PFMASTER-MASS FLOW AND VELOCITY

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GREENBANK ENERGY SOLUTIONS INC.

-POWER APPLICATIONS-

- **On-line measurement of pulverized-fuel (pf) distribution (pf split), velocity and mass flow-rate**
  - Improved burner and boiler stoichiometry
- **Measurement across total cross-section**
- **Non-intrusive, passive system**
  - Extremely low wear rate
- **Virtually unaffected by pf roping or 'practical' pf distributions**
  - Superior to probe devices
- **Inherent precision and calibration at manufacture**
  - Unaffected by changes in coal type and moisture content
- **Simpler commissioning with no on-site calibration required**
  - Factory calibrated from traceable standards
- **Very low maintenance**
  - Visual inspection required only during major outage
- **Safe, non-hazardous operation**
  - Designed to EExia intrinsic safety.
- **CE and Pressure Equipment Directive**
  - **Approved to 24 bar.**
- **Modular scaleable system**
  – facilitates expansion

Pulverised Fuel Meter for coal-fired power stations improves combustion efficiency and reduces emissions

ABB Instrumentation alliance

General Applications

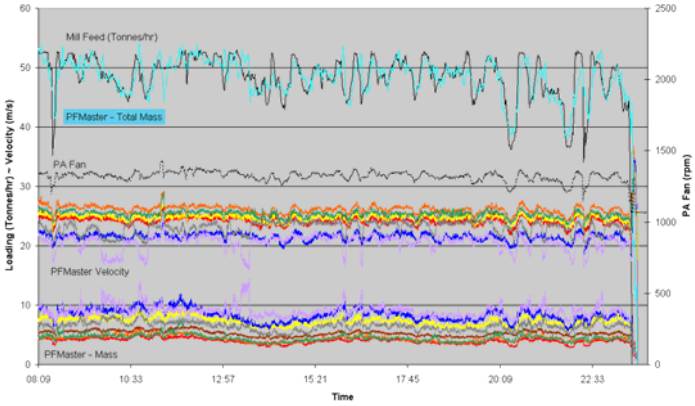
The ABB PfMaster system is for use on pulverised-coal feeds into boilers. A single processor can measure up to sixteen pulverized-fuel (pf) burner feeds from a single mill, and up to 24 PF coal pipes by removing the temperature measurement. Multi processors can be stacked to monitor the entire boiler.

Poor distribution of pf causes combustion inefficiency and also environmental issues.

Continuous on-line measurement enables performance monitoring and the possible application of a control system to maintain optimum furnace performance, such as :

- Individual secondary air control for burners to match coal flow to each burner, a reactive control measure.
- Mills that have multiple coal pipes exiting the classifier can use control valves to balance the fuel distribution.
- Application data has shown that reducing the Mill Primary Air for a given load can improve both classification and distribution. The PfMaster velocity information can be used for real-time trimming of mill air.

Greenbank Energy and ABB Instrumentation can offer advice on the benefits given your mill plant and burner configuration.



Graph above shows PfMaster sum of all burner flow rates from 1 mill vs. drag chain feeder speed.

Introduction—On-line vs. Sampling

Coal-flow transport behaviour and distribution to boiler burners has, up until now, proved difficult to meter. The dynamics of the coal flow are very dependent on factors such as particle size, roping and the physical plant layout..

The common way of checking the condition of the fuel distribution has been to use probe sampling devices. While these do provide a reasonable indication of the flow in a given pipe at a given moment, the time taken to sample up to eight pf feeds across one mill can take several hours, during which the mill conditions have changed and hence the volume of fuel in previously sampled pipes has varied.

The ABB PfMaster is capable of making continuous Rapid measurements of pf flow in all the burner pf feed pipes effectively simultaneously.

Any instabilities in the Mill performance and pf pipe work are instantly evident. Measurements are continuously updated and hence the output signals respond accordingly. The PfMaster is ideal for use within pf flow-control systems.

PfMaster – Sensor Spool Piece

The sensor, being a spool-piece, provides the highest performance in the presence of roping / mal-distribution of pf.

The technology works by sensing the charge conveyed by PF (pulverised fuel), and the distribution calculated by comparing sensors from each mill. Velocity is calculated as the time of flight between 2 of the sensor rings using cross-correlation.

Having a spool piece allows the measurement to be integrated around the whole circumference so that the effect of variable coal location in the pipe is overcome.

The sensor body is constructed from carbon steel and the sensor electrodes from stainless steel. The sensor is available in sizes DN15 to DN600 and in Victualic, Viking Johnson (VJ), Flange or Wafer mounting configurations.

<u>The benefits of spool piece vs. probe type sensors :</u>

- Wear of any intrusion into a PF pipe is a function of the coal type and its velocity. The PfMaster is non-intrusive, and the oldest installation has shown no measurable signs of wear over more than 5 years of operation.
- Greenbank can guarantee a minimum life of sensor spool pieces. All sensors are factory calibrated before shipping with certificate of conformity (no site calibration required).
- Excellent availability—no PfMaster system has ever failed or suffered down-time and required maintenance.
- The PfMaster meets the new EU pressure equipment regulations legally required for pulverised fuel systems.

Pressure Equipment Regulations 1999
Certificate of Conformity- EC Unit Verification
Form PER G

CERTIFICATE REFERENCE: SS42071811/1

MANUFACTURER NAME	ABB Instrumentation Ltd
ADDRESS	Oldends Lane, Stonehouse, Glos GL10 3TA
MANUFACTURER REFERENCE	V/28594 (Mr Charlie Jones)

EQUIPMENT DESCRIPTION	Pulverised Fuel Meter
CONSTRUCTION CODE	PD5500:2000 CAT 2
SERIAL NUMBER	V/28594/1/1 – V28594/1/8
DRAWING NUMBER(S)	SCX0321 issue 3, SCX0322 issue 4, SCX0327 issue 1 and SCX0328 issue 3
DESIGN PARAMETERS	16 bar / 0–160 °C
PRESSURE TEST DETAILS	24 bar 15 min ambient water on 6 Feb 2003

This is to certify that the pressure equipment identified above was subjected to EC unit Verification, including examination during and upon completion of manufacture, as required by the code of construction and inspection specification, and was found to meet with the provisions of the Pressure Equipment Regulations, subject to any conditions of use specified below.

Zurich Risk Services
Authorised Signatory

Notified Body No 0037
Date: 24 Feb 2003

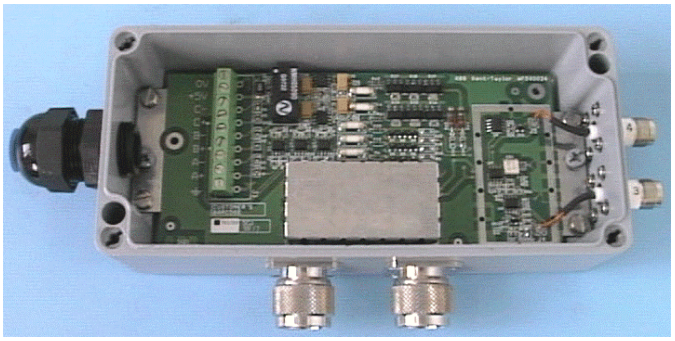
- The non-intrusive design is such that the instrument is uneffected by pressure excursions from the mill. At a UK plant such a pressure wave instantly snapped off all the competitor probe type sensors from a mill.

Sensor Electronics

Sensor connection to the signal-processing computer is by a single low-voltage multi-core cable, the design of which has been optimised to provide the highest rejection of possible interference signals generated on the plant.

Another feature of the sensor electronics is the incorporation, as standard, of barrier circuits to prevent any possibility, under fault conditions, of hazardous voltages igniting the explosive atmosphere present in the pipe-bore.

Signal-sensing utilizes the detection of electrostatic energy, which is naturally present on the pf particles. This passive sensing therefore eliminates any dangers which might be present with systems based on ionising radiation that put energy into the pipe, such as microwave techniques.



The sensor electronics enclosure is rated to IP65/NEMA 4, –20 to 70C and designed to EEx ib e (CENELEC & FM) hazardous environment safety standards.

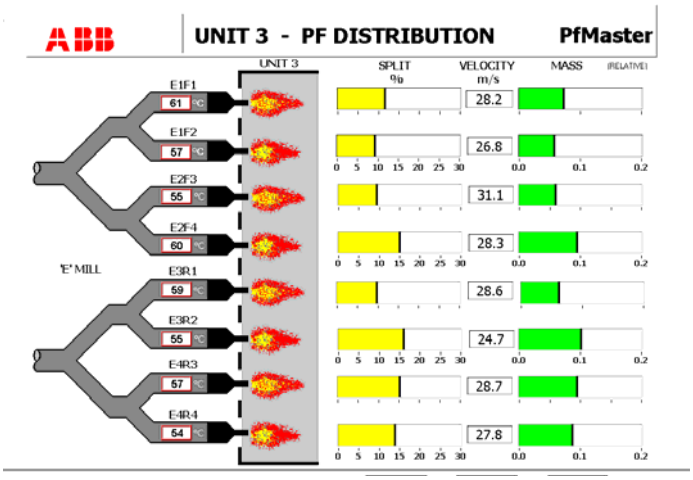
However, the main benefit to the user of sensor electronics other than safety are:

- The low strength static signal is amplified and allows low loss transmission over longer distances.
- The differential amplifier virtually eliminates noise pick-up which is necessary for rapid measurement and control.
- Competitor systems without such processing have to use rolling averages for measurement data and are not good at reactive control. PF master has a unique non-smoothed instantly reactive measurement of only a few seconds, ideal for any control purpose. (see trend bottom of page).

PfMaster – Signal Processor and Display

At the heart of the system is the signal processor which can handle up to 24 sensors and is shown on the front cover. The standard cabinet is IP65 in design.

Output options are either 4-20 mA current outputs, or rapid serial communications such as DH+ or Fast Ethernet OPC.



A number of 'Function' keys at the foot of the display allow the user to switch between other facilities which include:

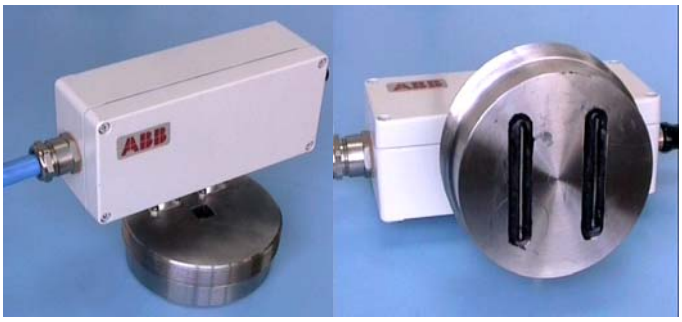
Set-up in which the ranging and output control is set

Trend shows the system's measured value over the past 60 minutes

Log sets the file and logging interval for the internal data-logging facility

Cal contains system calibration parameters which are accessible only through password controlled entry.

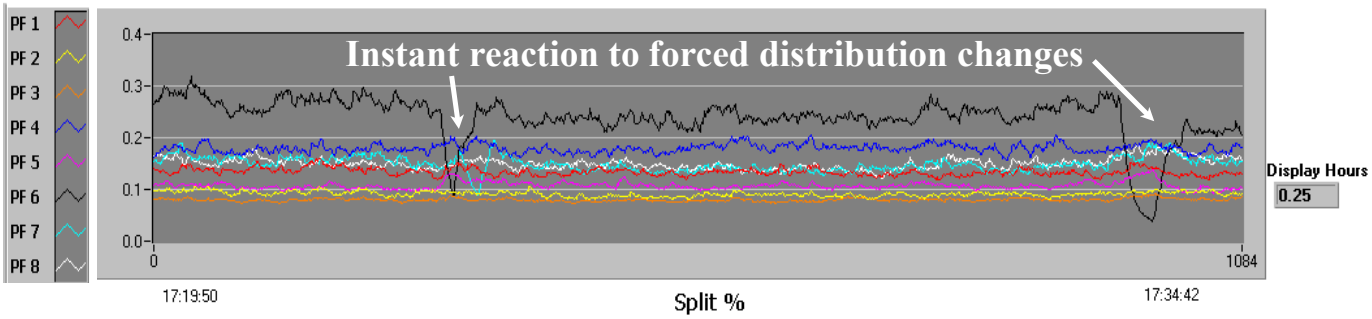
On-Line Velocity Meters



The Latest Low NOx burner designs have been designed for very low PF velocities, some as low as 16 m/s for optimum combustion. It is also well understood that mill classification is improved both on Dynamic and Static Classifiers with reduced PF velocity through the mill.

The On-Line Velocity Meter works on the same principle as the PfMaster, non-intrusive with the same quality sensor electronics & cabinet. The design fits via 4 inch BSP, and it determines velocity from the time of flight of material past its 2 electrodes via cross-correlation techniques of the two signals.

Use the cost effective On-Line Velocity Meter on mill outlet pipes in a control system to minimise primary air through the mill for better classification, distribution and burner combustion.



PFMASTER—MASS FLOW AND VELOCITY MEASUREMENT OF PULVERISED FUEL

GREENBANK ENERGY SOLUTIONS INC.
-POWER APPLICATIONS-

Typical Specification

PfMaster Sensor Spool.....

Size:
Up to 28 NB

Spool Piece:
Carbon steel – Compact, un-flanged

Mounting:
VJFA or sandwiched between flanges

Process Temperature:
-4°F to 320°F

Pressure Rating:
16 bar

Environmental:
IP65 / NEMA 4X

Measurements:
Absolute PF velocity
Burner PF split
Relative PF loading (concentration)
Mass flow rate – computed for each line from split and external total mass input (mill feed rate or similar)

PfMaster velocity sensor.....

As spool piece except :

Size:
100 mm / 4 inch

Mounting:
BSP thread

Measurements
Absolute PF velocity

Sensor Electronics.....

Supply:
5V, powered from signal processor

Ambient:
-4°F to 158°F

Environmental:
IP65 / NEMA 4X

Cabling:
Single multi-core screened cable
Standard sensor distance up to 200m, up-rated amplifier for longer distances.

Approvals:
Designed to EEx ia e (CENELEC & FM)
Zone 0 inside pipe
Zone 1 outside pipe (Approval pending)
EU Pressure Equipment Regulations

Signal Processor.....

Display:
SVGA integral monitor

Sensor Input Channels:
Up to 24 channel processor per cabinet system

Velocity range:
0.3 to 60 m/s

Optional Analogue Outputs 4-20 mA :
Fully programmable for velocity, split & concentration
Alarms programmable high/low points for velocity & split.

Optional Serial Data Communications
OPC Fast Ethernet
Data Highway plus

System Response Time:
<3.0s – suitable for continuous on-line PF flow control

Logging:
Velocity, split, concentration & optional temperature

File format – Comma delimited (.csv)*

Temperature:
50°F to 140°F

Control Cabinet Environmental:
IP54

Power:
<400VA
110/230V a.c. 47 to 63Hz