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Clarification of the effect of a-C:H coating's hardness on wear characteristic of a-C:H under Oil lubrication with MoDTC additives

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In this study, the effect of hardness on wear properties of a-C:H coatings under MoDTC-containing oil lubrication was investigated. a-C:H coatings with hardness of 300, 600, 800 and 1200 Hv were friction-tested against bearing steel balls. Under oil lubrication with MoDTC, softer a-C:H coatings than mating bearing steel balls showed higher specific wear rate than those under base oil lubrication. However, harder a-C:H coating than bearing steel balls, showed a convex shape in the wear traces. Therefore, it was clarified that the hardness of the mating material strongly affected the wear characteristics of the a-C:H coatings under lubrication with MoDTC.

Keywords (from 3 to 5 max): DLC coating, MoDTC additives, wear

1. Introduction

Diamond-like-carbon (DLC) coating have good friction properties and DLC coatings are expected to coat automobile engine bearing. However, some papers reported that Hydrogenated amorphous carbon (a-C:H) coatings highly wore out under oil lubrication with Molybdenum dithiocarbamate (MoDTC) [1] and the definite wear mechanism has not become clear.
In this study, the wear mechanism of a-C:H under oil lubrication with MoDTC was investigated by using a-C:H which had different hardness. I carried out friction test with the a-C:H and evaluated the effect of a-C:H hardness on the wear properties of a-C:H under oil lubrication with MoDTC.

2. Methods

2.1. Material and lubricants
The a-C:H coatings were deposited on steel disk (Ra = 8 nm: AISI steel grade: 52100). The hardness was 300 Hv, 600 Hv, 800 Hv and 1200 Hv and thicknesses were about 5 μm. These a-C:H were made by same method but with different conditions. Friction partner material was a bearing steel ball (Ra = 7 nm: AISI steel grade: 52100). The bearing ball hardness was 862 Hv. Base oil was poly-α-olefin 4 (PAO4) and MoDTC-containing oil was PAO4 with a 700 ppm MoDTC concentration.

2.2. Experimental condition
To evaluate the wear and friction properties of a-C:H coatings, I used ball-on-disk friction tester. Oil temperature was 80 ºC and sliding speed was 93 mm/s. Normal load was 1 N and test time was 100 min under base oil lubrication. On the other hand, normal loads were 1 N and 5 N and test time was 30 min under oil lubrication with MoDTC.

3. Result and discussion

Figure 1 shows the relation between a-C:H hardness and specific wear rate (SWR) of a-C:H disk. The open circle, cross mark and open triangle line indicate SWR of a-C:H disk at test load of 1 N under baes oil lubrication, at test load of 1 N under oil lubrication with MoDTC and at test load 5 N under oil lubrication with MoDTC. SWR of a-C:H disk increased under oil lubrication with MoDTC and SWR of softer a-C:H increased more. In addition, the more normal load increased, the more SWR of a-C:H disk increased under oil lubrication with MoDTC. The result which SWR of softer a-C:H increased under oil lubrication with MoDTC indicated that wear mechanism was affected by a-C:H hardness. Figure 2 shows optical images on wear track of a-C:H disks. There was blue tribofilm on a-C:H disk of 1200 Hv, but no tribofilm on a-C:H disk of 300 Hv. This results indicated that tribofilm derived from MoDTC may protect from wear of a-C:H. Tribofilm derived from MoDTC was observed on only a-C:H disk of 1200 Hv and this was suggested that harder a-C:H than mating material may be protected by tribofilm and there may be no increase of wear volume of a-C:H.

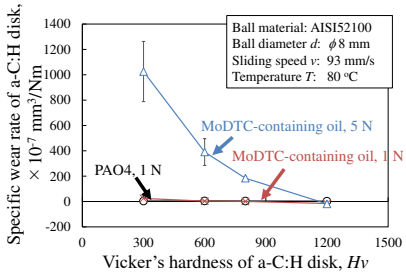

Figure 1: SWR of a-C:H disk with various hardness

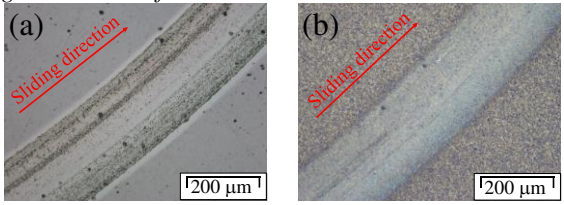

Figure 2: Optical images of a-C:H disks after friction test, (a) 300 Hv, (b)1200 Hv

4. References

[1] B Vengudusamy, et al. "Behaviour of MoDTC in DLC/DLC and DLC/steel contacts." Tribology International 54 (2012): 68-76.