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Experimental Study on Removal of Moisture in Coal to Enhance Boiler Efficiency

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***Abstract*: Electric power is the basic need for human beings in a day to day life. Major portion of electrical energy used for applications are produced from thermal power plants in which coal is the major source of fuel rather than any other fuels. The main objective of the project work is to increase the efficiency of boiler in thermal power plants. Coal used in steam power plants consists of 53% of moisture, 18% of carbon and other matters in which more percentage of moisture present in coal reduces the efficiency of boiler. In this experimental work, carbon content of coal was enhanced by both chemical and heating method. In chemical method, lignite sample was washed with ethanol for 30 minutes to reduce the moisture content and enhance the carbon value from 18% to 48%. In heating method, the lignite was heated in muffle furnace at 500ºC for 2 hours, which increases the carbon/unit sample by removing volatile matter present in the sample. From the result, heat treatment method is the appropriate one as it reduces more moisture than the chemical method.**

***Keywords*: Efficiency, Lignite, Moisture, Volatile matter.**

1. Introduction

As the demand for electricity has been increasing at a rapid pace in our country requires installation of more thermal power plant will be an obvious choice. The combustion efficiency of any boiler is an important factor as it directly controls the fuel consumption. Efficiency of boiler gradually reduced with longer run due to poor combustion of coal, heat transfer fouling and poor operation and maintenance. One of the major reason for drop in efficiency of the boiler is poor quality of coal which is having high content of moisture. Low – rank coals constitute a major energy source for the future as reserves of such high-moisture coals around the world are vast. Currently they are considered undesirable since high moisture content entails high transportation costs, potential safety hazards in transportations and storage, and the low thermal efficiency obtained in combustion of such coals. Hence various upgrading process have been developed to reduce the moisture content. Canadian lignite coal (425–1000 µm) was dried at different temperatures using different methods, namely hydrothermal treatment (HT), vacuum drying and hot air drying. These processes resulted in significant reduction (up to 9.65%) in moisture from as-received lignite coal (34%), especially at higher temperatures (300 and 325°C) using HT for 30 minutes [1]. Lignite coals give up their moisture more slowly than harder coals, but the higher volatile content tends to offset the effect of high moisture. For the combustion of pulverized material it appears essential to dry lignite. Further, lowest possible ash and moisture as well as high heat content are desired for combustion [2]. There are also other methods of coal drying. The typical example is drying of coal in a fluidized bed installation. In a fluidized bed, the solid particles of coal are exposed to air at a suitable temperature. Then the moisture contained in it is discharged into the heating air. This process lasts as long as the moisture content of the material is in balance with the temperature and moisture content of the surrounding air. The loss of moisture is proportional to the air temperature and the ability of air to by assimilate moisture [3]. There are different types of dryers available for coal drying. They are Pneumatic dryers, Fluid-bed dryers with spouted bed, Vibratory fluid-bed dryers, Shaft dryers, Mill-type dryers [4]. The above mentioned coal drying process are effectively influenced by parameters such as the temperature, the drying media flow rate, the sample thickness and the particle size. Therefore, by reducing moisture content in lignite the usage of furnace heat by moisture can be avoided which on contrary can be efficiently used for steam formation in boiler tubes [5]. This project work deals with the suitable and sustainable process of coal drying methods to reduce the moisture.

2. Experimental Setup and Procedure

The removal of moisture from lignite was done by using following two methods.

1. Chemical Treatment
2. Heat treatment

In chemical treatment method, removal of moisture from lignite was achieved by using ethanol as a reactant which reacted with water and evaporate by absorbing heat from surrounding. Experiment was carried out in hot air oven with 10 grams of powdered lignite in a glass beaker, 30 ml of ethanol solution, a stirrer, wattman filter. Initially the lignite is powered and 10 grams of sample was taken in glass beaker. The sample was mixed with sufficient amount of ethanol in test beaker. Now this solution was mixed using magnetic stirrer at 800 RPM for 30 mins. Then this solution was filtered with wattman filter paper. Finally, the sample was placed in hot air oven at a temperature of 150 degree Celsius for 1 hour.

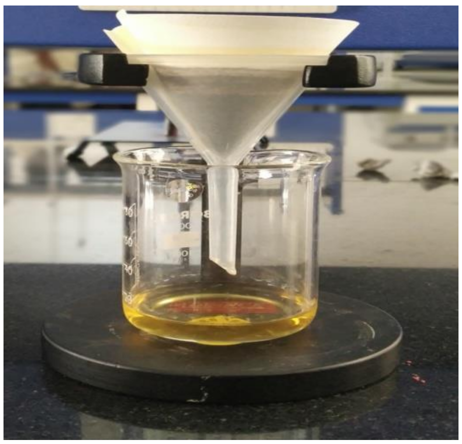

Fig. 1. Chemical treatment

In heat treatment process, heating furnace was used to evaporate moisture content and other volatile matters present in the lignite sample. Initially the lignite was powdered and it is weighed. The silica crucible was washed and rinsed with ethanol. Then 14 grams of lignite was placed in the silica crucible. The crucible was completely filled with the sample and it was closed with the lid to avoid oxidation. The crucible was placed in muffle furnace at a temperature of 500ºC for 2 hours.

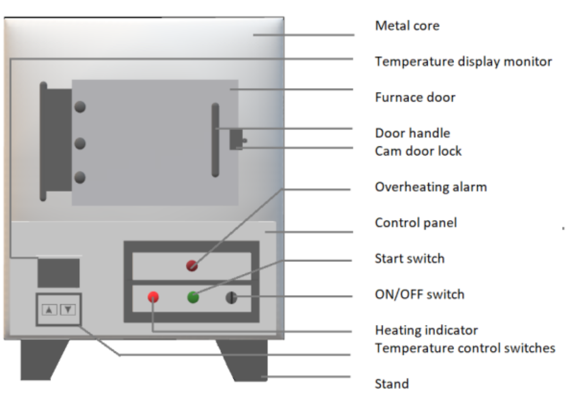

Fig. 2. Heat treatment process

Gravimetric method or loss-on-ignition was used to measure removal of moisture level. Procedure for measuring moisture level as follows: Four grams of coal that passed through a sieve of 2 mm mesh was further dried at 105 °C. Preliminary tests were carried out with samples that passed sieves of 2.0 and 0.5 mm mesh. After checking that there were no differences between SOC levels obtained for each mesh, so 2.0 mm was selected due to practical reasons. The samples were subjected to calcinations for 5hours at 300 °C (Miyazawa et al., 2000). Subsequently, the samples were weighed and the difference between the initial and final mass corresponded to the organic matter of the soil. A specification of the test equipment is shown in the table 1.

Table 1
Micro Balance Specification

Make	SHIMADZU
Model	AUW 220D
Range	0 to 220 grams
Least Count	0.0001 gram

Table 2
Proximate Analysis of coal

Properties	Units	Notation	Value
Moisture	%	M	53.70
Ash	%	A	4.48
Fixed Carbon	%	FC	18.82
Volatile Matter	%	VM	23.00
Gross calorific Value	Kcal/kg	G.C.V.	2693

Heat loss Calculation:

Proximate analysis was used to find the heat loss of coal during combustion inside the boiler. Properties of the lignite are shown in the table 2.

Percentage of heat loss due to evaporation of moisture present in coal during combustion:

$$= \left[\frac{\%M \times (584 + Cp\,(Tf - Ta)}{\text{GCV of fuel}} \right] \times 100\%$$

$$= \left[\frac{53.7 \times (584 + 0.42(173 - 36.55)}{2693} \right]$$

$$= 12.78\%$$

Nearly 13% of heat generated due to combustion was lost.

3. Result and Discussion

In order to reduce the heat loss due to moisture we undergo the chemical as well as heat treatment process for the removal of moisture (rise in carbon content) in coal. At end of chemical process, weight of the sample after the completion of process was 5.2 grams. This loss in weight when compared with the weight of lignite sample before chemical treatment (10 grams) indicates that, nearly 5 grams of weight contributed by moisture content in the lignite sample was evaporated. On the other hand, at end of heat treatment process sample weight measured and compared with sample before testing. Results shows there was a reduction in weight of 6 grams.

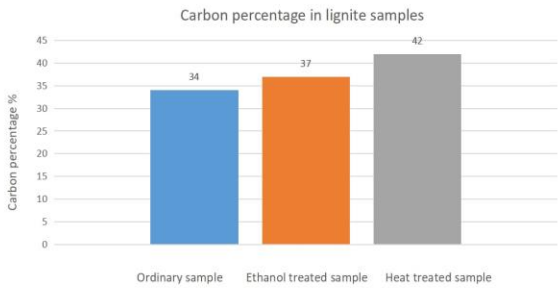

Fig. 3. Variation of carbon percentage with sample

Carbon content level was tested and results were shown in figure 4. Ordinary sample of lignite before processing contains only 34% of carbon. But in chemical and heat treatment process, its value reaches up to 37% and 42% respectively. It was clearly seen that heat treated sample has higher value of carbon than the ethanol treated sample. The raise in carbon content indicates the removal of moisture from the lignite. There is only 8% of moisture was removed from lignite in chemical treatment process. But in heat treatment process nearly 45.7% of moisture was removed.

Percentage of heat loss due to evaporation of moisture present in fuel:

$$L_3 = \left[\frac{\%M \times (584 + Cp\,(Tf - Ta)}{GCV\ of\ fuel} \right] \times 100\%$$

$$= \left[\frac{45.7 \times (584 + 0.42(173 - 36.55)}{2693} \right]$$

L_3 = 10.88%

Due to removal of moisture present in the lignite contributes reduction in 15 % of heat loss in boiler.

4. Conclusion

As the demand for electricity is rapidly increasing in our country which leads to wastage of energy from fuels used in power plants must be eliminated. Removal of moisture from coal was carried out and some salient points of this experimental work are listed below.

1. There is a raise in carbon content of the coal in chemical and heat treatment methods.
2. In Chemical treatment, there was 8% of increase in carbon content compared to sample.
3. In Heat treatment method, there was 19% of increase in carbon content of the coal compare to sample. Result clearly shows that heat treatment method provides good result compared to chemical treatment.
4. Removal of moisture from the coal contributes 15% reduction in heat loss during combustion in boiler which leads to enhance the boiler efficiency.

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