

ANALYSIS OF OPERATING PARAMETERS OF THE PROCESS WATER COOLING SYSTEM BASED ON THE PROCESS WATER SUPPLY SYSTEM COMPLEX OF TPP-6

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Abstract

Energy industry facilities are characterized by significant consumption of thermal energy in its various forms: saturated steam, hot water, as well as significant use of water resources for technological needs. The use of cooling towers has become quite widespread for technological processes, but due to their exhaustion of the working resource, the question of their modernization arises. The introduction of new supply systems, water spraying and sprinklers makes it possible to improve the operation process and reduce production costs.

Keywords: heat and power plant, technical water supply, cooling systems, cooling towers.

Introduction

The most important unit of a cooling tower is the nozzle (sprinkler blocks). The heat and mass transfer properties of the sprinkler, together with the aerodynamic ones, determine, mainly, the efficiency of the cooling tower, that is, they affect the choice of the required dimensions of a new cooling tower or the assessment of the thermal load capabilities of an existing cooling tower [1]. Various materials are used for sprinklers: wood, concrete, plastic. If clean water is cooled in cooling towers, the most economical is to use a film-type sprinkler. If the cooling water contains suspensions and oil products, film sprinklers are not recommended for use due to the possibility of clogging the gaps between the shields. In such cases, drip sprinklers have to be used. However, they allow a hydraulic load approximately 1.5 times less than film ones with the same cooling effect [2]. Recently, lattice nozzles made in the form of perforated polyethylene pipes have become widespread. They are laid in an orderly manner or in bulk. The lattice nozzle of the Balk-Durr company [3] consists of flat and wavy lattices with dimensions of 0.45x1.2 m, made of polyethylene. Their cells have the form of a rhombus with dimensions along the axes of 25x19 mm. When assembled, the nozzle is a three-dimensional structure with vertical channels in the form of an equilateral triangle with a base of 60 mm and a height of 18 mm. The required height of the nozzle is provided, most often, by two tiers of blocks (it is 0.9 m). The lattice nozzle of PR50 is similar to the Balk-Durr nozzle, but consists of long hollow elements with lattice walls, having the form of an equilateral triangle. PR50 are made of low-pressure polyethylene based on the 273-79 brand, which is not subject to destruction under the influence of insolation.

The purpose of the work is to analyze the operational parameters of the process water cooling system (cooling tower) and its technical solutions based on the complex of the process water supply system of TPP-6.

Research results

The technical water supply scheme of TPP-6 is single-lift. Two tower cooling towers with an irrigation area of 3200 m² each and a spray pool with a water mirror area of 28400 m² are used as circulating water coolers. To supply water to the condensers of turbines, heat exchangers of auxiliary equipment (oil coolers, gas coolers, etc.), the cooling tower and the spray pool, four circulation pumps of the OPV 3-110-KZ type are installed in the central pumping station. The pumps are axial rotary-vane vertical, with chamber water supply. The cooling water is supplied from the central station to the turbine condensers and to their auxiliary equipment via two pressure water mains with a diameter of DN 2400 mm, designed for a volumetric water flow of 65180 m³/h at an average flow rate of 2.0 m/s. The water heated in the condensers is supplied to the cooling tower and the spray pool via two drain pipes of DN 2200 mm for cooling. The drain pipes to the

cooling towers and the spray pool are designed for a volumetric water flow of 56,000 m³/h at an average speed of 2.05 m/s.

The water heated in the auxiliary equipment heat exchangers via a drain pipe of DN 1800 mm is discharged directly into the pre-chamber of the central heating system.

The water cooled in the cooling towers and the spray pool from their water collection tanks flows by gravity into the pre-chamber of the central heating system. From the water collection basins of each cooling tower, water is discharged sequentially via two drain pipes of DN 2000 mm, one drain pipe of DN 2800 mm, and then via a reinforced concrete channel with a cross section of 2500x2500 mm. From the water collection tank of the spray pool, water is drained through a reinforced concrete channel with a cross section of 2500x2500 mm. The drain channels of the spray pool and the cooling tower of station No. 2 in the area of the cooling towers of stations No. 1 and 2 are combined into one channel.

The replenishment of irreversible water losses in the STP (evaporation, removal, filtration, needs of the water treatment plant, third-party consumers) is carried out from the Desna River, on which a shore pumping station (SPS) for additional water has been built. Currently, four pumps of the 350D-90 type are installed in the SPS.

Water is supplied to the suction of the pumps through a flooded water intake head of type I with a reinforced concrete shell. The supply of additional water from the SPS to the TPP-6 site is carried out through two steel water pipelines of DN800 mm. At the TPP-6 site, these water mains are combined into a common collector (switching well), from where water is supplied separately for the replenishment of the HWW, the needs of the CWT, etc.

Water supply to external consumers is carried out through two water pipelines of DN 300 mm.

The main factors determining the choice of nozzle are heat transfer parameters, pressure losses, the total cost of the technical solution, etc. Reliability, including the availability of repairs, is a particularly important factor for thermal power plants and in other areas of use, where the cost of a cooling tower is a very small part of all costs, and the removal of a cooling tower for repair is large.

Plastic nozzles are required to have a volumetric mass transfer coefficient based on the fact that for the calculated cooling of water, a nozzle with a height of about 1 m and a value of the coefficient of aerodynamic resistance to air flow, which is approximately equal to the value of 10 - 15 speed heads, would be sufficient.

Various nozzle block schemes can be arranged from PR50. The most practical and effective, in terms of cooling capacity, is the scheme with horizontal laying of PR50 in rows in height. PR50 are placed close to each other with their rotation in each subsequent row at 90° relative to the prisms of the previous row. In the assembled form, the nozzle block is a three-dimensional lattice structure with horizontal channels of a triangular profile, which provides for the penetration of air and water in any direction. The practicality of such a scheme lies in its simplicity and the possibility of setting any calculated height with a multiple of 50 mm to ensure the necessary cooling of water. Most often, a height of 0.9 - 1 m of the nozzle block with PR50 is sufficient.

The prototype of the TP44 nozzle block from pipes with helical corrugations is a nozzle from pipes with a diameter of 63 mm with horizontal corrugations, which are intended for groundwater drainage. Adding not horizontal, but inclined placement of the corrugations in the form of a thread, of course, somewhat reduces the possibility of contamination of the pipe surface. At the same time, the forecast of a significant increase in the cooling capacity of the nozzle from pipes with a helical arrangement of corrugations did not come true. The larger the pitch of the screw (the steeper the slope of the corrugation), the greater the probability of the formation of a film of water in the groove (corrugation), which quickly flows down the screw cavity, i.e. the time of contact of water with air with minimal possibility of mixing of water layers inside the continuous film decreases [2]. Some twisting of the air layers adjacent to the walls of the screw pipes leads to a deterioration of the hydraulic regime of water flow to a sufficient extent, which is not compensated by anything. Thus, it can be reasonably stated that it is impractical to give the corrugations a large slope. It is justified to give them a slope to wash away the layer of deposits. For this, a hydraulic slope of the order of 0.15 (in TR 0.36) is sufficient. However, this does not give grounds to assert that such pipes will not be polluted, especially in the circulation cycles of petrochemical enterprises. In developed countries, nozzles made of solid-walled pipes have never been used because they are uneconomical in terms of the material consumption for their manufacture and the impossibility of achieving intensive heat and mass exchange between water and air inside the pipes, which make up 40-50% of the active volume of the cooling tower. If the water is not distributed evenly enough, some part of this volume may not participate in the cooling process at all. This, as well as the worse hydraulic regime of water flow in tubular nozzles compared to lattice ones, explains the difference in the mass transfer coefficient, respectively: 0.83 for tubular; 1.13 and

1.02 for lattice ones under the same conditions. The technological characteristics of nozzle blocks made of smooth strips can be significantly improved by mixing and turbulizing the contacting water and air flows. This can be achieved by using strips with straight or curved waves, perforation, rough or porous surfaces, as well as by making the film blocks of the nozzle with gaps between the tiers in height. As flow turbulizers, protrusions of various shapes, corrugations, which change the direction of flow and contribute to their mixing, can also be used. All these techniques, to one degree or another, increase the cooling capacity of the nozzle block, but, as a rule, also increase their aerodynamic resistance [3].

Thus, the cooling capacity of the nozzle block can be increased by applying artificial roughness by 10 - 20%, by making gaps in height by 25 - 30%, by forming waves depending on their size, direction and shape by 1.5 - 2 times, by selecting the optimal number of corrugations - approximately twice. In addition, the rational arrangement of the nozzle tiers in height with gaps can reduce material consumption by 25 - 30% and reduce aerodynamic resistance by 20 - 30%. In world practice, it has been established that the most effective in terms of economic, thermal and aerodynamic indicators are polymer nozzles made of thin corrugated strips and lattice elements of various designs - with a high saturation of the volume of the material for their operation in water with normal concentrations of contaminants and with a lower one - for significantly polluted water.

Conclusions

The above results of the technological analysis form the basis for the implementation of engineering and technical development for the existing technical water supply system of TPP-6. This should increase the reliability of heat supply to a significant part of the housing and communal services of the city of Kyiv, as well as contribute to reducing the negative impact on the environment.

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