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# ОПТИМИЗАЦИЯ СИСТЕМЫ ОХЛАЖДЕНИЯ ЭЛЕКТРОПРИВОДА МАГИСТРАЛЬНОГО НАСОСА

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**В данной статье рассматривается устройство магистральных насосов, режимы работы электродвигателей, а также способы их охлаждения. Представлены основные конструктивные элементы и узлы насосного агрегата. В работе предложено 3 способа оптимизации системы охлаждения электроприводов магистральных насосов, проведено описание холодильного цикла для смесевого хладагента-фреона.**

Ключевые слова: Магистральный насос, асинхронный электродвигатель, система охлаждения, оптимизация, предельная температура, режим работы, хладагент, циркуляционная система охлаждения.

# IMPROVEMENT OF THE ELECTRIC DRIVE COOLING SYSTEM IN THE MAIN LINE PUMP

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**The article describes the structure of main line pumps, operational conditions of electric motors and ways of their cooling. The main constructive feature and units of the pump unit are presented. The three ways of cooling system's improvement in construction of main line pumps are proposed, the refrigeration cycle for mixed refrigerant-freon is also given.**

Keywords: Main line pump, asynchronous electric motor, cooling system, optimization, high-limit temperature, operational conditions, refrigerant, circulating cooling system.

The main line pump is a hydraulic machine intended to convert electrical or mechanical energy into fluid flow energy for the purpose of pumping through main pipelines. Such machines applied to pumping petroleum products (especially, oil) belong to dynamic machines according to the mode of action. Nowadays, the main type of pumps, which are widely used is vane pumps. Let us consider the structure of the pumping units by the example of a centrifugal main line pump, which includes the following units:

- a snail-shaped pump casing for tangential inlet of the pumped liquid, which can be designed as a horizontal or vertical connector. The casing is equipped with two connections - suction and pressure;
- pump shaft with impellers, which are open, closed and semi-closed, designed to move and transfer energy to the pumped liquid. The energy is transferred to the shaft by an electric motor or electric drive;
- bearing units and lubrication system, to ensure free rotation of the shaft with impellers;
- sealing devices, designed to seal the machine structure against leakage of pumped medium. Various types of seals are used: gland seals, slotted seals, labyrinth seals and so on;
- electric motor or electric drive, which is assembled as a remote element, connected via a toothed coupling or made in a single housing design together with the pump. [2]

The above-mentioned fact must be discussed more particularly. Electric motors of series STM (synchronous three-phase electric motors), STMEP (synchronous three-phase motors explosion-proof), as well as asynchronous motors are widely used in petroleum transport. The fundamental problem in the exploitation of electric motors is overheating of windings and bearing units. This heat is transferred to the casing further and heats up the winding insulation. Subsequently, it reduces the service life of electric motors and the heat resistance of the insulation, which can lead to failure during long-term operation of the power unit. Cracking of insulation and loss of dielectric properties are also noted in the maintenance of pumps. The choice of secondary cooling method of the hydraulic machine electric drive depends on the possible operational modes it:

- constant nominal mode is the mode of operation when the load is constant for a long time. The operating temperature is the same at all points of the electric motor;
- short-term nominal mode is the mode with periodic start-stop of the electric machine. The temperature does not rise to its operating value. During the interval of stopping, the temperature of the electric motor drops to the ambient air temperature;
- repeated-short-term nominal mode consists of periodic shutdowns from the operation. The temperature also does not reach its operating values;
- repeated-short-term mode with frequent starts. In this case, temperature exceeding may occur due to the short time interval between starts. The temperature variation will depend on the frequency of starts and the time intervals between starts;
- repetitive-short-term operation with frequent starts and electrical braking. This mode is similar to the previous except the additional losses due to electric motor braking, which also affects the temperature rise of individual parts and accessory sections;
- intermittent nominal mode. This regime is characterized by the constancy of the electric motor operation in time, but with a period for its no-load running. The temperature does not exceed its permissible values. [1]

The electric drives of main line pumps are mostly operated in nominal mode. The possibility of overheating cannot be ruled out in this case. Therefore, an additional cooling system must be provided. In terms of cooling, motors with natural and artificial cooling are distinguished. Natural cooling is usually used for open machines.

Artificial cooling requires gas or liquid medium. An installation of impellers on the motor shaft end is an effective technique which forces an air stream onto the housing. When circulating air cooling is used internally, special air channels are made in the casing. There are two methods of air cooling:

having fans on the shaft and fans independent of the motor. It should be noted that this method is the prevention of overheating, but in the case of changing the mode of operation or increasing power, it is necessary to apply forced cooling.

Forced cooling with a fan stands out from above mentioned technologies, The impeller rotates due to its drive. Then, it is possible to increase the air flow. Also, circulating cooling systems with refrigerants are often applied for reducing the temperature. The main refrigerant is a hydrogen, which has a high heat capacity and thermal conductivity. Such units are rather expensive because they include a refrigerant cooling system with small heat exchangers.

Mixed refrigerants freons are used extensively in the field of electric drive cooling. Freon is used as a refrigerant due to its physical properties. It absorbs heat during evaporation and then releases it during condensation. The principle of operation is as follows: freon in gaseous state is extracted from the evaporator by means of compressor, compressed in mechanically reduced volume (in cylinder of air-pumps - piston), with simultaneous heating and transported to condenser. The freon cools down the motor to the ambient air temperature and enters the liquid state. The liquid freon flows through a throttling device (capillary tube or thermostatic control valve) to the evaporator, expands due to the low pressure after the throttling device, and again converts into the gaseous state. The expansion process is accompanied by the absorption of a large amount of heat, as a result of which the evaporator walls are cooled. Consequently, the temperature of the air inside the cooled volume decreases. The cycle repeats until the evaporator wall temperature drops to the value set by the thermoregulator, after which the thermoregulator opens the electrical circuit of the compressor and stops operation. After a while, the air in the cold room warms up and the thermo regulator turns the compressor back on under the influence of various factors [3]

Thus, the following common variants of optimization of cooling systems of electric pump drives can be identified:

- application of liquid circulation cooling. Oil can be selected as the liquid medium;
- selection of a blended refrigerant optimal for cooling under different operating conditions of the electric motor.
- installation of the impeller through a small multiplier, which will significantly increase the air flow rate.

Each of the methods of cooling the electric drive of the main pump has its own benefits and drawbacks. The main objective is the choice of the right energy-efficient and cost-effective system for each specific operating condition of the equipment. Undoubtedly, this topic requires more in-depth consideration, because stable and trouble-free usage of the main line pump is the key of the safe and successful oil transportation system. Hence, it is a strategically important production task.

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