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Development of Technical Solutions to Prevent Malfunctions Occurring in the Locking Joints of the Drill String

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ABSTRACT: This article presents the results of studies of faults occurring in threaded locking joints of a drill string, develops a mathematical model that allows determining the optimal parameters of heat and cryogenic treatment to ensure the rigidity of threaded locking joints of drill pipes during their restoration by surfacing, develops an effective method for restoring threaded locking joints of drill pipes by surfacing, and presents the results of experimental studies.

KEYWORDS: drill pipe, threaded locking joints, heat treatment, cryogenic impact, surfacing, drill string, wear of threaded joints, drilling, drilling accidents, restoration.

I.INTRODUCTION

Drill string failures have a direct negative impact on the efficiency of well drilling; eliminating failures in the drill string is the most difficult, expensive and time-consuming.

Rapid wear of threaded connections and the formation of cracks on their surface cause a number of complications during drilling operations.

Maintaining the operability of the threaded lock connections of the drill string and ensuring the quality of the threaded parts during operation is the main condition for ensuring the strength of their connection and preventing such malfunctions as abrasive wear, breakage and disconnection of threaded parts [1].

II. SIGNIFICANCE OF THE SYSTEM

Car tire recycling is environmentally and economically important. Methods of preparing carbon adsorbents from used tires were studied in the research work. The study of methodology is explained in section III, section IV covers the experimental results of the study, and section V discusses the future study and conclusion.

III. METHODOLOGY

During operation, the restoration of drill pipes by surfacing and coating of broken parts of the threaded lock joint serves to increase the efficiency of the drill string operation. However, one of the pressing problems today is the low quality of threaded lock joints restored by melt [2]. When restoring drill pipe lock joints by surfacing, the quality of the restored part depends on the coating material. Since parts of the drill pipe lock joints are made of 40KhMFA steel, it was necessary to determine a suitable coating wire and flux composition for this steel. As a result of a number of experimental studies, it was found that the most effective coating is obtained using 48OF-10 Np-30KhGSA coating wire and ELZ-FKN-1/55(B) ceramic flux in a 1:1 ratio [3].

It has also been established that the formation of a coating on the surface to be restored in several layers of small thickness provides high efficiency.

It has been verified that the efficiency can be increased by preheating the surface to be coated.

IV. EXPERIMENTAL RESULTS

When restoring drill pipes by the fusion coating method, it has been determined that preheating the surface to be restored allows for increased efficiency, the best result being achieved by heating the surface to be restored to 250 °C.

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The graph of the dependence of the hardness of the lock body and the coated surface on the temperature of the preheating of the coating material is shown in Fig. 1.

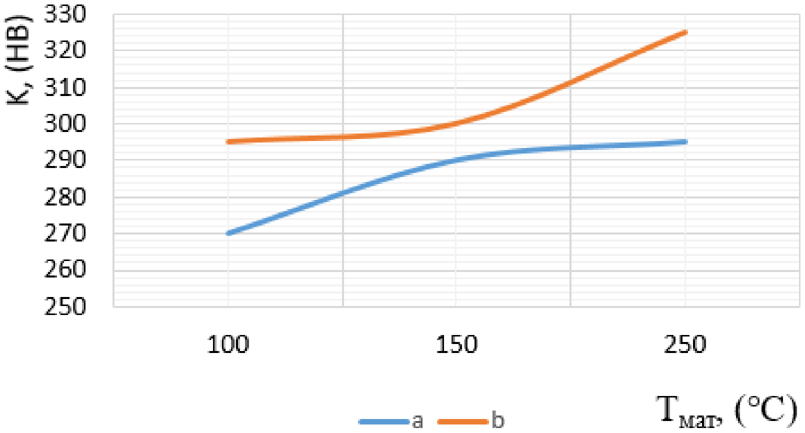

Fig. 1. Dependence of the hardness of the lock body (a) and the coating surface (b) on the preheating temperature of the coated material (T_{mat})

After surfacing and restoration of the threaded lock joint of the drill pipe, it is subjected to heat treatment to ensure its quality indicators of hardness, relative elongation under tension and tensile strength. The quality of the restored part depends on the heat treatment process.

A mathematical model has been developed that allows determining the optimal parameters of thermal and cryogenic treatment to ensure the rigidity of threaded lock joints of drill pipes during their restoration by surfacing.

It is known that each particle (atom or ion) that makes up the spatial lattice of solids oscillates around the state of equilibrium. The energy of bodies consists of internal energy caused by these vibrations.

In this case, the linear expansion of the body occurs due to a change in internal energy, which is mainly:

$$L_k = L_0 + \Delta L = L_0(1 + a\Delta T); \quad (1)$$

$$L_k = f_1(\Delta T), \quad (2)$$

where ***a*** - coefficient of linear expansion of a solid with temperature;
L_k – length after heating, (m); L_0 – original length, m; ΔL – variable length, (m);
ΔT – temperature difference, $\Delta T = T_2 - T_1$; T_1, T_2 – initial and final temperature values, respectively (°C).

The function variable from the above formula (2) is a function of length depending on temperature:

$$\delta_0 = f_2(L_k). \quad (3)$$

The ultimate strength is generally expressed as a function of the length of a solid. Considering that a solid change not only linearly but also volumetrically:

$$V_k = V_0(1 + 3a\Delta T). \quad (4)$$

Having designated $3a = \beta$, get the expression (5):

$$V_k = V_0(1 + \beta\Delta T). \quad (5)$$

A change in volume due to temperature results in a change in this strength:

$$\delta_0 = f_3(V_k) \quad (19)$$

As a result of compression of spatial bodies, Poisson's ratio arises:

$$v = \left(\frac{\varepsilon_D}{\varepsilon_K}\right) = \left(\frac{\Delta d * h_0}{\Delta h * d_0}\right), \quad (6)$$

where d_0 – original pipe diameter, (mm); Δd – change in pipe diameter, (mm); h_0 – initial pipe length (m); Δh - change in pipe length (m).

$$v = f_4(E), \quad (7)$$

where E – modulus of elasticity.

The Poisson's ratio of a solid is inversely proportional to its normal modulus of elasticity. Given this proportionality, we have function (8):

$$\delta = f_5(\Delta T, a, E, v). \quad (8)$$

According to the above expression, the load depends on the correct proportionality.

Let us determine the strength of the connection after welding the threaded lock joint of the drill string using the following formula:

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$$\delta = \frac{2a*k(T_2-T_1)(a_D-a_K)*E_k}{\left(\frac{E_k}{E_D}\right)(1+v_D)(1+(a_D-a_k)(T_2-T_1))+2-4v_k}, \quad (9)$$

where T – temperatures in columns, (℃); a – proportionality coefficient; v – Poisson's ratio; E – modulus of elasticity of the material (MPa).

To bring the change in time to the hardness scale by working out the strength condition, according to formula 1 the length of the change in size

$$\Delta L = \Delta v * \Delta t, \quad (10)$$

where Δt – period; Δv – rate of change; L=$\lim_{v \to 0} t$.

Based on the formulas given above, we derive the stability condition using the following formula:

$$\delta = \frac{2*k(T_2-T_1)(a_D-a_K)*E_k}{\left(\frac{E_k}{E_D}\right)(1+v_D)(1+(a_D-a_k)(T_2-T_1))+2-4v_k} * t, \quad (11)$$

where v_D and v_k – Poisson's ratio before and after heat treatment of a solid, respectively; K=0.36; a_d=0.8; a_k=0.7; T_2-T_1=-196 ℃; E_k=0.2 MPa; E_D=0.21 MPa; v_D=0.3; v_k=0.25.

After restoration of the threaded locking joints of the drill pipe by welding, its mechanical properties are improved based on heat treatment. Increased strength and corrosion resistance of the threaded locking joints of drill pipes can be achieved by cryogenic treatment. The result of cryogenic treatment in many cases depends on the interaction of the sequence of types of heat treatment, i.e. the sequence of interaction of the processes of obtaining hardening, cryogenic soaking, bringing it to room temperature and tempering.

After the threaded lock joint of the drill pipe was restored using the welding method, heat treatment was carried out using 3 different methods, a description of these methods is given below in Fig. 2.

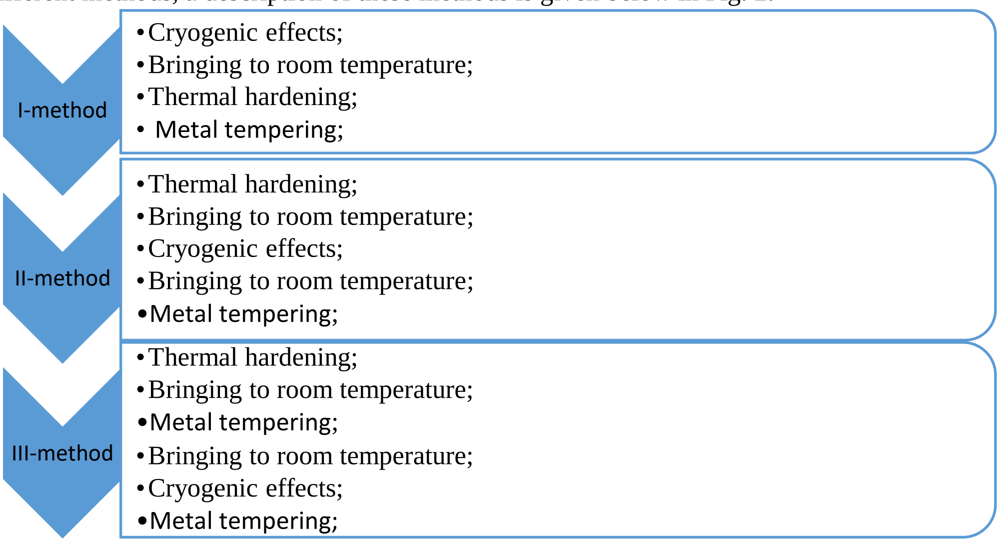

Fig. 2. Methods of heat treatment of threaded lock joints of drill pipes

During the experimental work, the hardness, relative elongation under tension, and tensile strength of the samples obtained by heat treatment methods for the above-mentioned threaded lock joint of drill pipes were investigated; the obtained research results are presented in Fig. 3 and Fig. 4.

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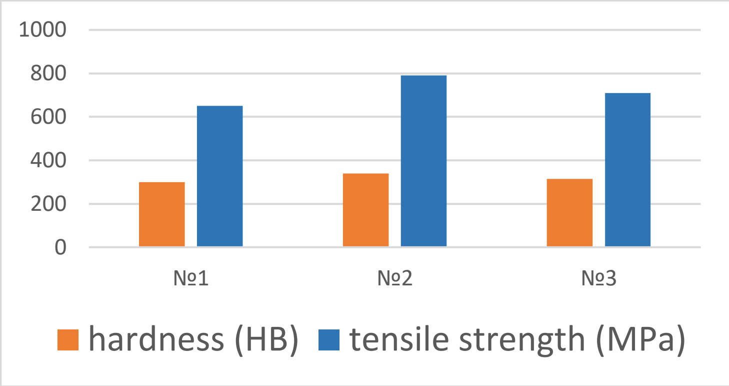

Fig.3. Indicators of hardness and tensile strength of the tested samples

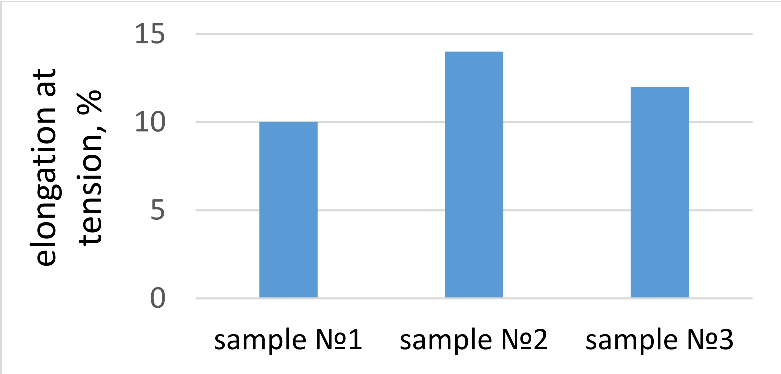

Fig.4. Relative elongation index of samples

The results of the conducted experimental studies show that the use of a complex method of thermal and cryogenic treatment of drill pipes by the method of coating by surfacing of parts of threaded lock joints, according to the scheme presented below in Fig. 5, allows to increase the hardness and tensile resistance of the threaded lock joint.

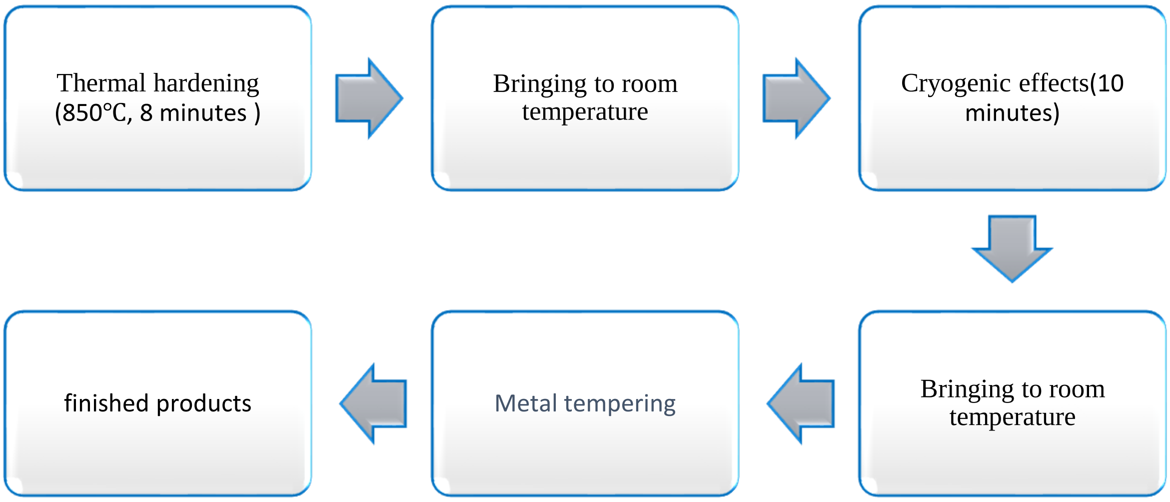

Fig. 5. Sequence of the heat treatment process of the proposed threaded lock connection.

V. CONCLUSION AND FUTURE WORK

The proposed method for restoring the drill pipe lock joint has shown high efficiency in the operation of the drill string. The use of lock joints restored by this method has reduced the number of accidents associated with the failure of threaded lock joints in the drill string in the Central Geological Exploration Party of the Geological Exploration Expedition of the Navoi Mining and Metallurgical Combine to 65%.

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