ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 3, March 2019

Simulation new tape of cooling towers fills of thermal power plants with COMSOL Multiphysics

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ABSTRACT:The article discusses the results of a numerical study of thermal power station cooling towers fills with using the COMSOL Multiphysics software. A comparison of the results of laboratory studies with full-scale ones. Proposed solutions for obtaining reliable data.

KEY WORDS: Cooling tower, thermal power plant, irrigator, circulating water supply systems, evaporative cooling, finite element method.

I.INTRODUCTION

The consumption of fresh water in industry can be significantly reduced by switching production to waste-free, anhydrous or low-flow technologies. However, many production processes do not always fully allow the use of such technologies. Then to the forefront in the implementation of the task of saving water in the industry come cooling water recycling systems with cooling towers of various types and designs [1].

Cooling towers are used in all industries. Their use is especially lot of in energy, chemical, oil refining, metallurgical and others, since the removal of low-grade heat from industrial devices using cooling towers is the cheapest way to save at least 95% of fresh water [1].

Most of the cooling towers used in the country were designed in the 60-70s of the last century, their main components of the device are morally obsolete, physically worn and do not meet modern requirements.

In process cycles where chilled water is used to obtain final products, for example, chemical processes, petrochemicals, mineral fertilizers, the dairy industry, an incorrectly chosen cooling method or an improperly designed cooling tower can reduce the yield of the final product by 1,5 - 2 times, not to mention quality reduction. This problem is particularly acute in the summer, because the lower the chilled water temperature, the greater the yield and the higher the quality of the product obtained.

The degree of realization of the advantages of circulating water supply systems in technical and environmental aspects in comparison with direct-flow systems, as well as the performance of process equipment, the quality and cost of products produced the specific consumption of raw materials, fuel and electricity depends on the efficiency of cooling towers.

The cooling process takes place due to the evaporation of a part of water when a thin film or drops drain it through a special sprinkler, along which air flows in the direction opposite to the movement of water. When 1% water evaporates, the temperature of the remaining mass decreases by 5,48 °C [2].

For most of the year, surface evaporation plays a dominant role in the cooling tower, and in summer in the heat, evaporation accounts for up to 90% or more of the heat given off by water. In winter, heat transfer is dominated by contact up to 50%, and in the coldest time of the year, up to 70%.

The creation of water recycling systems in the industry using cooling towers helps reduce the costs of enterprises for the consumption and discharge of process water, increase the efficiency of equipment use, so that the cost of the cooling tower pays off over several years. At the same time, such systems allow us to solve current environmental problems.

Basically the efficiency of the cooling process of circulating water on cooling towers is determined by sprinklers and water catchers, designed to provide the necessary surface contact of the phases with minimal air and hydrodynamic resistance.

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Currently, there is a great variety of designs of sprinklers and catchers of cooling towers, however, since industry tends to replace products made of traditional materials with polymer products with different sizes and shapes of sections, the demand for which is increasing both in the domestic and in the world market, there is a need to create new highly efficient and technologically advanced designs of sprinklers and water catchers of cooling towers from polymeric materials. In this case, irrigation and water trapping devices in each case must meet the technical requirements of state and industry standards for cooling capacity at minimal cost [3].
When choosing the type of irrigation device in each case, a comparison of the cooling capacity and the cost of the cooling tower should be made. The value of head loss during the movement of air in the irrigator and the water catcher is also an integral indicator of its work, since it characterizes the operating costs of the cooling tower. It is necessary to take into account a number of other indicators - durability, material wear and tear, strength and mass of the sprinkler and water catcher, ease of installation, availability of repairs and inspections, as well as the presence of suspended substances and aggressive impurities in the cooled water.

II. SIGNIFICANCE OF THE SYSTEM

The solution of problems aimed at saving energy resources and not reducing the main technical indicators of production requires the introduction of new high-tech technologies. When conducting a physical experiment to investigate the cooling tower, difficulties arise, as the visualization of the processes is technically very difficult.
The purpose of simulating a fills cooling tower is: to study the change in the velocity field of the gas flow inside the fills.To study the main technological characteristics of the developed fills design with tubes, aerodynamic tests were carried out to determine the aerodynamic drag coefficient of the fills devices and the cooling tower in the automotive area, its dependence on air consumption (air velocity).

III. LITERATURE SURVEY

The greatest contribution to the study of hydrodynamic and heat and mass transfer characteristics of fills was made by the following scientists and experts: Berman L.D., Ramm V.M., Lewis V.K., Merkel F., Poppe M., Zhavoronkov N.M., Aerov M. E., Levich V.G., Olevsky V.M.,Ponomarenko V.S. and other.
It should be also noted research related to the improvement of individual elements or the development of new types of cooling towers in order to improve heat and mass transfer processes. In most of the works, the analysis of the data of the operation of industrial cooling towers with different types of contact devices – the fills. It has been established that under equal technological and meteorological conditions, the type and location of contact devices affects the efficiency of the cooling tower.
The works also solve a set of tasks to increase their efficiency by creating and experimentally testing new designs of sprinklers and water catchers, optimizing the water distribution system, taking into account the distribution of air flows in the cooling tower, improving and experimentally working out the designs of water-spray nozzles. However, the application of the above and sub-home solutions to them is possible only at the stage of designing new circulating systems and cooling towers, or they require significant retrofitting of existing ones and stopping the operation of cooling towers for their implementation.

IV. METHODOLOGY

The total amount of evaporating water increases with increasing surface contact of water and air, so the design of the cooling towers, in which evaporative cooling occurs, provide for an increase in the surface of evaporation by creating a large mirror of liquid, splitting it into streams and drops or the formation of thin films flowing over the surface of the nozzles. The increase in the intensity of heat and mass transfer during evaporation is also achieved by increasing the velocity of the gas medium relative to the surface of the liquid. However, an increase in this speed should not lead to excessive liquid entrainment by the gaseous medium and a significant increase in the hydraulic resistance of the cooling tower.
The efficiency and reliability of cooling towers largely depend on the nature of the flow in the fills device. When designing cooling towers, reliable data on the structure of the spatial flow and local heat transfer are required, which in modern conditions can be obtained by numerical simulation? Like a physical experiment, calculations require constant

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and, if possible, extensive verification of the results obtained by comparing both with the data of well-controlled experiments and with the data obtained using various software tools.
This paper presents the results of calculations of three-dimensional turbulent flow in the cooling tower sprinkler. Numerical simulation is performed for the conditions adopted during the experiments.
As a characteristic area of heat transfer, an irrigation site located in a cooling tower was considered. The shape of this area is assumed rectangular with a vertically directed axis. The height of the fills in the cooling tower is 2000 mm, the size of the section is 500x750 mm. At the lower end of the fills, an ascending airflow velocity is set at 1 m/s. The walls of the fills are impenetrable (Fig. 1.).

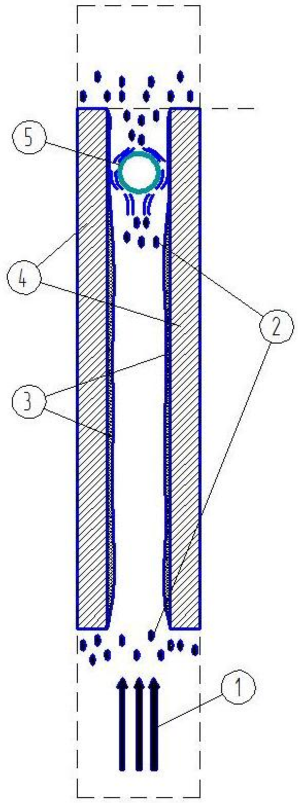

Fig1. Scheme of a flat irrigators (fills) (1- air, 2- water drops, 3- water film, 4- flat fills, 5- tube).

It should be noted that, given above, the parameters are assigned as boundary conditions for solving the considered problem from the condition of maximum correspondence to the actual heat exchange processes in cooling towers.The COMSOL Multiphysics package was chosen as a software system for simulating the operation of a compact cooling tower.
A mathematical model of the motion of water and gas is given as an incompressible fluid. The model of incompressible fluid includes: the Navies-Stokes equations (the law of conservation of momentum), the equation of continuity (the law of conservation of mass of a liquid); law of energy conservation; the equation for the diffusion transfer of a scalar quantity (the law of conservation of mass) and the k – e equation for the turbulence model.
The equation of continuity (the law of conservation of mass):

$$\partial\rho/\partial t+\nabla\cdot(\rho u)=0 \quad (1).$$

Momentum conservation equation (vector equation):

$$\rho\, \partial u/\partial t+\rho(u\cdot\nabla)u)=\nabla\cdot[-pI+\tau]+ F \quad (2).$$

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Energy conservation equation:

$$\rho C_p \, \partial T/\partial t+\rho C_p \, u\cdot\nabla T=\nabla\cdot(k\nabla T) \quad (3).$$

When temperature changes in a stream of liquid (gas) are small, a single-phase liquid (gas) can be considered as incompressible, i.e. ρ is a constant. This condition is true for all liquids under normal conditions, as well as for gases at low speeds. Then for constant density, equation 1 can be written as follows:

$$\rho\nabla\cdot u=0; \quad (4)$$

and equation 2:

$$\rho \, \partial u/\partial t+\rho(u\cdot\nabla)u)=\nabla\cdot[-pI+\mu(\nabla u+(\nabla u)^T)]+ F ; \quad (5)$$

To solve the system of differential equations, the finite element method was used.

V. EXPERIMENTAL RESULTS

The area in which the solution of differential equations was sought was divided into a finite number of sub regions (elements) in the amount of 68555 (Fig. 2), in each of which the type of approximating function was chosen arbitrarily. As finite elements, free triangles are used. The program determined their sizes and locations automatically.

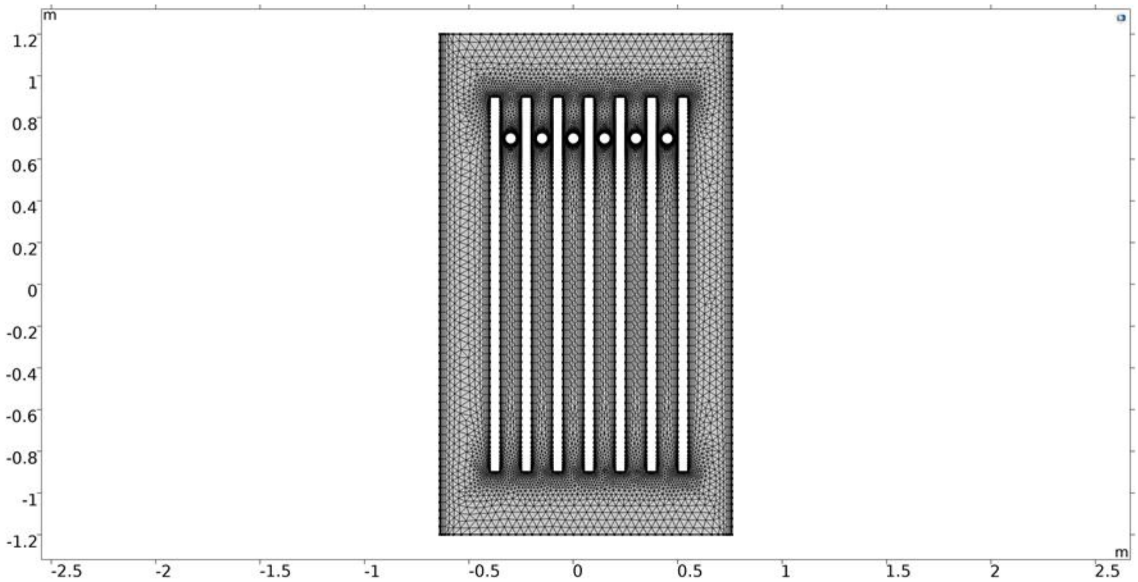

Fig.2. The original contours of the walls of a flat fill with tubes, divided into finite elements.

Then the boundary conditions are set and set. Next, the parameters of the calculation method and the method of numerical simulation are introduced.
When modelling cooling towers, it is necessary to take into account the unevenness of air velocities.
The study of the operation of the compact fan cooling tower using the COMSOL Multiphysics software package made it possible to determine the air velocity field inside the cooling tower and evaluate the operation of the polymer fill. Based on the work done, using the professional version of the COMSOL Multiphysics package, you can develop a complete mathematical model of the cooling tower operation to determine the efficiency of heat and mass transfer between cooled water and air.
The data obtained because of numerical simulation of the distribution of air velocity in the computational domain is shown in Fig. 3. Calculations are based on the perfect gas model. It was assumed that the flow is described by a system of stationary three-dimensional Naiver-Stokes equations and energy averaged over Reynolds.

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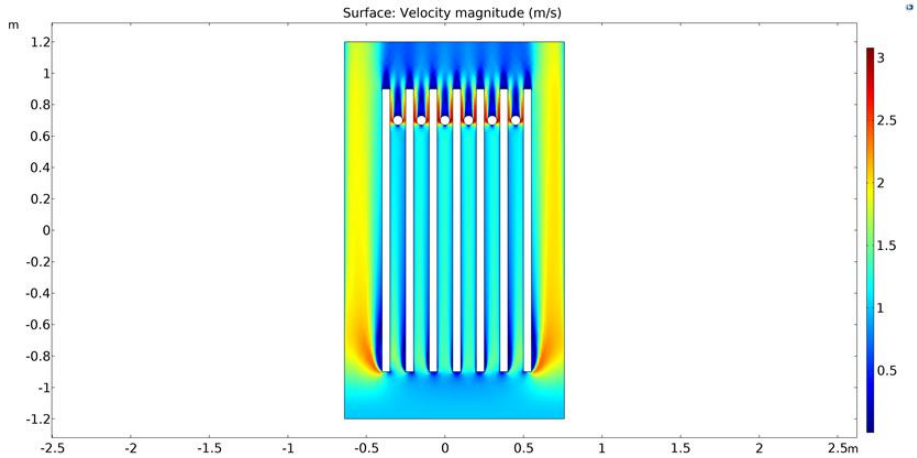

Fig.3. Fields of velocities in a flat fill with tubes, m / s.

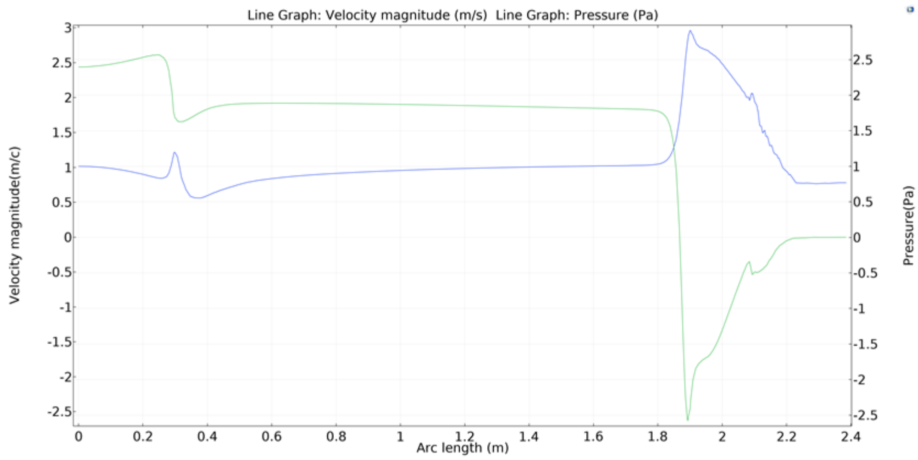

Fig.4. Graph of the velocity and pressure fields in a flat fills with tube.

VI.CONCLUSION AND FUTURE WORK

A comparison of the results of calculations using the COMSOL Multiphysics program and experimental data indicates a good qualitative and quantitative prediction of the velocity field and the pressure in the cooling tower fills. The zone of significant pressure increase near the air inlet to the irrigator was reproduced with sufficient accuracy for practice and the shape of the velocity distribution in the channel and beyond the outlet from the irrigator was correctly predicted. The picture of the pressure distribution obtained using the COMSOL Multiphysics package coincides qualitatively with the experimental data; however, in quantitative terms, the COMSOL program gives an average of 3% underestimate compared to the experiment.

Using the COMSOL Multiphysics research program, calculations of three-dimensional turbulent flow in the cooling tower fills were performed.

Comparison with experiment showed that when using the turbulence model, computing systems allow one to predict the flow structure in the sprinkler channel well, rather accurately resolving the details of the secondary flows.

REFERENCES

[1] Ponomarenko V.S., Arefev Y.I. Cooling Towers of Industrial and Energy Enterprises: Reference Guide. -M.: Energoatomizdat, 1998. 23-30 p.
[2] Burger R. Influence of packing cooling towers on the economic results of their work. Oil and Gas Technologies Journal, 2000, №6.
[3] http://www.ventenergo.ru/grad.php.
[4] Rakhmanov N.M. Study of the operation of a compact cooling tower with polymeric fills. Bulletin of TSTU. - Tashkent. TSTU. 2011. 80-83 p.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 3, March 2019

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