Fish protection structures on reservoirs of energy facilities as an important measure for the conservation of the herd of fish

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Abstract. Directed formation of ichthyocenoses on the basis of reservoirs - energy objects - an important task for pasture aquaculture. At the energy facilities to ensure the operation of the main equipment, the main issue is water supply. The water intake structure, as the main technological element of the water supply system, must uninterruptedly take out water, at the same time functioning as a fish protection facility. According to the requirements of the Russian legislation, the effectiveness of preventing fish and other aquatic biological resources from entering water intake facilities should be at least 70%. Fish protecting device (FPD), along with high fish protection characteristics, should have a reliability that allows to maintain their functions during the entire period of operation. There are three main principles for preventing the ingress of juvenile fish into water intake facilities using FPD: ecological, behavioral and physical. At the present time, the most common at water intakes are net FPD, morally obsolete, according to many practitioners. They account for more than 60% of all FPDs. Among the promising types of fish protection structures are air-bubble type structures that operate on the principle of an ascending water-air curtain formed by a system of bottom modules with aerating nozzles. Among the advantages of this type of FPD is the positive effect on the hydrochemical state of water bodies. Aeration promotes the oxidation of organic substances in water, contributing to a decrease in the level of eutrophication of the aquatic ecosystem. Further improvement of the FPD at power facilities is important for the work on the release of valuable fish species, especially sterlet juveniles when stocking the Kuibyshev and Nizhnekamsk reservoirs.

Introduction
In the developed “Energy Strategy of Russia for the period until 2020”, the development of the Russian electric power industry is oriented towards the scenario of the country's economic development. Achievement of the planned scale of electric power consumption takes into account active energy saving - both due to structural reorganization of the economy, and through organizational and technical measures in the industry. In our country, a huge amount of electricity is produced and consumed. It is almost entirely produced by three main types of power plants: thermal, nuclear and hydroelectric power plants. Virtually all energy facilities are closely connected with water bodies and exert a certain impact on water ecosystems.

At the same time, all water bodies at the present stage of the development of society are involved in the production of fish products in varying degrees of intensification. The desire to improve the condition of inland water bodies in the Republic of Tatarstan is evidenced by the adopted resolutions of the Cabinet of Ministers of the Republic of Tatarstan dated December 28, 2015 № 991 “On...
approval of the State Program for the Development of Commodity Aquaculture (Commodity Fish Culture) in the Republic of Tatarstan for 2016-2020”, Concept for the Creation of Aquabioculture Technopolis in Republic of Tatarstan, which was approved by the President of the Republic of Tatarstan at a meeting on December 18, 2016. As part of the development of aquaculture in the region, it is proposed to reduce wastewater discharges into water bodies, carry out measures for the rehabilitation of water bodies. These same tasks are important for the implementation of the Food Security Doctrine of the Russian Federation, approved by Presidential Decree No. 120 of January 30, 2010, “On Approving the Doctrine of Food Security of the Russian Federation” and implementing the Decree of the Government of the Russian Federation of April 15, 2014 No. 314 “On approval of the state program of the Russian Federation “Development of the fishery complex” (subprogram “Development of aquaculture”).

In accordance with the “Environmental Requirements for the Placement of Buildings, Structures, Structures and Other Objects” of the Federal Law No. 7-FL of January 10, 2002 “On Environmental Protection” when placing buildings, structures, structures and other objects, ensuring compliance with environmental protection requirements, restoring the natural environment, rational use and reproduction of natural resources, ensuring environmental safety, taking into account the nearest and remote ecological, economic, demographical and other consequences of the operation of these facilities and compliance with the priority of preserving favorable environment, biological diversity, rational use and reproduction of natural resources”.

At the energy facilities to ensure the operation of the main equipment, the issues of ensuring water supply are the main concern. A water intake facility (water intake) is a hydraulic structure for the extraction of water from a reservoir [1, 3]. Any water intake structure, as the main technological element of the water supply system, must continuously take out water, at the same time functioning as a fish protection facility.

In accordance with the Water Code of the Russian Federation, Resolution of the Government of the Russian Federation No. 380 of 29.04.2013 “On Approval of the Regulation on Measures for the Conservation of Aquatic Biological Resources and their Environment” - the use of water intake facilities not equipped with fish protection devices or structures is forbidden.

Fish protection facilities (hereinafter referred to as “FPF”) installed on water intake facilities, serve to prevent fish from entering working equipment. Modern fish protection devices are a composite, technically complex, part of water intake structures and influence the conditions of its design and operation. The main document for the design of water intake facilities is “SNiP 2.06.07-87 Retaining walls, navigable sluices, fish-passing and fish-protecting structures”, approved by Decree N76 of the State Construction Committee of the USSR of April 14, 1987.

Directed formation of ichthyocenoses on the basis of reservoirs - energy objects - an important task for pasture aquaculture. The increase in fish production by traditional methods based mainly on the extensive use of natural resources, nevertheless implies a significant amount of high-tech fishery operations in terms of the reproduction of valuable fish species for release tasks in water bodies in the directional formation of herds. Under these conditions, fish protection structures become especially significant factors of possible negative impact on the aquatic ecosystem. In connection with this, the improvement of the systems of FPF and FPD, which minimize the negative impact on ichthyocenosis during water intake, is topical [3, 7, 8].

**Results and discussion**

Modern applied models of FPD

FPD, along with high fish protection characteristics, should have a reliability that allows to maintain their functions during the entire period of operation. According to the requirements of the Russian legislation, the effectiveness of preventing fish and other aquatic biological resources from entering water intake facilities should be at least 70% [4, 5]. Modern efficient designs of FPD, in contrast to old ones, fully meet these requirements [6].
There are three main principles for preventing the ingress of juvenile fish into water intake facilities using FPD: ecological, behavioral and physical. Based on these principles, protection methods have been developed that determine the nature of the impact on the protection object. The main reason for the entry of fish into water intake facilities is the passive water transfer. The ingress of fish into water intake facilities is connected, on the one hand, with the physical impossibility of resisting the current, and on the other hand, with the absence of conditions for the orientation of fish in the stream, primarily with the lack of conditions for the visual orientation.

At the present time, the most common at water intakes are net FPD, morally obsolete in the opinion of many practitioners [9, 10]. They account for more than 60% of all fish protection devices. It is natural that in recent years more and more widely used are more technological and modern types of FPD [11]. The principle of operation of which is based on different methods. For example, the device of electric barriers is based on the irritating effect of electric current on the fish organism and the specific behavioral reaction of fish. This reaction is manifested in spatial orientation, involuntary migration of fish along the gradient of the field from the negative pole to the positive and sedative effect of the electric field on the central nervous system of fish. The effect of the electric field on the reaction of the fish is due to the presence in fish, as specific organs for the perception of electrical signals in the aquatic environment, the so-called electroreceptors (in some orders of fish it is Ampoules Lorentzini), and in the electrical nature of the processes in the nerve structures that control the muscle tissue of fish. Electroreceptors are specialized sensory organs for the perception of weak electric fields. That is, an electric field of the appropriate voltage is created in the way of fish, getting into which the fish feels irritated and tends to go beyond it.

Another modern type of fish protection structures are air-bubble type constructions (“air curtain”) [2, 12]. The FPD of this type operates on the principle of an ascending air curtain formed by a system of bottom modules with aerating nozzles. The principle of operation of this type of structure is to pump water to the FPD modules while simultaneously taking air through a separate pipeline-duct. The fish-protective effect of FPD using the principle of a water-air curtain is created by feeding a finely dispersed water-air suspension into the perforated pipeline. Experience in the application of hydrocavitation technology has made it possible to create a hydrocavitational aerator for obtaining a water-air suspension with air ejection from the atmosphere [4]. The outflow of the rolls of water-air curtains creates a stable surface fish-diverting flow, ensuring the removal of young fish to the area of the transit flow of the river. As a result, on the selected part of the reservoir, from the bottom to the water surface, a fish protection front is formed, which does not allow the fish to enter the water intake devices.

The use of the V-shaped beam of the barrier of the “Water-air curtain” type FPD improves the efficiency of work not only due to the presence of a double barrier front, but also due to the emerging outflow between divergent rays on the surface of the reservoir, this ensures the removal of juvenile fish to the edge of the fence.

The main types of impact of FPD based on a water-air curtain on fish juveniles are: tactile, visual, acoustic and mechanical. FPD based on a water-air curtain is distinguished by high reliability, simplicity of construction, absence of environmental pollution. An additional advantage of a water-air curtain is the protection of water intake from suspended and floating debris, which rises upward to the surface and is diverted from the water intake area by the surface current. Also, in winter, in the area of the water-air curtain, an airhole is formed, which, thanks to surface currents, protects the water intake from the ingress of floating ice and sludge. This FPD has a positive effect on the hydrochemical state, increasing the oxygen content both in summer and in winter due to the formation of airhole. Aeration promotes the oxidation of organic substances in water, thereby contributing to a decrease in the level of eutrophication of the aquatic ecosystem.
Prospects for the practical implementation of the development of FPD on the example of the Republic of Tatarstan

To reduce the ingress of fish into the water intake facilities at the shore pumping station No. 1 of the branch of JSC “Tatenergo”, Zainskaya GRES in 2015, FPD of the type “Water-air curtain” was installed, based on the reaction of avoidance by fish of low-frequency oscillations and intense ascending water-air jets. The indicator of fish protection effectiveness (Kef) of FPD for the study period for all seasons in 2016 averaged 72.4%, which is quite consistent with the normative indicators. Having received and analyzed the obtained data with positive results of the implementation of this investment project with high energy-efficient and environmental potential, the management of JSC “Tatenergo” decided to further install “Water-air curtain” type FPD at shore pumping stations No. 2 and No. 3 of the branch of JSC “Tatenergo” Zainskaya GRES. The works on the implementation of the 2 launch complex at the BNS No. 2 were implemented in 2017. In 2018, work is carried out to determine the effectiveness of the FPD installed on the water intake structure of the coastal pumping station No. 2. According to preliminary data, the indicator of fish protection effectiveness (Kef) FPD-2 will be higher than the normative indicators, which will positively affect the ecological situation in the reservoir.

In 2018, also at Zainskaya GRES, work is underway to install a water-air curtain-type FPD at the coastal pumping station No. 3. The implementation of the launch complexes of the FPD is accompanied by the development of not only the design characteristics of the FPD, taking into account the actual tasks, but also the operational and technical maintenance of the fish protective devices. For example, for a containment filter located above the water surface, a special double-purpose metal head was made: it closes the access to the equipment and additionally filters foliage, down, dust and other debris carried by the air masses from the air to the vestibule. Another example of improving the operation of the FPD equipment such as the “air curtain” is the introduction of a revision and subsequent mechanical cleaning of the aerating collectors and nozzles, since the efficiency of their operation in connection with the biofouling can be reduced. The problems of biofouling of hydraulic structures are acute at energy facilities [1, 14]. Exit from the working condition of aerators for the period of 2 years of operation was 2.8%. To ensure smooth and trouble-free operation of fish protection devices, it is recommended that in the complete set with the main equipment delivery of additional aerators and maintenance work [13].

Conclusions

The technology of “air curtain” has a number of advantages in comparison with other FPD, including: air intake from the atmosphere to create a water-air mixture in the nozzle aerator modules aeration in the absence of rubbing surfaces does not lead to contamination of the reservoir with oil products; the presence of air in the composition of the air-water mixture allows to significantly increase the diameter of the holes of the perforation of the aerating collector (up to 12 mm), which reduces the likelihood of their biofouling and increases the reliability of the FPD. The air supply to the distribution pipeline as a part of the water-air mixture reduces the dependence of the conditions for the formation of the air-bubble curtain on the depth of the distributor. Water-air modules allow for routine diving operations to clean up almost any of the clogged sections of the FPD circuit without dismantling them and raising them to the surface.

It is important that the air curtain does not injure fish of any size. The design of the “water-air curtain” type FPD is distinguished by high reliability, it is easy to maintain, besides, the curtain physically repels weighted and floating debris from the water intake, and in winter protects the water intake from floating ice and sludge. At the same time, the saturation of water with oxygen improves the oxidative capacity of water in the places of placement of FPD. Further improvement of the FPD at power facilities is important in the work on the production of valuable fish species, especially sterlet juveniles when stocking the Kuibyshev and Nizhnekamsk reservoirs.
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