HYDRAULIC INVESTIGATIONS OF ANTIWHIRL DISSIPATOR
OF OPERATING SPILLWAY OF THE TEL’MAMSK
HYDROELECTRIC PLANT

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An antiwhirl dissipator was proposed in [1] for use as part of spillways of medium- and high-head hydraulic developments. The authors of this invention carried out a significant volume of model investigations [2, 3] which made it possible to evaluate the flow characteristics in this type of structure and to work out a method for its analysis. Nevertheless, the flow conditions in a stilling basin of this type turned out to be so complex that despite the obtained investigation results its use as part of the structures of the Rogun and Kolyma hydroelectric plants was not approved because of uncertainty about its sufficient reliable operation.

As applied to the spillway structures of the Tel’mamsk hydroelectric plant (Fig. 1), a technical—economic comparison in the first stage of the working-out of the design showed good prospects for use of an antiwhirl dissipator in comparison with an alternative consisting in an ordinary stilling basin, whose parameters were determined by analysis.

In this connection, the Lengidroproekt Institute entrusted the following task to the VNIIG Institute: based on model investigations, to substantiate the construction of an antiwhirl dissipator for the operating spillway of the Tel’mamsk hydroelectric plant. The initial alternative was a dissipator worked out on the basis of analyses and investigations on a model to scale 1:100, made at the V. V. Kuibyshev Moscow Civil Engineering Institute.

According to the analysis data, the antiwhirl dissipator made it possible to reduce the mean flow velocity from 45 to 15 m/sec and the kinetic energy by a factor of 9, but it called for construction of a small stilling basin immediately downstream from it. In this connection, the total length of the two-stage dissipator as applied to the tunnel spillway of the Tel’mamsk hydroelectric plant with a design discharge of about 2000 m³/day, was 135 m for a stilling basin length of 50 m.

Analysis of results previously obtained on open models, including also models to scale 1:12 in a high-head laboratory of the SibVNIIG Institute, for a head forced to 75 m showed that several substantial aspects of the dissipator hydraulics were beyond the limits of the examination or insufficiently studied.

Most of these questions are connected with the fact that for high velocities of the deflected flows in the axial part of the dissipator a region is formed with lowered pressures which reach the limit of a physically possible vacuum. From data for the open hydraulic model to scale 1:100 this zone amounts to about 2/3 of the cross section of the dissipation chamber, which has a diameter of 11 m. In the design of high-head spillway structures it is usual to exclude the formation of the zone with cavitation flow, but in the given case the development of such zones is inevitable because of the adopted principle of operation of the structure.

At the time of design of the antiwhirl dissipator for the conditions of the Tel’mamsk hydroelectric plant there were no substantiated answers to the following questions:

Would the given dissipator be supercavitating (as considered by the authors of the invention)? In this case the cavitation whirls should be closed inside the flow and not in the streamline surfaces;

Would not the reproduction of the zone where the flow loses continuity lead to substantially different flow conditions in comparison with open models, in particular for the streamline walls of scroll cases, where centers of local cavitation destruction are formed?;
With what intensity will the energy dissipation take place in the dissipator, and which will be the actual and not hypothetically uniform velocity distribution in the outlet section of the structure? (In the absence of the corresponding data it may be assumed that under cavitation flow conditions dissipation of a significant part of the energy can take place also downstream from the antiwhirl dissipator — in the initial portion of the stilling basin).

The concept that an antiwhirl dissipator is a supercavitation element has led to weak development of the questions of its protection against cavitation erosion, although its need was not excluded by the authors of this invention. In particular, when required, it was decided to determine the optimal quantity of supplied air, to evaluate its effectiveness and influence on the discharge capacity of the structure, and to establish the energy dissipation effectiveness under these conditions.

Also insufficiently studied were the dynamic loads on the dissipator structure, the possible vibration of the dissipator itself as well as of the nearby structures, the effect of the construction of the aeration shaft, and the system of air conduits on the dynamics of the processes in the dissipator.

Taking into account the high rarefaction at the outlet from the aeration shaft, special attention should be devoted to the movement of the air in the headrace system. Supersonic velocities (~ 400 m/sec) and compression jumps may lead to sharp decrease in its discharge capacity under full-scale conditions, development of strong sonic effects, etc.

From model investigations, it followed that one should be convinced of the fact that it is not necessary to correct the outline of the dissipator construction elements as proposed for the conditions of the Tel’mamsk hydroelectric plant on the basis of analyses and tests on small-scale models.