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More from Your
Online Coal Analyzer

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On-line coal analyzers have been in commercial use for over two decades, with historical applications predominantly supporting coal production operations. Peabody Coal and Arch Coal, the two largest US producers, are among the coal suppliers that utilize Thermo Fisher Scientific on-line coal analyzers to reduce out-of-spec deliveries, improve consistency across a shipment, and utilize coal from multiple sources with widely varying qualities.

Today, power plant owners are also investing in the improvements that on-line coal analyzers can make to their bottom line. Constellation Energy is facing stringent, fleet-wide SO₂ and NO_x emissions caps and significant mercury reduction obligations required by Maryland's Healthy Air Act. Constellation is looking beyond these strict emissions limitations to coal market opportunities, installing six analyzers at their three Maryland coal plants to balance market opportunities with rigorous control of annual emissions. Initially sought for their ability to blend coals to a tight specification (i.e., sulfur), the unique needs of the power plant open a wide spectrum of new applications for the online coal analyzer. Concurrently, advancements in coal analyzers and their supporting software improve the applicability of the online coal analyzer to the coal-fired power plant.

A Brief History

On-line coal analyzers were first introduced to the coal and utility industries in the early 1980's. As with most new technologies, it took some time for the products to mature and for the industry to embrace them. In the case of on-line coal analyzers, that wholesale acceptance did not begin until the early 1990's but even then the usage varied widely.

It is ironic, given that power plants form a noticeable minority in the historical use of analyzers, that the first elemental coal analyzers actually came about through research sponsored by the US utility industry – specifically the Electric Power Research Institute. The Tennessee Valley Authority's Paradise plant and Detroit Edison's Monroe plant were the beta-sites for elemental coal analyzers from SAIC. Another analyzer supplier, MDH Motherwell, emerged in the early 1980's, with its beta test site at the prep plant at the Penelec Homer City power plant.

Despite the early utility interest in coal analyzers, it was the coal producers in the US and Australia that saw their promise and began fueling analyzer market growth. One of the analyzer producers who took over the leadership of this fledgling industry was Gamma-Metrics (now Thermo Fisher Scientific) in San Diego, CA.

Using the Technology

As the principles behind the scientific process of Prompt Gamma Neutron Activation analysis (PGNAA) have become accepted in the coal industry over the past 25 years, the evolution of the PGNAA analyzer has enabled customers to choose the type of analyzer best suited to their application, budget, and performance needs, and advanced software suites tailored specifically to their application. Power plants and rail load-out operators can choose to augment their PGNAA system with automatic blending software that will use the minute-by-minute elemental analysis and accompanying calculations from the on-

line PGNAA systems to blend multi-sources/types of coal to user-defined parameters such as percent ash, percent sulfur or calorific value.

Today's PGNAA coal analyzers come in essentially two variants: the Cross-Belt system and the Fixed-Geometry, sample-fed system. Just like the first PGNAA systems that were commercially accepted into the coal industry in the 1980's, today's Fixed Geometry PGNAA analyzers are the most accurate elemental coal analyzers found in the market. Because the analysis zone of the Fixed-Geometry PGNAA analyzer is optimized for maximum uniformity of analysis and is not impacted by second-by-second changes in belt loading that reduce the signal accuracy of any Cross-Belt system, the Fixed-Geometry system is still the analyzer of choice for applications that require the absolute best on-line accuracy. This level of accuracy is often utilized when contract loading a unit train or filling bunkers with blended coal to not exceed environmental emission limits such as SO₂.



Figure 1 : Thermo Scientific CQM, a fixed geometry PGNAA coal analyzer designed for optimum precision

The introduction and commercial acceptance of the Cross-Belt PGNAA coal analyzer has allowed many PGNAA customers to control their processes with a slightly less robust and less accurate elemental coal analyzer that typically comes at a lower installed cost. Cross-belt analyzers are generally easier to install than the sample stream analyzers and don't require a sampling system to function, yet the presence of a sampling system on the

same coal stream as the belt analyzer is strongly recommended for calibration and periodic assessment. These Cross-Belt systems are well proven in applications that demand moderate performance such as “run-of-mine” conveyors to help control a mine’s long-wall operation or for the truck load-out that is looking to analyze 100 percent of the coal in a 40 ton shipment. These analyzers perform best on belts between 36 and 48 inches in width, whose flow rates are fairly consistent, and whose coal topsize is no more than 2 inches.



Figure 2: Thermo Scientific ECA, a full flow PGNAA analyzer, here seen in tandem on bunker feed conveyors

An additional software option that has recently become available is silo product tracking that uses PGNAA elemental coal analyzers to give the operator an expanded knowledge of the composition (sulfur, ash, moisture, and calorific value) of coal conveyed to multiple downstream silos or bunkers. The minute-by-minute analysis and associated tonnage is tagged by its destination to create a database of the composition of all the coal entering a downstream silo. Armed with this information, as well as the rates of coal withdrawal from each silo, the software is able to determine the current average composition of the material in each silo. This valuable tool gives the operator real-time awareness of the silo composition, which can be used to spot coal quality trends that can

adversely impact the plant without operator intervention. In particular, silo product tracking can provide estimates of the coal quality about to enter a coal-fired boiler. It can alert the plant to potential derate situations or potential emissions excursions.

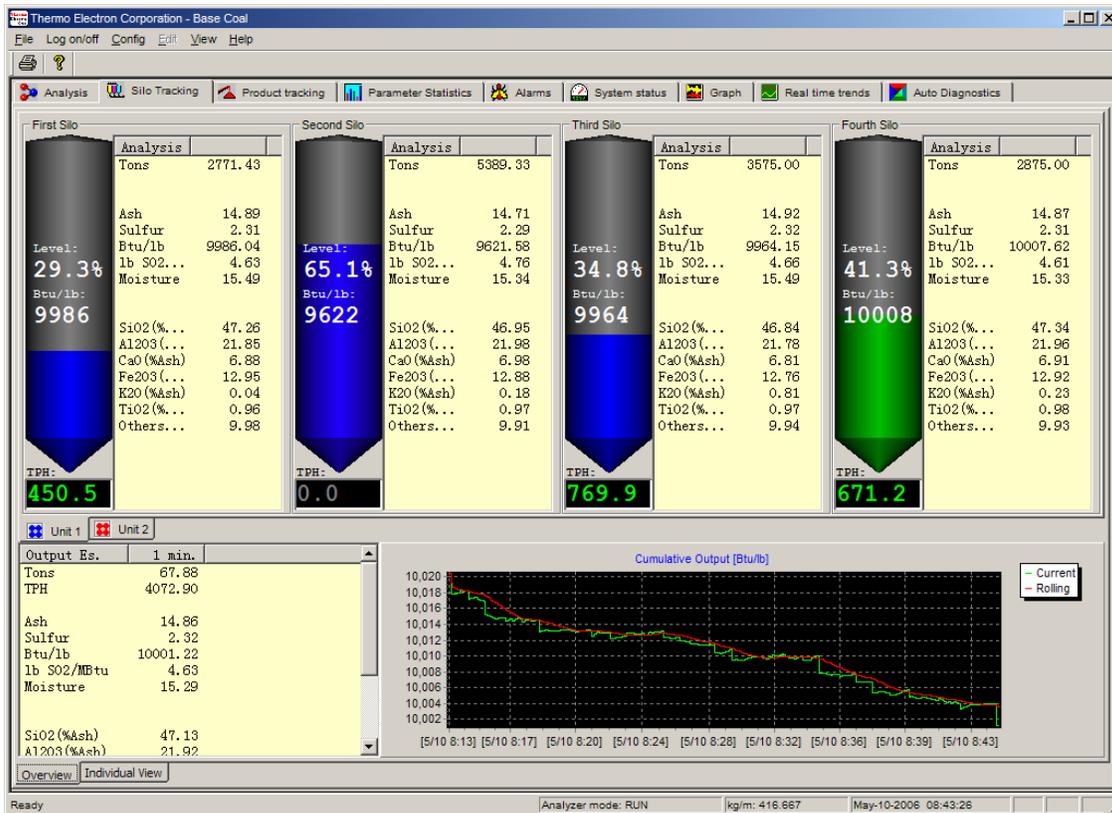


Figure 3: Thermo Scientific Silo Tracking Software, ideal for monitoring coal quality in power plant bunkers

Applying Analyzers to Meet Specific Needs

The following are examples of how on-line coal analyzers have been used by coal producers and coal consumers.

Multi-Source Blending

Arch Coal is no stranger to the use of coal analyzers to benefit their coal mining operations – Arch is the single largest user of elemental coal analyzers in the world. One of Arch’s most productive Appalachian properties was its Catenary Coal Samples mine complex south of Charleston, WV, until early 2006 when the mine was sold to Magnum Coal. The property consists of a surface mine and an underground mine, a prep plant, and a rail load-out. The mine produces products ranging from 10 to 33 percent ash, 0.5 to 2.5 percent sulfur, and 9,200 to 13,000 Btu/lb. The mine began implementing on-line analysis in 1993 with a Gamma-Metrics 1812C coal analyzer. In 2002, the mine added additional storage capacity, the ability to draw from four sources in meeting quality targets, a Coal Quality Manager (CQM) analyzer, and Coal Blending Optimization System (COBOS) software. The CQM produces analyses and the COBOS software can make feeder adjustments as frequently as each minute to satisfy the quality requirements

of a shipment. This system was the first in the world to blend automatically on two control variables; in this case, both sulfur and ash.

The mine ships unit trains from 10,000 tons up to 16,500 tons, at a load-out rate of 4,000 tph. The COBOS system tracks the cumulative quality of the train and automatically adjusts the feed proportions from the four sources to meet the sulfur and ash targets simultaneously. The benefits to Arch and now Magnum associated with the investment in the two stockpiles, the analyzer, and the blending software are twofold. With more consistent quality, mine personnel are able to meet their customer's quality specifications, thus building on their reputation as a consistent, reliable supplier. In addition, they give the mine and the prep plant much more operational flexibility knowing that they can handle wider ranges in source quality and still meet contract specifications.

A Utility Blending Application

Generating companies are also beginning to recognize the benefit of being able to carefully control blended coal quality. An example is Reliant Energy's Titus Station in Birdsboro, Pennsylvania. Titus consists of three 81 MW pulverized coal units. It was originally commissioned in 1951, and like most plants of its era, was constructed to burn a specific type of Eastern Bituminous coal that was in abundant supply and located in close proximity to the plant. In recent years, fluctuations in coal and emissions markets combined with dwindling availability of the design coal have caused Reliant Energy to consider burning alternate coals to reduce operating costs. As Reliant Energy considered available supplies, maintaining SO₂ emissions within an acceptable range became a concern. Their solution consisted of a new coal handling system including stacking tube stockpiles, an on-line coal analyzer, and an automated blending system. With these improvements, the plant has been able to increase coal supply options and still satisfy emissions requirements, without any degradation in heat rate.

At the heart of Titus' coal blending system is the Gamma-Metrics CQM on-line coal analyzer and COBOS control system. The coal yard was modified to contain two coal stockpiles, a new low sulfur stockpile storing 15,000 tons of coal using a concrete reinforced stacking tube, and a blended coal pile storing coal that is ready to burn in the plant. Due to space constraints, coal must be blended as it is unloaded from the train.

Coal blending using the on-line coal analyzer and COBOS software requires two separate and isolated sources of coal of identified chemical compositions. Lab analyses of both high and low sulfur coal sources are inputs to the system, along with the desired resulting SO₂ level. The initial target blend ratio needed to meet the target SO₂ level is calculated by the COBOS system based on the analysis of the two coal sources. During coal blending operation, low-sulfur coal reclaimed from the stacking tube is added to high-sulfur coal as it is unloaded from the railcar. After the blend point, a swing arm sampler cyclically cuts a sample of the blended product and directs it to the on-line coal analyzer. Key parameters are passed back and forth electronically between the analyzer and the control system via the COBOS Coal Blending PLC Modules. Based on input from COBOS, the control system makes the required adjustments to both low sulfur and high

sulfur feeder speeds to maintain the appropriate blend while maintaining coal throughput at a constant level. The system is configured to direct the blended coal to the plant bunkers, to the compliance coal stockpile, or to both locations simultaneously.

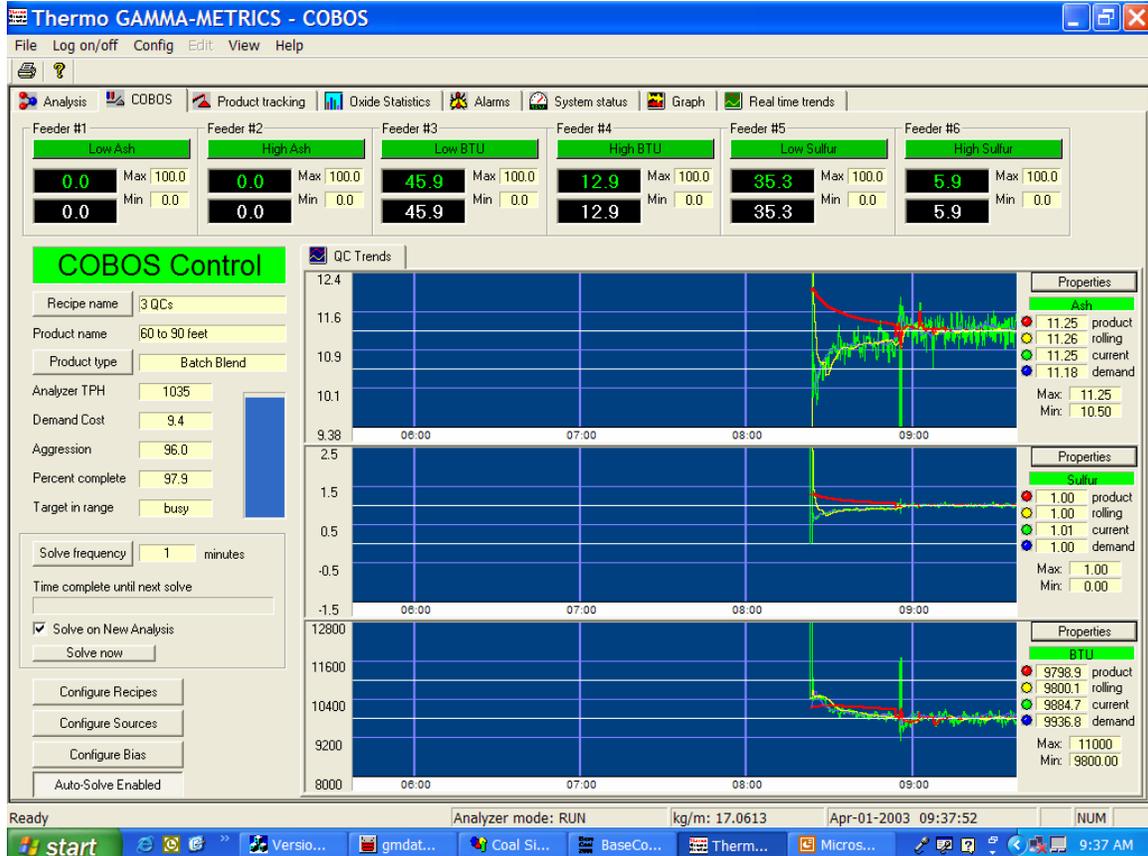


Figure 4: Thermo Scientific COBOS automated blending software, able to meet multiple control targets such as ash, sulfur and BTU/lb simultaneously

Reliant Energy considered various alternatives to increase fuel supply options while controlling SO₂ emissions at Titus. Due to the small size of the units, physical space constraints, and high capital costs for a scrubber installation, Reliant Energy opted to install an on-site coal blending system. The on-line coal analyzer and COBOS blending system was ideal because it allowed the plant to continue to burn its design coal as its primary coal supply, now blended with similar Eastern Bituminous coal that is low in sulfur, reducing SO₂ emissions while minimizing the impact to the plant. The system has maximized the fuel flexibility of the plant, giving Reliant Energy the ability to adapt to market changes in coal supplies, coal prices, and allowance markets thereby optimizing the economics of the plant.

Using On-line Analyzers to Improve Unit Performance

PacifiCorp has obtained significant value from the CQM analyzer installed in 2001 at their Hunter plant. The intended objective was to reduce lost generation and forced outages at the plant by controlling the ash fusion temperature. The availability at the Hunter Station has improved since the CQM installation for precise blending control.

Minute-by-minute data from the analyzer has allowed the plant to supply more consistent coal blends to the units and has allowed the plant to maintain acceptable ash softening temperature of the blend while utilizing as much less expensive, low fusion coal as possible. With a more reliable coal blend Hunter Station has regained electrical generation capacity and more consistently achieved the maximum rated capacity, as is shown in Figure 5. This figure shows the average unit capacity before and after CQM use for blending coals. In addition, Hunter Station can now more effectively burn fuels from a variety of sources. The CQM allows the plant to closely monitor the quality of the coal being delivered to the plant by their fuel suppliers, and as a result the consistency of the delivered coal has improved.

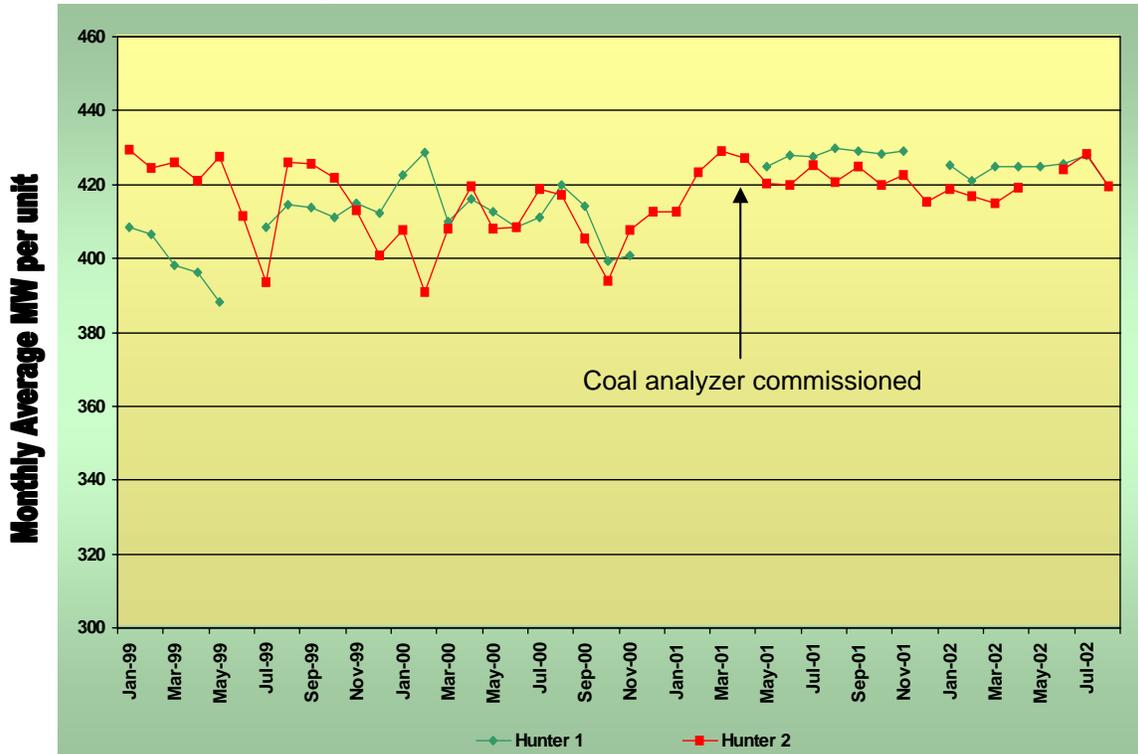


Figure 5: Average MW When Using a Thermo Scientific CQM to Blend Coals for Ash Softening Temperature

Finally, an unexpected bonus has been the earlier identification and correction of equipment problems in the plant. In the past, plant operations problems were often blamed on fuel quality, which was not known in real time. It would take at least a day for coal sample analysis results to come back from the laboratory. Now CQM results allow plant personnel to determine immediately whether there is a coal quality issue. If not, the plant can quickly move on to identifying and correcting the true source of the problem. There is less potential for lost generation because both quality and equipment problems are more rapidly identified and addressed.

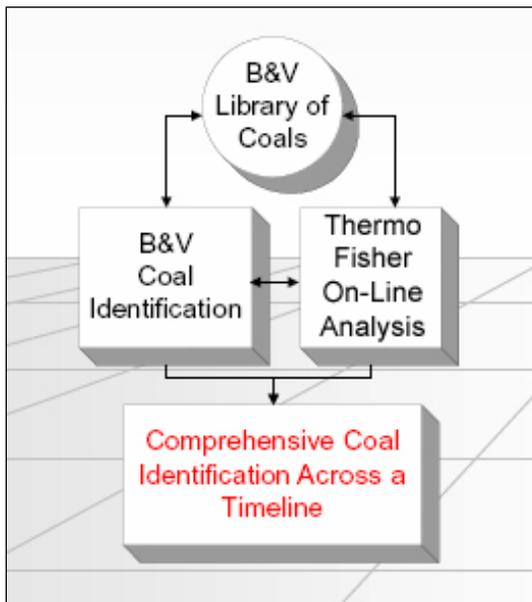
Breaking with Tradition: Maximizing Analyzer Benefit

Applying on-line coal analyzers to meet specific needs, as has been discussed thus far in this paper, represents an excellent opportunity for power plant improvement often with

very short payback. However, an even greater opportunity comes from improving upon the information provided by the analyzer and incorporating it on a large scale with other plant decisions and controls. This collaboration will increase profits and decrease operating problems at the plant. In considering this opportunity, Black & Veatch and Thermo Fisher Scientific have recognized the power of combining their respective tools to develop solutions that solve a greater problem than can be solved individually.

Honing In on Quality

Where lies the value of the data created by coal analyzers in the future? Exactly there, helping to predict the future based on what is learned from the past. Available systems currently “learn” how your unit reacts to certain coals. However this “experience” is most valuable if you know exactly what coal was put into the unit. To accomplish this, additional tools can be used in conjunction with the data provided by the coal analyzer to effectively identify an accurate and comprehensive representation of the coal that passed through the burners over a timeline. The first step is expanding the coal signature.



Coal signatures are maintained in a database library of complete lab analysis data, including the constants required by Thermo Fisher Scientific coal analyzers (MAF Btu, “ash other”, and bound moisture). The coal library may contain mine-supplied data, analyzer calibration data sets, or other samples taken in the coal yard or in support of test burns. This library can then be used two ways. First, by comparing the constituents accurately measured by the analyzer (sulfur and ash minerals) against library entries, the database can verify the validity of constants entered for the coal. As the data set grows, the library may be able to suggest the constants that should be used. Additionally, by tying back to sample data within the

library, the coal’s full signature can be identified (proximate, ultimate, and ash analyses; grindability, and ash fusion temperatures) providing a more complete picture of the coal being analyzed.

This coupling between the analyzer and the coal library allows a feedback loop that makes the resulting analysis more accurate and comprehensive. This is a very important step in ensuring an exact representation of the coals sent to the unit.

Matching Coal Quality to Performance

Once an accurate and comprehensive characterization of the coal loaded into the plant’s bunkers is available, this characterization can be combined with a documented account of how the unit reacts to various coals to develop coal/performance correlations. The result

is knowledge of “experience” of how each unit reacts to each coal. This exact process was applied, to a limited extent, at the Hunter power station. The coal blend setpoint was determined based on plant experience that identified the coal quality (in this case, fusion temperature) that caused detrimental ash deposition. Automating the data collection and correlation process allows much broader characterization and control.

There are many aspects of a unit’s reaction to a coal that can be used to effectively populate the “experience” knowledge base. These reactions and their criticality will vary greatly from plant to plant, but should span capacity, plant performance, emissions, and reliability. Metrics can be defined or added to observe a unit’s behavior in areas of greatest impact as different coals are burned. Many commercial tools can be used to track and record plant behavior including performance and emissions monitoring tools, plant predictive models, boiler cleanliness models, and any others that generate an observation of how the plant is operating at a given point in time. In addition, coals can be examined using predictive modeling tools such as EPRI’s Vista™ that emulate how the plant will react to a hypothetical coal. These predictive models are very powerful for running “what-if” scenarios and could be used to populate the experience database with information on coals the plant has not burned.

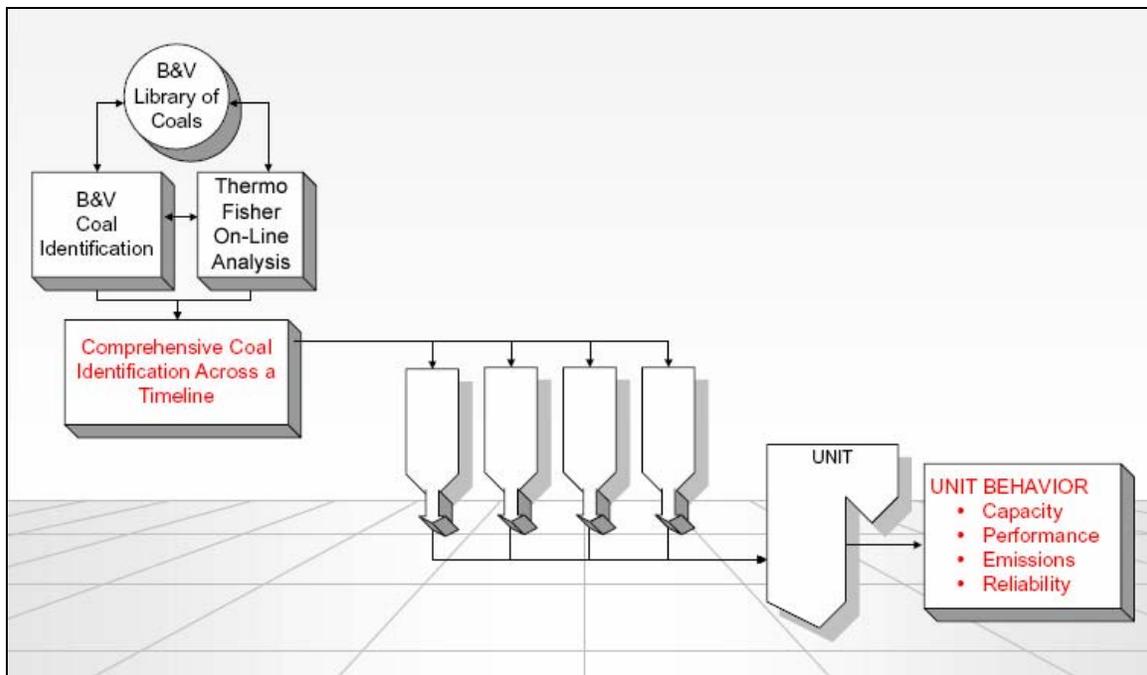


Figure 6: Automatically Documenting the Tie Between Coal Quality and Unit Behavior

Once this experience is captured, correlated, and stored in an easily accessible and understandable format, it allows a better prediction of how a unit will react to a particular fuel. Customized views into this experience record can provide insight into coal-related decisions including coal purchase, coal delivery, coal stockout, and silo fill. It can help identify coals to meet specific (high or low) capacity or emissions goals. Data trending can provide further insight into coal-related unit performance, emissions, maintenance, and reliability impacts.

Predicting Performance based on Coal Quality

There are several ways a good coal quality/performance characterization can bridge the gap between helpful information and informed operational decisions. One is to ensure that the coal loaded into the bunkers best meets the anticipated demand and current conditions of the plant. Another is to feed data forward to operators and others to help adapt to the loaded coal quality before it hits the burners, thereby minimizing coal-related operating hiccups.

COBOS blending software is currently used in conjunction with coal analyzers to meet a coal quality specification, and in the mining industry, different recipes or blend targets are developed and used to meet the requirements of the mine's various customers. The same concept can be applied at the power plant. In a common scenario, as power demand fluctuates, the quality of the coal required to meet that level of demand also fluctuates, and savings are obtained by switching or blending coals to match quality to power demand. Specifically, high quality coal is burned during weekdays followed by a lower quality blend for night or weekend hours. While this bunker loading regime is often approximated manually, the coal analyzer, blending software, and experience knowledge base reach an economic optimum without risking undesirable performance impacts. The blending software utilizes different recipes to correspond to high demand/low demand. The analyzer ensures the quality delivered to the bunker meets the desired quality. The experience knowledge base improves the blend target by considering the unit performance associated with each available coal or blend. As an example, an inexpensive coal known to cause slagging may be utilized on days when the demand drops at night, allowing the unit to shed slag. However based on experience knowledge base recommendations this coal will not be utilized when the unit will be operating at full load for extended periods. The same concept can be used to optimize to different emissions targets (such as ozone/non-ozone season).

While many detrimental plant impacts can be avoided in the coal yard via optimized bunker loading, some cannot. Minimizing delivered fuel cost, unavailability of a desired coal, or heavy rains will sometimes result in loading the bunkers with non-optimum coal. When this happens, ready access to coal quality and related experience information in the control room will help plant operators adapt to the coal before it hits the burners. In this case the coal library and experience knowledge base are used to their full potential. The coal analysis from the coal analyzer is augmented using the coal library to develop a complete coal signature. Using this coal signature, the experience knowledge base is mined to identify periods when this coal was burned in the past that provide relevant experience to the current situation (demand, equipment states, etc.). The coal signature and corresponding unit operating characteristics and unit performance are then available to support informed decisions regarding the operation of the plant.

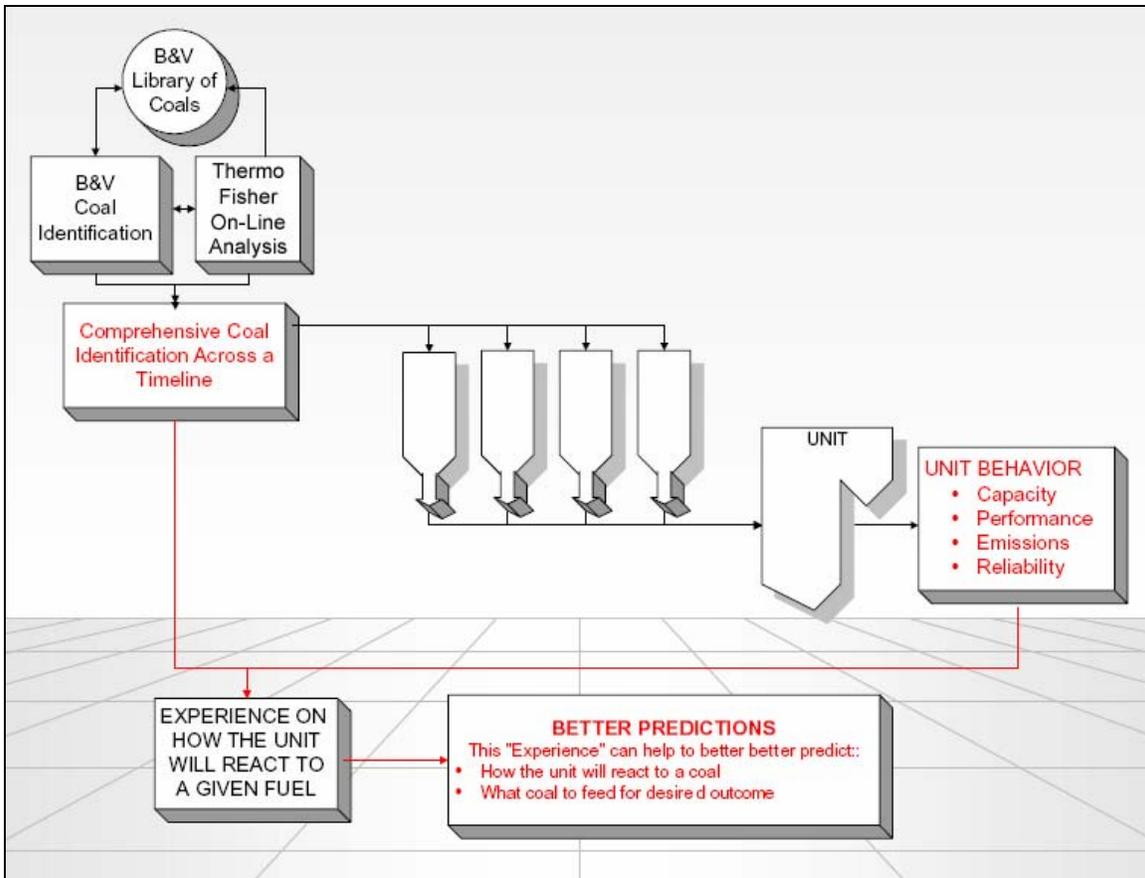


Figure 7: Utilizing Experience Knowledge Base to Predict Unit Performance for a Coal

Conclusions

Current coal analyzer technology can provide information to the plant about coal being bunkered. Combined with blending software, it improves the connection between the coal bunkered and the needs of the power plant. When used to filter against a detailed coal library, a more accurate and comprehensive signature of the coal can be identified. When combined with an experience knowledge base that ties coal quality to unit performance, the operation of the unit can be predicted.

When taken together, these methods can dramatically shift plant personnel’s focus from reactive to proactive. In the world of ever-changing complexities associated with power plant operation, there is less “flying blind” and more informed decisions made as a result. The inherent data capture and sharing helps circumvent aging workforce issues by capturing coal-related knowledge known only by certain personnel, and making it available to the entire staff. It helps analyze decisions made in the past as well as predict the future. This is our approach to answering the question we all have: how can we make better decisions, while making our daily tasks easier?