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Frequency-Controlled Electric Drive of Pumping Units

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Abstract — *In this paper, the mechanical characteristics of the frequency-controlled electric drive in pump electric drives are studied and analyzed.*

Keywords — electric drive; mechanical characteristics of a pump; motor torque; AC motors;

The operation modes of centrifugal pumps are most energy-efficient to regulate by changing the speed of rotation of their impellers. The speed of rotation of the impellers can be changed if an adjustable electric drive is used as the driving motor.

The design and characteristics of gas turbines and internal combustion engines are such that they can provide a change in the speed of rotation in the required range.

The process of regulating the speed of rotation of any mechanism is convenient to analyze with the help of mechanical characteristics of the unit.

Below we will consider the mechanical characteristics of a pump unit consisting of a pump and an electric motor. Fig. 1 shows the mechanical characteristics of a centrifugal pump equipped with a reverse gate (curve 1) and an electric motor with a closed rotor (curve 2).

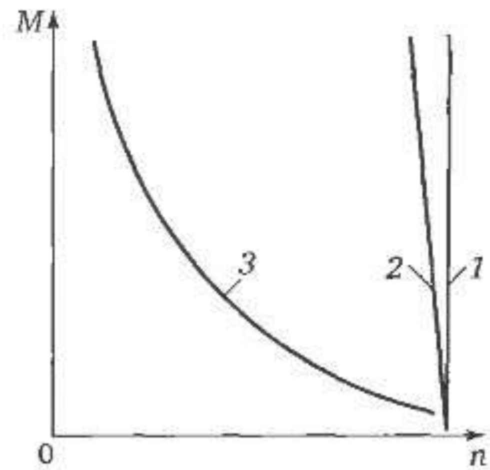

Fig. 1. Mechanical characteristics of the pump unit

The difference between the values of the motor torque and the pump resistance torque is called dynamic torque. If the motor torque is greater than the pump resistance, the dynamic torque is considered positive; if it is less, it is considered negative.

Under the influence of a positive dynamic moment, the pump unit begins to work with acceleration, i.e. accelerates. If the dynamic torque is negative, the pump unit will slow down, i.e. it will slow down.

When these moments are equal, the pump unit operates in a steady state, i.e. it operates at a constant speed. This speed and the corresponding torque are determined by the intersection of the mechanical characteristics of the motor and pump (point a in figure 1).

If the mechanical characteristic is changed in one way or another during the control process, for example, to make it softer by introducing an additional resistor into the rotor circuit of the electric motor (curve 3 in Fig. 1), the torque of rotation of the electric motor will become less than the resistance moment.

Under the influence of a negative dynamic moment, the pump unit begins to work with a deceleration, i.e. it is slowed down until the torque and the resistance moment are again balanced (point b in Fig. 1). This point corresponds to its own speed of rotation and its own moment value.

Thus, the process of regulating the speed of rotation of the pump unit is continuously accompanied by changes in the torque of the electric motor and the resistance moment of the pump.

The pump speed can be controlled either by changing the speed of an electric motor that is rigidly connected to the pump, or by changing the gear ratio of a transmission that connects the pump to an electric motor that operates at a constant speed.

In pumping plants, AC motors are used mainly. The speed of rotation of an AC motor depends on the frequency of the supply current f, the number of pairs of poles p and sliding s. By changing one or more of these parameters, you can change the rotation speed of the electric motor and the pump that is connected to it.

The main element of a frequency electric drive is a frequency Converter. In the Converter, the constant frequency of the supply network$f_1$is converted to the variablef_2. Proportional to the frequencyf_2 the speed of rotation of the electric motor connected to the output of the Converter changes.

Using a frequency Converter, virtually unchanged network parameters voltage U_1 and frequency $f_1$are converted into changeable parameters U_2 and $f_2$required for the control system. To ensure stable operation of the electric motor, limit its overcurrent and magnetic flow, maintain high energy performance in the frequency Converter must maintain a certain ratio between its input and output parameters, depending on the type of mechanical characteristics of the pump. These relations are obtained from the equation of the law of frequency regulation.

For pumps the ratio must be observed:

$U_1/f_1 = U_2/f_2 = const$

In fig. 2 presents the mechanical characteristics of an asynchronous electric motor with frequency regulation. When the frequency f2 decreases, the mechanical characteristic not only changes its position in coordinates n - M, but also changes its shape somewhat. In particular, the maximum torque of the electric motor is reduced. This is due to the fact that if the ratio U1/f1 = U2/f2 = const is observed and the frequency f1 changes, the influence of the active resistance of the stator on the motor torque value is not taken into account.

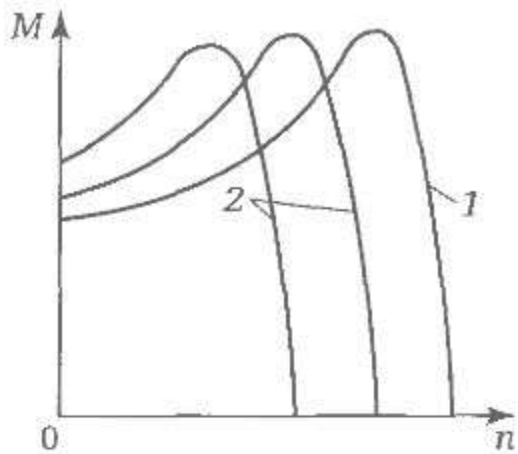

Fig. 2. Mechanical characteristics of the frequency drive at maximum (1) and reduced (2) frequencies

When frequency control takes this effect into account, the maximum torque remains unchanged, the shape of the mechanical characteristic is preserved, only its position changes.

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