

Low Friction Seal for Muddy Water with Textured Surface

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ABSTRACT

This paper describes that the effect of surface texture of sealing lip on lubrication and sealing performance examined experimentally on practical aspect. Hub seals of PAC type were used in this study. A test apparatus and operating procedure were shown. The seal which had texture on the lip had lower frictional torque than plain one. The effect of friction reduction with the textured surface preserved up to 15 cycles, which was equivalent to a travel distance of 30,000 km. The textured surface 10 μmRz with grease on the lip kept sealing performance up to -0.10 MPa in static and dynamic conditions. The endurance time of sealing of the textured surface was almost the same as that of the plain surface in seal endurance test with muddy water.

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2. INTRODUCTION

One of the environmental issues we are facing is global warming. It is said that one of the causes of global warming is the emission of greenhouse gas (carbon dioxide, methane, etc.). Recently, reduction of CO_2 emissions has been discussed internationally. The amount of CO_2 emissions from automobiles is said make up 20% of the total emissions. In order to improve global warming, reducing CO_2 emissions from automobiles is effective by improving fuel consumption. Friction reduction of seal component is one of the big trends to meet the demand of automotive industries.

Hub seals are used for hub bearing unit (Figure 1). There are various types of hub seals, such as the PAC type and the KB9Y type as shown in Figure 1. The function of the hub seal is to protect the bearings from muddy water and dust, and to prevent leakage of lubricant in hub bearing unit. On the other hand, it is said that approximately 50% in frictional torque of hub unit*2 is generated with hub seals. Typical hub seal, which is shown in Figure 1, has multiple lips for a radial side and an axial side. Frictional torque T (N m) is expressed generally by the following formula (1).

$$T = f \cdot P_r \cdot \frac{D}{2} \quad (1)$$

Where f is the coefficient of friction, P_r is load (N), and D is axial diameter (m).

It is possible to reduce the torque if the coefficient of friction f and the load P_r are decreased. In this paper the effect of surface texture of the sealing lips on lubrication and sealing performance was examined experimentally on practical aspect.

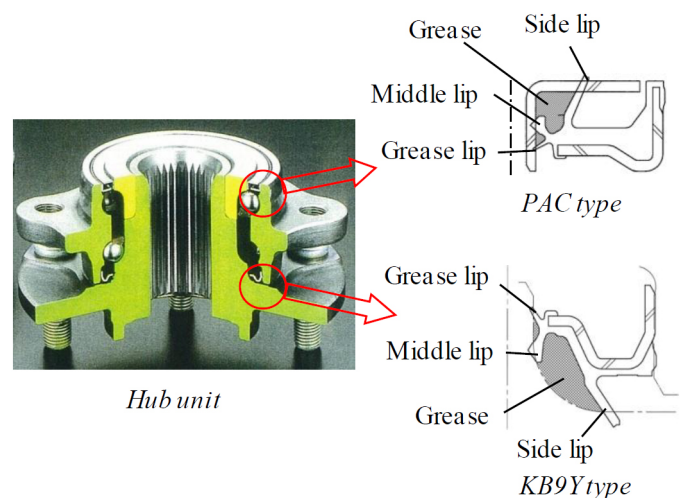
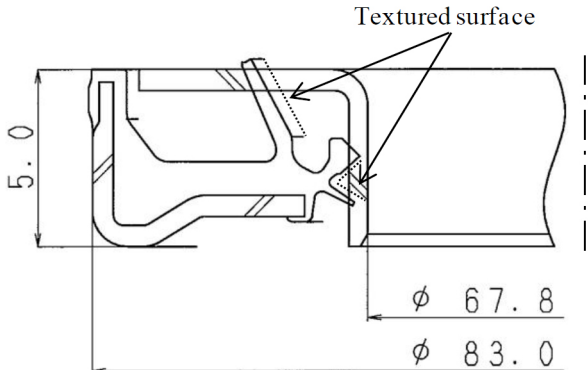


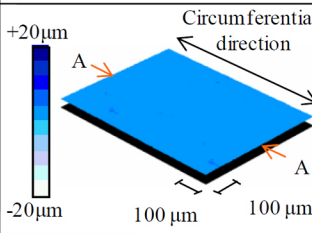
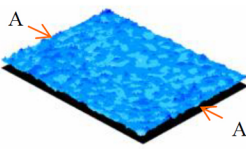
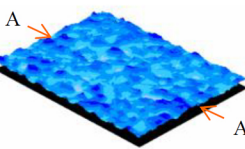
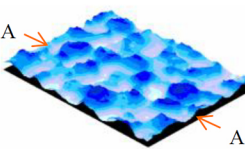
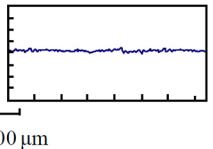
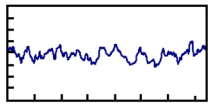
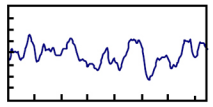
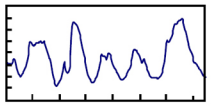
Figure 1. Hub unit*1 and hub seals

Table 1. Test samples

Specimen	Plain	Textured surface		
		10 μ mRz	20 μ mRz	30 μ mRz
Axial load, N	8	8	8	8
Radial load, N	3	3	3	3
Rubber material	Nitrile rubber			
Shape and dimensions, mm				

*The roughness indication in this report is based on ISO 4287: 1997.

Table 2. Surface topography of the side lip of test specimens

Specimen	Plain	Textured surface 10 μ mRz	Textured surface 20 μ mRz	Textured surface 30 μ mRz
3D roughness				
2D Roughness (A-A)				
Surface roughness, μ mRz	3.0	11.5	19.5	28.6

3. TEST METHOD

3-1. TEST SPECIMEN

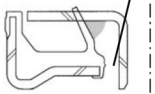
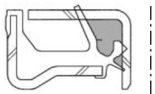
The PAC type seal was used in this study. Table 1 shows the test seal specimens. The surface texture which is a sort of mat finish called “pear-skin finish” is applied to a part of the lip surface of the specimens (the dotted line in Table 1). Three different textures were prepared by changing the magnitude of roughness. Table 2 shows that the surface roughness of the textured surface was roughly 10 μ mRz, 20 μ mRz and 30 μ mRz, respectively, which was measured with a laser scanning microscope. The magnification of their roughness, which includes not only height but spatial distance, varies according to those three textures. Note that

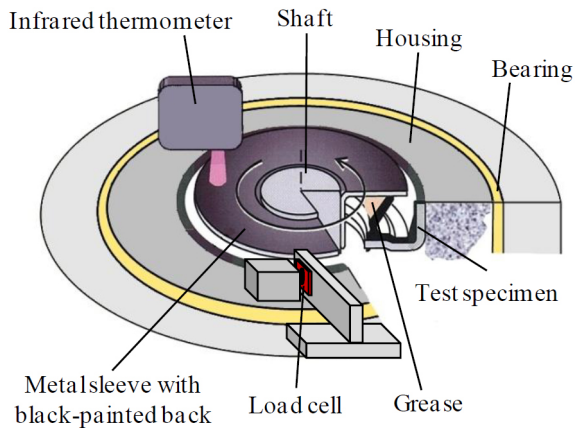
the axial load and the radial load were the same in all specimens as shown in Table 1.

3-2. TORQUE TEST

Table 3 shows the torque measurement conditions, and Fig.2 shows the schematic of the test apparatus. Certain amount of grease was applied to the lip surface of the specimen. The frictional torque between the seal and the metal sleeve was measured with the rotating force of the housing which was supported by the bearings. An infrared thermometer which allows measuring the sleeve surface temperature just behind the sliding area was installed in the apparatus. The back side of the sleeve is painted in black for the temperature measurement. The sliding temperature and the torque were measured simultaneously.

Table 3. Torque measurement conditions

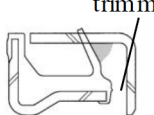
Specimen	Plain	Textured surface		
		10 μmRz	20 μmRz	30 μmRz
Shape	Single lip (side lip) trimmed 			
	Three lip (non-trimmed) 			
Lubricant	Grease			
Temperature	Ambient temperature			
Pressure	Atmospheric pressure			
Shaft speed, rpm	50 ~ 1000			
Lip interference, mm	Side lip: 0.9 Middle lip: 0.6 Grease lip: 0.3			
Test cycle	1 cycle: 0 rpm $\rightarrow$ 1000 rpm $\rightarrow$ 0 rpm at ± 10 rpm/s Total 4 cycles			
Breaking in	1000 rpm at 10 min			

**Figure 2. Schematic of torque measurement apparatus**

3-3. LONG TERM TORQUE TEST

A long-term torque test was performed in order to verify the durability of the effect of the textured surface. Table 4 shows the conditions of the long-term torque test. The specimen whose middle lip and grease lip had been trimmed was used in this test. Here, 15 cycles of this test would be equivalent to a travel distance of 30,000 km if diameter of the tires is 600 mm.

Table 4. Long term Torque test conditions

	Plain	Textured surface 10 μmRz
Test specimen	Single lip (side lip) trimmed 	
Lubricant	Grease	
Temperature	Ambient temperature	
Pressure	Atmospheric pressure	
Shaft speed, rpm	0, 1000	
Lip interference, mm	Side lip: 0.9	
Test cycle	1 cycle: 20 h rotate $\rightarrow$ 4 h rest Total 15 cycles	
Breaking in	1000 rpm at 10 min	

3-4. LEAK TEST

A water leakage test was performed under static and dynamic conditions. Table 5 shows the test conditions, and Fig. 3 shows the schematic of the test apparatus. As shown in Fig. 3, pressure chamber and water chamber were set up on the grease lip side and the side-lip side, respectively. The pressure chamber is able to keep pressure tightness by using a pressure seal even if the spindle rotates. The leak test was conducted under negative pressure in the pressure chamber, and water leakage from the water chamber to the pressure chamber was inspected by using water leak detector paste which changes its color as it touches water. The pressure was reduced little by little until the leakage occurred.

Table 5. Water leakage test conditions

	Plain	Textured surface	
		10 μmRz	20 μmRz
Test specimen	Single lip (side lip) trimmed 		
Lubricant	Grease		
Temperature	Ambient temperature		
Pressure	Pressure chamber: Atmospheric ~ -0.10 MPa Water chamber: Atmospheric pressure		
Shaft speed, rpm	0, 300		
Lip interference, mm	Side lip: 0.6		