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STUDY OF THE INFLUENCE OF THE MAIN ELEMENTS OF THE PUMPING SYSTEM ON ITS EFFICIENCY

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Abstract
The article presents the results of energy efficiency research of powerful pumping equipment for water supply. The influence of the main elements of the pumping system on its efficiency is investigated. Reliability of pumps operation is investigated.

Keywords: energy resources, efficiency improvement, pump, efficiency, inefficient operation.

Introduction

The overall energy consumption depends to a large extent on the pumping equipment. The efficiency of a pumping station is often lower than the efficiency of the individual pumps installed. The reason for low energy efficiency is a mismatch between the performance of the equipment and the system as a whole, as well as improper system management. In order to improve the efficiency of the enterprise, it is necessary to reduce the cost of operation of pumping equipment, increase its reliability and durability. Thus, modernisation of the equipment is required, taking into account all peculiarities of technological processes running in the system. The total consumption of energy resources depends to no small extent on the pumping equipment. The efficiency of a pumping station is often lower than the efficiency of the individual pumps installed in it. The reason for low energy efficiency lies in the mismatch between the operating characteristics of the equipment and the system as a whole, as well as in its improper management. In order to improve the efficiency of the enterprise, it is necessary to reduce the cost of operation of pumping equipment, increase its reliability and durability. Thus, modernisation of the equipment is required, taking into account all peculiarities of technological processes running in the system [1].

PROBLEM DISCUSSION

According to various estimates, up to 20-25% of the world's consumption of all electricity generated is for pumping equipment. In some industries this figure reaches 50% or more. Along with oil production, oil refining, chemical, pulp and paper industries, such industries include water supply and wastewater disposal, where up to 85% of pumping equipment operation costs are electricity costs. Since reduction of energy consumption for water supply organisations is a priority task, the economic efficiency of the water supply and sewerage sector as a whole is directly related to the use of pumping equipment. The current practice shows that pumping equipment is extremely inefficient. There are many cases when the efficiency of pumping systems does not exceed 10-20%, while the efficiency of pumps installed in them is 60-90%. The main reasons for inefficient operation of pumping equipment are: - installation of pumps

with head and flow rates exceeding the system requirements; - regulation of pump operation by throttling (using a throttle valve); - wear and tear of the equipment.

MATERIALS AND METHODS.

Let us consider the influence of the main elements of a pumping system on its efficiency. In general, a pumping system consists of a pump, pipework, shut-off control valves, suction and pressure tanks, as shown in Fig. 1.

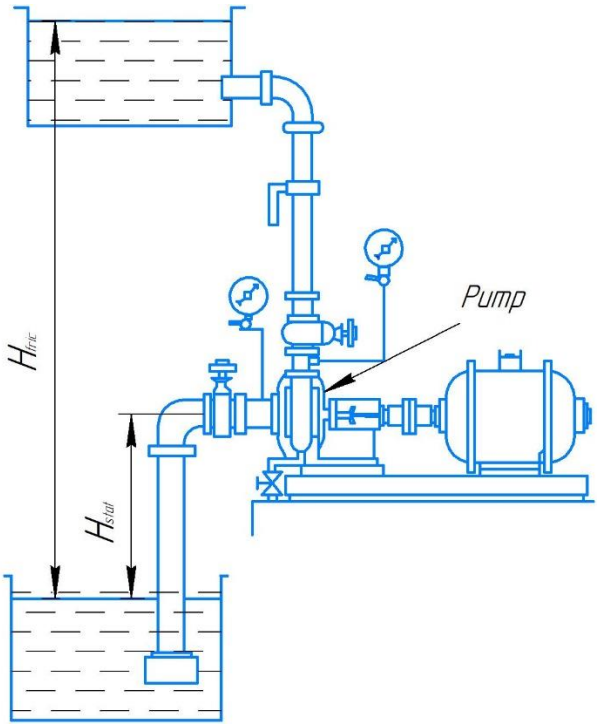

Fig. 1. General scheme of the pumping unit

Each of the system elements has its own hydraulic characteristics. The system characteristic includes two components: static head and dynamic head (friction losses). In general, the system characteristic is described by the following relationship [2,3]:

$$H_{sys} = H_{stat.} + H_{fric.}$$

The static head ($H_{стат}$.) is characterised by the geometric height to which the liquid must be lifted. Sometimes to the value of the pressure difference between the receiving and pressure tanks.

Friction losses ($H_{трен}$.) are the totality of all losses occurring in the system during fluid movement (friction in pipelines, losses in pipe fittings, etc.) depending on the value of the flow rate. In general, friction losses are determined by the formula:

$$H_{fric.} = k * Q^2$$

Q^2 is the flow rate;

k-proportionality coefficient.

A typical characteristic of the centrifugal pump most commonly used in water supply systems is shown in Figure 2.

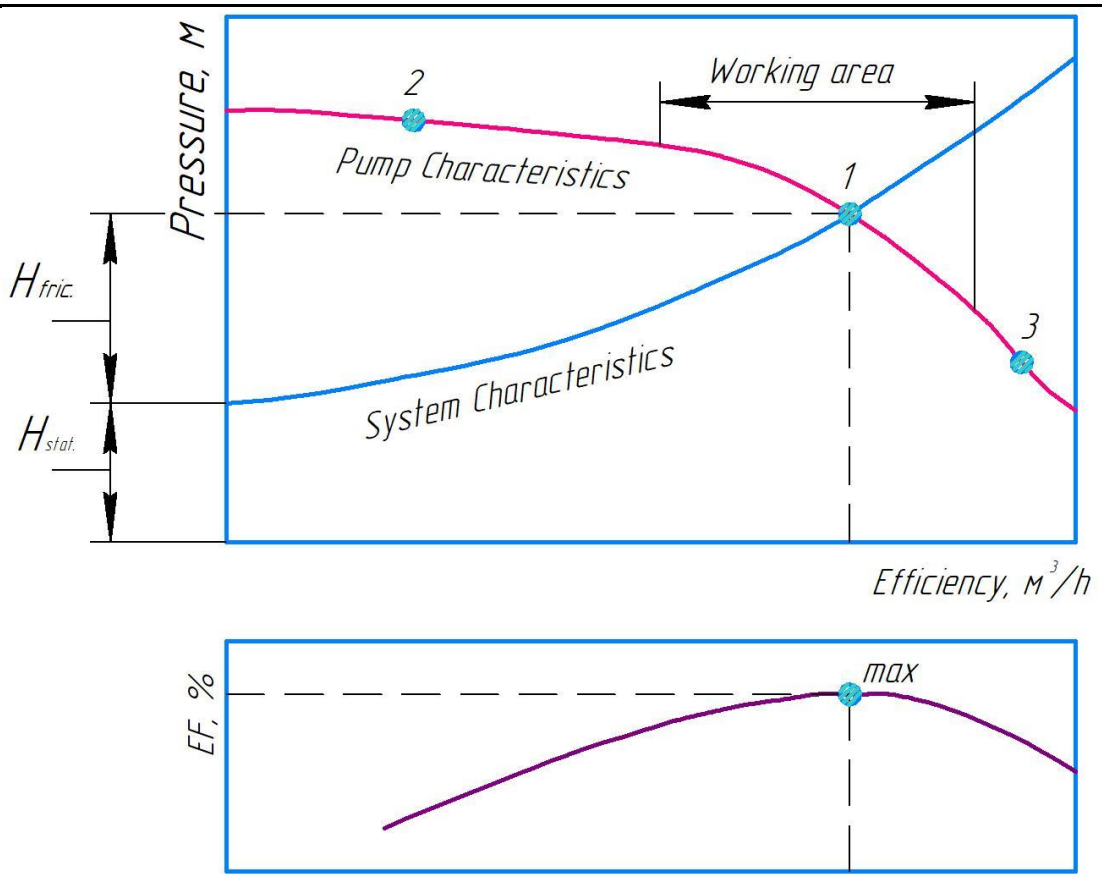

Figure 2. Pump and system characterisation. Pump operating modes

As a rule, the pressure-discharge characteristic of a pump indicates its operating range, i.e. the range of operating conditions that guarantee maximum reliability and the highest efficiency. The operating point of a pump installed in a system is determined by the intersection of the pump characteristic with the system characteristic. This point must be in the operating range of the pump characteristic (point 1, Fig. 2) [4,5]. If this condition is fulfilled, the efficiency of the pump reaches its maximum. Operation of the pump within the permissible range also ensures its reliability, while operation in the uncalculated range is characterised by low efficiency (points 2 and 3, Fig. 2).

RESULTS AND DISCUSSION

The consequence of operating the pump in uncalculated modes is also a significant reduction in its reliability, namely the occurrence of mechanical problems such as: - bearing failure; - mechanical seal failure; - shaft failure; - increased vibration[6,7]. The most common causes of equipment failure and the corresponding pump reliability curve depending on the location of the operating point are shown in Fig. 2.3

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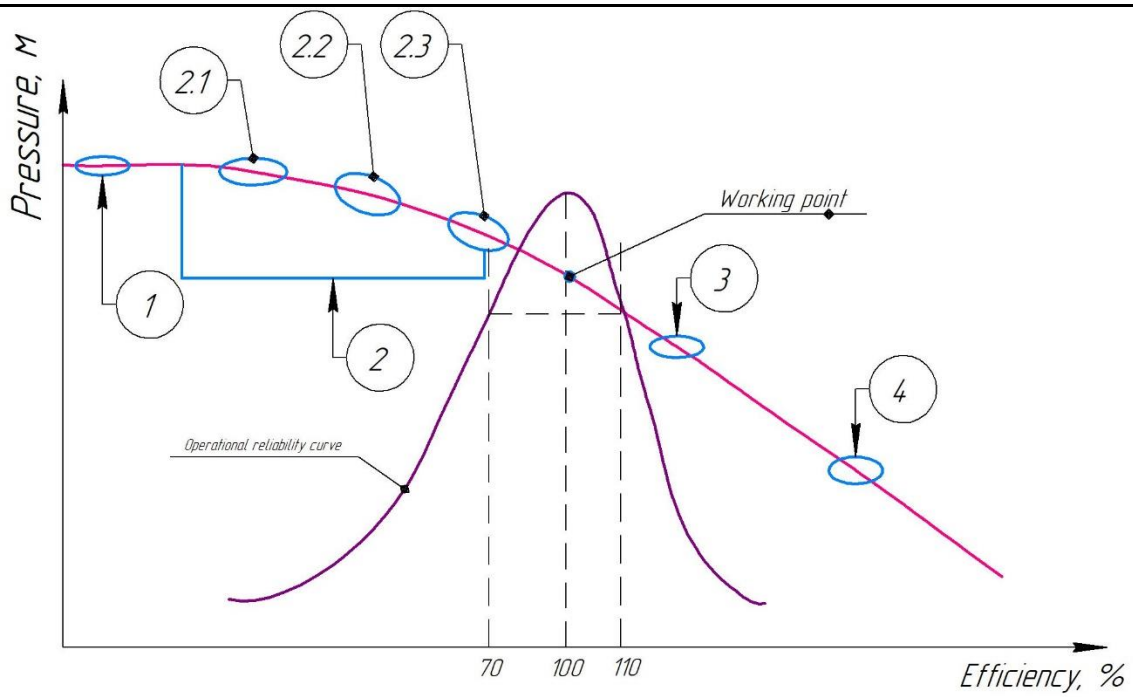

Fig. 2.3 Pump reliability curve as a function of the operating point position

As a consequence of the pump operating outside the operating range, there is: - significant temperature rise (point 1, Fig. 2.3); - reduction of the service life of bearings and seals (point 2, Fig. 2.3) due to vibration due to: possible cavitation (point 2.1), occurrence of flow recirculation at the inlet (point 2.2) and outlet (point 2.3) of the impeller; - reduction of the service life of bearings and seals due to vibration caused by flow detachment in the flowing part (point 3); - cavitation, overloading of the electric motor (point 4).

CONCLUSION

As a result of these problems, consumers often have the misconception that pumps are unreliable and inefficient, overlooking the fact that the cause of the malfunctions is due to incorrect operation at non-calculated conditions. In this connection, it should be emphasised once again that one of the main conditions for efficient and reliable pump operation is that the operating point of the pump is within its permissible operating range.

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