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Increasing the durability methods of the drilling string lock connection

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Abstract. An integrated approach to the technological preparation of production ensures the accuracy and quality of the surface layer of highly loaded parts, which increases the value of fatigue resistance, as well as forms compressive stresses. Analysis of the data obtained during the research showed that compressive residual stresses in the surface layer were formed by applying finishing operations. Increasing the fatigue resistance of the hardened surface leads to an increase in the durability of mechanical engineering products. At the same time, attention should be paid to the study of the surface accuracy and quality based on the technological process improvement.

1 Introduction

Currently, conical threads are very widely used for connecting pipes for oil and gas purposes in general and for connecting drilling pipes in particular [1-10]. The quality of these joints is determined by the following parameters: screwability, tightness and mechanical strength. The latter parameter largely depends on the contact pressures arising between the thread surfaces of the two parts of the connection - the coupling and the nipple [11].

From the analysis of emergency failures of drilling string elements, it is obvious that the failures are mainly of a fatigue nature, occurring mainly in threaded connections and accounting for 60% of all accidents with the drilling string [9]. Of the total number of observed failures, 23% occurred on the thread, 31% - on the connections of the weighted drilling pipe, 4.5% - on the nipple part of the drilling locks.

Vibrations in threaded connections lead to reciprocating sliding of the thread surfaces, which can subsequently lead to cyclic deformation, deterioration of the surface layer quality and gradual wear of the contact surfaces [12-19]. Worn surfaces can also be prone to surface cracking due to the local stress concentration in irregularities and corrosion pits [20-25].

The accuracy and quality of the threaded surface ensure tightness of the joints, fast screwing, and also increase the uniformity of load distribution between the turns of the thread, which, in turn, increases the reliability of the equipment as a whole. In this regard, modern drilling technologies require advanced finishing technologies [16].

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2 Methods of increasing wear resistance

Methods of increasing the wear resistance of rubbing parts can be divided into three large groups: constructive, technological and operational.
Constructive activities include:
• the choice of a node design in which there is minimal wear of the friction surfaces and high reliability is ensured with the lowest material costs for manufacturing;
• determination of the required frequency of the rubbing pairs surface, clearance tolerances and macrogeometry of parts [1, 2];
• rational supply of lubricant to the friction units and the creation of devices that protect the friction surfaces from getting abrasives on them.
Technological measures include:
• selection of machining modes, electroplating and chemical-thermal processes for hardening the surfaces of rubbing parts [6];
• correct installation and adjustment of friction units;
• rational repair of worn parts.
Operational measures are associated with the choice of rational modes and duration of running-in of the machine and its units during the first hours of operation, with the care of friction units, as well as strict performance of scheduled and preventive maintenance, as well as other works that reduce friction and wear during the service life of the machine and mechanism.
One of the ways to increase the fatigue strength of threaded connections is to improve the thread turns surface roughness [12, 13]. An analysis of studies concerning the effect of surface roughness on the fatigue strength and threaded connections durability allows us to draw the following conclusions (fig.1):
• with a decrease in roughness, the fatigue strength of machine parts increases [14]. This is especially important in the case of fixed threaded connections.;
• with a decrease in roughness, corrosion resistance increases [17]. With a low surface roughness, the gap between the contacting surfaces will be smaller, and there will be fewer cavities in which a corrosive substance can accumulate;
• with a decrease in roughness, the contact deformation decreases [20, 21]. This may be due to an increase in the actual surface contact area and, consequently, a decrease in pressure per unit surface area.

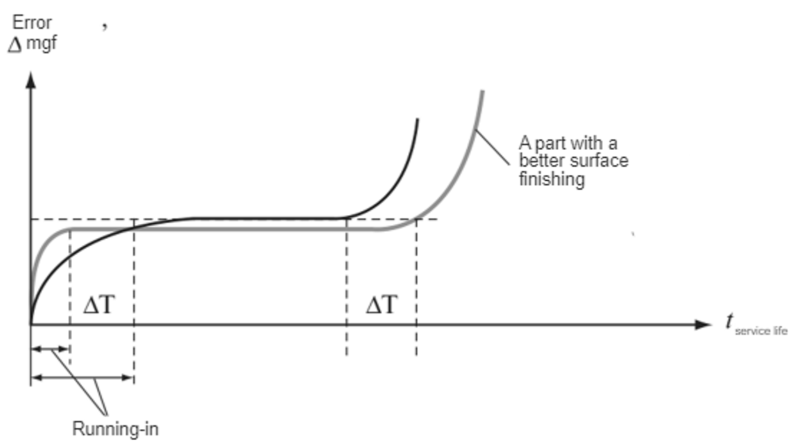

Fig. 1. The effect of the part surface roughness on the machines performance properties

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Traditional processes for obtaining surface cleanliness, such as grinding, honing and lapping, create micro-burrs, surface damage and residual stresses [22, 23]. Thus, it is necessary to resort to the search for new methods of surface finishing.

The technological directions of carving on parts are reduced to operations of mechanical, thermal, thermomechanical, and chemical thermal treatments [3]. Of the mechanical methods for strengthening the thread and the transition section from the head to the rod, roller rolling and shot blasting are used. For carbon and alloy steels, normalization, improvement, nitrocementation or cyanidation are used [4, 5]. To increase corrosion resistance, threaded products are subjected to oxidation, galvanizing, cadmium plating, chrome plating, nickel plating. Despite the wide range of materials and methods of manufacturing threaded parts, the problem of insufficient durability of threaded connections remains relevant.

It is known that two directions are effective to increase the thread durability of machine parts. Firstly, the surface layer hardening with the formation of a solid fine structure, the transition zone presence, the oxidation absence and surface decarbonization. In relation to the thread, the absence of warping and leash turns is important, as well as violations of the threaded surfaces accuracy parameters. Hardening of the surface layer increases the wear resistance and strength of the thread turns and the bolt rod. Secondly, finishing and hardening treatment, which ensures optimal roughness, texture of metal fibers and the presence of compressive residual stresses [7, 8].

Such a way to increase wear resistance is electromechanical processing (EMO), a competitive feature of the technology of which is the ability to flexibly control the parameters of high-speed contact electric heating and simultaneous hot plastic deformation of the surface layer material in order to form unique quick-hardened structures, change the microgeometry of the surface and reduce the grain size. It is the surface layer of the most loaded parts that largely determines the material's resistance to fatigue failure, contact endurance and other important operational properties (fig.2).

Fig. 2. Electromechanical locking thread finishing

Also, an effective solution to the problem is to increase the threaded connections durability by strengthening the surface of the thread cavity bottom. There are various methods of surface hardening, among which the most promising is surface plastic deformation and the most rational is roller rolling [10] (fig.3).

Fig. 3. The thread running-in with rollers

Increasing the durability and reliability of threaded connections is possible by forming rational compressive residual stresses, increasing microhardness and reducing the roughness of the thread cavity under the influence of plastic deformation force.
One of the finishing non-traditional methods of processing threaded surfaces, which can reduce the amount of surface roughness and improve wear resistance, as well as surface properties due to the interaction and relative movement of the tool and the workpiece, is the process of magnetic abrasive polishing [18, 25] (fig.4).

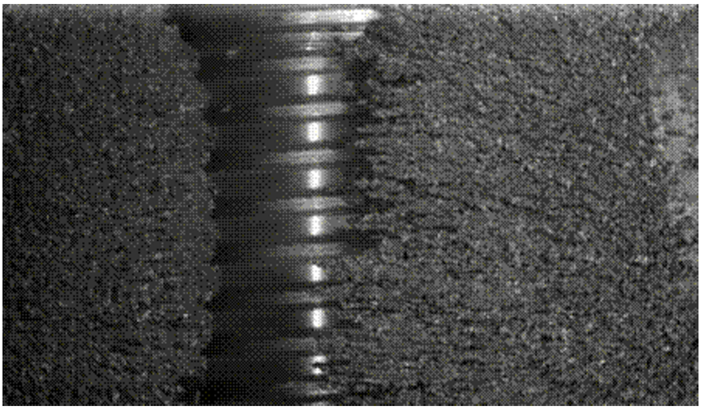

Fig. 4. The locking thread magnetic-abrasive polishing

This method makes it possible to reduce the amount of surface roughness and improve wear resistance, as well as surface properties due to the interaction and relative movement of the tool and the workpiece [15].

3 Conclusion

Based on the analysis of the methods of technological improvement of the locking joint threaded surface quality, it can be concluded that the identification of the quality influence patterns of the surface layer on the surface operational properties is of great scientific and practical interest. The determination of these patterns will also make it possible to develop recommendations on the selection of processing parameters in relation to highly loaded elements of the drill string.

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