THE IMPACT OF ANTIWEAR ADDITIVE ON SURFACE-FATIGUE PERFORMANCE OF DLC COATINGS IN ROLLING/SLIDING CONTACTS

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KEYWORDS
surface fatigue; hard thin-carbon coatings; ZDDP; tribochemistry; roller-element bearings

ABSTRACT
The surface fatigue performances of different types of DLC coatings including tetrahedral amorphous carbon (ta-C), tungsten-doped amorphous carbon (W-DLC) and (hydrogenated) amorphous carbon having a W-DLC bulk layer (W-DLC+a-C:H) lubricated with Base-Oil (BO) and BO+ZDDP are investigated using a modified-Micropitting Rig (MPR). The wear mechanisms in each coating have been studied using X-ray Photoelectron Spectroscopy (XPS), Scanning and Transmission Electron Microscopy (SEM and TEM).

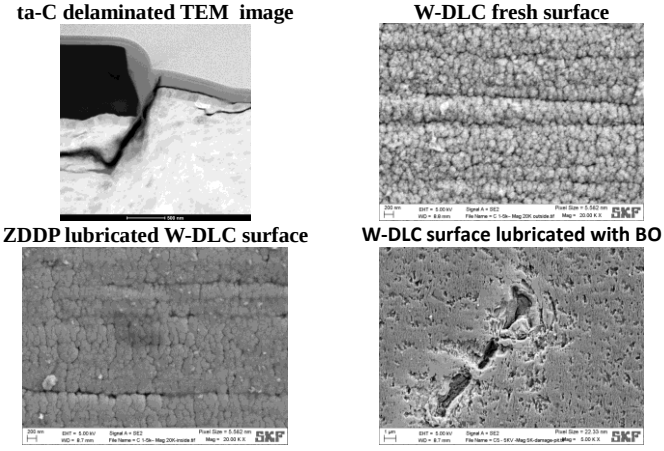
INTRODUCTION
Diamond Like Carbon (DLC) coatings due to their generally low wear and low friction properties are used in bearings, gearboxes and valve train components in automotive industry. Various parameters influence DLC coating properties and hence the tribological performance [1]. Moreover, lubricant formulation substantially influences the DLC coating performance [1] indicating the significant role of the tribochemistry.

In order to improve the lubricant performance anti-wear additives, such as Zinc Dialkyl DithioPhosphate (ZDDP), are used in bearings and gears lubricant formulations. Nevertheless, ZDDP under certain conditions enhances micropitting surface fatigue on steel surfaces [2]. The detrimental influence of ZDDP on micropitting and impact of tribochemistry on the performance of different DLC coatings necessitate mechanistic study of different DLC coatings with respect to different lubricant formulations under rolling/sliding surface-fatigue contacts.

METHODOLOGY
Experiments are carried out against rough steel counterbodies for durations of one and two-million contact cycles at 90°C under Slide-to-Roll Ratio (SRR) of 2%. W-DLC due to a superior performance was subjected to further experiments under SRR of 10%.

RESULTS AND DISCUSSION
While ta-C coating regardless of lubricant formulation undergone delamination originated from interlayer and substrate (Figure 1), a slight improvement in performance is observed for W-DLC+a-C:H where ZDDP was present in the lubricant showing a general local delamination and wear of the top a-C:H layer of the coating. In most of the regions the wear did not exceed the a-C:H exhibiting intact W-DLC bulk layer. Although ZDDP enhances micropitting on steel, it profoundly protects the W-DLC surface from wear and only slight polishing wear was observed on the surface as shown in Figure 1. Removing ZDDP from lubricant promotes micorpitting on the W-DLC. XPS confirmed that ZDDP-tribofilm formed on the surface protects the tungsten from oxidation and subsequent oxidative wear in agreement with TEM results.

Figure 1. TEM and SEM images of the castings



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