Failure Analysis of the Drilling Pump Valve Surface

Chen Yi

School of Mechanical and Electrical Engineering of Southwest Petroleum University, Chengdu Sichuan 610500, China

498919599@qq.com

Abstract

The drilling pump valve as the main structure of the pump valve system of the drilling pump valve, its 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, from one of the southwest petroleum to obtain the actual failure of pump valve, beginning to intuitive failure analysis, carrying on the macroscopic and low power of the optical microscope to observe the drilling pump valve. And then based on this, advances the corresponding reinforcement of the working face of the drilling pump valve.

Keywords

The drilling pump valve, Macroscopic observation, Failure analysis, Strengthening.

1. Introduction

The working environment of the drilling pump valve is bad. The collision frequency and cycles between the valve body and valve seat are very high. So the material should be improved the performance, increased shock resistance, decreased the wear of the metal and reduced the erosion problem of valve rubber because of the high pressure liquid. Therefore, the material of the drilling pump valve often choose 20CrMnTi, 20CrNiMo, 20Cr, 40Cr, 35CrMo, 20CrMo,etc. This valve is from a rig for southwest oil and gas fields, the pump valve selects 20CrMnTi material as the material of the valve body and seat. 20CrMnTi steel is a kind of typical low carbon and low alloy carburizing steel, it has the good hardenability, the good wear resistance and bending strength and high repeated impact resistance. According to the material mechanics performance listed of the pump valve in table 1, its elongation is greater than or equal to 10%. According to the plastic material and the standard of brittle material, 20CrMnTi has strong plasticity, belongs to the typical plastic material.

2. The introduction of pump valve material

Pump valve is the main part in drilling system, when working under the sand, corrosive slurry erosion, valve body and valve seat strike 120spm every minute. Pump valve sealing performance is easy to damage of its poor corrosion and wear resistance. Generally, the machining process of 20CrMnTi pump valve are the bar after forging, annealing or normalizing ,mechanical processing , carburizing, quenching, tempering, grinding processing. Its mechanical properties such as its strength and toughness are determined by the tempering temperature. 20CrMnTi material belongs to the hardenability of carburized steel, with its carburizing temperature about 920 ℃,after the carburizing precooling to 840 ~ 860 ℃ oil quenching directly, by 200 ℃ low temperature tempering after quenching [1].

According to GB/T 20066—2006Determination of iron and steel chemical composition with the sampling and sample preparation method of sample, sampling to test pump valve, its chemical composition and content was determined by chemical analysis method, shown in table 1.

Table 1. Composition analysis of experimental steels (mass fraction, %)

C	Si	Mn	P	S	Cr	Ti
0.22	0.28	0.88	0.016	0.006	1.08	0.07

3. The basic condition of pump valve work

Basic functions of drilling fluid in the process of drilling are protecting borehole wall, hanging row drilling slag, lubricating and cooling the drill bit and drilling tools [2]. Suspension drilling slag is the drill bit to broken down as the drilling fluid flow out of the bottom hole, the bit can contact to the bottom of new exposed rock. The drilling fluid pressure effect on casing can sustain in or close to the original formation pressure, avoid or reduce the stress of the sidewall imbalances, play a borehole wall to protect role. By drilling fluid flowing the bottom friction heat can take away the heat in a timely manner, and reduce the friction between the tool and borehole wall, reduce the abrasion and damage of drill pipe rotation, so as to achieve the role of lubrication and cooling bit drilling tools. As a result, drilling fluid circulation is essential to the drilling work.

Drilling mud is to realize the circulation of mud pump, the power end is to drive shaft rotation into the reciprocating movement of the piston, the reciprocating movement of the piston into the pump valve open and close, make the drilling fluid from the suction pipe into the pump cylinder, again by flowing through the discharge valve into the discharge pipe. Piston reciprocating pump is conveying fluid with high pressure, piston under the uniform rotation of the crank to drive the reciprocating movement of the sine law [3]. While crankshaft takes a turn and piston reciprocates at a time, it is corresponding to implement the suction and discharge drilling fluid at a time.

4. The failure analysis of pump valve

4.1 The macro analysis of the surface of valve failure

Drilling pump has the very high speed, and the pump valve body and valve seat hit more every minute, finally the probability of fatigue fracture between the valve body and valve seat is very large. While drilling fluid containing mud and debris from the valve gap flow through the valve body and seat for the flush, grinding and drilling fluid carrying grain to circulating pump valve impact erosion, make contact surface pitting or honeycomb pit, which all parts of the pump valve will be damaged.

From on macroscopic observation of the pump valve failure, in terms of the body sealing ring, the body sealing ring on the bottom edge and the cohesion of the body prone to fall off chunks of material or hard to fall off, sealing ring and seat contact cone parts due to the effect of erosion corrosion of the mud which is easy to produce linen small pits, see Fig 1and Fig 2. The damage of the valve sealing ring is material loss mainly, the loss caused by pump valve sealing. Drilling pump valve body and seat at work can generate the wear and deformations after a period of time, the valve body and valve seat reinforced contact site can see obvious deformation, the body parts contact with subsidence characters. Between the valve and valve seat frequently on the both cone has obvious block off. Seat cone comes into being two cone obviously, seat conical surface contacts with the body of the rubber sealing ring, cone under direct contacts with body rigidity, so cone socket appears the characteristics of sinking under the seat. The valve body and seat directly affects the work of the drilling pump valve sealing and the fast of the opening and closing valve after wear and deformation, eventually leads to the leakage of drilling fluid and the unpunctual circulation of the drilling fluid.

4.2 In low power microscope valve face failure

From low power microscope (models for EZ460D, choose eyepiece 10x, objective 3.5x) under observation, see Fig 3and Fig 4, finding on the surface of the valve has obvious erosion pit with the characteristics of water ripple erosion and erosion groove. The material of the valve surface produces plastic deformation and sharply develops a chisel pit, plastic extrusion or bump material accumulation and erosion wear morphology. There are abrasive wear properties of the plough cut type groove and a lot of minor scratches. And it can be clearly observed the typical fatigue wear properties of hemp dot and honeycomb flake peeling pit. Fatigue damage is local with deep a round hole. Because the force of solid particles in the drilling fluid shocking the surface of valve is not the same, the working face of the pump valve is formed all kinds of pit shades. Especially it found that the drilling pump

valve seat's cone and the vertical plane intersection damage very serious. Vertical plane appears many grooves where has some peeling pits on a cone. Therefore, in the low power microscope we obtain the most serious destruction place of the drilling pump valve.

Fig. 1 The drilling pump valve body sealing block off

Fig. 2 The drilling pump valve body sealing hole fall off

Fig. 3 The seat cone and the shape of vertical plane junction (×35)

Fig. 4 Water wave shape topography (×35)

4.3 From the failure pattern analysis of pump valve surface

Abrasive wear refers to the phenomenon or process of in the process of the hard grind grain or projections and work surface touch each other and finally surface material was lost [4]. Between the abrasive grain and the surface of the valve form a certain angle and relative valve surface sliding movement of the valve surface force can be decomposed into perpendicular to the normal force on the surface of the valve and parallel to the valve the tangential force, resulting in particle relative to the surface of valve to produce normal and tangential displacement, make the working valve surface produces the wear characteristics of mild scratch, chip or plough and groove [5].

Erosion wear refers to the fluid or loose solid particles at a certain speed and angle impact material surface so as to cause the wear and tear. According to different grain and the medium carried, the erosion wear can be classified as gas-solid erosion wear, fluid erosion wear, droplet erosion and corrosion, etc. The erosion wear of the drilling pump valve is caused by material surface particles at different particle velocity in the flow, impact Angle and the different grinding particle size particles with different kinetic energy after repeated impact [6]. When flow carries particles with different impact speed and angle to strike the solid surface, a redistribution of energy between the particles transforms the kinetic energy into other forms of energy, eventually resulting in the loss of the material in some parts.

Fatigue wear process can be viewed as the wear and tear which the solid particles and the surface of the pump valve relative roll or slid in drilling fluid, so as to the cyclic stress in the contact zone higher than the fatigue strength of materials and making the material with the residual stress, surface temperature, the structure of the organization, defect characteristics and plastic deformation in the different degree of change, the material of surface layer caused a crack and gradually expand, finally making the crack peeling off the above materials, resulting in the loss of materials.

5. Conclusion

Work through the pump valve failure analysis, in view of its bad working environment, according to the main failure forms, suggest to strengthen which becomes particularly important. It is recommend ed that where the valve face weak laser cladding cemented carbide powder, improve its strength, hardness and prolong its service life.

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