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Research on Air Preheater in Fluidized Bed Boiler in the Thermal Power Plant

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A B S T R A C T

In fact, many power plants are using circulating fluidized bed (CFB) technology. This technology may be allowed burn bad-quality coal (low calorific value, high sulfur content), fuel quality may vary in the wide range. Fuel in the boiler is recirculated, thus reducing NOx, SOx emissions during fuel combustion. In this plant, Air Preheater (APH) is an important device in a thermal power plant, which is responsible for utilizing the heat of exhaust gas from the boiler to heat the air supplied to the combustion chamber. This helps increase the thermal efficiency of the boiler, reduce fuel consumption and limit emissions to the environment.

The paper describes and studies the Air Preheater (APH) in the thermal power plant to reduce and to improve the ability to leak of a APH in thermal power plants.

Keywords: Air Preheater (APH), thermal power plants, coal, NOx, SOx…

Introduction

An air preheater (APH) that is not properly sealed can have a number of many advantages over the traditional seal made of metal strips, and the return on investment is also very fast.

It requires a large heat transfer surface per unit of heat recovery because of the relatively small difference between the flue gas temperature and the supply air temperature. The air preheater is usually located immediately downstream of the boiler, where it receives hot flue gas from the water heater and cold air. The hot air supplied by the air heater enhances the combustion of all fuels.

An Air Preheater is a heat exchanger that transfers heat from flue gases (exhaust gases) to the incoming combustion air. This process increases the temperature of the air going into the boiler, improving combustion efficiency and reducing fuel consumption.

In this paper, the air preheater (APH) will be described in details and some research will be discussed to provide solutions for improving the efficiency of An air preheater (APH).

Overview of the Air preheater

An Air Preheater (APH) is used in industrial systems particularly in thermal power plants for boilers, and furnaces as shown in Fig.1. The heating elements play a important role for change the heating performance of the APH. The plates are also changed at regular intervals in order to ensure uninterrupted performance of the APH.

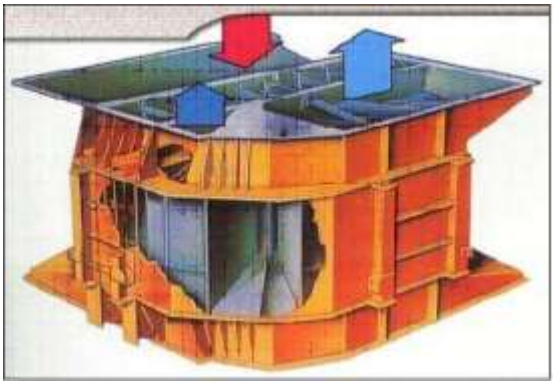

Fig. 1 - Air Preheater (APH)

There are three main types of air dryers:

- Tubular air preheaters (figure 2): These consist of a bundle of tubes, usually arranged in a shell and tube configuration. The exhaust gas passes through the tubes and the combustion air flows over the outside of the tubes, transferring heat.

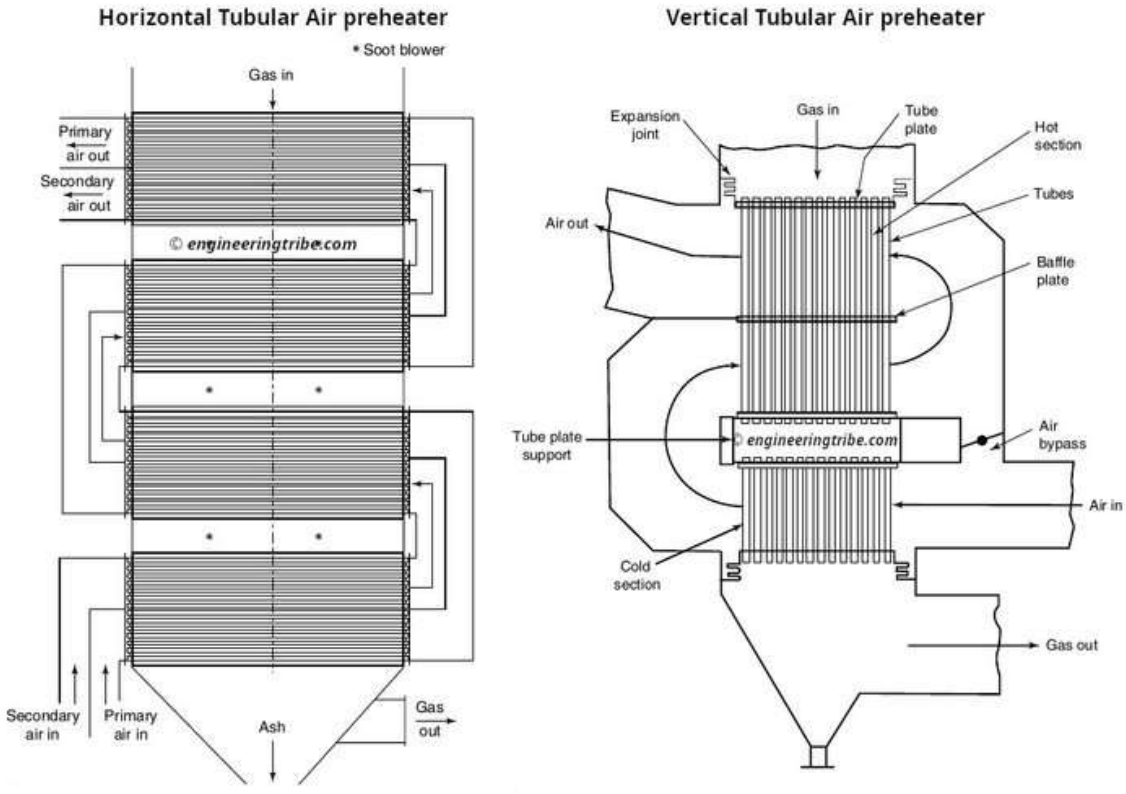

Fig. 2 - (Horizontal & Vertical Tubular Air-preheater)

- Plate air preheaters (figure 3): These use a series of metal plates, arranged in parallel, to separate the exhaust gas stream and the air stream. Heat is transferred through the plates.

Fig. 3 - Plate air preheaters

- ***Rotating plate regenerative air preheaters (RAPHs)*** (Figure 4)***:*** In this type, a rotating cylinder or wheel filled with heat-absorbing elements (such as a honeycomb matrix) is used. The rotating element alternately contacts the hot exhaust gas and the incoming cold air stream, transferring heat.

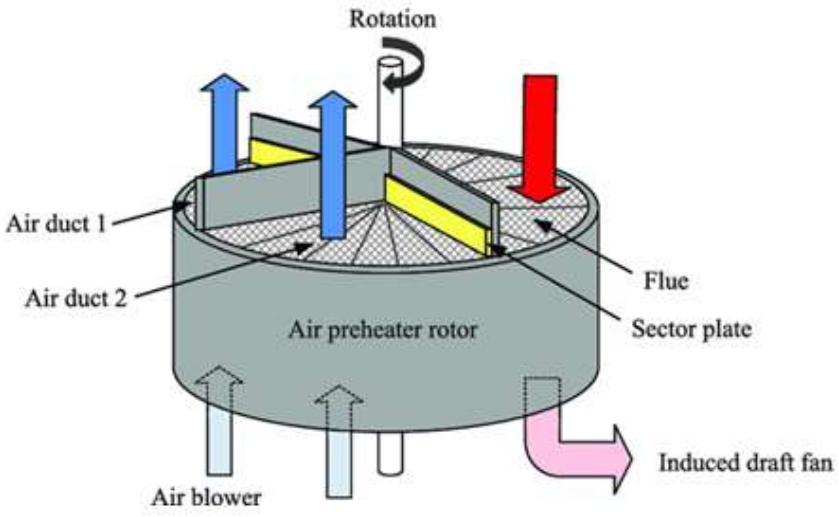

Fig. 4 - Diagram of Rotating plate regenerative air preheaters

The air heater utilizes the excess heat from the boiler exhaust to heat the air before supplying it to the combustion chamber. This mechanism brings two major benefits:

- Effective oxygen supplementation: Hot air increases the combustion rate, helping the fuel burn more thoroughly.
- Increased combustion efficiency: The device can raise the supply air temperature up to 100°C, especially effective with fuels with high humidity. In addition, this device also helps reduce exhaust gas temperature, reduce energy loss and protect the environment.

It is a heating device used at the end of the smoke outlet in the boiler system of a coal-fired thermal power plant, with the following main functions. Utilizing the heat of the exhaust smoke to heat the air supplied to the boiler, both reducing the heat of the exhaust smoke to avoid loss and improving the efficiency of the boiler and saving fuel used in the boiler. According to calculations, if the exhaust smoke temperature is reduced by 15 ^{0}C , the efficiency of the boiler can increase by 1% to improve energy efficiency by preheating the combustion air before it enters the furnace or boiler.

In Thermal power plant where the air supply to adjacent nozzles is different, a horizontal pressure gradient may form near the nozzle in the combustion chamber. In this situation, the air and entrained bulk material flow through the nozzle (from one nozzle outlet arm to the other) follows, accompanied by a partial separation of the bulk material in the outlet channel (Figure 5).

The nozzle through which the two-phase mixture flows is supplied with a smaller air stream than the adjacent nozzles. Under non-uniform velocity field conditions, backflow of bulk material into the airbox space may occur under different boiler load conditions. If adjacent nozzles are supplied with air of different flow sizes, conditions are favorable for the appearance of a horizontal pressure gradient.

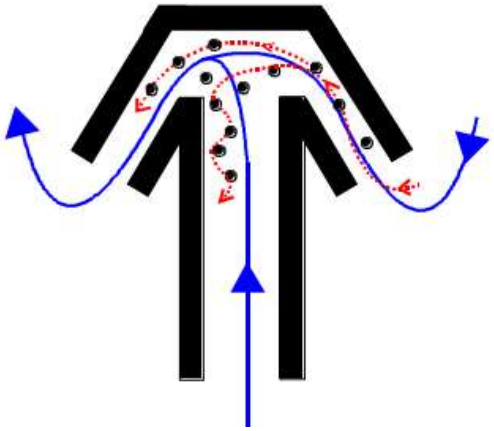

Fig 5 – specific type of Gas Nozzles Found in Circulating Fluidized Bed Combustion (CFBC) Boilers.

The air heater is the final heat transfer element before the stack. The air preheater will have sufficient surface area to provide necessary heat to the fuel equipment (burner, mill, etc.) and to lower the temperature to the level defined in the allowable combustion characteristics. For the air preheater, the heat transfer rate is determined as follows:

For the air pre heater, the heat transfer rate is determined as follows:

$q = mCp\ (T1-T2)$ (1)

Where, q= Heat transfer rate, Kcal/hr

m= Mass flow rate of flue gas, kg/hr

Cp = Approximate mean specific heat of gas, KJ/kg K

T1 = Gas temperature entering the air heater, °C

T2 = Assumed air heater exit temperature, °C

The radiation heat transfer coefficient is affected by the type of fuel and the partial pressure of the combustion products. The type of fuel affects the radiation characteristics through the emission of various types of fuel, while the partial pressure of these gases, especially and directly affects the radiation heat transfer process as in the figure 6.

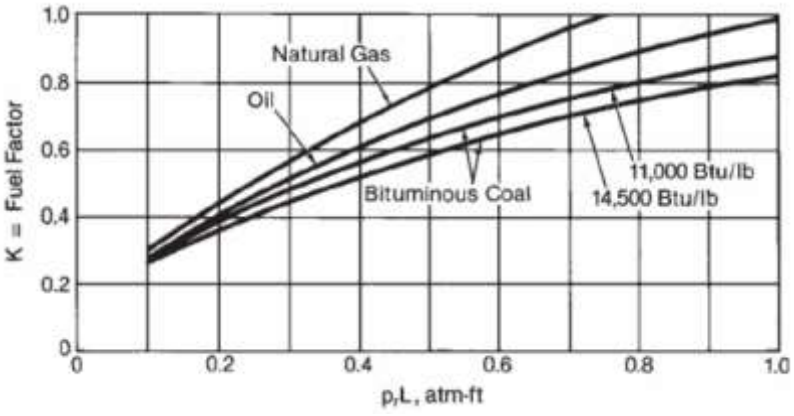

Fig. 6 -The radiation heat transfer coefficient on the fuel

In fact, the air heater is an indispensable component in modern boiler systems. The application of this equipment not only brings high economic efficiency through fuel saving and reduced operating costs, but also contributes significantly to environmental protection by minimizing toxic emissions. With such practical benefits, the air heater deserves to be seriously considered and invested in industries using boilers.

Conclusion

From the analysis of Air Preheaters APH, the benefits of using Air Preheaters are as below:

- Increase system efficiency: The air heater helps to utilize excess heat from the exhaust gas, converting it into useful energy to heat the air before supplying it to the combustion chamber. This helps to reduce heat loss and optimize heat exchange efficiency in the boiler system.
- Save fuel: With preheated air, fuel burns more thoroughly, reducing the amount of fuel needed. This directly reduces operating costs and increases the economy for the business.
- Reduce environmental emissions: By reducing the temperature of the exhaust gas and burning fuel efficiently, the air heater contributes to reducing the amount of CO2 and other toxic substances released into the environment. This is an ideal solution for businesses aiming for green and sustainable production.
- Extend the life of the equipment: The exhaust gas is cooled before being discharged, helping to protect important components in the system from the effects of high temperatures. As a result, the life of the boiler system and related equipment is extended, reducing repair and replacement costs. Using an air heater is not only an energy optimization solution but also a sustainable step, in line with the trend of modern industrial development.

In the future, the prioritize research in Viet Nam will be to develop and apply Air Preheaters but are environmentally friendly, build a system of charging stations and maintenance facilities, train human resources to operate the system, set appropriate charging standards, and have appropriate solutions.

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