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REDUCTION IN FATIGUE LIFE IN HYDROGEN ENVIRONMENT

In rolling contact bearings used for automotive electrical components and auxiliary machineries, a reduction in fatigue life attributed to subsurface-initiated flaking resulting from white structure formation has been one of the critical issues. Considering that hydrogen has been noted as the cause, rolling contact fatigue tests were conducted in hydrogen and in air to study the differences in fatigue life and structural change with a focus on the effect of hydrogen permeation into steel.

Fig.1 shows the rolling four-ball tester used in this study. In the cup filled with lubricating oil, three freely-rolling bearing balls were set, on which another bearing ball was placed under static pressure to simulate flaking in rolling contact. The upper and lower balls were made of SUJ2 steel and had a diameter of 15.88 mm and 15.00 mm, respectively (in accordance with JIS B 1501). As summarized in Table 1, two different lubricating conditions, partial and full elastohydrodynamic lubrication (EHL) were achieved by changing load and the kinematic viscosity of test oil in air or in hydrogen. As for the tests in hydrogen, commercially available hydrogen was continuously supplied from the bottom of the cup.

Fig.2 shows the fatigue life, i.e., the number of contact before flaking occurred under different conditions. The life of the ball in hydrogen was significantly shorter than that in air regardless of test condition. Fig.3 shows the cross section of the tested upper ball, in which a white structure formed only in hydrogen. The white structure is considered to consist of an aggregate of ultrafine ferrite grains changed from a martensite structure and was observed in the vicinity of the maximum shear stress or shear stress amplitude areas. In hydrogen, it seems that repetitive contact between balls stimulated the formation of white structure accompanied by crack development leading to flaking at an early stage.

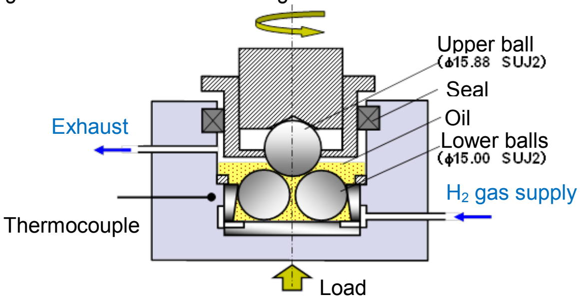

Fig.1 Main part of rolling four-ball tester

Table 1 Test condition

		Cond. 1	Cond. 2
Load, N (Max. Hertzian pressure, GPa)		2450(5.6)	980(4.1)
Lubricating oil		PAO400	PAO30
Kinematic viscosity, mm²/s	40℃	394	30.5
	100℃	40.1	5.9
Rotating speed/upper ball, rpm		1500	1500
Film thickness ratio		3<	1.4～2.0
Hydrogen gas supply, ml/min		15～20	15～20

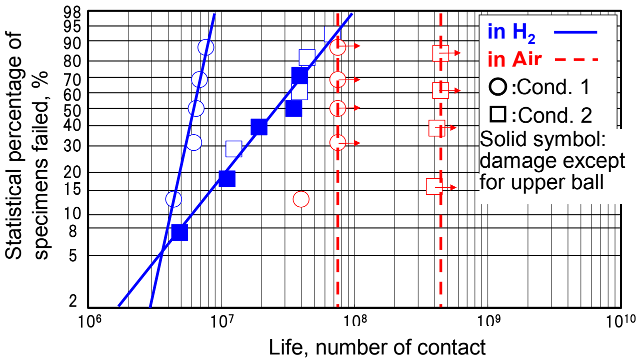

Fig.2 Fatigue life in hydrogen and in air

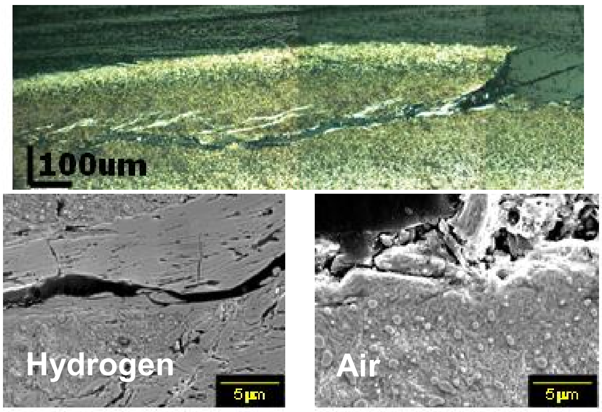

Fig.3 Cross-section of flaked upper ball

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