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The analytical study of friction reduction in instrumented single-cylinder block

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Diamond-carbon like coating has been widely used in friction reduction of motors. However, the interaction between DLC and commercially available engine oil is still unclear. In our project, commercially available fully formulated/base oil are employed for reciprocating sliding tests in DLC self-mated and DLC/steel mixed configuration. The different parameters as sliding velocity, contact pressure, temperature are tuned to investigate the impacts of sliding conditions on tribological behaviors. Furthermore, surface analyses (SEM, XPS, TEM, etc.) are performed inside/outside the wear track to interpret the tribological behaviors, thus to have a deeper understanding of the interaction between DLC and engine oil.

Keywords: diamond-like carbon, fully formulated oil, reciprocating sliding conditions

1. Introduction

Diamond-like carbon (DLC) has become attractive in automobile industry thanks to its excellent anti-wear property and superlubricity. For example, by tuning the mechanical properties of coatings, tetrahedral amorphous (ta-C) DLC self-mated configuration can reach ultralow friction regime ($0.01 < CoF < 0.03$) with the presence of ZDDP and the wear volume is ignorable [1]. Besides, CoF of steel/ta-C mixed configuration lubricated by glycerol can even reach into superlubricity regime ($CoF < 0.01$) [2]. Amorphous hydrogenated (a-CH) DLC self-mated configuration can also have CoF around 0.02 with PAO 6, but CoF increases with the presence of additives, such as ZDDP [3]. However, in the works mentioned above and most of the other works, the selected oils are mainly base oil + one/two additives. This does not meet the requirements of industrial application, in which the commercially available fully formulated engine oil is chosen.

2. Objects

In our project, we employ a-CH, ta-C and steel materials in order to have DLC self-mated and DLC/steel mixed configuration. The reciprocating sliding tests are performed with a new born fully formulated oil and its corresponding base oil, by tuning the sliding conditions we can have a deep understanding on the interaction mechanism between DLC and oil.

3. Methods

3.1. Materials

The ta-C coatings with different hardness and a-CH with 20% H are deposited on ball, cylinder and for reciprocating sliding tests. The uncoated steel ball and cylinder are made by 100Cr6, and uncoated disk is prepared in AISI M2. The selected lubricants are a new type of formulated oil and its corresponding base oil.

3.2. Tribological tests

Ball-on-disk and cylinder-on-disk sliding tests are performed thanks to a homemade linear reciprocating tribometer. The tests are carried out using DLC (ta-C + a-CH) self-mated, DLC/steel mixed and steel/steel (as reference) configurations. The pressure is tuned from 150MPa to 1GPa, maximum sliding velocity ranges from 5mm/s to 100mm/s. The initial lubrication regimes for both two configurations are in boundary.

3.3. Characterizations

The surface for inside/outside wear track is analyses by optical microscope, interferometry, SEM, XPS and TEM to interpret the tribological behaviors variations.

4. References

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