Research on Interference Leakproof Structure in Submarine Cable Gland

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Abstract. The leakproofness of the submarine cable gland is of very high requirement, the traditional leakproof method can hardly meet the requirement more or less. In this paper, by researching the interference leakproof structure, we creatively applied the elastic leakproof ring into the submarine cable gland. Through theoretical model analysis and test, it can be concluded that the leakproof device is able to work under 3.5MPa water pressure.

1. Introduction

The elastic material is elastic and incompressible, and the resulting self leakproof is generated by applying the initial interference or preload. If the interference leakproof (or self seaing) technology is applied to the underwater cable leakproof, the disadvantages in most of the current use of the extruded cable will be resolved.

In recent years, the O type ring gland is widely used in all kinds of leakproof devices. Figure 1 is a typical O type leakproof ring sealing device. The leakproof ring's cross section diameter is compressed by 1/10. This type of packing is sometimes made of rectangular, V or other shaped cross section [2-7]. The research of the elastic leakproof mechanism is important for improving the submarine leakproof technology.

2. Elastic material interference leakproof theory

By measuring the pressures of the leakproof ring from several sides, we found that the pressure of the circular rings is the sum of initial pressure between the fluid pressure and the component[8-12]. Therefore, P_s is always greater than P_f, this kind of leakproof can meet the basic requirements.
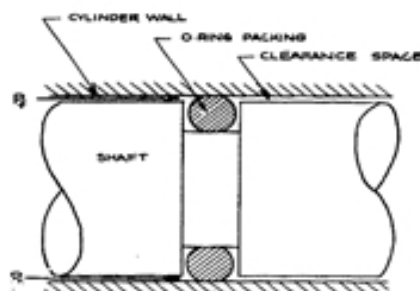

Fig. 1 Schematic diagram of O type leakproof ring

The Poisson's ratio of the rubber is about 0.500, that is, the initial pressure of the rubber in the opposite direction is the same as that of the constraint. Therefore, the rubber can transfer pressure like fluid. The pressure of the residual stress system should be expressed as:

$$\Delta\sigma_y = \Delta\sigma_z = \Delta\sigma_x(\frac{\mu}{1-\mu}) \quad (1)$$

Figure 2 shows the interference leakproof mechanism with rectangular cross section. The initial pressure of the rubber ring between the extrusion metal construction members is P_0. The system's fluid pressure causes a pressure relationship as shown in Figure 2 (b), which the fluid cannot

permeate through a circumferential contact surface, and the pressure is evenly distributed on the surface. The leakproof with cross section of circular or other has the similar pressure distribution.
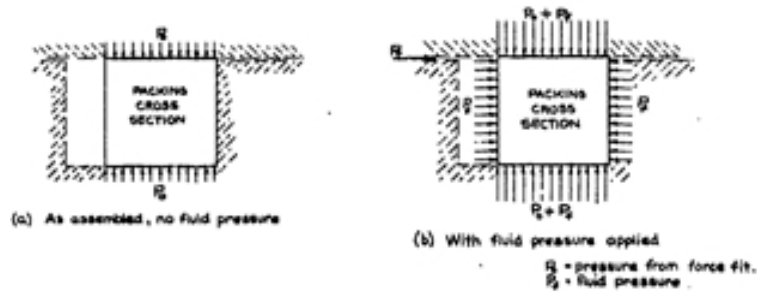

Fig. 2 the rubber interference leakproof mechanism under the fluid pressure condition

In the case of the O type ring, we conclude the formation mechanism of the over - interference leakproof of elastic materials from three aspects: [13,14]:

(1) The maximum contact pressure P_{fmax} is kept at the center of the contact surface, which is higher than the fluid pressure. Other cross section of the rubber leakproof ring have the same result of the O ring.

(2) In most cases, the excess reversible loss is swell other than compression caused by pressure, which is caused by the increase of the groove depth.

This leakproof is fully automatic, and does not depend on the friction force, nor is it affected by the friction between surfaces. Applying the interference principle in the cable leakproof, the proportion of the cable gland must be different from the standard O type leakproof ring, in order to cope with the cable diameter reduction caused by pressure.

3. Force analysis of the interference leakproof

In the above experiments, when the system is under pressure, the excess fluid will penetrates into the system rather than the air.
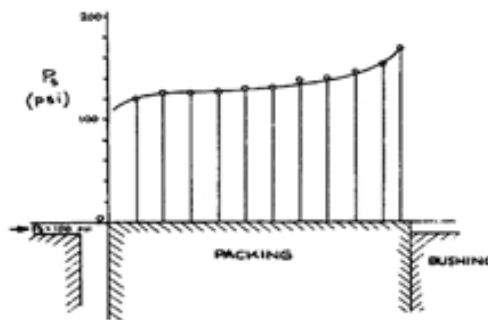

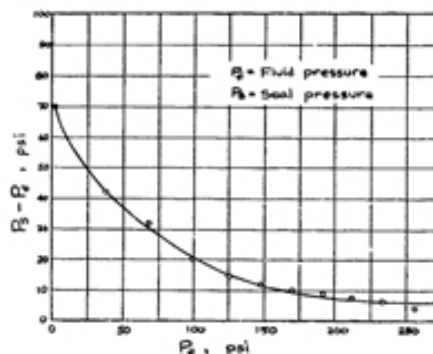Fig. 3 pressure distribution of leakproof surface

Fig. 4 Effect of the axial tightening of the surplus filler

Figure 4 shows the leakproof pressure range (P_s-P_f) varies with the fluid pressure P_f. Therefore, the impact of the nut pressure is to increase the leakproof pressure range (P_s-P_f), until the fluid pressure is replaced by the nut pressure. Then the leakproof became automatic, providing an approximately constant leakproof pressure.

4. Model analysis

The leakproof calculation of Rubber leakproof pieces relates theoretical knowledges of to solid mechanics, polymer materials, material mechanics and calculation, so it's difficult to conduct accurate theoretical research or to simulate. In this paper, the W-Rivlin model is used to simplify the strain energy function:

$$W=C_1(I_1-3)＋C_2(I_2-3) \tag{4}$$

In the formula, W is modified strain potential energy; C1 and C2 are the material constants, I1 and I2 are 1 and 2 invariants of the stress tensor, the stress strain relationship is:

$$\sigma=\delta W/\delta\varepsilon \tag{5}$$

(1) Compression--t

When the maximum contact stress of leakproof surface is greater than the operation the leakproof is realized, the rectangle ring's compression ratio is 8-14%, for example the 5.16mm rectangular ring has a compression t of 0.4128-0.7224mm, O - ring has the larger compression rate, 15% - 30%. When the compression ratio exceeds the maximum contact pressure, the O type ring fail to work. Therefore, the aging speed of the rectangular ring is slower than that of the O type.

(2) Working pressure

When the leakproof ring is loaded into the groove without working pressure, the leakproof surface contact pressure pm is generated by the pre tightening force p1, which is achieved by the pm=p1:

$$pm= p_1+kp \tag{6}$$

K is influence coefficient of liquid pressure on the contact pressure of the leakproof surface. Obviously, the pressure of the leakproof surface's contact area increases as the liquid pressure, it can be seen that the rectangular ring in the working pressure of the case of its variable is not large, and has good size stability.

5. Conclusions

(1) The interference leakproof structure can be directly applied to the submarine cable leakproof process, and the leakproofness is far better than the traditional way;

(2) The elastic leakproof ring made meet the requirements of the structure of interference leakproof splendidly;

(3)The elastic leakproof ring's interference cable gland leakproof structure, by the hydraulic pressure test, works under the 3.5Mpa which enables it to meet the requirements of deep diving submarine.

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