Improvement of Fluidized Bed Bottom Ash Cooler Performance in CFB Boiler

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1. Introduction

Fluidized bed combustion offer significant potential for uniform thermal field and low NOx emission. Sulfur in the fuel can also be captured in the bed. However, the pressure drop across the bed is a concern and must be determined. This paper provides the selective fluidized bed bottom ash cooler behavior from a 410t/h CFB boiler. A visual cold experimental apparatus at the ratio of 1:10 was set up to determine the global flow behavior. Under the condition of the steadily operating furnace, a series of cold experimental tests were completed with bed materials of ash floater. The relationship of various parameters, such as the velocity of the fluidizing air, the bed pressure drops, the height of the static bed materials in each chamber of the bottom ash cooler, and the relationship of the ash inlet pipe pulse air and the velocity of ash flowing from the furnace to the bottom ash cooler, were obtained. The numerical simulation of the cold flow characteristics on the gas-solid flow in the bottom ash cooler simulating the cold experimental tests were also carried out and are presented here. The results of the primary experiments and simulation indicate that according to the variation of the bed pressure drop, the velocity of the fluidizing air of each chamber could be adjusted to keep the steady operation of the selective fluidized bed bottom ash cooler. Thus modeling studies can assist in the design and development of fluidized bed combustors.

2. Key Features

The effect of the fluidizing velocity to the bed pressure drops and the height of static bed in the bottom ash with ash flowing into the ash cooler and discharged from the ash cooler synchronously is shown in Fig. 1. The bed materials started to fluidize when the fluidizing velocity was about 0.17m/s. When the fluidizing velocity changed from 0.17m/s to 0.3m/s, the bed materials decreased gradually, and the bed pressure drop of the ash cooler distinctively dropped. But the pressure drop of the selective chambers dropped more distinctively than that of other chambers.

As is known, there is a pressure-equalizing relation among the three pressure differences. With the raising of pulse air of ash inlet pipe from $3m^3/h$ to $6m^3/h$, the ash discharged rate increased as the airflow rate increases from 3 to $4m^3/h$ where it reaches its maximum with a steady fluidizing velocity of the furnace and the bottom ash cooler and then it decreased onward to $6m^3/h$. The high ash discharged rate meant the high velocity of the bed materials flowing among selective chamber and the other chambers in this case. It also meant the high velocity of ash flowing into the ash cooler from the furnace.

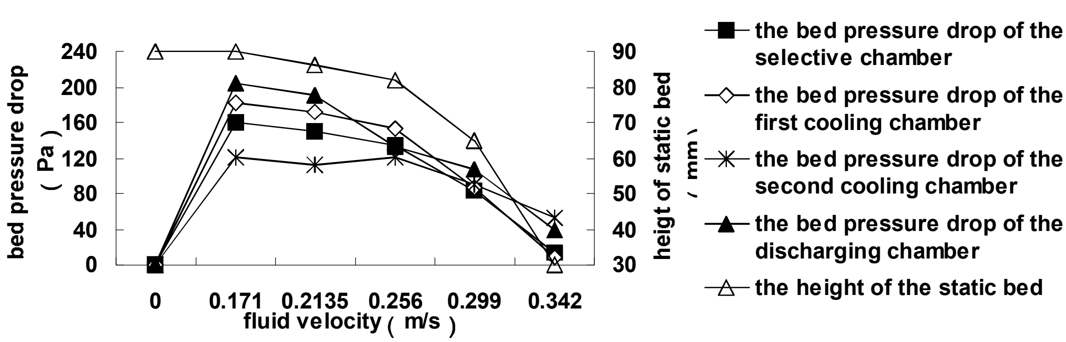

Fig. 1. Effect of the fluidizing velocity to the bed pressure drops and height of static bed under condition I.

The simulation was based on the experiments and the fluidizing velocity of each chamber was 0.25m/s and shown in Fig. 2. It was observed that the bed material flowed into each chamber and discharged from the ash cooler steadily when the fluidizing velocity was 0.25m/s. The bottom ash cooler also could not be jammed in this case.

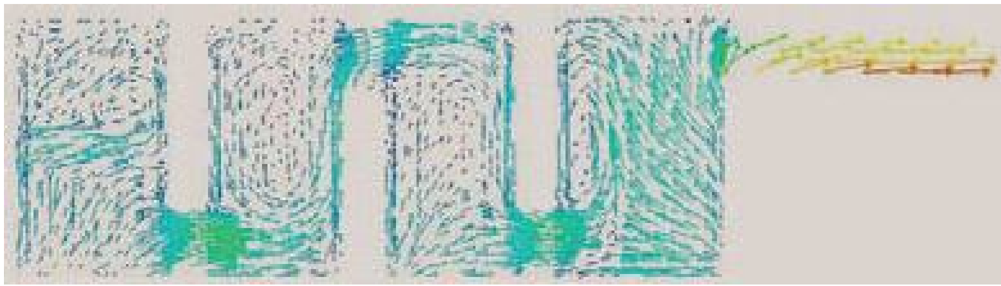

Fig. 2. Velocity distribution of the bed material at z =-0.19m in the cooler.

3. Conclusions

1) Under the operating condition of the bottom ash flowing into the ash cooler and the ash discharged from the ash cooler, the selective fluidized bed bottom ash cooler could be operated steadily when the fluidizing number was from 1 to 1.7; the height of static bed would decrease when the fluidizing number is larger than 1.7. The bottom ash cooler would be blown to be empty and the cooling effect would decrease if the fluidizing velocity were too high.
2) The bed material would return the furnace gradually on the condition of no ash flowing into the bottom ash cooler and no ash discharged from the bottom ash cooler.
3) Under the operating condition of bottom ash flowing into the bottom ash cooler but no ash discharging from the bottom ash cooler, the height of static bed would remain steady and the bottom ash cooler operated steadily when the fluidizing number was between 1 and 6.
4) The pulse air of the ash inlet pipe could influence the flowing of the bottom ash from the furnace to the bottom ash cooler.
5) For the same operating conditions, the results of cold numerical simulation were similar to the results of experiments.

4. References and Bibliography

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Author Biographies

The primary research focus of **Professor Xiofeng Lu** at Chongqing University, China, is on the engineering applications in various low pollution combustion technologies, especially in large scale of circulating fluidized bed combustion boilers, with the fundamentals of energy and environmental issues.

Professor Ryo Samuel Amano is a Professor of Mechanical Engineering at the University of Wisconsin, USA. He has been engaged in numerous researches including Fluid Mechanics, Heat transfer, Transport Phenomena, Combustion, Fluidized Bed Combustion. He has received a number of Research Awards and is now a leading author of many topics related to CFD, Circulating Fluidized Bed Combustion, and Propulsion Systems.