Advanced Science and Technology Letters
Vol.83 (ISA 2015), pp.98-101
http://dx.doi.org/10.14257/astl.2015.83.19

Study on FAS Heating Surface for Biomass Fuel Boiler

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Abstract. According to the fuel properties of biomass (straw), it analysis the element content of the Cl, S in biomass straw and alkali meta such as K, Na and the composition of biomass (straw) and ash, meanwhile it analysis the composition of fly ash deposits sediments on heating surface of straw fuel boiler and determines the components of depositional aggressive medium and its mass ratio. A simulation corrosion test is designed base on the mass ratio and other conditions; it obtains the corrosion morphology and corrosion products by scanning electron microscopy (SEM) and energy dispersive spectrometer (EDS). Finally it determines the process of alkali metal chloride deposition corrosion is mainly self catalytic oxidation corrosion.

Keywords: biomass (straw), heating surface of boiler, deposit corrosion medium, self catalytic oxidation corrosion.

1 Introduction

Ash deposition is an important problem in the process of biomass fuel heat utilization. It is product that volatile substances of biomass in the vapor phase condenses or adhere on the heating surface when it flows through the heating surface with flue gas and fly ash [1].In the biomass energy utilization, the biomass ash is an important factor which has effect on its utilization process, the ash deposition, corrosion and abrasion are closely related to the characters of biomass ash [2-6]. So the analysis on fly ash sediment of biomass fuel boiler heating surface is necessary to study the characteristics of biomass ash and the prevention of heating surface.

2 Analysis on the main fly ash product of straw combustion

The ash deposition on the heating surface is mainly produced by fly ash deposition of combustion product through burnout in the furnace. The composition of fly ash is directly related to the composition of ash deposition, and the composition of fly ash mostly associated with the morphology of main element migration precipitate through burnout. So it is necessary to discuss the migration precipitation regularity of main element which influence deposition corrosion during the combustion of straw.

ISSN: 2287-1233 ASTL

According to the content and form of Cl, S, K, Na in the straw, the migration precipitation regularity of main element which influence deposition corrosion during the combustionof straw as follows:

When the combustion temperature is lower than 850K, potassium mainly survives in KCl(s), K_2SO_4(s) component form, sodium mainly survives in $Na_2Ca_3Si_6O_{16}$(s) component form and little NaCl(s) component form. There are some reactions conduct during above process: Organic sulfur produces SO_2(g) by oxygenolysis and KCl(s) produces some HCl(g), so the SO_2(g) and HCl(g) exist.

When the combustion temperature reach 850K, KCl(g) and NaCl(g) are produced, with the rise of temperature, the content of KCl(g) and NaCl(g) increase, and KOH(g), NaOH(g) and K, Na ion are produced, K_2SO_4(s) exists at the same time.

When the combustion temperature reach 1300K, K_2SO_4(g) and Na_2SO_4(g) are produced, and NaOH(g) increases and NaCl(g) reduces.

Ca is non-volatile and Si is inert element, they will produce stable compounds, they exit in bottom ash in the solid form.

The main possible reactions are (M is K and Na):

Organic sulfur+O_2→SO_2(g) (1)

MCl(g)+H_2O(g)→MOH(g)+HCl(g) (2)

2MCl(g)+H_2O(g)+SO_2(g)+0.5O_2(g)→M_2SO_4(g)+HCl(g) (3)

2MOH(g) +SO_2(g)+0.5O_2(g)→M_2SO_4(g)+H_2O(g (4)

M_2SO_4(g)+H_2O(g)→2MOH(g) +SO_3(g) (5)

According to the check analysis of K, Na content in the fuel, the K content is 1~2 orders of magnitude more power than Na.

3 Analysis on fly ash sediment

According to the characteristic analysis of straw ash, the volatile constituents in straw enters gas phase at high temperature, its gas phase products are the main component of fly ash, its elemental composition is the important matter that affect the fly ash component. According to the temperature conditions and combustion temperature field in the furnace, it obtains the composition and distribution of gaseous material of combustion products:

The solid state constituent material(the compounds of potassium KCl, K_2SO_4) and the complex salt ($Na_2Ca_3Si_6O_{16}$) are main in fire grate, the gas state constituent material are main in the middle of furnace, but KCl, NaCl, SO_2 and a spot of K_2SO_4, Na_2SO_4(gaseous) are main exit in the area near the boiler heating surface.

According to the temperature of steam(hot water) in boiler heating surface pipe in area A of figure 1, it is usually between 400℃ and 535℃ in different boiler settings. So the KCl(g), NaCl(g) and little K_2SO_4, Na_2SO_4 in the fly ash will accumulate on the pipe and form the sediment. Meanwhile, the reference[14-16] confirmed the KCl, NaCl and little K_2SO_4, Na_2SO_4 are the main sediment on the biomass boiler heating surface. As shown in research, if a certain S in the fuel burn and produce the SO_2 or SO_3, the alkali chloride KCl, NaCl on the heating surface will be sulphating at high

temperature and produce K_2SO_4, Na_2SO_4 in the deposition layer. It shows that the fly ash sediments on biomass boiler heating surface are KCl, NaCl and K_2SO_4, Na_2SO_4.

In order to check above result of fuel theory analysis, it analysis the corrosion pipe which was cut from some biomass boilers in Liaoning province, the fuel of that boiler is corn straw, the corrosion pipe cut from the boiler pipe where the flue gas temperature is 850～950℃. Fe is the main deposition corrosion product in the inner layer, the content of K, Na and Cl is less, and there are some Si, Al, Mg and Ca in it, they may be the heating product that contained when the deposition of fly ash. In the corrosion product of middle layer, K, Na and Cl, S are enriched, the corrosion product content of Fe declined dramatically, the content of Si, Al, Mg and Ca increases slightly. In the deposition corrosion product of outermost layer, Si, Al, Mg and Ca are enriched, the content of K, Na and Cl, S decreased obviously.

As shown in above analysis, the result of fuel theoretical analysis is in line with fly ash sediment of actual straw boiler combustion product, the fly ash deposition at the temperature of 850～950℃(about 1100K) are main KCl, NaCl, K_2SO_4 and Na_2SO_4. It needs to determine the ratio relationship of each content after the corrosion medium is determined. The corrosion medium quality ratio relationship is determined base on the proximate analysis of straw and component analysis of straw ash. According to component analyzed data of straw fuel ash, the content of K_2O in the fly ash is 10.27%, Na_2O is 1.34%, SO_3 is 2.8%, Cl is 9.27%. As most inorganic substances in the ash exists in the form of oxide when the component detection and analyzing, it can not be shown in the form of chlorides and sulfide, it can be considered the K, Na, Cl, S in the ash all form the alkali metal chlorides and sulfide, the content ratio of the alkali metal chlorides and sulfide is the maximum of alkali metal ratio, the maximum of corrosion sediment content approach. According to above contents, it obtains the mass ratio of KCl, NaCl, K_2SO_4 and Na_2SO_4 is 63:13:5:1 by the conversion relation of the mass ratio and molar ratio.

4 Conclusion

(1) According to the analysis of S, Cl, K, Na content and the straw combustion characteristic, it obtains that the fly ash products are main alkali metal chloride (KCl, NaCl) during the combustion of straw fuel.

(2) According to the XRD analyzed result of corrosion tube in certain straw boilers, it determines the fly ash sediment are main KCl, NaCl, K_2SO_4, Na_2SO_4.

(3) According to above industry analysis and fly ash content analysis, it obtains the mass ratio of KCl, NaCl, K_2SO_4 and Na_2SO_4 is 63:13:5:1 by the conversion relation of the mass ratio and molar ratio.

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