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Research on the end Face of the Valve metal Seal Structure Intelligent Well inflow Control Valve

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Abstract

As one of the most advanced technologies in oilfield in the world today, smart well can be used to control the production of different lay in the oil well, and is an essential part of intelligent oilfield. This paper mainly introduces intelligent well systems, metal contact sealing mechanism and effect factors for metal seal, and explains surface treatment technics, and material selection for underground metal seal. Inaddition to that, researches on face metal seal structure of underground inflow control valve is made, which is the key component of intelligent well system. According to researches, analysis of influences for different sealing face taper to sealing efficiency, and relationship between contact pressure and contact face taper are made, by using software ANSYS to make model. As a result, contact pressure is in direct proportion to contact length with increasing of sealing taper. Therefore, it is necessary to choosing a higher value in order to ensure well sealing efficiency when making theoretical design for face metal seal.

Keywords: Intelligent Well ICV Taper Seal Sealing Pressure

Introduction

Intelligent real-time injection and production wells is a network management, working conditions and the use of a parameter downhole permanent sensors placed in the real-time acquisition of downhole equipment producing interval pressure, temperature, flow rate, composition, etc., through a communication cable or fiber optic cable the transmission signal

acquisition to the ground using the software platform for data mining, analysis and study, combined with automatic reservoir history matching techniques and the numerical simulation technology, a production and reservoir management decision-making information, and through the real-time control system feedback downhole oil production of remote control, reconfigured well structure and improve well productivity like production techniques.

Intelligent Well the main information collected downhole sensor systems, mine production control system, four part of downhole data transmission systems, ground data collection, analysis and feedback system. In the underground production control systems, downhole inflow control valve is an important part of the underground production control system, is a key part of the intelligent well system for real-time control.

Due to extensive environmental adaptability and insensitivity to the vast majority of chemicals, metal sealing technology is more suitable than the elastomeric seal for high temperature high pressure oil and gas wells and thermal recovery of heavy oil and other occasions. At the same time, compared to metal sealing technology elastomer sealing technology has many advantages, when considering downhole inflow control valve seal structure choice of metal-metal contact seal structure as downhole inflow control valve sealing method can provide a safe and normal work flow valve for guarantee. Inflow control valve on the end face of the metal to metal contact seal structure to make a study to analyze the impact of its size taper cone seal sealing effect.

Metal sealing mechanism and the factors affecting metal seal

Metal contact seal surface is the use of close fitting metal contact and the metal contact is applied perpendicular to the surfaces of the controllable load (pressure) to squeeze the metal seal surface deformation and make full use of the contact pressure of the contact surface of the metal deformation and flow to fill the gap between the contact surfaces between, so as to obtain a good sealing effect.

Metal sealing performance depends mainly on the surface quality of the sealing surface, the width of the sealing surface, the sealing surface of internal and external pressure, the yield strength and the sealing surface of the surface of the material than the pressure and other factors. (1) Sealing surface quality pair. The surface quality of the sealing contact surface as possible, the gap between the sealing surface is smaller, thus contributing to seal. (2) the width of the sealing surface. Sealing surface will increase the width of the media from the inside along the outer edge of the path of a leak to increase. Internal and external pressure (3) of the sealing surface. In fact, this pressure is the pressure to be sealed. Since the inner and outer sealing surface is pressure medium, have entered from the outer edge of the sealing surface of the trend, thus impeding the flow of sealing medium is outwardly so affect sealing performance. (4) sealing surface material. Sealing surface material in addition to general strength, corrosion resistance and other requirements, the greatest impact on the sealing performance is its hardness, metal seal surface is mainly subjected to greater than the pressure seal to prevent plastic deformation and crushed, but also improve the hardness , erosion-resistant seals and a corresponding increase. Ratio (5) sealing surface pressure. The average positive pressure acting on the sealing surface unit called

than the pressure seal. The sealing surface than the pressure of the sealing surface of the contact convex peaks are flattened, thereby increasing the actual contact area, reducing the size of the gap and the capillary channel is conducive to seal.

Empirical formula derived from the test results, depending on the width of the sealing surface of the sealing material test to obtain empirical formula :

$$q_b = m\left(\frac{a + cp}{\sqrt{b}}\right)$$

Where:

m-- coefficient and fluid properties related;

a, c-- coefficient associated with the sealing surface;

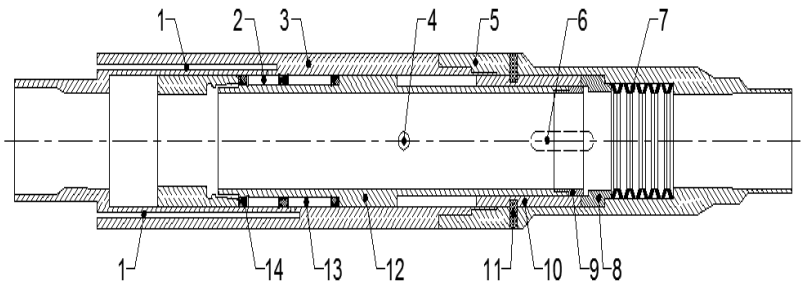
P-- fluid working pressure;

b-- sealing surface in the vertical direction of the fluid of the projection width.

Metal sealing pressure than the size of the direct influence of the metal seal assembly sealing reliability [4]. Under the same external conditions, the sealing pressure than small enough to provide sufficient contact stress, prone to leakage than the pressure is too large will cause instability and damage to the seal assembly. Under the minimum required to ensure the seal than the pressure of the situation, it can increase the sealing pressure than.

Inflow control valve and metal seal structure

At present, most of the downhole control valves are hydraulic control technology, downhole inflow control valve is an important part of the underground production control system, is a key part of the intelligent well system for real-time control. Inflow control valve is usually installed in the upper portion of the perforation, the lower portion of the packer, for selective mining separated oil, improve oil recovery . Downhole inflow control valve with sleeve structure, moved by hydraulic control to drive sleeve, changing the size of the control valve orifice size, the impact of the control valve inflow performance. Which is the core of intelligent well technology is the intelligent exploitation wells intelligent actuator. As shown in Figure 1 as having a metal seal structure of inflow control valve structure.



1- oil passage; 2- hydraulic; 3 - body; 4- stream mouth; 5- lower valve body; 6- orifice; 7- disc spring; 8- seal seat; 9- metal seal bead seat; 10- throttling sleeve; 11- pin; 12- hydraulic piston chamber; 13- lower hydraulic chamber; 14-sealing element

Fig.1 A flow control valve structure

Figure 1 shows the inflow control valve, the orifice 6, the metal seal ring and the valve seat 8 housing 9 that the end face of the metal seal structure. Metal sealing structure shown in Figure 2.

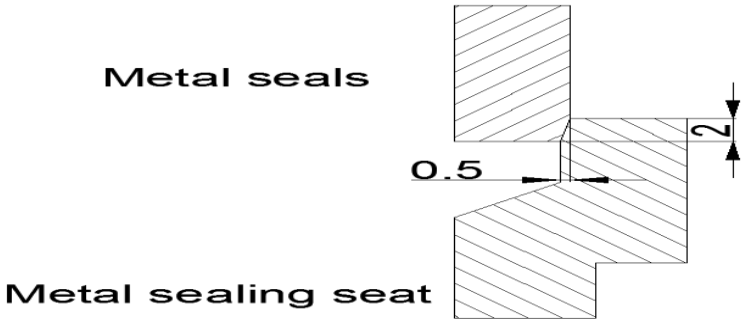


Fig.2 End face sealing structure diagram

Seal structure is mainly relying on the pressure of oppression butterfly spring metal sealing surface contact when closing the control valve is to rely on hydraulic pressure to force compression spring, when the control valve stroke is limited, so in the spring of oppression smaller size change, so the theory sealing pressure mainly influenced by the spring preload and the contact surface area :

$$q = \frac{F}{A}$$

In order to improve metal seal surface than the pressure to try to reduce the area of the contact surface and increase the spring preload. Reducing the width of the contact surface of the seal will be reduced, and therefore this width of the sealing surface takes 0.5mm, 86mm outer diameter of the metal ring, the axial contact area of about 135mm2. You can get the required theoretical spring preload of about 7000N. Metal seal and sealing pressure than the size relationship will later be analyzed using finite element software.

According to a conventional depth downhole inflow control valve is operated under downhole 3,000 meters, maximum reservoir pressure can reach 40MPa, consider the need to set downhole safety valve control the maximum pressure can reach 25MPa, so the design of downhole inflow control valve seal metal seal program than the pressure should not be less than 70MPa.

Finite Element Analysis of seal program

Underground metal seal relies mainly on maintaining the sealing position after the spring compression seal is achieved, according to ANSYS to-metal contact sealing pressure than are

simulated. Inflow control valve in a sealed state, the control valve on each side of the compression pressure can be regarded as balanced, and because the analysis is mainly sealed metal seal between the sealing surface for analysis than the pressure, and therefore ignored the valve non-axial symmetry, downhole seal model simplified calculation for the two-dimensional plane to simplify the structure. 3 shows a simplified model of the downhole seal structure, wherein the material is selected in FIG 42CrMnMo the elastic modulus of 2.06 $*10^5$MPa, Poisson's ratio is 0.3, the contact surface of the material selected for the type 40Cr, the elastic modulus: 2.06 $*10^5$MPa Poisson's ratio of 0.3. Figure 4 shows the seal structure meshing, and the contact portions of the grid refinement process.

In this section mainly analyzed for different sealing surface taper to discuss the contact pressure and the contact surface of taper relationship. Herein shall be a simplified model of the contact established relationship taper parameters using ANSYS order flow analysis model modeling, finite element model to facilitate the calculation.

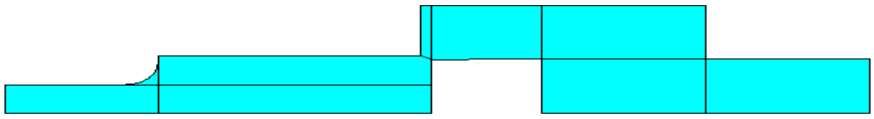


Fig.3 Simplified model of ANSYS

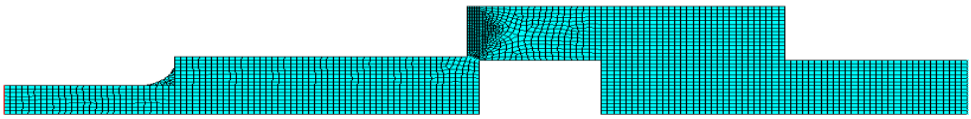
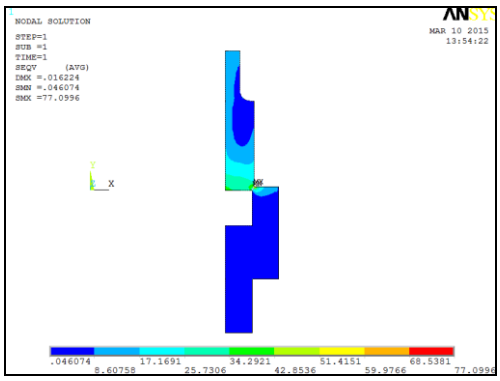


Fig.4 Sealing contact grid

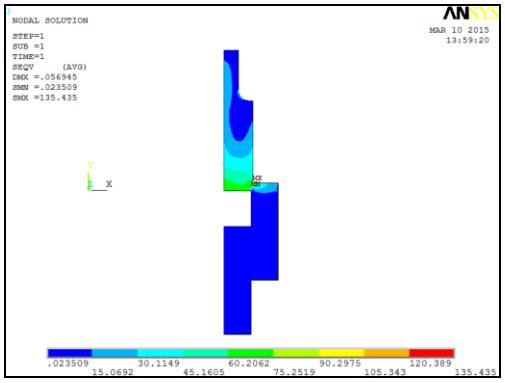
According to the mechanical balance of knowledge we can know, sealing spring force to ensure sealing face metal seal surface than the pressure. So the sealing force to be fixed by the external pressure has little effect. Therefore, in order to increase the theoretical sealing pressure than to try to reduce the contact width in the axial direction, as select the contact width of 0.5mm, with bevel variable length study metal sealing contact characteristics. In the control valve is used to provide a sealing force ranges: high 5000-10000N the disc spring, the seal can be obtained by the theoretical pressure ratio:

$$q = \frac{F}{A}$$

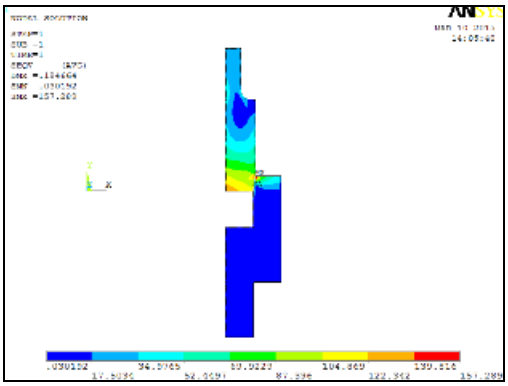
Where F is the spring force, A is the area of the contact surface of the axial projection.



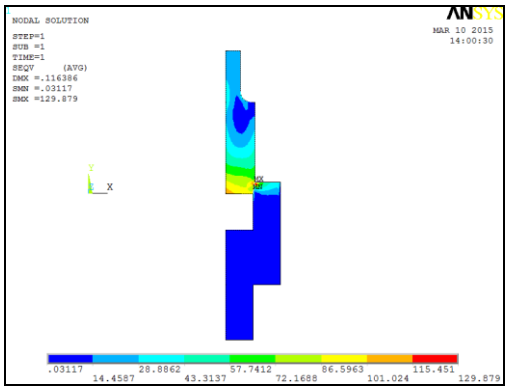
（a） L=1mm



（b） L=2mm



（c） L=3mm

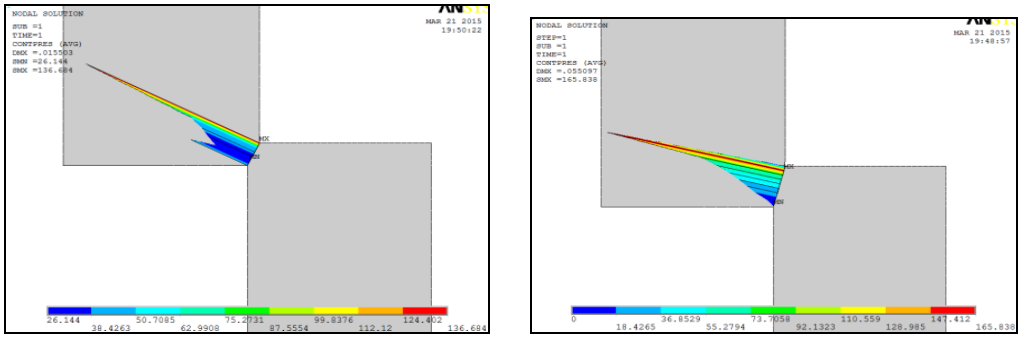


（d） L=4mm

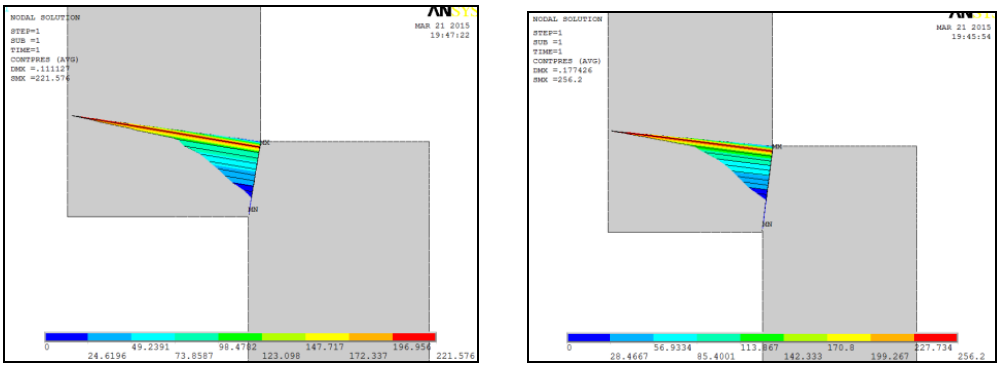
Fig.5 End face seal under different taper equivalent stress nephogram

The metal seal theory, sealing pressure than the average should be 2 times the sealing liquid pressure difference. Suppose the maximum sealing pressure can reach 30MPa, underground spring preload is set to 7000N. The theory than the pressure seal was 30MPa. The following discussion of the spring pressure to seal the valve.

From the ANSYS analysis results are shown in Figure 6 can be seen, finite element analysis and theoretical calculations there is a big gap, because the theory is to calculate the uniform distribution of pressure in the whole contact surface, and the finite element results the results of the contact surface is divided equally after the value of the contact pressure node is located on this section. FEM value is relatively more precise contact pressure to give 7 seal contact surface and the length of contact stress relationships through node contact surface.



（a） L=1mm （b） L=2mm



（c） L=3mm （d） L=4mm

Fig.6 Under different taper end face sealing contact stress

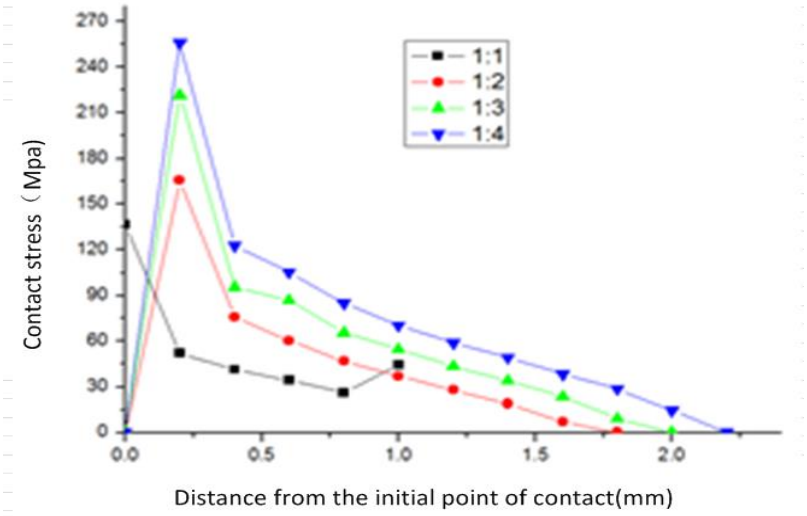


Fig.7 The end face sealing contact length and contact stress

Seal length from the contact surface and contact stress diagram can be seen in different conditions of specific exposure. The maximum sealing pressure on the sealing surface vary different taper, when the contact surfaces have a taper of 1: 1 as it contacts a length of about 1.1mm, i.e. the entire contact surface are in contact, but the total length of the contact 1.1mm;

when the taper is increased to 1: 4, the total length of the contact becomes 2.2mm, but in the opposite taper of 1: 1 is also more contact pressure increases, the maximum contact pressure of 250MPa. Taper relatively large air sealing effect is relatively good. Therefore, on the face seal design theory, should be selected larger taper value, so as to achieve greater sealing pressure to achieve a good seal.

Conclusion

By studying the structure of the end face of the metal seal downhole inflow control valve, the sealing surface for different taper to analyze the relationship between research and the contact surface taper contact pressure, obtained large air sealing effect is relatively good taper, contact pressure and the contact length with sealing taper increases proportional. In the structure of the metal seal design theory, should be properly chosen taper greater value to ensure good metal seal.

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