NUMERICAL MODELLING OF THE INFLUENCE OF THERMAL POWER PLANT ON THE AQUATIC ENVIRONMENT WITH DIFFERENT METEOROLOGICAL CONDITION

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Abstract This paper presents the mathematical model of the thermal power plant in cooling pond under different meteorological conditions, which is solved by three dimensional Navier - Stokes equations and temperature equation for an incompressible fluid in a stratified medium. A numerical method based on the projection method, which divides the problem into three stages. In the first stage it is assumed that the transfer of momentum occurs only by convection and diffusion. Intermediate velocity field are solved by method of fractional steps. In the second stage, three-dimensional Poisson equation is solved by the Fourier method in combination with tridiagonal matrix method (Thomas algorithm). At the third stage it is expected that the transfer is only due to the pressure gradient. Then are determined qualitatively and quantitatively approximate the basic laws of the hydrothermal processes depending on different meteorological conditions.

INTRODUCTION

Environment - the basis of human life, as mineral resources and energy are produced from them. Moreover they are the basis of modern civilization. However, the current generation of energy cause appreciable harm to the environment, worsening living conditions. The basis of the energy - are the various types of power plants. But power generation in thermal power plants (TPP), hydro power plant (HPP) and nuclear power plants (NPP) is associated with adverse effects on the environment. The problem of the interaction of energy and the environment has taken on new features, extending the influence of the vast territory, most of the rivers and lakes, the huge volumes of the atmosphere and hydrosphere. Previously, the impact of TPP on the environment was not in first priority, as before to get electricity and heat had a higher priority. Technology of production of electrical energy from power plant is connected with a lot of waste heat released into the environment. Today the problem of influence of the nature by power is particularly acute because the pollution of the atmosphere and hydrosphere increases each year. Another problem, of TPP is thermal pollution of reservoirs or lakes. Dropping hot water - is a push chain reaction that begins reservoir overgrown with algae, it violates the oxygen balance, which in turn is a threat to the life of all its inhabitants. Thermal power plants with cooling water shed 4 - 7 kJ of heat for 1 kW / h electricity generation. Meanwhile, the Health Standards discharges of warm water with TPP should not raise the temperature higher than $3^0 C$ in the summer and $5^0 C$ in winter of the reservoir's initial temperature. Spread of harmful emissions from TPP depends on several factors: the terrain, environmental temperature, wind speed, cloud cover, precipitation intensity. Speed deployment and increases the thermal pollution area - are meteorology conditions. Thermal pollution of reservoirs or lakes water that cause multiple violations of their state is a one representation of environment danger. Thermal power plants generate energy through turbines, driven by hot steam and exhaust steam is cooled by water. Therefore, from the power plants the water flows with the temperature of $8-12^0 C$ above the temperature of the reservoir is continuously transferred to the reservoirs or lakes itselves. Large TPP shed till 90 m ^{3}/s of heated water.

MATHEMATICAL MODELS

Numerical simulation was carried out on the Ekibastuz SDPP-I reservoir, located in the Pavlodar region, 17 km. to the north-east of Ekibastuz city, Kazakhstan. Technical water supply of SDPP-I was carried on the back of the circuit with cooling circulating water. The surface of the reservoir is at 158.5 m., the area is 19.6 km^2, the maximum size of 4 x 6 km., the average depth of 4.6 m. and a maximum depth of 8.5 m. at the intake, the volume of the reservoir is 80 million cubic meters. Selective intake and spillway combined type are used in the reservoir.Waste water enters the pre-channel mixer, then through a filtration dam uniformly enters the cooling reservoir. Water intake is at a distance of 40 m. from the dam at a depth of 5 m. Design flow of water 120 $m^3/\sec$, and the actual flow rate varies depending on the mode of TPP within 80-100 $m^3/\sec$. For the numerical simulation of this problem was constructed a real coastal circuit of Ekibastuz SDPP-I reservoir. In the reservoirs - cooling spatial temperature change is small. Therefore, stratified flow in the reservoirs - cooler can be described by equations in the Boussinesq approximation. For the mathematical modelling are considered the three dimensional equations of motion, the continuity equation and the equation for the temperature. Considers the development of spatial turbulent stratified reservoir - cooler [1, 2, 9, 10]. Three dimensionally model is used for distribution of temperature modelling in a reservoir [9, 10]

$$\frac{\partial \overline{u_i}}{\partial t} + \frac{\partial \overline{u_j}\,\overline{u_i}}{\partial x_j} = -\frac{\partial \overline{p}}{\partial x_i} + \nu \frac{\partial}{\partial x_j}\left(\frac{\partial \overline{u_i}}{\partial x_j}\right) + \beta g_i (T - T_0) - \frac{\partial \tau_{ij}}{\partial x_j} \tag{1}$$

$$\frac{\partial \overline{u_j}}{\partial x_j} = 0 \quad (i = 1, 2, 3). \tag{2}$$

$$\frac{\partial T}{\partial t} + \frac{\partial u_j T}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\chi \frac{\partial T}{\partial x_j}\right) \tag{3}$$

where $\tau_{ij} = \overline{u_i u_j} - \overline{u_i}\,\overline{u_j}$ (4)

$g_i -$ is the gravity acceleration, $\beta -$ the coefficient of volume expansion, u_i - velocity components, $\chi -$ thermal diffusivity coefficient , $T_0 -$ the equilibrium temperature, $T -$ deviation of temperature from the balance. For turbulent model used dynamic Smagorinsky model [5].

Numerical solution of (1) - (3) is carried out on the staggered grid using the scheme against a stream of the second type and compact approximation for convective terms [3, 7]. Projection method [6] is used to solve the problem in view of the above with the proposed model of turbulence [4]. It is anticipated that at the first stage the transfer of momentum occurs only through convection and diffusion.

Intermediate field of speed is solved by using fractional steps method with the tridiagonal method (Thomas algorithm). The second stage is for pressure which is found by the intermediate field of speed from the first step. Three dimensional Poisson equations for pressure are solved by Fourier method for one coordinate in combination with the tridiagonal method (Thomas algorithm) that is applied to determine the Fourier coefficients. The numerical algorithm for three dimensional Poisson equation was parallelized on the high-performance system [6, 8].

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