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Study on issues of uninterrupted power supply, energy-saving and improving the quality of electrical energy of water facilities

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Abstract. This paper analyses the results of studies of uninterrupted power supply, energy saving issues, problems of improving the quality of electrical energy of irrigation pumping stations and electrical consumers of water facilities. The current state of the power supply system is described, and the analysis of the existing situation is carried out. On the basis of comparison of theoretical calculations and practical measurements of the consumption of electrical energy, discrepancies in the results were determined. A solution was found to the problem of reducing the actual consumption in relation to the calculated ones. Recommendations are given for ensuring uninterrupted power supply, solving the issues of increasing the energy efficiency of the equipment in operation for energy conservation and saving electrical energy by improving quality indicators.

1. Introduction

A rapid growth of population requires a sharp increase in food production consisting mainly of agricultural products [1]. At the present time, a huge amount (about 28 million hectares) of land in Uzbekistan is allotted for agricultural land [2]. These territories are located in areas with different natural conditions, sometimes often not ensuring the timely availability of the optimal ratio of all factors for the normal growth and development of plant.

According to the climatic indicators of the natural zones of the Republic of Uzbekistan, the amount of precipitation ranges from 100 to 200-250 mm. During the summer months, very little precipitation falls, but the average evaporation rate is more than 1400-1700 mm. Natural moisture is extremely low;

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the temperature regime is highly changeable. The average temperature in the summer month of July is 26-320C in July, in winter it ranges from 10 to 140C. The annual total air temperature at 100C is 3600-55000C. The annual frost-free period ranges from 195 to 254 days [2].

Abundant heat and light favors the cultivation of valuable heat-loving crop, cotton, wheat, rice, vegetables, grapes and other food and industrial products [3, 4]. However, these agricultural products can only be grown through irrigation.

When the natural moisture ranges from 2 to 7% [2], with such an amount of precipitation, it is impossible to grow agricultural products. Therefore, additional watering is required for normal plant growth and development.

In the zones of cultivated agriculture, land irrigation has a number of features. With low amounts of earth's precipitation in the soil, a sufficient supply of moisture is not created; therefore, irrigation is sometimes necessary before sowing agricultural crops [5]. In addition, high air temperatures and low air humidity lead to a significant increase in water consumption by plants in cultivated areas. Therefore, frequent watering with large rates is necessary.

To achieve the rapid development of the plant and obtain a high yield, it is recommended to irrigate with running river water with a temperature above 15 ^{0}C. Watering with warm water at 15 – 20 ^{0}C helps to strengthen the root system of the plant, improve the quality of products, reduce the consumption of water consumed per unit of yield from 6 to 20% and increase the yield of 14-20% [2, 6].

Suspended sediments contained in the flowing waters of rivers improve the aggregate and agro technical state of the soil [7, 8]. In the process of sedimentation of water sediments, potassium carbonate accumulates from the irrigation water and is enriched with organic substances, which contributes to the formation of a lumpy soil structure. Fine fractions of clayey sediments with a particle size of less than 0.005 mm contain nutrients and have a high agrochemical value [2, 9]. In terms of chemical composition, suspended sediments are close to clays, where silica, alumina, humus predominate and contain calcium salts and organic substances, which contributes to the creation of aggregates and a lumpy soil structure. Therefore, great importance depends on irrigation with river water in which the amount of sediment is mainly 1.5 kg / m^3.

In irrigation water, the permissible content of soluble salts is up to 0.10 %, that is, 1 g/l, while about 1000 g of dissolved salts enters the soil for every 1000 m^3 of water. The permissible content of salts in irrigation water also depends on its chemical composition and water-physical properties of soils: it is higher on light soils than on heavy ones. When water mineralization is from 2 to 5 g/l, it is necessary to take into account the chemical composition of salts, the properties of soil and irrigated crops [1].

Among the Central Asian states in the Republic of Uzbekistan, due to the favorable geographic location, convenient weather and climate conditions, a rich soil environment, a high culture of agriculture, the use of modern and highly efficient technology and technology for growing crops is of great importance to the problems of water supply.

According to the above-described nuances of the culture of agriculture and the absence of natural sources of running water for water supply of the region, water supply issues importance.

The next reason for a serious approach to water supply is the consumption of water from the Transboundary Rivers Amu Darya and Syr Darya in standardized valuesusing machine lifting.

This circumstance is associated with the preparation and solution of a number of complex tasks in the field of transportation, storage, supply of water, the degree of readiness of mechanical machines and pumps and a mechanical drive, power supplies, power transformer substations, power lines, switchgears, electric motors, automatic control systems, monitoring and metering systems, etc.

Depending on the nature of the terrain, the height of the irrigated water rise, unfavorable climatic conditions, the complex composition of the soil and the terrain, which is not uniform in different regions of the Republic, the issues of water supply and irrigation of the areas of cultivated crops acquire a different nature and importance in, which requires an inadequate solution and the degree of complexity of the tasks.

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Especially irrigation and water supply is carried out with the help of canals and water sources when it is carried out with the participation of electromechanical machines from lower reservoirs and floodplains of rivers with a rise to a great height, a huge amount of water with transmission over long distances [10, 11].

Therefore, for uninterrupted, high-quality water supply and improvement of the reclamation state of irrigated areas, it is necessary to solve the following tasks:

- application of water-saving technologies and careful use of water resources;
- rational operation of water pipelines, canals and equipment for water supply facilities;
- optimal operation of all pumping station equipment,
- in accordance with the maintenance and repair schedules, to steadily carry out technical inspections, repair and preventive measures and renovation of electricity and water supply equipment;

Pumping stations use mechanical motors or electric motors to drive pumping units.

The high cost of fuels and lubricants, uninterrupted delivery, supply and satisfaction of demand in full are obstacles to the widespread use of mechanical motors to drive pumping units.

An electric drive are widely used to avoid the complex factors described above and to achieve ease of operation, uninterrupted power supply, a clean environment, automation of control and monitoring, pumping units with. Electric drive of pumping units is the most convenient and efficient way of operation and meeting the requirements of the present. However, a number of problems need to be addressed in more detail in order to save electrical energy, reduce the cost of the specific volume of water supply, reduce energy losses, ensure optimal operation of electromechanical equipment and extend the time for scheduled repairs,.

2. Methods

Uninterruptible power supply, ensuring the trouble-free operation of power-supplying transformers, linear equipment, automatic control and monitoring systems, prolongation of the scheduled repairs of electric pumping units are the main criteria for the optimal operation of pumping stations. For this reason, we pay special attention to solve the problems of energy efficient water supply. The energy efficiency of water supply is assessed with the specific consumption of the consumed electric energy for the supply of 1 m^3 of water to consumers.

Every year, in the water sector, especially in pumping stations, from the side of electric motors to drive pumping units in the Republic, more than 14% of the total generated or about 8.4 billion kWh of all electric energy are consumed. For this reason, the issues of saving electricity and the rational operation of the entire fleet of equipment for the power system of water facilities, the problem can be considered along with the topical ones.

At present, market relations have been introduced in the system of agriculture in the Republic. However, along with the main costs for seeds, fertilizers, sowing, etc. due to the high costs of water supply (operation of electric pumping units, electric energy, etc.), the cost and price of the grown agricultural products are growing every day.

In order to determine the influencing factors for the pricing of agricultural products, it will be appropriate to study in detail the participation of each element of the water supply system.

A modern water supply system consists of many complex units and elements. These include water source (river, lakes), supply, outlet and distribution channels, pumping stations equipped with electric pump units (pumps driven by an electric motor), low and high voltage power supply lines and a transformer substation of a pumping station, high voltage power lines, sources of electrical energy or power plant, automatic control systems and control of electrical and mechanical equipment of the pumping station, vehicle fleet and vehicles and maintenance personnel.

Among the above factors, in the interaction of the water supply mechanism, the most active factor is an increase in energy consumption due to deterioration in the quality of electrical energy in the processes of machine lifting of water from reservoirs, which is associated with additional costs for electrical energy.

Ensuring the required quality of electrical energy, reliability, uninterrupted operation and energy saving in power supply systems are the main tasks of power supply of water facilities [12-17].

When powering electrical consumers of a three-phase network, supplying pumping stations for indicators of the quality of electrical energy are taken as a change in voltage, frequency and violation of the voltage sinusoidal mode due to the connection of one or two-phase consumers or three-phase equipment with an uneven load in phase to a three-phase network, i.e. having different loads and types capacities.

To identify the reasons for the overspending of electrical energy and the deterioration of its quality indicators, studies were carried out at the Chirchik pumping station of the Tashkent region.

At present, the Tashkent region has 133 pumping stations equipped with asynchronous electric motors with a capacity of 55 to 320 kW, rated voltage 380 V. Of these, pumping stations equipped with a three-phase electric motor with a cosφ = 0.84 ... 0.86 power of 250 kW is 78 % of the total. Basically, pumping stations are powered by separate trunk networks with a standard voltage of 380 V [10, 11].

In the course of the study, during measurements, a discrepancy between the voltage level of the supply network in the aisles 360 ... 370 V, in relation to the nominal, was established.

When measuring the active power factor of the drive electric motor in place of the passport indicators cosφ = 0.84 ... 0.86, in fact it was cosφ = 0.78 ... 0.82.

Especially when starting and stopping the electric motors of the pumping stations, there was a large fluctuation in the mains voltage (in the aisles 355 ... 400 V), which is considered an abnormal phenomenon.

One of the reasons for this is the connection of single-phase consumers to a three-phase power supply network. In our opinion, the connection of one phase consumers (drainage electric pumps, lighting devices, etc.) to a three-phase network has led to an asymmetric load in phases. In addition, the excessive length of power lines, the obsolescence of the current of wires, insulating means of overhead and cable lines, transformers, switching devices, starting protection devices and electric motors are also factors that have led to an increase in the permissible rates of electrical energy losses.

According to the established norms for the operation of electrical networks and the requirements of indicators, the quality of electrical energy in networks with a voltage of U_n = 380 V at a frequency of f = 50 Hz, the coefficients of active and reactive power - $cos\varphi$ and $tg\varphi$ should be within: $cos\varphi \geq 0.97$ and $tg\varphi \leq 0.25$.

For a detailed analysis of the excessive consumption of electrical energy, it would be appropriate to give the main indicators and technical characteristics of electric motors, changes in which may lead to a violation of the rated power consumption.

In the passport of the electric motor, the nominal value of voltage - U_n, current - In, active P_p power and active power factor - $cos\varphi$ is given, with a change in any of the indicators, adequately lead to an increase in electrical energy consumption.

Active power creates a torque on the machine shaft, and reactive power participates only in the oscillatory processes of the machine's electromagnetic field and creates additional loads for power lines and transformers.

An increase in reactive power (Q_n) in an electric motor results in a power factor mismatch between $cos\varphi$ and $tg\varphi$. It is associated with an increase in energy losses i.e. excess energy consumption to create an excessive electromagnetic field around the stator winding.

The active power of the electric motor is calculated from the formula (1):

$$P_n = \sqrt{3} \cdot U \cdot I \cdot cos\varphi, \quad kVt \tag{1}$$

Knowing the values of the active power and active power factor, the reactive power of the electric motor can be found by the following formula (2):

$$Q = P_n \cdot tg\varphi, \quad kVAr \tag{2}$$

It is impossible not to assess the existing set of negative factors in pumping stations that impede the normal functioning of any mechanical and especially electrical equipment, which ultimately reduces the terms of normal maintenance and operation. These include severe operating conditions (high humidity and damp environment), excessive length and height of the pressure pipeline, frequent changes in the cavitation reserve of water in the advance chamber (due to a sharp jump in the change in the water horizon in the supply channel or water source), excessive water pollution (high and large-scale water flow), constant voltage fluctuations in the power supply networks of pumping stations (frequent starts and stops of high-power electric motors powered from the same network), intermittent and frequent starts and stops (emergency shutdowns, turns on, transfers to a backup power line from the main power source, the transition to a backup power supply, etc.) can be the cause leading to a deterioration in the quality of electrical energy, an increase in energy losses, an accelerated reduction in the service life of electrical equipment, which ultimately brings closer the inevitable period of overhaul.

In the course of research, it was found that the value of the active power factor greatly affects the deterioration of the quality of electrical energy. Especially during the period of operation, repeatedly repaired electric motors experience a progressive increase in the loss of electrical energy associated with a change in the magnitude of the current.

In our opinion, the drop in the value of the active power factor and the increase in the operating current of the electric motor are associated with the quality of the repair (use of spare parts, glue, etc. of poor quality or not meeting the requirements of the standard) and the use of outdated repair technologies (using the method of annealing and mechanical stretching) when removing old windings from the internal slots of the electric motor.

The firing technology, when removing the old winding, often leads to annealing, deformation and deterioration of the quality of the packages of steel grooves of the stator and rotor, burning of insulation, insulating varnish and glue to the formation of carbon deposits and dirt in the winding grooves, to the destruction of the grooves of the stator and rotor windings, deterioration of the electromechanical properties of metal packages of steel, deformation of the stator housing and rotor shaft with subsequent misalignment.

Analysis of scientific and technical reports on the operation of electrical equipment of pumping stations in this region show that about 52% of electric motors have worked for more than 20 years. In electric motors installed and put into operation in the 80-90s of the last century, i.e. those who have been working for about 30-40 years or more, the main factor in the decrease in energy performance is outdated models and the lack of necessary spare parts to restore them to their original state. About which one can guess that the equipment during operation has undergone several major refurbishment.

The next factor in increasing energy consumption is the deterioration in the quality of electrical energy in power supply networks. The loss of electrical energy is also due to the low operational and technical condition of the power supply equipment and lines.

To confirm the above, we carry out a theoretical calculation of the consumption of electrical energy of the PK95 pumping station located in the Bastanlyk district of the Tashkent region.

The pumping station consists of 7 pumping units equipped with asynchronous motors of the M 280-6 series.

According to the passport, the electric motor has the following indicators: rated voltage - $Un = 380\ V$, rated current - $I_n = 98\ A$, set frequency - $f = 50\ Hz$, active power factor - $cos\varphi = 0.85$, power - $P_n = 55\ kW$, speed - $n = 1000\ rpm$.

To calculate the consumption of electrical energy, we will compose the following formula (3):

$$WR = P_n \cdot t_{day} \cdot 30 \quad (3)$$

where: t_{day} - daily operation time of the electric pump unit, hour.

30 - the average number of days in a month, days.

According to formula 1.3, we calculate the consumption of electrical energy consumption by an electric motor for one month:

$$WR = P_n \cdot t_{day} \cdot 30 = 55 \cdot 24 \cdot 30 = 39600\ kW/\ h$$

Using the passport data of the active power factor $cos\varphi = 0.85$, we find the value of the reactive power factor $tg\varphi = 0.62$.

To determine the amount of reactive energy consumption, we will compose the following formula (4):

$$WQ = P_n \cdot tg\varphi \cdot t_{day} \cdot 30 \quad (4)$$

Using formula 1.4. we will carry out a calculation to determine the consumption of reactive energy:

$$WQ = P_n \cdot tg\varphi \cdot t_{day} \cdot 30 = 55 \cdot 0.62 \cdot 24 \cdot 30 = 24\,552\ kvar/\,h$$

According to the calculation, one pump unit with an electric motor with a power of 55 kW consumes *WR = 39600 kW/ h*, reactive energy *WQ = 24 552 kvar/ h* for 30 days.

To determine the annual (seasonal) consumption of electrical energy, we will compose the following formula (5):

$$W_{Ryear} = P_n \cdot T \quad (5)$$

Where *T* is the number of hours of operation of the electric pump unit during the irrigation season.

Considering that pumping stations operate during the year only during the irrigation period of up to 9 months, and at the same time, each pumping unit during this period has breaks for prevention in the aisles of 30% of the total operating time per year.

To determine the actual number of hours of operation of the electric pump unit during the irrigation season, we will compose the following formula (6):

$$T = (t_{day} \cdot 30 \cdot 9) \cdot 30\% \quad (6)$$

Determine the number of operating hours of the electric pump unit during the irrigation season according to formula 6:

$$T = (t_{day} \cdot 30 \cdot 9) \cdot 30\% = (24 \cdot 30 \cdot 9)\ 30\% = 4536\ hours$$

Using formula 5 we determine the annual (seasonal) consumption of electrical energy of one electric pumping unit in the form of active power:

$$W_{Ryear} = P_n \cdot T = 55 \cdot 4530 = 249\,150\ kWh$$

We find the annual (seasonal) consumption of one unit:

To determine the seasonal consumption of electrical energy in the form of reactive power, we will compose the following formula (7):

$$W_{Qyear} = P_n \cdot tg\varphi \cdot T \quad (7)$$

Based on formula 7, we determine the seasonal consumption of electrical energy in the form of reactive power:

$$W_{Qyear} = P_n \cdot tg\varphi \cdot T = 55 \cdot 0.62 \cdot 4536 = 154\,473\ kvar/\,h$$

According to the above described methodology, we determine the consumption of electrical energy at the PK95 pumping station in which 7 electrically powered units are installed:

$$W_{Ryear} = 294\,480 \cdot 7 = 2{,}061\,360\ kWh$$

$$W_{Qyear} = 154{,}473 * 7 = 1{,}081{,}311\ kvar/\,h$$

However, according to the readings of electric energy metering devices, the actual consumption $W_{Ryear} = 2{,}190{,}200\ kWh$, $W_{Qyear} = 1{,}168{,}739\ kvar/h$ than the calculated one, although the pumping units worked 4350 hours during the season, i.e. less by 180 hours than calculated.

The discrepancy between the actual consumption of electrical energy and the calculated ones became the basis for finding a solution and conducting research and development work.

For the experiment in the PK95 pumping station, 3 electric motors with the same technical characteristics were chosen. All electric motors are powered by one transformer and 3-phase network.

In the course of the experiments, the voltage, current and active power factor of electric motors were measured using tariffed (standardized and having a certificate of conformity) measuring meters "Mercury 230" in the period from March 20 to September 25, 2019.

All investigated electric motors were overhauled, the technical condition corresponds to the passport indicators (they have the same power $P_n = 55\ kW$, rated voltage $U_n = 380\ V$, rated current $I_n = 98.2\ A$, with active power factor $cos\varphi = 0.85$). According to the description of the repair company, the windings, bearings and all necessary worn parts were replaced.

To conduct an experiment to identify excessive consumption of electrical energy in the pumping station, 3 electric pumping units were chosen and identical technical parameters out of 7.

Electric motor No. 1 according to the passport has the following indicators: rated power - $P_n = 55$ *kW*, rated voltage - $U_n = 380$ *V*, rated current $I_n = 98.2$ *A*, active power factor $cos\varphi = 0.85$.
To determine the compliance of the passport data with the actual indicators, we measure the data of the electric motor.
Mains voltage: in phases $U_A = U_B = U_C = 380$ V.
Current, in phases: $I_A = 98.7$ A; $I_B = 98.6$ A; $I_C = 98.4$ A.
Measurement values of active power factor $cos\varphi_{cp} = 0.99$. In voltage phases $cos\varphi_A = cos\varphi_B = cos\varphi_C = 0.99$.
Based on the readings of the measuring device, we determine the difference in the current deviation in phases:
$I_A = I_{A.measure.} - I_{A\ passport} = 98.7 - 98.2 = 0.5\ A;$
$I_B = I_{B.measure.} - I_{B\ passport.} = 98.6 - 98.2 = 0.4\ A;$
$I_C = I_{C\ measure.} - I_{C\ passport.} = 98.4 - 98.2 = -0.2\ A.$
We determine the average value of the phase currents according to the following expression:

$$I_{cp} = \frac{I_A + I_B + I_C}{3} = \frac{98,7 + 98,6 + 98,4}{3} = 98,6A$$

According to the results of measuring the electric meter "Mercury 230" according to the phase value of the active power factor is $cos\varphi_A = cos\varphi_B = cos\varphi_C = 0.85$.
Accordingly, the calculated value of the active power factor is:

$$\cos\phi = \frac{P}{\sqrt{3}\cdot U \cdot I_{cp}} = \frac{55}{1,73 \cdot 0,38 \cdot 98,6} = 0,85$$

In a similar way, measurements were made of the technical parameters of electric units in the period from March 20, 2019 to September 20, 2019.
In the course of the research, it was revealed that during the operation of the electric pumping units, the currents in the voltage phases began to increase in comparison with the initial value and in each phase in different ways.
At the same time, the active power factor began to decrease, which was the reason for the excessive consumption of electrical energy due to heating losses. When measuring the active power factor lower than the permissible value or inconsistency between the phases, the device showed an incorrect value ($cos\varphi = 0.99$).
With the increase in the service life of the electric pumping units, there was a gradual increase in the current and a decrease in the active power factor.

3. Results and Discussions

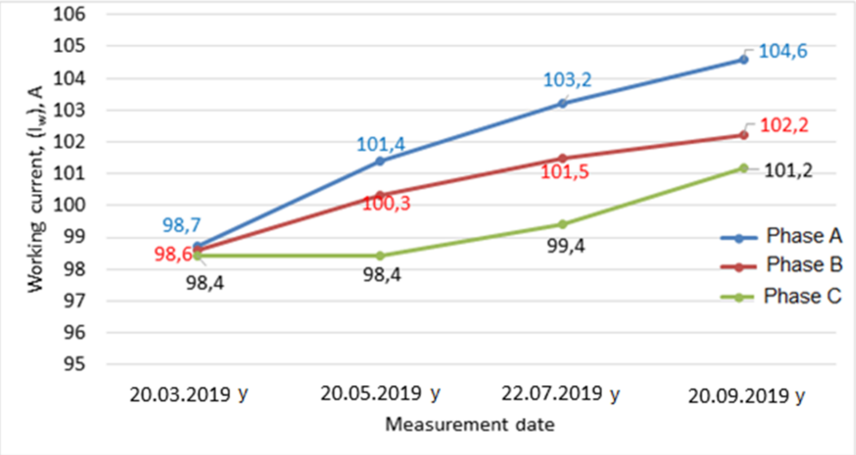

Figure 1. Graph of changes in operating currents of electric motor No. 1

The results of measurements of the electric motor No. 1 (electric pump unit No. 1) Included in the table, and for a visual representation of the change processes, a graph of the change in current and active power factor was built (Figure 1 and 2).
The curved lines of the graph show that at the beginning of the irrigation season when the electric pump unit was put into operation (March 20, 2019), according to the measurement results, the operating currents in the voltage phases *A* and *B* were equal to $I_{pA} = I_{pB} = 98.7$ A, the current of phase *C* $I_{pC} = 98.4$ A.
After two months of operation (May 20), the measurements revealed an increase in the current in phases A by $I_{pA} = 103.2$ *A* and *B* $I_{pB} = 101.5$ A.
Further in the period from July 22 to September 20, 2019, show an upward trend, an increase in all voltage phases, i.e. in phase *A* with $I_{pA} = 103.2$ A at $I_{pA} = 104.6$ A, in phase *B* with $I_{pB} = 101.5$ A at $I_{pB} = 102.2$ A, in phase *C* with $I_{pC} = 99.4$ A at $I_{pA} = 101, 2$ A which leads to losses of electrical energy.
The changes are negative consequences of electrical and mechanical factors such as: strong overheating of the electric motor in uninterrupted operation, poor quality of repair, deterioration of the electrical resistance of insulation, an increase in the resistivity of the winding wire due to loss of resource in the metal, an increase in mechanical resistance on the shaft of the electric motor and pump associated with deterioration of bearing lubrication.
All these factors are indicative indicators of the deterioration of the active power factor of the electric motor and the efficiency of the electrical equipment of the pumping station. This is evidenced by the graph of the change in the active power factor depending on the phase current built on the basis of measurements (Figure 2).

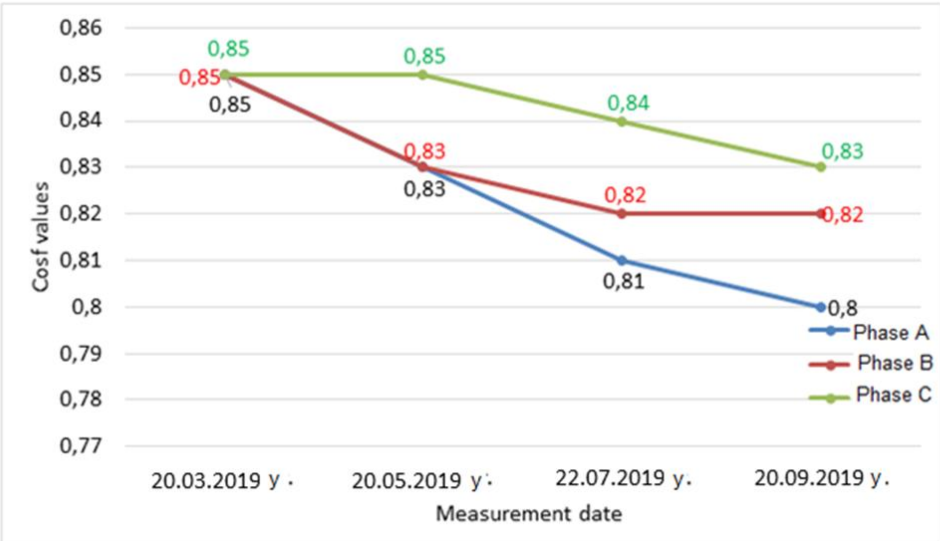

Figure 2. Graph of changes in active power factor (cosφ) of electric motor No. 1

According to measurements, the active power factor (cosφ) when measured after starting the electric motor in phases *A*, *B* and *C* were the same, $cos\varphi_A = cos\varphi_B = cos\varphi_C = 0.85$.
Measurements after two months of operation on May 20, 2019 revealed a decrease in $cos\varphi$ in voltage phases *A* and *B* by 0.2, while in phase *C* it remained unchanged at 0.85.
Starting from May 20 to September 20, 2019, there was a decrease in $cos\varphi$ indicators in all three voltage phases, i.e. in phase *A* from 0.83 to 0.8; in phase *B* from 0.83 to 0.82; in phase *C* from 0.85 to 0.85.
Due to the decrease in the active power factor, the electric motor began to heat up and began to consume more electrical energy, i.e. current consumption has increased (Figure 1).

The heating is explained by the fact that with a drop in the value of the active power factor in, there is a lack of power in the electric motor and to replenish it; the machine consumes more current from the network.
Similar measurements were made with other investigated electric pump units No. 2 and No. 3) and graphs of changes were built (Figure 3, 4, 5 and 6).
Curved lines of the graphs for the change in current and active power factor can be characterized by descriptions of the graphs built for the electric motor No. 1 (Figure 1 and 2).

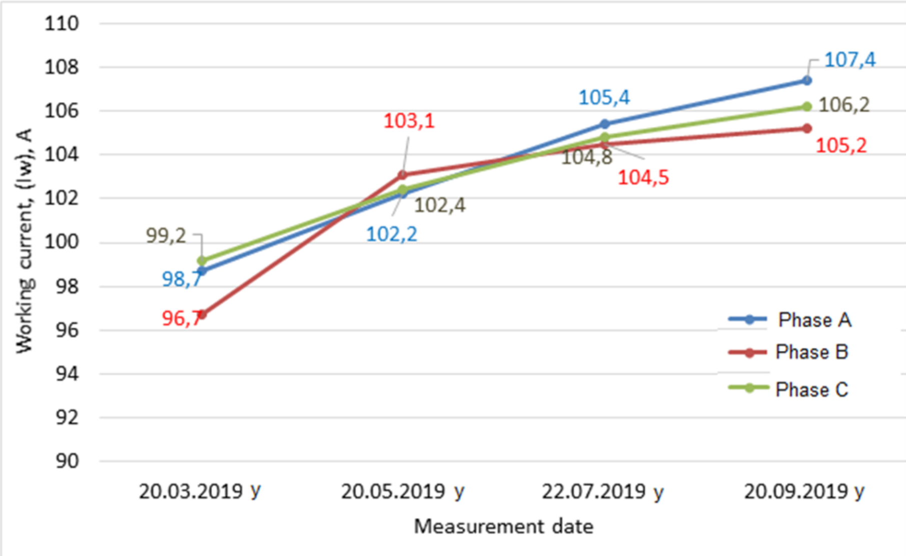

Figure 3. Graph of changes in operating currents of the electric motor No. 2

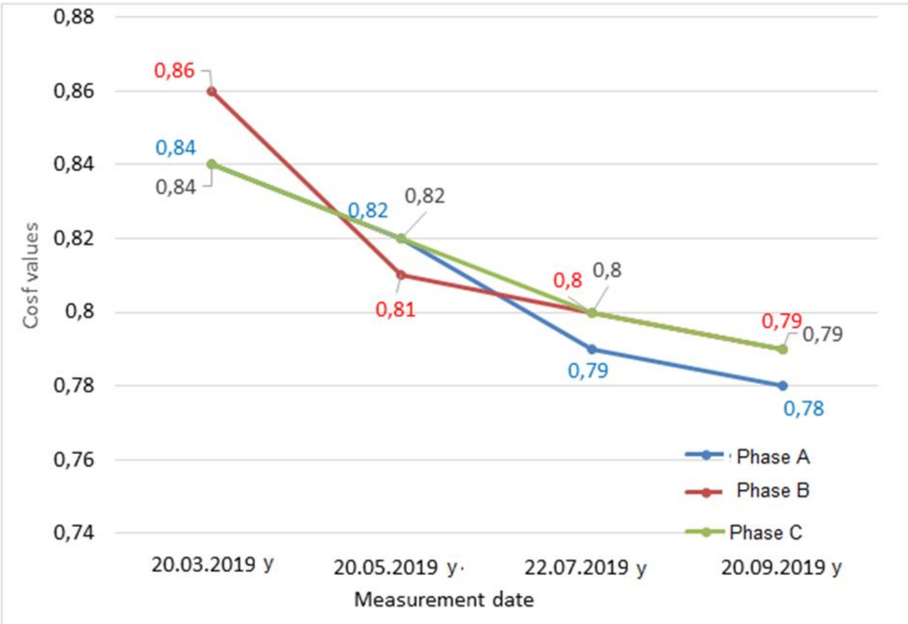

Figure 4. Graph of changes in active power factor (cosφ) of electric motor No. 2

Analysis of the graphical changes in the operating current and active power factor of the investigated electric motors in phases A, B and C shows that in the initial period (from March 20 to May 20), the measurement parameters coincide with the passport data. Operating currents and active power factors of each phase meet the required standards.

However, after some time, during the operation of the electric pump units, under the influence of objective and subjective factors, the parameters of the electric pump unit undergo changes for the worse.

Objective factors include heavy workload, poor water quality, deterioration in the quality of electrical energy in the power grid, etc. Subjective factors include the quality of repair work, spare parts, and the qualifications of repair personnel, which ultimately lead to high energy costs due to the deterioration of the active power factor values.

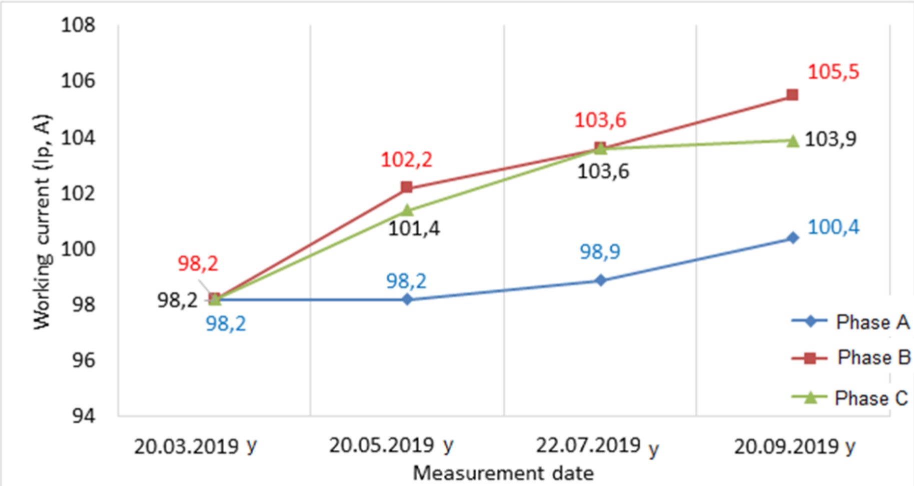

Figure 5. Graph of changes in operating currents of electric motor No. 3

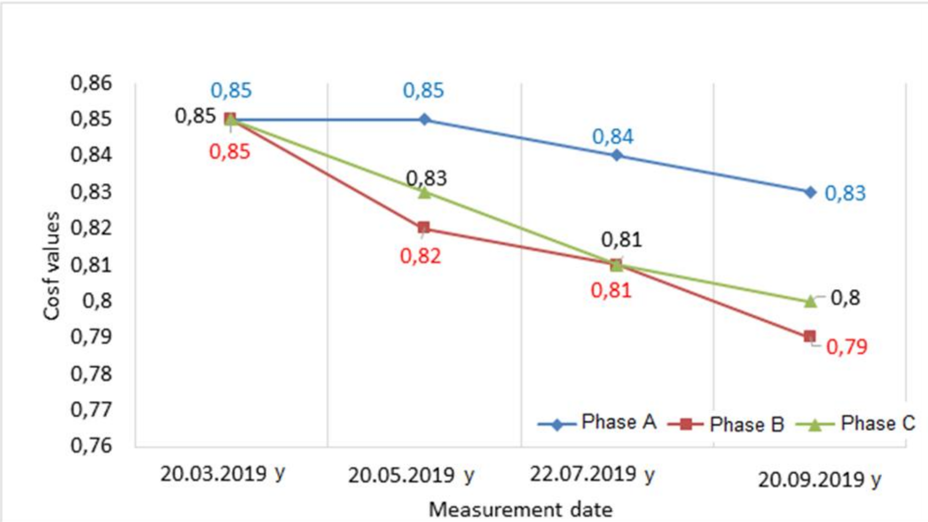

Figure 6. Graph of changes in active power factor (cosφ) of electric motor No. 3

Usually, in electric motors with a lower energy index, such as the power factor as in our facility, reactive energy consumption inevitably increases during the irrigation season.

The above problem has several solutions, and therefore we are discussing the most convenient aspects of this or that hypothesis. In our opinion, the results of the discussion of each decision bring us closer to choosing the most profitable option.

1. Updating the equipment fleet.

2. The use of compensating quipment for power losses or the introduction of equipment to increase the power factor from the power supply circuit
4. Use reserve or alternative energy sources in the power supply system.

When applying the most profitable option, it is necessary to take into account the financial and technical aspects of each of the above.

For example, in a pumping station, the renewal of the equipment fleet requires an integrated approach of complete replacement of all hydraulic, mechanical and electrical equipment in the building reconstruction raft. The solution of which is complicated with great costs, technical means, effort and time.

In our opinion, in order to achieve the best performance, it is necessary during the operation period, depending on the current or power, voltage and operating modes of consumers of electrical energy, based on measurements and calculations, to choose capacitor banks that have a system for regulating operating modes. Which has the ability to change the load, the mains voltage changes in inverse proportion to the current, i.e. The compensating installation regulates the required reactive power according to the flow rate.

To increase the cosφ when choosing electrical equipment, the following circumstances must be taken into account:

- selection of transformers and electric motors of optimal power;
- in electric drives operating with constant indicators, it is necessary to choose electric motors with high energy indicators;
- taking into account the conditions of technological processes, it is necessary to plan measures to limit the idling of asynchronous motors and transformers, the use of technical means that improve the technical and economic indicators of the power supply system by influencing the consumption and generation of reactive power;
- the calculation of compensating devices must be performed taking into account the dynamics of the load growth and the phased expansion of electrical networks. For each stage, the capacity of the compensating devices, the place of installation, the need for regulation and regulation parameters are determined.
- when calculating compensating devices, technical conditions of power supply enterprises are taken into account.
- make a complete replacement of the winding and busbars of electric motors during overhaul.
- it is necessary to carry out a complete renovation of the entire fleet of electric motors, control panels, power supply networks in the pumping station.

At the same time, the indicators that require special attention to reduce energy consumption leading to the elimination of electrical energy losses in the power grids of pumping stations are inconsistencies in the values of the power factors, which often constitute and which must be compensated to the required one, and ensuring a soft start of asynchronous electric motors with a squirrel-cage rotor.

Improvement in the energy performance of pumping stations can be achieved with the renewal of electric motors, electrical equipment and linear equipment, recalculation of the permissible current and voltage losses of economically unprofitable sections of lines, transformers and other power supply and protective equipment.

During the period of major repairs, according to the calculations, it is necessary to completely or partially replace the most important sections of current-carrying conductors of lines, power supply sections that are in an emergency state, or with a low energy index in comparison with the standardized ones. Reconstruction of power lines, power equipment allows uninterrupted and trouble-free power supply to consumers with a higher quality of electrical energy.

To achieve these goals, comprehensive measures are required for the optimal operation of all elements of the power system, from power transformers to the consumer.

According to existing methods, to reduce active and reactive losses, it is necessary to limit the idle operation time of transformers, power lines and elements of the power supply system. Selection of transformers with a higher energy index for overload and short-circuit currents, selection of consumers of optimal power and load. And it is necessary to use renewable energy sources and reactive power compensators to save and compensate for the lost part of the energy and to supplement the required amount of active and reactive power.

Considering that Uzbekistan has a huge potential for solar energy and there are all the necessary opportunities to convert it to electrical energy, then, in our opinion, the use of this potential to compensate for lost energy in electrical networks will be correct.

Currently, in the countries of near and far abroad, including in Uzbekistan, active preparation and implementation of photovoltaic systems (PVS) for generating solar energy for electricity is underway [18].

However, it is impossible to supply the converted electrical energy with the help of the photoelectric stations directly to the centralized electrical network, since a number of problems must be solved to transfer electrical energy from the photoelectric stations to the central power supply network [17, 19, 20]:

1. Converting DC to AC
2. Converting one phase voltage to three phase
3. Stabilization of sinusoidal harmonics of voltage fluctuations
4. The presence of a sufficient amount of solar radiation
5. Have in stock the required number of photo electrical panels of photoelectric stations with sufficient power
5. Availability of inverters of sufficient power and control parameters

The solution to the above problems allows the addition of power losses and an increase in the voltage drop of the power supply system.

In our opinion, a comprehensive approach based on the use of alternative energy sources and reactive power compensation is needed to compensate for power loss and prevent voltage drop.

To increase the active power factor, we propose the inclusion of compensating devices consisting of synchronous compensators or capacitor banks complete with reactors into the power supply network of electric motors.

4. Conclusion

1. The main reason for the increase in the loss of electrical energy is the deterioration of the quality of electrical energy, which is associated with difficult operating conditions, obsolescence of hydraulic, electromechanical, electrical and power supply equipment and low quality of repair and restoration work.

2. To improve the quality and save electrical energy:

- renew the park of electromechanical, electrical and power supply equipment as necessary;
- unload three-phase networks from single-phase consumers by connecting from a separate power source or network;
- introduction of alternative or renewable sources of electrical energy for power supply of single-phase or low-power consumers of the pumping station;
- on the basis of systematic measurements, calculate the active power factor by voltage phases and select compensating devices for power factor compensation;

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