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HVAC Design Strategies for Municipal Waste Incineration Power Plants

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Abstract: In recent years, relevant government departments have achieved the goal of reduction and harmless application through the development and implementation of municipal waste incineration power plants, in order to advocate ecological and environmental protection. At present, in order to further achieve the goal of sustainable development, municipal waste incineration power plants have actively responded to the national call and requirements as well as made overall arrangements for the energy-saving design and optimization design of their internal system. Therefore, with the concept of sustainable development, this paper studies and analyzes the problems of the HVAC design as well as suggests related strategies for municipal waste incineration power plants in order to provide relevant reference.

Keywords: Municipal waste incineration power plants; HVAC system; Design optimization

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1. Introduction

With the continuous advancement of urbanization, the amount of urban waste has been increasing year by year. Taking the data of urban waste production in 2020 as an example, the urban waste production in 2020 was as high as 360 million tons. Without comprehensive treatment, environmental pollution and other related problems may occur. Combined with the current comprehensive treatment situation, in order to strengthen the implementation of municipal waste disposal, relevant government departments and competent units are actively tackling the shortcomings of traditional municipal waste disposal methods in accordance to the concept of sustainable development and ecological environment protection. Among them, as an important platform for the effective treatment and recycling of municipal waste, municipal waste incineration power plants not only need to optimize and improve their waste incineration process and other related methods, but also optimize and improve the unit equipment that is prone to energy consumption and pollution problems, especially the heating, ventilation, and air conditioning (HVAC) system.

2. Analyzing the optimization design strategy for the air conditioning system in municipal waste incineration power plants

2.1. Optimize the selection of air conditioning system

Considering the building pattern of municipal waste incineration power plants and the operation characteristics of air conditioning load, the designers should select appropriate air conditioning system for efficient application by incorporating the air conditioning system configuration with the characteristics of the aforementioned factors. From previous experience, air-cooled or water-cooled multiconnected air conditioners, split air conditioning for auxiliary air conditioning, and so on can be used for the operation of

the air-conditioning system in municipal waste incineration power plants. At the same time, unitary air-conditioner equipment can also be used for safety application [1].

It should be noted that for those municipal waste incineration power plants with steam or hot water waste heat, on the premise of ensuring that the technical and economic conditions meet the requirements, the designers should prioritize the combination of lithium bromide absorption chiller and hot water heat exchanger to further enhance the operation level of the air conditioning system. This combination can create an air conditioning circulating water system with good performance, which has high feasibility value.

2.2. Optimization of design matters

The purpose of the air conditioning system is mainly to ensure the reliable operation of various instruments, meters, and control elements as well as meet the comfort of indoor staffs. The air conditioning system will meet the air parameter requirements in the rooms, including temperature and humidity, so as to realize the safe, reliable, and normal operation of waste incineration power plants.

The cold (hot) water or cooling water pipeline of the air conditioner realizes the cold air or hot air regulation process through the air conditioning equipment. In this process, it is prohibited to directly connect to the electrical automatic control room. At the same time, in order to prevent condensate water from dripping, key facilities such as air conditioning equipment and air supply pipe need to be placed appropriately based on the requirements of the scientific layout. They are generally not placed directly above the electrical control equipment. For electrical houses, designers should appropriately configure and apply the air conditioning system according to the outdoor temperature to achieve a cooling effect or use the ventilation system to achieve the same effect. With regard to the setting of the residual pressure and air volume value of the fresh air equipment of air conditioning, it is suggested that designers should reasonably set it according to the pressure difference between air-conditioned room and the outdoor surroundings [2].

In addition, the environment of the slag crane control room and garbage crane control room is relatively poor. In order to improve production efficiency and reduce cost investment, fresh air can be provided by using silent forced draft fan. Different from other blower equipment, the silent blower has relatively obvious features of low noise and low power consumption. Most importantly, the silent blower has the function of adjusting high and low wind volumes, which is convenient for operation. However, the silent blower is easily affected by outdoor environmental factors during operation. For example, when the outdoor temperature is too low or the humidity is too high, a large amount of fog will be generated at the indoor air supply outlet. In response to this, designers should make reasonable improvements to the structure of the silent blower based on the climatic conditions of the location. For example, it can be equipped with an electric heating function to reduce the fog at the air outlet.

3. Analyzing the optimization design strategy for the heating system in municipal waste incineration power plants

In order to effectively improve the operation efficiency of the heating system in municipal waste incineration power plants, the designers need to actively optimize and improve the operation mode and process content of the heating system based on the operation requirements of the heating system of municipal waste incineration power plants. Taking a garbage power plant as an example, the power plant mainly uses the hot water heating system to realize efficient operation. Among them, the supply water temperature and return water temperature of the heating mediums are set to 85℃ and 60℃, respectively. In order to achieve good heating effect, a certain number of radiators should be set up to enhance the on-site heating effect. It should be noted that after setting a sufficient number of radiators, a heating system is not required. In this way, not only the power consumption of the heater is reduced, but also the dust accumulation of the heater.

It should be noted that waste power plants are not suitable for steam heating systems. The main reason is that the radiator inside the system and the outer surface of the pipeline accumulate dust easily, which is not conducive to the efficient operation of the heating system. In addition, the steam system starts up relatively slowly and the operation stability is low. Therefore, it is not suitable. In addition, for workshops with relatively large air circulation, designers can use water pipe facilities for thermal insulation treatment. In the process of heat preservation, good heat preservation effect can be achieved by setting electric heat tracing and anti-freezing. For the boiler room and flue gas purification room with heat source, it is suggested that the heat load should be calculated according to a scientific and reasonable calculation principle. In the calculation process, it is not necessary to consider the heat dissipation of the equipment and pipeline [3]. However, it is necessary to consider factors such as building envelopes to ensure the internal temperature of the plant when production and furnace stops as well as the production safety when production and furnace stops during winter.

At the same time, hot air curtains can be placed at the main entrance and exit of unloading halls and main control buildings, so as to prevent the invasion of cold air and ensure that the odor from indoors does not spread to the outside.

4. Analyzing the optimization design strategy for the ventilation and smoke extraction system in municipal waste incineration power plants

4.1. Deodorization and ventilation design of garbage pool

With the implementation of ecological and environmental protection policies as well as sustainable development strategies, municipal waste incineration power plants need to adhere to the spirit of the Central Committee of the Communist Party of China and the State Council's deployment and decision-making as well as constantly fight the battle of pollution prevention and control. However, it is difficult for municipal waste incineration power plants to avoid the odor caused by waste fermentation during operation. In order to effectively reduce the odor, the anti-odor design content should be emphasized, especially the anti-odor design content of waste ponds.

In the specific optimization design process, anti-odor design measures can be taken from two aspects: exhaust and air inlet. On one hand, in terms of exhaust design, the primary air required for the combustion of the incinerator is set above the garbage bin. When the incinerator is in operation, the primary air fan sends the air polluted by waste substances in the waste bin into the incinerator, where methane, hydrogen sulfide, methyl sulfide, and other odorous substances are burned and decomposed in the incinerator, so as to achieve the purpose of deodorization. At the same time, the primary air fan extracts a large amount of air in the garbage bin, so as to maintain a negative pressure state and ensure that the air in the garbage bin does not escape outward through the gap, thus guaranteeing the air quality in the area where the waste incineration power plant is located. On the other hand, in terms air inlet design, designers should not only pay attention to enclosure leakage, but also on the source of external gas between garbage pools. From previous experience, odor problems usually occur at the air inlet of discharge doors between garbage pools, garbage leachate channels, leachate treatment plants, etc. [4]. In order to reduce the air inlet and odor between garbage pools, there are several measures that can be taken.

Through the two principles of odor control and the analysis of the causes of odor leakage from operating waste incineration power plants, several measures should be taken for the deodorization of waste incineration power plants.

(1) After the installation of pipes, air ducts, cables, and cable trays, they should be sealed tightly. The construction quality should be strictly controlled during on-site construction, and flexible sealing measures should be adopted as much as possible to avoid leakage gaps due to thermal expansion during

later operations. In addition, records should be made for operation inspection in consideration of the air ducts, pipes, cables, etc. passing through the wall of the garbage pool.

(2) If the door in and out of the garbage pool is not tight, the lock hole and door crack will cause an overflow. An airtight chamber with two closed doors should be set up. Since the odor is highly corrosive, the sealing device of the door should have reliable anti-corrosive performance.

(3) The wall between the garbage pool and the incineration workshop should reach the roof to completely separate the two workshops. The upper wall of the garbage pool should be made of dense block, and the gap between the garbage pool grid and the garbage pool should be about 300~450 mm. Upon the completion of the garbage pool, flexible materials with good corrosion resistance should be used for sealing to ensure that the joint between the wall and the roof does not leak and that the garbage pool is in a completely closed space.

(4) The elevator shaft should be kept away from the garbage pool, and outdoor fresh air should be directed into the elevator shaft to maintain air circulation as well as prevent air retention in the elevator shaft.

(5) The garbage crane control room facing the garbage pool has a special colloidal sealing glass, which should be sealed inside and outside. The ventilation system directs fresh air into the garbage crane control room to create a positive pressure, thus further preventing the garbage pool odor from entering the garbage crane control room.

(6) The visiting channel and garbage pool should be completely separated from each other in the building. The unloading hall should be sealed with special colloidal sealing glass inside and outside. Outdoor fresh air should be directed into the visiting passage to ensure the long-term maintenance of micro positive pressure.

(7) The central control room is a place for visitors to visit. The central control room and the operation floor should be arranged on the same floor height. Visitors can visit the central control room by using the elevator. After the central control room, they can stop by the unloading hall and garbage pool through a completely closed visiting channel as well as the garbage dumping site by the garbage truck through the installed glass window. Turning back, they will pass by the incineration workshop, flue gas purification room, and steam turbine operation floor through the visiting channel (with glass windows). The access channel should be completely sealed. The treated fresh air should be directed into the visiting channel to meet the fresh air demand and maintain a positive pressure of about 10~15 Pa in the channel, so as to prevent the odor from leaking through the gap.

(8) Based on the process needs, the odor between the leachate channels is directed to the garbage pool for unified treatment. However, in view of the positive pressure state of the odor in the air duct behind the air outlet of the fan, if the air duct is not made properly, a leakage may assume and thus seriously affect the air quality. Therefore, the fan should be placed close to the exhaust outlet, and the check valve should be placed at the fan outlet.

(9) For the air duct passing through the floor or wall between the garbage pool and leachate ditch, a steel plate or angle steel should be embedded around the reserved hole and connected with the air duct through the expansion joints (bellows).

(10) Before decoration, it is necessary to strictly check the parts prone to odor leakage and confirm that the through wall casing and reserved holes have been sealed tightly at all visiting channels of the incineration plant. All kinds of through wall casings and reserved holes should be recorded in detail. If there is odor leakage in the future, it will be convenient for inspection.

Other than that, designers should focus on the strict setting of ventilation times between channels; they should strictly control the negative pressure effect at locations prone to leakage, such as the unloading door and loading ramp. With regard to the optimization of the primary and secondary fans of the boiler, air suction treatment should be carried out from the garbage pool. The designers should configure and apply

an odor treatment device suitable for the current boiler operation state according to the specific configuration quantity and operation time of the boiler. It should be noted that if the suction volume of the boiler cannot meet the requirements of negative pressure deodorization, priority should be given to the use of biological deodorization or chemical washing deodorization devices.

4.2. Dust and fog proof ventilation design of slag discharge room

The high-temperature slag generated during boiler operation can be reasonably discharged after the soaking and cooling treatment by a slag dredger. The treated high-temperature slag is usually discharged into the slag pit. However, it should be noted that when a large amount of slag falls into the slag pit, the generated fog and dust will have a negative impact on the environmental quality of the operation area and the visibility of the operators. In order to prevent production safety accidents, mechanical ventilation must be set in the slag discharge room.

In the specific optimization design process, the designers need to create an exhaust outlet at the upper part of the slag outlet. After being treated by the dust and mist removal device, it can be reasonably discharged into the outdoor environment. In order to reduce the energy consumption from the operation of fans, it is better to select frequency conversion fan. Different from the conventional system, the variable frequency drive can efficiently operate based on the outdoor air temperature. Its operating frequency is controlled by means of phased regulation [5].

4.3. Smoke exhaust and ventilation of boiler room and flue gas purification room

The fundamental purpose of the smoke control system is to provide guarantee for fire safety management as well as evacuation and rescue work. From previous experience, municipal waste incineration power plants cover a relatively large area and have numerous on-site units and equipment. In case of potential fire hazards, these plants will face greater difficulties in terms of personnel evacuation and emergency rescue compared to other buildings.

In order to strengthen the emergency management of potential fire hazards, municipal waste incineration power plants should be equipped with a sufficient number of fire-fighting equipment, such as fire hydrants and mobile fire extinguishers. In addition, there should be fire lanes at the periphery of the main powerhouse. These fire lanes should be designed in a circular way and equipped with an appropriate number of outdoor fire hydrants. It should be noted that for important areas such as the boiler room and steam turbine room at the main powerhouse, the monitoring system should be used by the operators to realize 24-hour uninterrupted monitoring.

In terms of HVAC, the pressurized air supply system should be set up in the front room of the smokeproof staircase, the front room of the fire elevator, and other areas. For enclosed staircase with external windows, external windows or openings with an area of no less than 1.0 m^2 should be set at the highest part; those with a total area of not less than 2.0 m^2 should be set every five floors on the outer wall of the staircase, and the layout interval should not be more than three floors.

In the main control building, corridors and rooms that are not equipped with the natural smoke exhaust system require the mechanical smoke exhaust system, and a 280℃ smoke exhaust fire valve should be placed at the inlet of the exhaust fan. The smoke exhaust volume is calculated according to the unit smoke exhaust volume of 60 $m^3/(h \cdot m^2)$ and the maximum value of the sum of smoke exhaust volume of any two adjacent smoke control zones in the same fire compartment. In case of fire, the fire control center initiates the normally closed smoke exhaust damper and smoke exhaust fan of the smoke exhaust pipe on that floor. When the flue gas temperature reaches 280℃, the smoke exhaust damper is fused and closed, and its interlocking smoke exhaust fan is closed. It will manually reset after the fire.

5. Conclusion

In a word, the scientific layout and optimal design of the HVAC system for municipal solid waste incineration power plants will not only reduce the operation energy consumption, but also enhance the operation efficiency of their system equipment. In view of this, in order to better respond to the national sustainable development strategy and the call of ecological and environmental protection policies, municipal solid waste incineration power plants should timely make up for the shortcomings existing in the current HVAC system design. It is necessary to take the initiative to modify the process content and key facilities of the HVAC system in line with the operation requirements of these power plants, so as to better promote an efficient and stable operation in municipal solid waste incineration power plants.

Disclosure statement

The author declares no conflict of interest.

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