Tribological performance of DLC/cast ironand steel/cast iron system when lubricated in fully formulated oils with different concentration of MoDTC-type friction modifier.

Shahriar Kosarieh[1)*],Ardian Morina[1)],Jonathan Flemming[2)], Emmanuel Lainé[2)] and Anne Neville[1)].

[1)]Institute of Engineering Thermofluids, Surface and Interfaces (iETSI), School of Mechanical Engineering, University of Leeds, LeedsLS2 9JT, UK.
[2)]Infineum UK Limited, 1 Milton Hill Abingdon, Oxfordshire, UK

[*]Corresponding author:S.kosarieh@leeds.ac.uk

1. Introduction

The application of non-ferrous Diamond-like carbon (DLC) coatings have become an attractive Surface Engineering solution as they showuniquetribological properties including low friction and better wear resistance resulting in improved fuel economy and durability of the engine components in contact. Commercially available oils are optimised to work on conventional ferrous surfaces and are not necessarily effective in lubricating non-ferrous surfaces.

Our previous study showed that fully formulated oils with low concentration of MoDTC provided high friction but excellent wear performance[1]. In this work, the friction and wear properties of a hydrogenated DLC coating under boundary lubrication conditions have been investigated and the tribological performance compared with that of an uncoated steel system. The main focus was to investigate whether or not increasing the level of MoDTC source would reduce the friction while maintaining the good wear performance provided by fully formulated oils.

2. Experiments

The experiments were carried out using a pin-on-plate tribotester. The plates were HSS steel plates coated with 15 at.% hydrogenated DLC (a-C:15H)which were sliding against cast iron pins. One type of fully formulated oil with and without ZDDP and twolevels of MoDTC type friction modifier (Typical and High) were used in this study.

In addition, different surface analysis including optical and scanning electron microscopes (SEM) were used to observe the wear scar and make measurements of the durability of the coatings. X-ray photoelectron spectroscopy (XPS) analysis was performed on the tribofilms to understand the tribochemical interactions between oil additives and the DLC coating. UV Raman microscopy and Nano-indentation was conducted to observe the changes in the structure of the coating, which can provide a better insight into the wear mode and failure mechanism of such hard coatings.

3. Results

Based on the physical observations and tribochemical analysis of the wear scar, increasing MoDTC level would decrease the friction for both a-C:15H/CI and uncoated steel/CI systems.In addition, wear performance of a-C:15H coating would dependsignificantly on the concentration of MoDTC type friction modifier in the oil while having little or no effect on the uncoated steel wear.

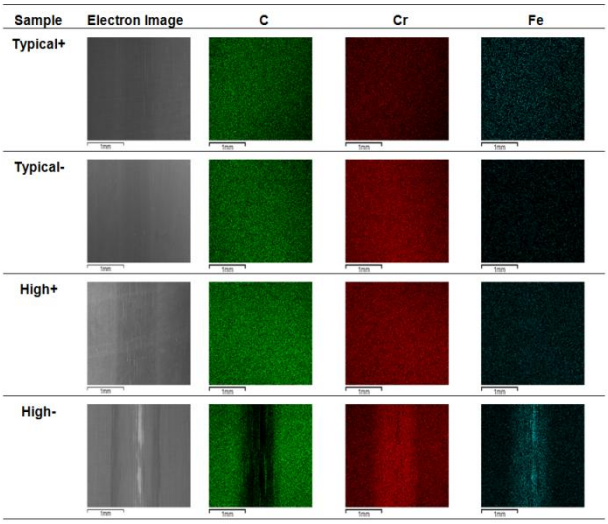

Figure 1 SEM image of a-C:15H coating along with EDX mapping of the C, Cr and Fe atoms.

4. Conclusion

Although high concentration of moly decreased the friction in the steel/CI system, it can promote wear of a-C:15H DLC coating in oils without ZDDP and this wear can be mitigated by the addition of ZDDP. However, the presence of ZDDP in the oil increased the friction for both systems. This study showed that the presence of ZDDP in fully formulated oils can promote some level of confidence that an additive solution can be tailored for the mitigation of DLC wear with formulation carrying a high level of Mo-FM (High+). However, further investigation of DLC wear induced by MoDTC is still essential.

5. References

[1] Kosarieh, S., et al., *Tribological performance and tribochemical processes in a DLC/Steel system when lubricated in a fully formulated oil and base oil.* Surface & Coatings Technology.