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COOLING TOWERS

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This article deals with the process of water cooling in cooling towers. It also gives the classification of adverse water supply cooling systems at industrial enterprises. Having analyzed the peculiarities of cooling tower exploitation in different conditions, the authors give the initial data for the estimation of their reliability and their technical-economic assessment as well as the ecologico-economical liability of the cooling towers and their separate constructions.

Cooling towers are constructions (devices) applied for the process of water cooling with the help of free air. Nowadays the cooling towers are applied in systems of adverse water supply while cooling heat-exchange apparatus. The importance of such systems is really high especially in power, chemical, oil-refining and other industries due to the fact that even today the outlet of the low grade heat source from the industrial apparatus with the help of cooling towers is still considered to be the cheapest and helps to economize not less than 95% of fresh water [1].

The most productive cooling tower in the world is the cooling tower for the Atomic Power Station – ISAR II in Germany [2]. It cools 216 000 cubic meters of water per an hour. Its height is 165 meters and the base diameter is 153 m.

The systems of industrial water-supply are designed to establish water delivery to the plant of needed quantity and of appropriate quality. After the cooling process, mostly with the help of cooling towers, and after its purification (if needed) the bulk of water returns to the system, some part of backwater is lost during the evaporation, the drop priming, the leak flow and the dumping as the form of system expulsion.

Technical-and-economic as well as ecological aspects of the cooling tower appliance in industrial water-supply systems are the fallowing. The temperature requirements of the drop priming at the enterprise are established by the technological process and by the running ability of the equipment. When choosing the type of the cooling tower for the temperature maintenance one should consider the water contamination possibilities by the industrial products during the water rotation cycle.

The cooling process takes place with the help of some water masses evaporation while the water drains in a thin film or in drops along the special irrigator, where the air stream is brought in the opposite direction from water (*ventilator cooling tower*). In *ejection cooling towers* the cooling process is achieved with the help of the formed environment which is very close to the vacuum environment that is established by special jets. During the evaporation of 1% of water, the temperature of the remained water mass is lowered by 5,48 °C, and in ejection cooling towers – by 7,23 °C. As a rule, the cooling tower is applied when there is no opportunity to use big reservoirs of water for the cooling process.

Specifications

The main parameter of the cooling tower is the *irrigation density rate*. It means the specific value of water consumption for 1 m^2 of the irrigated surface. The main part specifications of the cooling tower are defined with the help of the technical and economic assessments depending on the volume and the temperature of the cooled water and the atmospheric parameters (temperature, humidity, etc.) in the place where the cooling tower is erected.

Classification

Depending on the type of the irrigator, the cooling towers are divided into filmy, dripping, spraying, dry.

By means of air feed they are divided into ventilating (the draft is caused by the fan kit); tower-shaped (the draft is caused with the help of the high stack); opened (atmospheric) – it means they use the wind power and the natural convention when the air is fed through the irrigator; ejected – they use natural catch of the air during the water irrigation through special openings.

Under the direction of the environment flow (cooled water and air) they are divided into those with the backflow (the highest temperature step, the strongest aerodynamic resistance); with the crossflow (the weakest aerodynamic resistance, lower droplet entrainment); with the mixed current (the construction of the cooling tower has both the backflow and the crossflow).

The operation mechanism is based on the spillage of hot water through the jets (nozzles), thereby the cooling process takes place. Very often the ambient airflow is added to this process with the help of the axle fan

kit. The essential area for the cooling process, the surface of its air-contacting, is set up in the cooling tower on its irrigating systems (irrigators), they can be dripping, filmy, complex.

There exist non-irrigating cooling towers where high-head irrigating nozzles are adjusted inside the tower under the drainage. These so called irrigating cooling towers are less effective than the cooling towers with spraying or filmy irrigators as the square of the water contact surface is relatively less.

Cooling towers are used for cooling the bulk amount of water, they exceed the amount of water used at works in several times. These cooling towers are used mainly at heat power or at nuclear power plants. The height of big Cooling towers, manufactured from monolithic concrete, can reach up to 90 m and have irrigating square up to 90 3200 m^2.

Opened cooling towers can be of two types: spraying and dripping. The first represents a small spraying pool which is protected on all sides with louvre boards. They protect bulk water splashes from coming out of the pool in great amounts. In the dripping cooling tower there exist the irrigator, unlike in the spraying one. The application area of opened cooling towers is found out on the basis of the following conditions: irrigated density 0,8…1,4 kg/(m^2 sec); temperature step of hot and cooled water 5…10 °C.

By means of heat disposal of the atmospheric air the cooling towers are classified into *evaporative* (heat disposal from water to the air is carried out mostly by means of the evaporation). *Radiator* or *dry* (heat disposal from water to the air is carried out through the cooling wall (side) due to the thermal conductance and the convection). *Complex* (where heat disposal is carried out due to the evaporation and the thermal conductance or convection).

Maintenance of cooling towers during a winter time. During a winter time the maintenance of cooling towers can be complicated due to the freezing process of their structures (frame), especially this happens in severe climate conditions. Freezing of the cooling towers can lead to the critical condition with the following deformation and collapsing of the sprinkler due to additional strain from ice that can be formed on its surface. Freezing of the tower usually begins at the external air temperature below 10° C and happens in places where cold air contacts with small amount of warm water when coming into the tower. Internal freezing of the tower is dangerous because of intensive fog formation which can be found only after the sprinkler had collapsed. To avoid freezing, water is being sent only to several towers, sometimes with decreasing consumption of circulating water.

Energy conservation in cooling towers. Specific hydraulic loading on the cooling towers is estimated by the technology calculations. It depends on the parameter estimations of the atmospheric air with the specified percentage of the frequency, on the required water temperature step, on the estimated cooling water temperature, on the chosen type and the construction of the cooling tower.

In order to prevent cooling tower frosting and its breakdown one must facilitate equal distribution of the cooled water on the surface of the irrigator and look after the equal density of the irrigating process on the single part of the cooling tower (only necessary for the spray cooling towers). The forcing fan is also forced to freeze, it happens so due to the incorrect or inaccurate usage of the cooling tower (for ventilating cooling towers). While using ejection cooling towers, the biggest part of these problems fades away due to the absence of either a ventilator or a spray [3].

The choice of the cooling tower's type is brought out with the help of the technological estimations taking into account many factors. For example, the water consumption rate and the heat amount, taken from the product; machineries and the cooling fittings; weather, geologic and hydrolic conditions of a building spot; placing the constructions and development of surrounding territory; chemical composure of water.

Splash type cooling tower should be used if there are suspensions combined with oils and petrochemicals in the circulating water and if there is a possibility of allocation of calcium carbonate (chalk) as a scum.

The environment protection. Nowadays the demands for the environmental protection have been risen above. The cooling tower as the source of the environmental damage should be considered by using two following factors: as the noise source and as the source of the harmful substances emission during the process of their outlet to the atmosphere. That is why all cooling towers should meet the existing norms of the environmental protection. Especially those that concern the noise reduction.

When choosing the place for the cooling tower one must follow some special rules: cooling towers should be erected on the open air, where there exists fast wind flow of hot and humid air; cooling tower orientation should be chosen relying on the wind streamline of the town; the air entrance into the cooling tower and its coming out should not have any obstacles.

Conclusion. The cooling tower, chosen for water cooling of any industrial objects, must provide the water cooling process at normal or even highest thermal load in any, even the most uncomfortable conditions of the environment, determined by the climatic data of the region. Only the correct and right choice of the cooling

tower type, of the spray and the ventilator will benefit in the workable system which will react correctly on the changes both of environmental conditions and of thermal load of the industrial processes.

REFERENCES

1. Градирни промышленных и энергетических предприятий : справ. пособие / под общ. ред. В.С. Пономаренко. – М. : Энергоатомиздат: 1998. – 376 с.
2. [Электронный ресурс]. – Режим доступа: http://ruwikipediaorg/wiki. – Дата доступа: 15.10.2016.
3. Защита от шума : СНиП 23-03-2003. – Взамен СНиП II-12-77 ; введен : 01.07.82. – М. : Гос. комитет СССР по стандартам, 1981.