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COMPARISON OF EQUIPMENT USED FOR REGULATION OF WORKING CHARACTERISTICS OF THE MAIN PUMPS ON OIL PIPELINES

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The main goal of this article is to determine the most effective and reliable method for changing the characteristics of pumping units. Since during the operation of pumping units the consumption of hydrocarbon energy carriers by consumers is unstable, the question arises of reducing the energy costs for the the electric motors input at pumping units. There are a number of methods for solving this problem. Here we will consider two basic and effective methods of regulating the performance that are currently used at the constructed pumping stations: the use of a frequency-controlled drive and a hydraulic coupling. A number of advantages and disadvantages of these methods are given and a conclusion is made as to which is more suitable both in terms of efficiency and reliability.

The condition for effective operation of pumping and compressor stations of main pipelines is continuous control of their performance. The performance control reduces energy costs and adapts the pressure and flow to the operating conditions of the transport system. So, with regard to the operating conditions of the oil transportation system seasonal fluctuations of oil consumption are unavoidable due to start-ups and stops of pump units and changes in oil flows through separate pipelines.

No pipeline works with the same capacity during the year. The reasons for work that differs from initially scheduled can be the following: insufficient amount of pumped liquid in the reservoirs, repairing works on the pipeline route without stopping pumping, organization of ground discharges, stop of the intermediate pumping stations or change in viscosity of the pumped liquid [1].

Regulation of the pump supply [2] and ensuring its operation at the required point is possible both by changing the resistance of the pipeline and by changing the characteristics of the pump. The pump speed can be changed in the following ways: either using variable speed motors or at a constant speed of the electric motor with an adjustable hydraulic clutch or a high-voltage variable-frequency drive.

The variable frequency converter (VFC) provides the ability to operate equipment at various speeds, which is realized by converting a general-purpose supply with a constant frequency and a constant voltage to a current with variable frequency and alternating voltage. Transformation is carried out electronically without moving parts and without side effects that are undesirable to the user. The efficiency of modern frequency converters ranged from 96.5% to 98.5%. One of the producers of this type of units is Danfoss which sells its production all over the world.

This method has the following advantages:

1) VFC allows regulating both minimum and maximum operating pressure at the inlet of the main pumping unit.

2) When using the VFC, no additional soft starter is required.

3) Frequency control reduces the number of replaceable pump rotors.

4) VFC can be used to redistribute oil streams when it is necessary to drop some of the oil to other directions, with the discharge being either permanent or variable.

5) Advantages of using VFC to maintain pumping modes are evident, associated with a sharp change in the rheological properties of the pumped medium (density, viscosity). For example, if one of the sections of the pipeline starts pumping oil with a higher density or viscosity, and this requires pressure increase - this is easily done by changing the speed of the pumping unit.

Above, the advantages of using VFC were compared with other frequency control methods. However, when installing an inverter, the following important aspects of its operation must be considered: significant increase in value and investment costs during operation. This type of device is also the source of electromagnetic interference.

A hydraulic drive is a set of devices designed to drive machines by means of a pressurized working fluid while performing control functions.

The adjustable turbine coupling produced by Voith is a hydrodynamic coupling. It transfers the energy coming from the engine due to the dynamic forces of the fluid flow circulating in the closed working cavity between the pump wheel on the leading (primary) shaft and a similar turbine wheel on the driven (secondary)

shaft. With a variable turbo coupling, the filling fluid can vary to any degree between the full and empty state. Due to this, infinitely variable speed control of the working machine is possible in a wide range when working with different load characteristics.

Voith company has considerable experience [3] of equipping of pumps and compressors of main pipelines with adjustable hydrodynamic drives, offering various types of hydraulic couplings for capacities up to 35 MW. One of the largest projects implemented with the participation of Voith Turbo in the CIS countries is the equipping of the East Siberia-Pacific Ocean-2 oil pipeline with the Voith hydraulic couplings.

The choice of hydraulic couplings as an adjustable pump drive is explained by a number of significant advantages:

– saving investment costs: not yielding to the frequency-controlled drive in the accuracy and speed of automatic control of the pump's performance, the hydraulic coupling has lower cost and does not require a whole series of additional investment costs.

- compactness: the hydraulic coupling occupies an area several times smaller than the frequency converter.

– high reliability and durability with minimal maintenance costs: the operating time without failures of the hydraulic clutches supplied for the ESPO-2 is 154,000 hours, and the running costs are reduced only to the replacement of oil (if the service requirements are met - every 5 years). Working for 30-40 years, the hydraulic clutch remains maintainable, while the frequency converter, due to the rapid change in the element base, becomes almost non-repairable in 8-10 years of operation.

– high adaptive ability of the hydraulic coupling for use in various designs, different operating conditions: adjustable Voith hydraulic couplings show the same technical readiness, both in the Arabian deserts and on offshore platforms of the North Sea or the Sakhalin shelf. They are suitable for operation in both high and low temperature conditions, high humidity and dust, high salt content in the air, etc.

Damping property is an important advantage [4] of the hydraulic coupling, which protects all drive elements from impact loads, thereby increasing the resources of the pump unit.

Another example of the application of hydraulic clutches for regulating the capacity of gas-pumping units in the main gas pipeline is the compressor station Cheboksarskaya (Russia) where hydraulic clutches were installed in 2005.

Nevertheless, hydraulic couplings have one drawback - it has a lower efficiency than the VFC.

Comparative characteristics of devices for regulating the speed of the VFD and the hydraulic coupling show that the first version (VFR) has large mass, several times larger than the size. This method has strict requirements at the installation site, and the time between failures is one fourth (40,000 h) of the operating time of the hydraulic clutches (160,000 h).

On the basis of the foregoing, it is obvious that the use of VFC is more effective, but is also more difficult to operate and maintain and less fault-tolerant.

Due to the high cost of the VDC equipment (about 3 times more than the cost of the hydraulic coupling) and the high cost of operating costs, the payback of the VFC relative to the hydraulic coupling during the operation period (40 years) is possible only if the oil is pumped constantly. Based on the presented criteria, it can be concluded that the hydraulic coupling is cheaper to maintain, more reliable and durable in operation.

Thus comparable analysis of equipment used for regulation of working parameters of the main pumps on oil pipelines showed that application of the hydraulic coupling is more preferable according to its operational capabilities and cost effectiveness.

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