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Study of Coal Properties and Flue Gas Temperature of Sagardighi Thermal Power Station

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Abstract*— In this paper work has been presented for coal properties and flue gas temperature of Sagardighi Thermal Power Station. For any industrial workings, the temperature estimation is an important parameter. Hence for Thermal power station the temperature estimation of flue gas is very important parameter. The coal is being received in Thermal power station from collieries. After receiving the coal, it has to be sent for pulverization. Coal is being burnt in furnace and produces steam pressures in Boiler. For producing this Pressure, the proper combustion of coal is very important. Whether the proper combustion of coal is taken place or not, it can be known by measuring the Flue Gas temperature. The temperature of flue gas can be measured in Thermal power station by thermocouples, pyrometers and other contact type sensors. This temperature measurement of flue gas is an extremely difficult and it may damage sensors because of high temperature. The basic properties of coal are Gross Calorific Value (GCV), Fixed Carbon (FC), Ash content, Volatile Matter (VM) and Moisture content.

Keywords: GCV, Fixed Carbon, Ash, VM, Moisture, Temperature.

I. INTRODUCTION

In power station it was observed that coal parameters and temperatures **[8,14]** play very important role to generate constant power. This research describes the process of estimation of flue gas temperature as well as power generation.

Gross Calorific Value (GCV)

The amount of heat produced by complete combustion of unit mass of coal in the excess air or oxygen.

Combustion

Chemical Energy ⟹ Heat Energy

If Moisture Content < 2% , then GCV= 91.7 x FC + [75.6 (VM - 0.1 Ash)] - 60 M

If Moisture Content >2% , then GCV = 85.6 [100 - (1.1 Ash + M)] – 60 M

Fixed Carbon (FC)

It is the portion of coal that remnants as rest after VM distils off, after sum of the moisture content and Ash content in the coal is subtracted. It is obviously carbon, but holds minor amount of the hydrogen, oxygen, nitrogen, and Sulphur not driven off with the gases.

Fixed Carbon = 100 - [% of Moisture + % of Ash + % of VM]

Coal Ash

It is the main pollutant which discharged from any thermal power station. It contains heavy metals viz. calcium, aluminium, sodium, nickel, and arsenic, among others. This Ash is of two types namely Fly ash and Bottom ash. Fly ash is sent to the Cement factory and brick factory to produce Cement and brick respectively. To throw out the bottom ash, the authorities have acquired a very large tracts of land near the thermal station which is called the Ash Pond. This Ash pond is basically to prevent the ash content into the air.

Ash Content = (weight of Residue/coal sample) x 100

Volatile Matter (VM)

VM is basically the loss of percentage of mass, adjusted for moisture, while coal is heated out of connection with the air under the standard conditions. During the experiment, 1 g of sample has to be located into a lidded type crucible (to block entry of air), which is arranged in a furnace at 910°C or 950°C for 7 min.

VM% = [(Coal sample weight - weight of coal after heating)/weight of coal sample] x 100%

Inherent Moisture (IM)

Inherent Moisture is the moisture which remains in coal after natural drying in the atmosphere. The Inherent Moisture is confined within the molecular structure of the coal which can be removed at temperature of 105°C.

Inherent Moisture % = (weight of coal sample – weight of coal after 1 hr heating) x 100 / weight of coal sample

Total Moisture (TM)

The coal which is disclosed to touch with water in the seam or in the coal yards or in the washery, or coal wetted due to rain or by water spray due to some unwanted situation handling may lead free or visible water. This water surplus the moisture within the substance, is considered as total moisture.

TM % = (IM + Surface Moisture) %.

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Flue Gas

Flue gas is the gas which is coming out to the atmosphere through a duct or tube or vent or chimney for delivering exhaust gases from the furnace, boiler of thermal power station. Quite often, the flue gas refers to the combustion exhaust gas produced at power generating stations. The composition of flue gases are depending upon burning materials, but it is generally consist of mainly nitrogen derived from the combustions of air, carbon dioxide (CO_2) and water vapor as well as excess oxygen. It further contains a very little percentage of a number of pollutants, such as particulate matter (like soot), CO, NO , and SO.

II. LITERATURE REVIEW

Literature review has its own significance in any research work. It briefly summarises the scope of the work and work done before the relevant topic. The various journals like national and international journal of Electrical Engineering, Computer Science and Engineering, conference publications and Masters level thesis report are downloaded for the purpose of review and finalization of the present topic.

Anagha and Rege (2010) [1] studied the images of digital photography and the technique of image processing **[17-20]** used to evaluate the temperature from all visible heat sources. The colour dominance technique eased for the formulation of equation which determines the correlation among the colour temperatures of several zones in the image . Using thermocouple the real temperature was measured and same used for calibration. Authors in **[2]** discussed the regulation of the membership functions in the fuzzy system taking ANN as the tool. The proposed controller based ANN for the temperature control of a water bath system which is to be compared with PID and fuzzy controller. **Usamentiaga et al. (2012) [3]** proposed a system of measuring temperature of the pouring molten pig iron using an infrared aided computer vision system. Although the system undergoes two challenges: the position of the stream to be detected in the respective infrared images and elimination of the corresponding pixels related to the slag which covers the part of the stream. The calibration of emissivity and temperature level made the system able to differentiate the molten pig iron from the slag **[6-8].**

Mane and Patil (2015) [4] explained a system of image processing and Neural Network which was used for temperature estimation of visible heat sources. One camera was used to take images of heat sources and the thermocouple was used to estimate actual temperature. ANN was implemented for generating the approximation of the temperature corresponding to the captured images for calculation of the actual temperature. Thermocouple was used to measure actual temperature Simulated ANN system was used to make the datasheet of captured images and estimated temperature **[9,11]. Pramila R. Gadyanavar and D. A. Kulkarni (2017) [5**] wrote a framework for temperature prediction of warmth sources which was suggested with the help of image preparing and neural system. Engaging camera, image was taken it could be heater, boilers consists of 'liquid metals', 'burners', 'modern blazes' and so forth. The images taken and its temperature would be documented in a chart. Temperature was calculated applying the temperature sensor and various kind of devices. After this pre-preparing of pictures, then making the color change arrangement with the help of the color mixture of Red, Green, Blue (RGB).

Block diagram of the work:

The coal properties i.e Gross Calorific Value (GCV), Fixed Carbon, Ash Content , Inherent Moisture and Total Moisture (TM) of Sagardighi Thermal Power Station from 1st February'22- 27th Nov '22 have been taken and temperature of flue gas was also taken for the same period of time as few samples have been shown in table 1.

Table.1 Coal properties and Flue gas temperature readings

Date	GCV (Kcal/Kg)	FC%	ASH%	VM%	IM%	TM%	FLUE GAS TEMPERATURE (DEG C)
01-02-2022	3556	31.5	42.8	21.8	3.9	8.6	631.485
02-02-2022	4017	36.2	31.6	24.1	8.1	13.6	623.689
03-02-2022	4079	35.4	30.8	26.3	7.5	14.2	632.741
04-02-2022	3758	32.6	36.1	24.3	7	12.9	627.42
05-02-2022	3494	31.8	38.2	23.6	6.4	12.3	625.949
06-02-2022	3679	34.2	32.1	25.5	8.2	14.9	634.471
07-02-2022	3802	33.6	33.2	24.4	8.8	15.5	628.806
08-02-2022	3965	33.7	33.7	24.5	8.1	14.3	629.628
09-02-2022	4670	41.1	32.6	22.2	4.1	7.8	633.411
10-02-2022	4135	36.9	29.8	25.8	7.5	14.2	624.222

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After taking these data it was processed. The 80% of processed data will be used to train the ANN and SVM model and rest 20% of processed data will be used to test the model.

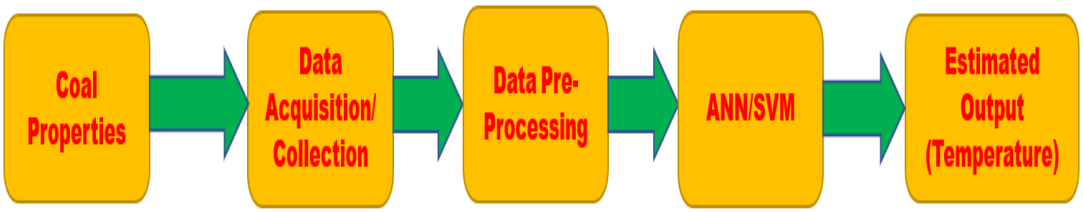

Figure 1. Work Flow diagram of temperature Estimation

Data Acquisition/Collection

All the data of different parameters like Gross Calorific Value (GCV), Fixed Carbon, Ash Content , Inherent Moisture (IM), Total Moisture (TM) and Temperature of Flue gas have been collected from Sagardighi Thermal Power Station, West Bengal. One set of reading for the parameters of GCV, Carbon, Ash, IM, VM for each day has been collected. The temperature readings were recorded on hourly basis. To get a single value of temperature for each day, those readings were averaged over 24 hours. All the data are taken from Unit #3 of the mentioned plant. The data readings were taken on daily basis from the period 01st February 2022 to 27th November 2022. The readings in the present data set were recorded after keen observation from different modules generating the various working parameters in the Plant. The entire data set comprises of approximately 300 data readings.

Data Pre-Processing

The data pre-processing step is accomplished using filtering technique of the data and removing the undesired values present in the entire data set. The pre-processing step mainly focused on preparation of the data set in proper working format. Redundant and irrelevant data points are being removed in this particular stage.

Artificial Neural Network (ANN)

The ANN model **[10,12,13,16]** has been used for prediction of outputs in the present work. The prediction using ANN was a kind of regression model for accurate generation of the results. ANN was considered in this work as

(i) A neural network could implement tasks that a linear program could not.
(ii) When an item of the neural network declines, it could continue without some issues by its parallel features.
(iii) A neural network determines and does not require to be reprogrammed.
(iv) It can be executed in any application.

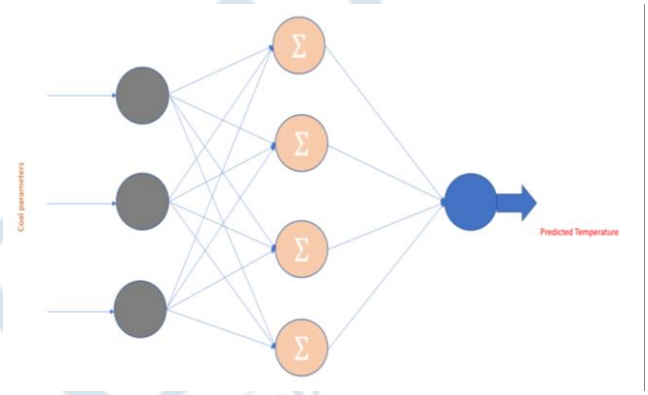

Figure 2. ANN model for suggested work

SUPPORT VECTOR MACHINE (SVM)

SVM is a supervised machine learning model **[15]** which may variously classify the data points over the different division or grade of data. It can classify and estimate the data based on the three different type of Kernels namely 'Linear Kernel', 'Polynomial Kernel' and 'RBF Kernel'.

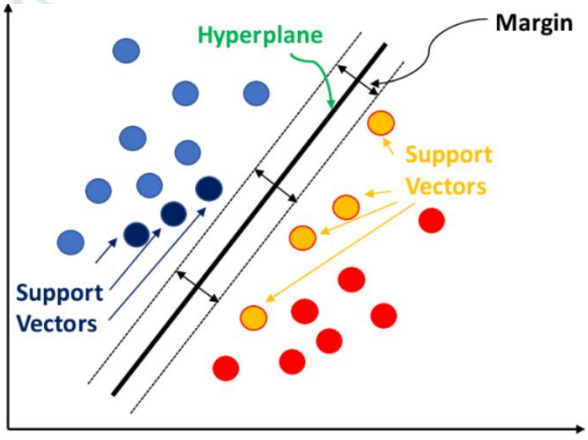

Figure 3. SVM Classifier [9,21]

III. CONCLUSION

This paper contains an overview of coal parameters viz. GCV, FC, ASH, TM, VM and also Flue gas temperature. All the data were taken from Sagardighi Thermal Power Station, West Bengal. It has been observed that while gross calorific value of coal increases then the flue gas temperature also

increases. If volatile matter increases too high then temperature does not sustained. If Moisture content is less then the temperature of flue gases may be increased. With the increase of Ash content the flue gases temperatures decreases.

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