Roll forging die design and parameter optimum of CoilFlat-CT-Liner

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Abstract

The oil casing is a steel pipe used to support oil and gas well wall in the drilling process to ensure the smooth operation of the drilling process and the normal operation after well completion. As the working environment becomes more demanding, cement job becomes more and more difficult. For example, when the cementing work of deep well is carried out, it is difficult to carry out the ordinary casing to the bottom of the well. Based on the concept of CoilFlat-CT-Liner casing developed by Marinovition of Germany, this article designs a kind of folding continuous casing which can be wound to the drum. The CoilFlat-CT-Liner has the advantages of easy to descend a well and no need to consider the connection strength of the connection. In this article, the shape and size of the folding mold are designed and simulated in DEFORM-3D simulation software.

Keywords

Oil casing, Plastic forming, DEFORM, Roll forging.

1. Introduction

The novel design of CoilFlat-CT-Liner has many outstanding advantages: (1) The width of the tube is less than the outer diameter after the full circle, which is more convenient to descend a well. (2) Without regular thread joint, it can greatly improve the casing efficiency, reduce the possibility of underground complicated situation during cementing, and do not consider the connection strength of the connection. (3) It can be wound to the drum to make it more energy efficient and efficient in transportation and downhole process.

At present, the internal pressure forming is usually used for the thin and complicated tube, this technology has been widely used in automotive and aerospace industries. In this article, due to the large size of the oil casing, the pipe wall is thicker and the internal pressure forming is difficult, so the extrusion and roll forging are used. This forming method has a high requirement on the pattern die which involves many parameters. In this paper, we will discuss the groove shape of roll forging die and its arc radius and turning radius.

2. Casing material selection and size design.

2.1 Material selection for casing

The casing material adopts N80 steel, its yield strength is the minimum 553MPa maximum 758MPa, the strength of extension is 689MPa.

2.2 Casing size design.

Because the CoilFlat-CT-Liner is mainly used in the last few paragraphs of well cementation, it is convenient to use the smaller cross-sectional area before expansion, so it is smaller in size. This paper takes the specification of 7in casing in the standard of petroleum drilling, with the outer diameter of 177.8mm, the inner diameter of 161.7mm, the wall thickness of 8.05mm, and the pipe length of 2000mm for the DEFORM simulation analysis.

3. Roll forging die design

3.1 Roll forging die groove design

Because the research topic is to forge the oil casing roll into a "U" shape, in order to have a smaller cross-sectional area and be more convenient to descend a well and winding to the roller. So, at the beginning of the design, the semicircular groove was selected for simulation test. As is shown in Fig .1. It can be seen from the figure that the top die and bottom die are semicircular arc. Under the design of this groove, the casing can be made of normal roll forging, and the blank space between the top and bottom dies is piled during the roll forging process. The formed casing is shown in Fig. 2. It can be seen that the casing is only fitted at one point between the upper and lower sides of the casing, and the cross-sectional area is larger and the casing is not easy to be wrapped in the roller.

In the further discussion, the arc radius difference of the upper and lower dies is set to two sets of pipe wall thickness, as shown in Fig 1b, so as to achieve the effect of adequate fitting on the upper and lower wall of the casing. However, such a design, because there is not enough space between the top die and bottom die, makes it difficult for the mold to bite into, and the tube is not able to roll forging after the roll forging. Therefore, the top die was cut in part and the final groove was obtained as shown in Fig.1c.

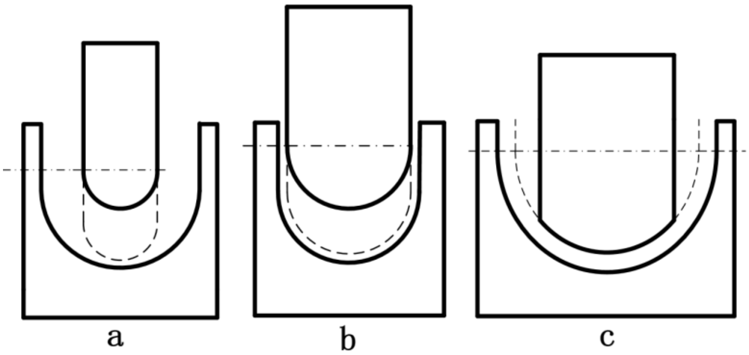

Fig. 1 Roll forging die groove design

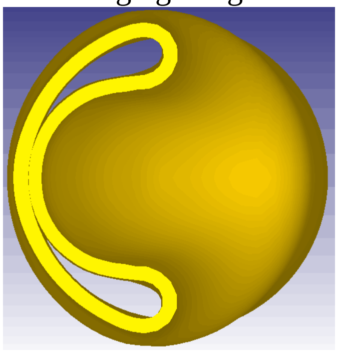

Fig. 2 Simulation result of type A die groove

The specific parameter design of groove type is shown in Fig .3. The die arc diameter is 194mm, the upper die arc diameter is 161.8mm, and the width of the top die is 60mm. The relationship between the arc radius of the upper and lower modes is shown as follows:

$$R_2 - R_1 = 2t \quad (1)$$

$$\mathrm{L} = D_1 - 2a \quad (2)$$

where:

R_1 represents the top die radius, R_2 represents the bottom die radius,mm

t represents the casing-wall thickness,mm

L represents the The width of upper die,mm

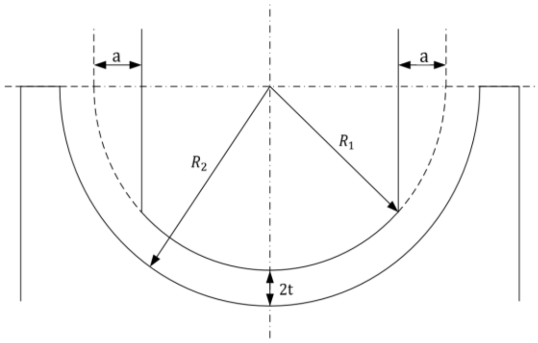

Fig. 3 Parameter design of die groove

The cross section of the casing is shown in Fig .4:

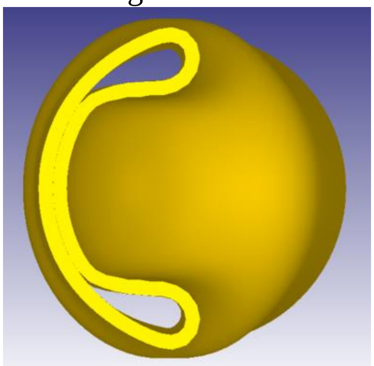

Fig. 4 Simulation result of type C die groove

3.2 Arc radius design of the roll forging die

The radius of the roller forging is closely related to the final shape of oil casing after roll forging. It is not hard to see, the closer the arc radius is to the diameter of the casing, the smaller the casing width is, but also more difficult for the roll forging process. Here, three control groups were selected for analysis, as shown in Fig .5. In contrast, the bottom die arc radius of type A matched group was 182mm, the bottom die arc radius of type B matched group was 186mm, and the bottom die arc radius of type C matched group was 194mm.

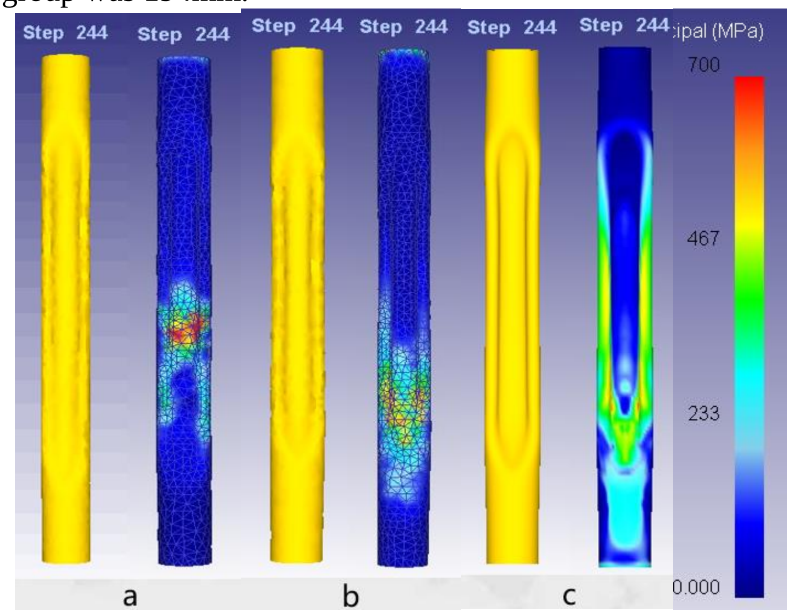

Fig. 5 Simulation result of different arc radius

It can be seen that the arc radius of different roller forging has great influence on roll forging. The smaller the arc radius, the greater the stress value of the casing, and the stress concentration. In the control group A, the maximum stress value of the casing is close to 700MPa. During the roll forging to the 244th step (second pass), the grid was destroyed and the hexahedral mesh was automatically divided into tetrahedral mesh; In the control group B, the maximum stress value of the casing is about 500MPa, and the grid damage occurred at 244 steps. In the control group C, the stress distribution of the casing is relatively average, the stress value is smaller, only the stress value of more than 500 is in the local area, and the roller forging can be carried out normally.

3.3 Turning radius design of the roll forging die

As the rotation radius of the roll forging die directly influences the slope of the inclined plane after the forging of the tube, the smaller the slope is, the more difficult the expansion is. Therefore, it is necessary to choose the greater radius of gyration. Here, three control groups were selected for analysis, as shown in Fig .6. In contrast, the forging die turning radius of type A matched group was 300mm, the forging die turning radius of type B matched group was 350mm, and the forging die turning radius of type C matched group was 400mm.

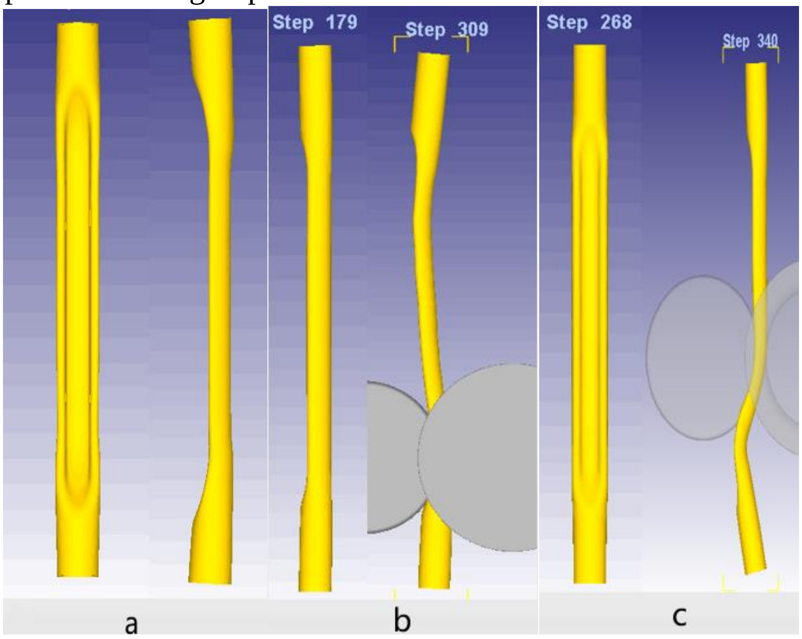

Fig. 6 Simulation result of different turning radius

According to the contrast simulation it can be seen that when the turning radius is set to 350 mm and 400 mm, the casing in the process of roll forging are damaged (generates a force with roll forging die), and the amount of damage increases with the increase of turning radius.

4. DEFORM-3D simulation result analysis

Through the above control experiment, we learn that In the design of roll forging die with, hope to get as far as possible little arc radius and large turning radius, and when taking the bottom die arc radius of 194 mm, turning radius is 300 mm, tube billet in the process of roll forging material damage will not occur. In this case, the groove type is selected as the roll forging tool shown in Fig.1c, and the turning radius is 300mm, the arc radius is 194mm, then the finite element simulation is performed in Deform-3D.

The equivalent strain distributing graph is shown in Fig .7, and the equivalent stress distributing graph is shown in Fig .8. It can be seen from the simulation results that the maximum value of the equivalent strain is in the inside of the forming, and the greater the equivalent stress value indicates that the deformation of this part is larger, and the stress in the non-deformation part is basically zero. Overall, the deformation is relatively uniform. There are no large distortion points, indicating that there is no tendency to crack. From the distribution of the equivalent stress, it can be seen that the large deformation amount is located in the place where contact extrusion with the roller forging die roller occurs, and the maximum stress value is 722MPa.

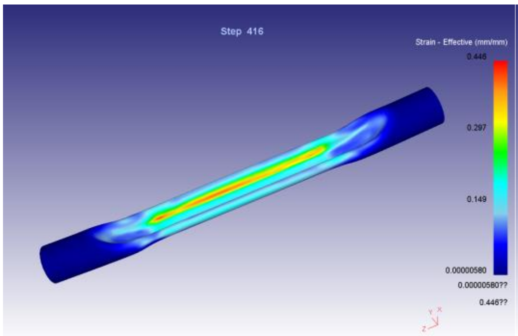

Fig. 7 Strain distributing graph

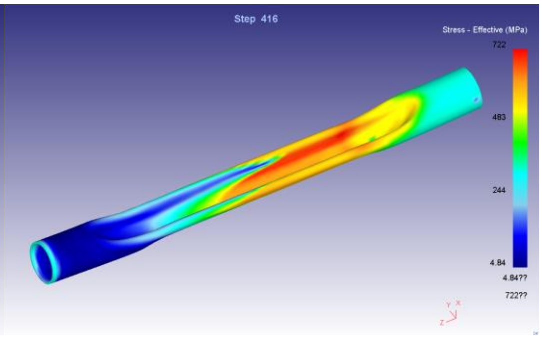

Fig. 8 Stress distributing graph

5. Conclusion

Based on CoilFlat-CT-Liner as the research object, this paper studied the plastic forming technology of oil casing. Through the DEFORM-3D numerical simulation software, the casing is extruded and rolled successfully, and the simulation results are good. The influence of different arc radius and turning radius on the simulation result is discussed. And then got the stress and strain distributing graph of CoilFlat-CT-Liner in the process of roll forging. It is concluded that the tube billet can be formed normally when its arc radius is 194mm and the turning radius is 300mm, and the shape size is ideal after forming.

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