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SOME PROBLEMS OF SAVING WATER AND ELECTRICITY IN IRRIGATION SYSTEMS OF UZBEKISTAN

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НЕКОТОРЫЕ ПРОБЛЕМЫ ЭКОНОМИИ ВОДЫ И ЭЛЕКТРОЭНЕРГИИ В ИРРИГАЦИОННЫХ СИСТЕМАХ УЗБЕКИСТАНА

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Аннотация. Поскольку доступ к водным ресурсам во многих регионах мира становится ограниченным, все более важным становится эффективное и устойчивое орошение. Все дело в обеспечении достаточного количества влаги для максимального урожая без использования избыточного количества воды и энергии, чем это абсолютно необходимо. Откачка воды для орошения может быть значительным расходом для орошаемых земель. Повышение эффективности насосной станции является сегодня очень актуальной проблемой еще и потому, что она повышает рентабельность орошаемых земель. Стандартная процедура проектирования насосной станции заключается в выборе насоса, удовлетворяющего максимальным требованиям как по расходу Q, так и по давлению H. По этой причине насосы часто бывают слишком мощными, слишком большими и неэффективными. В статье рассматривается возможность снижения энергопотребления насосного агрегата за счет применения методов управления работой электропривода. Материалом для статьи являются результаты расчетов по повышению КПД насосной станции «Хамза I», которая входит в систему Аму-Бухарского машинного канала (АБМК).

Ключевые слова: дебит; давление; регулирование частоты; Преобразователь частоты; гидроудар; БТИЗ транзистор.

Abstract. In terms of the area of irrigated land used in agriculture, Uzbekistan occupies one of the first places in the world. To date, more than 2.1 million hectares of land are covered by irrigation systems. For irrigation, 1130 pumping stations are used, of which 76 are large with a capacity of Q = 100m^3/sec, 496 stations of medium power with a capacity of Q = 10m^3/sec and 561 small pumping stations with a capacity of Q = 1m^3/sec. In terms of electricity consumption, pumping stations use more than 20% of the total volume of energy produced in the Republic per year. Taking into account the climatic changes that have begun in the world, and also bearing in mind the shortage of water and electricity in the republic, there is an urgent need to regulate the performance of pumping units. In the world practice of pumping stations operation, to regulate the productivity of the "pump-pipeline" system, [1] are used: bypass lines; throttle valves; standby pumps; systems for regulating the speed of rotation of the impeller of a centrifugal pump. Analysis shows that these methods are ineffective in terms of saving electrical

energy, and the method of turning on and off the standby pump unit creates a risk of water hammer in the supply pipeline system. It is well known that the rotation speed of the pump impeller directly depends on the rotation speed of the drive shaft. Slowing down the rotation of the impeller reduces the amount of energy transferred to the water, and therefore the power consumption of the pump. Its rotation speed can be controlled in several ways [1]:

• Mechanical methods: variable speed pulleys; the pump is directly connected to the mechanical motor; replaceable reducer

• Couplings: hydraulic and magnetic

• Electric method (asynchronous motors with variable frequency drive).

The operating experience of pumping units shows: mechanical control methods are dangerous due to hydraulic hummer in the pipeline system, as for speed control by couplings, their use is limited by the capacity of the pumping units. Today, the most used methods for regulating the performance of the pump-pipeline system are: regulation with valves on the pipeline and regulation with the speed control of the Asynchronous Electric Drive of the pump using the Frequency Control method. In work [3], studies have been carried out that determine the effectiveness of both methods from the point of view of energy saving.

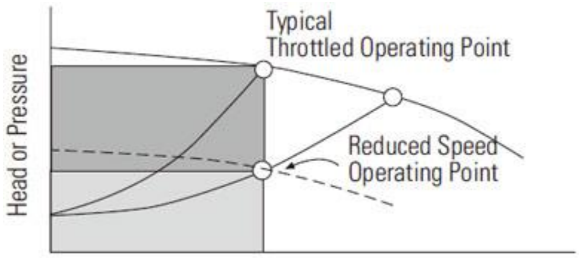


Fig 1 Diagram of operation water pump with Variable Speed Drives (VFD)

It is clear from Fig. 1 that when regulating the pump performance Q by throttling with a valve, we certainly reduce Q, but at the same time the consumption of electrical energy not only does not decrease, but even increases due to an increase in pressure in the pipeline and, as a consequence, friction losses increase. This can be seen from the resistance curve of the "pump-pipeline" system (Fig. 1). If we reduce the rotation speed of the pump impeller, adjusting the speed of the electric motor, then in this case we reduce the pressure H in the pipeline, we obtain a given performance Q and save electrical energy. This can be seen from the graph in Fig. 2.

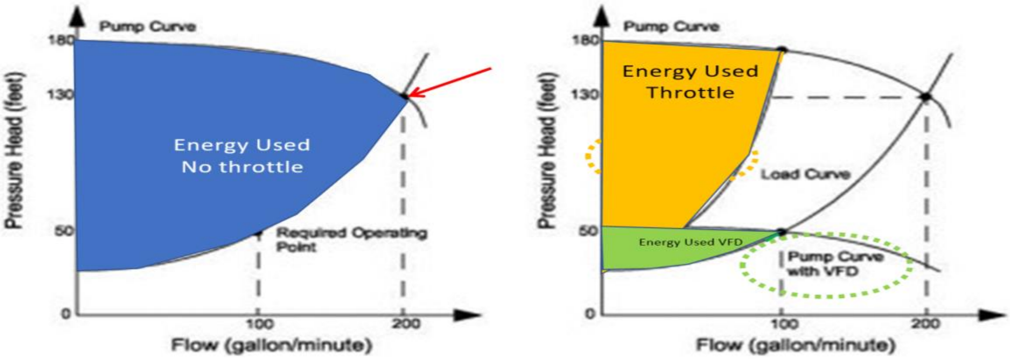


Fig 2 Diagram of the distribution of electrical energy consumption: a-without regulation of the pump rotation speed; b-with regulation of the speed of rotation of the centrifugal pump.

Comparing the energy consumption in Fig. 2 a, b, it can be seen that with the same operating parameters of the pump, the energy consumption in the case of Fig. 2a is much higher than in the case of Fig. 2b when we adjust the operating parameters of the pump with a throttle valve and change the speed of the pump electric drive using the VFD system. A particularly large gain is given to us by the use of a VFD speed control system. Based on the results of the analysis, the article investigates the effect of energy savings when operating a centrifugal pump when using a VFD speed control system of an electric pump drive.

II Methods.

It is known that centrifugal pumps operate following the law of similarity, and of course these laws regulate the operation of the impeller in the entire speed range [2].

$$Q2=Q1 \times (n2/n1) \qquad (1);$$

$$H2=H1 \times (n2/n1)2 \qquad (2);$$

$$P2=P1 \times (n2/n1)3 \qquad (3);$$

According to the laws of similarity, the flow Q of an impeller of a given diameter will change in direct proportion to the speed n of the impeller according to (1), while the pressure H created by the pump will change in proportion to the square of the speed (2). The power P required to rotate the impeller will vary in proportion to the cube of the speed. The main parameter that allows smoothly and in a wide range to regulate the rotation speed of the Asynchronous Motor (IM) of the centrifugal pump drive is the frequency f. Analysis shows that today Frequency Control (PD) is the most effective method for controlling the speed of blood pressure [3]. This method provides significant energy savings and high control accuracy. The task of the frequency converter is to regulate the performance. If it is necessary to increase the pump performance, the frequency converter increases the pump rotation speed, if it is necessary to decrease the performance, it decreases it. The peculiarity of the VFD method is that by changing the frequency it is necessary to change the stator voltage of the AM –U.

$$\frac{U}{f^2} = \text{const} \qquad (4);$$

$$n0 = \frac{60f}{p} \qquad (5)$$

Expressions (4.5) are a mathematical expression of the VFD law.

Formula (4) shows the law of voltage change U, to control the operation of centrifugal pumps and fans.

The method is technically implemented by the VFD scheme in Fig. 3.

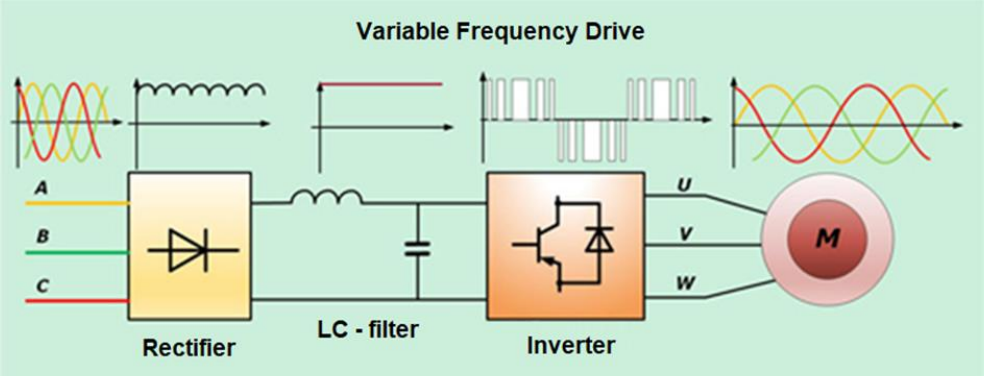


Fig. 3. a) Block diagram of the VFD system for the electric drive of a centrifugal pump.

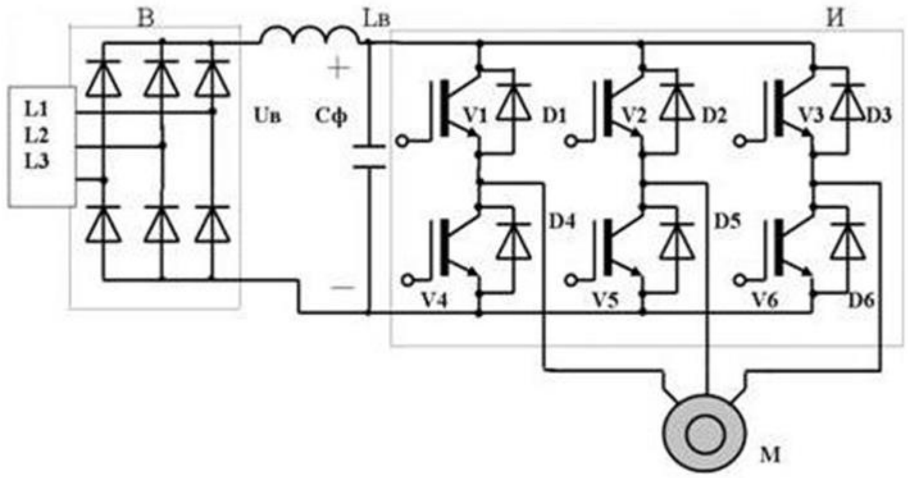


Fig. 3. b) Schematic diagram of a VFD regulator for an electric drive of a centrifugal pump.

The VFD block diagram, Fig3 (a), consists of a diode rectifier, an L-C filter, and an Autonomous Inverter (AVI) controlled by a Pulse Width Modulator (PWM). The value of the circuit also lies in the fact that the PWM system allows you to control the speed of Induction Motor(IM) while simultaneously changing the frequency f and voltage U using the digital form of the signal generated by the Automatic Control System (ACS) [4,5].

III. Results and Discussion

Using formulas (1-5), we calculated the economic effect of regulating the speed of the pump drive BP using the VFD system. For the calculations, we used the technical data of the Hamza I pumping station, which is part of the pumping station system of the ABMK-Amu Bukhara Machine Canal association. The station is used to supply water from the Amu Darya river to the main irrigation canal. Pump capacity Q = 3600m^3/min and lift height (pressure) H = 120m. Using formulas (1-3), we calculated the change in the main parameters of the Pumping Unit and the possible saving of electrical energy depending on the change in the rotational speed of the electric drive.

Table 1 Parameters of the AD drive of the centrifugal pump.

Type of I.M	$P_н$, кVT	n, rotating/min	Eff, %	cosϕ	Km	Weight(Kg)
450 X 613 6кV	500	1000	94,4	0,85	1,8/2,2	2620

Table 2 Range of changes in the rates of blood pressure depending on the change in frequency f.

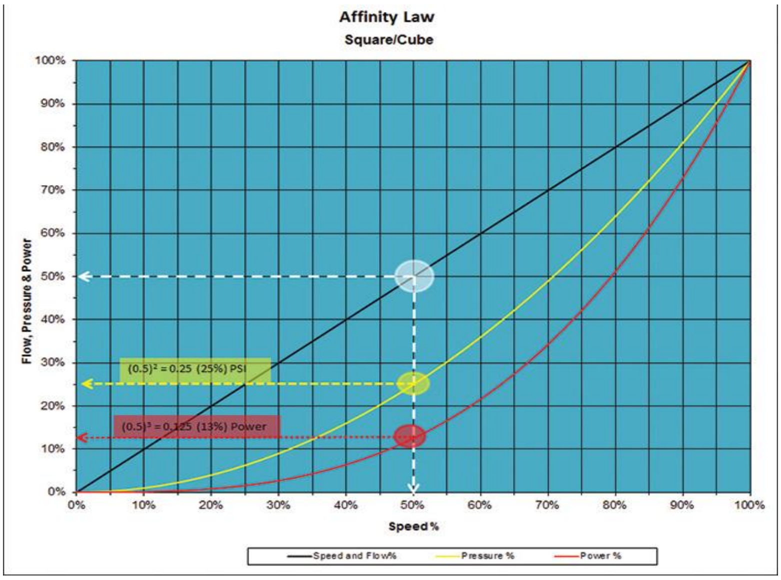
f(Hz)	25	35	40	45	50
n(%)	50	70	80	90	100

The calculations used formulas (1-5) The calculation results are summarized in Table 3

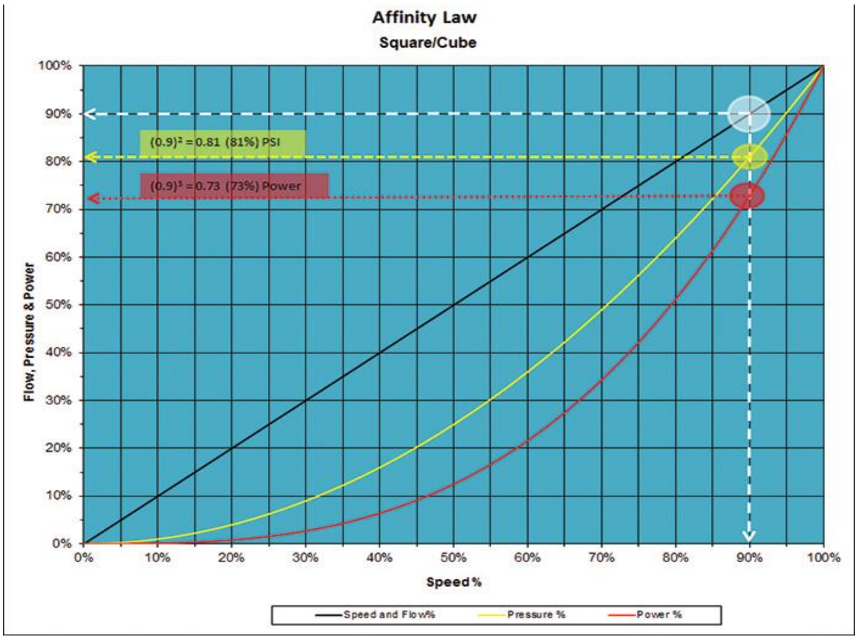
Table 3 Parameters of the pumping unit with variable speed.

F(Hz/%)	25/50%	35/70%	40/80%	45/90%	50/100%
n(rpm)/%	500/50%	700/70%	800/80%	900/90%	1000/100%
Q(m3/min)/%	1800/50%	2520/70%	2880/80%	3240/90%	3600/100%
H(m)/%	30/25%	60/49%	77/64%	97/81%	120/100%
ɤP(кW)/%	66/13%	181/39%	271/51%	386/73%	529/100%

Based on the results of calculations, graphs of changes in the main parameters of a centrifugal pump were plotted depending on changes in the rotation speed



4a- for f = 25Hz;



4b - for f = 45 Hz; n = 90% nn

Fig 4 Graph of changes in the operating parameters of the VFD system of a controlled electric drive of a centrifugal pump.

Thus, the analysis of Figures 2, 4 shows that with a decrease in the speed of rotation of a centrifugal pump, according to the affinity law, simultaneously with the saving of electrical energy (3), the performance of the pump Q (1) decreases and the pressure in the pipeline H (2) decreases. Results of experiments carried out at the pumping station

Hamza I showed that when using a speed control system for an electric drive of a centrifugal pump, the most optimal results, taking into account all three pump performance indicators (Q, H, P), are given by regulation in the range (100-80)% of the rotation speed n Fig. 5.

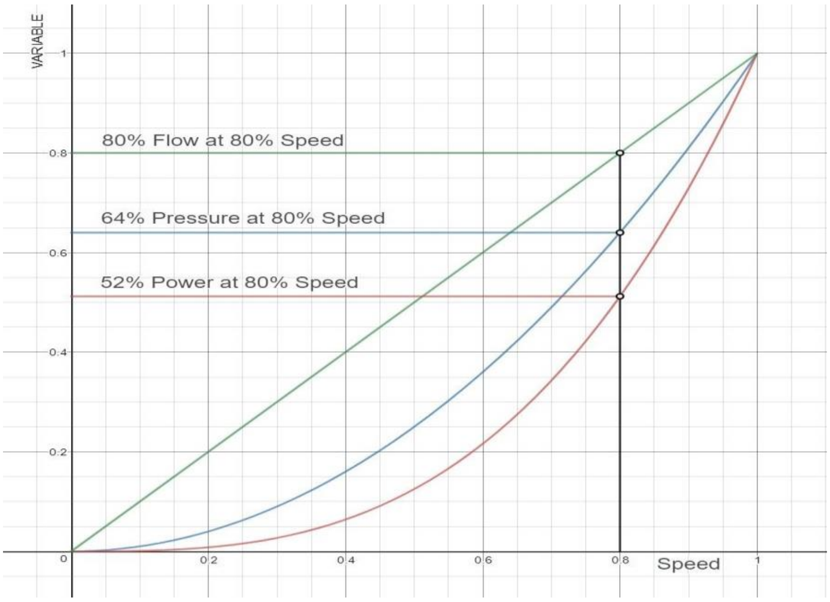


Fig. 5 Graph of changes in the main indicators of the electric drive of a centrifugal pump at n = 80% nn

The results of the experiment are calculated and placed in Table 4.

Table 4.

% speed	% flow Q	% Power consumption
100	100	100
90	90	73
80	80	51
70	70	34
60	60	22
50	50	13
40	40	6
30	30	3

Conclusion.

1. The projected climatic changes in the CA region pose stringent requirements for irrigation systems used for irrigated agriculture in terms of water and electricity savings.

2. The most noticeable advantage of variable speed pumps is the energy

savings, which in many cases are quite significant.

3. Of all the possible options for controlling the speed of a centrifugal pump, the optimal is the frequency control of the speed of the electric motor.

4. The use of a frequency converter allows not only to stabilize the pressure in the network, but also to achieve the necessary smoothness of its change when the pump is turned on and off.

5. The use of PD to regulate the speed of a centrifugal pump, gives a practical effect in the frequency range from f = 0 to f = 50 Hz. The specificity of the PD law does not recommend using frequencies f> 50 Hz because of the need to increase the voltage U>Un.

6. The calculation results given in the article show a sustainable economic effect, up to 50% savings in electrical energy used at the pumping station due to the use of the VFD system.

7. The use of VFD, in addition to saving energy, has the effect of reducing vibration and increasing the life of the seals in the valve system. This is very important for used hydraulic systems.

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