SUBSTANTIATION OF THE POSSIBILITY OF REPAIRING SUCKER RODS

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The technology of restoring sucker rods has been developed and tested on the example of 20N2M steel. At high levels of bending stress applied to samples from restored sucker rods, fatigue life in the environment of formation water was shown to increase by almost an order of magnitude compared to samples from an unused rod. The developed technology makes it possible to extend the service life of sucker rods and the periods between scheduled measures for diagnosing their state.

Keywords: sucker rods, fatigue tests, steel 20N2M, fatigue life

Introduction. In the process of oil production, a large number of sucker rods of various types and designs are used. Sucker rods are non-rigid cylindrical rods with heads at both ends [1]. In the process of operation sucker rods work in conditions of a complex stress-strain state (stretching, bending and compression). The load on the rods is increased by the corrosive action of aggressive components of technological environment, which leads to the formation of various types of defects. Among the most common are wear of the sucker rod body (as a result of their contact with the tubing in the process of reciprocating movement), dents, pits of a corrosive nature, etc [2 – 5]. Rod columns are periodically dismantled, their condition is analysed and some of the long-used sucker rods are repaired. In this article, the method of restoring the technical characteristics of sucker rods will be considered, in order to continue the operability of these structures.

Processing technology. Repair of worn-out sucker rods includes the following operations:

1. The used sucker rods are subjected to incoming hardness control (behind Brinell) with their subsequent sorting into two parts. The hardness of one of them is lower, and the second is higher than the regulated value, namely HB $\leq$ 240 or HB $\geq$ 240.
2. Sucker rods are sorted by ovality due to mechanical abrasion (one of the sections).
3. Cutting off the upset heads, without fillet residue, on the workpiece to the nominal diameter. The bevel of the cut is no more than 0.5 mm.

4. Mechanical cleaning of spent sucker rods by blast-jet cleaning in 3–5 passes (until the rod surface is completely cleaned).

5. Removal of chamfers 3×30° from both ends of the workpiece on a chamfering machine.

6. Correction of workpieces on a 2-roll, skew-roll correcting machine. The curvature of the rods after that should be no more than 1 mm/m.

7. Turning on a centerless lathe of spent sucker rods with a diameter of about 25 mm to their diameter of 22.06 – 22.03 mm, with a diameter of about 22 mm to their diameter 19.05 – 19.02 mm, in accordance with GOST 13877-96. Defects (cracks, dips, undercuts and other mechanical defects that lead the rod beyond the minimum diameter) are not allowed on the turned surface. If defects are found on the surface of the rods turned to a diameter of 22.06–22.03 mm, then the rods are re-turned to a diameter of 19.02–19.05 mm, and rods with a diameter of 19.02–19.05 mm are re-turned to a diameter of 16.02–16, 05 mm. The surface finish after turning of all rods is $R_a = 0.63$.

8. Sorting of finished products by diameters and surface in accordance with GOST 13877-96.

9. Lubrication of the sucker rods workpiece by atmospheric corrosion inhibitor.

10. Issuance of a quality certificate for the manufactured sucker rods workpiece.

After that, new sucker rod heads were upset on a horizontal forging machine according to known technology. The next stage is heat treatment of metal rods (normalization by heating to a temperature of 920–950°C with cooling in air). As a result, the mechanical characteristics of the rod material are improved, in particular, the residual stresses are reduced and the plastic characteristics of the metal, namely relative elongation and impact toughness are increased. Correspondingly, the brittleness of the metal is reduced.

After heat treatment, the body of the sucker rod is straightened by stretching it in a heated state. The maximum tensile force is 250 kN. Cold processing is carried out after complete cooling. In order to reduce the residual macro-stresses and ensure the straightness of the sucker rod body, a method of cold correction and adjustment of the longitudinal load of the sucker rods has been developed and researched. The technical result is achieved by preliminary elimination of the local curvature of their bodies, elastic and plastic deformation of the rods and control of residual plastic deformation. The final operation of sucker rod restoration is mechanical processing of the rod head.

Results of experimental studies of sucker rod samples. Repair sucker rods according to GOST 13877-96 were made of different grades of steel (Table 1). For the study of fatigue strength, 18 samples of 420 mm length, different grades of steel and different diameters were received. Formation water from the well was used as a working medium. Its mineralization was 106596 mg/l and pH 7.08. It contained anions, mg/l (63968 Cl^{-1}, 207 SO_4^{-2}, 293 HCO_3^{-1} and the rest – CO_3^{-2}) and cations, mg/l (37512 (K^{+} + Na^{+1}), 4008 Ca^{+2}, 608 Mg^{+2}, 50 Fe^{+3}) and oil with 10% hydrochloric acid solution. The samples were tested under different loads and bending stresses with a frequency rotation near 16 Hz on a ZKSH-25 machine [1]. Corrosion fatigue of sucker rods with a diameter of 19, 22 mm at a load frequency of 15.2 Hz was researched. During ultrasonic control, the ZKSH-25 machine was stopped, camera with the test medium was removed, and the test was continued after 20–30 minutes. Control was carried out several times a day. To carry out experimental studies, the stresses acting in the fracture section of the samples were calculated. The obtained data are summarized in Table 1.

Table 1. Fatigue test results.

Number of samples	Grade of steel (Ukraine)	Diameter of rod, mm	Bending stress, MPa	Number of cycles, 10^6	Note
2	38KhHM	22	140	10.165	Not broken
2a			200	8.57	
9		19	200	5.5	Broken
9a			300	4.33	
10	20N2M		200	5.63	
10a			250	4.85	
13	38KhHM		180	10.0	Not broken
13a			300	7.13	
19	35H2		300	1.9	Broken
20			250	3.0	

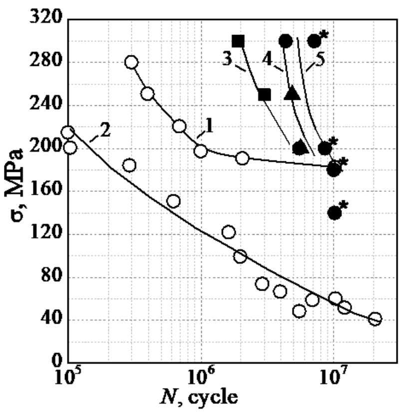

Fig.1. Fatigue curves of steel 20N2M obtained during testing of samples from a new sucker rod with a diameter of 22 mm in air (1) and in formation water (2) and corrosion fatigue curves of steels, 35H2 (3), 20N2M (4) and, 38KhHM (5) obtained by testing samples of repaired sucker rods with a diameter of 19 and 22 mm in formation water. (Specimens not broken are marked an asterisk*).

The results of fatigue tests showed that the proposed method for repairing sucker rods made it possible to significantly (at high bending stresses by more than an order of magnitude) increase the number of cycles before sample failure in formation water. In particular, when comparing curves 1 and 6 in Figs. 1, corresponding to 20N2M steel from new and repaired rods, respectively, the positive effect of rod repair becomes obvious. Taking into account the high level of loading of sucker rods at a large drilling depth and their significant bending with the inevitable deviation of the well from its normal orientation when it encounters high-strength rock sections along the drilling path, the developed repair technology can be recommended for use in the actual drilling process.

Conclusions. A technology has been developed for the restoration of sucker rods used in the process of drilling oil wells. The results of experimental testing of the proposed technology for the restoration of drill rods, carried out on the example of steel 20N2M, showed that after their repair, the fatigue endurance of the samples in the formation water environment significantly exceeds that characteristic of samples from a new rod. The technology tested on 20N2M steel gives grounds to assume that the service life of sucker rods made of other steels will also be extended. The obtained test results can also be useful for justifying the extension of the rod defect control interval, which should be carried out at the well every 2 years.

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