Wear transition as a function of surface texture anisotropy and formation of boundary layers

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This article presents an experimental study of how wear transition depends on texture anisotropy of surface roughness and formation of boundary layers. An experimental series was performed on a SAE 52100 steel lubricated sliding contact of ball-on-disc type, by conduction of a transient single-pass wear test. The wear test was conducted for 18 different sliding velocities in the range 0.038-1.194 m/s. Lubrication in the tests was boundary and mixed while test lubricant was an ISO VG 150 paraffinic mineral oil in which were added TPPT and a PN based additive, both multipurpose AW+EP additives.

Test discs were fine grounded to a strong anisotropic surface texture with uniformly directed grooves. When the test ball contacts the test disc for the first time, direction of the texture in relation to the sliding velocity is unbiased. After the first contact, rotation of the test disc changes this direction. Formation of the boundary layers on the test discs was varied at four levels. The boundary layers were formed on test discs prior to assembling of lubricated contacts ('in vitro') performing simple pre-forming procedures. By assembling and running the lubricated contacts, formation of the boundary layers continues in common conditions ('in situ'). The 'in vitro' formation was varied as follows. At the base level, that was no 'in vitro' formation and the boundary layers were mainly formed during the fine grinding of the surfaces. At second level, the test discs were heated to 200 °C, held at this temperature for three minutes and after put to the room temperature ('in vitro'-oxidation). At third level, the test discs were processed like for the second one, but immersed in the lubricant ('in vitro'- immersion). At fourth level, the test discs were processed also like for the second one but covered with a film of the lubricant when they reached 200 °C ('in vitro'- covering).

In order to evaluate wear after conduction of the test series, on-line test recordings for friction and normal force were compared with appearance of the test tracks and SEM-pictures of characteristic points on the test tracks. Occurrence and propagation of wear damages under regime of the boundary lubrication, were shown to accelerate at points of the test tracks where directions of the test sliding velocity and the grinding grooves are parallel to each other. This was clearly distinguished both visually as wear damages at the test tracks and graphically as suddenly peaks on friction recording.

In conclusion, the wear transition was shown to strongly depend on texture of the surface roughness under boundary and mixed lubrication. Further, the 'in vitro' formation of the boundary layers was proved to decrease the risk of the wear transition.

Keywords: Wear transition, surface texture anisotropy, boundary layers and boundary lubrication.