Design of Counterflow Hyperbolic Natural Draft Cooling Tower

When a power plant is built in an area where water resources are not abundant, a cooling tower is usually used as a cooling means. In order to obtain a steady stream of electrical energy, the working fluid (usually water) needs to be recycled between the heat source and the cold source. The cold source here is realized by circulating cooling water. The steam in the low pressure cylinder of the steam turbine is cooled and condensed into saturated water in the condenser by the circulating cooling water outside the tube bundle. After the circulating cooling water absorbs heat, the temperature rises, and the cooling water with the increased temperature is sent to the cooling tower for heat and mass transfer with the air. After the cooling water passes through the heat release, the temperature drops, and the air temperature rises to become hot and humid air and then discharges to In the atmospheric environment, the cooling water with reduced temperature falls into the cooling tower sump and flows through the circulating water channel to the circulating water pump sump. The circulating water pump boosts the cooling water and then heats up to the condenser again. .

The function of the cooling tower in this cycle is to exchange heat with the air cooling source. The cooling water in the circulating water system enters the spraying zone through the water distribution device and sequentially passes through the packing zone and the rain zone, wherein the heat transfer in the packing zone The mass transfer process is the core of the heat exchange process between the high temperature cooling water and the low temperature air in the cooling tower. If the cooling tower is properly designed, the cooling tower outlet water temperature is lower within a reasonable range, so that the steam turbine low pressure cylinder can maintain a proper vacuum and the unit thermal efficiency can be maintained at a high level. Therefore, it is very necessary and economical to study cooling towers.

2 one-dimensional algorithm
The algorithm currently used in cooling tower design is still the coma method given by Michael in 1925. Michael used the difference between the helium in the air layer and the helium in the humid air as the driving force for the heat dissipation of the water in the air. The process of deriving the formula of the classical coma method is given. The Michael formula of the enthalpy difference method can solve the cooling number, that is, the cooling task, and the cooling tower water heat transfer characteristic formula can solve the cooling performance of the cooling tower. When the cooling task and the cooling performance are satisfied, the cooling tower heat is satisfied. After the calculation is completed, the power calculation is performed by the balance of the lift and resistance of the cooling tower. When the cooling tower heat and power calculations are balanced, when the circulating cooling water outlet temperature can meet the design requirements, the designed cooling tower should be selected in the actual project.

The one-dimensional calculation method has given specific calculation formulas in the "Design Code for Industrial Circulating Water Cooling", which will not be enumerated here. In this paper, only the selection of some parameters in the one-dimensional algorithm is analyzed, and the calculation parameters are correctly selected to obtain more accurate calculation results.

2.1 Thermal characteristic expression
The thermal characteristics refer to the cooling capacity of the packing. Different fillers and arrangements have different expressions. These empirical expressions are tested by industrial towers, and then obtained by fitting the formula to obtain the specific test and fitting. For the method of formula, refer to "Test Method for Performance of Cooling Tower Water Filling Packer, Water Remover and Splashing Device". Therefore, choosing a thermodynamic expression with better precision and extended performance is a key step in the accurate calculation of the cooling tower. The thermal characteristics of some counterflow cooling tower packings are given in the 2003 edition of the Industrial Circulating Water Cooling Design Code, and the heights of the packings calculated by these expressions are all 1 m, so the packing of non-1 m height is selected. The calculation formula referenced in the calculation needs to find the data by itself. The China Institute of Water Resources and Hydropower Research has carried out a large number of experiments on the counterflow natural ventilation cooling tower. In the 2014 edition of the Industrial Circulating Water Cooling Design Code, the thermal expressions under different arrangements of different packings are given, which greatly expands the use of counterflow. Cooling tower design accurate basic formula [1].

Since a large amount of test data is tested in the industrial cooling tower or test device, the water distribution zone, the watering filler zone and the rain zone are considered together, and the actual design of the cooling tower inlet height and the industrial cooling tower or test device There is a difference in the tail cooling height, so in some cases the thermal expression as the cooling capacity needs to be corrected. The China Institute of Water Resources and Hydropower Research and the Northeast Electric Power Design Institute have completed this work and obtained a formula for calculating the number of additional cooling due to the height of the air inlet.

In view of the consideration of the expansion and correction of the cooling number, the author believes that the thermal characteristic expression given by the China Institute of Water Resources and Hydropower should be preferred when calculating the cooling tower cooling number.

2.2 Evaporation water quantity heat correction coefficient
There is evaporation in the heat exchange project between the circulating water and the humid air in the cooling tower packing. The circulating water quantity is not constant during the cooling process. Therefore, when calculating the cooling number, it is necessary to consider the correction caused by the heat taken away by the evaporation water quantity. The "Code for Design of Industrial Circulating Water Cooling" also gives the correction coefficient of the amount of heat taken away by the evaporation water. Different opinions are given for the correction coefficient at the left and right ends of the Michael formula. The author's consideration on this issue is that if the influence of the correction factor is taken into account in the cooling tower packing test, the calculation of the cooling number also needs to consider the influence of the correction factor [2]. In the "Cooling tower watering filler, water eliminator, splashing device performance test method", it is clarified that the thermal characteristic formula is based on the corrected cooling number to fit the coefficient of the formula, so when designing the algorithm The correction factor is located at the integral end of the Michael formula.

2.3 Watering area

The watering area is an important design data for the counterflow natural ventilation cooling tower. Therefore, it is especially important to select the appropriate watering area for the calculation of heat and power. In the 2014 edition of the Industrial Circulation Water Cooling Design Code, the provisions in the 2003 edition that “the area of the leaching water should be immersed in water and fully ventilated” should be deleted. The water spray area often proposed in cooling tower design is the nominal water spray area, which is the value of all areas on the top of the packing. In the actual cooling tower packing area heat exchange, it is often affected by the area and volume occupied by the water leaching structure and the water distribution structure. If this part of the influence is not considered, the calculated cooling capacity will be slightly larger, which is unsafe for production. Therefore, the author believes that it is reasonable to deduct the area occupied by the structure to obtain the effective shower area for thermal calculation when performing thermal calculation. In the calculation of power, only the effect of the cross-section wind speed is considered. Therefore, the nominal water spray area can be used for calculation of the whole tower resistance calculation.

2.4 Outlet water temperature initial value

A tower water temperature value needs to be assumed during the initial iteration of the cooling tower calculation. The amount of ventilation in the actual operation of the counterflow natural ventilation cooling tower is limited. After cooling, the water temperature cannot be cooled to the cooling limit, ie the wet bulb temperature. Therefore, the initial value of the tower water temperature should be set to the wet bulb temperature for the iteration starting point. However, in the northern region, considering the safe operation, the water temperature in the winter operation needs to be kept above 12 °C. Therefore, the initial value of the tower water temperature should not be considered too low in the winter calculation. It is necessary to consider the district water distribution, the circulating water bypass and the suspension wind shield. The calculation input is calculated by lowering the height of the inlet and the like, and the initial value of the water temperature of the tower after the protection measures can be iteratively calculated from 5 °C [3].

3 quasi two-dimensional algorithm

When the cooling tower watering area is less than 8000m2, the one-dimensional algorithm is more accurate for the cooling tower calculation. This is because the flow field in the cooling tower is approximately one-dimensional, and the cooling tower raining in the watering area exceeding 8000m2 is not more than 13000m2. The flow field in the area is two-dimensional, and can still be approximated as a one-dimensional flow field in the filling and spraying area. Therefore, the cooling tower rain zone can be taken out separately and tested, and the cooling tower rain zone calculation can be obtained through simulation test. method. Using the obtained rain zone thermal formula plus the one-dimensional simulation tower test results for the packing and spray zone, the one-dimensional algorithm can be used to calculate the thermal calculation of the cooling tower. The result is approximately equivalent to the two-dimensional flow field calculation result. This simple algorithm avoids the drawbacks of flow field approximation in one-dimensional algorithms without having to perform very complex two-dimensional calculations. When the water spray area exceeds 13000 m2, the packing and spray area also appear as two-dimensional flow. Therefore, it is necessary to carry out trial or numerical simulation to calculate the design of the ultra-large cooling tower.

Therefore, the author believes that the cooling tower is generally the most convenient and efficient algorithm when the cooling area is less than 13000 m2.

4 Conclusion

By analyzing the problems encountered in the design of the counterflow natural ventilation cooling tower program, the author's calculation of the shallowness of the cooling tower is: (1) Selecting a more accurate and accurate expression of the thermal characteristics; (2) Correction of the evaporation water quantity The coefficient is considered at the integral end of the Michael formula; (3) The watering area should be considered differently in the calculation of heat and power; (4) The initial value of the water temperature of the tower is considered to be the wet bulb temperature; (5) The proposed two-dimensional algorithm can improve the accuracy and effectiveness of the cooling tower calculation.