Strengthen the process of the drilling pump valve

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Abstract

The drilling pump valve as the main structure of the pump valve system of the drilling pump valve, it's service life affects the working efficiency of the drilling pump. In order to improve the service life of the pump valve, enhance their working performance, first of all, with the aid of scanning electron microscopy analysis of the failure, from microscopic found on its failure mechanism, and then based on this, advances the corresponding reinforcement scheme.

Keywords

The drilling pump valve, Microstructure, Failure analysis, Strengthening process.

1. Introduction

Drilling mud is called the heart of the drilling pump in the drilling industry, pump valve is an important part of this heart, the failure of pump valve problems got the attention of scholars in the early 19th century. At present, the research is gradually push forward the oil industry. Since the 19th century, in order to improve work efficiency of drilling pump and increase economic benefits of oilfield, in view of the wearing parts of drilling pump failure research has gained great development. If drilling pump wants to realize the transmission of drilling fluid, drilling pump valve can work properly is the key. When the suction valve and discharge valve on work, cyclical impact, the flushing action of drilling fluid, all kinds of solid particles will cause its damage， causing the failure of pump valve appear different characteristic. So the analysis of the pump valve failure mechanism, finding out the strengthening technology of pump valve have high theoretical research value and practical significance.

2. Micro failure characteristics of the valve working conical surface

By means of multiple sampling from the failure of pump valve conical surface, observation and analysis under the scanning electron microscopy (SEM), found these failure characteristics from some pump valves.

（1）The conical surface of valve present furrows formed under the effect from the appropriate particle, and with a lot of spalling pit. see Fig 1.

（2）There are some corrugated erosion pits and material accumulation of overlapping on the conical surface of valve, at the same time , there are some characteristics such as groove ,pit , ridges, and visible shallow scratches. see Fig 2.

（3）There are obvious brittleness cracks appeared on the conical working surface of valve, see Fig 3.

3. Pump valve failure mechanism

3.1 The analysis of the characteristics of microscopic failure shown in figure 1

The number of cycle impact between valve body and seat is more, so general selection the material with strong plasticity, such as 20CrMnMo, 20CrMnTi,etc. This type of alloy steel containing inclusions in general, such as Al2O3,mCaO·nAl2O3,2FeO·SiO2, etc. Due to the presence of these inclusions produce fatigue spalling is inevitable, and the more inclusions, the more chance of producing a flake[1].As shown in figure 4,a tiny fraction of massive spalling of the pit spalled by this

reason. Moreover, the drilling pump working under a high pressure will lead to high impact load produced by the valve plate, the seat will produce severe plastic deformation, the high temperature produced by surface layer can make the organization changes under the surface, surface partial hardening. If the surface layer and shallow layer contain nonmetallic inclusion, surface crack and shear stress become acute angle to extend under the surface, and the shallow layer crack extend to the oblique surface. When the surface crack and shallow surface crack are interconnected, the metal block surrounded by cracks comes into being stripping, the stripped debris was taken away by drilling fluid, formed spalling pit. Due to containing inclusions in materials, the fatigue spalling is not the main form of fatigue damage in the process of pump valve work.

Pump valve under high working pressure, the body affected by repeated cyclic force, overmuch number of impact between valve plate and seat, force of material beyond its elastic limit, the micro cracks can occur easily in pump valve internal , in material surface or internal crack initiation, crack extension, finally formed the wear particles or integral fracturing, the pump valve failure because of the overall fatigue damage. This is the main cause of peeling pit shown in figure 1 .

Analysis shows that, reducing the inclusion in the material, reducing the source of crack germination, can reduce the fatigue wear. Reducing the lattice defects, refining the grain size, can reduce the rate of crack propagation.

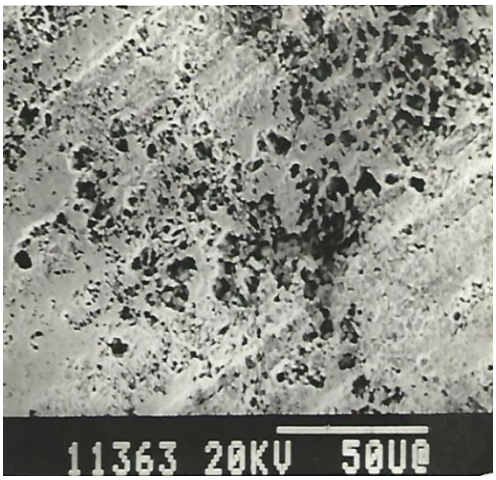

Fig 1 micro failure characteristics

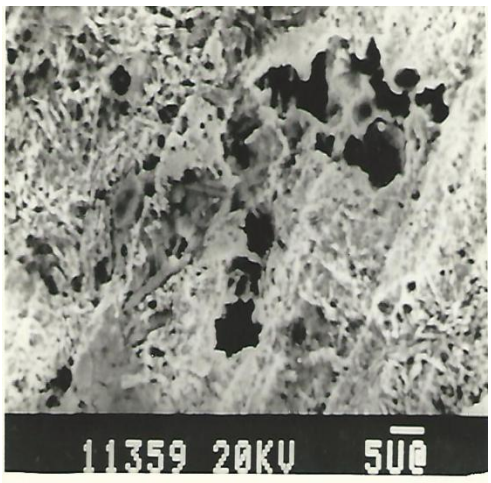

Fig 2 micro failure characteristics

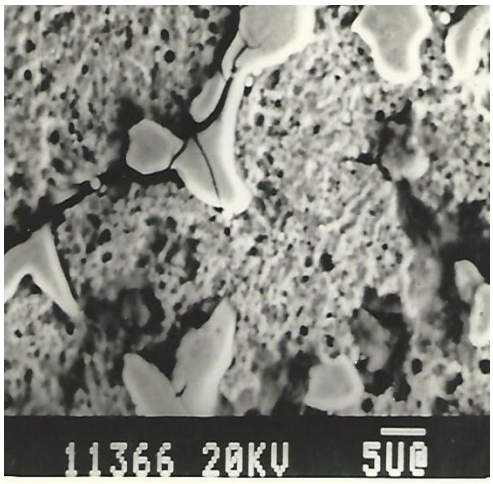

Fig 3 micro failure characteristics

3.2 The analysis of the micro failure characteristics shown in figure 2 and 3

Cycle rotation movement of crank will drive the reciprocating motion around of the connecting rod, so as to realize pump valve suction valve and discharge valve opened and closed, and then achieve the function of transporting the drilling fluid. Under the pressure difference produced by the action of the crank, connecting rod and piston , the valve open and form a clearance, drilling fluid through the valve gap into the valve body and valve seat quickly, scour valve working surface, that will contain some particles in drilling fluid. When the abrasive surface contacts with the body or the seat , they only interact at the top of the micro convex body, the actual contact area is very small, so the pressure of the micro convex body on the contact area is very high, that is sufficient to cause plastic deformation, then produce furrows on conical surface of valve.

The drilling fluid through the valve clearance contains particles which rushing at the conical surface of valve with a speed, and there must be energy exchange in the process of the collision between particles and material. If the spherical particles are vertical incidence at the conical surface of valve, firstly, that will produce a creasing in the conical surface of valve, the incident energy is enough to make its produce plastic deformation. In this way, the material which is squeezed to the cupped pit indentation will form convex edges, material accumulation. If the spherical particles or rectangular particle moves to the conical surface of valve, that will make its appear plough wrinkle or cutting. Abrasive particles glide across the work surface of the valve, only plough out some ditch, and put the material forward or on both sides, if the material produces large plastic deformation but it doesn't break away from the matrix in cutting, that will become plough wrinkled. The accumulation of material around furrow , under the function of repeated shocks and repeated plastic deformation, the convex of metal comes into being work hardening or plastic fatigue, in the end ,removed by the abrasive particles and formation of wear debris.

For high brittleness hard brittle material, the indentations are often apparent with the surface cracks, these cracks are probably because of the surface hardness of the layer is too thin or the matrix hardness is too low[2].These cracks extend from the corners of indentation to the internal material, produced two main types of cracks, one is the middle of the crack which is perpendicular to the surface and another is the transverse crack which extend from the bottom of the indentation to the surface. Once a crack cross each other or extensions to the surface, material particle loss.

Analysis shows that the strength and hardness on the working surface of the valve is very important, we should prevent material particles from being squeezed into the material, making the material produces accumulation, causing the follow-up series of damage. Moreover, if only elastic deformation occurs , plastic deformation does not occur, the material will not have abrasive wear caused by the plastic fatigue. On the analysis of brittle crack failure, hardness change should be

reasonably controlled from the valve conical surface to the core , in case the hardness difference is too big.

4. Strengthening measures

Through the above analysis, according to all kinds of mechanism of the pump valve damage, the wear failure of the pump valve working conical surface is one of the important factors which affects the service life of the pump valve. From the microcosmic organization, using of improved technology makes the pump valve material grain refinement, reducing lattice defects, that is conducive to the service life of the pump valve. When the material crystal refinement, the corresponding crystal boundary is increased, effectively prevented extension of the fatigue cracks[3].Quenching and tempering are the most commonly used reinforcement steel process. After quenching and tempering, a large amount of residual austenite and carbide of lamellar martensite and a small amount of precipitation are on the surface organization. As shown in figure 4.

Fig 4 microstructure

In recent years ,the metallographic observation shows that microcrack will form when martensite grow collide with each other, and then ,it develops into macroscopic crack under the action of other stress and makes the fatigue life of the parts decreased obviously. First, the formative martensite observed under microstructure will run through the austenitic grain and apportion the crystal. After that the formation size of the martensite is limited the long size martensite has more chances of collision and impact with other martensite , and thus the sensitivity of the microcrack along with the increasing of the length of martensite piece , very fine martensite rarely appears cracks[4].The primary martensite is run through by the austenitic, so to some extent, the size of the austenite decide the formation size of martensite, correctly using the processing measure of controlling the size of austenitic grain has an effection on refining grain size, that is to say the proper heating temperature and holding time. As early as the beginning of the 20th century, the Soviet Union first put forward the technology of subzero treatment, now it has been widely used in the steel reinforcement in our country. Cryogenic treatment can make the residual austenite reduced to a minimum, prompt transformation from the residual austenite to martensite, The fine carbides precipitate separated out from the martensitic matrix can eliminate internal stress[5],it plays a part in dispersion strengthening of the matrix, refines the organization , separates out fine carbides[6], and improves the wearability of materials. So materials for cryogenic treatment after quenching and then tempering treatment, refined material particles, eliminated the part of the internal stress, thus, improved the wear resistance.

Pump valve in the process of abrasion on practical work, the plastic deformation and fracture repeate over the valve working conical surface, once abrasive dust formation and then begin the next cycle,

the material surface shift to a new state at each cycle. At the same time, the work surface is prone to corrosion, when drilling fluid in the pump valve interacts with the valve work surface, chemical or electrochemical reaction occurs between them, at the same time, corrosion formed in the surface. the corrosion products is often not firm adhesion, easy to peel, and the new surface continued to react with medium. Thus it can be seen, strengthening of pump valve working surface, increase the surface strength, wear resistance, corrosion resistance can achieve the purpose of improving its service life.

5. Conclusion

Work through the pump valve failure analysis, in view of its bad working environment, according to the main failure forms, suggest to hardening first, and then tempering after cryogenic processing, hardening at the valve working conical surface finally.

References

[1]Jiang Xishan. The metallograph of special steel[M].Beijing: China machine press,2003:128-192.
[2]Zhou Xirong, Luo Anxian, Wang Ziyu. Failure analysis of fracturing pump valve[J]. China Petroleum Machinery,1991,18(9):21-24,56-6.
[3]Zhou Qiusha, Zhou Xirong, Wang Ziyu. Discussion on microscopic failure mechanism of fracturing pump valve[J]. Oil Field Equipment,1991,20(5):33-35
[4]Liu Yunxu. Principle of metal heat treatment[M].Beijing: China machine press,1981:111-114.
[5] Paulin P. Cold cuts[J]. Cutting Tool Engineering, 1992, 44(5): 61-62.
[6]Liu Chengjie, Hua Yinchu, Wang Ziyu. The effect of cryogenic treatment on wear resistance of carburized steel 20Ni3Mo[J]. Materials for Mechanical Engineering, 1998, 22(4): 37-38.