The anti-friction performance of nano-copper additives in lubricated oil for the cylinder liner-piston ring tribo-systems

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The study aims to gain the insights into the interactions between concentrations of nano-copper powder lubricating additives and the tribological performance of cylinder liner and piston ring (CLPR). Tests are performed on a reciprocating sliding test-rig, and the tribological performances are characterized by the friction coefficient and wear mass loss. Compared with the engine oil without nano-copper powder additives, the experimental results indicated that an appropriate concentration (e.g., 2 wt.%) of nano-copper powder could significantly improve the tribological performances of the CLPR. The impacts of concentration of nano-copper powder additives on tribological performance of CLPR were revealed.

Keywords (from 3 to 5 max): nano-copper additives; cylinder liner piston ring; tribological performance; marine diesel engine

1. Introduction

Frictional losses of the cylinder liner piston ring (CLPR) have a negative impact on a marine diesel engine's fuel economy and reliability. Lubricant and additive technologies are thereby introduced and have great importance on the tribological performance of CLPR friction pairs. Nano-copper lubricant additives have recently been discovered (in the 1980s) and found to be effective in reducing friction and wear [1]. Meanwhile, an appropriate concentration of nano-copper powder additives can significantly affect the tribological behavior of nano-particle suspension in engine oil [2]. With respect to the reduction of frictional losses in diesel engines, it is significant to gain the insights into the tribological performance impact of concentration of nano-copper powder additives on CLPR.

2. Methods

Firstly, the cylinder liner and piston ring specimens made of cast iron (QT500) and cast iron (HT300) respectively were prepared and weighted. Seven types of engine oil with different concentrations of nano-copper power additives are generated, including 0%, 0.25%, 0.5%, 1%, 2%, 4%, and 8%. Subsequently, a series of tests are performed on a reciprocating sliding test (Figure 1).

Secondly, the force of friction, position, and other parameters are collected continuously in real-time during the sliding tests. The coefficient of friction is calculated following:

$$COF = \frac{f}{F} \quad (1)$$

Where, f (N) is the force of friction, F (N) is the applied load, and COF indicates the coefficient of friction.

Finally, two different loads and speeds are applied to simulate the real working condition. Four tests were conducted under different loads and speeds. Among them, seven tests with different concentrations of nano-copper power additives were conducted under a certain load and speed.

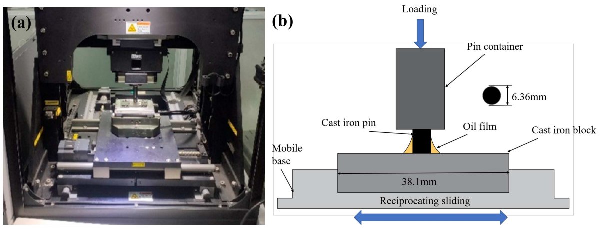

Figure 1: reciprocating sliding test apparatus: (a) R-tec-tribo-tester; (b) schematic view of the experimental process.

3. Discussion

The results of frictional tests indicated that the engine oil with 2 wt.% of nano-copper powder additives could significantly improve the tribological performances of the CLPR, compared with the engine oil without nano-copper powder additives. It can be explained by the fact that the deposition of nano-copper powder decreases the shearing resistance. By contrast, relative higher (e.g., 8 wt.%) concentration of nano-copper powder additive is favorable for aggregation in the engine oil, which manifest itself in an increased friction coefficient and wear mass losses of piston ring. The concentration of nano-copper powder additives can affect the tribological performance of CLPR and there is an optimum value. This study aids in understanding the tribological performance impact of concentration of nano-copper powder additives on CLPR.

4. References

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