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CONSTRUCTION
THE FORMATION OF LIVING ENVIRONMENT

Environmental Aspects of Operation of Irrigation Pumping Stations In the Context of Climate Change
Iqlim o'zgarishi muhitida sug'orish nasos stansiyalari ekspluatatsiyasining ekologik jihatlari

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Abstract

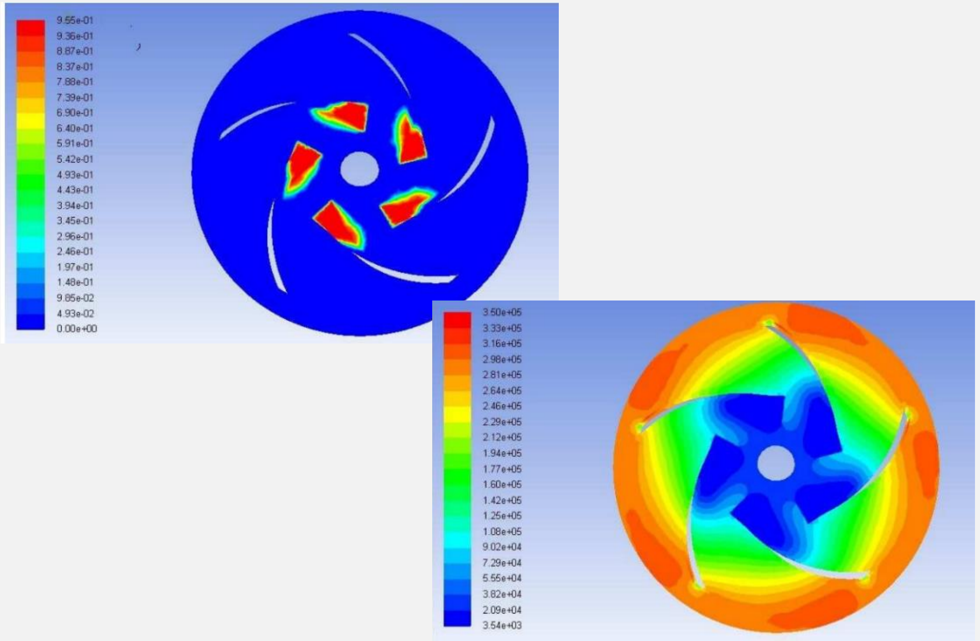
Increased workloads to meet the needs of a growing population have posed a number of new challenges for professionals working in the field of ecology and other sciences that study the impact of climate on the environment and buildings. The article presents the main goals for the development of pumping stations based on the development of criteria and prioritization of improving the efficiency of operation, which are formulated by the authors for the strategic, functional, morphological structure of pumped water lifting systems operating in various climatic and hydrological conditions. Research methods include the study of the ecological state of water bodies in the Aral Sea basin and their impact on the management of pumped water systems. The main criterion for research is the modernization of pumps, taking into account the operation of the main structures, their operating modes and structures. The negative consequences of the Aral Sea crisis are associated with the use of large irrigation pumping stations for decades. The conclusions include an updated calculation of the main elements of the hydraulic unit of pumping stations in various regional conditions, the conditions for changing the water supply and the maximum use of the potential energy of surface water sources.

INTRODUCTION

The experience of operating large machine channels shows that up to 29% of failures in the operation of pumping units are caused by unfavorable hydraulic processes in the interface structures, water level drops of the channels [3,8]. Monitoring of natural processes refers to systems of purposeful observations related to solving problems of forecasting and control. In connection with the above, there is a need to create hydrodynamic monitoring on machine water lifting systems, as a subsystem of water management monitoring. At the first stage of solving this problem, it is advisable to monitor the environmental conditions of operation of large irrigation systems with pumping stations.

MATERIALS AND METHODS

The materials are compiled taking into account the main goals and criteria of priorities for improving the efficiency of the operation of the PS. Based on the analysis of the methodological provisions for organizing an observation system, environmental monitoring takes into account databases on the state of water bodies on the dynamics of variability of environmental conditions over tens of kilometers of these systems, which, in principle, integrally reflect environmental conditions in the Aral Sea basin as a whole. Changes in the pump head are analyzed under the influence of water losses, hydroabrasive wear and cavitation erosion of its elements.



RESULTS

In the early 70s of the XX century, intensive water intake from the Amudarya and Syrdarya rivers began for irrigation and washing of fields, and other water management needs. In some years (1982, 1989, 1995) the water did not reach the Aral Sea at all. In other shallow years (1985 and others), the annual runoff did not exceed 5 cubic km, despite the fact that the total flow of the Amudarya River is estimated at 65.9 cubic km.

The Aral Sea, a unique drainless body of water in the Central Asian region, began to dry up before the eyes of one generation, having a negative impact on the ecological, social and economic conditions of the entire region. A significant impact on the volume of water flowing through the main water source of the Amu Darya River is exerted by the largest systems of machine water lifting located on the territory of the Republics of Uzbekistan, Turkmenistan and Tajikistan: Amubukhara, Amuzang, Karshi (KMC), Karakum canals and some large PS (Zhayhun, Sherabad, Bek-yab, etc.)

RESULTS

Among the most important tasks of analyzing regional water bodies (features of the hydrological and hydrogeological regime, priority indicators of the quality of the aquatic environment, the structure of water consumption and water disposal, the main sources of pollution), the choice of technical means that provide the necessary information, its transmission, storage, processing and analysis. The main tasks of monitoring are to establish the factors that determine the risk of a general hazard of the PS, to identify deviations from design solutions, damage, structural defects of structures that can cause technical and environmental accidents.

RESULTS

The wear of the elements of the flow paths of pumps during operation due to cavitation and abrasion by suspended sediments leads to a deterioration in the operating modes of the PS. The pump diagnostic system makes it possible to increase the operational reliability, including by preventing the installation of defective parts, clarifying the scope of future repairs to restore the performance of the units [4,21].

The flow of failures of structures of the PS in general terms can be determined by a multi-parameter function, which has the following form:

$$\omega(\tau) = f\left[\omega_h(\tau), \omega_{es}(\tau), \omega_{cr}(\tau), \omega_{gg}(\tau), \omega_{cc}(\tau), \omega_o(\tau)\right], \quad (1)$$

where $\omega_h(\tau)$ - generalized parameter of hydraulic conditions;

$\omega_{es}(\tau)$ - conditions of erosion or siltation;

$\omega_{cr}(\tau)$ - constructive reliability;

$\omega_{gg}(\tau)$ - geological and geotechnical conditions of the channel;

$\omega_{cc}(\tau)$ - climatic conditions;

$\omega_o(\tau)$ - operating conditions.

RESULTS

Changes in the pump head $H(t)$ under the influence of water losses, hydroabrasive wear and cavitation erosion of its elements during operation can be represented as a product of parameters

$$H(t) = H_T(t)\eta_v(t)\eta_h(t), \quad (2)$$

where $H_T(t)$ - theoretical head as a function of t, m;

η_v (t) - pump volumetric efficiency as a function of t;

η_h (t), - hydraulic pump efficiency as a function of t.

The values of the quantities in formula 2 are found by determining the operating points on the characteristics of the pump and pipeline in accordance with the planned water supply schedule for the planned period and the mode of operation of the PS. In the formulas ηp is added - the efficiency of the pipeline, taking into account losses in the pressure pipeline and due to local resistances.

Errors in nature management lead to the destruction of the environment surrounding a person and, accordingly, a deterioration in the quality of his life. In summer, almost complete drying is observed in the lower reaches of such large rivers as the Amudarya, Syrdarya and their tributaries (Fig. 1).

RESULTS

Fig.1. Valley of the Chirchik, the largest tributary of the Syr Darya
"Compiled by the authors"

RESULTS

In the Central Asian region, the increase in water consumption for irrigation and other needs of the national economy will continue. The conducted studies have shown that a further decrease in the volume of the Aral Sea and a decrease in its warming effect will lead to an inevitable reduction in the growing season with all the ensuing negative consequences for the cultivation of heat-loving crops grown in the Lower Amudarya region [7,16]. The drying up of the sea is proceeding at such a rapid pace that it has already far outstripped all previous forecasts on this issue (Fig. 2,3).

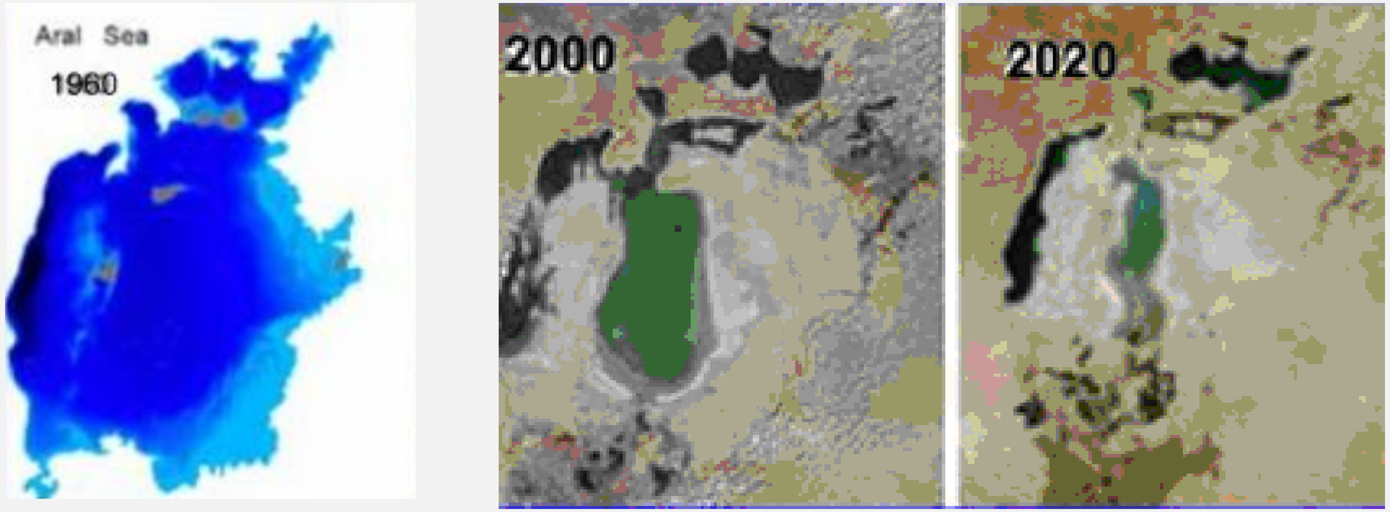


Fig.2. Changes in the water area of the Aral Sea with a decrease in its level "Compiled by the authors"

RESULTS

This imposes special difficulties on the operation of irrigation PSs associated with the development of methods for assessing the mutual influence of climate and optimizing the energy-saving regimes of PSs [2,12]. Annually, up to 7-8 billion kW/h is spent on the PS of irrigation systems, not counting diesel fuel. It is possible to reduce the electricity consumption at the PS by approximately 10-15%, mainly due to the control of the energy saving of the MWS. In connection with the sharp rise in prices and the growing shortage of energy resources, the problem of reducing their consumption by large PS comes to the fore. The lack of priority work on this problem makes it impossible to optimize the PS modes at the current level of operation.

RESULTS

This imposes special difficulties on the operation of irrigation PSs, in particular, in terms of pump wear with an increase in the temperature of the pumped water and ambient air.

Their impact on the liquid causes: cavitation associated with pulsations and collapse of cavitation bubbles, vortex effects in the form of microflows, acceleration of diffusion processes [18,22]. The kinetic energy of collapsing bubbles, concentrated in a small volume of the flow part of the pumps, is converted partly into a power impulse and partly into thermal energy. In the flow, electrokinetic phenomena also occur, due to the directed movement of particles, which affect the wear processes of casing and working units of pumps [19].

In flows that have only volume elasticity, mainly longitudinal waves propagate, in which particles of the medium are displaced in the direction of wave propagation. For a plane longitudinal wave, the wave equation has the form

$$\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2}, \quad (3)$$

where y — flow particle displacement;

c — wave speed;

x — coordinate.

Periodic compressions and expansions of each flow layer in which an elastic wave propagates can be considered as a result of the action of a variable pressure, the amplitude of which is equal to:

$$P = \rho c A = \rho c V_a \quad (4)$$

where ρ — density of water;

V_a — particle velocity magnitude amplitude;

A — velocity amplitude.

RESULTS

The scale of investment policy renewal requires tougher requirements for resource-intensive projects. Reconstruction of the MWS can give the greatest economic and environmental effect. The development of a strategy to improve the efficiency of water use in the MWS in the Zarafshan river basin showed that, first of all, it must be implemented by reducing the consumption of water, energy carriers, optimizing operating modes and pump characteristics [6,17].

The listed directions take into account the environmental aspects of the operation of the PS, the reduction of unproductive losses of water and other resources. The primary problem of operation and reconstruction of the MSW in the Aral Sea basin is currently being activated by the development of new energy- and resource-saving operating technologies with a possible MWS ring and the transfer of their water intakes. The main energy saving measures are related to the development of information-advising systems for controlling the modes of structures and pumping and power equipment according to the main criterion of their efficiency.

RESULTS

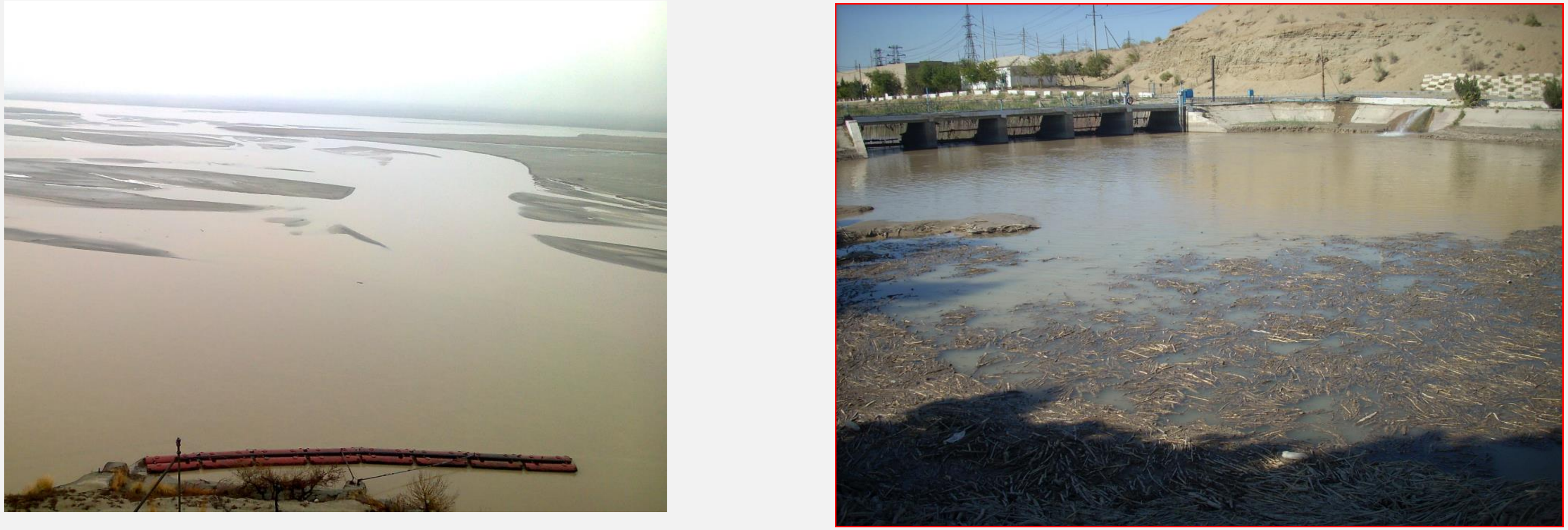


Fig.4. Combined devices for changing the structure of the flow "Composed by the authors"

RESULTS

The redistribution of velocities within the flow with the transformation of its movement has already been carried out by us in a number of cases for a closed flow in the flow part of pumps.

The main differences in MWS are: free flow surface; often very stretched and non-symmetrical shape of the cross-section of the flow; large cross-sectional dimensions (antechambers), requiring the use of special water intake designs [8,9].

Recently, due to the transition of the Nurek reservoir from irrigation to energy operation, autumn-winter releases have been increased by 2-3 times and, conversely, summer releases have decreased by 2 times, which leads to artificial low water, complicating the provision of water intake in summer, causing floods and additional destruction of canal slopes (Fig. 5).

Fig.5. Destruction and siltation of sections of KMC canals "Compiled by the authors"

DISCUSSION

When assessing the risk, using operational or experimental data, graphs of only time dependences for the elements of the PS are built. Using the latter, one can only determine the probabilistic parameters that characterize the reliability of the elements for the full cycle of their operation.

Obviously, the less stable the operation of the water management system when considering these parameters, the greater the probability of failure and the greater the damage that can be caused to the national economy with an increase in costs to compensate for it.

CONCLUSIONS

1. Increased workloads to meet the needs of a growing population have set a number of new challenges for specialists working in the field of ecology and other sciences that study the impact of climate on the environment. Measures to improve reliability and safety under various adverse climatic conditions should be based on the accumulation of experience in the operation of the MWS. The processing of statistical materials on operated large PS and their elements makes it possible to concentrate the relevant data in a form that allows them to be used by the operating personnel. The analysis of these statistical data makes it possible to develop appropriate measures, sharply reducing research related to the theory of probability and mathematical statistics.

2. Measures have been developed for energy and resource saving, using information-advising systems for controlling the regimes of PS structures in various regional conditions; maximum use of the potential energy of surface water sources. At the same time, it is allowed to eliminate unproductive losses of electricity, pressure and drops in water levels, and reduce the height of the water rise. The authors have created a number of fundamentally new technical solutions to improve the efficiency of water use in the face of climate change.

CONCLUSIONS

3. During cavitation tests of pumps, an increase in head and efficiency of the pump was recorded before the start of cavitation. This can be explained by the fact that before the start of cavitation, the separation of water from the walls of the channels of the impeller begins and the friction resistance decreases with a corresponding increase in the efficiency of the pump. The introduction of combined devices for changing the flow structure in the water supply structures of the PS was carried out. However, with large dimensions of water intake structures of modern large stations, these devices are not always able to actively influence the distribution of whirlpool branches over the entire depth of the flow, which leads to an intensification of the exchange of velocity and pressure pulses between transit and whirlpool layers with the opposite direction of velocities. Theoretical and practical studies are needed to reduce the intensity of funnel formation in the water intake chambers of pumping stations, to prevent air leakage into the suction pipes of hydraulic units.

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Questions?

Thank you for your attention!

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