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DESIGN OF HEAT PIPE AIR PREHEATER FOR 10 T/H GAS-STEAM BOILER

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ПРОЕКТИРОВАНИЕ ТЕПЛОВОЙ ТРУБЫ ПРЕДВАРИТЕЛЬНОГО ВОЗДУХОПОДОГРЕВАТЕЛЯ ДЛЯ ПАРОГАЗОВОГО КОТЛА 10 Т/Ч

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Abstract. This design is aimed at energy -saving and designed a heat pipe air preheat to recover 10T/H steam gas boiler flue heat waste heat, thereby increasing the efficiency of the boiler and reducing gas consumption. This article first introduces the thermal pipe, heat pipe heat exchange, and boiler thermal system, and then focus on the design and optimization of the heat pipe air heater. This design optimizes the thermal pipe specifications of the heat pipe air heater and the parameters of the fins. At the same time, the sealing structure, the fixed structure, and the airport structure are optimized. Subsequently, the UG software created a three -dimensional physical model model and rendering model, and finally proposed corresponding countermeasures on equipment corrosion, thermal pipe life and tube vibration problems. This design uses Excel software to make design calculation tables. Through input parameters, the results of the results of the number of thermal pipes can be obtained.

Аннотация. Рассматриваемая конструкция предназначена для предварительного нагрева воздуха с тепловой трубкой. Даны основы проектирования и оптимизации воздушного нагревателя тепловой трубы. Эта конструкция оптимизирует характеристики тепловой трубы нагревателя воздушного нагрева тепловой трубы и параметры плавников. Оптимизированы герметизирующая структура, фиксированная структура и структура аэропорта. Программное обеспечение UG создает трехмерную физическую модель и модель рендеринга и, наконец, предлагаются меры по коррозии оборудования, сроку срока службы труб и проблем вибрации труб. Используется программное обеспечение Excel для изготовления таблиц расчета дизайна. Благодаря входным параметрам можно получить результаты количества тепловых труб.

Keywords: energy conservation, heat pipe air heater, optimized design, 3D modeling.

Ключевые слова: энергосбережение, воздушный нагреватель, дизайн, 3D моделирование.

Since my country's carbon neutralization policy and the 14th Five -Year Plan are officially implemented, the industrial gas boiler field has paid more attention to energy saving and emission reduction. The heat pipe air pre -heating device is a high -efficiency energy -changing equipment, which can pass the large heat under small temperature difference conditions, which is conducive to energy recovery [1]. At the same time, studies have shown that the heat pipe air heater can effectively reduce gas consumption in the waste heat recovery of flue gas, and has an energy saving effect [2].

By improving the thermal efficiency of boiler and improving gas combustion conditions, the energy saving effect of boiler can be achieved. Reducing the loss of smoke is one of the effective measures to improve the thermal efficiency of boiler. At the same time, the loss of smoke was mainly related to the smoke exhaust temperature. The literature [3] points out that the boiler smoke exhaust temperature will increase by 1%every 12°C to 15°C; the increase in the temperature of the air air is conducive to the combustion of fuel. Studies have shown that for every 100°C for helping the air temperature, fuel consumption can be reduced by 7~8% [4]. Therefore, the maximum reduction of the smoke exhaust temperature and the improvement of the temperature of the air air has a significant energy saving effect. As a high -efficiency energy -changing equipment, the heat pipe air heater can fully recover the waste heat of the flue gas, which can achieve reducing the smoke exhaust temperature and increase the burning assistance. Effect of air temperature.

This design uses steel and water gravity heat pipes. Gravity thermal pipes use the phase change of their internal work to change the heat exchange. The hot and cold flow is used to achieve heat exchange through the input and output of heat pipe heat. At present, this type of thermal pipe has been successfully applied in the fields of residual heat recovery, energy conservation and environmental protection [5], and played an increasingly important role. The heat pipe air heater is a heat exchanger composed of a limited heat pipe. The structure is relatively simple. Among them, the winged thermal tube welded with the wings, the purpose is to strengthen the heat transfer; The diameter of the pipe is connected; the middle parts supports the role of the heating tube, and the air is separated from the flue gas to prevent the two from penetrating each other and affect the heat exchange effect. The 10 T/H steam gas boiler used in this design is used to provide 1.25 MPa industrial saturated steam. By conducting thermal calculation and verification of the boiler system, the system thermal error is 0.0012%.

The heat pipe air heater cooled at 216.50°C to 100°C, and the smoke exhaust temperature decreased significantly. At the same time, the cold air of 25°C was heated to 178.75°C, which increased significantly the temperature of the ignition air. Through the thermal balance of the boiler, the thermal efficiency of the boiler system was 93.92%, an increase of 5.7%, from the thermal efficiency when the reaining heat recovery was performed, and the fuel consumption was reduced by 6.28%. This design uses conventional design methods. Select the parameters first, then perform related calculations and school checks, and finally optimize. The calculation and resistance calculation of heat transfer contains a large amount of calculation formula. This article is limited to space, and only briefly introduces it. In the heat transfer calculation, the total number of thermal pipes is determined by the heat pipe thermal resistance and heat transfer coefficient through the heat pipe heat resistance and heat transfer coefficient. The total thermal resistance RT consists of 9 heat-transmission heat resistance [6]:

$$R_t = \sum_{j=1}^{9} R_j \tag{1}$$

The heat transfer coefficient K:

$$K = \frac{1}{R_t A} \tag{2}$$

Among them, A is the heat transfer area of the heat pipe. Single heat pipe heat transfer Q_s:

$$Q_s = KA\Delta T \tag{3}$$

Among them, ΔT is the average temperature difference.
The total number of thermal pipes N:

$$N = \frac{Q}{Q_s} \tag{4}$$

Among them, Q is the total heat. The resistance is calculated based on the definition of the *Eu* number Eu:

$$Eu = \frac{\Delta p}{\frac{\rho u^2}{2} Z} \tag{5}$$

$$\Delta p = Eu \frac{\rho u^2}{2} Z \tag{6}$$

Among them, Δp is the flow resistance; ρ is the fluid density; u is a fluid flow rate; Z is the vertical tube drainage. Calculate Eu with Robinson-Briggs formula:

$$Eu = 18.93 \mathrm{Re}^{-0.316} a^{-0.927} (\frac{a}{b}) 0.515 \tag{7}$$

Among them, Re is Renault; a is a horizontal relative distance; b is a longitudinal relative distance. This design compiles the calculation formula and process into the Excel table. Through the input parameters, the calculation results can be drawn to facilitate the optimization of the parameters. The value of thermal pipe specifications and the value of the fins is related to whether the design is optimized. This design controls the parameter variables, and specifically studies the effects of each parameter on the design results. Through statistical analysis, find out the relatively optimal value. The standard size of the common pipe diameter of thermal pipe [7] has: 25 mm, 32 mm, 38 mm, and 40 mm. The effects of the pipe diameter on design are shown in Table 1.

Table 1

PIPE DIAMETER EFFECT ON DESIGN

Pipe diameter/mm	*Total amount of thermal pipe/root*	*Pipelines/rows*	*Single tube K*	*Flue gas side resistance/Pa*
25	286	26	310.1	425
32	240	24	282.8	392
38	216	24	269.7	414
40	216	24	259.3	399

It is found through Table 1 that when the diameter of the pipe increases, the number of thermal pipes is gradually decreasing and tending to equal; the heat transfer coefficient of the single tube is declining; the flue gas side resistance is not obvious, and the 32mm pipe diameter flue gas side resistance is the smallest. Through analysis and comparison of the data trend of Table 1, this design selects the 32mm pipe diameter design scheme. The scheme is in a moderate position in the number of thermal pipes, the number of tubes and the heat transfer performance, and the flue gas side resistance is the smallest. Standard steel pipe wall thickness [7] includes: 1.8 mm, 2 mm, 2.3 mm, 2.6 mm, 2.9 mm, 3.2 mm. As the thickness of the tube wall increases, the heat transfer coefficient of the heat pipe will decrease. At the same time, in order to ensure the welding strength, the wall thickness is generally not less than 2 mm. So it is more appropriate to choose the wall thickness of 2 mm. By controlling variables, the degree of impact of the parameters of the flue gas side fins on the design of the heat exchanger is studied.

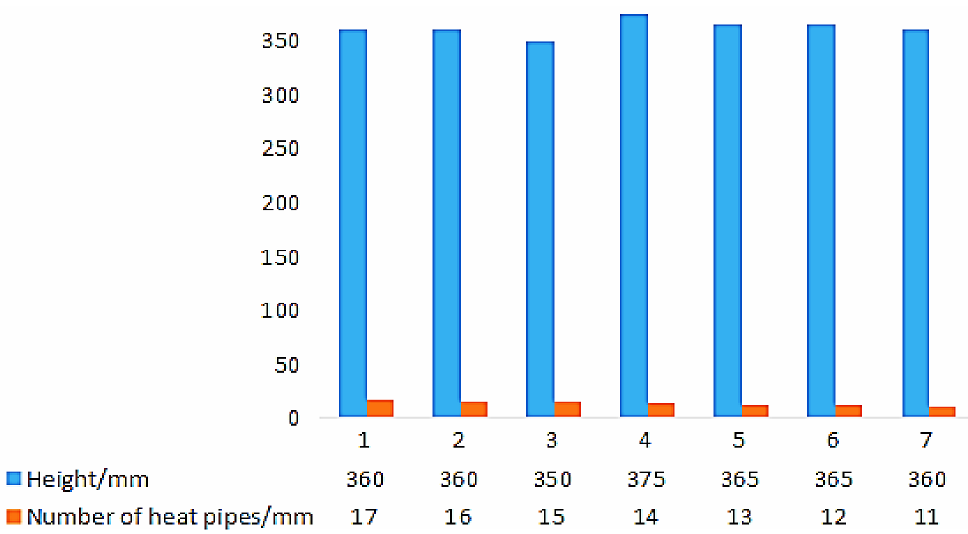

Figure 1. The relationship between the height of the flue gas side wings and the number of thermal pipes

According to Figure 1, Figure 2. Figure 3, it can be seen that when the height of the flue gas side wings is 15 mm, the number of thermal pipes is the least; when the thickness of the flue gas side wings is 0.5 mm, the total flow resistance is the smallest; When the spacing is 2.5 mm, the amount of heat exchanger is the least.

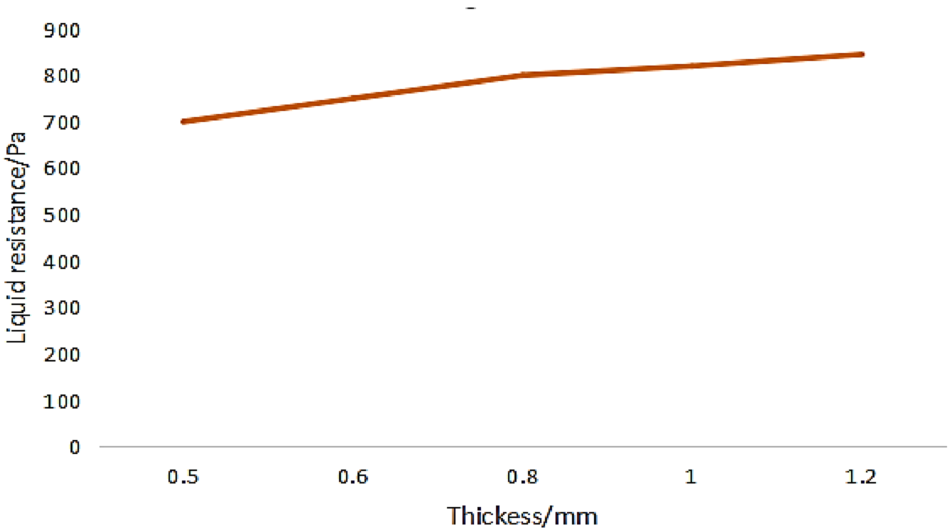

Figure 2. The relationship between the thickness of the flue gas side and the fluid resistance resistance

The value of the value is included in Figure 4 to calculate the process. Among the design results obtained, the heat transfer coefficient, flow resistance, and the number of thermal pipes are optimized, so the value of the parameter of the foam side fins can be determined. The selection of the wing tablet parameters of the air side is the same as the idea of the smoke side the preferred parameter scheme obtained by the air is: 17 mm height; the thickness of the wings is 1.1 mm or 1.2 mm.

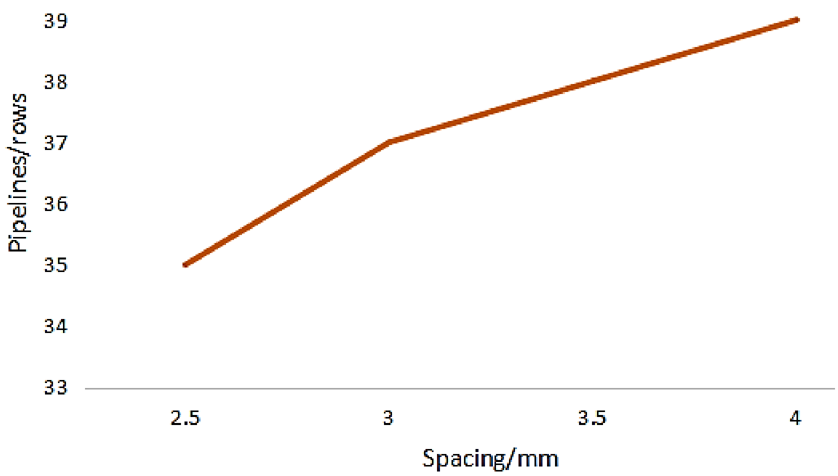

Figure 3. The relationship between the spacing and vertical tube of the flue gas side wing tablets

After the preliminary selection of the parameters, a small -scale adjustment and trial calculation is needed to determine whether the optimal parameter acquisition is still available. Finally, the optimal parameter scheme that comprehensively debts is shown in Table 2.

Table 2

WING PARAMETER

	Wings height/mm	*Wings thickness/mm*	*Wings Spacing/mm*
Smoke side	17	0.5	2.5
Air side	17	0.9	2.5

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This design adopts a cone -sealing form and optimizes the sealing method on the basis of this.

Ordinary cone surface seal adopts a specific cone sleeve. After welding the cone ring with the thermal tube is fixed, the cone seal is sealed through the pores of the cone ring with the pistols. This method is simple, but the sealing performance is average. If it is applied to a small heat exchanger, there will be a condition that the cover surface is damaged due to the fixed fixing; High, but the craftsmanship is more complicated, and there are many parts. The welding seal of the cone surface increases the welding process of the cone ring and the septum. Therefore, it is difficult to have a problem of sealing failure. The reliability is high. See Figure 4.

In addition, the thermal pipe and the septum are welded into a whole, which is in line with integrated design ideas. Therefore, this design uses cone surface welding dense sealing form.

This design applies UG NX 10.0 software to build a three -dimensional model of the heat pipe air heater. Three-dimensional physical modeling is performed by using sketch commands, stretching special signs, mirroring tools, array tools, and construction tools.

The physical model is shown in Figure 5 (a). Subsequently, the solid model is colored and rendered. By setting the physical materials and scene lights, the more real rendering model is obtained, as shown in Figure 5 (b).

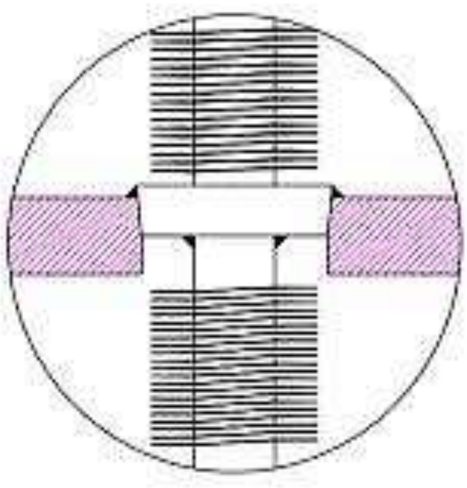
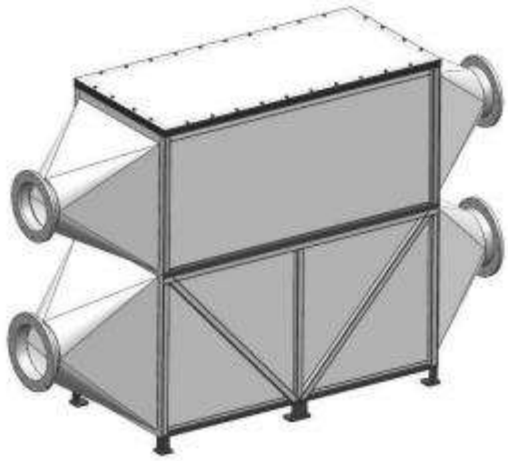


Figure 4. cone surface welding dense seal



(a)

(b)

Figure 5. Thermal pipe air preheating UG 3D model: a - three -dimensional physical model; b - three -dimensional rendering model

In this design, the burning pipeline of the boiler is natural gas. Its H_2S content is 0, and there is no SO_3 in the flue gas. It solves the problem of dilute sulfuric acid corrosion [8].

(1) Water dew point corrosion

In the process of parameter optimization, this design uses the minimum tube wall temperature limit index to control the wall temperature at 65°C and above, so that it is greater than the water dew point temperature of the water at 57.9°C.

(2) Nitrogen oxide corrosion

Because there is no liquefied water, the NO_2 that may exist in the flue gas cannot be dissolved in water to form a strong acid, which solves the problem of nitrogen oxide corrosion. The service life of steel and water gravity heat pipes is related to the incompatibility of steel water.

(1) Working environment

The working temperature range of working-quality water in the heat pipe is 50~260°C [9]. The minimum working temperature in the heat pipe in this design is 60°C, and the maximum flue gas temperature is 216.5°C. It can be seen that the working temperature is within the required range. And combined with the measurement of smoke prevention and corrosion problem is solved, so the working environment of the heat pipe is safe.

(2) Not compatibility

Carbon steel and water can occur in electrochemical corrosion, which produces non - condensed gas hydrogen, which affects the heat transfer performance and service life of the heat pipe. It can be solved by the following two points: First, based on national standards, the treatment process [9] is used for heat pipe manufacturing, such as an erosion agent and inner wall passivation treatment. The second is to add the original block, such as CUO back to the original block, fixing it in the upper end of the thermal pipe condensation section. Reliability. It actually proves that if a composite renewal agent mainly based on CUO is adopted, the working life of the thermal pipe can reach 6-8 years [10].

The tube will vibrate in the airwing of the airflow, and even resonance. Large vibration or resonance will destroy the stability of the equipment structure. The main method of anti-vibration anti-vibration is to increase the inherent frequency of tube control [11], which can be achieved by strengthening the fixation of the tube. This design uses the upper and lower partitions to achieve the horizontal fixing of the heat pipe in the upper and lower partitions, and the vertical fixing of the thermal tube in the form of intermediate welding sealing. From the perspective of the design structure, it has a strong vibration resistance. The upper parts and thermal tube are completely welded, which can further strengthen fixation, so theoretically it is more difficult to occur with major vibration and resonance problems.

This design is designed for 10T/H steam gas boiler thermal pipe air preheat, focusing on completing the optimized design and three-dimensional modeling work. The optimized design is achieved through the following two points. One is to control the parameter variables, study the influence range of each parameter one by one, and conduct data statistics and analysis to obtain the optimized value of the thermal pipe specifications and the fins parameters; The study of the sealing method determines the form of the cone welding sealing structure, as well as the optimized design of the tube fixation, the basic framework and the airport of the heat exchanger. Use UG 3D software to complete the three-dimensional physical modeling and physical model rendering. The full text finally proposes corresponding solutions to the problems that may exist in the heat pipe air heater, such as equipment corrosion, the life span of the heat pipe and the vibration of the tube.

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