

## Technical Paper

# Life Improvement of Floating Seal

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*Floating seal is a seal used in a rotating body exposed to silt and sand. A longer part replacement due to a longer seal's life results in improving construction machinery's availability and decreasing life cycle cost. Here, we have developed a new floating seal for tough wear operation sites. This new seal enables two or three times longer life as compared to conventional ones.*

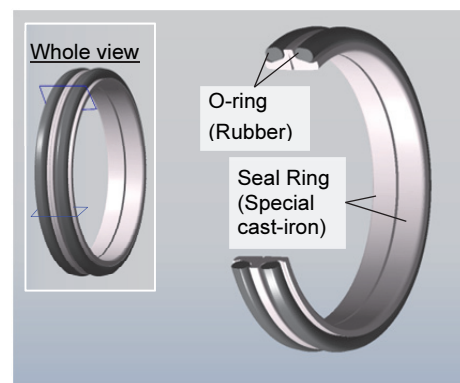
**Key Words:** Floating seal

## 1. Introduction

Since undercarriage of a crawler-type construction machine is always exposed to silt and sand, a seal to be used for the parts mounted on the undercarriage requires functions to prevent internal oil from leaking as well as to prevent foreign materials invading, such as silt and sand. A general rubber seal (lip seal) suffers immediate wear of its rubber sliding parts due to silt and sand, and therefore “floating seal (Refer to **Fig. 1.**)” is used for this purpose.

The floating seal is a kind of a combination seal composed of high hardness cast-iron seal rings and rubber O-rings. This seal, because its metal seal rings slide across each other, has great durability against the wear by silt and sand. This, however, not completely resistant to the wear, is regarded to be an expendable part in which the wear due to silt and sand proceeds as the operational time elapses. Longer life of the floating seal, therefore, can improve availability of a construction machine and decrease the life cycle cost.

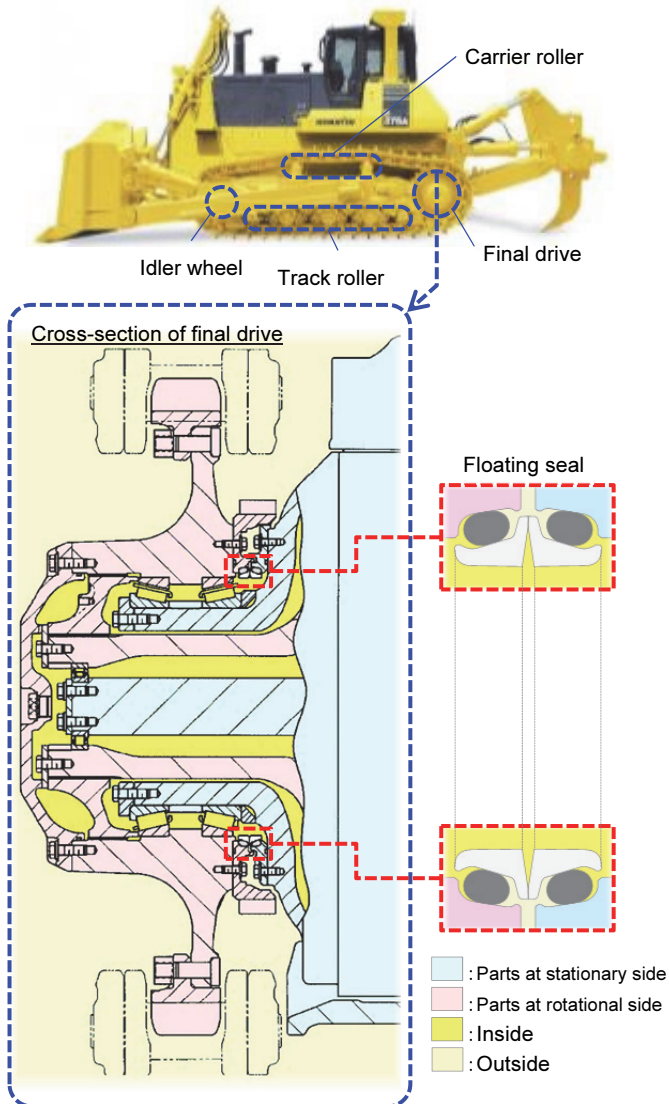
Here, we report our newly developed longer-life floating seal.



**Fig. 1** Floating Seal

## 2. Structure and function of floating seal

A floating seal is used for the rotating components as shown in the area framed by a dash line in **Fig. 2** which are mounted on crawler-type construction machines such as bulldozers and hydraulic excavators for the purpose to prevent the internal oil leaking as well as foreign materials invading, such as silt and sand. This is composed of the cast-iron seal rings and rubber O-rings and utilizes the pair of identically-shaped seal rings facing each other during use as shown in **Fig. 1**.



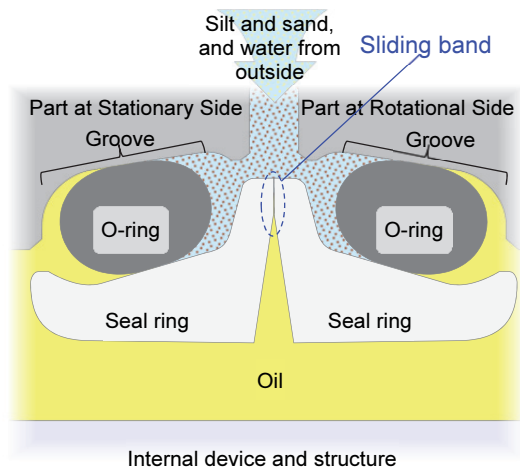
**Fig. 2** Application Example of Floating Seal

The cross section of the attached part of the floating seal is shown in **Fig. 3**. The seal rings are attached via O-rings to each part at stationary and rotational sides. On the parts where the seal rings are attached, the grooves to insert O-rings have been already processed. The shape of the groove is designed according to the seal shape. Inserting the O-ring-attached seal

ring into the groove makes the seal ring attached to each part. Assembling these parts to face each other makes the seal rings contact each other, as shown in **Fig. 3**. The pressing force to make the seal rings contact each other is generated by the O-rings deformed between the groove and the seal ring.

The sliding band where the seal rings contact each other become the boundary between stationary and rotational sides, and this band cuts off torque transmission between stationary and rotational sides and prevent internal oil from flowing out and external foreign material such as silt and sand from invading.

Sustaining these functions requires both of the seal rings to keep pressing each other with a certain force. When pressing force is too large, it may lead to wear increase due to the damage of the seal sliding surfaces, whereas when pressing force is too small, it may result in insufficient contact between the sliding surfaces so that the oil can flow out or silt and sand can invade. Therefore, keeping the pressing force at a proper level contributes to the wear life improvement of floating seals.



**Fig. 3** Cross-section of Floating Seal Attached Part

The seal ring, although made of hard special cast-iron material with high wear resistance against silt and sand, gets surely worn away with time due to silt and sand (Refer to Fig. 4.). As shown in Fig. 4 (b), as the wear by silt and sand proceeds, the sliding band moves towards the inner side by little and little. In this case, the wear proceeds with generating a new sliding band at the inner side, and finally the sliding band reaches the inner periphery of the seal ring as shown in Fig. 4 (c), when the life terminates due to the wear by silt and sand. Since this wear rate varies with a seal ring material, the selection of proper seal ring material also contributes to the wear life improvement of the floating seal.

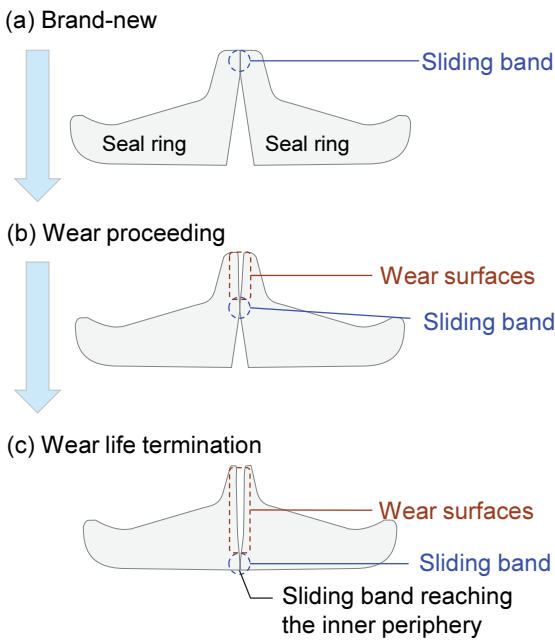


Fig. 4 Proceeding of Wear by Silt and Sand

### 3. Problems of floating seal

#### 3.1 Packing of silt and sand

On the practical use of the floating seal, one of causes for shortening the wear life is clogging of silt and sand (hereinafter called packing) generated in the space between the seal ring and the O-ring inserted groove (Refer to Fig. 5.). Experiences show that the packing often occurs at the operational sites of the silt and sand with high percentage of finer particle size as shown in Fig. 6.

In the condition as shown in Fig. 5, the seal rings and O-rings are forced by the packing generated in the space so that the pressing force which acts on the sliding band should increase. As a result, the wear accelerates and the life shortens.

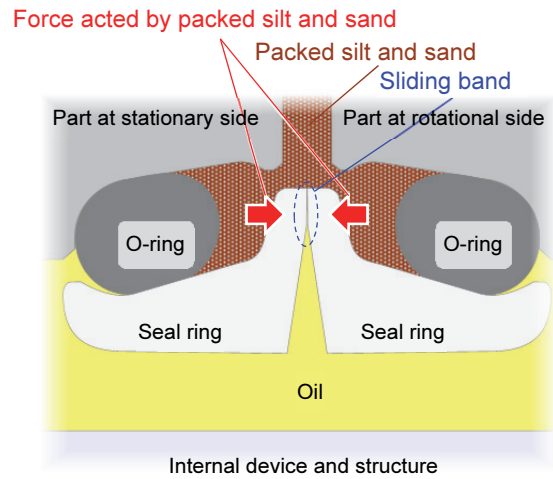


Fig. 5 Influence of Packing

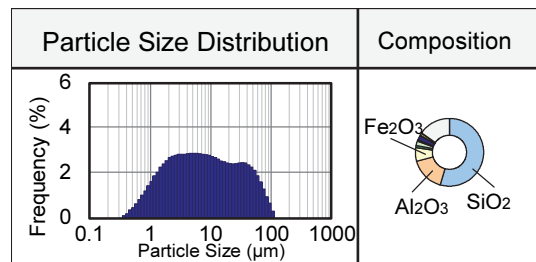
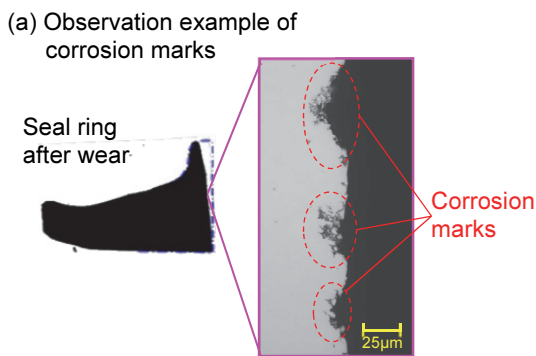


Fig. 6 Analysis Example of Silt and Sand at an Operational Site where Packing Often Occurs

### 3.2 Corrosion wear

One of the other causes for shortening the wear life of the floating seal is corrosion wear due to acidic soil. **Fig. 7** (a) shows the example of observation of the wear surface of the abnormally-worn seal ring and the corrosion marks were found on the worn surfaces. In addition, a great amount of sulfuric acid component ( $\text{SO}_4^{2-}$ ) was detected in the silt and sand attached to the surrounding area of the seal ring where such corrosion wear was found as shown in **Fig. 7** (b). The above results suggest that the wear is accelerated if the seal ring is corroded by the sulfuric acid which exists in the silt and sand in addition to the wear due to the silt and sand.



(b) Analysis example of silt and sand

Sample No.	Measurement result of anion (unit: ppm)		
	$\text{SO}_4^{2-}$	$\text{NO}_3^-$	$\text{Cl}^-$
1	53	—	2.6
2	40	1.1	2.4

**Fig. 7** Observation Example of Corrosion Marks and Analysis Examples of Silt and Sand

## 4. Consideration on measures

### 4.1 Outline of measures

The following two methods were considered as the measures for improvement of the floating seal in order to solve the above mentioned problems.

(1) The shape of the seal ring and the O-ring inserted groove was improved to keep the pressing force between the seal rings at a proper level.

(2) A new seal ring material was developed to improve the surface pressure resistance and the corrosion resistance.

As the measure (2), a nickel-based material was newly developed while conventionally the iron-based material had been used, and in the following section we describe this material in detail.

### 4.2 Sliding characteristics of developed material

To check if the surface pressure resistance is increased, sliding characteristics of the newly developed material and the conventional one were evaluated with a sliding test using ring-shape test pieces. The test method and the test results are shown in **Fig. 8**.

In this test, as shown in **Fig. 8** (a), a pair of ring-shape test pieces was placed with the one on the other, with having their thrusting surfaces contact each other in a similar way to the case of seal rings, and the one was kept stationary and the other was rotated. With immersed in lubricant oil, one of the test piece was rotated in the same circumferential velocity as that of the practical seal use, and then the surface pressure was increased step-by-step while the change of the friction coefficient was measured. The time-point when the friction coefficient drastically increased (red x mark in the Fig.) was considered as the moment when adhesion wear condition occurred, and the surface pressure in this moment was interpreted as the surface pressure value of sliding limit (hereinafter called limit of surface pressure).

The test results of the developed material and the conventional cast-iron material are shown in **Figs. 8** (b) and (c), respectively. The developed material showed twice higher limit of surface pressure than the conventional one.

### 4.3 Corrosion resistance of developed material

To check suppressing effect of the corrosion wear, the corrosion resistance of the developed and the conventional materials was evaluated by an immersion test in sulfuric acid.

The materials which were cut out of developed and conventional material seal rings, polished with emery paper, and then covered over the unpolished area with masking tape were used as test pieces. These test pieces had been immersed in sulfuric acid solution of 5 wt% in beakers for 20 hours, and then the depth of the corrosion per year (hereinafter called corrosion rate) was calculated from the weight change.

**Fig. 9** (a) shows a test result. The corrosion rate in the vertical axis is shown in the scale relative to that of the conventional material being 100. It was confirmed that the developed material showed great improvement on the corrosion resistance against sulfuric acid.

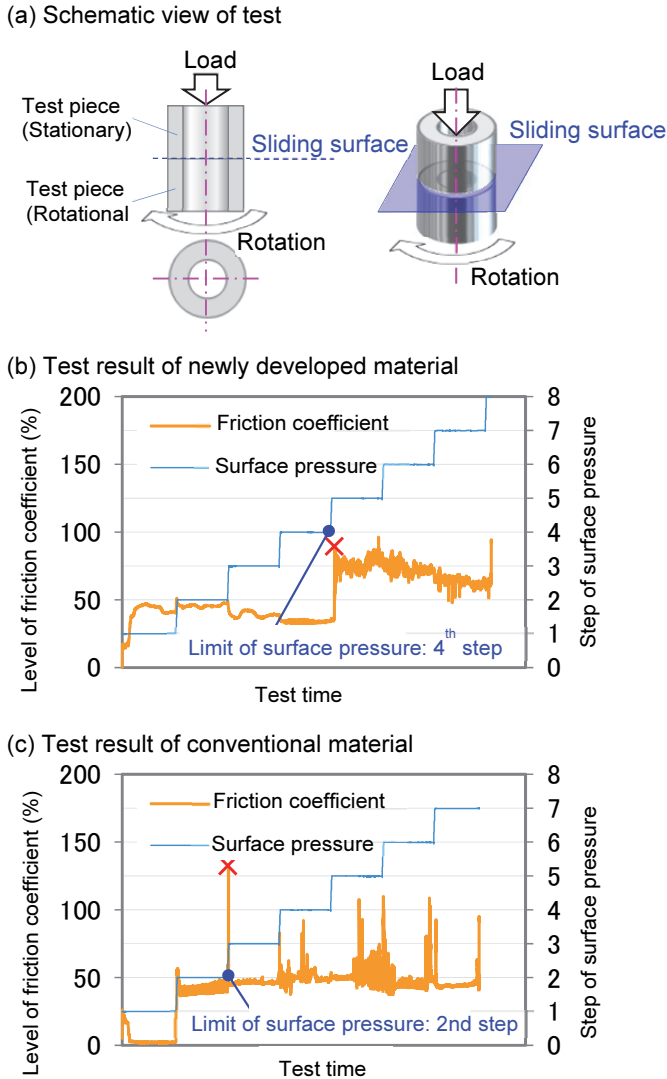


Fig. 8 Sliding Test Results

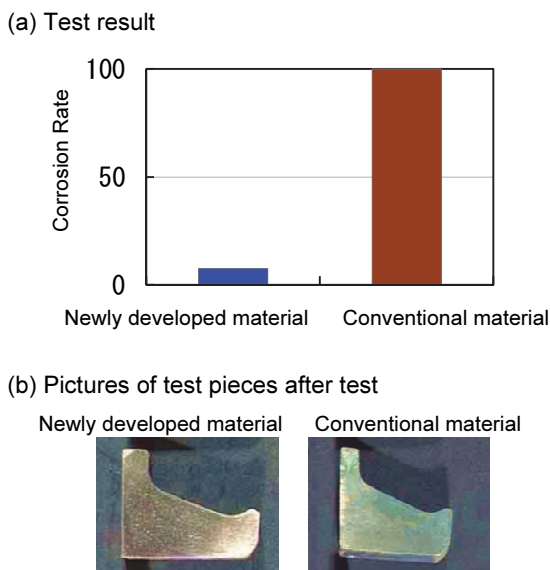


Fig. 9 Immersion Test Result

### 5. Field tests at customers' sites

We examined if this new floating seal produced benefits as we had expected by field tests at customers' sites where two problems which were mentioned above such as the packing and the corrosion wear often occurred. The prototype floating seals of each specification were manufactured depending on different models of bulldozers for each site, and both the conventional and the developed seals were assembled into the left and the right sides of a single vehicle, which were later retrieved after operating for a certain time period, and then the wear volume was measured.

On the field tests, characteristics of the customers' sites and the developed seals are shown below.

[Machine model A]

Site: The silt and sand are fine and the packing tends to often occur.

Developed seal: The seal ring shape is improved and the developed material is used.

[Machine model B]

Site: The soil is acidic, which easily makes the seal corroded and worn.

Developed seal: The developed material is used (The shape is the same as that of the conventional one.)

Field test results for machine model A (the sites where the packing often occurs) are shown in Fig. 10. For the machine model A, the tests are based on two levels of the operational time. The data can be linearly approximated because the wear volume of the seal ring is roughly proportional to the operational time from our experience, and as results it was found that the developed material had 1/2 to 1/3 of wear volume compared to the conventional seal.

Field test results for machine model B (acidic soil site) are shown in Fig. 11. The developed seal had roughly 1/2 of wear volume compared to the conventional one.

From these results, it was confirmed that for both types the developed seal was expected to have roughly 2 to 3 times higher improvement of the wear against silt and sand compared to the conventional one.

## 6. Conclusion

It was confirmed that the floating seal applied the newly developed material was expected to show 2 to 3 times longer wear life against silt and sand compared to the conventional seal based on the field test results.

Both developed products are now put to practical use, and the specifications are set for the areas where the packing often occurs and where the corrosion wear is easily caused.

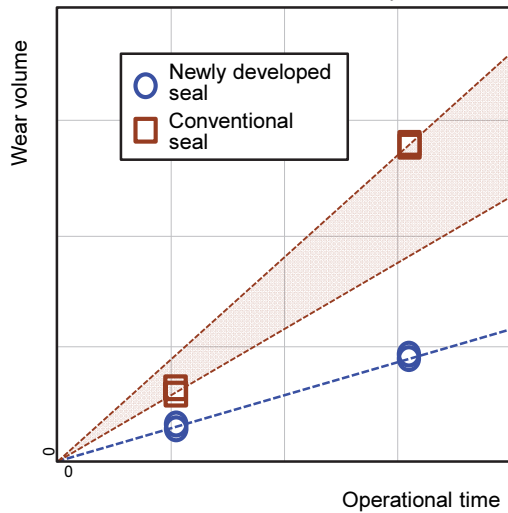


Fig. 10 Field Test Results of Machine Model A

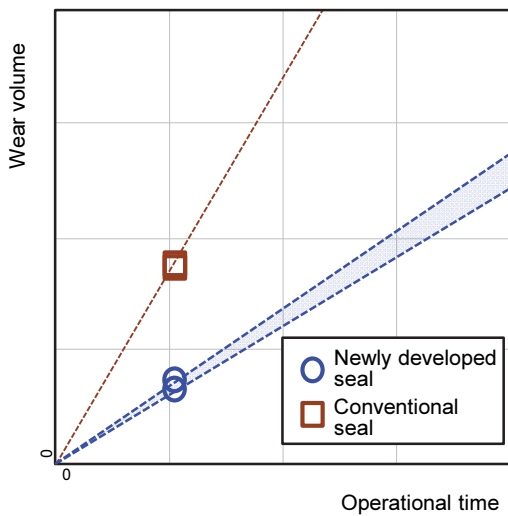
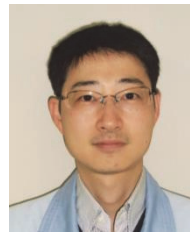


Fig. 11 Field Test Results of Machine Model B

### Introduction of the writers



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### [A few words from writers]

The floating seal which we developed this time is limited to the area-specific specifications, but we would like to utilize the know-how we acquired for another future floating seal. We would greatly thank many people for their cooperation.