Application of Heat Pipe Technology in Thermal Power Plant

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Abstract. As is known to all, China's main power plant to pulverized coal furnace is given priority to, all the losses from the burning of coal in boiler, exhaust loss is a main power plant boiler heat loss, exhaust smoke temperature is higher, the greater the exhaust heat loss of exhaust temperature data indicated that every 15 ~ 20 ℃, exhaust heat loss will be increased by 1%, corresponding to a 2% increase in coal consumption. When the air temperature of exhaust smoke temperature is higher than in boiler, part of heat is produced without being used, which affect the safety of boiler efficiency and operation efficiency, at the same time can also cause serious pollution to the environment. Therefore, it is of great significance to reduce the exhaust temperature effectively.

1. Introduction
Heat pipe is a small can make the temperature gradient, the quantity of heat from one place to another place of high efficiency heat transfer element, it makes full use of the principle of heat conduction with phase change, rapid heat transfer properties of the medium heat through heat pipe will be hot objects quickly to the heat source, its thermal conductivity than any known metal heat conduction ability. It is of great significance to improve boiler efficiency, save energy and protect environment [1].

2. The working principle and characteristics of heat pipe

2.1. The working principle of heat pipe
Inside the heat pipe is a metal tube with a liquid absorbing core, which is closed after removing the non-condensing gas and filling it with a certain working liquid. According to the second law of thermodynamics, heat can be transferred spontaneously from a hot reservoir to a cold reservoir, so as long as there is a temperature difference, there will be heat transfer. The heat pipe element is the heat transfer through evaporation, which can increase the temperature difference on both sides.

In a sealed metal tube, an appropriate amount of liquid work is pumped into a vacuum, which becomes a heat pipe. When one end of the heat pipe heating, vaporized liquid, steam under the effect of differential pressure flow to the heat release end, gives off heat to the cold source and condensation, condensation of liquid by gravity, capillary force and centrifugal force circumfluence, form a loop, will be a lot of heat from the heated area passed to the heat dissipation area [2].

During the whole process of heat transfer within the heat pipe, its working steps can be divided into the following points:
(1) The heat transfer from the hot end to the interface is carried out by the suction core and the pipe wall filled with the working medium;
(2) In the interface on the side of the suction segment, the liquid is heated and evaporated;
(3) The steam from the phase change flows from the heat absorption segment to the heat discharge section;
(4) In the interface on the side of the hot segment, the gas condenses to release heat and form a liquid;
(5) With the working medium, wall and suction core as the transmission channel, the heat is passed from the interface to the cold end.

2.2. Characteristics of heat pipe
(1) Strong heat transfer performance. Heat transfer of heat pipe is realized by two phase changes of internal medium, and its thermal resistance is small and the thermal conductivity is high.
(2) Have good isothermal characteristics. The inner space of the heat pipe is filled with saturated steam and the interior is in equilibrium. The pressure difference between the two ends is very small and approximately isothermal.
(3) Reversibility of heat flow direction. Because of the heat pipe is the power of the internal movement of capillary force, to a common heat pipe in horizontal direction, the either side can be heated as heat-absorbing section, and the other end of the heat output from inside to outside as heat removal section.
(4) Adjustable heat pipe wall temperature. Because the evaporation section and the condensing section can be adjusted to change the heat flux density, in practice, by adjusting the management temperature, it avoids the low-temperature corrosion zone.
(5) Constant temperature characteristics. For the controlled heat pipe, with the increase of heat input of the condenser thermal resistance decreases, the opposite will increase, so when the heat input has a larger change, gas temperature fluctuation is not much, namely the temperature controlled, realize constant temperature function.

3. Application of heat pipe in power plant
3.1. Heat pipe air preheater
The heat pipe air preheater is used to heat the flue gas of the boiler and heat through the superconducting heat transfer of the heat pipe, which is used to preheat the boiler combustion air or other drying purposes.
Will belong to boiler flue gas waste heat recovery is used to heat the air heat transfer between gas and if the traditional heat exchange technology, it is difficult to make internal and external wall and floor, which can make heat transfer area is large, compact equipment is not enough, supply air and energy consumption. Using heat pipe heat exchanger can make equipment more compact, the energy consumption dropped sharply, at the same time, the heat transfer enhancement also make contact with flue gas heat pipe wall temperature rise, which may reduce the dew point corrosion, improve the service life of the equipment.
The heat pipe air preheater has the following advantages:
(1) Obviously improve the metal wall temperature, reduce the low temperature corrosion, and effectively prevent air leakage;
(2) reduce the power consumption of fan and fan;
(3) enhanced heat transfer ability and improved thermal efficiency of boiler;
(4) It obviously alleviates the problems such as accumulation of dust and ash in hot area.

3.2. Heat tube type oil cooler
The cold oil heater is an important part of steam turbine in the work. It is mainly used for cooling turbine turbine oil and so on, realizing the continuous and safe operation of the steam turbine bushing under the specified temperature, and fully guaranteeing the normal working efficiency of the steam turbine. The heat pipe coolers effectively solve some stubborn problems in the application of the coolers in the steam turbine, such as oil pollution. At the same time, the cooling efficiency can be
improved, and the water resources can be saved. Although in terms of investment than heat pipe cold oil is slightly higher than that of shell and tube type cold oil machine, but from the perspective of cost performance and development consideration, oil heat pipe cooling device on the overall efficiency is more better than that of shell and tube type cold oil machine, has a broad development prospects [3].

Principle of heat pipe cold oil: higher temperature of the turbine oil from the oil inlet into the oil chamber through the heat pipe heating period, because of the heat transfer performance of heat pipe is very high, it will absorb the energy to heat pipe cooling section, and then taken away by cooling water. The cooling water chamber must be in the upper part because the working fluid in the heat pipe is returned by gravity. This is not the same as conventional column - tube coolers. In this way, the heat transfer between the inside and outside of the tube becomes the heat transfer between the two parts of the heat pipe, which creates the conditions for the complete separation of oil and water. The fouling heat resistance of heat transfer surface has great influence on heat transfer, while the surface cleaning of heat pipe is much easier than the inner surface, which will reduce the daily maintenance work of the coolers equipment.

Its structure is: hundreds of root welding in the middle part of the heat pipe and heat pipe 100 mm apart two circular porous plate, the outside of a perforated plate for heat pipe evaporation (turbine oil section, also known as the heating section), another the outer edge of the porous plate for heat pipe condenser (cooling water, also known as the cooling section). The two sections are mounted in two separate circular shells, and the flanges are bolted to the perforated plates respectively.

3.3. Semi-open self-regulating gravity heat pipe
Self-adjusting gravity heat pipe technology, which can reduce the exhaust temperature significantly and have a significant energy saving effect, can reduce the exhaust temperature significantly by using the exhaust heat of the boiler to provide cooling and heating [4].

Half open self-adjusting gravity heat pipe working principle is: the heat pipe evaporation absorb the external heat, make part of the liquid evaporation boiling, steam through adiabatic section into the condenser, the condensation of liquid under gravity flow into the hot well, and then back into the heat pipe evaporation cycle again. In order to ensure that the heat pipe works at a little higher than atmospheric pressure, it is specially designed to have a stable pressure mechanism, which is to connect a u-shaped tube on the steam outlet pipe, and the u-shaped pipe has holes and sealing slots [4]. When working normally, the difference between the liquid column in the sealing layer and the u-shaped tube is the pressure of the heat pipe (gauge pressure). When the heat pipe pressure is raised, the steam will be discharged through the u-shaped tube to the sealing trough. Under low load pressure, the liquid column will rise along the u-tube until the pressure is balanced. As long as the u-tube is sufficiently high, the liquid can be prevented from pouring into the heat pipe. In order to guarantee the stability of heat pipe liquid level in the load fluctuation, the liquid level self-regulating mechanism was designed based on the two-phase flow principle. The two phase flow sensor and the heat pipe are connected, and the two phase flow regulator directly USES the steam force to control the circulation area of the backflow liquid, thus regulating the return flow [6].

Compared with ordinary heat pipe, the semi-open self-regulating gravity heat pipe has the following characteristics:

(1) The working liquid is backflow by gravity, without the need of capillary core and siphon mechanism, without strict heat transfer limit, simple structure, convenient processing and low cost.

(2) The heat pipe does not need a vacuum. It works under atmospheric pressure. It is a normal pressure vessel and is safe and reliable.

(3) Adopt a new type of pressure self-regulating mechanism to ensure that the high load is not overpressured, and the low load is not inverted.

(4) It has the function of liquid level self-regulation, which can effectively prevent the full liquid and dry phenomenon caused by unstable liquid level when the load fluctuates.
(5) The semi-open structure is adopted, which is convenient for night and start-up. Non-condensable gas can be discharged automatically, and can be discharged regularly to ensure the qualified quality of work.

4. Conclusion
In recent years, our country's economic construction to speed up the development and utilization of resources, the need for electricity is on the rise year by year, the successful use of heat pipe technology in thermal power, not only can improve the efficiency of energy utilization, also reduce a lot of energy loss, effectively realized the purpose of saving energy and meet the demand of social development. However, the implementation of heat pipe technology also faces a lot of technical difficulties, which also requires researchers to work hard to overcome. It is believed that heat pipe technology has great potential for improvement and competitiveness, and the prospects of application in thermal power plant are optimistic.

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