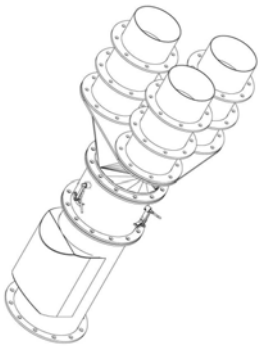
GREENBANK
Enhancing Performance

Coal Flow Measurement, Balancing, and Boiler Optimization.



One of the most significant causes of carbon-in-ash (LOI or un-burnt coal) and Nitrous Oxide emissions (NOx) into the atmosphere is the imbalance and delivery of the pulverised fuel (PF) delivered to the boiler through the burners particularly on a front (and rear) walled boilers.

A burner which has too high PF to air ratio contributes to carbon-in-ash. A burner which has too low a PF to air ratio contributes to NOx. Further, a burner which delivers PF at too high a velocity, not only causes increased erosion in the PF system and high carbon-in-ash levels but can cause detachment of the flame within the boiler. PF which is delivered at a velocity too low can cause fall out of the PF particulate and create dangerous pipe blockages and the possibility of a flash back from the boiler which can, in turn, create an explosion.

Effective control, balancing and monitoring of PF distribution provides:

- **Correct air to fuel ratio at burners**
- **Minimum but safe transport velocity**
- **Reduction in Mercury emissions**
- **Improved particulate fineness**
- **Improved burn and stoichiometric conditions**
- **Elimination of flame detachments**
- **Reduction in PF system erosion**
- **Reduction in carbon-in-ash**
- **Reduction in PF system pressure drop**
- **Saving volume and pressure of primary transport air.**

Greenbank has identified the need to assist both boiler designers and plant engineers to monitor and improve the distribution of coal to the burners and we also have, along with industrial partners ABB Instrumentation developed innovative technologies which give power plant engineers the ability to optimize the performance of their boilers.

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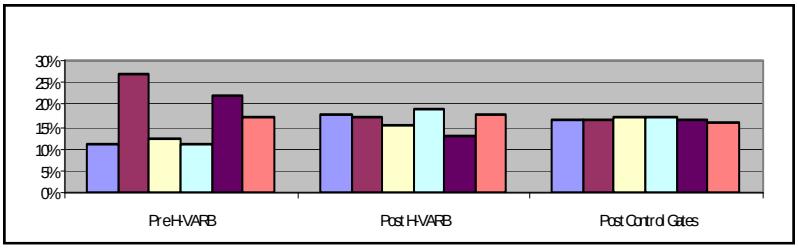
Optimizing PF Distribution and Velocity

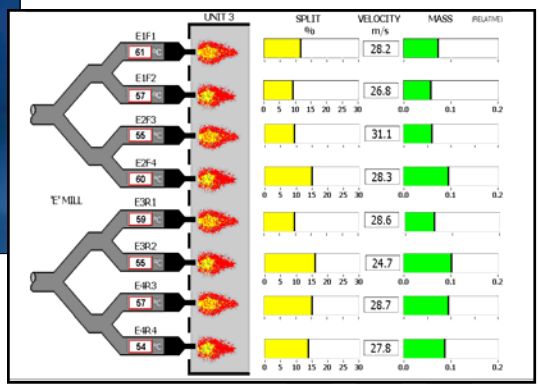
The VARB Family of PF Diffusers are designed to break the PF 'roping' effect created by elbows in the PF pipelines. PF elbows classify the content of the pipes sending the larger particles with higher momentum to the extrados of the pipe.

These concentrated areas of coal travel through the pipeline and create high levels of erosion and premature failure of pipes. Where the pipeline has splitters, the 'roping' of PF within the pipe cannot be evenly distributed unless a VARB is installed prior to the splitter.

Not only does the VARB ensure even mass flow distribution of PF down each splitter outlet, its mixing effect also ensures the PF particle size distribution is also consistent down each pipe leg.



The chart indicates PF distribution at 6 burners where 2 x 3-way splitters were installed in 2 pipelines running from a classifier. The improvement in distribution after fitting a Horizontal VARB then trimming the Control-Gates can clearly be seen



The PfMaster Coal Flow On-Line Monitoring System

The PfMaster System rapidly and accurately measures the concentration (or relative distribution) and the velocity of Pulverised fuel being delivered to each burner.

This percentage concentration measurement can be used to ensure the correct air to fuel ratio is being delivered to the burners. In conjunction with a Gravimetric Feeder, the system is able to report accurately the mass flow or TPH of coal being delivered down each pipeline.

The velocity measurement can be used to trim or adjust the rate of primary air and as such help assist in accurately controlling the delivery speed of PF to the burners.

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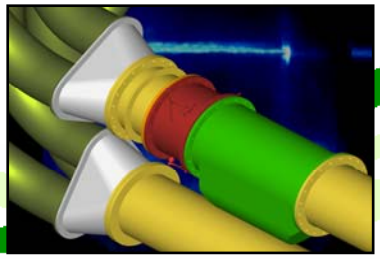
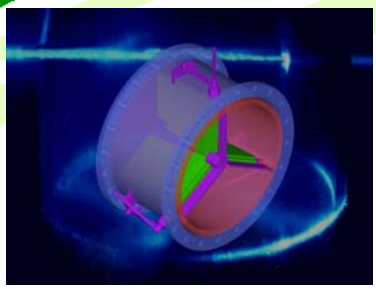
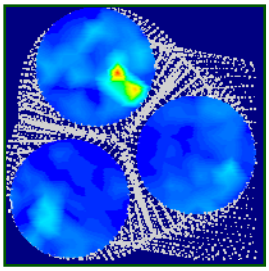
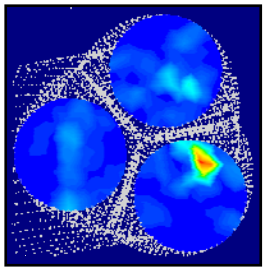
Optimizing PF Distribution and Velocity







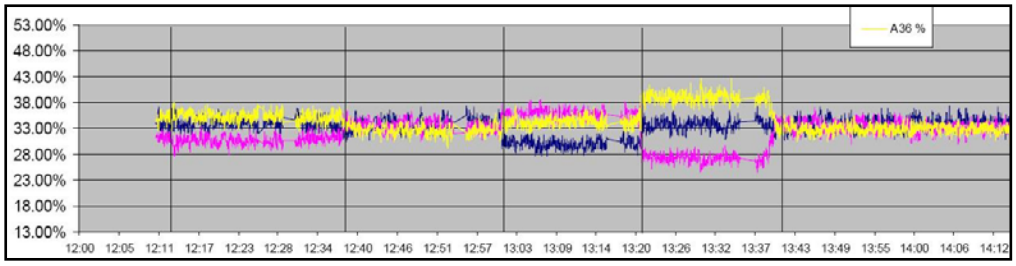


Control-Gate™ PF Trimming Technology

The Control Gate Technology developed by Greenbank fits between the outlet downstream of the VARB and the inlet to the splitter and is designed to fine tune and balance the PF flow down each splitter leg.

The device is cleverly designed, and as such the internal PF diverter vanes are intended only to capture PF. This means the trimming or balancing of PF down each splitter leg will not affect the air to fuel ratio of fuel being delivered to the burners.

Trimming of the control gates can be seen on the chart below. Using the PfMaster on-line monitoring system, by altering the diverter vanes the PF can be trimmed and balanced down a 3-way splitter to an ideal 33.33% split in PF distribution.



The G-CAM Carbon-in-Ash Monitor

The G-CAM uses the latest microwave technology, a combination of microwave power absorbed, microwave phase shift in degrees and change in resonant frequency of the cavity Q for highest possible accuracy. It measures at multiple locations (up to 4) across the exit of the economizer before the air heater using 1 x G-CAM cabinet.

The System has been proven to offer continuous fully automatic operation with many techniques employed to be maintenance free with yearly service intervals.

G-CAM measures the whole volume of large amounts of ash collected, with 15 g samples collected and measured in typically 5 minutes. The system is fully automatic, and can automatically divert numerous G-CAM measured ash samples into a large sample collection bin for laboratory analysis of ash quality.

Accuracy better than +/- 0.5 % carbon-in-ash for measurement range 0-5 % Carbon, +/- 0.6 % carbon for 6-10 % carbon.

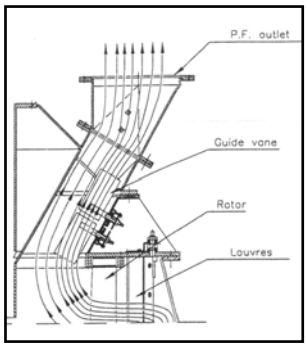
G-Cam (Retrofit Shown)
Carbon-in-Ash

The Benefits of Good PF Distribution and Velocity Control

Improved fineness of coal allows for complete combustion of the coal particles given sufficient oxygen. Completing combustion of all coal gives a higher combustion efficiency.

Incomplete combustion results in a residual carbon-in-ash or commonly called LOI (Loss on Ignition). LOI is a simple method of determining how much carbon is left when the ash is burnt in a laboratory.

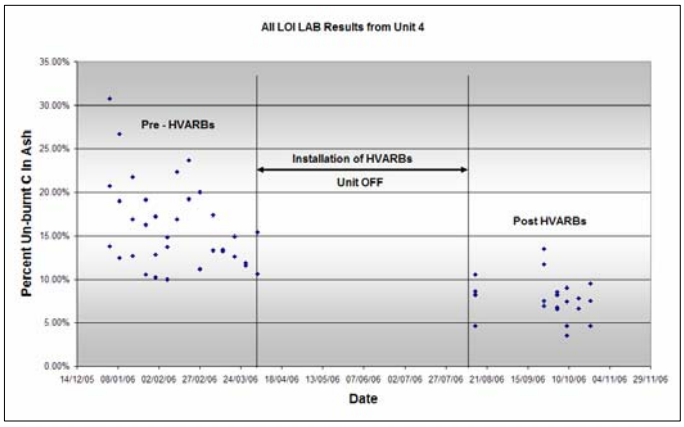
Hence, LOI or un-burnt carbon is key to the direct measurement of the combustion efficiency for a given coal. Keep in mind variations in coal source have differing properties (fixed carbon in the coal, heating value and volatiles) and ash levels.



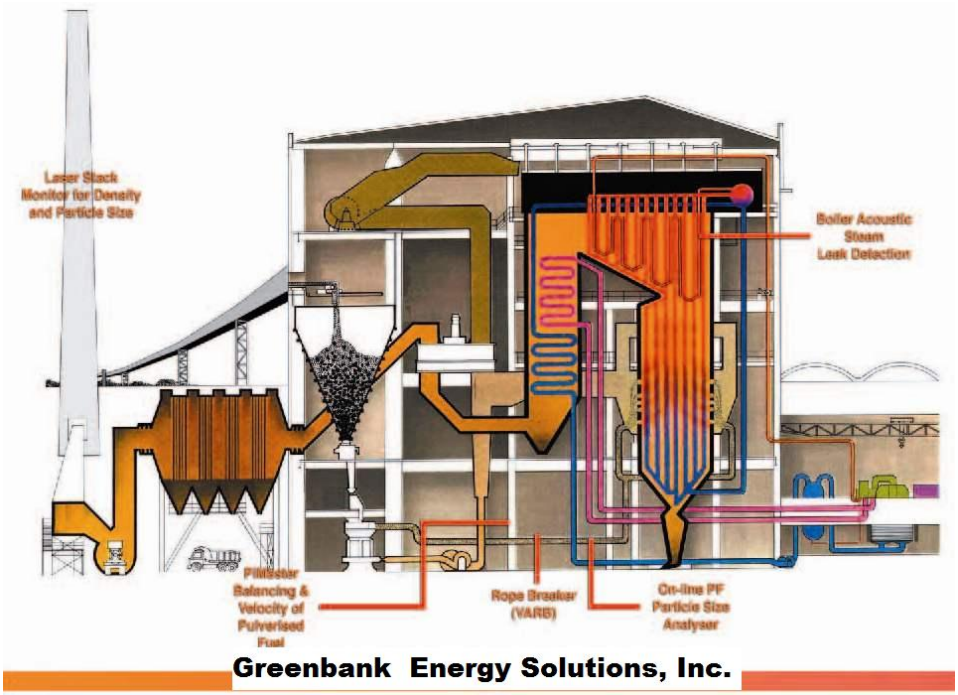
Balancing of PF Distribution on a Multi-Outlet Classifier

The benefits of good PF monitoring, distribution and control can be found in many ways. Correct utilization of the equipment supplied by Greenbank has achieved:

- PF distribution: Improved at splitters from in excess of +/-20% to under +/-3% (PfMaster and VARB)
- Fineness: Up to 7% improvement passing 75µ (using PfMaster velocity info)



Greenbank Range of Boiler Technology And Capabilities



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