HYDRAULIC AND THERMODYNAMIC ANALYSIS OF A RESERVOIR FOR A THERMAL POWER PLANT

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Introduction

In the framework of the so-called *Eocene* program, at the proximity of the community *Bicske* the construction of a thermal power plant is in progress. The anticipated capacity of the power plant is 1920 MW. The cooling water for the power plant will be furnished by the *Póc-valley* reservoir with an effective storage capacity of about 2.5 million m^3, in the immediate vicinity of the power plant. Up to 1995, the water of the reservoir will be made up from the *Nagyegyháza* mine inflow and thereafter from *Danube* water used already as cooling water in the *Százhalombatta* power plant. Both the mine inflow and the *Danube* water will be supplied through a pipeline to the reservoir. Their maximum discharge is $Q = 1.8$ m^3/s, the temperature of the mine inflow being 12 °C and that of the Danube-water 12 to 28 °C. The cooling water drawoff from the reservoir is the same as the discharge: 1.8 m^3/s, and the desired water temperature is at least 8 °C because the cooling water is added chemicals in the water treatment plant prior to utilization; the dosage depends on the water temperature. Upon commission, the *Department of Hydraulic Engineering*, Technical University Budapest, performed the hydraulic and thermodynamic investigation of this reservoir in 1979, with the concrete objectives presented below.

The investigation of the reservoir

The investigations aimed at finding the optimum points of reservoir inflow both for the mine water and Danube water where

— in any season of the year, the water at the minimum temperature desired can be withdrawn,

— water inflow does not impair the water quality to a degree likely to risk the cooling water supply to the power plant.

In fulfilling these requirements, two contradictory factors faced us. First, from the aspect of water quality, it is favourable to keep it moving, stirring and changing. Second, to respect a specified minimum temperature of the withdrawn water, particularly in winter, requires technically to conduct the stored water to the intake-work at a minimum heat loss. This is only possible if the discharge water is retained in the reservoir for as short a time as possible, excluding the important water masses in the reservoir from the process of forced stirring.

According to the above, the optimum point of inflow has to be marked out, relying on a compromise method of investigation involving both the change in water quality and the minimum water intake temperature.

Investigation method, appliances and equipment

Mathematical models suitable for the direct calculation of the characteristics of intricate thermodynamic and water quality change processes in open reservoirs of different spatial shapes are not yet available. Therefore the characteristics of thermodynamic and hydraulic phenomena have been determined by means of a physical model while the change in water quality, by making use of measurement results for reservoirs similar by size and operation to the ***Póc-valley*** reservoir.

The physical model to scales $M_H = 1:200$ and $M_V = 1:25$ has been constructed from concrete (Fig. 1). The model tests were ruled by *Froude's* similarity law meeting practical requirements. During the test process, operating temperature conditions were maintained both in the model and in its environment.

Conversion factors according to Froude's invariant are:

$\lambda_V = 5$ (for velocity);

$\lambda_Q = 2500$ (for water discharge);

$\lambda_t = 40$ (for time);

$\lambda_T = 1$ (for water temperature).

Models of the water intake and inflow structures have been constructed to scale $M_V = 1:25$.

The water temperature was continuously measured *vs.* time at the water intake as well as at 28 points inside the reservoir (Fig. 1) during the experiments. The measuring procedure was automated and the evaluation of the results computerized.

Suggested places of intake

Each water intake alternative was investigated for three storage levels ($H = 167.30$ m; $H = 164.00$ m; $H = 159.60$ m above Baltic sea level), and for two discharges: 1.8 m^3/s and 1.2 m^3/s. Water intakes were made at the elevations 161.00 m and 158.10 m above B. S. level.

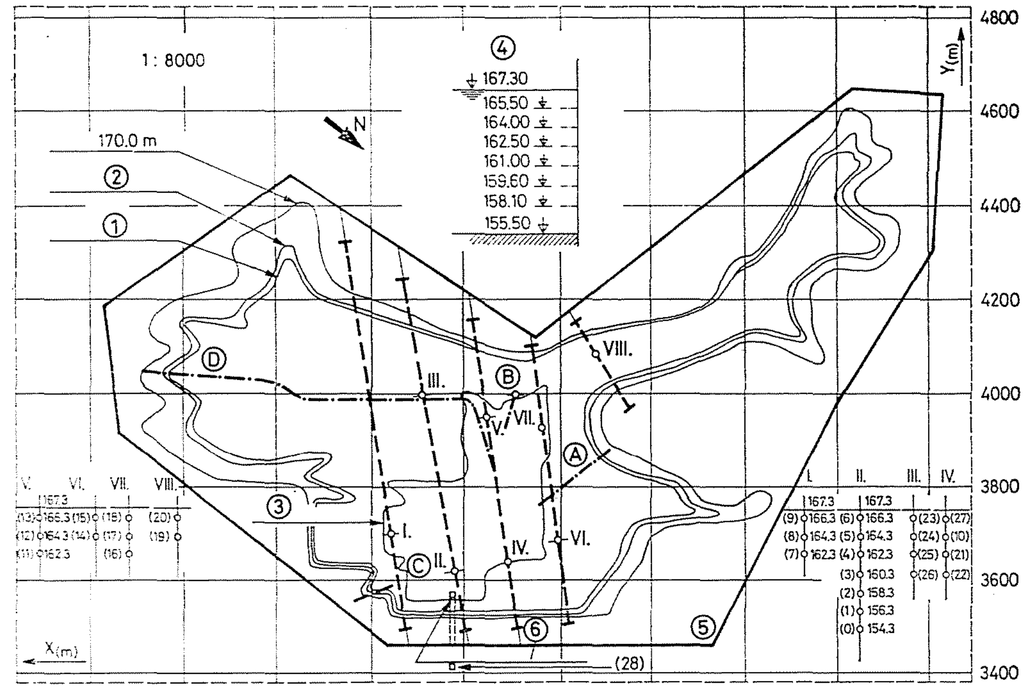

Fig. 1. Layout plan of the Póc-valley reservoir. Arrangement of the sensors for measuring water temperature: 1 = maximum storage level in operation 167.3 m; 2 = impounding head 167.85 m; 3 = minimum storage level in operation 159.60 m; 4 = water intake alternatives; 5 = datum line; A B C D inflows; 6 = water intake structure

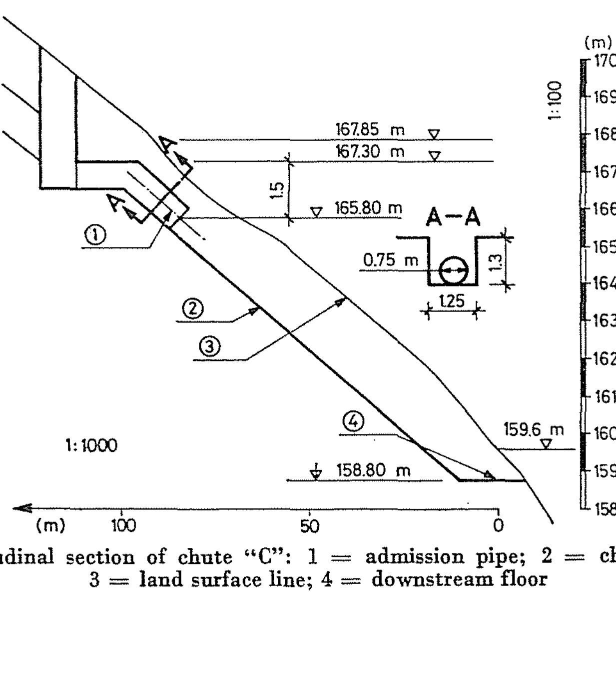

Fig. 2. Longitudinal section of chute "C": 1 = admission pipe; 2 = chute bottom line; 3 = land surface line; 4 = downstream floor

The reservoir was investigated in steady state, namely the inflow and intake discharges per second were the same.

The test results and the experiences obtained on operating reservoirs verified the following alternatives for the inflow points (Fig. 1):

— for mine-inflow water: chute at point "A",

— for Danube-water intake: in cold seasons (in winter), chute at point "C", in warm seasons (in summer) open channel at "D",

— convenient both for mine-inflow and for Danube water intake: double operation structure at "B".

The longitudinal section of the inflow chute at "C" is seen in Fig. 2. The chute for the mine inflow at "A" is of a similar construction. The chutes satisfy in the first line the requirements for the temperature of the water withdrawn from the reservoir. They are advisably located in the vicinity of the intake structure. Also the accommodation of the intake pipe of the pipeline according to Fig. 2 is thermodynamically justified.

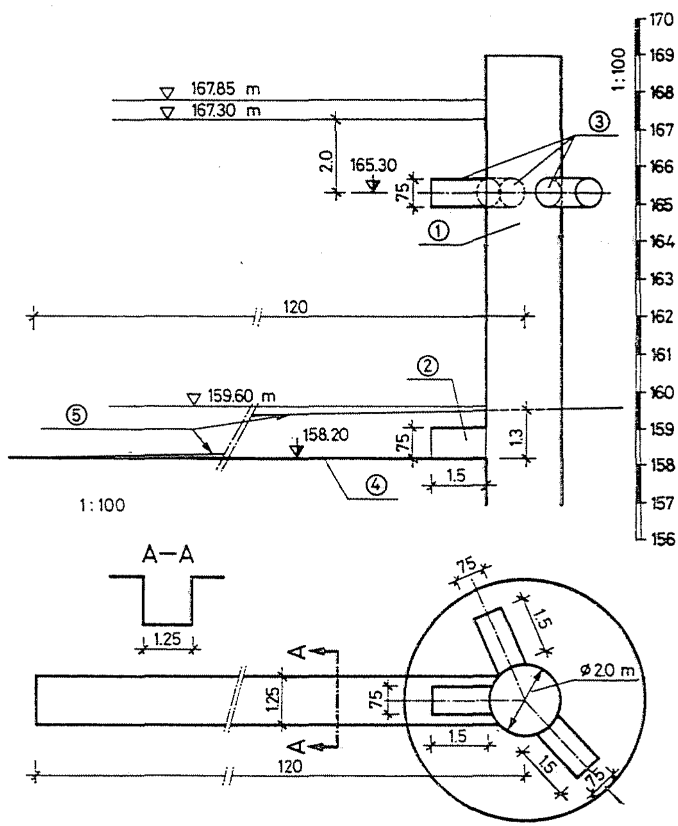

Fig. 3. Double function inflow "B": 1 = reinforced concrete cylinder of at least 2.0 m diameter; 2 = admission piece for maintaining the temperature of the water withdrawn from the reservoir; 3 = admission pieces for stirring the storage water; 4 = chute bottom line

The double-operation structure suggested for point "B" is seen in Fig. 3. The intake structure has a double function. In the cold season, when the unfavourable change of water quality is irrelevant, and the water withdrawn from the reservoir can only be kept artificially at the required temperature, the admission of the mine-inflow or Danube water is conducted through an admission piece to the intake structure with as little heat loss as possible. In warm weather when the temperature of the stored water is convenient for the water treatment plant, but the needed water quality demands the movement and exchange of the water particles, this is realized by opening the admission pieces No. 3.

Summary

The thermodynamic measurement results verified that any of the three designs suggested for the intake provides cooling water at minimum 8 °C from the reservoir.

According to hydrodynamical investigations and water quality measurements in operating reservoirs in the case of applying the intake designs suggested, a water quality drop in the reservoir such as to endanger the cooling-water supply of the power plant is unlikely to occur.

In final account, since there are three intake alternatives for the cooling water supply of the power plant, from the aspects of quality and temperature of the raw water utilized for cooling water, selection of the optimum intake point has to be decided as a function of construction costs, realizability and operability of the engineering structure.

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