Effect of Pressure on Packer's Sealing Performance

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Abstract The sealing performance of packer under different setting pressure is studied in this paper, and the finite element analysis is carried out. Firstly, the finite model of packer is established by using ANSYS software. Different setting pressure are provided, which cause the compression change of packer rubber. The relationship between the setting pressure and the compression distance and the maximum contact stress of the packer rubber is found out by analyzing this change, including the gap between the rubber and the central pipe and the contact stress between the rubber and the inner wall of the casing. Finally, the observed phenomena and simulation data are analyzed and summarized, and the influence of the setting pressure on the sealing performance of the packer is obtained.

Keywords Setting pressure · Packer · Sealing performance · Finite element analysis · Rubber

1 Introduction

Well completion engineering is an important part of oil drilling and production, directly relates to the service life and output of oil well [1]. Compression packer is a kind of important oil well completion tool. It mainly plays the role of separating different production layers, fracturing, acidification, water injection and so on. Sealing performance is the core property of packer [2], Rubber is the core part of packer, and it is the working part of packer, which is directly related to well completion quality and underground safety. RIVENBARK M, et al. designed a

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DHM-type compression packer. The packer with double sealing components, hydraulic sealing, mechanical releasing [3]. With the sealing performance of ultra-deep well RTTS packer analyzed, Tong Shaokai put forward packer sealing failure criterion [4].

The study on the creep and stress relaxation of packer rubber provides the basis for the optimization of packer sealing structure. In this paper, the optimum seating load is obtained, owing to finite element analysis of the compression distance and maximum contact stress of packer.

2 Finite Element Model

The geometrical model of the packer sealing structure is established in ANSYS [5]. In the mesh generation, the sealing rubber is the main object of the calculation and analysis. As shown in Fig. 1, polygon mapped mesh generation is used. Non-critical components, such as Center tubing, casing, base, use free meshing generation. The number of the grid nodes is 1766, the number of units is 511, and the average value of the unit quality is 0.9424. As the cement bond on the outside of the casing, the casing is fixed, the central oil pipe, the pressing block and the base are provided with radial displacement constraint, and the base is bound with the central oil pipe.

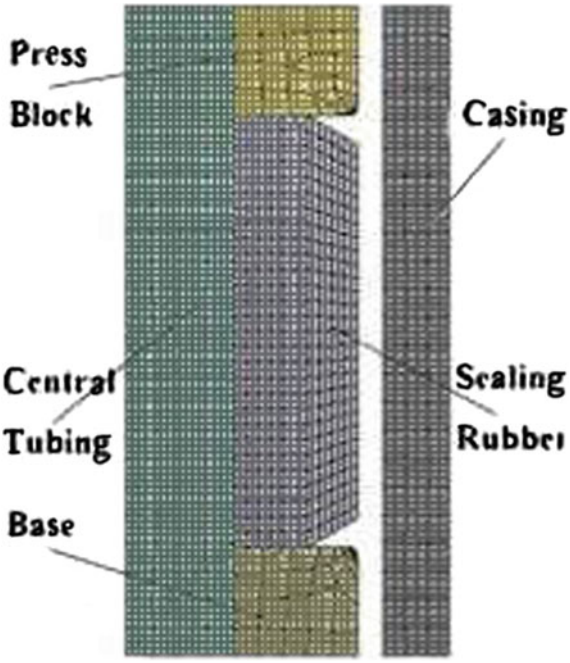

Fig. 1 Meshing diagram of sealing structure

3 Analysis on Sealing Performance

When the compression packer is positioned below the preset position, the pressure is injected through the central pipe to compress the rubber so as to realize the action of sealing. Reasonable setting pressure can ensure the sealing performance of packer [6]. Too little setting pressure does not complete the sealing or incomplete sealing, and too large setting pressure will cause damage to the rubber. Therefore, it is necessary to analyze the effect of different setting pressures on the sealing performance of the packer.

When the setting pressure reaches 12 MPa, the amount of deformation of the packer sealing rubber is shown in Fig. 2, and the contact stress between the sealing rubber and the casing is shown in Fig. 3. Caused by the increasing of setting pressure, the deformation reaches 27.748 mm, simultaneous the maximum contact pressure reaches 3.4978 MPa. At this point, the gap between the rubber and the center tube is completely disappeared and the rubber has been basically compacted, which means that the packer completes the sealing. And the annular gap between the center oil pipe and the casing is sealed.

The distribution of the contact pressure between the sealing rubber and the inner wall of the casing under different loads is shown in Fig. 4. In pacing with the setting pressure increases, the stress in the contact region rises as a whole. When the setting

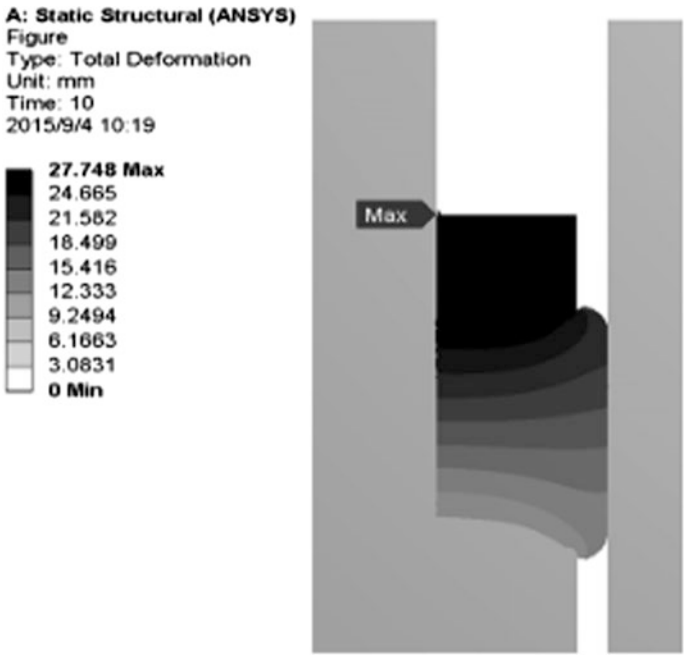

Fig. 2 Total deformation

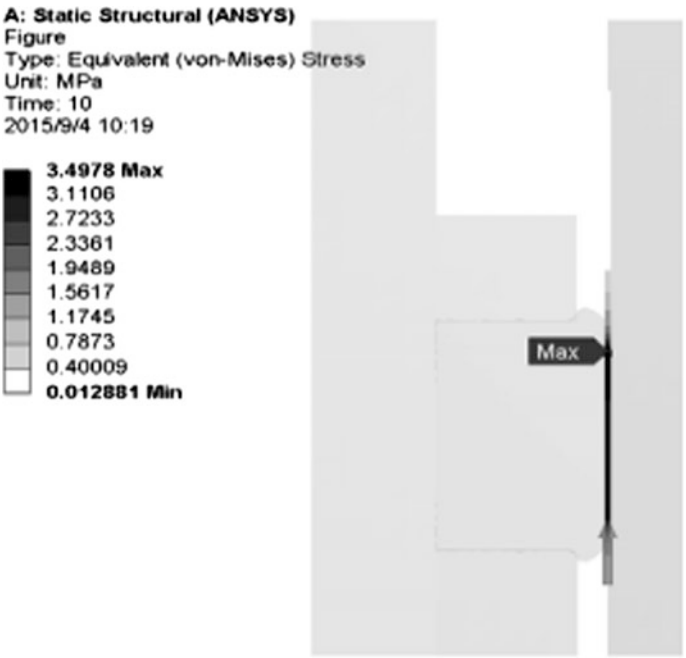

Fig. 3 The contact stress distribution

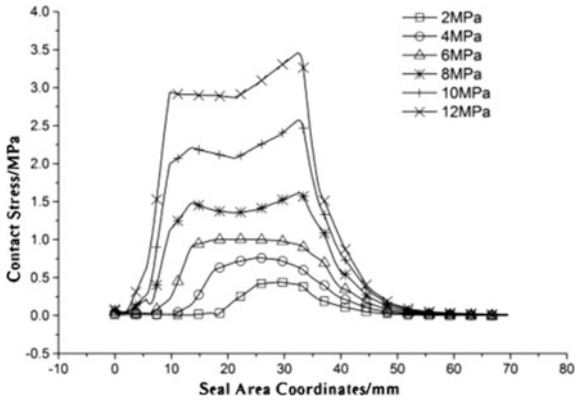

Fig. 4 Contact pressure distribution

pressure is between 2 and 6 MPa, the contact stress curves indicate that the rubber is always in the gap with the central tubing and the rubber is not fully contacted with the inner wall of the casing, which are single peak curves. When the setting pressure is small, the radius of curvature of the rubber bends towards the central tubing, but the rubber begins to bend in the direction of the casing after contact with the central tubing with the increasing of setting pressure. Due to the limitation of the

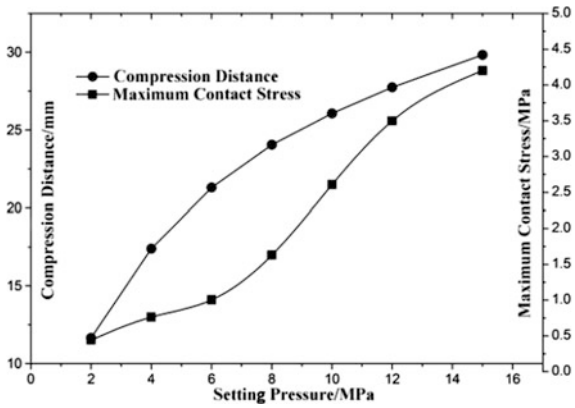

Fig. 5 Effect of setting pressure

central oil pipe, the rubber produces two bends between the upper and the lower, and the two bends simultaneously point to the inner wall of the casing. Precisely because of this, when the setting pressure is more than 8 MPa, the curves have two stress peaks.

Figure 5 shows the change of the compression distance and the maximum contact stress of the packer sealing rubber under different setting pressure. As can be seen from the diagram, with the increase of the setting pressure, the compression distance of the sealing rubber is increasing, but the slope of the curves is decreasing. After the stress reaches 10 MPa, the growth curves of the compression distance begin to become gentle. This is because, as the pressure increases, the rubber is constantly compacted and the compressibility decreases slightly. In the contact pressure curves, the curves grow slowly in the range of 0–6 MPa. And within 6–10 MPa range, the slope increases and the rate increases rapidly. When setting pressure exceeds 14 MPa, the contact pressure increases gradually. After the setting pressure reaches 15 MPa, it is also shown in the figure, the compression distance is almost stable at around 30 mm, and the contact stress is between 4 and 5 MPa. At this point the packer has reached the sealing requirements, can achieve a stable seal.

4 Conclusion

In this paper, the finite element model of the sealing parts is established according to the actual size of the compression packer and the experimental material constants. The simulation results show that the optimal setting pressure of the packer is 15 MPa, and the limit value both of the compression distance and the contact stress are 30 mm and 4.25 MPa respectively.

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