Axle-Box Rotary Shaft Lip Seal for High-Speed Shinkansen Cars

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When the speed of Shinkansen cars is increased to a range of 350-400 km/h, there is a concern that oil leakage from the axle-box rotary shaft lip seal could increase to the extent that it would be difficult to ensure normal lubricating conditions for the axle bearings, because the higher shaft rotational speeds make sliding conditions severe. We therefore developed a new axle-box rotary shaft lip seal for high-speed Shinkansen cars with the ability to withstand exceptionally severe sliding conditions.

The results of bench tests of axle-box rotary shaft lip seals are shown in Fig. 1. Conventional seals 1 and 2 both showed oil drips under high-speed conditions, indicating that neither is suitable for high-speed Shinkansen cars (see Fig. 1 (a)). An examination of the seals and oil throwers after the tests showed that lip radial loads were normal, and hardness measurements indicated that the degree of rubber deterioration was small. The amount of wear on the parts of the oil throwers in contact with the lip was also negligible. However, an observation of the lip contact surface of each of the conventional seals revealed outbreaks of flaking on almost the entire circumference (see Fig. 1 (b)). In particular, the outbreaks of flaking on the two conventional seals were more conspicuous under high-speed conditions than under current speed conditions. The outbreaks of flaking of conventional seal 1 were more conspicuous than those of conventional seal 2. It was considered that those outbreaks of flaking were caused by an increase in shear force and contact surface pressure, due chiefly to increases in slip speed and pressure changes. From these facts, it was determined that the oil leakage under high-speed conditions was largely due to the outbreaks of flaking.

Therefore, for the new lip seal for high-speed Shinkansen cars, we adopted fluoroelastomer, which is superior to acrylic rubber in terms of durability and physical strength. We also changed the rubber material filler to restrain early-stage outbreaks of flaking caused by an increase in shaft rotational speed. Furthermore, in order to restrict any change in lip position caused by pressure changes that occur, for example, when the train passes through a tunnel, the rigidity was improved by changing the size and shape. A photo of the test-manufactured lip seal is shown in Fig. 2, and its cross section is shown in Fig. 3.

Our test-manufactured lip seal maintained the original sealing performance with no oil oozing even after the shaft was turned with the number of rotations equivalent to a vehicle running distance of 750,000 km (see Fig. 1 (a)). An examination of the lip seal and oil thrower after the tests showed no problem with the lip radial load, the rubber hardness or the oil thrower. An observation of the lip contact surface showed that the surface condition was satisfactory with few outbreaks of flaking (see Fig. 1 (b)). From these results, it was confirmed that our test-manufactured lip seal has sufficient durability even under high-speed conditions. Because of its satisfactory performance, we consider it suitable as an axle-box rotary shaft lip seal for high-speed Shinkansen cars.

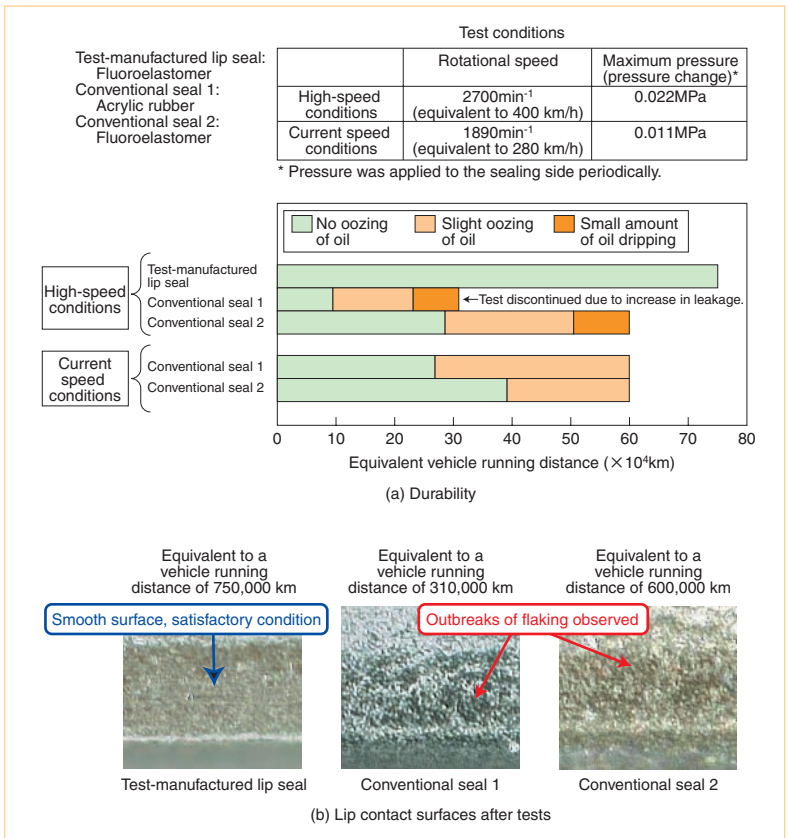

Figure 1. Results of bench tests of axle-box rotary shaft lip seals

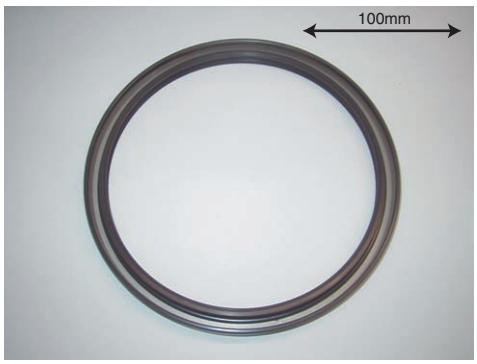

Figure 2. Test-manufactured lip seal

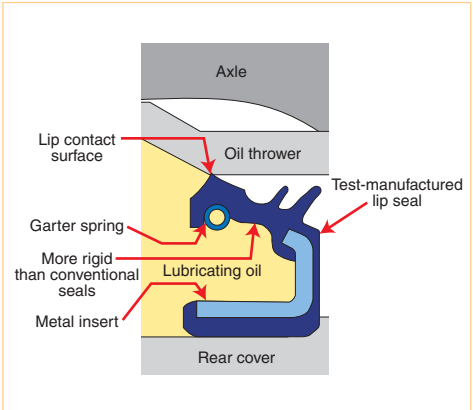

Figure 3. Cross section of test-manufactured lip seal