KYODO YUSHI TECHNICAL BULLETIN

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NS compound's Contribution to Preventing Reduction of Fatigue Life in Hydrogen

It was reported in the last issue (KYTB 8) that the reduction of fatigue life in hydrogen is due to repeated rolling contact to allow hydrogen to permeate into steel to form a condensed layer beneath the steel surface. In this issue, following KYTB 7 where certain types of rust inhibitors and anti-wear additives effectively prevented hydrogen from permeating into steel, a nitrogen/sulfur compound (hereafter called NS compound) was examined to verify its potential for fatigue life extension.

Accelerated fatigue life testing was performed using a rolling four-ball tester as in KYTB 8 to evaluate the fatigue life under static load in hydrogen or in deuterium. In the test cup filled with lubricating oil, three freely-rolling bearing balls were rotated by another bearing ball placed on the top of them. In the experiment using the same four-ball tester reported in KYTB7, some organometallic salts effectively prevented flaking when added to the lubricating oils. To cope with today's severe operating conditions of rolling bearings for electric auxiliary components in vehicles, similar experiments were carried out to find a more effective additive for flaking prevention.

This experiment focused on the potential of a NS compound for fatigue life extension. Table 1 summarizes the results of four-ball life tests. Fig.1 shows the cross section of the rolling track of the upper ball tested with or without NS compound. While the ball lubricated with organometallic salt A, the most effective additive recognized in the previous experiment, had a L_{10} life of 46×10^6, NS compound prevented flaking up to a L_{10} life of 75×10^6 presenting no evidence of white structure formation.

Table 1 Additive's contribution to preventing the reduction of life

Additive	None	Organometallic salt A	NS compound
L_{50} life, 10^6	6.4	75<	75<
L_{10} life, 10^6	3.4	46	75<
White structure formation	Yes	No	No

Similar to KYTB 8, TOF-SIMS analysis was carried out on the cross section of the upper ball tested in deuterium to study the existence and condition of deuterium in steel. Fig.2 shows the chemical images of deuterium. The steel ball in the lubricating oil with NS compound had an abundance ratio of deuterium of nearly one as compared to that in nature, which represents that almost no deuterium permeated into steel. These results suggest that NS compound effectively prevents the reduction of fatigue life associated with hydrogen permeation into steel by forming a film on a rolling track surface.

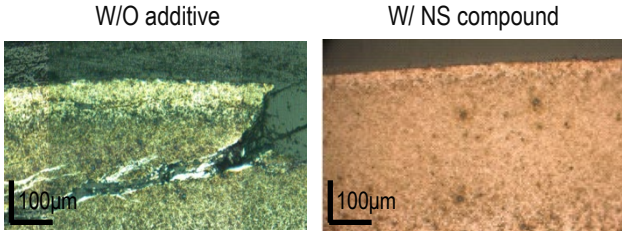

Fig.1 Cross-sectional observation

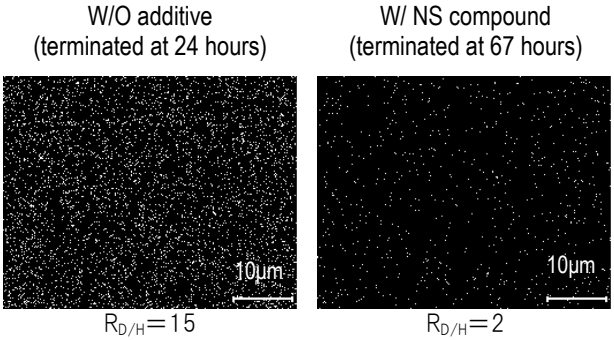

Fig.2 Chemical image of tested ball and deuterium ratio ($R_{D/H}$)

$$R_{D/H}=\frac{D^-/H^- \text{ (TOF-SIMS intensity ratio)}}{D/H \text{ (abundance ratio, in nature)}}$$

T. Komoriya, J. Imai, T. Endo, Y. Fukushima, M. Muto, S. Nakazawa, Y. Okada, H. Nanao and S. Mori: Proceedings of JAST Tribology Conference (Tokyo 2013-5) F13.