Development of a control station for oil pumping machines based on permanent magnet synchronous motors

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Abstract-- The article describes a modern control station for rod well-pumping units designed to increase oil production efficiency, developed by the KSEU research team, and presents the station's distinctive characteristics that can improve both the economic and technical components of the rocking machines work. Keywords: control station, rocking machine, pumping units, productivity.

1. Introduction
The control station for rod well pumping units (CS RWPU) allows you to maintain the most efficient mode of operation of oil pumping units [1], due to the following functions:
- monitoring the parameters of the operating modes of the pumping units (dynamograms, gram wattmeter, current, voltage, etc.)
- regulation of the flow rate of the well, due to the commutation of the motor drive, complete engine shutdown, change in rotation speed in the presence of a frequency converter.

Existing well control systems for monitoring are easy to use [2]. However, there are some disadvantages: it is necessary to carry out individual measurements and tests; there are no automated tools and the complexity of commissioning. It is worth noting that specialists are required to attend and supervise work at the construction site. Depending on the actual situation at oil fields, wells are most often grouped. Using centralized management, intelligent control, and separate management, you can significantly simplify the configuration and reduce the amount of service [3]. The main development trend in solving this problem is the creation of digital intelligent field management systems.

Developed on the base of synchronous motors with permanent magnets CS RWPU is designed for:
- improve the performance of pumping units;
- diagnostics of the technical condition of equipment;
- more energy-efficient work in low-yield deposits;
- costs prevention optimization;
- protection of the controlled electric drive from emergency conditions;
- collection, processing, and preparation of data on the technological parameters of CS RWPU; 
- provision of wireless data transmission on technological parameters of CS RWPU;
- the implementation of the functions of the intellectual network of oil fields with the purpose of operational monitoring and management of oil production, electricity consumption, localization of emergencies, and reduction of electricity losses [4].

2. UNIQUE CHARACTERISTICS OF THE DESIGNED CS RWPU

A. Sensorless control of permanent magnet synchronous motors (sensorless technology)
Unlike induction or collector motors, a synchronous motor is not self-sufficient, and its operation is impossible without a special control system, the function of which is to supply voltage to the stator windings depending on the position of the rotor, so that in this case the generated electromagnetic field attracts the poles of the rotor magnets, and it rotates at a certain angle. Maintaining the stator and rotor orthogonality, the maximum motor torque is maintained at different speeds, which prevents the rotor from falling out and ensures the synchronous machine operates at maximum efficiency. The control system implemented in the frequency converter determines the coupling vectors of the magnetic flux in the motor and the rotor position (indirect position measurement) by the instantaneous current values in the stator phases and by solving a system of differential equations generates the output voltage according to a special algorithm [5]. Thus, the system can operate without a rotor position sensor, which, as you know, is the most unreliable and expensive element. This control method allows reducing the cost and overall dimensions, increasing the reliability of the electric drive and controlling the valve motor not only for short distances but also for long distances - hundreds of meters and even kilometers, which is important for oil production facilities.

**B. RWPU adaptive control**

The station regulates the rated engine speed (and other parameters) depending on the technical condition of the rocking machine and the actual situation in the well, which makes it possible to use the engine more efficiently and economically [6].

The control system automatically adjusts the speed based on energy-saving indications, liquid level, pump fullness, overload, underload, compression of rod equipment, gas or sand pollution level, and other parameters. The control system optimizes the operating mode and power consumption of the power supply drive, reducing the excess power supplied to the pump by reducing the speed during operation at maximum load. Consequently, the station increases productivity in oil fields, helps to save electricity, reduces emissions and significantly reduces operating and maintenance costs.

It should also provide wireless data transfer on the technological parameters of the RWPU.

**C. Reducing the dimensions of the drive motor by 2 sizes, reducing its inertia**

An important property of permanent magnet synchronous motors (PMSM) is the efficient use of space, i.e. high compactness [7]. Asynchronous motors with similar energy characteristics will be much heavier and larger than the PMSM.

All this is possible due to innovations in the field of designing synchronous machines, and therefore, reducing the size, and achieved about 39% increase in compactness, compared with asynchronous machines. If we evaluate, basin on the standard sizes, then similar asynchronous motors will be 2 sizes larger compared to the PMSM. Additional benefits of synchronous machines:

- weightless by more than 45%;
- the inertia value is less than 50%.

From these advantages, we can conclude that the start-up process of the PMSM is less than half the time. Also, synchronous machines are characterized by a high value of torque (including in the state of the lower range of rotation speed).

**D. The decrease in losses of the electric power in power supply networks**

Voltage losses in the distribution line of the system are determined only by the active power of the load since the reactive power in the line when using PMSM is practically zero. In this case, there is no need to use compensating devices, it is possible to reduce the cross-section of wires, reduce the power of step-down transformers. The entire power system will operate significantly more stable. Due to the high power factor, high PMSM efficiency, reduction of losses in the distribution network, the efficiency of the entire distribution system is growing (by 5 - 6%) compared with the use of induction motors [8].
3. Conclusion.

A developed control station for rod well-pumping units based on synchronous motors with permanent magnets is considered, from the point of view of distinctive features that will improve the efficiency of rocking machines. These are:

- Sensorless control of permanent magnet synchronous motors (sensorless technology)
- RWPU adaptive control
- Reduction of weight and size parameters due to the features of the PMSM;
- Reduction of electricity losses in the supply networks through the use of PMSM as compensating devices.

It is worth noting the relevance of creating digital oil fields, the main elements of which should be intelligent control stations.

Based on the conclusions presented in the article, it is possible to state the prospects of the proposed technical solution and the possibility of its application in the field of oil production not only in Russia but also in other countries.

4. Conflict of Interests

The author confirms that the materials presented do not contain a conflict of interest.

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