Analysis of the use of downhole pumping equipment (DPE) at the Tevlinsko-Russkinskoye field

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Abstract. The problem of operating ECP in the zone of low production rates is very relevant for a number of leading oil companies, since most of the wells are operated by such pumps. The adopted values of the boundaries of the working part of the characteristics of the pump are indicators: 0.75–1.25. According to preliminary estimates, 31 % of the ECP at the Tevlinsko-Russkinskoye field are operating outside the operating range, which leads to a decrease in the operating efficiency of downhole pumping equipment (DPE). The average well production rate for oil was 8.6 tons per day, for liquids – 89.5 tons per day, for water content – 90 %. This article presents an analysis of the ECP operation in the Tevlinsko-Russkinskoye field. The work describes the complications of the DPE when it is used beyond the right and left borders of the working area. On the basis of pilot field works, the possibility of using alternative DPE has been described. At the end of the article highlighted the main problems relating to the operation of wells and equipment.

1. Introduction
The choice of a pumping unit for the operation of marginal wells is not always as obvious as it would seem. It is considered, for example, that the use of bottom hole pump on this fund is more preferable, since they have higher (compared to electric centrifugal pump) efficiency and are characterized by relatively low power consumption at low feed rates.

Unfortunately, in the last 2 decades, subsoil users in Western Siberia in the operation of oil wells with flow rates from 10 to 30 m³/day. and the decision fully gave preference to installations of electric centrifugal pumps (ECP). In this connection, with the high water cut of these wells, the low efficiency of the ECP of low productivity and the low cost of oil on the world market, these wells become unprofitable. [1]

2. A brief analysis of the mining well stock
As of January 1, 2017, the production fund of the Tevlinsko-Russkinskoye field amounted to 1,663 wells, of which: ECP – 1,636 (98 %), submersible pump installation (SPI) – 14 (1 %), while separate production (WSP) – 13 wells (1 %).

In the operating fund there are 1564 wells, in the idle – 27 (1.6 %), in inactivity – 97 (5.8 %).

By the end of 2016, the operating fund of the Tevlinsko-Russkinskoye field amounted to 1,560 wells. In comparison with the beginning of the year, the number of wells equipped with ESP systems increased from 1540 to 1545, in turn, the number of wells operated by the SPI decreased (from 6 to 2).
Technological indicators at the end of the year: the flow rate of oil and liquids decreased (by 0.57 and 2.97 tons/day, respectively), the water content of the production increased (by 0.97 %).

3. Operation of wells using ECP
Almost all oil production in the Tevlinsko-Russkinskoe field is provided by electric centrifugal pump – 4,717 thousand tons (99 % of the total oil produced in 2016).

Figure 1 presents an analysis of the work of the DPE of the existing stock of wells operated by ESPs, which revealed:

- 69 % or 1064 wells are operated within performance limits;
- 12 % or 192 wells behind the right working area;
- 19 % or 293 wells behind the left work area.

![Figure 1. Distribution of existing production wells (number) along the boundaries of the ECP working area](image)

**3.1 Operation of the pump beyond the right edge of the working area**
The pump operation beyond the right edge of the working area occurs with reduced efficiency, as well as with large wear of the upper textolite washers of the impeller. This, in turn, sooner or later leads to their abrasion and friction of the metal on the metal, accelerates the wear of working bodies and increases the likelihood of their jamming and breaking the shaft.

**3.2 Operation of the pump beyond the left edge of the workspace**
The left boundary of the working area is determined by the flow, below which the head begins to drop. The service life of the lower support bearing is significantly reduced by the increasing axial force acting on the impeller. Cooling conditions deteriorate as the pumping rate decreases. Heating of the pumped liquid in an electric motor can reach significant (critical) values. The likelihood of premature failure of the ESP increases due to the lack of necessary cooling of the installation units and, as a result, a decrease in cable insulation (R-0).

Excessive heating contributes to the formation of scaling, which also causes a further reduction in supply and increases the likelihood of seizure of the working bodies. Operation beyond the left boundary may lead to unstable operation, stopping and restarting equipment, thereby increasing the load on the insulation of the SEM and cable, increased consumption of hydraulic oil, the risk of contamination by mechanical impurities, etc.

In order to avoid premature failures of deep hole pumps, in cases of reducing the dynamic level, it is recommended to carry out measures to limit fluid withdrawal (fitting wells, reducing engine speed), reducing the size of the pump, changing the mode of operation (from ECP to bottom hole pump), or lowering the ECP of a larger size with the short periodical work mode.
4. Analysis of the work of the periodic wells
As of January 1, 2017, 233 production wells (15 % of the total operating ECP fund) of the Tevlinsko-Russkinskoye field are operated in a periodic mode of operation.

The considered wells are operated mainly by domestic-made ECPs (229 wells), imported ones – TDK (4 wells), with a nominal capacity of 15 to 160 m³/day.

One of the reasons for the withdrawal of DPE from continuous operation were:

- low coefficient of productivity (on average 0.23 m³/day.atm);
- reduction of reservoir pressure (on average by 28 % of the initial);

4.1 Methods of operation of the periodic wells
Automatic reclosing mode (automatically reclosing). The automatic reclosure mode can lead to a large amplitude of bottomhole pressure, a decrease in the volume of production in comparison with continuous operation. This is due to an increase in the average dynamic level of the reservoir fluid above the pump intake, a decrease in depression to the reservoir and, as a result, a reduction in the flow of reservoir fluid into the well.

109 wells are in operation in the field in the AR mode. On average, in one cycle, the operation time was 1.1 hours (65 minutes), the accumulation was 2.5 hours (148 minutes). At the same time, the operational indicators are as follows: dynamic level – 1991 m (the depth of the DPE descent is 2347 m), liquid flow rate – 17 m³/day, oil – 4.6 t/day, with a water content of 59 %.

Short re-work mode. The optimal selection of operating times and well shutdowns in the accumulation, does not significantly reduce the dynamic level, contributing to the preservation of continuous fluid withdrawal.

In this mode, on average, the operating time is 0.3 hours (20 minutes), the accumulation is 0.6 hours (36 minutes), 124 wells are in operation. ECP are used with a capacity from 25 to 125 m³/day. The average parameters of the wells: the dynamic level of 1993 m, the flow rate of the liquid 20 m³/day, oil 4.8 tons/day, the water-cut rate was 68 %.

5. Application of alternative DPE in the field
According to generally accepted criteria for the selection of the method of operation of production wells, the most optimal, for objects with low productivity Tevlinsko-Russkinskoe oil field, is the use of centrifugal pumps [2–4]. Alternative mining methods are difficult:

5.1 Use of electric screw pumps
Pilot field tests of screw pumps complete with a control station manufactured by Netzsch Pumps Rus in 2015 were carried out at two wells in the Chamber of Commerce and Industry of Povneftegaz. As a result, in the first well, the UEVN did not fulfill the warranty period (24 hours), in the second one it was 5 days (the well did not enter the mode). Both failures were due to pump seizure due to elastomer swelling. In other words, the cage swelling is caused by an incorrect selection of the type of elastomer (in particular, the content of aromatic hydrocarbons in borehole fluids is not taken into account).

Screw pumps, in wells, work in harsh conditions under the influence of many adverse factors: aromatic compounds, high temperature and pressure, abrasive mechanical impurities, gas (including hydrogen sulfide and carbon dioxide). In this connection, increased requirements are imposed on the materials of the clips.

An increase in the operating time of screw pumps can be achieved through the use of holders made of elastomers, the composition of which is selected on the basis of specific well conditions, in particular, the physicochemical properties of the formation fluid.

In 2017, the OPI of high-pressure electric pumps with a modified elastomer composition was resumed at the fields of LLC LUKOIL-Western Siberia, for oil production from low-yield wells, with a large depth of descent (more than 2000 m).

In the case of positive results and appropriate decisions on further implementation, it is recommended to consider the use of this DPE in the low-yield fund of the Tevlinsko-Russkinskoye field.
5.2 Installation of jet and hydraulic piston pumps
The lack of sufficient operating experience and its own facilities for maintenance and repair, prevents the introduction of tandem installations ECP-JP (jet pumps with submersible drive).

Thus, for wells with a low productivity factor, a significant dynamic level and a small inflow of production from the reservoir, the method of periodic operation is most preferable.

6. Causes of premature repairs of ECP
In January 2017, 221 premature repairs were carried out on the well stock operated by the ECP.

The main reasons for repairs:
- salt deposition of DPE (PCT, ECP) 9 %;
- ECP operation in difficult conditions of 5 %;
- corrosion of DPE 3 %;
- clogging of ECP with mechanical impurities of 2 %, table 1.

Table 1. The reasons for all premature repairs of the ESP for 2016

| Reason for repair                        | Number of repairs |
|-----------------------------------------|-------------------|
|                                        | pc.  | %    |
| GTM                                     | 143  | 64.7 |
| The fault of service organizations      | 29   | 13.1 |
| Salt Deposition                         | 20   | 9.0  |
| ECP operation in difficult conditions   | 10   | 4.5  |
| Corrosion of DPE                        | 7    | 3.2  |
| ECP clogging                            | 5    | 2.3  |
| Crash                                   | 6    | 2.7  |
| Uncontrolled operation of ECP           | 1    | 0.5  |
| Total                                   | 221  | 100  |

Figure 2. The distribution of existing production wells ESP for reasons of repair
7. Conclusion
Based on the analysis of technological modes of operation of wells and the analysis of equipment failures given above, the main problems relating to the operation of wells and equipment were highlighted.

7.1 Operation of ECP outside the operating range
According to preliminary estimates, 31% of the ECP work beyond the boundaries of the working area: 19% beyond the left border, 12% of the ECP – beyond the right border. These wells are characterized by a decrease in the operating efficiency of downhole pumping equipment and an increase in the risk of premature failure of DPE. In subsequent repairs, it is necessary to select the DPE that ensures a given flow rate of the reservoir fluid with the ECP indicators closest to the optimal flow, head, and power, based on the operating characteristics of the unit size. For newly commissioned wells, as well as for wells, after conducted geological and technical measures, including hydraulic fracturing, it is recommended that the ESP unit be lowered with a valve engine (for subsequent control of the extraction of produced fluid).

In order to avoid premature failures of DPE, in cases of reducing the dynamic level, it is recommended to carry out measures to limit fluid withdrawal (fitting wells, reducing engine speed), reducing the size of the pump, changing the mode of operation (from ECP to SPI), or lowering the ECP of a larger size with the SPW mode (short periodical work).

7.2 Periodic well stock
At the mining ESP fund, 233 wells (15% of the operating ECP fund) are operated periodically.

According to the results of the analysis, for some of the wells it is possible to switch to a more favorable one – a permanent mode of operation, by selecting an ECP corresponding to the current pressure-flow rate characteristics for WM.

7.3 Application of alternative DPE (jet, piston pumps)
Due to the lack of operating experience, its own maintenance and repair facilities is not recommended.

The ability to use the installation of electro-screw pumps – only the results of their repeated, field test trials, planned in 2017.

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