SECTION XI. TECHNICAL SCIENCE

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The dependence of the turnaround time of oil wells, equipped with electric centrifugal pumps, from process parameters

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Abstract

Among the factors that determine the magnitude of the turnaround time, the high content of gas in the annulus of wells equipped with electric centrifugal pumps. The authors investigated the dependence of the turnaround time on the technological parameters.

Keywords: turnaround time, installation of an electric centrifugal pump, gas factor, dynamic level

During the operation of wells equipped with submersible centrifugal pumps (ESP), one of the main indicators characterizing the process of operation is the overhaul period of operation of the submersible equipment. The magnitude of the overhaul period is determined by the magnitude of the taken into account failures (underground repairs). The considered failures are the difference between the total number of underground repairs (failures) and repeated repairs. The turnaround time of wells with ESP, located on the Romashkonsky field, is more than 900 days.

We will analyze the dependence of the turnaround time on the dynamic level of wells equipped with ESP, with a high gas factor. To do this, we use the results of field research, which is the initial statistical information collected from oil fields. In the field of studying mutual relations, the task of statistics in the most general form is to quantitatively analyze their direction and availability. To solve this problem, apply the method of correlation analysis. The statistical software packages for electronic computers present correlation methods. The correlation coefficient is in the range from -1 to $+1$. For processing the experimental data, we apply the least squares method to obtain the function. This method consists in fulfilling the following condition: according to the regression equation, the sum of the squared deviations of the practical values of the dependent variable from the determined ones should have a minimum value. We construct graphical dependencies on the basis of the normal distribution of points, which is characterized by the behavior of data using the arithmetic mean and standard deviation.

The dynamic level of the studied wells equipped with ESP is in the range from 0 to 1300 m, the average value of the dynamic level is 765.82 m. The gas factor of the wells is 58 m³/t. As a result of processing the production data, a graphical relationship between the turnaround time and the dynamic level has been built.

Fig. 1. Dependence of the overhaul period on the dynamic level

In fig. 1 shows the dependence of the turnaround time on the dynamic level of the N_{din} well, on the basis of which an equation with a coefficient of determination is obtained $R^2 = 0,8744$.

From the graph in fig. 1 it follows that with a decrease in the dynamic level, the turnaround time of wells decreases according to the law of a semicubic parabola.

Since the magnitude of the dynamic level significantly affects the depth of the pump suspension, the graphic relationship between the turnaround time and the depth of the pump suspension is determined (Fig. 2). The accident rate of the ESP increases with increasing pumping depth, since with increasing depth of discharge from the reservoir, the removal of mechanical impurities increases, therefore, the number of accidents associated with clogging of working apparatuses also increases. Deep suspension of the submersible pump leads to additional consumption of tubing pipes, cables, the number of pump stages, an increase in the time of tripping and an increase in the likelihood of breaks in the installation elements. Descending the pump to the perforation intervals, the maximum depression is ensured on the reservoir, and as a result - large flow rates of wells and a large inflow. However, the probabilities of a wellbore collapse, removal of mechanical impurities to the bottom and clogging of the well, as well as clogging of this pump increase with increasing depression. Also, an increase in the pumping depth, which causes an increase in the required head and the flow of the installation, leads to an increase in the axial dimension of the pump unit.

Fig. 2. The dependence of the turnaround time from the depth of the pump suspension

By approximating the dependence of the turnaround time of work on the depth of the pump suspension N_{susp} , an equation with a coefficient of determination was obtained $R^2 = 0,8785$.

From the graph in fig. 2 it follows that with an increase in the depth of the pump suspension, the turnaround time of the wells decreases according to a linear law.

In addition to the direct influence of free gas on the operation of a submersible pump, it is necessary to consider excessively high or excessively low pressure at the pump intake and, accordingly, bottomhole pressure. Low pressure leads to a decrease and possibly to disruption of the installation flow due to the large content of annular gas at the pump intake (more than 20% in volume), a large number of underground equipment failures, especially in winter. An overpressure at the pump intake leads to an unnecessarily deep suspension of the installation and, as a result, to an additional consumption of tubing pipes, cables or a limited supply of liquid column above the pump intake; increase in lifting time; increased probability of breakages in the installation, cable damage; loss of oil production, etc.

To analyze the graphical dependence of the pressure at the reception from the turnaround time, we use the field data.

Fig. 3. Dependence of the overhaul period on the pressure at the inlet of the submersible pump

In fig. 3 shows the dependence of the turnaround time of work on the pressure at the pump intake P_{intake} , on the basis of which the equation with the coefficient of determination is obtained $R^2 = 0,921$.

From the graph in fig. 3 it follows that with a significant decrease in pressure at the pump intake in the wells, which are operated by the ESP, a decrease in the overhaul period of well operation occurs.

Consider the process of increasing the wellhead pressure parameter values, which cause an increase in the annular gas pressure in the well. High gas pressure in the annulus entails a decrease in the overhaul period of the underground equipment operation. As a result of data processing, a graphical dependence of the interrepair period of work on the annular space pressure was constructed, which is assumed to be equal to the wellhead pressure (Fig. 4).

Fig. 4. The dependence of the turnaround time of work on the gas pressure in the annulus

In fig. 4 shows the dependence of the turnaround time of work on the gas pressure in the annular space of P_{gas} , on the basis of which the equation with the coefficient of determination is obtained $R^2 = 0,9648$.

From the graph in fig. 4 it follows that with increasing gas pressure in the annulus at wells operated by the ESP, a significant decrease in the overhaul period of well operation occurs.

Results

From the analysis of the experience of the ESP in the studied oil fields, the negative effect of high gas pressure in the annulus on the equipment performance has been established. The power and logarithmic dependencies of the turnaround time of work on the technological parameters of the pump were revealed:

- with an increase in the annular gas pressure at the wells operated by the ESP, a significant decrease in the overhaul period of the wells (a determination coefficient $R^2 = 0,9648$) occurs;
- with a decrease in pressure arising at the pump intake at the wells operated by the ESP, a decrease in the overhaul period of the wells (reduction coefficient $R^2 = 0,921$) occurs;
- with an increase in the depth of the pump suspension, a decrease in the overhaul period of the well operation (determination coefficient $R^2 = 0,8785$) occurs.

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