COMPARATIVE ANALYSIS OF TECHNICAL AND OPERATIONAL CHARACTERISTICS OF CONTROLLERS USED TO AUTOMATE THE OPERATION OF ROD DEPTH PUMPS

ABSTRACT

The paper examines the technical and economic characteristics of the most common controllers from popular manufacturers in the United States, designed to automate the operation of rod depth pumps installed in oil-producing pumping machines. The main functional components, including sensors and actuators, are presented. A comparative analysis of the functionality is made, namely, the operating modes of the automation systems for switching on and off electric motors of rod pumps.

The main distinguishing features of the presented controllers is that some of them lack any sensors and in which the dynamograms are controlled in the function of currents and voltages. In addition, there are also types that use radio communication with the main control and control panel, which greatly simplifies wiring diagrams, eliminates the need to install relatively long cable networks.

Keywords:rod depth pumps, oil well, AC electric motor, dynamogram, sensors, rocking machine.

INTRODUCTION

The modern approach to the automation of oil production processes dictates strict requirements for software and hardware complexes for monitoring and controlling rod depth pumps (RDP). This is due to the depletion of oil reservoir resources, the high cost of electricity, the desire of oil companies to reduce well repair costs and use their personnel more efficiently. If earlier technical means allowed only periodic measurements of technological parameters at wells by operators using portable sets of equipment, then modern microprocessor controllers permanently installed in the fields makecontinuous automatic monitoring of them is possible. In relation to wells operated by rod depth pumps, this means measuring such technological parameters as dynamogram (dependence of the force on the polished rod on the movement of the suspension point of the rods), dynamic level, wattmetrogram (dependence of power consumption on the movement of the suspension point of the rods), the influence of the gas factor, pressure at the wellhead, daily well productivity and others [9,10]. At the same time, the control functions must provide remote switching on and off of the drive motor, emergency shutdown of the installation, periodic operation, smooth control of the rotation speed using a frequency converter [1,3]. By now, a number of developers and manufacturers of controllers and control stations for SHGN installations are known.

The use of modern intelligent controllers provides solutions to such tasks as automation of the rocking machine, optimization of equipment operation modes, prompt identification of emergencies and inconsistencies in equipment operation modes, prompt transmission of information about the condition of the object to the operator's console via a telemechanics system.[1-8]

Telemechanics systems are currently being built, as a rule, using a radio channel. Therefore, a typical control station includes a controller, a power switch for switching on and off the electric motor, a radio modem and a set of sensors for technological parameters. Individual control stations include frequency converters for regulating the speed of rotation of the electric motor. An attempt is made below to consider the functionality of these controllers and compare their characteristics.

TASK OF THE ARTICLE

The main objective of the presented work is the following

1. give a brief description of the work of typical controllers from the most popular manufacturers in the USA;
2. briefly outline the principles of installing sensors at the technological site and connecting them to the terminals of the controller cabinets;
3. note the distinctive features of the operation of controllers in which the control is performed in the function of currents and voltages and in which position and force sensors are not installed;
4. Show the characteristic features of controllers with radio communication with the control panel.

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4. Show the characteristic features of controllers with radio communication with the control panel. The software of the SAM Well Manager controller provides dynamogram detection of individual faults in the pumping unit. "Archived" data can be viewed directly at the well in the form of diagrams and reports on the built-in display. The SAM Well Manager controller provides the ability to work with two configurations of dynamometer sensors:

1) the force sensor is located on the rod above the upper traverse (Loadtrol type sensor), the Hall effect position sensor is mounted on the output shaft of the gearbox;

2) The balancer deformation sensor is combined with the balancer tilt angle sensor.

The controller provides 3 modes of operation:

1) all switching on and off of the electric motor is performed by commands from the control room;

2) the electric motor is switched on and off according to the set time settings (periodic operation);

3) the control is carried out automatically based on the results of the analysis of dynamograms.

The controller has an analog output for connecting a frequency converter to smoothly adjust the rotation speed of the electric motor.

The Lufkin SAM Well Manager controller (Figure 1) is by far the most widely used worldwide [2,4]. The controller provides for the connection of analog force and position sensors, as well as discrete position sensors located on the shaft of the electric motor and the output shaft of the gearbox. Data from these sensors are used to monitor and control the operation of the pumping unit and to visually display graphical data on a liquid crystal display or on a laptop computer screen in an easy-to-understand format.

The SAM Well Manager controller uses the generated dynamogram to determine the degree of filling of the borehole with liquid. If the analysis shows that the well has been emptied, the pump is turned off and the well is put into accumulation mode. In this mode, it is filled with liquid again, after which the control unit turns on the pump motor and begins pumping.

Figure 1. The SAM Well Manager controller (SEM 212) from Lufkin

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Currently, these controllers are installed in the SCUD control stations manufactured by the ATSBPO EPU of JSC Tatneft. The disadvantage of this system is the high cost. For example, the cost of only a Lufkin controller complete with dynamometer sensors is commensurate with the price of an entire control station in a complete set of domestic production.

eProduction Solutions Company It offers a number of controllers for installation on SHGN wells at once. These are the CAC2000, CAC8800, ePIC, ePAC and iBEAM controllers. The functionality of the first three controllers is similar to Lufkin's SAM Well Manager. It provides for the connection of passive force sensors located on the rod (Loadtrol type sensor) or on the balancer, as well as sensors for the movement parameters of the rod of several types: Hall sensors located on the crank shaft, sensors for the angle of inclination of the balancer and potentiometric angle sensors. The measurement of signals from analog sensors is performed by a 12-bit ADC with a frequency of 20 Hz. It is possible to calibrate the sensors directly at the well. There is a keyboard and a graphical display for viewing data (Figure 2). The degree of balance of the counterweights of the pumping unit is determined. Unlike previous products, ePAC is a complete system of adjustable electric drive for a pumping unit. It allows you to vary the pump swing speed within wide limits, as well as separately optimize the stroke time of the plunger up and down

Figure 2. The CAC8800 controller from eProduction Solutions

The most original development of the company is the iBEAM controller installed on the rocking machine balancer (Figure 3). It is reinforced with a clamp on the balancer, and a solar battery is located on its upper surface, ensuring the autonomous operation of the device. There is a built-in rechargeable battery for night operation. Combined strain and tilt sensors of the balancer are installed directly next to the controller. The measured dynamograms are transmitted via a low-power radio transmitter to a receiving terminal located near the electric motor control unit. This system completely eliminates movable cables from sensors and power supply cables, and consequently increases reliability and durability. Currently, about 25 thousand wells worldwide are equipped with the iBEAM controller.

In some cases, it may be advisable to service a whole cluster of nearby wells with one controller. This feature is implemented in the controller of the company “International Automation Resources".

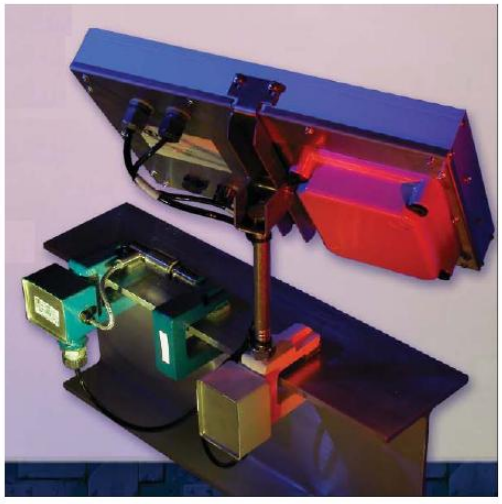

Figure 3. The iBEAM controller from eProduction Solutions

But the use of passive analog force sensors limits the length of the connecting cables to several tens of meters. Therefore, special converters are used to connect remote sensors

The output signals of the passive sensors are converted into a current signal of 4-20 mA. However, even a current analog signal is subject to electromagnetic interference, and the use of sensors with a digital output would be more appropriate in this case.

The AEPOC 2100 controller from Automation Electronics differs from the others in the high resolution of the ADC (Figure 4).

Figure 4. Automation Electronics AEPOC 2100 controller

A 16-bit ADC is used to digitize signals from force and displacement sensors. In this case, motion sensors, potentiometers, "liquid" and "dry" inclinometers can be used as a displacement sensor. A flexible algorithm for determining the flow failure allows you to work with horizontal and heavily gassed wells.

ABB, the world leader in the production of power electronics, has released the ALC 600 controller. The controller (Figure 5) provides for the connection of force and position sensors and is designed to work together with a frequency converter. There are 12 variants of control stations with this controller for electric motors with a capacity from 6 to 100 kVA. A heating system is provided in the cabinet to work in a cold climate. In recent years, SHGN control controllers have appeared that do not require any external sensors for their operation, the so-called "sensorless" controllers. An example of such systems is the SPOC Automation controller and the Guardian controller from R&M Energy Systems . The controllers do not require any external sensors (dynamometer sensors) for their operation. Information about the force and position of the rod is calculated through the measurement of electrical parameters.

Figure 5. ABB ALC 600 controller

The controllers work in conjunction with frequency converters. Due to the absence of external sensors, the cost of the automation system is reduced, reliability is increased, and installation time is reduced. Another advantage of this approach is the versatility of application: the same controller can control both SHGN and screw and electric pumping units.

However, it should be noted that the dynamogram obtained in this way will be very approximate, which will negatively affect the quality of control and diagnostic results.

CONCLUSIONS

Comparing these characteristics, the following conclusions can be drawn:

1. All imported systems use passive force sensors, which imposes restrictions on the length of the connecting cables and does not allow the installation of a single controller for servicing a well cluster [3,5].

2. To determine the position of the rod, almost all controllers allow the use of capacitive tilt angle sensors, potentiometric angle sensors and Hall sensors mounted on the output shaft of the gearbox and beating off the lower dead center. At the same time, a sensor is not used anywhere that fixes two dead points – the lower and the upper, although the time of the rod stroke up and down may not coincide. 3. Most controllers have the function of regulating the swing speed of the SHGN by means of a frequency converter. Monitoring of electrical parameters (wattmetrograms) is usually not provided. However, in some systems, the speed of rotation of the motor shaft is measured using a Hall sensor, which allows you to calculate the mechanical torque on the shaft of an asynchronous motor.

4. To view archived data and adjust operating modes directly at the well, some controllers have a built-in display and keyboard, others require an external laptop computer. Most controllers have algorithms for analyzing dynamograms with the determination of characteristic faults and with the determination of the point of failure of the supply.

5. All controllers have the functions of remote control of the SHGN electric drive from the control room, and also allow periodic operation of the well according to specified time settings and the degree of filling of the pump with liquid.

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