Finite Element Analysis of Metal Seal Ring of Casing Head

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Abstract

The casing head is an important connection between the casing and the wellhead device. It is an important equipment in the oil and gas production operation. It is usually used to fix the wellhead, connect the wellhead casing string, and bear the gravity of the technical casing and the oil casing. The annular space between the tubes is sealed to provide a connection for the installation of the blowout preventer, the tubing head and the tree. The quality of the casing head directly affects the safe production of a well. The upper and lower ends of the metal sealing ring are in contact with the hanger and the casing head body, and the sealing of the hanger and the casing head body is achieved by extrusion deformation. In order to improve the sealing performance of the casing head, a metal sealing ring was designed and subjected to finite element analysis and evaluation.

Keywords

Casing Head; Sealing Performance; Metal Sealing Ring; Finite Element Analysis.

1. Introduction

The casing head is used in drilling and completion engineering. It is used to connect the surface casing after surface completion. It is the foundation for installing the wellhead anti-spray device. It suspends the casing other than the surface casing and accepts some or all of the casing. The weight of the tube, the casing head also seals the annular space of each layer of casing, and withstands the pressure of the casing annulus, and can perform special operations in an emergency.

In order to improve the sealing performance of the casing head, domestic scholars have done a lot of research in recent years. Sinopec New Star Company Dezhou Petroleum Machinery Plant Liu Zhonghuai, Wang Kunyu, etc. [1] developed a new type of quick-fit casing head, which can simplify and shorten the installation procedure of the wellhead blowout preventer, and adopt BT seal, without removing the anti-spray protection In the case of the sprayer, the secondary seal can be effectively performed, and the BT type apron is always in a completely closed state, and the durability is good, thereby ensuring the safety and reliability of the seal. However, in the field, the rubber seal is increased in pressure in the field, the casing head seal is subjected to excessive pressure, and the rubber seal has insufficient pressure resistance, resulting in premature seal failure. Zhang Chuan and Zhao Lin of Baoji Petroleum Machinery Co., Ltd. [2] invented a casing head that can compensate for the X metal gasket ring. The casing head does not need to be fitted with a rubber seal, and the pressure ring is pushed by the grease injection. The lower extruded metal gasket ring forces it to deform to compensate for the seal. Yu Kaibin [3] of Great Wall Drilling Engineering Co., Ltd. studied the step-supporting casing head. The API thread seal is combined with a special thread grease seal, and the sealing system of the sleeve head is independent of the hanger and does not affect the sealing effect due to wear.

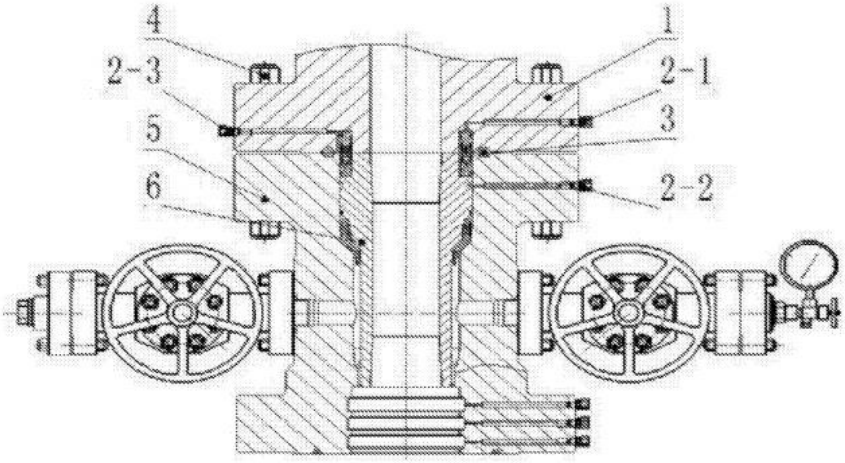
Although the existing researches have proposed different sealing structures and sealing methods, they have certain limitations and cannot withstand high sealing pressures. In order to improve the sealing

performance of the casing head, a metal sealing ring was designed in this paper, and the finite element analysis and evaluation of the metal sealing ring were carried out.

2. Metal seal ring design and parameter settings

2.1 Metal Seal Ring Design

The new metal sealing ring is designed to be in contact with the hanger and the casing head body in the upper and lower ends of the casing head, as shown in Fig. 1. The upper and lower ends of the metal sealing ring are in contact with the casing head body and the hanger, and the joint between the casing hanger body and the casing head is achieved by the weight of the upper casing head and the tightening force of the bolt. The structure of the seal ring is shown in Figure 2.



Tube head; 2-1 grease single-flow valve; 2-2 sealed pressure test single-flow valve; 2-3 annular test single-flow valve;3-metal seal ring; 4-bolt; 5-sleeve head; 6-sleeve hanger

Fig. 1 Schematic diagram of casing head structure

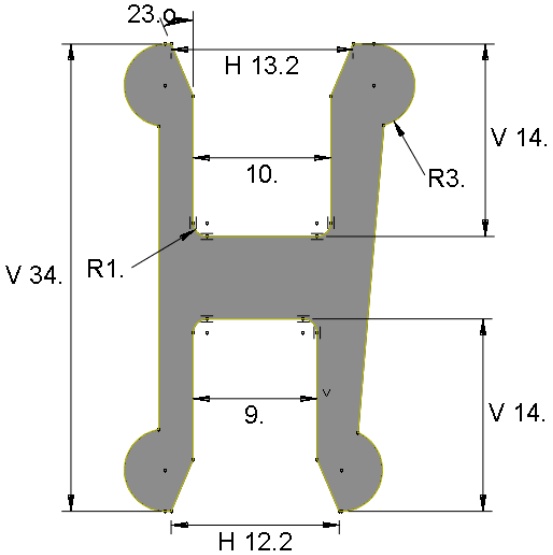


Fig. 2 Metal seal ring structure diagram

2.2 Seal structure parameter setting

Considering the working environment and stress of the metal sealing ring, the alloy steel material 0Cr18Ni9 is used. The finite element model uses the ideal elastic material constitutive model. The elastic phase is simulated by two parameters: elastic modulus E and Poisson's ratio. The mechanical properties of the material are shown in Table 1.

Table 1 Material force-study performance parameters (0Cr18Ni9)

Modulus of elasticity(MPa)	Poisson's ratio	Yield strength(MPa)	Tensile strength(MPa)
194000	0.285	≥205	≥520

3. Establishment of finite element model of metal sealing ring

According to the structural characteristics and load characteristics of the metal seal ring, the whole metal seal ring is selected as the research object. At the same time, considering the contact characteristics of the metal sealing ring, the model is meshed after the model is equipped, using the free meshing technique, and the metal sealing ring adopts the four-node quadrilateral bilinear hybrid non-coordinating unit CAX4IH, grid. The result of the division is shown in Figure 3. Throughout the analysis process, the axial freedom of the bottom of the casing head body is constrained; in the analysis step 1, the axial freedom of the analytical rigid body in contact with the top of the mandrel hanger is constrained, and in the analysis step 2, the analytical rigid body is analyzed. Apply an axial displacement load of 7 mm downward.

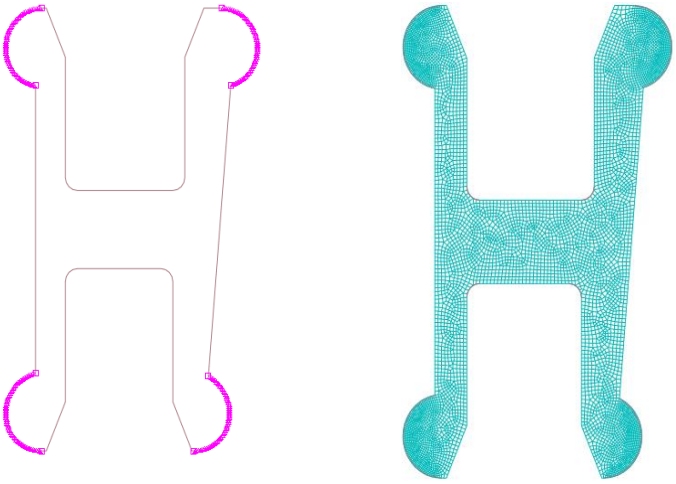


Fig.3 Metal seal ring mesh model

4. Analysis of structural strength calculation of metal sealing ring

For the finite element analysis results of the structural strength of the metal seal ring, the calculation results are analyzed and evaluated mainly by the Mises stress.

After the assembly is completed, the metal seal ring Mises stress distribution, plastic strain, and contact pressure distribution are sequentially shown in Fig. 4, Fig. 5, and Fig. 6.

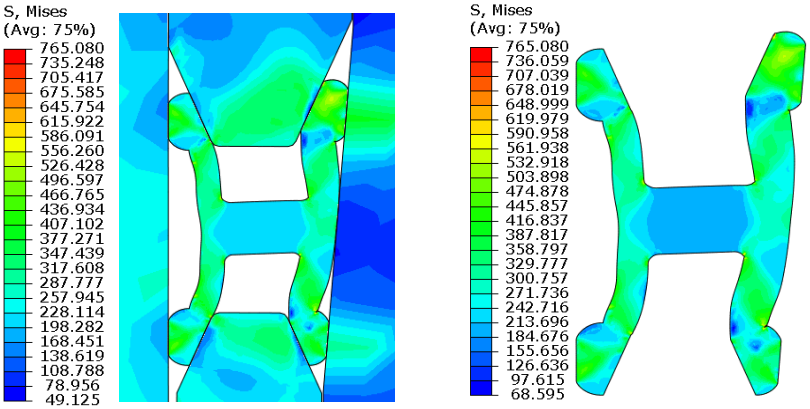


Fig. 4 Metal seal ring Mises stress distribution

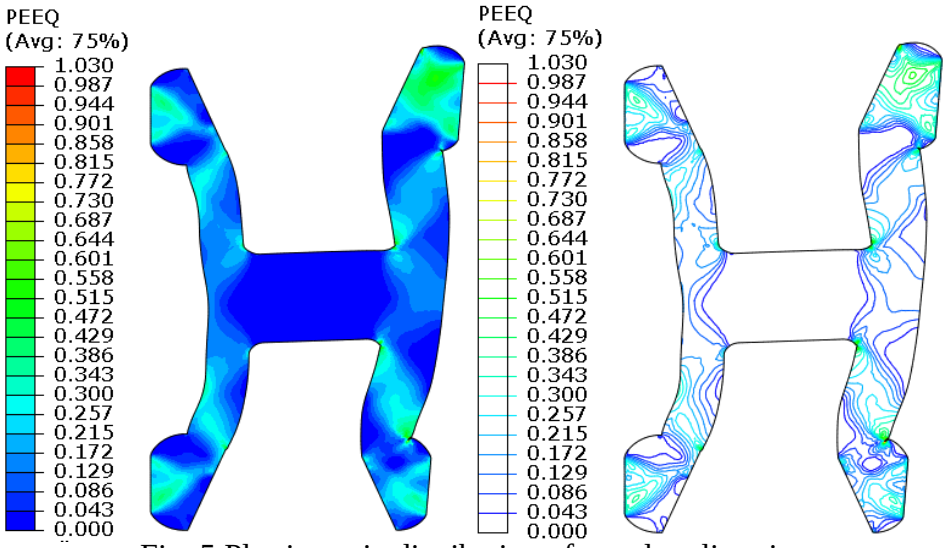


Fig. 5 Plastic strain distribution of metal sealing ring

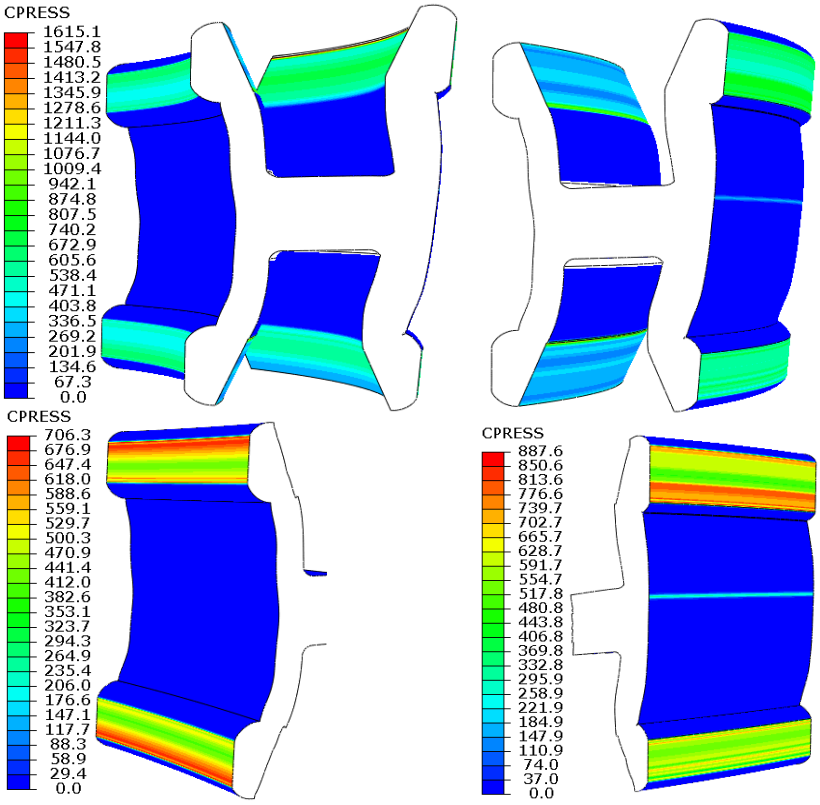


Fig.6 Metal seal ring contact pressure distribution

Fig.4 to Fig.6 show the state of the X metal seal ring when the seat displacement is 7.2 mm.

(1) It can be seen from Fig. 4 that the metal seal ring is severely deformed, and the intermediate portion outside the seal ring has been in full contact with the hanger body, and the maximum Mises stress reaches 765 MPa, exceeding the ultimate strength of the material (520 MPa);

(2) It can be seen from Fig. 5 that the plastic sealing ring has a large plastic strain, and a region with a large plastic strain occurs in a region where the upper and lower ends are in contact with the hanger and the casing head body;

(3) It can be seen from Fig. 6 that the maximum contact pressure is 706.3 MPa in the contact area with the hanger, and the maximum contact pressure with the casing head body is 887.6 MPa. The sealing

ring is connected with the hanger and the oil casing head body. The upper and lower ends of the contact have a large contact pressure, and the structure has a good sealing performance.

5. Conclusion

In this paper, when the axial displacement load is applied to the metal seal ring by the finite element analysis method, the metal seal ring is seriously deformed, and the plastic strain is generated in the contact area with the hanger and the casing head body, the metal seal ring and the hanger and the oil pipe. The contact pressure between the upper and lower ends of the head body is large, which proves that the metal sealing ring has better sealing performance.

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