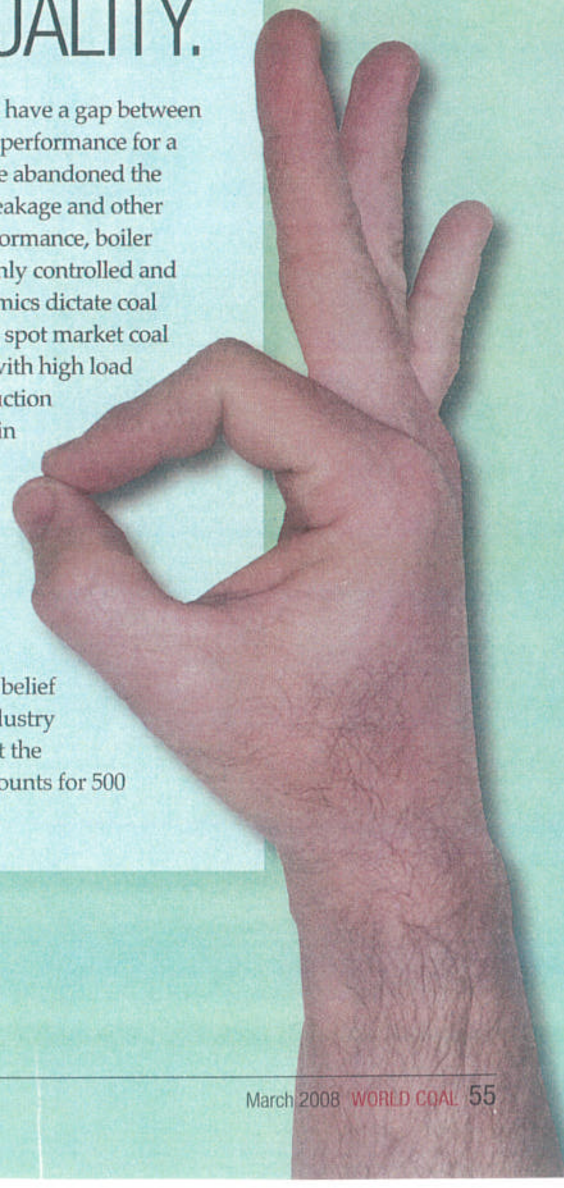
QUALITY COUNTS

STEPHEN K. STORM, STORM TECHNOLOGIES, INC., US, CONSIDERS DIFFERENT WAYS OF MEASURING COAL QUALITY.

Operators of large utility power plants throughout the industry have a gap between understanding the plants' coal quality and the steam generator performance for a number of reasons. First and foremost is the fact that many have abandoned the 'old fashioned results engineering' tests of coal fineness, air in-leakage and other manual performance monitoring of boiler and combustion performance, boiler efficiency and heat rate. Secondly, coal quality just isn't commonly controlled and managed to the extent possible with today's technology. Economics dictate coal purchases, not coal qualities. Thirdly, the combination of varied spot market coal purchases for economic production considerations, combined with high load factor operation of coal units due to comparatively lower production costs when competing with natural gas and other fuels, results in less 'natural de-slagging' of boilers. Considering the age and condition of many of the coal-fired power plants in the US, as well as the installation of environmental control equipment, the industry heat rates have escalated such that the difference between the industy's best and average plant heat rates is well over 1000 Btu/kWh. Much of this is related to the challenges with low NOx firing systems and increased auxiliary horsepower consumption. However, it is the author's belief that accounting for the heat losses is necessary to reduce the industry averages. Upon completion of performance surveys throughout the industry, Storm Technologies, Inc. routinely and commonly accounts for 500 - 600 Btu that is controllable at the boiler.



How can it be overlooked that 500 - 1000 Btu is equivalent to 5% - 10% in fuel savings? That's not to mention the inter-relationship with a reduction in CO_2 emissions and forced outage rates that could be reduced with improved plant performance. Before discussing the role of coal analysers in our industry, let's first review the methods of boiler efficiency measurement for a large steam generator. Simply, heat rate (Btu/kWh) and/or efficiency are measured by the ratio of energy output to the energy that is input into a system.

Methods of measurement

- The input-output method. This is a simple procedure, but it requires extreme accuracy of the measurement of the fuel flow rate, fuel quality, steam flow leaving the steam generator, feed water flow into the boiler, steam pressure and temperatures, steam quality and the pressure and temperature of the feed water to the boiler.
- Heat loss method. This method measures the various heat quantities that are lost to the steam generator. Again, the procedure is fairly simple. However, ASME code procedures must be taken into account for measurement of the flue gas chemistry leaving the boiler as well as the air side and fuel quality measurements. Major losses include:
  - Loss due to heat in dry flue gas.
  - Loss due to moisture in fuel.
  - Loss due to moisture from combustion of hydrogen.
  - Loss due to combustion in refuse.
  - Unmeasured losses (usually determined with a manufacturer's margin).

Figure 1. Test personnel coal sampling at the discharge of multiple gravimetric coal feeders during a boiler efficiency test.

As with any performance programme, if you can measure it, you can manage it. So, with that said, now let's review the bare minimum of inputs required to determine efficiency of a steam generator.

Required measurement variables

- Raw coal ultimate analysis and HHV.
- Fuel flow measurement.
- Air inlet temperature.
- Feed water flow.
- Steam flow, pressures and temperatures.
- Steam quality.
- Boiler exit flue gas measurements (multiple locations, including the actual furnace exit).
- Air heater outlet flue gas measurement.
- Carbon in the refuse (bottom ash and fly ash).

Figure 2. Multi-point flue gas sampling probes for boiler efficiency testing.

In summary of the test variables required for efficiency and heat rate measurement, it should be noted that there is the capability to measure all of these variables online. Most of the methods of measurement are simple and proven. However, many are overlooked. The one that is overlooked most often when determining performance is coal quality.

Coal analyses

Today, most coal-fired power plants obtain coal analyses by either trusting the coal supplier with mine analyses data or taking physical samples onsite at plant itself. If samples are collected onsite, they are typically sent off to a commercial laboratory and the results are available in weeks. Because of this, on-line analyses of coal with proven coal analysers that provide real-time data have substantial merit.

This technology has advanced over the past couple of decades, and it seems obvious to the author as to why these are needed by the end users involved with power generation. However, let's just take a minute and review the benefits again. These are as follows.

Benefits

- You can determine coal quality in real-time, which gives operations time to react and prepare for a poor coal quality. For example, close monitoring of slag via local checks or with in-furnace cameras, furnace exit gas temperature (FEGT) monitors, CO measurements and draft checks.
- It assists with quality control of fuels purchased.
- It assists with sorting or blending for environmental compliance.
- Control of SO_2 emissions to the atmosphere.
- It can assist with reducing fouling and slagging if you know the quality of the fuels and the ash fusion temperatures with the same fuel source or blended coals.

In December last year an article was written by Rod Hatt of Coal Combustion, Inc., US, in World Coal entitled 'Looking even closer,' and he expanded on the variations of nuclear coal analysers available and even provided updates on the EADS Sodern CNA analyser. As the author understands it, this is the only analyser that directly measures all major elements (up to 12) including carbon, oxygen and sodium, and which determinates a reliable calorific value without prior knowledge of coal type.

Real-time coal analysis

Integration of on-line fuel quality measurements in real-time is essential

Figure 3. Multi-point flue gas sampling probes for boiler efficiency testing.

Figure 4. Insitu flyash sampling for representative flyash samples being collected during a boiler efficiency and comprehensive performance test.

Figure 5. Sodern's Pulsed Fast and Thermal Neutron Activation (PFTNA) coal analyser.

to the future of power generation in a competitive generation market.

Simply, the most efficient coal-fired power plants equipped with the most efficient pollution control equipment are capable of producing power with comparable emissions to an LNG-fired gas turbine. With today's ultra low NOx firing systems installed on utility boilers and FGD systems capable of removing nearly 100% sulphur oxides (SO_2), 'fuels flexibility' is the name of the game in today's competitive power generation throughout the US. As a consultant that travels throughout the US and internationally, the correlation of improved fuels flexibility with those who impose stellar plant O&M and make combustion optimisation an ongoing project seems obvious. Quite simply, those who neglect the fundamentals and essentials of combustion typically lock themselves into a 'fuels in-flexibility' position. Improvements in pulverised coal combustion with solid fuel measurement and injection systems are closely paralleling the evolution of internal combustion engines for automobiles and precision measurements must not be underestimated. The thought of neural networks being the 'brain' for large steam generators that can sort through enormous amounts of plant operations data, consider objectives, and then make corrections based on empirical data and experience in real-time is also great technology. However, the success of a neural network is dependent upon precise inputs in their effort to optimise overall performance.

Although efficiency measurement is a key indicator to the overall performance of today's typical steam generators, the standards or essential pre-requisites to optimisation of the unit performance should always include some key factors or standards such as the following 13 essentials.

The essentials of optimum combustion for Low NOx firing on a PC-fired boiler

- Furnace exit must be oxidising, preferably 3%.
- Fuel lines balanced to each burner by 'clean-air' test ± 2% or better.
- Fuel lines balanced by 'dirty air' test, using a dirty air velocity probe, within ± 5% or better.
- Fuel lines balanced by fuel flows within ± 10% or better.
- Fuel line fineness >75% passing a 200 mesh screen and <0.1% on a 50 mesh screen.
- Primary airflow shall be accurately measured and controlled within ± 3% accuracy.
- Primary air/fuel ratio shall be correct and accurately maintained when above minimum.
- Over-fire air shall be accurately measured and controlled to ± 3% accuracy.
- Fuel line minimum velocities shall be 3300 fpm.
- Mechanical tolerances of burners and dampers within ± 0.25 in. or better.
- Secondary air distribution to burners within ± 5% to ± 10%.
- Fuel feed to the pulverisers smooth during load changes and measured and controlled as accurately as possible. Load cell equipped gravimetric feeders are preferred.
- Fuel feed quality and size should be consistent. Consistent raw coal sizing to the pulverisers is a good start.

Storm Technologies, Inc. (STI) has developed productive ways to measure and employ the essentials of optimum combustion. The inter-relationships of total boiler performance must be considered when attempting to optimise combustion. The overall performance, operability, load response, reliability, and capacity are all inter-related. STI's preferred approach is 'global,' or comprehensive in nature, taking into account pulveriser mechanical adjustments, fuels, soot blowing, airflow measurement, furnace oxygen and other factors. Reliability of industry boilers (tube leaks, fouling, and slagging) can be impacted negatively by secondary combustion, and consequent super-heater and re-heater tube metals overheating. This is also due to water wall wastage from non-optimised fuel distribution. Power generation cost or production costs can be impacted by not optimising the pulverisers and then compensating with more expensive fuels that are of higher HGI. Fouling and slagging can also be a large, negative impact on efficiency, capacity, and heat rate due to poor fuel fineness and distribution. All of these issues mentioned are very common and stem from non-optimum combustion of coal. Once again, these warrant precise measurement of the inputs!