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DEVELOPMENT AND JUSTIFICATION OF ENERGY-SAVING METHODS OF OPERATING MODES CONTROL OF CENTRIFUGAL PUMP UNITS

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Oybek Mukhammatkulovich Kurbonov
Navoi State Mining and Technological University, P. M.B 210100, M. Torobiy street 129-building, 29-apartment, Navoi, Uzbekistan
Contact information: tel. (998 97) 228-25-06
e - mail: agent7001.oq@gmail.com
oybek7001@mail.ru

Abstract.

Rational and energy efficient operation of drainage equipment used at mining enterprises is possible through the introduction and use of modern methods of controlling the operating modes of the pumping unit.

Now, the methods and means used for regulating the operating modes of pumping units do not meet modern requirements, and many enterprises still use outdated methods for regulating the operating modes of pumping units, which entails significant energy losses and an increase in the cost of the product obtained.

In our article, we examined and substantiated experimentally the possibility of achieving savings in electrical energy, as well as increasing the reliability of operation of pumping units based on the use of modern methods of regulating operating modes.

Key words.

pump, energy efficiency, operating mode, supply, choke, gate valve, characteristic, pressure, and fluid flow rate.

Introduction

One of the most effective ways to increase the efficiency and economy of pumping units operating with variable load, perhaps, is the use of an adjustable electric drive. The carried out studies of the results of the use of a REB showed that in some cases its installation leads to a tangible energy saving, and in others it is insignificant, and thirdly, the installation of the drive does not provide economic operation. The study of methods and forms of application of a variable speed drive indicates that in practice, the most technically simple and economically least effective methods of controlling pumping units are used, such as stabilizing the pressure at the pump outlet. The degree of utilization of the energy saving potential, in this case, is no more than 16-26%, which leads to the fact that most of the potential, even after the installation of a variable speed drive, remains unclaimed. One of the main reasons for this situation is the insufficient study of the influence of a controlled electric drive on the operation of drainage plants [1].

However, the issues of choosing the optimal operating modes of pumping units depending on the operating conditions have not been thoroughly studied. Research and determination of optimal operating modes of pumping units under various operating conditions is an urgent scientific and practical problem, the solution of which leads to an increase in the reliability and efficiency of pumping units of industrial enterprises [2].

Purpose of the work

The aim of the research is to develop effective methods of energy saving during the operation of pumping units based on the use of modern automation and optimization control methods.

Discussion of the problem

The problem of growing electricity shortages can be most effectively solved on the basis of the development of energy saving systems and means. Reducing energy costs is primarily achieved by increasing the efficiency of its use [12].

Pumping equipment of various technological cycles is one of the most significant consumers of electricity in industry [3].

The issues of energy saving during the operation of pumping units are very urgent and require increased attention from both designing and operating organizations.

Operation of the pump in rational modes of operation ensures its reliability, while operation in irrational modes is characterized by a decrease in the efficiency [4].

In case of irrational operation, the following mechanical problems arise: failure of bearings, failure of mechanical seals, breakage of shafts and increased vibration [5].

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. 1.

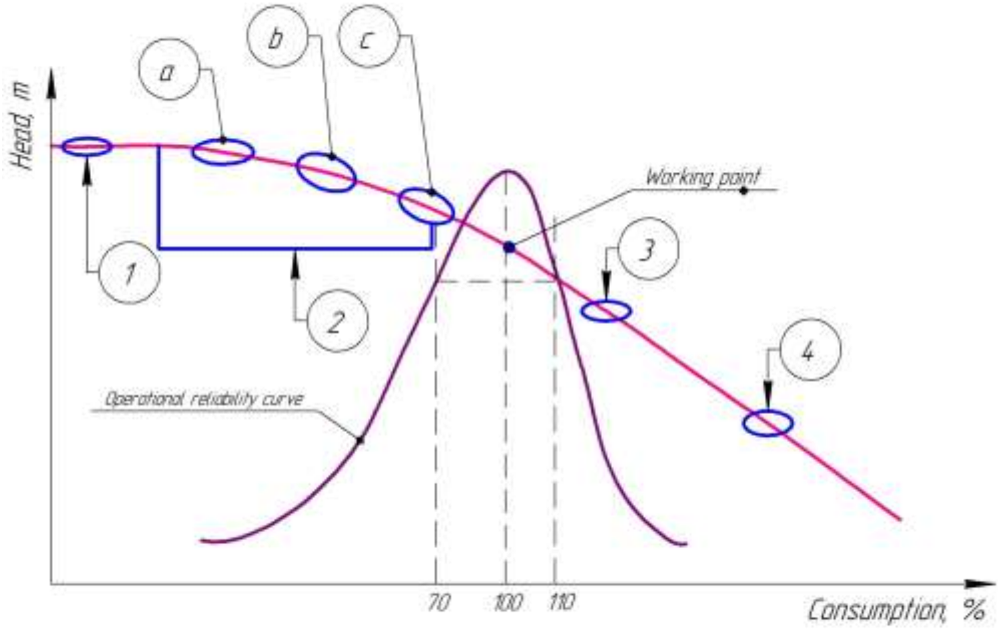

Figure 1: *Pump reliability curve versus duty point position.*

1- significant increase in temperature 2-. reduction in the service life of bearings and seals: a- due to vibration reason: possible cavitation, b and c- the occurrence of flow recirculation at the inlet and outlet of the impeller, 3- reduced service life of bearings and seals due to vibration caused by flow separation in flow path, 4- cavitation, overload of the electric motor.

In connection with the occurrence of these problems, consumers often have a false opinion about the unreliability and inefficiency of the pumps, while it is overlooked that the cause of the malfunctions is improper operation in irrational modes. One of the main conditions for efficient and reliable operation of the pump is finding the operating point within its optimal operating range [9].

The implementation of energy-saving measures determines the need to improve the performance of centrifugal pumps, which are the most common type of pumping equipment [6].

The basis for increasing the efficiency of centrifugal pumps is the improvement of operating modes, depending on the operating conditions, which significantly affect the efficiency of a centrifugal pump [11].

To solve the problem associated with the exceeded indicators of the head and flow of the pump, it becomes necessary to change the operating parameters, which causes a change in the characteristics of the pump and system. The lack of regulation of pumping units significantly affects its efficiency. Since the volume of water consumption at enterprises is not constant and with small needs, part of the energy is lost [10].

The choice of the optimal operating modes of the pumping unit is a difficult task, which predetermines the effectiveness of the main parameters of the unit as a whole; the determination of the optimal operating modes of the pumping unit requires experimental research.

Materials and methods

The issues of energy-saving modes and methods of effective control of the modes of dewatering plants were considered by many authors who studied the problems of optimization and improvement of operational parameters, while many dependencies that affect the operating mode of pumping units, such as changes in the static and dynamic liquid level, as well as external factors and composition of the liquid [6,7,8,9,10].

To determine the main dependencies that affect the effective operation of drainage installations, we carried out experimental studies of the operation modes of the installation.

The study of the operating characteristics of a centrifugal pump with various control methods was carried out on laboratory installations SGU-TsNS-012-6LR-PK, which contains a centrifugal pump, a pressure meter, a flow meter, controls and controllers. A general view of the laboratory setup SGU-CNS-012-6LR-PK, on which the experimental work was performed, is shown in Fig. 2.

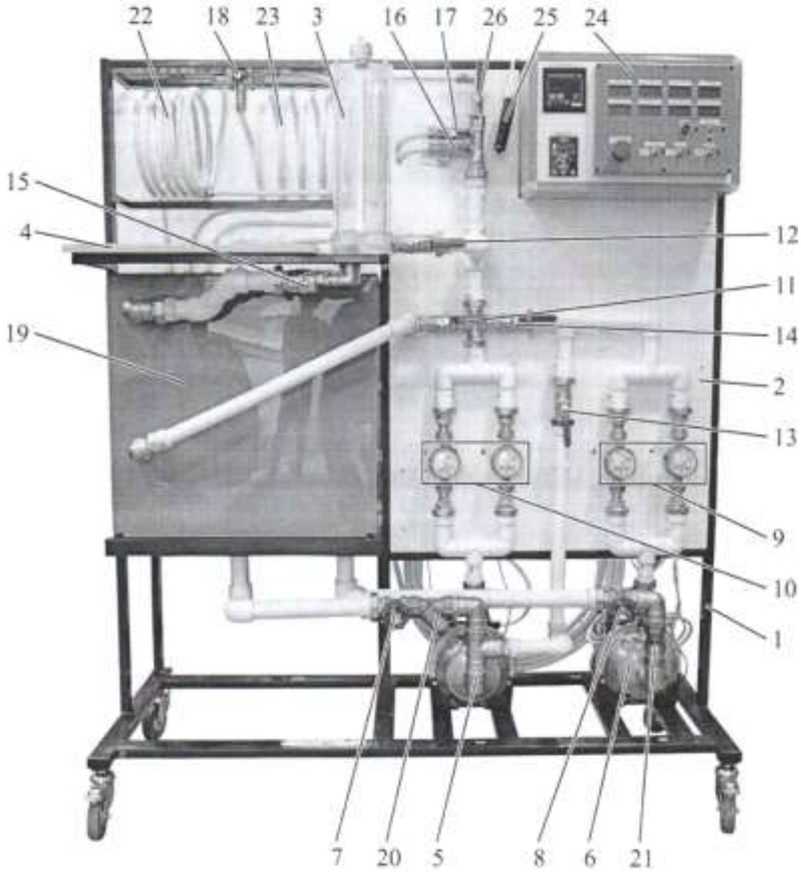

Figure 2: *Laboratory stand SGU-CNS-012-6LR-PK.*

1- Frame, 2- mounting panel, 3- dimensional container, 4- shelf for PC (laptop), 5- centrifugal pump with frequency control, 6- centrifugal pump, 7,8- gate valves, 9,10- flow meters, 11, 12,13,14,15 - ball valves, 16,17,18,26 - taps, 19 - tank, 20.21 - filters, 22,23 - pipelines, 24 - electronic control unit, 25 - stopwatch control knob.

During the experiments, the pressure-flow characteristics of the pump and the pumping station were measured, the pressure and flow rate of the liquid at various points of the system were determined.

Results and discussion

The results of the experimental studies carried out made it possible to obtain the following results, which will lay the foundation for energy saving during the operation of pumping units.

Experimental work yielded the following results:

- Dependence of the power consumption of the pump (W) on the pump flow when regulating the flow using a proportional valve;
- Dependence of the power consumption of the pump (W) on the pump flow when regulating the flow using a frequency converter;

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- Dependence of the power consumption of the pump (W) on the pump flow when regulating the flow using a frequency converter and a PC.

Figure 3 shows the graphical dependence of the pump power consumption (W) on the pump flow (l/min) when the flow is controlled using a proportional valve. On which it is observed that with an increase in the pump flow for every 14 l/min, the power consumption increases by 150 W.

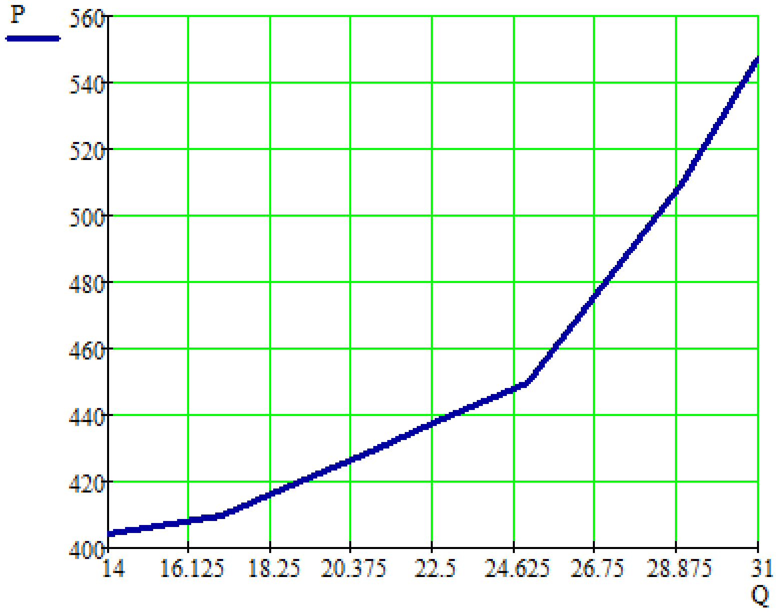

Figure 3: Graphical dependence of the power consumption of the pump (P, W) on the pump flow (Q , l/min) when regulating the flow using a proportional valve .

In fig. 4 shows a graphical dependence of the pump power consumption (W) on the pump flow (l / min) when regulating the flow using a frequency converter.

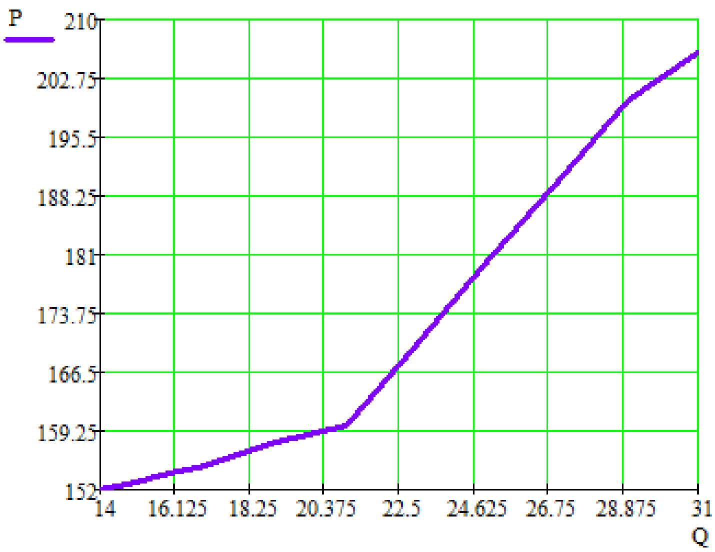

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Figure 4: shows a graphical dependence of the pump power consumption (W) on the pump flow Q (l/min) when regulating the flow using a frequency converter.

In fig. 4, an increase in power consumption is also observed, in this case, with an increase in pump flow for every 14 l/min, an increase in power consumption by 50 W occurs. Thus, the use of a frequency converter allows you to obtain the required supply, consuming only 60 W of electrical energy.

Savings when using a frequency converter instead of a proportional valve is about 250 W, for 14 l/min, which is also shown in the form of a graph in Fig. 5

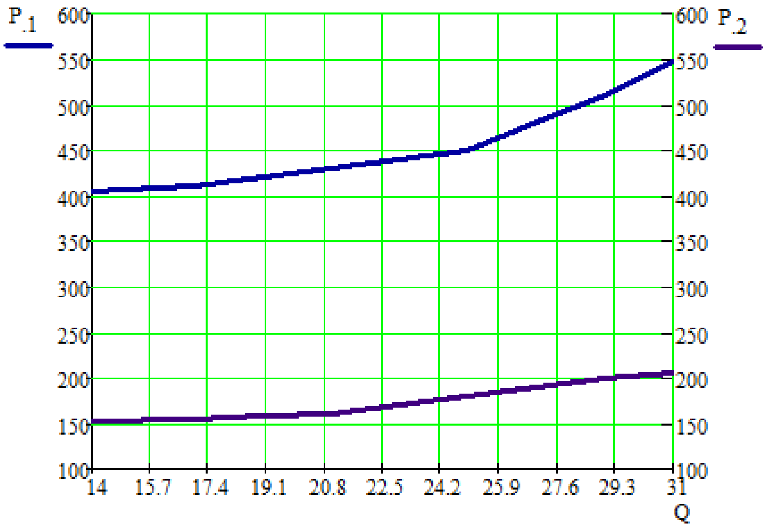

Figure 5: Graphical dependence of the pump power consumption (W) on the pump flow (Q, l/min) when regulating the flow using a proportional valve (P1, W) and a frequency converter (P2, W).

The most economic benefits of the operation of pumping units, it is possible to obtain using a frequency converter and personal computer, PC with regulation of operating modes. In fig. 6 shows a graphical dependence of the power consumption of the pump (W) on the pump flow when regulating the flow using a frequency converter and a PC.

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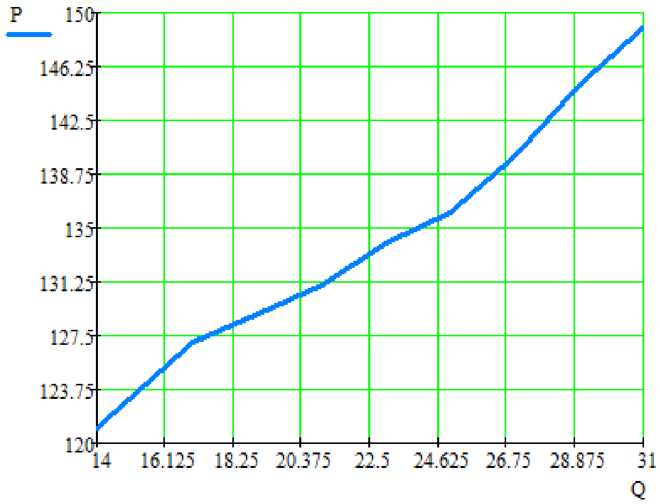

Figure 6: Graphical dependence of the power consumption of the pump (P, W) on the pump flow (Q, l / min) when regulating the flow using a frequency converter and a PC.

From Figure 6, it is observed that the use of a frequency converter and a PC to regulate the pump flow contributes to significant savings in the electrical energy consumed by the pump drive, while the savings in electrical energy consumed for the same received supply is 110 W.

The effectiveness of a particular control method is determined by the characteristics of the system and its change over time. In each case, a decision must be made depending on the operating conditions and characteristics of the system. When choosing a method of regulation, it is very important not to fall under the influence of the stereotypes that have developed recently. So, according to one of them, the use of a frequency converter helps to reduce energy consumption. However, frequency regulation does not always lead to a decrease in power consumption, and sometimes even gives the opposite effect. The use of frequency control is advisable when pumps are operating in a system where friction losses prevail (friction losses in pipelines and valves) [13].

Conclusions

Our studies have made it possible to obtain the following main conclusions, which in the future allow us to select successfully the optimal methods for regulating the operating modes of centrifugal pumping units.

In the course of the studies, it was found that the use of the proposed equipment allows reducing energy costs by 67% during the operation of pumping units.

In addition, it helps to increase the efficiency of pumping units, reduces the likelihood of sudden failures, and increases the safety of workers.

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