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Automation of management and control system for wellhead equipment of a production well

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Abstract. This article proposes a version of the management and control system for the wellhead equipment of the production well. It considers the analyzed and confirmed currentness of the use of such a system. The main functions of the system allow continuous control of actuators of the wellhead equipment in real time. It solves the problem of the operational stabilization of pumping equipment and ramping up the well to the optimum operation.

1. Introduction

Electric submersible pumps (ESPs) for operating in water cut, high-output, deep, and directional well use widely in oil production. Without having a long stem between the pump and the drive, ESPs allow the pump to transmit significantly more power (up to hundreds of kilowatts). That means increasing the efficiency of this type of equipment. Besides, the electric submersible pump is a type of dynamic pump having soft-grade operating characteristics. However, it is sensitive to gas, the viscosity of the pumped fluid, and the presence of solid particles in it. The characteristics regulated by technical specifications, such as the content of non-associated gas intake, the number of solid particles, and the viscosity, are difficult of accomplishment due to technical and organizational reasons. The operation of wells by ESP helps to achieve high technical and economic characteristics in several fields in various oil regions.

Special design submersible electric motor drives the electric submersible pump. The electric motor power occurs energy from the surface supplied by a cable from a step-up autotransformer or transformer through a control station that contains all control and measuring equipment and automation [1].

A set of various technical measures and the picking up of technological parameters accompany ramping up the well to the optimum operation, as well as maintaining it.

Oil pulling to the surface, the gas that accumulates in the annular space of production wells (between the flow strings and the casing) is released. An excess amount of the gas leads to unintended consequences in the operation of the wells, such as increasing the dynamic head and the formation of gas hydrates.

When extracted products contain the non-associated gas, the pressure and, accordingly, the efficiency of the electric centrifugal pump unit may decrease, and the equipment can overheat due to insufficient cooling. There are also risks of pump starvation and in-shift downtime, which leads to premature equipment failures. If the amount of non-associated increase, the number of required ESP stages increases, their pressure characteristic decreases. That causes a decrease in the depression exerted on the formation and leads to the well production rate decrease.

2. Analysis of the well operation mode

Currently, the equipment that is available in Russia (ESP) does not provide steady operation with a gas content above 100-200 m^3/t of oil.

Figure 1 shows a diagram of the values of the production well indicators.

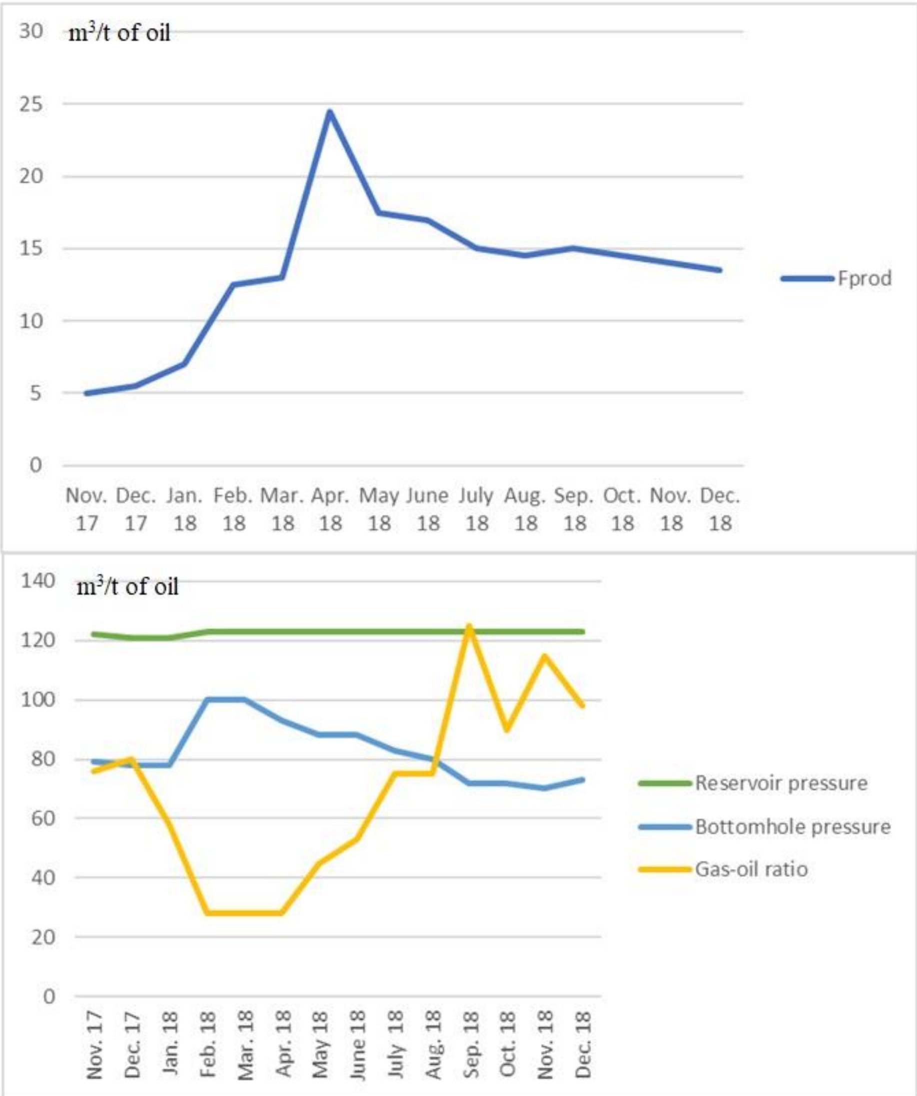

Figure 1. The values of the production well indicators: F_{prod} – productivity factor.

Figure 1 shows that the amount of gas dissolved in production fluid increases when decreasing the pressure. That leads to the decay productivity factor of production well due to decreasing depression because of exposure to gas (impossible to increase depression due to gas impact on operating of ESP).

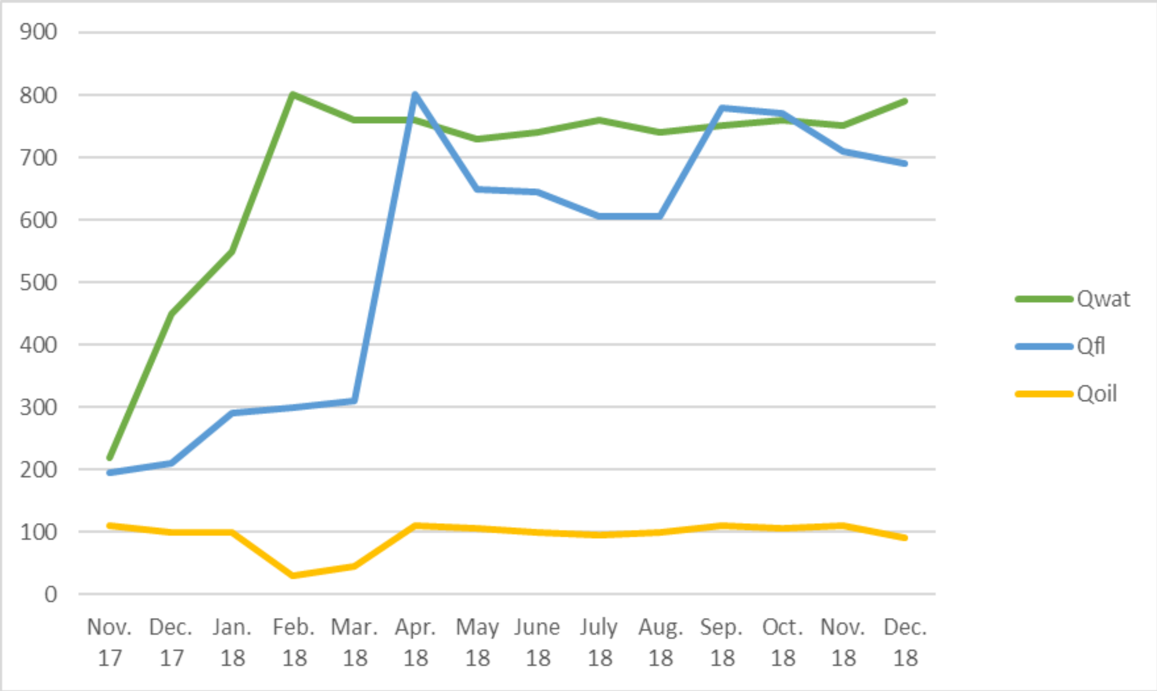

Figure 2. The volume of the fluid pulling out of the well: Q_{wat} – water volume; Q_{fl} – fluid volume; Q_{oil} – oil volume.

Figure 2 shows that oil production does not increase when the volume of produced fluid increasing.

It is typical to use the following technological methods during operation for the majority of wells characterized by a high gas factor: using a bean on the shock reducer or operating in the "i-lim" mode, which involves automatically changing the current/frequency of the ESP operation when the load changes [2]. These technological solutions are necessary to stabilize the operation of pumping equipment due to a falling off of load to prevent supply failure and stop the well. It happens because of the high gas factor and gas discharge in bundles. There is almost no liquid at the pump reception at some point in time.

If the control station can set the "i-lim" mode, the nip of shock reducer produces manually by the oil and gas production operator, whose constant presence at each well is not possible.

Limiting the selection leads to a decay in efficiency and additional heating of the ESP. The minimum allowed flow rate that provides cooling of the electrical submersible motor must not be less than the calculated one. At the same time, it is necessary to estimate the head of the ESP spent on lifting the fluid as the required head rate increases when increasing the wellhead pressure. Limiting the flow rate by shut-off valves does not allow [3-5]..

All the above points show the need for effective choke adjustment in the course of performance in the process of working operations to prevent the occurrence of oddities [6].

In this regard, it remains pertinent to use technical and technological means of wellhead equipment automation implemented based on an adjustable bean, a controlled drive, and a control system. By the technological data received from the ESP control station, the designed system allows adjusting the position of the bean to stabilize the operation of the pumping equipment in real-time. Figure 3 shows this system.

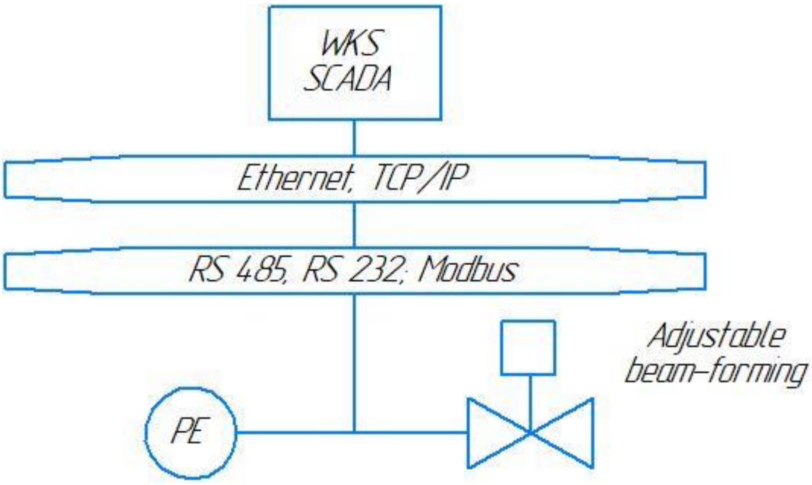

Figure 3. Diagram of the operation of wellhead equipment automation.

This paper is considered to be the calculation of the geometric dimensions of the heavy-duty bearing parts of the drive system and determination their materials with subsequent processing for the manufacture of the drive gearbox of the control actuators of the wellhead equipment. This paper contains the technical requirements for the production of the gearbox base member and the frame of the drive system.

The calculated data will use to produce detailed documentation of the drive system parts. That will determine the requirements for the production of the most critical parts of the eccentric gearbox, gears, and input shafts. Also, difficulties in manufacturing special gears will be described, as well as determining the degrees of accuracy and hardness of surfaces [7-8].

3. Conclusions

Therefore, the automated control system of wellhead equipment of a production well, which equipped with an adjustable choke and controlled by drive and control system, will allow us to adjust the performance of the ESP by a method of choke restriction using computer-aided procedures. That increases the efficiency optimization of the modes of wells with ESP.

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