G-CAM

Greenbank Energy Solutions Inc., 185 Plumpton Ave. Washington PA 15301
Tel (724) 229-1180 / Fax (724) 229-1185
Web Page: www.greenbankenergy.com

GREENBANK ENERGY SOLUTIONS INC.

CARBON IN FLY ASH MONITOR

Why measure carbon-in-ash online ?

Residual carbon in ash is the percentage of un-burnt carbon left in the ash when burning coal, and is a good measure of the efficiency in combusting the coal particles in the furnace. Reducing carbon level by 1 % absolute can typically generate savings of 1 million Dollar per year for a large boiler.

Additionally, residual carbon-in-ash is also one of the key measures of the quality of the ash for sale to the cement industry.

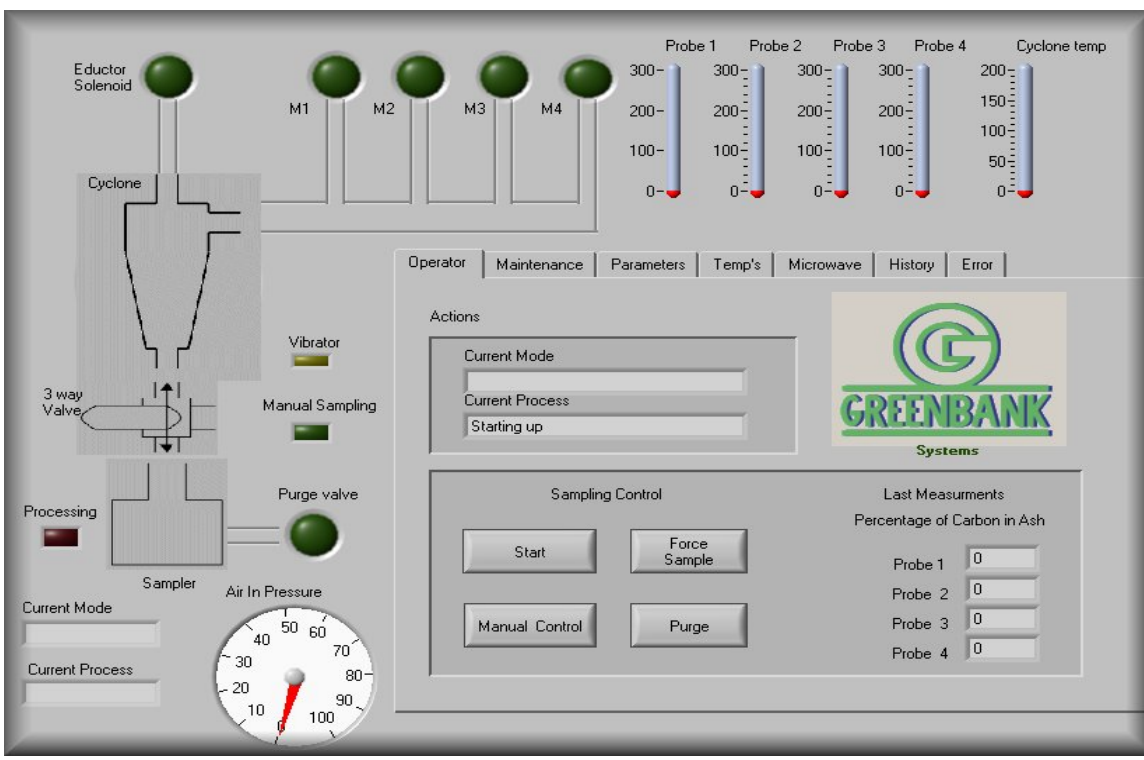
Un-burnt carbon particles are a function of an incomplete combustion process, and can be due to a number of reasons :-

- Incorrect coal to air ratio at fuel rich burners due to poor coal distribution to the burners.
- Large size particles and velocity through the burner flame
- When staging the combustion using over fire air some carbon does not complete combustion.

Stations moving to low NOx burners or implementation of over fire air at the top of the furnace in a program to reduce emissions usually experience increases in carbon levels in the ash due to a combination of the above factors.

Studies have shown that the main effect on carbon for wall fired boilers is typically coal distribution, as the relative increase in un-burnt carbon increases exponentially with lack of air at a few fuel rich burners.

The ability to quickly and accurately measure the un-burnt carbon in the furnace allows operators to identify poor mill settings or combinations, or improve combustion settings for a particular coal or load requirement.



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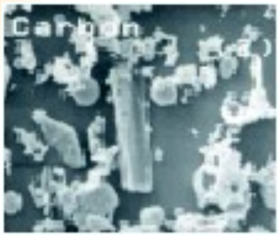
How to measure carbon-in-ash and benefits of using microwave



Carbon seen in flyash

All techniques that determine carbon-in-ash properly require a measurement of the carbon level for a known fixed amount of ash to give the percentage accurately. The amount of ash produced by different coals varies greatly with coal type and quality, with some coals producing over three times as much ash as others on the same boiler.

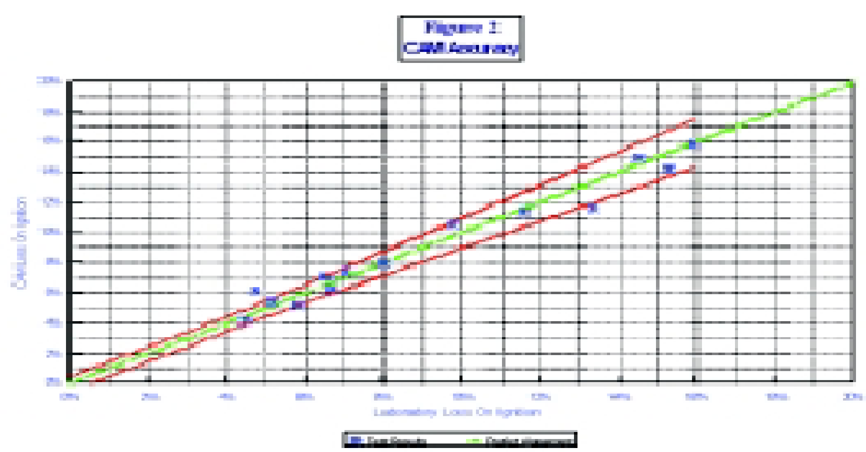
Hence, it is a common mistake to determine the amount of carbon in a flue gas for a given boiler load without simultaneously knowing the amount of ash in the same volume, and such an approach is only use as a trend which would shift calibration with coal property changes.


G-CAM Analyzer Cabinet

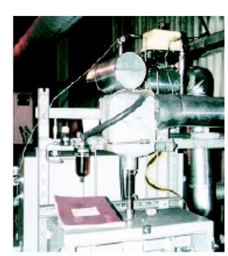
Laboratory methods take an ash sample, and then burn it to measure the loss in weight, which is due to completing the combustion of the carbon to CO_2. Other elements which can still be burnt-off from the sample are also included in this weight loss which is always higher than true carbon level. A more accurate lab method is to determine the volume of CO_2. Repeating this combustion process automatically in an on-line instrument is prone to reliability issues.

Microwave of a few milli-Watts can be used which is highly affected by the dielectric properties of carbon and not the ash. Microwave is unaffected by the color or shading of the ash that can change with coal type, which plagued early optical techniques.

Microwave also passes through the whole volume of the ash being measured, which is a benefit over other old technologies which only looked at a small portion of the surface even if that sample itself was large in volume. Not all microwave techniques are equal in performance, and the precision is determined by the method employed and microwave component design.



G– CAM Calibration curve



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More about the microwave technology

The measurement utilize a high tolerance wave guide and latest solid state microwave electronics allowing for precise measurement of microwave attenuation, phase shift and change in wave guide cavity resonant frequency to determine carbon in ash as accurately as possible. Phase shift is a measurement of the slow down of the microwave passing through the volume of ash, and determination of resonant frequency requires use of measurements at multiple microwave frequencies.

Where to collect the ash sample ?

For combustion, collecting the ash after the economizer at multiple points allows for an understanding of the difference in combustion between the A and B sides of the boiler. Many boilers typically have an imbalance between the two sides, and this corresponds well with typical O2 and CO measurements which are normally split for the same reasons.

It is important that these samples offer a good representation of the combustion ash from the whole boiler, and as such 2 sample locations per boiler side or 4 in total is a good traverse of the boiler giving a picture of combustion across the boiler.

It is not just the number of sampling locations that is important, samples must be taken in a timely manner and with sufficient ash. For a small boiler only 2 sample locations are recommended, a medium size typically 500 MW up to 4 sample locations, and larger boilers over 600 MW can have 6 to 8 sample locations using 2 G-CAM instruments.

Ash can also be collected or sampled from the precipitator hoppers. The differences in carbon levels when moving between hoppers is not consistent, and varies with coal type, combustion and precipitator performance. Larger carbon particles typically fall in to the first row of hoppers due to gravity, but there is variability in electrostatic properties of different ashes compensated by sulphur injection. In addition, smaller carbon particles in particular are prone to an effect referred to as ‘carbon bounce through’, where high carbon levels can be seen in later rows in the precipitator. Taking ash measurements after the economizer is not effected by precipitator performance variations.

G-CAM key features for combustion control

- Measures at multiple locations (up to 4) across the exit of the economizer before the air heater using 1 G-CAM cabinet. Large boilers > 600 MW can use 2 G-CAM systems.

- Many boilers typically have combustion differences between that A and B sides of the boiler outlet, and G-CAM allows operators to identify combustion imbalances which are usually more prevalent in wall fired designs.

- 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 amount of ash collected, with 15 g samples collected and measured in typically 5 minutes. This is around 5 kg per day depending on boiler load and coal type. Each Probe samples using a 1.25 inch (~32 mm) probe internal diameter.

- 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. Range to very high carbon levels and coal type independent.

- Latest microwave technology, uses combination of microwave power absorbed, microwave phase shift in degrees and change in resonant frequency of the cavity Q for highest possible accuracy.

- High availability, designed requiring only yearly servicing and no scheduled maintenance requirements or attention needed by plant engineers.

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Carbon in Fly Ash Monitor

G-CAM Specifications

Measurement Performance

Accuracy :	+/- 0.5 % for range 0-5 % Carbon, +/- 0.6 % carbon for 6-10 % carbon
Carbon in ash Range :	Up to 50 % carbon
Ash Measurement :	Microwave absorption, phase shift and resonant frequency Q
Outputs to plant :	Four of 4-20 mA current outputs for % carbon per probe Ethernet OPC - Carbon in ash, Probe temperature and Ash loading.
Connectivity :	OPC Ethernet to plant and removable storage media compact flash

Sampling performance

Sample probes :	Each Probe 1.25 inch (~32 mm) probe ID, 316 stainless steel
Sample representivity :	Up to 4 sample probes per G-CAM across economizer . Large boilers > 600 MW recommend 6 - 8 sample locations
Sampling rate :	Approx 15 g sample in 5 minutes, and up to 5 kg per day fully analyzed per cabinet. Depends on Boiler load & coal type.
Probes to G-CAM :	Up to 30 meters, self cleaning intelligent ash handling system
Control valves :	High temperature stainless steel ball valves with 24 VDC actuators.
Sample lines :	Heat traced, typically 15 amps at 110 VAC.
Sample collection :	Option for samples to be automatically collected in sample bin

G-CAM cabinet details

Enclosure dimensions ;	W1105 x H1215 x D405 mm, 2 mm sheet steel rugged design.
Environmental ;	Floor or wall mount with cabinet cooling, 0 - 50 deg C, 95 % RH
Display :	IP 65 industrial color touch screen on door
Power requirement :	110 VAC at 15 amps with low voltage 24 VDC controls
Air requirement :	Compressed air supply 60 – 100 psi, minimum ¾ inch pipe. System includes water, oil and particulate filters to 1 micron.
Control system :	National instruments PLC industrial controller

Operation and Maintenance

Servicing requirement :	Designed for 12 months Continuous operation, No weekly or monthly maintenance requirements.
Consumables and spares :	Spares for 4 years operation recommended.
Availability :	Better than 98 %.

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