Online and in real-time

ABB’s carbon-in-ash instrument is a measurement system designed to perform online analysis of the unburned carbon content in boiler fly ash. Unlike other instruments currently on the market that provide only intermittent results, sometimes taking up to 12 minutes, ABB’s CIA instrument delivers continuous “true” real-time feedback to the boiler control system for closed loop control strategies, improving combustion efficiencies within power plants.

Its unique patented non-extractive monitoring system incorporates advanced microwave technology for reliable and accurate measurement of unburned carbon in boiler fly ash. In addition, the ABB carbon-in-ash instrument measures the quality (%) and the quantity (g/m³) of the ash produced in a power generation facility. Good quality ash may be sold as a profitable by-product to the construction industry, instead of having to pay for its disposal in costly landfills.

The instrument is designed for easy installation and minimal maintenance. Other benefits include:
- patented non-extractive online measurement technology
- highly accurate measurements in real-time
- in-situ measurement methodology
- potential reduction of unburned carbon-in-ash by 1-5 % when integrated into a boiler control system
Theory of operation

Fly ash is the combination of inert and inorganic residues resulting from the combustion of pulverized coal, which contains a varying of carbon or coke particles. Their presence in the fly ash is a measure of inefficient fuel utilization, which means that more fuel must be burned in order to obtain a desired plant load. Carbon absorbs microwave radiation; other elements in the fly ash do not. By repeatedly reflecting microwave signals numerous times within the boiler back-pass between parabolic mirrors, the amount of unburned carbon in the fly ash can be accurately measured.

During the measurement process, the carrier frequency of the transmitted signal is varied across a 100-MHz range. Whenever a resonance is encountered, a peak occurs. The amplitude of the peak resonance decreases in proportion to the amount of carbon in the back-pass. From the peak amplitude, ABB’s carbon-in-ash instrument calculates carbon in grams per cubic meter, utilizing a separate set of electro-dynamic dust probes to measure the fly ash loading.

Competing methods for measurement of unburned carbon in boiler fly ash are deficient in several regards:
- they are mostly extractive. A specified quantity of fly ash must be captured in order to analyze its carbon content. Mechanical extraction systems require constant surveillance and increase maintenance costs.
- they are typically representative of only one location within the flue gas stream or hopper silos. Only multiple sensors, averaged together can come close to the true level of unburned carbon-in-ash. Multiple sensors and their corresponding control units increase cost.
- they require the expense associated with employing additional analytical equipment.
- they are largely ineffective as a means of optimizing fuel utilization or controlling NOx emissions in real time, because of long delay times in measurement and intermittency of the reporting.

Main system components

Hardware:
- Microwave transmitter and receiver
- Control cubicle
- Dust probes
- Slide gate and transition assembly

Software:
- Carbon-in-ash engineering tools
The main component of the carbon-in-ash instrument is a 94-GHz microwave assembly with slightly parabolic “mirrors.” The sender and receiver mirrors create a resonant microwave cavity across the furnace back-pass or economizer ductwork. Total ash loading is determined by “dust probes”. A stand-alone data acquisition board (DAS) receives the carbon and ash signals, from which the percentage of carbon in the ash is calculated and transmitted to the control or combustion optimization system.

**Services**
- Kick-off site investigation
- Site visit during installation
- 1 week start-up support/training
- Follow-up site visits as necessary

**Applicable boiler types**

ABB’s carbon-in-ash instrument is designed for all balanced-draft non-pressurized boilers. Boilers with higher pressure levels in the back-pass just after the economizer are not suited for the carbon-in-ash instrument at this point in time.

**Unobstructed line of site between mirrors**
A direct line of sight in the boiler back-pass, after the economizer is required between the two microwave mirrors, which must be at the same height and at least 30 feet (10 meters) and no more than 80 feet (24 meters) apart from one another. This back-pass width requirement covers 95% of all utility boilers widths in the power generation market.

**Access portals for microwave mirrors**
Two entry points located on opposing sides of the boiler back-pass after the economizer are required for mounting the microwave receiver and sender, and two more are required for the dust probes. The two microwave access points require an opening of 24 inches (61 cm) in diameter for the microwave unit and a smaller opening 1.5 inches (4 cm) in diameter for the dust probe.

**Connectivity**

<table>
<thead>
<tr>
<th>Connectivity</th>
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<tbody>
<tr>
<td>Carbon density</td>
<td>4 - 20 mA passive loop</td>
</tr>
<tr>
<td>Ash density</td>
<td>4 - 20 mA passive loop</td>
</tr>
<tr>
<td>% carbon in ash</td>
<td>4 - 20 mA passive loop</td>
</tr>
<tr>
<td>Modbus</td>
<td>RS - 485 serial link</td>
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</tbody>
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**ABB’s carbon-in-ash instrument advantages**

- Integral part of a complete boiler management system: ABB, the world leader in distributed control systems for power plants, can offer its CIA instrument integrated seamlessly into ABB advanced combustion control and optimization solutions, including ABB flame scanner systems or into 3rd party control systems.
- In-situ: measures carbon passing through a 24-inch (61 cm) diameter cylinder across the entire width of boiler back-pass providing the most representative measurement of unburned carbon in ash
- Real-time sampling: 1 every second
- Low maintenance: simple design can be maintained with furnace cold or in service
- Automatic mirror alignment
- Accuracy: 1% absolute across duct width
- System cost: instrument cost, installation, low annual maintenance
- Coal-type independent

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