MECHANICAL EQUIPMENT OF GATE CHAMBERS OF HIGH-HEAD SPILLWAYS

I. F. Kochanov and S. V. Farmakovskii

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The structures of many large hydrostations include deep spillways (dewatering outlets) with high parameters. For example, the diversion tunnels of the I and II levels of the Rogun hydroelectric station under construction are calculated for passing discharges up to 1880 m³/sec each at a head on the main gates up to 200 m.

The development and creation of gates that can close large openings at high heads makes it possible to reduce the number of spillway levels and to use the temporary diversion spillways after relatively uncomplicated reconstruction as service spillways, thereby substantially reducing the cost and time of construction of the hydrostation.

For example, the creation of the mechanical equipment of the deep spillways of the arch dam of the Inguri hydrostation, calculated to regulate discharges at heads up to 181 m, made it possible to dispense with the second level of spillways, the construction of which was stipulated by the specifications, and to reduce the cost of the dam by about 6 million rubles [1].

Table 1 gives the parameters of deep spillways which presently can be considered mastered.

Table 2 gives the parameters of emergency-guard gates and main gates of deep spillways with a design head greater than 100 m.

In the majority of cases vertical lift and radial gates with a hydraulic drive are used in deep spillways being operated and designed at large hydrostations, which is explained by the sufficiently high reliability and technological efficiency of the indicated equipment. The possibilities of these types of gates are still far from exhausted.

To solve the stated problem, design and technological studies of components and elements of the mechanical equipment were carried out to determine the limiting parameters of slide and roller gates with polyethylene seals; radial gates with gate hinges on slide bearings; and hydraulic drives of increased parameters. The layouts of gate chambers of deep spillways were also studied, including a comparative analysis of various types of deep spillways.

The comparative analysis of various types of spillways was performed with consideration of the hydraulic parameters of the spillways, general construction characteristics, and schemes of passing the diversion discharges and changeover to passage of the operating discharges (for the diversion spillways subsequently used as permanent or temporary spillways).

During the general study of variants of the layout of mechanical equipment of gate chambers of deep spillways the following problems were examined: hydraulic regimes behind the regulating gates; composition and arrangement of mechanical equipment over the length of the deep spillways; types of layouts of gate chambers with vertical lift and radial regulating gates; size and shape of the openings closed by the emergency-guard and main gates.

The main results of the general study of variants of the layout of the mechanical equipment of gate chambers of deep spillways with prescribed parameters are as follows: two types of deep spillways—tunnel and dam—are examined [2]; the chamber of the emergency-guard and main gates can be located at the start, middle, and end of the spillway; a free-flow regime should be provided behind the main gates; the installation of a guard gate which can be withdrawn without special drawdown of the reservoir is provided for in the inlet section; a layout with airtight covers located directly above the gate chamber and with a hydraulic drive as the main lifting gear is a rational type of layout of the chamber of the emergency-guard and main gates; the distance between the emergency-guard and main gates is taken as the minimum possible from design considerations; vertical lift gates are used as the emergency-guard gates in all cases; the necessary degree of convergence of the gate chamber is provided by means of a convergent channel-orifice in the case of a vertical lift main gate and by means of a smooth convergent channel in the case of a radial gate [3, 4];
The number of bays in the gate chamber, as a rule, varies from one to three.

The main results of studying the structural elements of the mechanical equipment are: it is advisable to use support runners with DSP-B laminated wood bushings and wheel supports with axle boxes with DSP-B bushings as the support-running parts of vertical lift gates of high-head deep spillways; it is advisable to use supports with four bearings with DSP-B bushings as the gate hinge of high-head radial gates; the most prospective seals of vertical lift and radial gates are those deformed by hydraulic action with a polyethylene sealing element; the frames and embedded, fixed parts (casings) of vertical lift and radial gates are made in the form of welded constructions from plate steel with provision of minimum welding deformations and high technological efficiency in manufacture and installation; it is advisable to locate the bypass devices in the construction part of the structure with the inlets situated behind the emergency-guard gates and with intake of water from adjacent conduits (bays); in a number of cases the seal control system can be used as a backup bypass device; hydraulic drives with short-stroke hydraulic cylinders are used as mechanisms for operating the high-head vertical lift gates.

The cross-sectional shape of the conduits within the gate chambers is taken rectangular as the simplest and the most technologically efficient.

To substantiate the optimal ratio of the height of the outlet to the inside width ($\alpha$), we estimated the volumes of excavation of the upstream and downstream sections of the tunnels and especially the gate chamber and also the mass of mechanical equipment of the chamber as a function of $\alpha$.

It was established that both the volume of excavation and the mass of equipment of the chamber change insignificantly with change of $\alpha$ from 1 to 3, and the final choice of $\alpha$ in each specific case can be made from layout and design considerations.

To substantiate the rational number of bays of the gate chamber, we estimate the total cost if the gate chamber of a tunnel spillway as a function of the number of bays. It was established that for a given total area of the chamber outlets being closed its cost is practically independent of the number of bays, and the problem of choosing the rational number of bays when designing can be solved from layout and design considerations. In particular, with a change from a one-bay chamber to a two- and three-bay with a constant total area of the outlets being closed one achieves: an increase of the opening reliability of the spillway structure as a whole; a decrease of the loads on elements of the mechanical equipment and the possibility of using in connection with this components that have been checked in operation; a decrease of the size of the outlets and the possibility of creating in connection with this standard-size structures (metal lining, gates, and their casings); the use of standard-size equipment permits a marked improvement of its quality, an increase of reliability, and also a substantial increase in the rate of construction works.

An increase in the number of bays above three can be justified, as a rule, only by the possibility of creating standard-size equipment.

As shown by hydraulic investigations performed by the hydrodynamics laboratory of the Moscow Special Design Department for Steel Hydraulic Structures (Mosgidrostal'1), in the case of a multibay chamber separated by intermediate piers asynchronous operation of the bays is permissible from the viewpoint of the hydrodynamic loads on elements of the chamber and cavitation erosion.