

ON THE GLAZE LAYER FORMATION IN ZINC AND MANGANESE PHOSPHATE COATINGS

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ABSTRACT

Casing connections in the oil and gas industry are typically coated with zinc and/or manganese phosphate for corrosion protection during storage. The presence of phosphate coatings is also known to give beneficial tribological performance during the assembly by preventing galling.

It was shown in previous work that zinc and manganese phosphate coatings form a hard and smooth glaze layer in dry sliding [1]. This was explained by the generation and compaction of the generated phosphate debris particles. Owing to this property, phosphate coatings provide excellent surface protection [2].

The research presented here is aimed at exploiting these properties for the design of environmentally friendly lubricants. Therefore, the mechanism behind its formation needs to be understood to fully benefit from the generation of this glaze layer and the surface protection.

Glaze layers were generated in a pin-on-disc and ring-on-ring set-up under dry and lubricated conditions. Six base oils with different polarity and viscosity were used. The generated glaze layers were investigated with atomic force microscopy to measure the particle size and their packing. The crystal structures of the initial and glaze layer were determined with X-ray diffraction. A cross section of the glaze layer was made using focused ion beam and inspected using a scanning electron microscope. Hardness was measured using nano-indentation.

The results show that glaze layer hardness is driven by Van der Waals interaction and governed by particle size and their packing. The highest hardness is achieved in dry sliding conditions because this generates the smallest particles and closest packing.

The interaction is modified by the presence of a lubricant in two ways. The particle size generated is larger because of the lower interfacial shear stress and the Van der Waals interaction is weaker because of encapsulation by the lubricant. Therefore, the glaze layer generated has a lower hardness in lubricated conditions.

Based on the experimental work a model is developed for the resulting hardness based on Van der Waals interactions as a function of the Hamaker constant, particle size and packing.

The model can be used to select a base oil that maximizes the synergy with the phosphate coatings based on its physical properties.

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