Wear resistance increase of sealings of mud end of pump

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Abstract. In this paper, the qualification and the principle of operation of mud pumps are considered. The analysis of the malfunction of the hydraulic part of the pump is also considered. The importance of the work is due to the fact that it was proposed to introduce a support and sealing part of the cuff made of a material of different hardness. The working conditions of the drilling pump from the adopted drilling technology are also considered. An experiment was conducted with the help of which the dependence of the degree of wear of the seal on time was revealed, depending on the material. The importance of the work is due to the fact that the introduction of the support and sealing part of the cuff from a material of different hardness was proposed.

1. Introduction
In the oil, gas and petrochemical industries, all processes associated with pumping various liquids are carried out by pumps.

Pumps are hydraulic machines designed to convert the mechanical energy of the engine into the energy of the pumped (suction, discharge) liquid.

2. Qualification and function of mud pumps
The mud pump is designed for pumping flushing fluid during operational and deep exploration drilling of oil and gas wells in conditions of moderate climate, moderate cold climate, moderately cold marine climate, tropical marine climate, dry tropical climate, humid tropical climate. The main purpose of the mud pump is to ensure the circulation of drilling mud and prevent its settling during drilling, as well as the rise of the drilled rock to the surface. The mud pump cleans the bottom hole and the well from the rock [1].

In the piston pump pumping the liquid, the working chambers are alternately filled with liquid and its displacement occurs as a result of an increase or decrease in their volume, respectively.

Piston mud pumps consist of mechanical and hydraulic parts.

The hydraulic part is used to convert the mechanical energy of the piston or plunger into the mechanical energy of the liquid. The mechanical part is designed to convert the movement of the input link of the drive into the reciprocating movement of the piston or plunger.

The volume of the working chamber is determined by the position of the piston: the minimum corresponds to the left limit position of the piston and is called the volume of the dead space, the maximum corresponds to the limit right position of the piston. The difference between the maximum volume and the volume of dead space is called the useful volume of the working chamber [2].
When the piston moves to the right (suction stroke), the volume of the working chamber increases, and the pressure in it decreases. The pumped liquid under the influence of atmospheric pressure opens the suction valve and fills the working chamber. At this time, the discharge valve is closed.

During the reverse stroke of the piston, a pressure is created in the working chamber that exceeds the pressure in the discharge pipe, the discharge valve opens and the liquid corresponding to the useful volume of the working chamber is displaced.

Depending on the operating conditions, the properties of the pumped liquid and the purpose, piston pumps differ in the device and design of the parts.

3. Fault analysis of the hydraulic part of the mud pump
The piston of the cylinder sleeve moves in the medium of the washing liquid at a pressure of 10-30 MPa. Its speed varies from 0 to 2 m/s. The service life does not exceed 100 hours [3,5].

The piston is a steel core with vulcanized rubber cuffs. Due to the fact that the diameter of the piston lips is increased compared to the diameter of the sleeve hole, an initial compression is created — the basis for the correct action of the self-sealing cuff. When pumping, the cuff that displaces the cylinder fluid is pressed against the surface of the cylinder sleeve by liquid pressure and friction forces, which prevents the penetration of the pumped liquid into the gap between the piston and the cylinder sleeve.

The second cuff is mated with the sleeve by the action of elastic forces of rubber. The piston is lubricated by the pumped liquid. The piston is mounted on a rod attached to the slider, which transmits power from the drive part to the hydraulic part [4-6].

To improve the technical level of single-acting three-piston mud pumps and the level of their competitiveness, it is necessary to modernize the wear-out parts.

The drilling mud pumped by pumps is characterized by a significant density (up to 2.4 g/cm³) and viscosity (up to 50 cSt). At a large drilling depth, its temperature can reach 60...80° C. In addition, the drilling mud contains solid abrasive parts of the drilled rock and a weighting agent of various shapes and sizes (from microns to millimeters), and in some cases also oil, acids, alkalis, various chemical reagents, dissolved gas. Previously performed studies have found that with an increase in the density and viscosity of the pumped liquid, the suction capacity worsens and the volume flow of the pumps decreases, and with an increased gas content, the uneven flow increases. The presence of abrasive particles in the working fluid negatively affects the durability of pump assemblies and parts, which are also characterized by cyclic loads from the pressure of the pumped medium. The operation of mud pumps is characterized by changing conditions in a wide range.

For mud pumps, the determining factor is the fact that their operating conditions depend on the adopted drilling technology and, as a rule, cannot be changed in order to increase the durability of components and parts.

The experience of drilling rig operation shows that mud pumps account for a significant share of failures and time spent on repair work, amounting to up to 50% of their service life. At the same time, the largest number of failures falls on the parts of the hydraulic part.

4. The use of cuffs made of a material of different hardness
According to the results of the research, improvements were made to the components and parts of the hydraulic part of the pumps [7-9].

The improvement made is as follows: in order to increase the durability of the piston, it is proposed to perform the support and sealing parts of the cuff from a material of different hardness, and the support part of the cuff is made of a material of greater hardness, neglecting such quality as elasticity. The support cuff will be protective and take on the main deformation from abrasive particles settling on the walls of the sleeve. This will reduce the load on the sealing cuff, which in turn will be less rigid, but more elastic. It is recommended to provide the shoulder with rectangular grooves for the purpose of additional coupling it with a combined seal [10-11].

The criteria for choosing the material of blanks for the piston collar are the physical properties of the material. The most suitable for the operating conditions of the product, structural alloy steel 40KHN.
In most analogues of mud pump pistons, rubber is used as sealing cuffs. Rubber is a relatively cheap and widely available material, in mass production, sufficiently technological and satisfying the warranty period assigned by the manufacturer, but rubber products have a number of disadvantages: the addition of natural components that give elasticity reduces the service life of rubber; Adverse weather factors and operating conditions intensively destroy rubber: high and low temperatures, ozone and ultraviolet radiation, fuel and oils.

In the modern production of replaceable pistons, polyuritan is also actively used. The choice of polyurethanes is not accidental and is based on significant operational and technological advantages that distinguish polyurethanes from other elastomers, for example [12-14]:

- they are one of the most resistant to abrasive wear, they are resistant to most organic solvents, to ozone and ultraviolet rays, sea water, resistant to high temperatures up to +120 °C, frost resistance up to -70 °C;
- the strength characteristics of polyurethanes are higher than those of most elastomers; polyurethanes are practically not subject to aging and do not change their characteristics during the entire service life;
- the strength of the polyurethane-metal bond is significantly higher than in similar rubber-metal compounds;
- they are one of the most resistant to abrasive wear, they are resistant to most organic solvents, to ozone and ultraviolet rays, sea water, resistant to high temperatures up to +120 °C, frost resistance up to -70 °C.

After conducting the experiment, the dependence of the degree of wear of the seal on time, depending on the material, was revealed, shown in figure 1.

![Figure 1](image_url)

**Figure 1.** A graph of the dependence of the machine's performance on the operating time. 1 – rubber seal; 2 - polyurethane seal; 3 - seal made of a material of different hardness.

One of the main factors that reduce durability and lead to the failure of parts and assemblies is the effects of corrosion-active media and abrasive wear.

The use of polyurethanes as a coating material allows you to increase the maximum load on the product up to 4 times, and resistance to abrasive wear up to 10 times compared to rubber. Polyurethanes
are one of the most resistant materials to abrasive wear, since the mass loss of a polyurethane plate during abrasive wear (aluminum oxide, angle 60°) is 0.05 % of the weight in 60 minutes, while for hardened steel it is more than 0.5 % in 13 minutes.

5. Conclusion
Having considered various types of mud pumps and conducted an experiment, problems with the malfunction of the hydraulic part of the mud pump were identified. The development and implementation of the support and sealing part of the cuff, for sealing the piston of the mud pump, from a material of different hardness is very relevant.

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