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S K-edge XANES measurements of tribofilms generated on steel blocks from belt-drive continuously variable transmission fluid

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Introduction

Recently, belt-drive continuously variable transmissions (CVTs) have attracted attention because they give better fuel efficiency than conventional automatic transmissions. Belt-drive CVT fluids (belt-drive CVTFs) are required to have a high friction coefficient between metal surfaces in order to transmit forces efficiently[1]. Friction coefficients are governed by the the tribofilms generated on the metal surface by lubrication. So, in order to develop high-performance belt-drive CVTFs, it is necessary to clarify the nature of the tribofilms.

In this paper, we report change in chemistry of the S species in the tribofilms generated on steel blocks during friction tests.

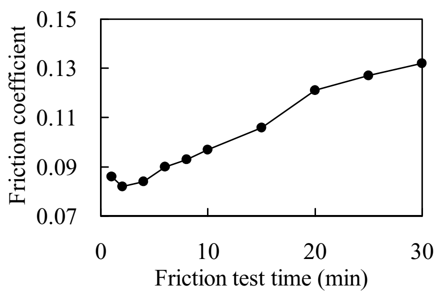
Experimental

The block-on-ring friction test[2] was employed to prepare tribofilms and measure the friction coefficients of the test fluid. The test conditions are described elsewhere[3]. Tribofilms after various durations of the friction test were then subjected to XANES measurement. The concentrations of S, P, Ca and Mg in the test fluid are 1400, 310, 200 and 180ppm, respectively.

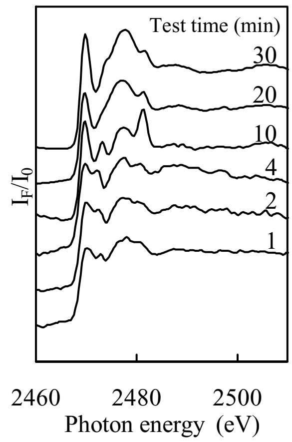
The S K-edge XANES measurements were carried out on BL-9A. The samples were placed under a flowing helium environment, and the spectra were collected using a fluorescent ion chamber in the fluorescence yield mode.

Results and Discussion

The friction coefficient changed as a function of the test time changed (Fig. 1). This suggests that the chemistry of the tribofilms changed during the friction test. Sulfur-containing compounds in CVTFs are thought to react with metal surface easily and play important roles to form tribofilms. Thus, the S K-edge XANES specta were examined. The shape of the S K-edge XANES spectrum changed, as the friction test time (Fig.2). This indicates that the chemistry of the S species in the bulks of the tribofilms changed as the test time changed. So, in order to estimate the compositions of the S species in the tribofilms, the XANES spectra of tribofilms were deconvoluted with those of sulfur-containing model compounds expected to be in the tribofilms.



As a result of deconvolutions, it was found that the tribofilms were mainly composed of FeS, FeS_2 and alkyl sulfide at the shorter friction test time points, corresponding to the lower friction coefficient points(Fig. 3). As the test time increased, or the friction coefficient became higher, the ratio of FeS_2 in the tribofilms decreased and the ratio of FeS and alkyl sulfide increased.



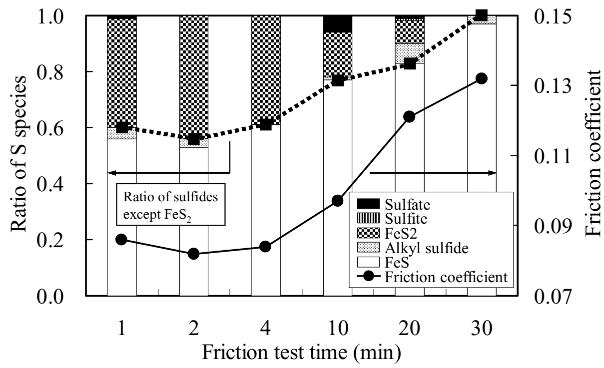


Fig. 3 Ratio of S species in bulks of tribofilms

Therefore, the followings were suggested. (1)As the ratio of sulfides except iron disulfide becomes higher, the friction coefficient becomes higher. (2)Iron disulfide is not effective for increasing the friction coefficient. (3)The decrease of the friction coefficient in the early stage of the friction test is caused by the formation of iron disulfide. (4)As the friction test time increases, the iron disulfide disappears and the friction coefficient increases.

References

[1] Y. Mabuchi *et. al, Trib. Trans*. **43**, 229 (2000) .
[2] William C. *et. al*., '98 TVT Symposium', 82 (1998).
[3] Y. Iwanami *et. al., Physica Scripta* **T115,** 332 (2005).

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