Design and Analysis of Hydraulic Weighing Sensor Sealing System

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Abstract

Hydraulic load cells are simple and robust, and are widely used in various places. Due to its working characteristics, the sealing system of hydraulic load cells is essential. This paper introduces a new type of sealing system, which simulates the structure and sealing.

Keywords

Load Cell, Seal, Low Leakage.

1. Introduction

The hydraulic load cell means that when the gravity of the object is subjected to the action, the pressure of the hydraulic oil increases, and the degree of increase is proportional to the gravity of the object. When the pressure is increased, the mass of the measured object can be obtained [1]. The utility model has the advantages of small size, convenient installation, relatively stable work, adaptability to a harsh working environment, long service life, and the like, and is suitable for being applied in a wire rope tension detecting system of a hoist. However, the current sealing device usually adopts an O-ring, a V-ring or a Y-ring. If such a sealing device is used, the problem of hydraulic oil leakage may occur at the position where the piston contacts the cylinder during use. It directly affects the working performance of the hydraulic load cell. In severe cases, even the detection failure occurs, so it is necessary to design a suitable sealing method.

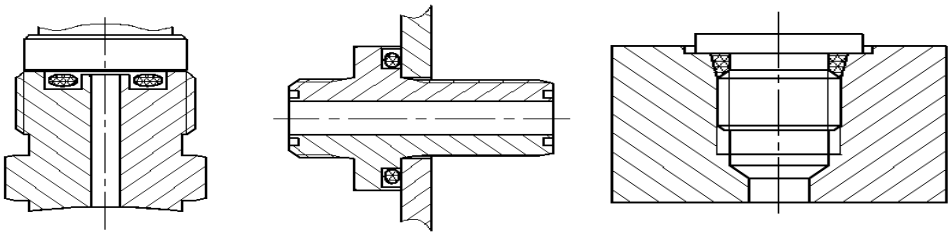
2. Sealing System Design

2.1 Sealing Device Overview

The correct and proper use of the sealing device is the key to ensuring the stable operation of the hydraulic load cell [2-3]. If the sealing device is unreasonably used to cause leakage of the working medium, the volumetric efficiency of the hydraulic cylinder will be lowered. When the leakage is serious, the working pressure may not reach the required value and it may not work properly. Therefore, the sealing device and the seal determine the pressure level, stability reliability and service life of the hydraulic cylinder at a large level.

The classification of the seal is analyzed below:

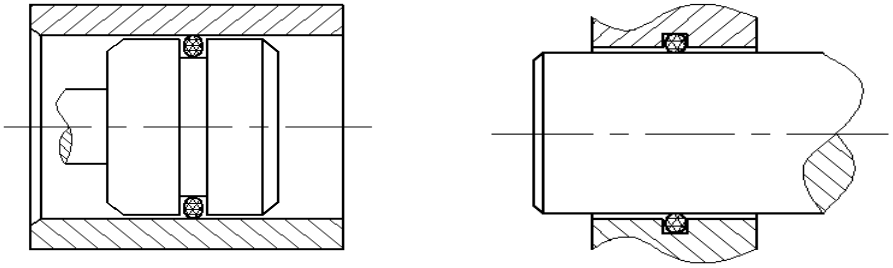
(1) According to whether there is relative movement between the sealed coupling faces, the seal includes a static seal form and a dynamic seal form. The static seal can be divided into a plane static seal, a cylindrical static seal and an angular static seal. If the hydraulic working medium leaks from the inside to the outside, it is called static sealing by the internal pressure plane; when the hydraulic working medium leaks from the outside to the inside, it is called static sealing by the external pressure plane. A schematic diagram of the static seal is shown in Figure 1.



(a) Static seal by internal pressure plane (b) Static seal by external pressure plane (c) Angle static seal

Fig 1. Schematic of static seal

(2) According to the form of motion between the sealing faces (rotational movement or sliding), the dynamic seal further includes a rotary seal form and a reciprocating seal form. A schematic diagram of the dynamic seal is shown in Figure 2.



(a) Hole seal (radially sealed piston seal) (b) Shaft seal (radially sealed piston rod seal)

Fig 2. Schematic diagram of reciprocating motion seals

In engineering applications, commonly used seals include O-ring seals, square seals, V-ring seals, etc. The following commonly used seals are analyzed and introduced [4]:

(1) O-ring seal

Advantages: O-ring seal is a hydraulic seal commonly used in hydraulic cylinders, which has the advantages of good sealing performance, simple structure and easy manufacture.

Disadvantages: O-rings have a large amount of compression deformation when working, and this deformation will generate a large static friction resistance. In some low-voltage transmission systems, large static friction resistance is likely to cause low-pressure creep and other undesirable phenomena.

(2) V-ring seal

Advantages: V-shaped sealing ring has the characteristics of high pressure resistance, reliable performance, long service life and good sealing performance. It can be used in occasions with poor lubrication or poor working conditions, and can be used in combination.

Disadvantages: the structure is complex, the frictional resistance is relatively large, the structure size is large, the frictional resistance increases significantly with the increase of the number of sealing rings, and is only suitable for application in low-speed hydraulic cylinders.

(3) Y-ring seal

Advantages: reliable sealing performance, good pressure resistance and simple structure, suitable for application in high-speed variable pressure, large stroke hydraulic cylinders.

Disadvantages: Since it is a one-way seal, if it is to be used in a case where a two-way seal is required for a piston, it is necessary to use a Y-shaped ring in pairs, and the axial dimension will become large and the installation is difficult.

(4) U-ring seal

Advantages: The U-ring seal has good sealing characteristics, but it needs to be combined with the tin bronze support ring (because this type of seal is easy to turn over when used alone).

Disadvantages: The frictional resistance generated by this type of sealing ring during operation is very large, and the frictional resistance generated will increase with the increase of the working pressure of

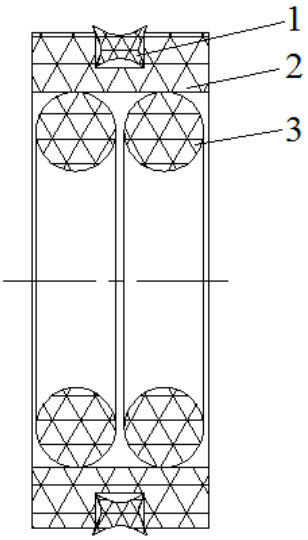
the hydraulic cylinder. It is only suitable for the hydraulic cylinder with very low working pressure or hydraulic cylinder. The occasion where the running speed is not high.

2.2 Design of Low Leakage Coaxial Seals

The V, Y, and U-shaped seals mentioned above all belong to the lip seals, which prevent the leakage of the working medium by contact stress. However, the contact area between the lip and the sealing surface of the sealing member is small, and wear is likely to occur during the working process, and the sealing effect after abrasion is significantly reduced.

If a coaxial seal is used (the O-ring is superimposed with the above-mentioned lip seal), even if the lip is worn, a large contact stress can be caused, thereby sealing, and the seal is The frictional resistance generated by the method is small, and the work process is relatively reliable and stable.

Although the coaxial seal has improved performance in some performances compared to the lip seal, there is a leak path between the slip ring and the O-ring of the coaxial seal, and the plastic for making the slip ring is generally Hard, the surface sealing effect of the reciprocating coupling is not as good as rubber, so it is necessary to design a low-leakage coaxial seal.



1—Star Circle 2—Sealing Ring 3—O-Ring

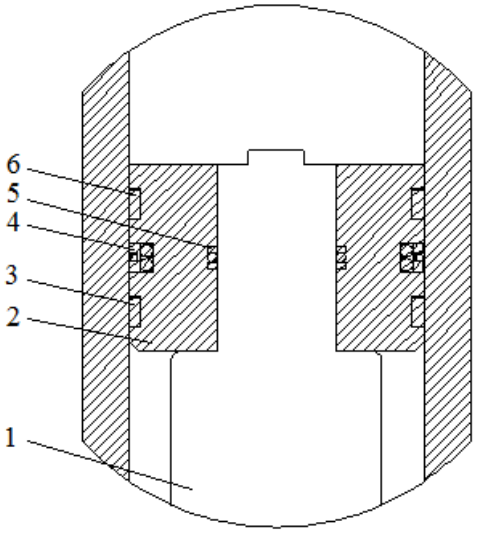
Fig 3. Low leakage coaxial seals

In combination with the characteristics of the above various sealing members, the elastic body of the low-leakage coaxial sealing member is designed as two O-rings, and the friction sealing surface which is in contact with the coupling surface of the fitting member and functions as a sealing ring is a plastic ring and an X-shaped ring. Its structural form is shown in Figure 3.

Since the low-leakage coaxial seal adds rubber seals to the metal and plastic friction sealing surfaces, its dynamic sealing performance is better. At the same time, the two O-rings are used to press the slip ring against the coupling surface. The ring is more energetic, so the initial seal (static seal) performance is better. The low-leakage coaxial seal also has the following characteristics: high sealing pressure, small leakage, small structural size, safety and reliability, low friction, no creep, long life and so on.

2.3 Sealing Device Design

In the actual engineering application, a sealing device is added at both the piston and the piston rod. The piston sealing system is mainly taken as an example for analysis and introduction. According to the above analysis and comparison of the seals, the hydraulic load cell uses a low-leakage coaxial seal as a sealing device in the piston sealing system, and its cross-sectional view is as shown in Figure 4. According to the above analysis, the use of the sealing device will greatly reduce the leakage of the hydraulic medium, and can extend the service life of the coaxial seal.



1—Piston rod 2—Piston 3, 6—Support ring 4—Low leak coaxial seal 5—Static seal

Fig 4. The piston seal system of the low leakage coaxial seal

In the selection of working medium, the system uses low temperature lubricating grease. The combination of low-temperature grease and low-leakage coaxial seal has the characteristics of good sealing and good lubricity, which can greatly reduce the frictional resistance between the piston and the cylinder wall. It is suitable for weighing sensors with high range and high precision [5].

3. Finite Element Simulation Analysis of Sealing System

3.1 Comparison of Finite Element Simulations of Two Sealing Systems

In order to ensure the application effect of the project, the simulation module of the SolidWorks software is used to perform finite element analysis on the deformation of the new sealing device and the sealing device used in the current project.

Firstly, the finite element analysis is carried out for the sealing device commonly used in the current engineering. According to the above introduction, the seals commonly used in engineering applications include O-rings, V-rings, U-rings, etc. The O-ring is taken as an example for simulation analysis

The leakage in the sealing system is mainly caused by the deformation of the seal. Therefore, the deformation of the seal is mainly simulated here. The main steps of the simulation are as follows:

The first step: adding materials for O-ring seals and low-leakage coaxial seals respectively (the O-rings currently used are basically made of synthetic rubber, and the materials used in the piston seals of this system are filled separately). Bronze and NBR);

The second step: adding a clamp, because the sealing member is embedded in the piston sealing groove, the piston surface is fixed surface here;

The third step: adding a load, here considering the force under normal working conditions;

The fourth step: dividing the grid separately;

The fifth step: running to obtain the simulation results, the results are shown in Figures 5 and 6, respectively.

Analysis of simulation results: According to the above two figures, the deformation amount of the low leakage coaxial seal is much smaller than that of the O-ring. Since the leakage of the hydraulic working medium is mainly caused by the deformation amount of the sealing member, it is known that the sealing effect using the low leakage coaxial sealing member is better.

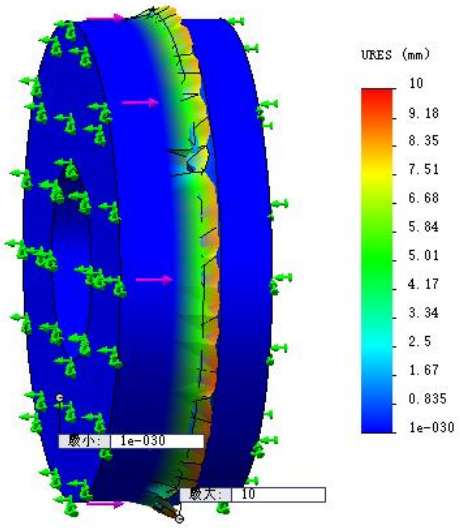


Fig 5. O-ring simulation analysis

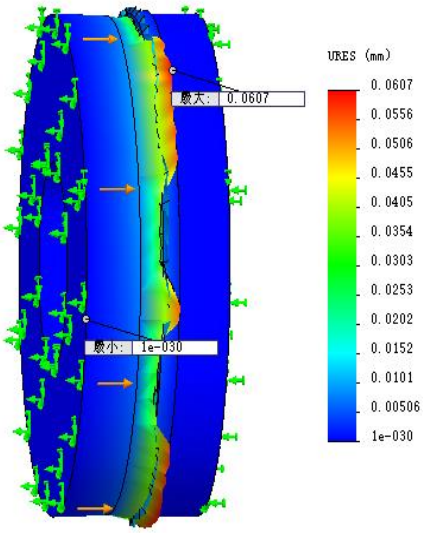


Fig 6. Low leakage coaxial seal simulation analysis

3.2 Leakage Simulation Analysis of Sealing System

Using SolidWorks Flow Simulation software to simulate the leakage of low-leakage coaxial seals, you can get the flow trajectory and leakage trajectory of the working medium under pressure during the working process. The steps are as follows:

(1) Define the project name as: seal ring leakage simulation;

(2) Select the unit standard as an international standard;

(3) Defined as internal fluid, checked to eliminate the absence of a flow chamber;

(4) Define the internal fluid as a low temperature grease;

(5) Define “Results and Model Accuracy” as Level 3;

(6) Add model boundary conditions (inlet volume flow and static pressure);

(7) Insert a global target, including flow rate, relative pressure, dynamic pressure, etc.;

(8) Dividing the grid, the grid precision coefficient is three levels;

(9) running the loading result;

(10) Select "Insert" in the section and flow trajectory and define it, and obtain the velocity section map and velocity flow trajectory diagram, as shown in Figure 7 and Figure 8, respectively.

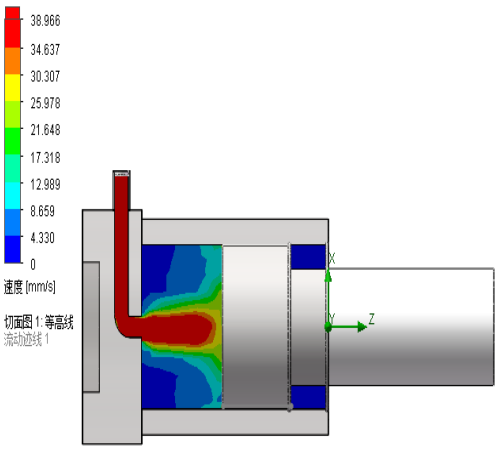


Fig 7. Diagram of the speed plane

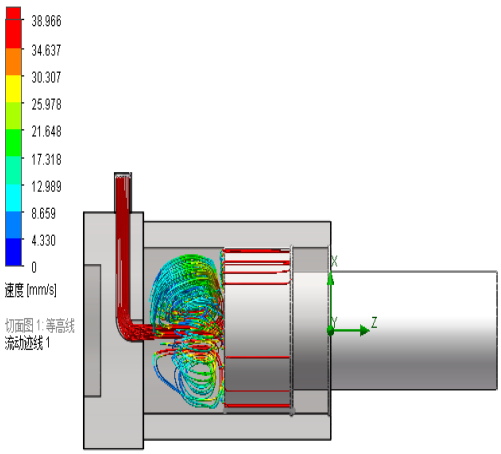


Fig 8. Trajectory chart of velocity flow

4. Conclusion

This paper focuses on the working requirements of hydraulic load cells, researches and designs a low-leakage coaxial sealing device, and uses simulation software to analyze and compare the difference between the new sealing device and the sealing device commonly used in engineering, using SolidWorks Flow Simulation. The software simulates the leakage of low-leakage coaxial seals, studies the leakage trajectory of the working medium, and improves the accuracy in engineering applications.

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