Advanced Energy

Application Note

MEASUREMENT OF FURNACE EXIT-GAS TEMPERATURE (FEGT)

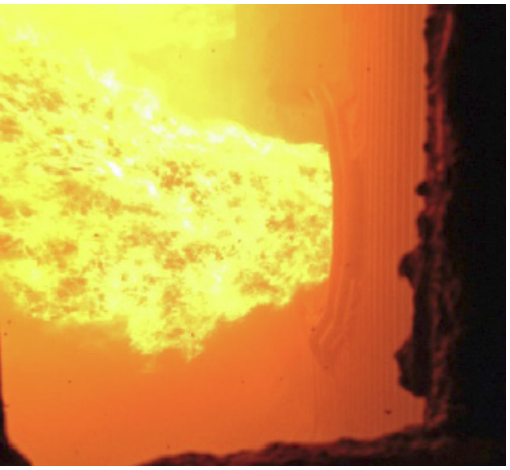


Figure 1: Burner flame in a coal fired power plant

The Opportunity

Monitoring the performance of a power boiler can be a challenging task.

One of the primary parameters for monitoring the performance of a power boiler is the furnace exit-gas temperature (FEGT). This measurement provides a direct indication of the heat transfer to the furnace water walls at a particular load condition, and sets expectations for performance of the superheat and re-heat processes.

Figure 2: Slag on tubes

If the FEGT is too high, residual fly ash will fuse to the pendants and tubes forming slag (Figure 2), reducing the heat exchange efficiency to the tube walls. This can lead to increased soot blowing operations, tube corrosion, reduced load operation, and possible safety issues.

A low FEGT value may indicate excessive radiative losses to the water walls or an incomplete combustion process resulting in lost efficiency. Fuel quality, excess air, burner selection and tilt, low NO_x operation, and heat transfer issues all affect the exit-gas temperature. By monitoring the FEGT, operators can balance and optimize their combustion process and safeguard the boiler furnace.

Various techniques such as acoustical detection, thermocouples, and thermal modeling have been utilized to obtain the exit-gas temperature.

- Acoustical detection systems are expensive to install and their accuracy can be affected by the noise of sootblower operations.
- Contact thermocouples need to be located near the top of the furnace where the gas stream vibrations may result in mechanical stress, limiting their lifetime. In addition, thermocouples have a limited reach and measure only a small point, making them sensitive to local variations.
- Theoretical thermal modeling (Figure 3) is generally based on extrapolation from the flue gas temperature at the exit of the furnace, tube, water and steam temperatures, and the temperature of the burners in the lower furnace. This technique does not provide a direct measurement of the FEGT and has the potential accumulation of multiple errors during the extrapolation process.

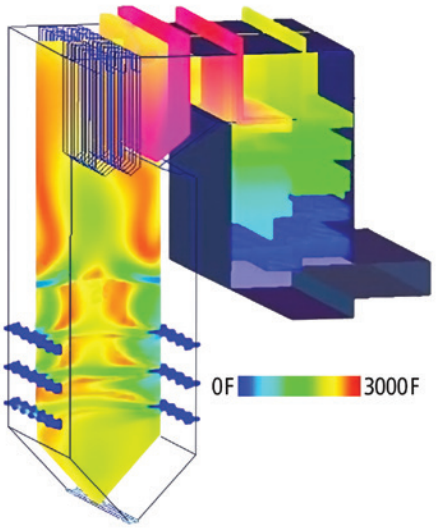


Figure 3: Thermal model of boiler

Direct infrared temperature measurement of the exit-gas temperature offers a non-contact FEGT measurement that avoids many of the difficulties of these other techniques.

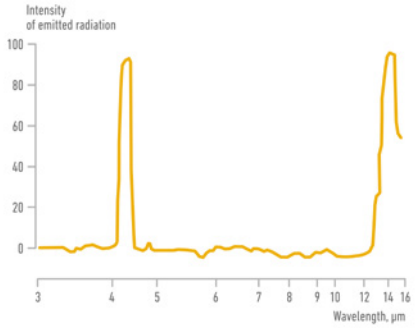


Figure 4: Spectrum of CO_2 emission

Our Solution

LumaSense Technologies has brought over 50 years of industrial infrared temperature and gas measurement experience to the development of a new system solution specifically designed to more effectively monitor the exit-gas temperature (FEGT) in boiler furnaces.

The LumaSense solution utilizes our IPE 140/45 pyrometer with a custom narrowband filter (near 4.5 µm) to monitor the CO_2 emission line from the hot combustion gases (Figure 4).

Typical fossil fuel combustion processes contains approximately 10% CO_2. The radiative emissions from these molecules can be accurately measured to obtain the temperature of the hot gas, while not being affected by furnace wall or tube conditions.

By adjusting the pyrometer depth of focus, we can obtain an effective profile of approximately one half of the total furnace width and obtain the average temperature for the furnace exit-gas region.

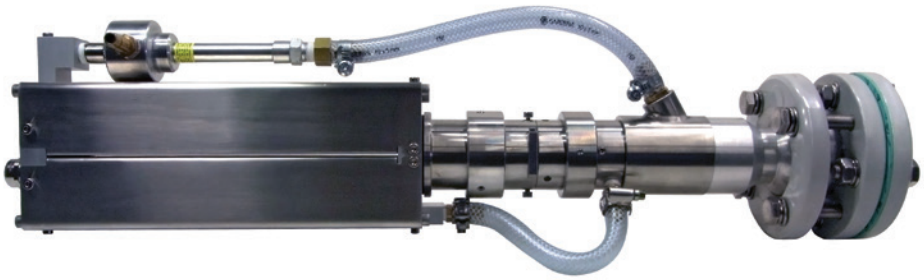


Figure 5: FEGT system

The FEGT solution (Figure 5) has been designed for harsh industrial environments and includes the following components:

- **IPE 140/45 Infrared temperature sensor** with custom CO_2 filter and precision adjustable optics. Includes digital, alarm, and analog outputs.
- **Protective sealed jacket assembly.** Stainless steel enclosure including vortex air cooler and air filter, for continuous usage applications.
- **Air purge assembly** with extended site tube and removable CaF_2 window assembly to minimize contamination of pyrometer lens.
- **Mounting flange (Ball flange)** for ease of mounting and alignment. Allows users to scan across furnace for determining temperature profiles.

The FEGT system is easy to install and maintain, even while the boiler is online. Operators can permanently mount the system outside the furnace on a port installed on a standard observation door to sight on the midstream of the gas exit path. The installation allows the door to be unobstructed so that it can be opened for visual inspections as required. The mounting location is generally near the boiler nose at the boundary between the lower radiative zone and the upper convective region such as show in the system diagram on page 4. Operators could mount two FEGT systems to allow full coverage of the furnace.

The pyrometer can continuously measure temperatures from 400 to 2000 °C, with an accuracy of better than 1% of the temperature reading. In addition, the analog output is linear 0 to 20 mA (or 4 to 20 mA) and can be fully sub-scaled.

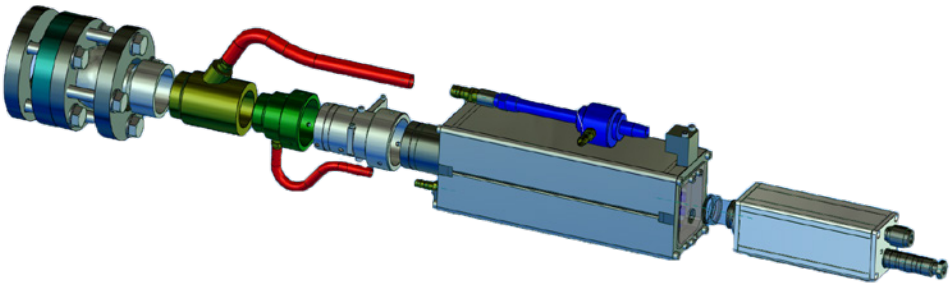


Figure 6: Exploded diagram of the LumaSense FEGT system

Operators can set adjustable alarms to give warning of FEGT changes, such as deviations from the set-point ~50 °C. below the ash fusion temperature, where slagging and fouling occur. This temperature is also where boiler efficiency is maximized. The alarm set-point can be digitally adjusted for different run and fuel conditions.

Alarms can also be used during boiler start-up conditions to warn when the furnace probes should be retracted. These probes are typically used to monitor rising exit-gas temperatures to ensure that the boiler tubes are not overheated. They must be withdrawn before burnout at ~550 °C.

Users can tie the FEGT outputs into the plant's control system for initiation/control of sootblowing operations and monitoring during combustion tuning processes.

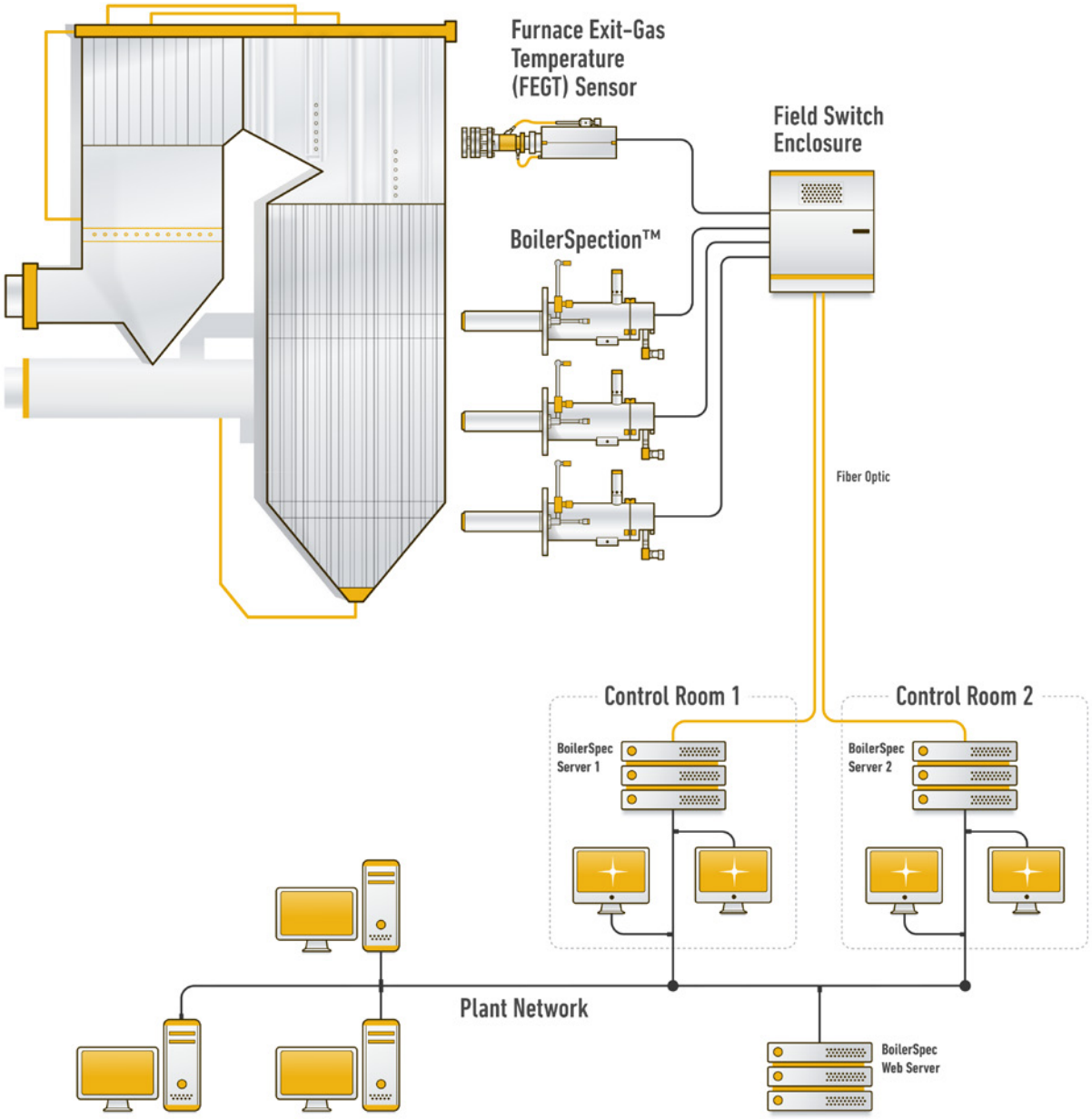
The LumaSense FEGT system can increase plant efficiency by continuously providing the gas exit temperature, allowing operators to optimize the coal-fired boiler combustion process, and minimize the possibility of slag deposition. This system can also be advantageous for waste incinerators where monitoring the FEGT can insure that temperature is above that needed to decompose toxic materials.

Your Benefits

- ✓ **Minimize unwanted slag accumulation and fouling** by controlling FEGT below the ash fusion point.
- ✓ **Optimize and tune heat transfer** by monitoring FEGT under varying process conditions. Measure and quantify trade-offs of heat rate and NO_x & SO_2 emissions.
- ✓ **Set alarm triggers** to determine precisely when to take corrective actions and initiate soot-blowing operations. Minimize soot blowing operations to increase pendant lifetime.
- ✓ **Maximize boiler efficiency** by running under optimal load conditions.
- ✓ **Prevent failures** by continuously and proactively monitoring the furnace temperature. Minimize unscheduled outages and reduced power conditions.
- ✓ **Easily installed** and maintained while boiler is online.

FEGT & BoilerSpection System Configuration

The FEGT system can be integrated directly into a plants control system or as part of a more complete solution as shown here.



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