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Research Paper

Corrosion and viscous ash deposition of a rotary air preheater in a coal-fired power plant

Heng Chen, Peiyuan Pan, Huaishuang Shao, Yungang Wang *, Qinxin Zhao

Key Laboratory of Thermo-Fluid Science and Engineering of MOE, School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an, Shaanxi 710049, China

HIGHLIGHTS

- Corrosion and viscous ash deposits of a rotary air preheater in a coal-fired boiler were studied.
- Corrosion and viscous ash deposition were caused by the condensation of H_2SO_4 rather than NH_4HSO_4.
- The mechanisms of corrosion and viscous ash deposition were analyzed.
- The coupling formation model of corrosion and viscous ash deposition was proposed.

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ABSTRACT

The corrosion and viscous ash deposition characteristics of a rotary air preheater were investigated. Deposit samples and corroded heat transfer elements were taken from the air preheater of a 300 MW coal-fired power plant in China and analyzed by X-ray fluorescence, X-ray diffraction and scanning electron microscope equipped with energy dispersive X-ray spectroscopy. The results show that the serious corrosion and viscous ash deposition were both caused by sulphuric acid condensation rather than ammonium bisulfate deposition. The mechanisms of corrosion and viscous ash deposition were discussed and the coupling formation model of corrosion and viscous ash deposition was proposed.

1. Introduction

As heat recovery devices, air preheaters are applied to raise the temperature of combustion air into boilers and recover heat from flue gas after economizers [1]. At present, there are mainly two types of air preheaters applied in utility boilers: tubular air preheater and rotary air preheater. Tubular air preheaters are usually used in 200 MW and lower capacity boilers, and rotary air preheaters are mainly applied in boilers of 300 MW and above. Compared with tubular air preheaters, rotary air preheaters have the advantages of higher heat transfer efficiency and less occupying space [2].

Large-capacity steam boilers generally use tri-sector rotary air preheaters [3], in which high temperature primary air and low temperature secondary air are heated in separate sections, as shown in Figs. 1 and 2. The air preheater consists of a cylindrical shell and a rotor packed with bundles of thin metal plates called heat transfer elements. The rotor rotates between counter flowing air and flue gas streams. Hot flue gas enters the air preheater from the top and cold air enters from the bottom. As the counter-flow is commonly used, the hot end is at the top, and the cold end is at the bottom [4]. By the rotating matrix, heat is transferred from the flue gas to the air [5], which improves the boiler efficiency.

There are three common types of heat transfer elements: DU type, CU type and NF type [6]. Heat transfer elements consist of corrugated plates and positioning plates, as shown in Fig. 3. Typically, the materials used for heat transfer elements are mild steel at the hot end and low-alloy corrosion-resistant steel or enameled mild steel at the cold end [7]. To assure the cleanliness of an air preheater and avoid fouling or plugging, air preheaters are equipped with special soot blowers installed at the flue gas inlet and/or outlet [8].

As air preheaters are located in the low temperature zones of boilers, their heating surfaces are prone to suffer dew point corrosion [3]. When fossil fuels containing sulfur are burned in boilers, a small amount of SO_3 is formed in the combustion process. The SO_3 combines with the water vapor existing in the flue gas to form

* Corresponding author.
E-mail address: ygwang1986@xjtu.edu.cn (Y. Wang).

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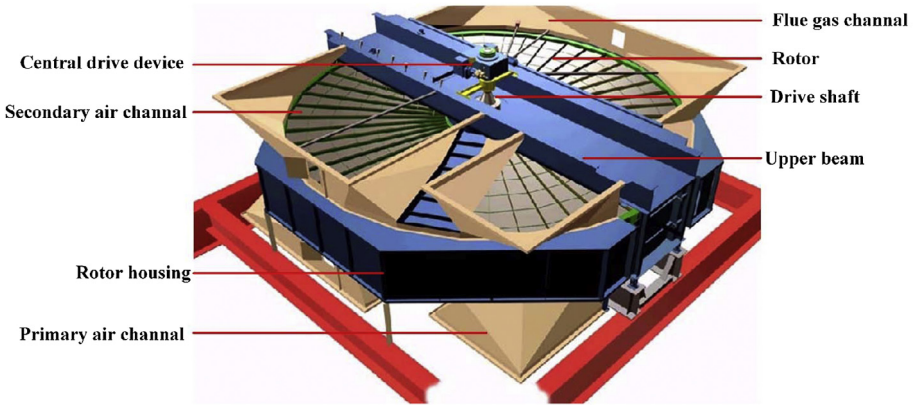

Fig. 1. Structure of a tri-sector rotary air preheater.

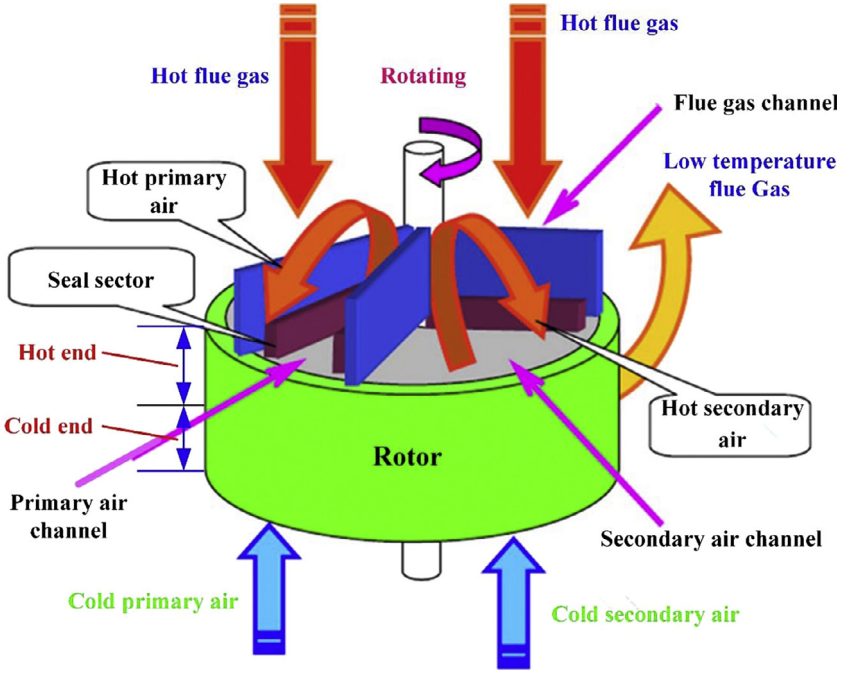

Fig. 2. Working principle of a tri-sector rotary air preheater.

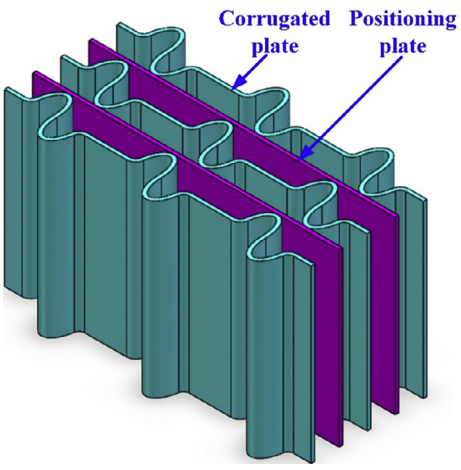

Fig. 3. Structure of heat transfer elements.

sulphuric acid vapor [9]. When the temperature of heating surface is lower than the sulphuric acid dew point temperature, the sulphuric acid vapor will condense on heating surface [10] and cause deterioration of heating surface, which is called dew point corrosion. The cold end of an air preheater often suffers from serious dew point corrosion. What's more, the condensed acid also attracts ash in the flue gas and causes viscous ash deposition on heating surface, which usually leads to the fouling/plugging of flow channels.

In order to achieve significant emission reduction of oxides of nitrogen (NOx), selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) have been applied in coal-fired power plants to treat the flue gas. During the operation of SCR and SNCR systems, liquid ammonia or urea is injected into the flue gas as reducing agent. But the unreacted ammonia will leave the system with flue gas, which is called ammonia escape [11]. Some of the escaped ammonia will react with sulphuric acid and/or sulfur trioxide present in the flue gas to produce ammonium bisulfate (ABS), which begins to condense at about 150 °C. Since ABS is