Low Torque & Long-Lifetime Swivel Joint LFR JOINT™

1. Introduction

The aging of the population, one of the major social issues in Japan, is currently causing a very serious situation in the manufacturing field as well. In particular, the aging of experienced workers in the manufacturing field has been progressing, but securing enough young engineers and the succession of techniques has not been keeping up with the speed of aging. The decline in technical ability in the field is already happening in the production field of every company. Additionally, the trend of aging population is rapidly spreading overseas, and this is also a significant issue from the global perspective.

In such situation, actions to streamline operating costs at each process are intensifying by considering all the various factors together including maintenance of facilities. This is because in order to gain maximum benefit with limited number of staff, streamlining with a more permanent perspective, which takes man-hour for maintenance and long-term reliability into account, is now required in addition to short-term cost reductions in purchasing facilities and materials. These issues are not only the matters imposed on the equipment that are the main force in a process, but also items such as sealing materials and joints, which have been considered as consumable supplies but have considerable roles to play.

LFR JOINT™, the swivel joint introduced in this issue of Valqua Technology News, is a solution-type of product developed while collecting customers' comments from the field.

We would like to introduce this product because it is a product which makes a significant contribution to our customers' maintenance cost reduction and productivity improvement of facilities using the techniques we have fostered as a manufacturer of seal products.

2. Issues of conventional swivel joints

A swivel joint is a collective term for a joint which has the ability of continuous rotation and oscillating movement at low speed. It is widely used as an important part which carries various types of liquids (such as hydraulic oil, air, water, etc.) considered as blood in each process.

Figure1　Cutaway model of LFR JOINT™

For example, swivel joints are applied as joints in the hose part of robots installed in automatic production lines of the aluminum diecasting process to reduce the load on the hose by eliminating twists caused by the robots' complicated movements and high frequency of operation.

However, swivel joints generally have high rotational resistance and the effect of load reduction on the hose is not sufficient, causing premature fractures in the hose. This has been an issue that considerably decreases productivity of the process.

As another example, under severe environmental conditions (high temperature, pressurized liquid, dust, etc.) such as in steel plants, there were some cases in which the interval between maintenance of the production line became shorter because the sealing material on swivel joints were quickly worn down.

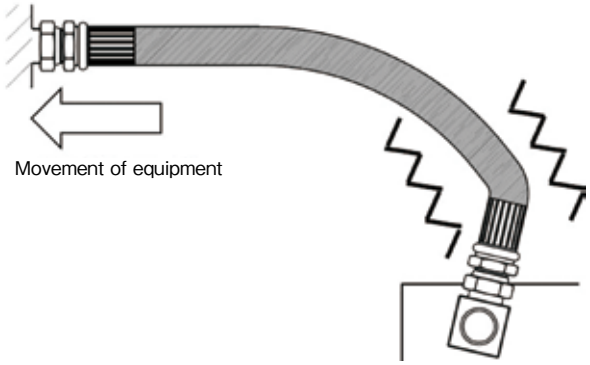


Figure2 Example of premature fractures in the hose

3. Cause of the issues

The two issues of swivel joints described above, 1) high rotational resistance and 2) short life, are largely due to the sealing material that is used.

O-rings, mainly made from rubber, are commonly used as the sealing material for swivel joints. During low-speed rotation or oscillating movement, this O-ring fills the gap by sliding against the rotational axis and prevents liquid leakage.

However, due to the characteristics of rubber material, frictional resistance when sliding against the rotational axis is extremely high. Furthermore, this tendency is even more significant when fluid pressure is high. These factors cause the swivel joint to have an extremely high rotational resistance and hinders the intended rotational and oscillating movement.

In addition, rubber is generally not a material which is resistant to abrasion. Therefore, O-rings are severely worn down, especially under adverse lubrication conditions at high temperature and high pressure, and this results in shortening the life of the swivel joints themselves.

4. Solution by LFR JOINT™

LFR JOINT™ is a swivel joint which solved the long-standing issues with swivel joints and realized both low-torque and long life.

Various innovative designs are applied to the sealing mechanism and also to peripheral aspects such as the seal groove. In this issue of Valqua Technology News, the sealing mechanism is explained.

5. Sealing mechanism of LFR JOINT™

In order to solve the issues of swivel joints, LFR SEAL™, a sealing material for rotational movement was specially developed for LFR JOINT™. Figure3 shows a cross-section diagram of LFR SEAL™.

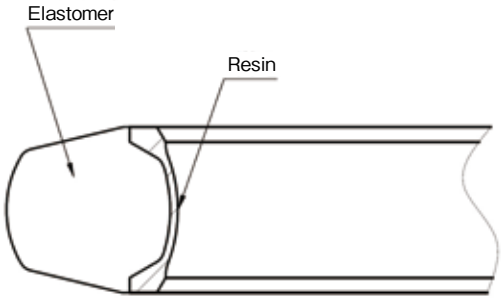


Figure3 Cross-section diagram of LFR SEAL™

5-1) Torque reduction

In order to reduce torque in swivel joints, it is necessary to reduce sliding resistance of the sealing material, but we considered that sliding resistance is related to friction coefficient, contact area with the other surface (rotational axis), and tension force. The

resulting design was produced by resolving each of these factors and is shown in Figure3.

Ⅰ.Friction coefficient

Resin of low friction coefficient was compounded with elastomer by forming them simultaneously inside the sealing where the other surface (rotational axis) comes in contact.

Ⅱ.Contact area

When fluid pressure is applied, a tilt generated by the tapered face of the non-pressurized side coming into contact with the groove face makes it possible to control the contact area of the arc sealing face that is in contact with the rotational axis. Thus, the increase in the contact area resulting from increased pressure can be suppressed as shown in Figure4.

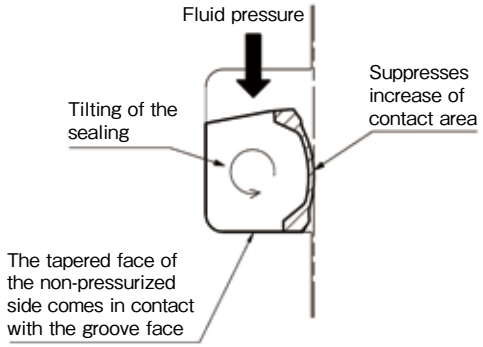


Figure4　Control of the contact area

Ⅲ.Tension force

The volume of external diameter of elastomer at the base was reduced and the inner face and the outer face that become the sealing face were designed to be arc-shaped to reduce tension force.

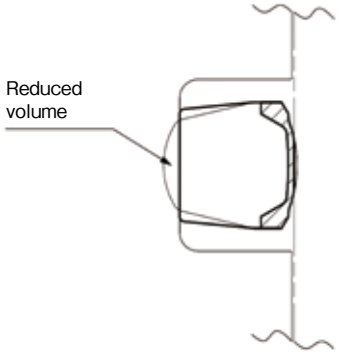


Figure5　Shape of external diameter of elastomer part

5-2) Life prolongation

It can be said that improving the durability of the sealing material is an effective means for life prolongation of the swivel joints because the life of swivel joints is deeply related to leakage from sealing material.

This sealing employs resin for the sliding face of the sealing and its durability is superior to an O-ring which slides on a rubber face. Also, as described in 5-1, the mechanism to reduce torque decreases friction heat generated during the sliding of the sealing and this reduces abrasion and fatigue of the sealing material.

6. Effects of LFR JOINT™

6-1) Increasing the life of accessories such as hose material

Figure6 shows a comparison of rotational torque of LFR JOINT™ and a conventional swivel joint with an O-ring. It shows that torque rises only slightly with LFR JOINT™, even if fluid pressure is increased.

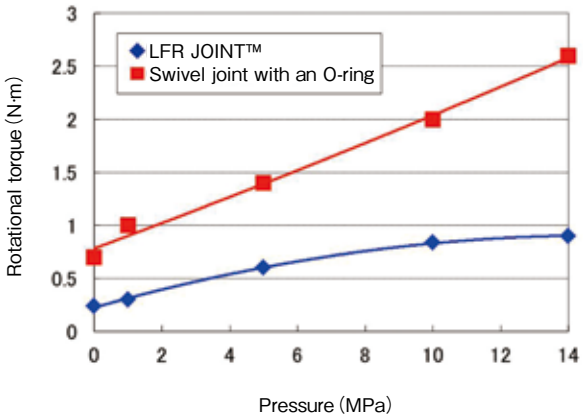


Figure6　Comparison of rotational torque

This considerably reduces the rotational load on accessories such as hose material.

In market performance, the lifetime of hoses was actually extended, and the life-prolongation effect even reached a maximum of ten times longer in some cases.

6-2) Life improvement of joints

Figure7 shows a product life comparison of LFR JOINT™ and a swivel joint with an O-ring, and Table1 shows the test conditions.

This shows that maintenance costs for joints can be reduced because the life of LFR JOINT™ is more than double when compared to our conventional joints.

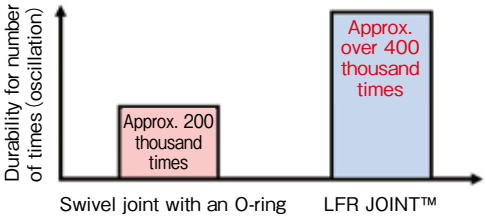


Figure7 Life comparison

Table1 Test condition for life comparison

Fluid	Air
Pressure	0.7 MPa
Temperature	120℃
Angle of oscillation	90 degrees
Diameter of rotational axis	ϕ42

Also, Figure8 shows a comparison of the cross-sections of the sealing material before and after life testing. The thinner line represents the cross-section before the test and the solid line after the test.

The O-ring for conventional swivel joints was severely worn away after approximately two hundred thousand times of oscillation and this abrasion caused leakage. On the other hand, LFR SEAL™ attached to LFR JOINT™ did not show any major abrasion even after approximately four hundred thousand times of oscillation and was still capable of continuous operation.

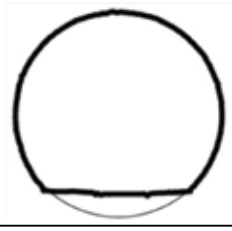
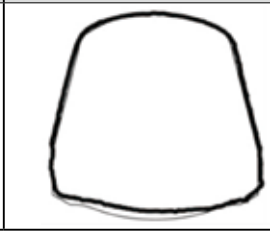
O-ring for conventional swivel joints (leakage after approx. two hundred thousand times of oscillation)	LFR SEAL™ attached to LFR JOINT™ (capable of continuous operation even after approx. four hundred thousand times of oscillation)
	

Figure8 Comparison of sealing cross-sections before and after life testing

7. Conclusions

The Valqua Group aims to evolve into an "H&S company" that provides not only sealing products but also peripheral services and this product is our first unit product that is a part of our strategy.

We will continue to develop products to meet market demand, but also dig out unmet needs together with our customers and work hard to provide true solutions by merging innovative technologies and services.

8. References

1) Akihiro Nagano, Valqua Technology News, No.30, 9-13, 2016

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