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Investigations into the air heater ash deposit formation in large scale pulverised coal fired boiler

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HIGHLIGHTS

- Mineralogical and chemical analysis provided valuable insights into precursors of ash deposits.
- Dew point calculations reveal that temperature could be another contributing factor for deposition on air heater sections.
- No reported information on air heater deposits and mineralogy in the literature.
- Current study indicate that large temperature fluctuations are a significant factor in deposit formation.

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ABSTRACT

A mineralogical study was undertaken of air heater deposits in a 300 MWe pf boiler located in Western Australia in order to understand deposit formation in the air heater sections of the boiler as an aid to implement possible remediation actions. Several air heater deposit samples were collected in the selected regions of the air heater along with samples of the feed coal, bottom ash and fly ash for comparison of ash chemistry and mineralogy. The deposit samples were examined using a combination of ash chemistry and quantitative X-ray diffraction analysis; the ash samples by bulk chemical analysis to determine the major element chemistry and mineralogy by quantitative X-ray diffraction.

Chemical and mineralogical analysis showed that the deposits are unusual in containing high amounts of sulphate, particularly of aluminium and, to a lesser extent, iron. From the analyses it appears that the formation of the deposits is due to the high sulphate content which is acting as a cementing agent. There is an indication that temperature could be another factor in formation of the deposits, with a decrease in temperature leading to the formation of sulphurous acid which then reacts with the reactive glassy amorphous fly ash phase to form the aluminium and iron sulphates. Dew point calculations indicated that this is a possible deposit formation mechanism based upon the air heater temperature data obtained from the utility. There was no evidence that unburnt carbon has played a significant role in deposit formation. Large temperature fluctuations resulting from the inherent nature of the operation of the air heater are a significant factor in deposit formation and a practical solution to consider would be the use of an SO_2 absorbent placed prior to the air heater.

1. Introduction

It has been well established by several researchers over the last few decades that ash deposition on boiler components and associated equipment within a power utility is a sizable problem. The build-up of ash deposits causes several operational problems, leading to unnecessary outages requiring periodic maintenance [1–3]. When fuels containing sulphur are fired in heaters or boilers, sulphur dioxide, and to a lesser extent sulphur trioxide, are formed in addition to water vapour. This may lead to the formation of sulphuric acid which may condense on heat transfer surfaces, leading to corrosion and destruction of the surfaces [4,5]. For utilities involving post combustion strategies (such as selective catalytic reduction and non-catalytic reduction, ammonium bisulphate forms on boiler components when ammonia combines with sulphur trioxide present in the flue gas [6]. The problems are much more pronounced when ash blockages occur on the heat recovery systems such as the air preheater. The purpose of an air preheater is to recover the heat associated with exit flue gases from boiler,

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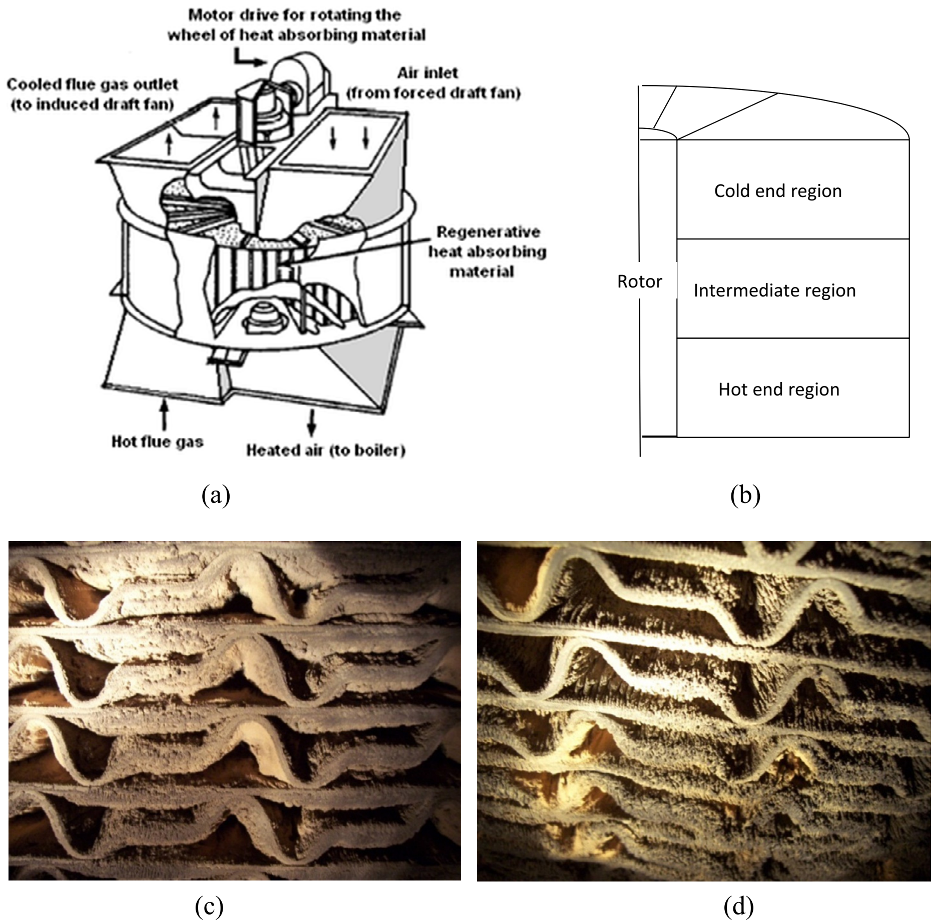

Fig. 1. Figure showing the schematic of an air preheater (a) [adapted from Ref. 4], sample collection regions (b) and (c) and (d) photographs of hardened ash on the bottom cold side of the heat exchanger system (c) and (d). The deposit samples come from the leading edge of the elements shown in figures (c) and (d) and from a depth of 100 mm into the elements.

Table 1
Proximate and ultimate analysis of coal (as received basis in wt%).

Proximate analysis	Range	Average value	Ultimate analysis	Range	Average value
(%db)			(%daf)		
Moisture	22–31	25.0	Carbon	73–76	73.5
Ash	4–10	8.0	Hydrogen	4.2–4.9	4.8
Fixed carbon	22–34	29.8	Nitrogen	1.2–1.5	1.2
Volatiles	36–48	37.7	Sulphur	0.3–1.3	1.0
Specific energy (MJ/kg)	18.8–21.5	19.6	Oxygen	18–20	19.5
Ash analysis (%db)			Average		Range
Coal type	*Sub – bituminous. (from Western Premier Mine, Australia)*				
SiO_2			51.4		47–59
Al_2O_3			33.5		31–36
Fe_2O_3			7.4		5–10
CaO			1.8		0.4–2.1
MgO			0.86		0.2–1.1
Na_2O			0.24		0.02–0.3
K_2O			0.33		0.2–0.4
TiO_2			0.99		0.4–2.0
Mn_3O_4			0.07		0.06–0.08
SO_3			0.21		0.06–0.35
P_2O_3			1.60		0.65–2.15

mainly to enhance the thermal efficiency and control the heat likely to be lost in the flue gas. As a consequence of deposit build up, on these heat recovery systems, the heat transfer rates will be altered significantly, thereby reducing the efficiency of thermal boiler systems.

In this study, a chemical and mineralogical investigation was undertaken of ash deposits in an air preheater of a typical 300 MWe local power utility located in Western Australia. The power utility employs a typical rotary preheater (mainly used for large water tube boilers) wherein hot flue gas flows through one