A METHOD FOR SOLVING A SPECIFIC PROBLEM IN HYDRAULIC STRUCTURES

Uktam Ibrogimovich Begimov
Associate Professor, Department of Digital Technologies, Alfraganus University

Abstract

The conducted research has proven that the main cause of failure in reservoirs and pumping stations is the interaction and interpenetration of the flow phases involved and the inadequacy of the design for the multiphase fluid.

This article applies methods from the theory of interpenetrating multiphase fluid flow to the problems of increasing reservoir stability and justifying the parameters of coupling structures to pumping stations, taking into account multiphase flows.

Keywords: Hydraulic engineering, reservoirs, suction pipes of pumping units, sediments with dispersed mixtures, dam walls, single-phase flow, multiphase flow.

INTRODUCTION

Reservoir stability issues and the substantiation of stable hydraulic parameters for pumps and pumping stations have been studied by many authors. These studies were conducted for single-phase flow using pool coupling theory.

Research has shown that the primary cause of failure in reservoirs and pumping stations is the interaction and interpenetration of the flow phases involved and the inadequacy of the design to handle the multiphase fluid.

As is well known, momentum theory can be applied to establish the energy compatibility of hydroelectric power station coupling structures, but only for single-phase flow. It has also been proven that for single-phase flows, the presence of suspended sediments in the pumped water leads to siltation of the forepipe of pumping stations, which reduces the velocity of water approaching the receiving water. The multiphase nature of the fluid plays a key role in the occurrence of hydraulic features (such as the formation of an air vortex at the pump suction pipe).

Due to the complexity of the problems, many of these issues have thus far been considered only theoretically and investigated in a one-dimensional setting. Advances in modeling methods and computer technology have expanded the practical application of multiphase fluid models to the study of reservoir stability improvements and the substantiation of pump station coupling parameters. As is well known, during interphase penetration and interaction, the velocity vectors of different phases are directed in different directions, resulting in collisions of these velocities. These

collisions are primarily responsible for the formation of an air vortex at the pump suction pipe, the appearance of bubbles, and other resonant phenomena in the fluid.

Research Objective:

The interpenetrating motion of two or more media can be considered as their motion in a porous medium. For any one of these media, the others will constitute the porous medium in which they move. When phases interact and interpenetrate within a fluid, energy is released from each phase, and this energy is expended to overcome the resistance of the surrounding phases and adjacent solid boundaries (bottom outlet walls, tubular reinforced concrete outlet walls).

To construct a mathematical model of the free surface curve of a two-phase flow in the forecourt of a pumping station.

To construct a two-phase model of the energy compatibility of hydroelectric power station coupling structures.

Due to the complexity of the problems, many of these tasks have thus far been considered only theoretically and investigated in a one-dimensional setting. Advances in modeling methods and computer technology have expanded the practical application of the multiphase model to the study of reservoir stability improvements and the validation of coupling parameters for pumping stations.

The energy released during the interaction of fluid phases (sediments with dispersed mixtures, dam walls) leads to flow pulsation and cavitation, which is the primary cause of resonant conditions in hydraulic structures—reservoirs and in the connecting structures of pumping stations.

To derive calculation formulas for establishing reservoir stability criteria and coupling parameters for the stable operation of pumping stations.

To study processes occurring in the interior of feeder pipelines to a pumping station.

The connecting structures of pumping stations include the foredeck (a non-prismatic section connecting the feeder channel of a river or canal to the pumping station intake), the intake (where trash racks and the suction pipe of the pumping units are installed), pressure pipelines, a pressure basin, and the beginning of the discharge channel.

The problems of reservoir stability and the justification of stable parameters for pumps and pumping stations have been studied by many authors. These studies were conducted for single-phase flow using pool coupling theory.

As is known from hydraulics, the flow of a stream transitioning from an upstream to a downstream pool is called pool coupling. Pool coupling is sometimes understood to refer to a set of technical measures associated with transferring flow from an upstream to a downstream pool. During the transition from a turbulent flow to a

calm one, a hydraulic jump is formed. This hydraulic jump creates energy compatibility between the upstream and downstream pools of the stream.

A decrease in the velocity of water approaching the intake, even under conditions precluding cavitation of the pump unit, leads to the formation of an air vortex at the pump's suction pipe, which creates conditions for the cavitation process to occur.

To establish the energy compatibility of hydroelectric power plant coupling structures, momentum theory can be applied, but only for single-phase flow.

It has also been proven that for single-phase flow, the presence of suspended sediments in the pumped water leads to siltation of the forecourt of pumping stations, which reduces the velocity of water approaching the receiving water.

The multiphase nature of the fluid plays a key role in the occurrence of hydraulic features (e.g., the formation of an air vortex at the pump's suction pipe) in single-phase flow. As is well known, during interphase penetration and interaction, the velocity vectors of different phases are directed in different directions, and these velocities collide. These collisions are primarily responsible for the formation of an air vortex at the pump's suction pipe, the appearance of bubbles, and other resonant phenomena in the liquid.

Thus, the problem of establishing the compatibility of multiphase water flow in all hydraulic structures and pumping station facilities can be resolved using multiphase fluid methods, taking into account the presence of a large amount of sediment (second phase) in the water (first phase).

Creating a dynamic model of three-phase flow (water, floating elements, and flow aeration) from a reservoir to an inlet structure and further along a water supply system to the tailrace, as well as methods for substantiating the phase coupling parameters of the upper and lower reaches, can reveal certain complex processes and resolve complex single-phase flow hydraulics problems.

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