Effect of Temperature on Micro-Pitting Strength of Carburized Steel

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1. Introduction

The gear systems of moving vehicles can be made more compact and lightweight by increasing contact pressure on gear tooth surfaces. However, in the carburized steel gears that are conventionally used in moving vehicle gear systems, micro-pitting sometimes occurs on gear tooth surfaces at about half the pressure of general design criteria [1]. The strength of this micro-pitting is affected by changes in temperature of gear tooth surfaces [2], but is not fully understood. We report on the effect of temperature on the micro-pitting strength of carburized steel.

2. Experiment

We used two-roller-testing-machines with a force-feed lubrication system to evaluate micro-pitting strength. The temperature of the test roller surface and the coefficient of friction between the test and the mating roller were measured. The specifications of the rollers are shown in Table 1 and those of the lubricating oils and test conditions are shown in Table 2 and 3. To clarify the effect of temperature, sliding velocity, contact pressure, and D-value [3] that indicates the severity of the lubrication were kept at just about the same.

Table 1 Specifications of test and mating roller

		Test roller	Mating roller
Diameter	[mm]	28.4	127.6
Radius of crowning	[mm]	—	50
Material	[—]	SCM420	
Heat treatment	[—]	Carburizing, quenching, and tempering	
Surface hardness Hv	[—]	701	689
Surface roughness Rz	[µm]	2.0	1.0

Table 2 Specifications of lubricating oils

		Oil A	Oil B	Oil C
Kinematic viscosity @40℃/@100℃	[m^2/s]	9.755 /2.553	90.53 /10.85	451.8 /32.82
Density	[g/cm^3]	0.8581	0.8750	0.8868

Table 3 Test conditions

		Test1	Test2	Test3
Sliding velocity	[m/s]	0.1		
Maximum Heltzian contact pressure	[GPa]	3.0		
Lubricating oil / temperature	[—] [℃]	Oil A 43	Oil B 105	Oil C 150
D-value [3]	[—]	46	44	44

3. Results and Discussion

The relationship between damage ratio, i.e., the ratio of the area of micro-pitting to the area of the sliding surface and number of cycles, is shown in Fig .1. The temperature (T) of the test roller surface and coefficient of friction (μ) between the test and the mating roller are also shown in Figure. 1. In Test 1 and 2, the damage ratio was about the same regardless of the number of cycles. On the other hand, the damage ratio was increased in Test 3 as compared to Test 1 and 2. The coefficient of friction was just about the same in each test condition, and the temperature of test roller was almost the same as that of the lubricating oil. Although not shown, there was no significant difference in micro Vickers hardness of the test roller in depth at 50-µm intervals in each test condition. From the above, we estimated that the difference of micro-pitting strength was caused by differences in test roller temperature, and conclude that hardness in the range shallower than 50 µm is important.

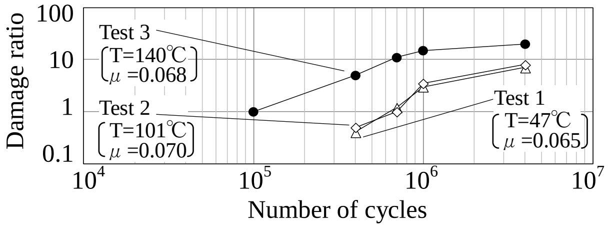

Fig .1 Relationship between damage ratio and number of cycles

4. Summary

The damage ratio was 7~8% when the temperature of test roller was 47 ℃ and 101℃. On the other hand, damage ratio was about 20% when the temperature of test roller was 140 ℃. Therefore, we estimated that micropitting strength had fallen to a low level due to the rise in temperature of the roller.

5. References

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