

The Design of Oil Seal Transmission Shaft for Screw Drill

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Abstract—The most of thrust bearing group's lubrication way of screw drill is drilling fluid lubrication. Abrasive wear and drilling fluid corrosion could happen easily on thrust bearing group in this lubrication way. Aiming at this problem, through analyzing the structure of traditional transmission shaft assembly and make sure the possible structure of causing leakage problems, know the main structure affecting the oil lubrication way can be divided into three categories, screw joint structures, the clearance fit of relatively static and the relative rotating clearance fit. According to these three problems, a series of actions are taken to improve the transmission shaft assembly and these problems affecting the oil lubrication structure of bearing group's come true, so as to realize the transformation of the bearing group's lubrication from the drilling fluid to the oil storage.

Keywords- Screw drill; Oil lubrication; Sealing ring; Metal corrugated pipe; Shell

I. INTRODUCTION

With the development of the oil drilling industry in our country, higher and higher demands are proposed for the main power drilling equipment performance and reliability, however, the screw drill tool's working life is not very well as a whole in China. In the process of drilling operation, the thrust bearing group's load is complex, the degree of load fluctuation is high, the load's impact is strong and the bearing group's working environment is poor which result from the frequent occur of bearing group's failure. Nowadays, the main method of lubrication for screw drilling tool is drilling fluid lubrication. The method of lubrication effect is limited. Solid carried by the lubricating fluid and the lubricating fluid's corrosion effect is for the bearing group. So improving the thrust bearing group's lubrication method is good for improving the bearing group's working life.

II. THE STRUCTURE OF THRUST BEARING GROUP AND ITS WORKING PRINCIPLE

Screw drill tool mainly composed of four parts, they are bypass valve assembly, motor assembly, universal joint assembly and transmission shaft assembly. Transmission shaft assembly (as shown in figure 1) is one of the most important parts of the screw drill. It transmit the drill press and the torque to the drill bit. The thrust

bearing group is the weakest link in the transmission shaft assembly, Its main function is to bear the axial load^[1]. In order to realize the oil lubrication of the thrust bearing group, it is necessary to analyze the structure and working principle of the traditional transmission shaft assembly in this place, and then optimize its performance. During the drilling operation, more than 90% of the drilling fluid enter the passage of the transmission shaft through water cap and then flow to the lower part. About 7% of the drilling fluid pass the gap between the upper TC bearing static ring and dynamic ring, flowing through the thrust bearing group to cool and lubricate it^[2].

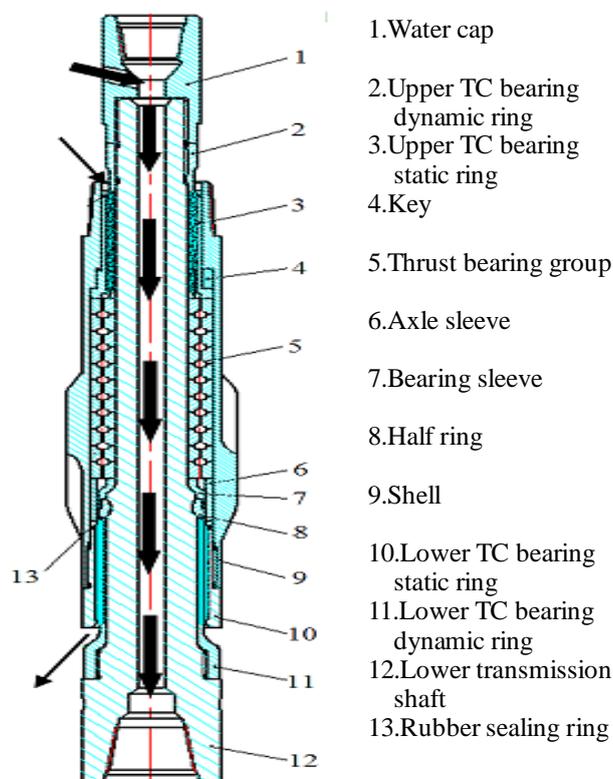


Figure 1. Transmission shaft assembly

Take the outer diameter of the screw drill is 172mm for example, the speed of transmission shaft is relatively

low (90~160r/min), the mainly load of thrust bearing group is relatively large axial load and Relatively small friction torque (the radial load is mainly beard by upper and lower TC bearing), the axial load is mainly composed of static drill pressure (60~150KN) and additional load caused by vibration (as big as 25%~50%static pressure)^[3]. The working environment of thrust bearing group is bad and its load is huge. In our country, most of the thrust bearing group 's lubrication method is drilling fluid lubrication . Compared with oil, the drilling fluid is not only more corrosive but also contains solid particles, under the effect of the huge load, the solid particles tend to wear thrust bearing group seriously and even lead to the occurrence of roller collapse. Setting up a reliable seal on both ends of the thrust bearing group is necessary to realize the thrust bearing group for oil lubrication. By analyzing the traditional transmission shaft assembly and make sure the likely lead to the occurrence of leakage structure, three kinds of problem need to be solved^[4, 5].

(1) Screw connection structure, the related structure include the connecting structure of upper TC dynamic ring and transmission shaft, the connecting structure between the TC static ring and the shell of transmission shaft, the connecting structure between lower dynamic ring and transmission shaft. This kind of structure have a relatively small amount of leakage, but the screw connecting structure which is used for connection obviously can't meet the requirements of reliable sealing.

(2) The relative static clearance fit, the related structure include, the matching method between the upper TC static ring and the shell of transmission shaft. This matching method have a relative large amount of leakage and need to be improved.

(3) The clearance fit which have a relative rotation, the related structure include the connecting structure of upper TC static ring and upper TC dynamic ring, lower TC static ring and lower TC dynamic ring. Due to the existence of relative rotational motion, this matching method have the maximum amount of leakage and the reliable sealing is difficult to achieve. These factors are the main difficulties need to be solved.

III. THE REALIZATION OF OIL LUBRICATION STRUCTURE

A. Seal of screw connection structure

The structure of thread connection have small amount of leakage and belong to static connection, the reliable sealing is easy to achieve, there are two different sealing methods can be selected.

The first sealing method, sealing ring can be added in the gap, take the connecting structure of upper TC dynamic ring and transmission shaft for example. The sealing ring can be added to the corresponding section of the transmission shaft, through research, the main factor affecting the working time of the transmission shaft is the torque, axial force and radial force are in the second place. Take the outer diameter of the screw drill is 172mm for example, its working torque is 8500N.m and the brake torque is 15500N.m. As shown in figure 2, carry on the stress analysis of transmission shaft with the braking torque as the load. The analysis shows that, while the sealing ring can be added to achieve sealing, but it will

also bring some adverse impact, the rectangular groove can reduce the diameter of the related section of the transmission shaft and lead to the stress concentration phenomenon. So it should be cautious about the sealing method.

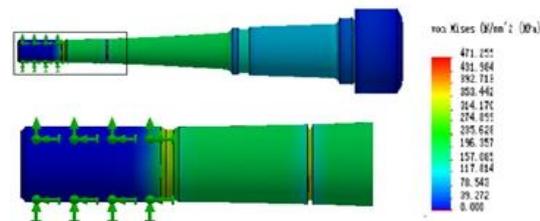


Figure 2. The stress analysis of transmission shaft

The second sealing method, change the type of thread, making it have the property of sealing by smearing 680 glue in the thread connection part, which can improve the reliability of its sealing property. This method solved the problem of sealing without reducing the strength of equipment, but it requires a higher precision of processing the thread.

Both of the schemes can achieve sealing requirements, in the process of practical application , select some kind of sealing method reasonably according to the actual situation. Joint sealing methods can also be applied in special situation.

B. The sealing of relative static clearance fit

For the relative static clearance fit, take the matching method between upper TC static ring and the shell of transmission for example, For this structure, sealing ring can be added to the gap between the TC ring and the shell, but there are two ways to add the sealing ring.

The first method, set the seal ring on the upper TC static ring, the main load of upper TC static include the friction torque comes from upper TC dynamic ring, radial force and axial force comes from the thrust bearing group. The friction torque has the greatest impact on it. Assuming that the friction torque is 1000N.m, as shown in figure 3, according to the stress analysis results of upper TC static ring. Although the load of upper TC static ring is complex, however, the friction torque is not great and the stress concentration phenomenon is not obvious. Therefore, the affect of adding the sealing ring on the TC static ring for the structural strength is not big.

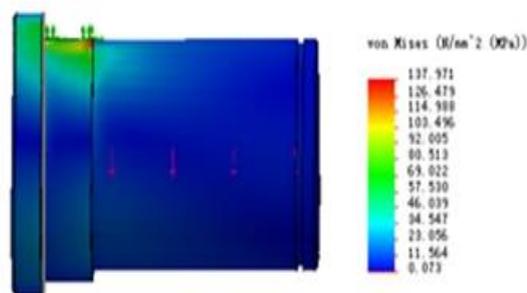


Figure 3. The stress analysis of upper TC static ring

The second method, set the seal ring on the shell of transmission shaft, Compared with the load of the upper TC static ring, the load of the shell is mainly a series of radial forces and the axial forces comes from the upper and the lower TC static ring, the force is relatively simple and the wall thickness is relatively large, the addition of the sealing ring on the shell has little effect on the structural strength. However, the difficulty of installing and machining increased.

C. The clearance fit which have a relative rotation

For the clearance fit which have a relative rotation, because this coordination not only have a relatively large gap and leakage, but also there is a relative rotation, it is difficult to achieve reliable sealing. In such a situation, if simply add the rubber ring will inevitably increase the amount of wear and affect the sealing effect, in order to achieve a more reliable seal, so as to realize the transformation of the bearing group by the drilling fluid lubrication to the oil storage, there will combine the traditional sealing and the new metal bellows mechanical seal to improve the seal effect. In order to fully grasp the metal bellows mechanical seal performance and improve the structure of metal bellows, the following will focus on exploring and analyzing the method of metal bellows mechanical seal.

The metal bellows mechanical seal has the advantages of simple structure, compact size and easy to install, it was used in high temperature of aviation and aerospace initially, and gradually be promoted in the field of instrumentation, metallurgy, petroleum, chemical and other fields^[6]. Compared with ordinary mechanical seal, metal bellows mechanical seal use the metal corrugated pipe instead of spring structure, making it have a better performance in pressure resistance, corrosion resistance and flexibility. It can work in high temperature and low temperature more reliable. Metal bellows mechanical seal has a relatively stable sealing performance and longer working life. If the metal bellows mechanical seal can be used to the oil seal structure of the thrust bearing group, it will enhance the reliability of sealing structure^[7, 8].

For the relative rotation clearance fit, if just setting a seal ring in the clearance, the sealing effect will become bad with the wearing of rubber ring, and eventually lose the sealing effect. Metal bellows mechanical seal has the effect of compensation, pretension and buffering. If the sealing method were applied to the sealing of the relative rotation clearance, while the seal ring is worn, the corrugated pipe can provide radial compensation in time, maintaining a certain pressure and providing a reliable and lasting sealing effect^[9, 10]. Good elasticity is conducive to the realization of metal bellows seal, therefore, in the premise of not affecting the stability of bellows, a large wave number, wavelet distance, small wall thickness, asymmetric structure can be chose. Supposing the wave number is 7, wave distance 5mm, wall thickness 0.4mm, inner diameter 95mm, outer diameter 120mm and use the asymmetric structure. As shown in figure 4, finite the element analysis of mental bellows.

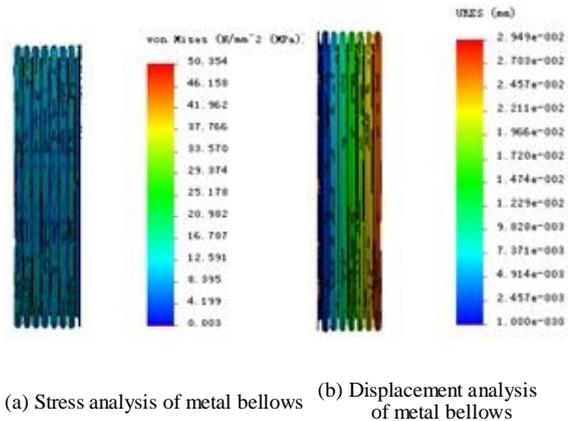


Figure 4. The analysis of stress and displacement for metal bellows

From the analysis of above picture, because the transitions of metal bellows are connected by big filet, using this structure, there is no obvious stress concentration in the pre tightening force, meet the working requirements, the metal bellows can continue provide the pre tightening and this sealing structure is more reliable.

IV. TO ACHIEVE THE COMPENSATION OF OIL

The mechanical seal of metal bellows works under the relative rotating structure, not only require it has a reliable sealing performance, but also a excellent working life, this requires a certain oil film between the sealing surface, so as to make it in good lubrication condition. The absolute seal does not exist, the presence of oil film gap will inevitably lead to the occurrence of small leakage, therefore, need to set oil holes on the transmission shaft to facilitate the timely replenishment of oil, realize the compensation of oil lubrication actually.

To prevent the outflow of oil, need to install the sealing screw in the oil hole. In the process of the work, the sealing screws may need to be disassembled to supplement the lubricating oil, the sealing screw is set to an internal star countersunk head screw to prevent excessive wear of sealing screws in the drilling operation. Setting the countersunk head screws need a certain wall thickness, Set the oil holes at the wear-resistant belt and the upper part of shell have a certain wall thickness. The shell that add oil holes as shown in figure 5.

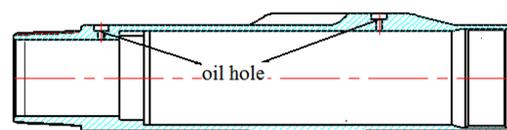


Figure 5. The shell add oil holes

V. THE FINAL STRUCTURE

By analyzing the structure of the traditional screw drill transmission shaft assembly. At the basis of the original structure, in the light of the three kinds of connection modes which may cause leakage, improve the sealing performance of the transmission shaft assembly, so as to realize the oil lubrication of thrust bearing group. As shown in figure 6, the oil lubrication transmission shaft

assembly. Compared with the traditional transmission shaft assembly, the improved transmission shaft assembly has the following advantages.

(1) Using oil lubrication to replace drilling fluid lubrication, which effectively avoid the abrasive wear of the solid particles in the drilling fluid and oil lubrication effect is better than drilling fluid lubrication. It is conducive to the improvement of the working life of the thrust bearing group.

(2) The seal effect is easy to realize, the structure is improved on the basis of the traditional transmission shaft assembly. The structure is simple and feasible.

(3) The sealing effect is reliable, for the department existence of relative rotation is difficult to achieve reliable sealing. Combine the traditional mechanical seal and the new type of bellows mechanical seal, the traditional rubber ring can realize reliable sealing in the early period of oiling. Metal bellows mechanical seal has the effect of compensation, pretension and buffering. Can seal reliable by compensate the axial rubber ring's wear.

The structure realized the transformation of the bearing group by the drilling fluid lubrication to the oil storage, and effectively avoid the negative effects of drilling fluid lubrication will greatly improve the working life of thrust bearing group.

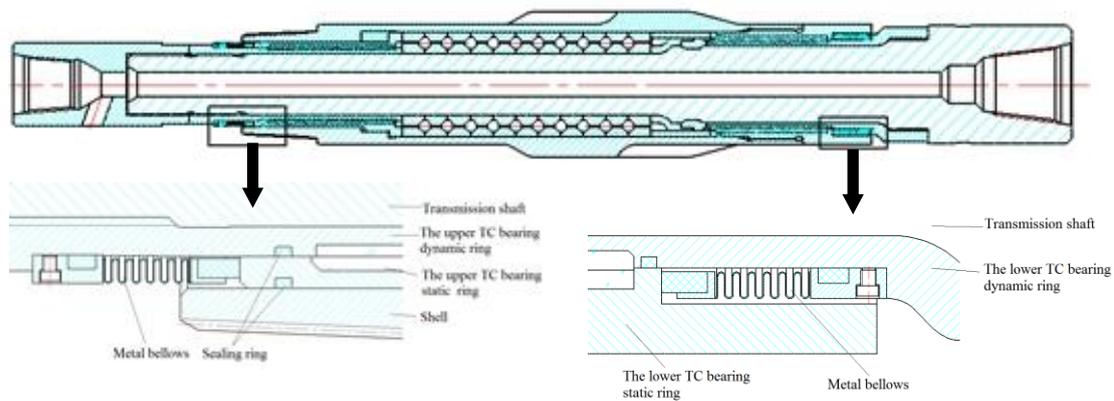


Figure 6. The structure sketch of oil lubrication transmission shaft assembly

VI. CONCLUSIONS

To realize the change of thrust bearing group's lubrication mode from drilling fluid to oil. The main problems need to be solved are as follows.

(1) For screw connection structure, sealing ring can be added in the leakage gap or changing the type of thread, making it have the property of sealing and connection, at the same time smearing 680 glue in the thread connection part to improve the sealing effect.

(2) For the relative static clearance fit, sealing ring can be added in the leakage gap at the proper place to realize sealing structure.

(3) For the clearance fit which have a relative rotation, if just add sealing ring in the gap, the sealing effect would reducing as the the smearing of the sealing ring. Using both the traditional sealing method and metal bellows mechanical seal to improve the sealing effect.

(4) Besides, the other details can be improved according to need. For example, setting oil hole in the shell of transmission shaft and channels in the proper position of TC bearings for facilitating the process of oiling.

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