

Comparative study of tribological behaviour of steel/steel and steel/nanocrystalline diamond contacts lubricated by organomolybdenum and ZnDTP

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1. Introduction

Nowadays, the control of energy consumption is a priority, especially for the automotive industry. The reduction of energy consumption of diesel engines can be reached through the minimization of friction losses of some engine parts, like the ring-piston-liner. Some authors blame this part to be responsible for 40% of friction losses in the entire diesel engine, particularly in case of mixed and boundary lubrication [1].

To overcome this problem, various chemical additives can be added to engine oil. These compounds interact with steel surfaces or coatings deposited on these surfaces and form protective layers to reduce friction coefficient between the two surfaces in contact. Fire segment, in his capacity as head segment is subjected to severe conditions and therefore to significant wear. That is why we propose to apply a coating of NanoCrystalline Diamond (NCD). Subsequently, it is needed to formulate a lubricant suitable for both steel/steel and steel/NCD contacts.

2. Nanocrystalline diamond coatings

Nanocrystalline diamond coatings were elaborated by MW-PECVD (Plasma Microwave-Enhanced Chemical Vapour Deposition) process and have unique properties in terms of resistance to wear, abrasion and corrosion and they can exhibit very low friction in certain conditions [2]. For this study, we selected a NCD coating combining both strong mechanical properties and very low surface roughness (see Table 1).

Table 1 : Main properties of NCD coatings

Gaseous mixture	Diamond purity (%)	Hardness (GPa)	Biaxial modulus (GPa)	RMS (nm)
CH ₄ -CO ₂ 50%	75	60±5	550	20

3. Experimental details

For tribological experiments, a reciprocating cylinder-on-flat tribometer was used to simulate the ring/cylinder contact geometry in thermal engines. Friction pairs were made of 100C6 steel cylinder and NCD-coated Ti-6Al-4V alloy flat. The wear track was 5 mm long, the temperature was 80°C and the frequency used is 5Hz with the sinusoidal sliding speed A normal load of 50N ensures initially a maximal contact pressure of 270MPa. The lubricant is composed of grade 4 poly-alpha-olefin base oil, organomolybdenum friction modifier and zinc dialkyl-dithio-phosphate (ZnDTP) antiwear additives.

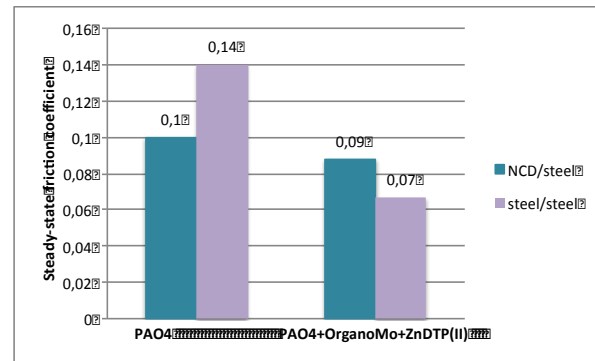
After friction experiments, the samples were washed

with heptane in an ultrasonic bath. Then, surface analyses were carried out inside and outside the tribofilm by X-Ray Photoelectron Spectroscopy (XPS), and Time Of Flight Secondary Ion Mass Spectrometry (TOF-SIMS).

4. Results

Figure 1 compares the steady-state friction coefficients obtained with the PAO4 alone and PAO4 with additives. It is clear that the presence of additives decreases friction in both cases, even if they appear more active on ferrous surfaces (see Fig. 1). Moreover, Organomolybdenum does not contain sulfur therefore it is a more environmentally friendly additive.

Fig. 1: Comparison of steady-state friction coefficient of steel/steel and steel/NCD contacts lubricated with PAO4 only and with a lubricant composed of PAO4, Organomolybdenum and ZnDTP(II).



6. Conclusion

In this work, we would like to understand lubrication mechanism and explain differences between steel/steel and steel/NCD behavior.

5. References

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