in the mixed lubrication regime by approximately 20 nm. Although this is only a modest increase, the effect on friction is pronounced (up to 41% under these conditions), due to the strong dependence of friction on film thickness in the mixed regime. Conversely, in the full film regime, texture caused a reduction in film thickness and hence increased friction force, compared with the non-textured reference. Both textured and non-textured friction values show nearly identical dependence on film thickness, (showing that, under these conditions, texture-induced friction reduction results entirely from the change in film thickness). These results are important in providing film thickness data to validate piston-ring lubrication models and also in helping to understand the effect of surface roughness on texture performance.

Keywords: Surface texture, Surface patterning, Piston rings, Optical interferometry, Thin film lubrication.