Practice of permanent presence and equipment of Karshi main canal

Oleg Glovatskiy[1], *Rustam* Ergashev[2*], *Ilhom* Kurbonov[1], *Boybek* Kholbutaev[3], *Ilkhom* Pirnazarov[3], and *Adkhamjon* Rajabov[4]

[1]Research Institute of Irrigation and Water Problems, Tashkent, Uzbekistan
[2]"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National research university, Tashkent, Uzbekistan
[3]Jizzakh Polytechnic Institute, Jizzakh, Uzbekistan
[4]Samarkand State University of Architecture and Civil Engineering named after Mirzo Ulugbek, Samarkand, Uzbekistan

Abstract. The research aims to develop new energy-saving modes of operation of the Karshi main canal with a cascade of pumping stations designed to irrigate the virgin lands of the Karshi steppe with water from the Amudarya River. The article discusses some calculation methods and control parametric tests of pumps by measuring the main parameters: flow, pump head, electric motor power, NPSH, and pump efficiency. Normal operation of pumping stations requires compliance with cavitation conditions of pumps of certain levels downstream. The authors have given recommendations on the use of a new floodwater design and obtained the flow's main characteristics in the section under consideration, taking into account the hydrometric characteristics. Further work continues to improve the scheme of water supply facilities by introducing new means of regulating the operation of pumping station elements into the scheme.

1 Introduction

In world practice, urgent tasks are being solved to reduce the costs for operating pumping station (PS) facilities due to new operating technologies. The Karshi cascade, being a vital facility, serves a population of over 1.5 million, supplying water to an irrigation system that provides water to 400,000 hectares of the Kashkadarya region in southern Uzbekistan and several districts in Turkmenistan. It is necessary to achieve a reduction in electricity consumption by at least 2% through the introduction of energy-saving methods for regulating the operation mode of the PS [1,2]. The practice of modernizing the main structures and equipment of the Karshi main canal (KMC) includes elements of the inlet canal and PS-1. Obtaining the full-scale ratios of the Amudarya River - the supply channel - PS-1, which determine the cascade flow, is important for the operation of the KMC.

*Corresponding author: erustamrah@mail.ru

2 Methods

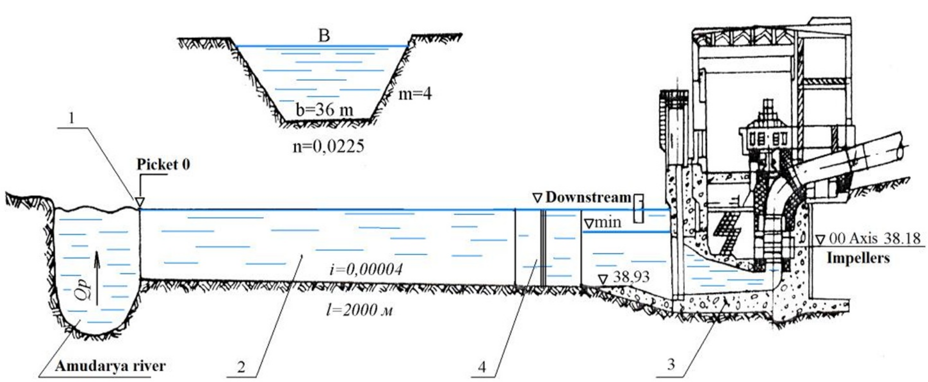
The methodological basis of our research is to solve the problem of improving the operating modes of machine channels by creating favorable hydraulic conditions for the operation of equipment, eliminating unfavorable modes with increased costs for cleaning water supply tracts from sediments and driftwood. In the research process, methods of control and algorithmization of systems with distributed parameters were used according to the principles of system analysis. Processing of the results of field studies was carried out based on the laws of hydromechanics. The results of studies of irrigation institutes on the largest cascades generally accepted standard methods for testing pumps, statistical processing of the results of measuring the parameters of units for their further use and application were used [3,4].

3 Results and Discussion

The main tasks of a comprehensive analysis of the work during the operation of the head part of the "channel-pumping station" systems are to identify changes in the processes of the hydrodynamics of the guide systems, to establish the factors that determine the risk of danger of the NS during unsteady movement of water in water intakes, water intakes, the flow path of hydraulic units, to test the mathematical model of the physical picture of hydraulic phenomena during operation of pumps [5,6] experimentally.

In the article, the authors determined the maximum possible supply of PS-1 for the horizon in the Amu Darya at the water intake point (Pulizindan Cape) with a 95% probability of ∇ 43.4 m at conditional elevations.

At present, there is a damless type of water intake in which the levels in the river determine the levels in the canal supplying water to the PS-1. Solutions to operational problems are necessary for the entire water supply complex (Fig. 1).



1 is water intake, 2 is inlet channel, 3 is PS-1, 4 is trash containment facility

Fig. 1. Scheme of hydraulic unit of PS KMC

Normal operation of pumping stations requires compliance with cavitation conditions of the pumps of certain levels in the downstream (DWL), below which the operation of the pumps is not allowed [7,8]. With low horizons in the river Amudarya, this condition mainly determines the maximum water intake of PS-1 and, consequently, the maximum possible supply of the entire cascade. Obtaining full-scale ratios of the river Amudarya - the supply channel - PS-1, which determine the cascade flow, is important for the operation of the

KMC.

The supply channel is made in an earthen channel. According to the project, it has a trapezoidal section, a bottom width of 35 m, a slope factor of 4, a length of 20 km, and a bottom slope of 0.0004. Let's denote the minimum allowable DWL PS-1 - $\nabla DWL_{\min}$. If the mark is in the river Amudarya or, which is the same, at the zero station of the canal $\nabla \text{Pickets}_0$, then the difference in values gives the maximum value of the head available to overcome the forces of friction during the flow in the entire section of the canal

$$\nabla \text{Pickets}_0 - \nabla DWL_{\min} = \Delta h_{\max} \tag{1}$$

Let us consider the joint operation of the supply channel and PS-1 under the conditions of the difference in the actual geometry of the channel and the channel according to the design data after reconstruction.

On fig. 2 shows the dynamics of changes in the channel diameters in some fixed sections in different periods of the year. Such significant deviations of the canal geometry from the norm during the operation of the cascade complicate the operation of the PS-1 and threaten the disruption of the water supply schedule in conditions of low horizons in the river Amudarya. So, for a horizon of 95% security with the existing geometry of the supply channel and the degree of purification, PS-1 can give no more than 92.5 m^3/s. In contrast, the water supply schedule in recent years requires supply up to 160-170 m^3/s.

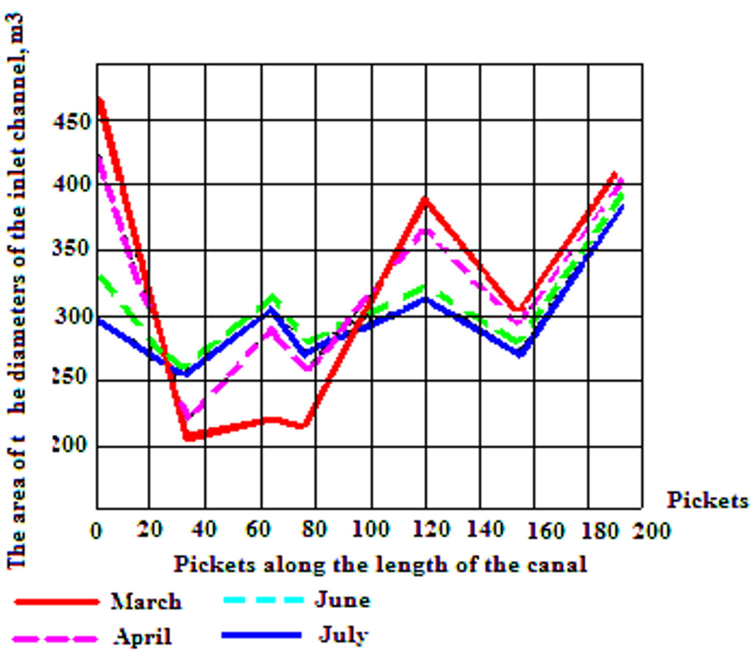


Fig. 2. Actual cross-sectional areas of supply channel PS-1 KMC in fixed sections; cross-section dynamics

In addition to the operating conditions associated with a change in the diameters of the supply structures due to sedimentation, the parameters of the pumps are greatly affected by the clogging of the trash grate and the formation of a water drop on the grates [9,10]. Installing a floating seafloor in front of the PS-1 forward chamber was the only measure of protection against the fin from 1978-1986. With the curvature of the bed of the inlet channel, it is possible to install a trapdoor of a similar design on the last bend in front of the pumping station (Fig. 3).

Fig. 3. Installation of floating seal at water intake of KMC

In this case, the shovel, without compromising navigability, enhances the natural transverse circulation of the surface, garbage-carrying layers, directing them to the alignment of the outer section of the trash-retaining grid. Combining a sump and a trash grate will ensure efficient flow cleaning over the entire cross-section with one working section of the grate cleaning machine.

The main type of full-scale tests of pumping units in operating conditions is control parametric tests, during which the actual indicators and characteristics are checked, which determine the ability of the pumps to guarantee the nominal effective water supply of the PS. In the practice of PS operation, 30-40% of the total number of parameters to be controlled are controlled, which worsens the efficiency of the units.

The purpose of the tests is to analyze the change in the operating parameters of pumps over time, depending on the service life and technical condition, from improvements and upgrades made to the design [11,12]. The composition of the control tests includes the measurement and calculation of the following parameters: flow, pump head, electric motor power, cavitation reserve, pump, and unit efficiency [13,14]. Before the start of testing, a revision of hydrometric rails is carried out, the selection and preparation of a measuring point for installing a pressure gauge, the selection and preparation of a measuring point on the machine channel for measuring the flow velocity in the channel; clarification of the actual geometric parameters of the flow at the measurement site.

At Karshi PS-6, six units of the same type were subject to control tests (Fig. 4). The design parameters of pumps - OPV 10 - 260G and OV 10 - 260 were compared: flow up to 38-40 m^3/s, head - 24 m, minimum flooding - 7.0 m, efficiency - 86% with field data [15,16].

Fig. 4. Layout of units in engine room and hydraulic devices for breaking vacuum on pressure pipelines

During the tests, the following parameters were measured and recorded: flow, pump head Q, m^3/s; H, m, power N, kW, consumed by the drive motor, water levels in the supply channel, suction chambers, and the pressure basin. The measured parameters were used to calculate the efficiency of units and pumps and the specific energy costs [17,18].
The developed pressure for a pump with a suction pipe was determined by the formula:

$$H = P_m \cdot 10^4 / \gamma + (\Sigma\zeta)V^2 / 2g \tag{2}$$

where: H is the total head of the pump, m; P_m is pressure according to the EKM manometer -10 kg/cm^2 (2.94 kg/cm^2); γ is specific gravity of pumped water, 1000 kg/m^3; V is the velocity in the pressure pipeline in the pressure gauge connection section, m/s, the cross-sectional area at the pressure gauge installation site was 10.4m^2; $\Sigma\zeta = \zeta_{in} + \zeta_{\text{confuser}} + \zeta_{\text{knee}}$ are the sum of the coefficients of hydraulic resistance is the sum of the coefficients of local hydraulic resistances at the inlet, the confuser transition from D 7.0 m to 3.0 m and the knee.

Considering this value of local hydraulic resistances, they amounted to: ζ_{in}=0.5; ζ_{knee}=1.19, ζ_{confuser} = 0,1272.

The coefficient of hydraulic resistance of the confuser transition from diameter D_1 to D_2 is determined by the formula:

$$\xi_{\text{confuser}} = \xi_{\text{entry factor}} \left(1 - \frac{D_2^2}{D_1^2}\right) \tag{3}$$

where: $\xi_{\text{entry factor}}$ is conical entry resistance coefficient.

The average value of the coefficient of hydraulic resistance on the confuser will be λ_{av}=0.0134

Substituting all values of quantities into formula (2), we have

$$H = 2.94 \cdot 10^4 / 1000 + 181718 \cdot 3.22^2 / 2 \cdot 9.81 - 3.66 = 27.55 \quad m.$$

Energy savings are the main effective factor in installing new pump components and parts. Given the complexity and versatility, specific energy consumption should be used as a comparable indicator of the quality of operation and energy efficiency of pumping equipment at various and different types of pumping stations. According to preliminary calculations, the new modified impeller and straightener operation will save 560,000 kWh of electricity [19-24].

Modernization of the main components and parts of pumps of the type OPV-260 for the PS cascade will ensure the speedy completion of the KMC cascade rehabilitation program, significantly increase the service life of pumping equipment, and, in turn, protect the region's guaranteed water supply.

4 Conclusions

1. The Karshi main canal with the PS cascade is designed to irrigate the virgin lands of the Karshi steppe with Amudarya water. As a result of testing the units, the supply of PS was determined for the permissible minimum water levels in the fore chamber of the station.
2. The refined difference in the actual channel geometry after reconstruction affects the

natural transverse circulation of the surface layers of the flow and the cavitation qualities of the upgraded pumps. Further work continues to expand and identify the design scheme of the water supply facilities of the PS unit and the development of control options with the introduction of new means of regulating the operation of the PS elements into the scheme.
3. The combination of a lagoon and trash-retaining structures proposed by the authors effectively cleans the flow throughout the entire section. The control parametric tests analyzed the changes in the operating parameters of the pumps and the technical condition, from the improvements and upgrades made to the design.

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