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The 7th International Conference on Measurement and Control of Granular Materials

(MCGM 2006)

August 26-28, 2006 Shanghai, China

IFMCGM

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Introduction

The 7th International Conference on Measurement and Control of Granular Materials (MCGM2006) will be held in Shanghai, China on Aug. 26-28, 2006.

With the preparation of 7th ICMCGM, it is significant for us to review the history of IFMCGM development since 1988 when the First International Conference on MCGM was held. In the past 19 years, all Councilors of IFMCGM have given their selfless great contributions and wisdoms to the globalization of MCGM development. The Organizer has deeply cherished the memory of some late VIP founders of IFMCGM such as Prof. Koichi Iinoya (Japan), Prof. B. Scarlett (The Netherlands) and Prof. D.F.Bagster (Australia) who all had passed away in the past few years. Their spirits will impel younger members and Councilors of IFMCGM to develop the MCGM field unceasingly in the future!

Nowadays, researchers and engineers almost in every country put their financial and labor forces into MCGM projects and have gotten great results of academic researches and industrial applications. Scientists and experts in the world are in cooperation with each other to solve technical and theoretical difficulties in MCGM field. MCGM field has become a worldwide important branch both in science and economic development.

With the rapid economic growth in the world, the great expansion of MCGM instrument and systems has been made since 1988. The techniques and control systems (also sensors and devices for measuring purposes) in MCGM field have been tremendously developed with contributions from almost all of researchers and experts in the world. The Organizer hopes that all attendees can experience the newest research results and also find the new way for globalization of cooperation in MCGM field.

Shanghai is the largest industrial and financial center both in China and Asia. It is the most beautiful tour city in China, now. More than hundred thousands of tourists all over the world are visiting there each year. Warm and oceanic climate in four seasons every year is very comfortable for travelers. International airlines and inner train systems are very convenient for all travelers to and from Shanghai and everywhere in the world. The city area is $5800km^2$ with a large population of 12.83 million. It will be a great opportunity for all attendees to have the academic meetings and wonderful tourism in Shanghai, China. You will be moved with the rapid economic growth in Shanghai during the Reforming Period of China. You will be the most honorable guests of Shanghai' s people. It can be firmly convinced that the MCGM2006 Conference will be a successful one in mutually efforts from you and all attendees!

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The 7th International Conference on Measurement and Control
of Granular Materials (MCGM 2006)

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Section 1

Measurement and Control of Granular Materials

Measuring Pulverised Fuel Using Electrostatic Meters

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[1] University of Teesside, [2] PFM Consultant LLP, [3] ABB Ltd

Abstract: This paper describes the performance of electrostatic meters for measuring and controlling pulverised fuel on coal-fired power plant. The instruments are being successfully marketed worldwide. Typical data obtained from on-line measurements of pulverised fuel (PF) flow in a large-scale power plant demonstrate how the system can be used to measure the fuel velocity and distribution (split) to indicate the conveying conditions in each individual conveyor.

Results from laboratory tests carried out on a bifurcating system show that the split between two conveyors can be balanced by controlling the back pressure with PF meters providing on-line feedback of mass flow measurements. Based on the results, some of the immediate benefits of continuous PF metering are discussed showing the potential to increase plant efficiency by optimising the fuel distribution to the burners.

Keywords: Pulverised Fuel, Electrostatic Meter, Measurement & Control

Introduction

Coal fired power plant generate about 40.1%[1] of all electrical power worldwide in Year 2003. The coal is pulverised, mixed with air, and the mixture is then pneumatically conveyed to the burners via, typically, 48 conveyors of 350-600mm diameter. Accurate measurement and control of the mass flow rate of the PF in each conveyor is of critical importance to improving combustion efficiency as well as lowering the carbon content of the ash and reducing greenhouse gases and other emissions. The potential environmental and economic benefits due to effective PF monitoring and thus combustion control are extremely significant. In a study by PowerGen[2], the economics of PF distribution control have been analysed, suggesting that improving PF distribution in combination with a combustion optimiser can provide benefits by a reduction in NO_x emissions of up to 30% with simultaneous improvements to efficiency thereby providing significant economic and environmental benefits.

The introduction of tighter environmental legislation has required power generators to operate in compliance with increasingly stringent emission regulations. As the power generating market becomes even more competitive, power stations require further increases in efficiency whilst, at the same time, not exceeding the emission regulation limits.

The importance of maintaining the correct air-to-fuel ratio is clearly indicated in Fig.1 showing that, for optimum combustion, the air-fuel ratio must be maintained within narrow limits.

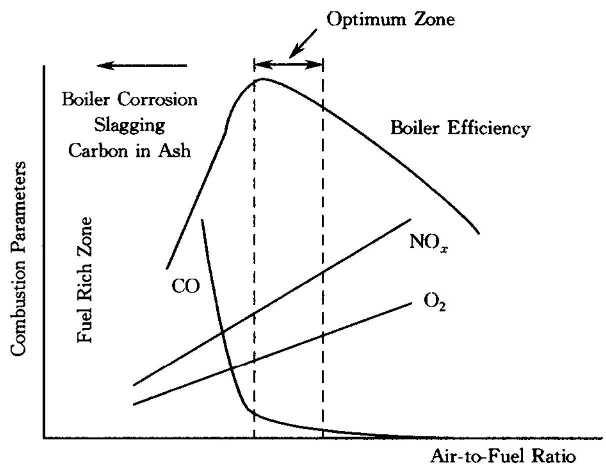

Fig.1 Combustion Parameters Vs Air to Fuel Ratio

1. Instrumentation Principle

A common phenomenon in solids pneumatic transport is electrical charging of the conveyed solids[3]. The primary sources of electrification are due to frictional contact and charge transfer from one object to another. Electrical signals produced on the sensors can be considered to originate from charging due to inducement when charged particles pass through the "sensing volume" and to particles impacting with the inner surface of the sensors.

During the passage of charged particles, variations in level of the charge signal on the sensor can be used as an indication of solids concentration[4,5]. "Dynamic" electrostatic sensors measure such variations or fluctuations. It is obvious that this is not an absolute measure of solids concentration or mass flow rate since the charge level depends on many factors such as the chemical composition of the solids, the particle size distribution, moisture content etc. The PF meters, manufactured by ABB based on the above principle, trade marked PfMaster are commercially available now. Fig.2 shows ABB PfMasters waiting for dispatch.

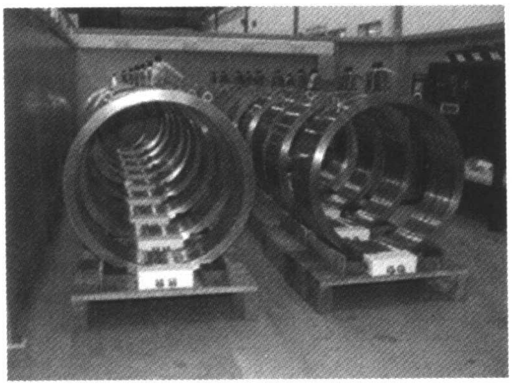

Fig.2 ABB PfMaster Meters Waiting for Dispatch

For a given material with a constant moisture content and particle size distribution, under lean-phase conditions the solids mass flow rate is assumed proportional to the signals induced on the sensor[6]. Results shown in Fig.3 and Fig.4 support this assumption. These were obtained from tests on a pneumatic conveying rig in a laboratory at the University of Teesside. The solids material used was Fillite[7] with particle sizes ranging from 5μm to 500μm in diameter. The conveying air mass flow rate was kept constant whilst the solids mass flow rate varied. The solids velocity was around 26m/s. These were "lean phase" conditions with the solids to air ratio (mass to mass) ranging from 0.1 to 0.5.

In Fig.3, V1 represents the solids velocity, Mair is the mass flow rate of the air and Vrms the root mean square value of the sensor output voltage. Fig.4 illustrates the instantaneous relationship between the sensor's output and the solids mass flow rate at a constant velocity constant. The rate-of-change of the "solids mass curve" is the mass flow rate.

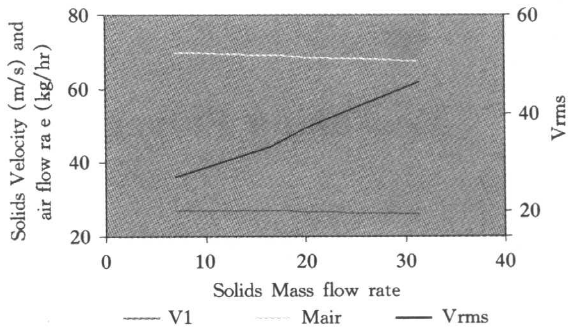

Fig.3 Meter's Output Vs Solids Mass Flow Rate

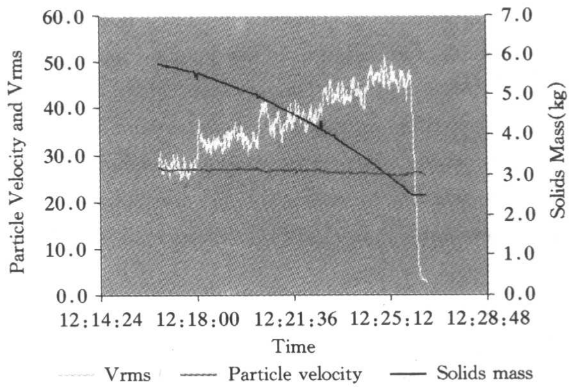

Fig.4 Recorded Signals of Laboratory Test

2. Plant Measurements of Pulverised Fuel Distribution

Optimum fuel combustion requires the correct air/fuel ratio to be applied to each burner and a uniform fuel distribution between burners. However, in practice this might not be the case since uneven fuel delivery to the burners may occur at the conveyor splitting points and the air-to-fuel ratio in conveyors may vary.

Fig.5 shows the measured fuel distribution on a 500MW boiler to each of eight burners fed from a single mill during the mill start up operation. The measurement shows that, while the flow rate at each individual burner progressively increases in response to corresponding increases in the mill feed rate, substantial differences exist in the fuel distribution between the burners. In addition, fluctuations of fuel flow rate in all pipes are obvious. As the mill feed and primary air (PA) fan speed stabilise, the coal flow rates of all eight burners converge, but some differences remained. Ideally, the fuel distribution should be uniformly distributed between the burners under all conditions.

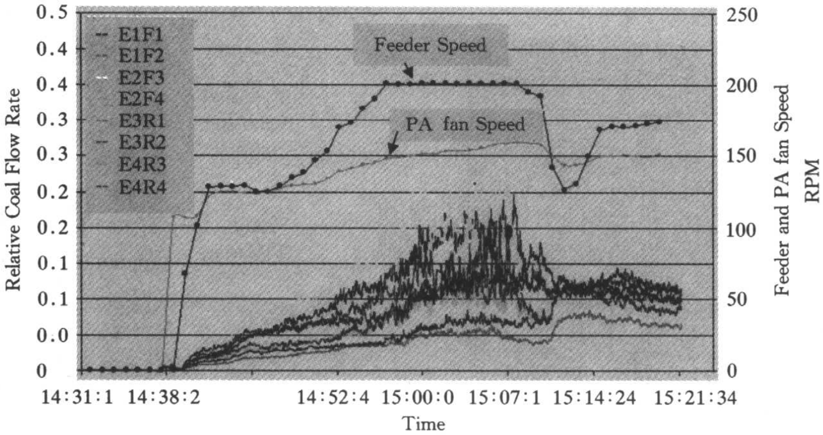

Fig.5 Fuel Distribution to 8 Burners during Mill Start-up Operation on a 500MW boiler

3. Measurements of Pulverised Fuel Velocity

In order to safeguard plant operation, coal flow should be maintained at a velocity above the safe conveying limit to prevent coal particles dropping out of transportation[8]. Conversely, it is also desirable to avoid excessively high coal velocities in a pipeline. High velocity solids are extremely abrasive, causing severe pipe wear and shorten equipment life, resulting in increased maintenance costs and reduced plant availability. It also requires higher auxiliary power to drive the PA fan and forced draft (FD) fan, resulting in unnecessarily high plant operating costs.

The measurement trials show another possibility that may be achievable, which is control of the secondary air by measuring the coal velocity. Fig.6 shows typical flow velocities in the pipelines. The eight measured velocities show significant differences. Since there is a correlation between the particle velocity and the air velocity, the differences imply variations in airflow rates to the burners. It would appear cost effective to integrate the particle velocities to control the secondary air to achieve the correct air-fuel ratio at each burner. In addition, particle velocities measured at the burners can be valuable in providing continuous feedback information for optimising the PA/PF ratio. This is of relevance in locations where accurate primary air measurements are difficult to achieve.

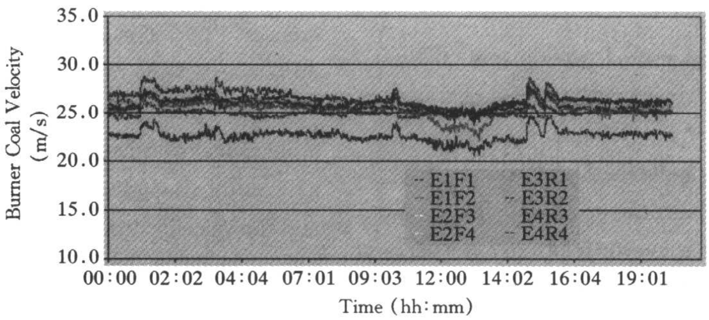

Fig.6 Typical Coal Flow Velocities Measured Using PFMaster meters on a 500MW Boiler

Fig.7 shows the variation in coal flow velocities during a mill shutdown. The increase in velocities just prior to mill shutdown results from "mill purging".

It is clear from the above that installation of PF meters has enabled plant operators to "visualise" the PF transportation in pipelines assisting in diagnosis of plant operation problems, preventing malfunctions and minimising plant downtimes. There are numerous examples of other advantages to be gained.

Fig.8 shows velocities [upper coloured traces] and mass flow rates [lower coloured traces] logged from the feed to a 500MW boiler. The top coloured trace is the sum of the mass flow meter readings, which is very close to the total mill feed input. Naturally there is a delay as the coal is pulverised but these results are very convincing.

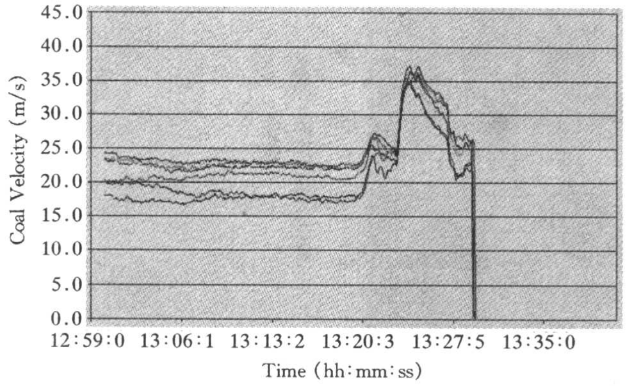

Fig.7 Velocities Measured during a Mill Shutdown Process

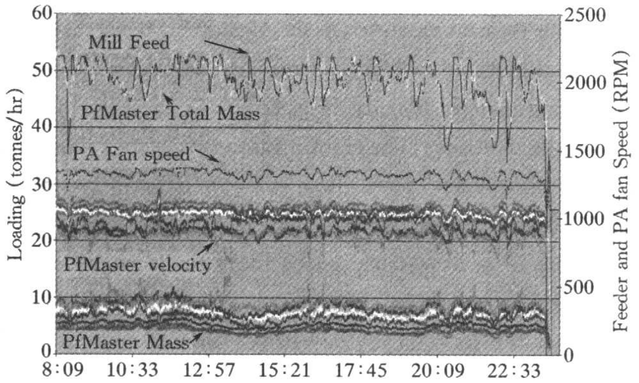

Fig.8 Total mass flow rate indication and Mill Feed rate

4. Laboratory Tests on Control of PF Distribution

UK Government [DTI] sponsored experiments on PF split control were carried out at the Coal Research Laboratories of Casella CRE Energy, Stoke Orchard, Cheltenham, U.K. Low volatile anthracitic pulverised coal was used as the conveyed material. The "vertical upwards" flow was supplied from a 63mm diameter conveyor fed from a hopper. Output from each of the 40mm conveyors was fed into separate hoppers each fitted with a load cell so that the mass flow rate in each conveyor could be measured. The split value was controlled using a modified butterfly valve in one of the conveyors. Relative mass flow rate signals were obtained from two ABB PFMaster electrostatic meters and the split was calculated by the PC and fed to the controller, whose output was used to actuate the butterfly valve, thus altering the restriction to the flow. The aim was to equalise the split to ±0% after unbalanced split was introduced by the diverter at ±x%. The solids concentration range used was typical of that used in power generation applications.

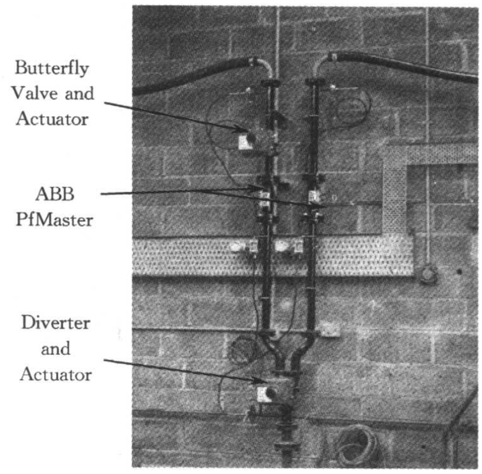

Fig.9 Split Control Test Rig

The project[9,10] was intended as a prelude to larger-scale control of pulverised fuel split on power plant. This paper demonstrates the simplest laboratory version that, on a full-scale plant, finds its equivalent in the form of control of a flow damper.

5. Control Results

Many experiments were undertaken showing variations in velocity and split for different solids loadings and different values of initial percentage split. One example with an initial split of ± 10% with a set-point split of ± 0% is given in Fig.10, but a more detailed description can be found in references[9,10]. The initial split experiments extended to ± 30% over a wide range of solids loadings. In each case balance was achieved. The system was tested over the full operating range of the test rig at velocities from 15m/s to 30m/s. Control was possible over the full range of solids loading and the velocities could also be maintained to ensure safe conveying conditions.

6. Conclusions

PF measurement trials conducted on full-scale power plant have clearly demonstrated that immediate and significant improvements to the generating plant can be achieved. Use of these on-line measuring instruments in conjunction with PF control devices allow burners to constantly operate at their optimum design value. There is no intrusion into the pipe so that no wear to the meters has been detected on units