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Fluidized bed with heat exchanger: An advance equipment for moisture removal from coal

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ABSTRACT

In the rainy season, the coal from coal mines are totally wet and it takes lots of time (10 to 12 days) to get dry. Such type of coal cannot be used for the boiler. The Additional new equipment fluidized bed with heat exchanger for removal of coal moisture can be used. If CHP will work on such advanced equipment which is reliable and have less maintenance cost then the efficiency of the plant get an increase. In the present paper, the advance coal handling unit consists of a fluidized bed with heat exchanger. An integrated solution of coal handling plant is given to meet the increasing production needs.

Keywords— *Fluidized bed, Heat exchanger, Flue gases*

1. INTRODUCTION

The advance equipment fluidized bed with heat exchanger is designed by considering the moisture contain in the coal. In rainy season the coal is totally wet, and such type of coal cannot be used directly for thermal power plant.

The coal from the coal mine are having moisture greater than 50% and most of the time the coals are like a mud. So some time it is very difficult to handle such type of coal. For such type of coal there is no arrangement in present coal handling plant. Generally in coal handling plant the wet coal from coal mine are put into stock yard for 10-12 days to remove the surface moisture from the coal and then is used for further process. In rainy season most of the coal mines get closed due to the rain fall. If there is no coal then there is no generation of electricity.

2. COAL

The coal is nothing but a combustible rock with 50% by weight by carbonaceous material. Actually Coal comes in four main types or we can say ranks i.e. lignite or brown coal, bituminous coal or black coal, anthracite and graphite. Each rank of coal has a set of physical parameters which are controlled by moisture, volatile content and carbon content. Generally, in Indian thermal power station the coal used is having different grade with their calorific value. Mostly E and F grade coal are used in India. Blending is done on coal to get average D grade. The different calorific value with ash contain as shown in table 1.

Table 1: Different grades of bituminous coal

Grade	Calorific value (K cal/kg)	% ash , moisture
A	7620	19.57
B	5601-6200	19.57-23.17
C	4941-5940	23.17-28.68
D	4201-4940	28.69-34.65
E	3361-4200	34.06-40.14

3. PROBLEM STATEMENT

In the present coal handling plant there is no any kind of arrangement for the moist coal. If coal is contain 1% moisture then the flame stability get disturbed by 0.07% and the boiler efficiency get reduced by 0.1% to 0.2%. With increase in 1% moisture the

CO2 emission get increase by 0.4%. In the present coal handling plant the conventional method is used to dry the coal that is coal is put in stock yard for 10-15 day to remove the surface moisture from the coal.

By adopting this method only surface moisture is get removed to some extend but the other type of moisture cannot be removed here. To increase the efficiency of the plant it is necessary that the coal which plant using is free from moisture or contain less amount of moisture. There is also need to focus on the rate of moisture removed from the coal. The time required to remove the moisture should be less in order to achieved higher efficiency.

3.1 Drawbacks in present coal handling plant

There are many drawbacks in present coal handling plant some of them which are related to the handling of coal and moisture content of coal are mention below.

- In the rainy season coal from the coal mines are generally contain moisture greater than 40% -50%, even some time it is 65% and such coal are directly put in stock yard.
- To remove the surface moisture from the coal it take 10-12 days and then also total moisture content from the coal cannot be removed. Only surface moisture gets reduced to some extent. Hence it is totally wasting of money and time too.
- Most of the people think that the coal mills which are present in the coal handling plant are used for the removal of moisture but it is not for the removal moisture content. The main function of coal mills is pneumatic transport of coal particle from coal mills to the boiler. The boiler is always maintain at negative draft and at such condition to feed the coal to the boiler is not easy task. Hence pneumatic transport is used.
- Due to high moisture content, coal is put in stock yard to dry. It takes very large area hence coal handling plant is the largest plant in coal based power plant. The cost of this plant is also too high.
- The power input to the crusher house get double due to the increased in the moisture content of coal. When moisture content gets increase, problem start arises in crusher house.
- The boiler efficiency reduces with increase in the moisture content. With increase in 1% moisture the boiler efficiency gets reduced by 0.1% - 0.2%. Generally coal which is feed to the boiler contains 10% moisture. So it is very important to reduce the moisture to 100%.
- The flame stability also gets affected by the moisture content. If coal contain 1% moisture then the flame stability get disturbed by 0.07 %. In order to increase the flame stability the moisture should be less as much as possible.
- For the production of 1 unit 0.700 kg of coal is required. As there is moisture in coal, there is no chance for proper combustion to take place in boiler. So it is very important that the coal should have as far as less amount of moisture.
- The moisture content in coal influences the emission. The CO2 emission gets increase by 0.4% when there is increase in moisture content by only 1%.

3.2 Objective of the project

To overcome the all above problems which generally faced and to increase the efficiency of thermal power plant by utilizing waste heat, here project focussing on to design such equipment which reduce the moisture contain in the coal.

Based on the limitation for present coal handling plant, the main two objectives have been decided they are as follows:

- The first objective is to reduce the moisture content from the coal.
- The second objective is to utilize the waste heat of flue gases hence to improve the efficiency of the plant.

If the moisture content of coal gets reduced to very high extent then not only single objective is achieve. By looking in deep, when moisture content reduce the flame stability, boiler efficiency, CO2 emission, cost of coal handling plant gets reduced.

In order to reduce the moisture content from coal the heat energy is required so rather than creating any another source of energy the project focus on to use the waste heat of flue gases. By doing this saving of energy and waste heat utilization achieved.

4. SETUP AND EXPERIMENTS

4.1 Material

The coal sample used in this study is Boundary Dam lignite. Samples were sieved and kept sealed before and after experiments. The proximate analysis of Boundary Dam coal was measured using a Leco TGA701 thermo-gravimetric analyzer and is presented in table 2.

Table 2: Proximate analysis of boundary dam coal

Fixed carbon %	Ash %	Volatile Matter %	Moisture %
23.4	13.4	40.5	21

4.2 Material density measurement

The particle density used in fluidized beds is the apparent density defined as Particle mass divided by its hydrodynamic volume. This volume is the one seen by the fluid and includes the particle and its open and close pores. This density is different from the absolute density which accounts for the real volume of the particle (apparent volume minus the pores). Measuring apparent density of porous materials is not an easy procedure because common methods measure the absolute density. In this study the apparent density of coal samples was measured using water displacement method. A bottle of known weight was filled with an amount of water with measured weight. A small number of coal particles were weight measured and added to the bottle. The change in the water level was written down immediately, before water diffuses into the particles pores. The measured density for Boundary Dam coal was 1400 kg/m^3.

4.3 Setup for fluidized bed

The figure 1 shows the experimental setup for fluidized bed. In this setup the fluidized bed is connected to the heat exchanger. The air distributor is provided below the fluidized bed. In between the bed and air distributor the porous plane is provided. The fresh air is compressed by using compressor or primary air fan. The mass flow rate of fresh air is controlled by the mass flow controller. The pressure gauge and temperature sensor are provided after the heat exchanger to check the pressure and sense the temperature. The heat exchanger is design in a way that there is a path for primary or fresh air and another path for the flue gases. The mass flow controllers are also provided with in the path of flue gases to control the mass flow rate which influence the temperature of the fresh air.

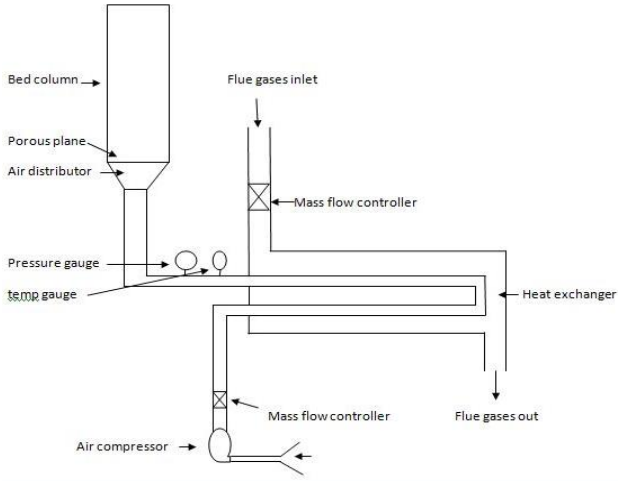

Fig. 1: Experimental setup for fluidized bed with heat exchanger

4.4 Working

Experiments were carried out using the setup schematically depicted in table 6.1. In the experiment process first air is pumped into a mass flow rate controller to be set to the desired mass flow rate. Air is then heated up in a heater controlled by a temperature controller. The temperature controller takes the heater temperature by a thermocouple and adjusts the mass flow rate of the flue gas so as to heat the primary air to the desired temperature. Hot air leaves the heater and enters the bed through a porous distributer to keep the air flow uniform across the bed entrance.

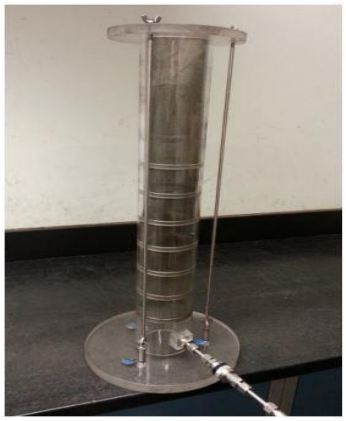

Fig. 2: Fluidized bed column

After the desired temperature is reached, a certain amount of coal is introduced to the bed and the experiment starts. The air flow rate is stopped at certain time intervals and the weight of the whole bed is measured using a microbalance. The experiment continues until no significant change is observed in the bed weight. Subtracting the weight of the empty bed from the measured weight values, the mass of samples in the bed is calculated at each time interval.

5. DISADVANTAGES

- Require less time for removal of moisture.
- There is no extra heat required for moisture removal.
- Better heat utilization from waste heat of flue gases.
- Moisture reduced to 100%.
- Flame stability increases by 1.61%.
- Coal consumption gets reduced.
- Reliable and Less maintenance cost.
- Finally efficiency of plant gets increase by 3.41%.
- Reduce CO_2 mass emission by 8.1%.

6. CONCLUSION

By adopting above mention technology fluidized bed with heat exchanger, not only increase the plant efficiency but also heat utilization can be obtained. For the removal of all moisture contains from the coal will require the few hours. If there is 1% moisture contains in the coal then the flame stability gets disturb by 0.07%, efficiency by 0.1% - 0.2% and CO_2 emission increase by 0.4%. Here moisture content is reduced to 100%. So the CO_2 emission reduced, flame stability and efficiency gets increased. Hence directly achieve higher efficiency.

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