Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2017, 4(12):507-512**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Implementation of Gravimetric Feeder Control System for Efficient Coal Feeding in Thermal Power Plants

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Abstract Gravimetric and volumetric feeders are widely used as the standard mechanism employed to feed input material (coal) into the boiler in a thermal power plant. Coal properties are known to vary owing to reasons such as source of coal, chemical composition, atmospheric conditions, mining & crushing methods etc. While the change in chemical composition affects the heat output upon combustion, the change in physical properties such as volume & density leads to measurement inaccuracies, which in turn affect the planning & production process. The gravimetric feeder control system (GFC) helps in compensating the variation in density and volume by facilitating precise feeding of fixed weight of coal in response to a boiler fuel demand. This ability to accurately weigh the coal provides significant improvement over volumetric types in terms of matching the fuel delivered by the feeder to the actual process energy required on coal fired units. The gravimetric feeder thus facilitates proper planning of coal requirement, feeding of coal as per demand and helps avoid wastage. The objective of the paper is to explain the coal feeding efficiency of GFC is with in tolerable range (+/-0.5%), which is set by the customer.

Keywords Gravimetric feeder controller (GFC), coal, load cells, optimum combustion of fuel, Feedrate, Calibration

1. Introduction

Coal an abundantly available natural resource is used as input fuel in thermal power plants for generating power. Thermal power plants burn the coal in the boiler to generate thermal energy which in turn is used to convert water into steam. As the amount of coal required for a typical power plant is huge, both in terms of volume and weight, there is a need for huge infrastructure to transport it from mines, store at the plant, process before usage and to deliver into the boiler. Coal is stored in huge coal yards which are a few hundred meters away from the plant. It is processed and delivered into the boiler using mechanised conveyor belt systems. The conveyors feed the coal from different levels called coal mill elevations into the boiler for combustion. The amount of fuel input to boiler is measured and controlled as per the demand raised from the control room. The raw coal from the yard is transported to the pulverisers where it is crushed and routed into the boiler. There is a need to measure the coal before it enters the pulveriser. The cost effective means of controlling the input is by measuring the coal mass through feeders. The most feasible and accurate means of measurement envisaged is to weigh the coal while being transported on the conveyor belt. This is implemented by regulating the speed of the conveyor system and taking measurements using load cells at appropriate points. Through this the total coal weight fed into the boiler can be computed. The feeder must deliver the coal mass at a rate proportional to the demand. This must be done independent of coal physical parameters. The methods of feeder control systems used are volumetric method and Gravimetric method of which the later is accurate and is referred to as Gravimetric feeder control system. The coal feeding efficiency of GFC is calculated by taking percentage error between coal consumed as per customer records and coal consumed as per GFC readings, detailed in test results [1,3,4].

2. Overview of Gravimetric Feeder Control System

Gravimetric feeder weighs material on a belt between two fixed points (span) precisely located in the feeder body (Fig 1). A roller, located midway in the span and supported at each end by precision load cells, supports half the weight on the span. The load cells generate an electrical signal directly proportional to the weight supported. The control electronics measures multiple samples of the output of each load cell in a second duration. If the load cell outputs are within the expected range, they are added to obtain total weight of coal per unit of belt length. Belt speed is determined by sampling the output of a tachometer attached to the motor shaft, multiplied by a calibration factor to convert it into a belt speed signal. The control system multiplies the speed and weight signal for the feeder rate of fuel output. Finally, the controller compares the actual feeder output to the output required by the boiler control, and adjusts the feeder motor speed in a closed loop till the set point is reached. Feeders provide an accuracy of $\pm$ ½ % of totalized weight when calibrated and maintained well [1].

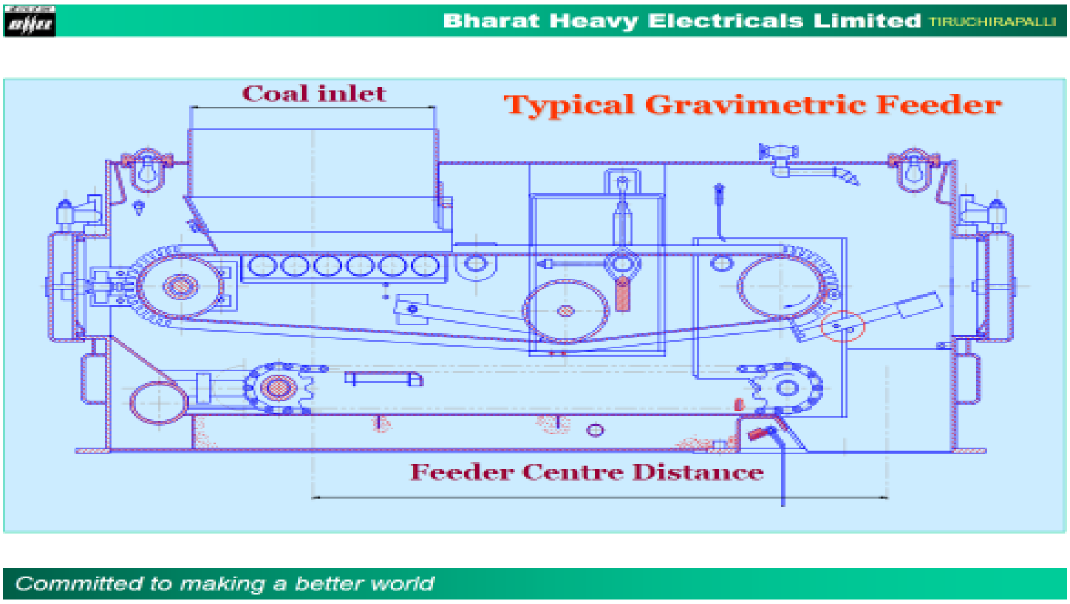

Figure 1: Coal feeder system with the load cells

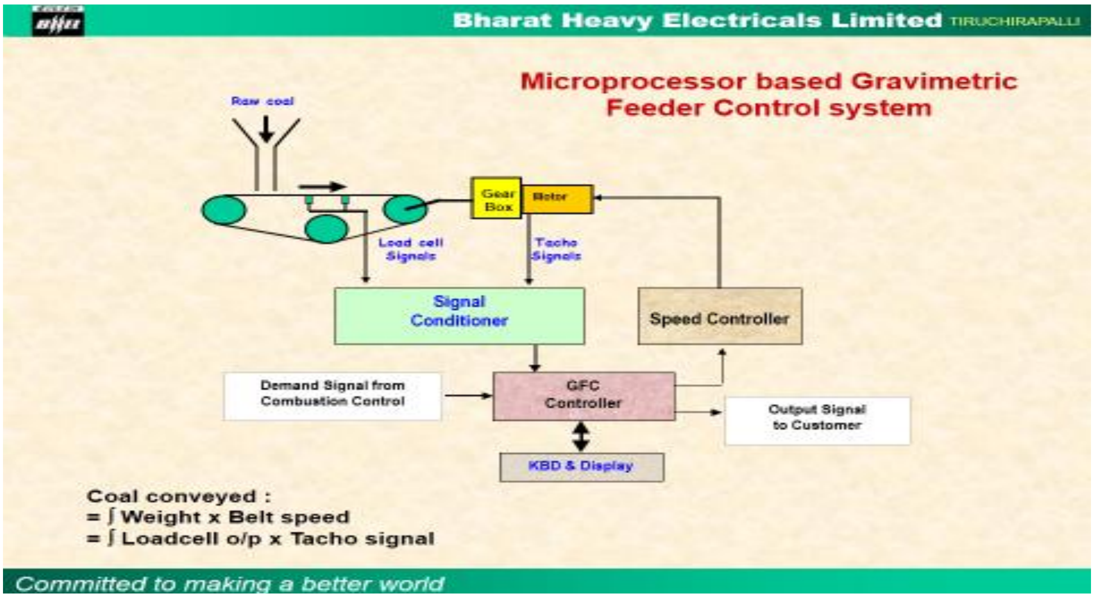

Figure 2: Block diagram of Gravimetric Feeder Control system

3. Implementation of Gravimetric Feeder Control System

A GFC consists of two main parts viz. a mechanical component and associated electronic hardware. The electronic hardware is based on a controller, which is centered on a 32 bit embedded processor of Pentium architecture. Operator interface is provided through a 32 switch membrane key panel for input and a two row 40 character vacuum fluorescent display for output. All field inputs and outputs are handled through intelligent I/O modules which are housed in a EURO standard rack. The controller works on a real time operating system. All the control parameters of the gravimetric feeder are fed in to the controller through the key board and are stored in non-volatile memory. Apart from the alphanumeric display, the operational status of the GFC is displayed by bright lit LEDs. The microprocessor based electronic control system uses special circuits, software routines and stores data and program parameters in nonvolatile memory. The GFC consists of Power supply, Processor module, input and output modules, keyboard along with display and motor speed control module. All I/Os are optically isolated with respect to processor and its associated circuits. Analog circuits used to amplify and convert the load cell outputs are located separately in the feeder local panel. The display / keyboard located on the Remote panel door provides the means to communicate and receive information from the processor, for parameter setting, mode selection etc. The display / keyboard assembly consists of a vacuum fluorescent to display messages and process data for operator convenience.GFC Controller consists of the following major hardware components CPU, Interface, I / O Rack, Relay module, Power supply, Keyboard and Display [1].

- **CPU:** DIN rail mounted embedded industrial PC with inbuilt 48 digital I/O module.
- **Interface:** DIN rail mounted interface arrangement between CPU and I/O rack.
- **I/O rack:** Standard Euro rack with a 8 slot backplane to house I/O modules.
- **Bus interface:**Facilitates communication between CPU & I/O modules through back plane.
- **Analog input:** This is a 16 channels module handling 4 – 20ma current inputs.
- **Analog output:** This is a 16 channel module handling 4-20ma current outputs.
- **Digital input:** This is a 32 channel module handling 24 VDC field inputs.
- **Digital output:** This is a 32 channel module handling 24 VDC/100mA solid state outputs.
- **Pulse input:** This is a 18 channel pulse input module which measures frequency/pulse width.
- **Relay module:** This is a 8 channel Relay output module with 230vAC @5A contacts.
- **Power supply:** This is a DIN rail mounted 24 VDC/12 A power supply.
- **Keyboard:** This is a 32 key membrane keyboard with legends identifying the functions.
- **Display:**It is a 2 line x 40 characted alpha-numeric dot-matrix display.

The operating system used is VxWorks and the application software is developed in 'C'. The application software is developed, compiled, linked and burnt into the flash. The software takes operator inputs from the various function keys & numeric input keys. Some of the function keys provided are NEXT, PREV, PROG, CLS, ENTER, ESC, etc. The GFC status is provided through LEDs indicating states such as FEEDER RUN, GRAVIMETRIC, VOLUMETRIC, ALARM and TRIP. Other Operational keys include TARE CAL, SPAN CAL, TOTAL DISPLAY, TOTAL RESET, SELECT DATA, NEXT, SELF CHECK, SPL FUN, REMOTE, BELT REV, INCH, LOCAL, CLOCK SET, etc.

GFC system has to be calibrated prior to actual operation. Ithas to be calibrated with no load operation and then with full load operation. In no laod operation, which is called as tare calibration done by removing any weight on the conveyor belt like coal.After successful calibration with no load it has to be put into full load calibration, i.e span cal calibration.In full load calibration conveyor belt is suspended with a weight, which is equal to the maximum weight of coal on belt at any point of time, which is equal to 83 Kgs in general.Generally conveyor belt elongates with long run and the elongated belt can not be used for opearation as it creates problems like load cells weight reading mismath,improper coal flow etc. This kind of situation can be eliminated with calibration.After calibration it gives the results like belt length is with in the range or not.

After successful calibration of GFC system it is put into actual operation where coal feedrate is caliculated based on load cell readings (coal weight) and motor speed from tachometer. During operation the system tries to match the caliculated feedrate with the demand feedrate (the required feedrate, which is an external signal from

DCS system), through motor speed. Based on the load cell readings coal consumtion data is updated continiously as material total.

4. Advantages of Gravimetric Feeder Control System

The change in density described above is primarily due to change in moisture content and sizing of the coal. Gravimetric Feeders monitor the weight of the coal and changes the speed of the belt to compensate for the change in density. This precise control of feed rate, and thus the actual weight of fuel sent into the boiler, allows maintaining of proper fuel to air ratio which leads to optimum combustion and minimizing the presence of unburnt carbon.

In the present global environment, the emphasis on emissions monitoring and control requires maintaining of very precise fuel to air ratio which in turn requires precise measurement of coal being fed into the boiler. Gravimetric feeders provide verification of the “as used” fuel to assist in the compliance with established standards.

Gravimetric feeders allow continuous monitoring of the fuel flow. In the event of occurrence of a feed rate error or a component malfunction, an alarm signal is provided along with an error message. This allows correction of a problem at an early stage and prevents unscheduled outages. Usage of actual coal feedrate signal used as reference for combustion air control results in optimum combustion of fuel. Optimum air/fuel ratios reduce the possibility of furnace upsets during load changing. Accurate control of combustion air reduces NOx emissions. Accurately controlled fuel and air ratios reduce formation of sulphates and thereby reduce corrosion.

5. Test Results of GFC System

Given below in Fig.3 is the HMI membrane panel of BHEL make GFC system as seen during operation.

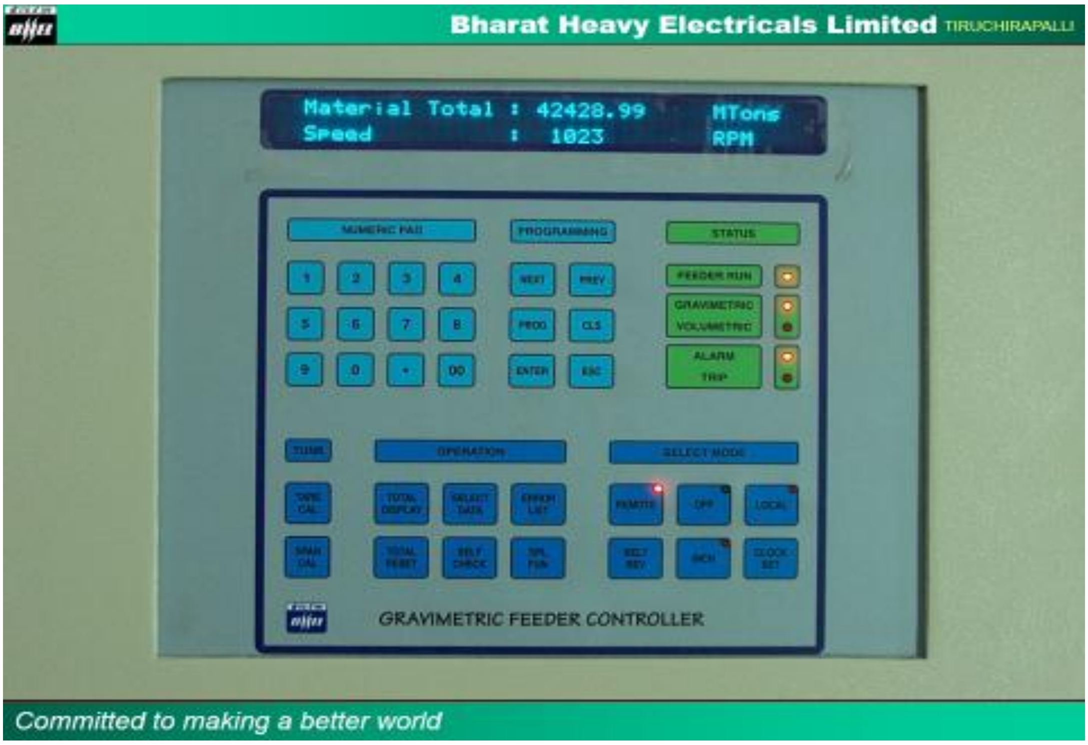

Figure 3: The HMI panel of BHEL GFC system

Figure 4 below shows BHEL make GFC system which has undergone several tests before being installed at multiple sites.

Figure 4: BHEL make GFC system

The GFC system has been subjected to material totalizer accuracy test at our factory test bed and has been tested successfully in presence of our customers. The test results are as follows [2]:

S. No.	Actual Weigh Reading (I/P)	Feeder reading (O/P)	error	%error
1	3207	3215	8	0.25
2	3243	3254	11	0.34
3	3182	3187	5	0.16
4	3169	3182	13	0.41
5	3236	3246	10	0.31
6	3251	3265	14	0.43
7	3214	3223	9	0.28
8	3229	3245	16	0.49
9	3247	3253	6	0.18
10	3233	3246	13	0.4

Feeder readings shown above have been noted after completing the accuracy test cycle at Feeder GUI with the GFC software. Actual weight reading was noted by weighing the coal collected at the bottom of the feeder during the test cycle. The collected coal was weighed using a calibrated weighing machine.

5. Conclusion

Efficiency of the coal feeding is achieved within the tolerable (+/- 0.5 %) range, which is the requirement of customers, using the gravimetric feeder control system. The test results achieved are testimony to the accuracy and consistency of the GFC system.

Acknowledgements

We acknowledge with thanks, the support given by BHEL to take up and complete the development work in the above research area. We would also like to thank our esteemed customers and all colleagues from BHEL who have supported us during the course of the project and provided required facilities and assisted us with valuable technical guidance without which the work could not have been completed.

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