KYODO YUSHI TECHNICAL BULLETIN

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LUBRICANT'S CONTRIBUTION TO PREVENTION OF SHORTENED FATIGUE LIFE IN HYDROGEN

The rolling four-ball tests as reported in our previous issue (KYTB 6) demonstrated a reduction in fatigue life in hydrogen environment, where repetitive contact between balls stimulated the formation of white structure accompanied by crack propagation leading to flaking at an early stage. The same tests were carried out to examine the effect of lubricating oil additives on fatigue life in hydrogen and confirmed that certain types of rust inhibitors and anti-wear additives can prevent shortened fatigue life.

Fig.1 shows the rolling four-ball tester used in this study. In the cup filled with air or hydrogen, three bearing balls were rotated by another bearing ball placed on the top of them to simulate fatigue flaking in rolling contact. In our previous test (KYTB6), two PAOs of different kinematic viscosities were used as a lubricating oil to provide two lubrication regimes, full EHL (condition 1) and partial EHL (condition 2), where the ratio of minimum oil film thickness to composite surface roughness was above 3.0 and 1.4 to 2.0, respectively. The test results showed that a white structure formed only in hydrogen and the life of balls in hydrogen was shorter by one order of magnitude than that in air. With these results in mind, this study examined the effect of organometallic salts in lubricating oil on fatigue life in hydrogen.

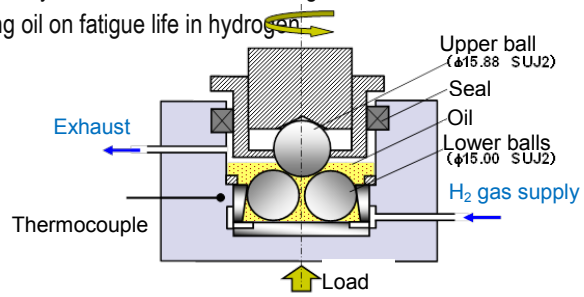

Fig.1 Main part of rolling four-ball tester

Table 1 shows the results of the tests under full EHL condition. Under this relatively mild lubrication condition, some organometallic salts used as a rust inhibitor or an anti-wear additive, especially organometallic salts A and B effectively extended the fatigue life when added alone. With organometallic salts A and B, no white structure formed likely because these rust inhibitors formed a dense adsorption film on the ball surface which prevented hydrogen from permeating into the steel.

Meanwhile, in the presence of solid contact under condition 2 (Table 2), a white structure formed even when organometallic salts A and B were added. Organometallic salt B had little effect in extending the fatigue life. The adsorption film seemed to have disappeared due to wear allowing hydrogen permeation. However, when used in combination with organometallic salt antiwear additives D or E, these rust inhibitors prevented white structure formation and significantly extended the flaking life. It is considered that the antiwear action of organometallic salts D and E helped the adsorption film remain and enabled extended life.

J. Imai and Y. Imai : Proceedings of the JAST Tribology Conference, Nagoya (2008-9) 351 (in Japanese).

Table 1 Results of rolling four-ball tests in hydrogen (Condition 1)

Additive	None	Rust inhibitor			Anti-wear additive	
		Organometallic salt A	Organometallic salt B	Organometallic salt C	Organometallic salt D	Organometallic salt E
L_{50} life, 10^6 rotations	6.4	75<	70<	22	75<	34
L_{10} life, 10^6 rotations	4.3	46	16	16	-	6.2
White structure formation	Yes	No	No	-	Yes	Yes

Table 2 Results of rolling four-ball tests in hydrogen (Condition 2)

Additive	None	Rust inhibitor		Rust inhibitor + Anti-wear additive		
		Organometallic salt A	Organometallic salt B	Organometallic salt A + D	Organometallic salt A + E	Organometallic salt B + E
L_{50} life, 10^6 rotations	33	112	32	230<	63	230<
L_{10} life, 10^6 rotations	9.6	69	20	-	24	-
White structure formation	Yes	Yes	Yes	No	Yes	No