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TECHNICAL SOLUTIONS TO IMPROVE THE PERFORMANCE AND UTILISATION OF PUMPING EQUIPMENT

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Abstract
The article studies methods and ways of increasing the efficiency of submersible pumps, as well as modernisation of structural elements of their control means to increase the efficiency and utilisation rate of pumping equipment using innovative technical solutions of Grundfos company.

Keywords: Pump, efficiency, electric motor, electronic device, solution level.

Introduction

The analysis of research of methods and ways to improve the efficiency of submersible pumps, as well as modernisation of structural elements of their control means shows that to increase the performance and efficiency of pumping equipment is achieved by using innovative technical solutions of Grundfos. [1] The solution of the problem is achieved by using electronic frequency converters in pump drive control systems. In the models of Grundfos pumps used in the technology of in-situ leaching of minerals it is more effective to use synchronous electric motor with permanent magnets in the rotor, this technical solution allows to increase the motor speed up to 10700 $min^{(-1)}$.[2]

DISCUSSION OF THE PROBLEM

In order to maintain the well pump performance, we recommend a set of electronic equipment that reliably protects the pump against dry running, voltage surges, over or under current, low insulation resistance, phase sequence disorder, phase current/voltage asymmetry (for three-phase motors), over or under power factor (cos φ), over or under power factor (cos φ), over or under harmonic coefficient of input voltage, over operating temperature and provides soft start, which avoids the impact of start-up, and ensures that the pump is not subjected to the effects of over or under voltage surges. [3]

It is recommended to equip equipment and devices for control and protection of electric motors of submersible pumps with CU 3-electronic device for control and protection of electric motors, R 100 device for manual control and diagnostics, SM 100 sensor module for receiving and

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registering data received from external sensors and for controlling flow, pressure, dynamic water level and conductivity.

The CU 3-electronic device for monitoring and protection of electric motors, machines, cables and cable couplings at currents up to 400 A, supply voltages from 200 to 575 V and frequency 50/60 Hz, and can be integrated in a control cabinet.[4]

The CU 3 module monitors the following parameters:

the value of the system insulation resistance to earth before switching on the motor;
motor temperature (submersible motor with Temrsop temperature sensor);
motor current consumption and current asymmetry;
supply voltage;
phase sequence.

CU 3 protects in the case of:

dry running of the pump;
of incipient defects in the motor;
the motor temperature is too high;
nutritional damage.

The standard version of the CU 3 contains:

relays for star-delta starting and starting with a starting transformer.
relay output for external fault messages.

The CU 3 module can be used for three-phase submersible motors from all companies and provides:

- continuous monitoring of the energy consumption and pump performance. In this way, it can be checked whether the pump is correctly matched to the specific application
- allows to exploit the one that requires minimum operating costs out of a group of wells.
- selecting the optimum maintenance interval

The CU 3 module has a special solution level reduction function, whereby the solution level is reduced to the pump inlet (required no water). When this minimum water level is reached, the pump is switched off due to a drop in load, after which the pump will only automatically switch on after a certain time, which can be programmed using the idle time / run time function available in the R100 remote control unit. Precise switching off of the pump when it starts to run dry is achieved by selecting a pump with a known excessive delivery parameter. By installing the pump at a certain depth, a constant water level can be ensured. This allows the water level to be lowered as required by the user. In addition, it is also possible to select an upper switching level for the pump, in which case the pump will start automatically at the maximum excess head (max. level). For the user, this means that the pump will prevent the water from rising above the maximum level, which can be set arbitrarily by the user.[5]

The idle time / run time function allows the user to select any run time or pump idle time from 1 to 60 minutes. The value is entered using the remote control unit R100. For the idle time / run time, 60 minutes is entered using the R100. The pump is switched off by the CU 3 in the event of dry running conditions (underloading of the pump), after which the dead time function is activated. The longer the pump runs without dry-running conditions occurring, the shorter the dead time.

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DISCUSSION RESULTS

By combining the CU 3 with a level gauge, pump tests can be carried out at each well. For this purpose, the corresponding water level height is measured for each delivery. In this way, it is possible to establish how much water naturally flows into the well and thus create the most optimal operating conditions for the pump. This increases the service life of the pump and the well, as the risk of air entering and water containing foreign matter entering the well area is reduced.

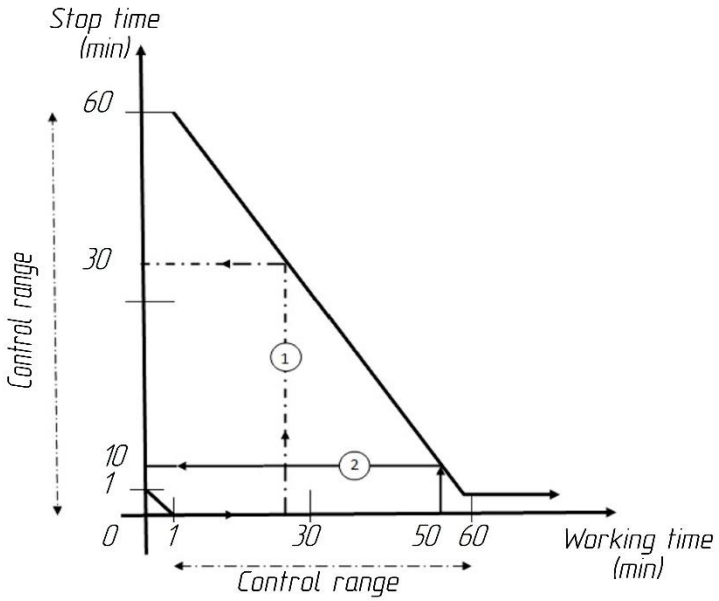

Figure 1. Schematic diagram of the pump unit control range

As a result of testing of pumping units in the well, the following dependencies are obtained.

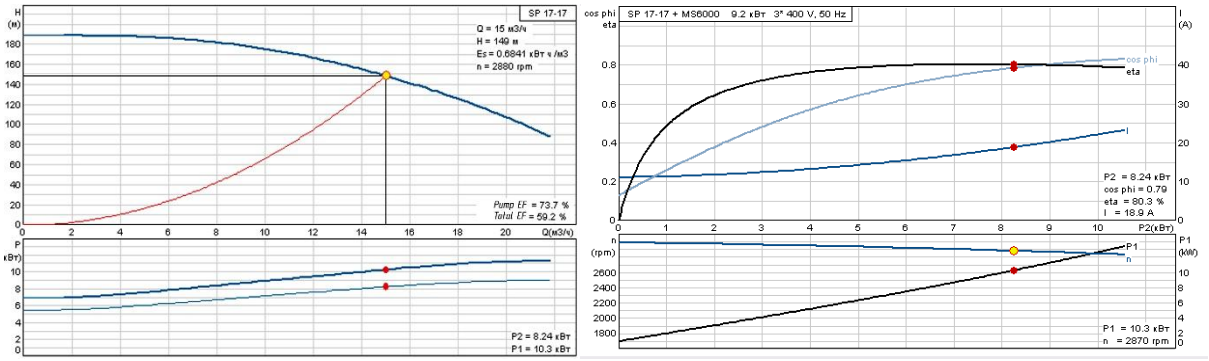

Fig. 2. Dependences of submersible pump performance on head, speed, specific power consumption, efficiency and power factor

Analysis of the results of downhole testing of pumping equipment and graphs of pressure and mode characteristics shows that the main indicators were: pump capacity Q=15m^3/h; head H= 149 m, speed n= 2880 rpm; specific power consumption Es=0,6841 kWh/m3; pump efficiency =73,7%; total efficiency=59,2%; power factor cos f=0,79; consumed power of one pump stage P2= 8,3 kW; total power P_1=10,3 and current I=18,9 A.

To protect the pumping equipment it is recommended to use specially designed devices for protection against gas cavitation and "sanding" at the pumping part of the well, which consists of a production string (1); polyethylene vinyl chlorite pipe (PVC-non-metallic casing) with diameter D-145-165 mm (3) and pumping equipment such as Pump SP 17-17 with MMC-6000 engine (4). The pump unit is inserted into the inner part of the tubular device and fastened. The productive liquor enters the suction part of the pump unit through the mouth of the non-metallic casing. At the same time, due to the pressure difference and density difference between air, rock particles and reagent, they are separated. Air enters the atmosphere, solid particles are deposited at the bottom of the well, and the productive solution is pumped out by the pumping equipment.

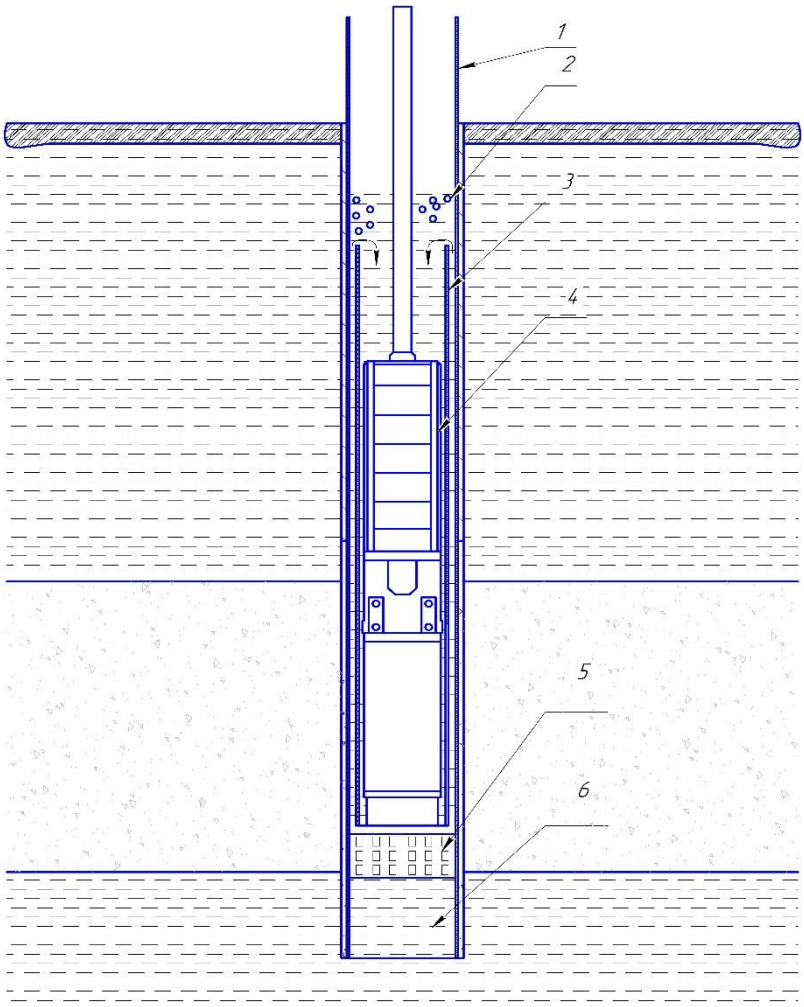

Figure 3. Devices for protection against gas cavitation
1-Explosion column; 2- Gas bubbles; 3- PVC (non-metallic casing) 4- SP 17-17 pump; 5- Filter; 6- Sump.

As a result of researches the recommendations on completion of modular device CU 3 - equipment and devices for control and protection of electric motors of submersible pumps and devices for protection against gas cavitation and "sanding" at the pumping part of the well were developed:

- the well pump operation is supported by the built-in electronics Su-3 complete with sensor module CM and PT, which reliably protects the pump against dry running, voltage surges, over or under current, low insulation resistance, phase sequence failure, phase current/voltage asymmetry (for three-phase motors), increased or decreased power factor (cos φ), increased harmonic coefficient of the input voltage, excessive operating temperature and provides a soft start, which avoids the risk of damage to the pump.

-The continuous monitoring of the pump by means of the CU 3 allows the selection of maintenance intervals to be optimised. At present, pump care and maintenance is usually carried out after a certain period of time or when faults occur. Both approaches are not conducive to optimal and cost-effective operation.

-The CU 3 module in combination with a pressure sensor can also regulate the liquor level by means of the idle time / run time function and by selecting the upper switching level of the pump and thus increase the utilisation rate of the pump unit.

A non-metallic safety casing separates the air, rock particles and reagent due to pressure difference and density difference. Air gets into the atmosphere, solid particles settle to the bottom of the well, productive solution is pumped out by pumping equipment and the negative issue of air cavitation during operation of pumping equipment is solved.[6-7]

CONCLUSION

As a result of implementation of the proposed technical solutions and recommendations the service life of pumping equipment reaches 7850-8000 machine-hours, the equipment utilisation rate increases by 28-30% and allows reducing the energy consumption of pumps by 25-30%.

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