STUDY OF FLOWMETERING STATIONS IN HYDRAULIC TURBINES AT HYDROELECTRIC PLANTS

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At the present time, hydraulic turbines are, as a rule, equipped with flowmeters, which are differential manometers with remote transmission of readings; the manometers are joined to piezometers at flowmetering stations in spiral chambers (Fig. 1). A quadratic relationship between the flow in the hydraulic turbine and the pressure drop between two points of the measuring station, which are located on different radii of the spiral chamber, is assumed on the basis of the flow measurements. Actually, this relationship is not always quadratic.

In general form, the relationship between the drop $\Delta h$ at the flowmetering station and the flow $Q$ is determined by the expression

$$Q = k \Delta h^{1/n}, \quad (1)$$

where $k$ is a calibration constant. It has a different value for each flowmetering station. In cases where simultaneous measurements of the discharge through a hydraulic turbine by some direct method, e.g., by the vane method, and the differential head $\Delta h$ are made, the factor can be determined from Eq. (1). In this case, the readings of secondary flowmetering devices can be expressed as values of water discharges.

If the turbine discharge is steady, the discharge is computed from the differential head and is expressed as:

$$Q = \sqrt[1/n]{\Delta h}. \quad (2)$$

Comparing that discharge with the discharge computed from model characteristics of a turbine in satisfactory operating condition, which is operating at optimal efficiency, and setting $n = 2$, one obtains an approximate value of the calibration factor and, correspondingly, of discharges for all other conditions, with an error of $\pm 2\%$ where the relationship between the differential head turbine discharge is quadratic. Even this approximate discharge determination is of practical interest for the rational operation of hydroelectric plants and outlet considerations. In cases where the relation between the differential head and discharge is not quadratic, the error in determination by this method may reach $\pm 6\%$ [1].

The computed discharge is employed to plot power curves for determining the performance of hydraulic units; this makes it possible to select operating conditions that enable the units to run at optimal efficiency. These performance curves attach special significance to the introduction of automated systems for technical-process control (ASTPC), with the use of which optimal operating conditions of the hydraulic units are selected based on their individual characteristics. It should be noted that computed and real relative power performance curves of hydraulic turbines during intake-delivery testing are assumed to be comparable at the present time [2]. It is natural that the shape of the relative operational or working performance curve will be closer to the true shape, the more accurate the calibration relationship is when plotted.

In connection with this objective of the studies of flowmetering stations on hydraulic turbines in hydroelectric plants, we obtained data on parameters of the functional relationship between differential head and discharge. The parameters were analyzed as they apply to the different water-supply courses and various conditions of unit operation, including turbine heads that vary considerably during initial filling of the reservoir. The analysis also touched upon the stability of the calibration factors. Some results of these studies are discussed below.

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During the investigations, we had to ascertain whether the relationship between differential head $\Delta h$ and discharge $Q$ was close enough to quadratic; whether significant variations in head affect the calibration factor $k$ and exponent $n$; whether the quadratic character of the relationship between differential head and discharge is retained in cases where the spiral chamber is coupled with a double conduit, and to what extent this relationship is stable; whether the quadratic character is retained in cases where the piezometers in the flowmeasuring station are positioned in the chamber elements of a direct-flow capsule unit, and to what extent the calibration curve is stable in this case.