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Automated Coal Blending With Two Control Parameters at One of Arch Coal's West Virginia Mining Complexes

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ABSTRACT: 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. In 1993 they installed a Gamma-Metrics 1812C analyzer at their Samples mine complex in Eskdale, WV, to help monitor and sort the mine production. Then in 2002, in conjunction with an upgrade to the nearby Toms Fork loadout complex, Arch installed a Thermo Electron CQM analyzer in the loadout tower, where the analyzer is fed primary stage material from a 3-stage sampling system. This analyzer is used to control the quality being loaded into each unit train, to ensure that the customer's product meets the contract specification.

The Samples mine complex produces about 5.5 mtpy, serving approximately eight customers in a typical month. These utility customers each have very different quality needs, and the mine relies heavily on the analyzer to achieve the different contract specifications. The real-time information from the upstream 1812C analyzer helps the mine sort to, and track the quality of, the coal placed into two silos and two stockpiles. Then the loadout CQM analyzer, in conjunction with automatic coal blending software (COBOS) from Thermo, blends the coal from these four sources to achieve not only shipments which on average meet the contract specifications, but which are also consistent in quality throughout the train.

This paper discusses how the analyzers are used, what level of performance they achieve, and how the blending software makes it all happen.

Mine Layout and Operations

One of Arch Coal's most productive properties is its Catenary Coal Samples mine complex located some 30 miles south of Charleston, WV. The property consists of a surface mine and an underground mine, a prep plant, and a rail loadout. Storage includes, two 35,000 ton stacking tube stockpiles and two 10,000 ton silos just upstream of the rail loadout. The mine produces products ranging from 10 to 33% ash and 0.5 to 2.5% sulfur. Calorific values range from 9,200 Btu/lb to almost 13,000 Btu/lb.

Most of the mined coal, apart from "RASH" coal, is cleaned, and deposited in stockpiles downstream of the prep plant. Dozers and loaders fill trucks with coal from these stockpiles, and the trucks haul it to a nearby truck dump where an overland conveyor moves it from the top of the hill, to the bottom, where the coal is diverted to one of the silos or one of the stockpiles. The mine maintains different target qualities in each of these four inventories, to facilitate the subsequent blending. Blending is accomplished automatically with variable rate feeders

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controlling the proportions reclaimed to the nearby Toms Fork loadout. Figure 1 below depicts the general coal handling scheme.

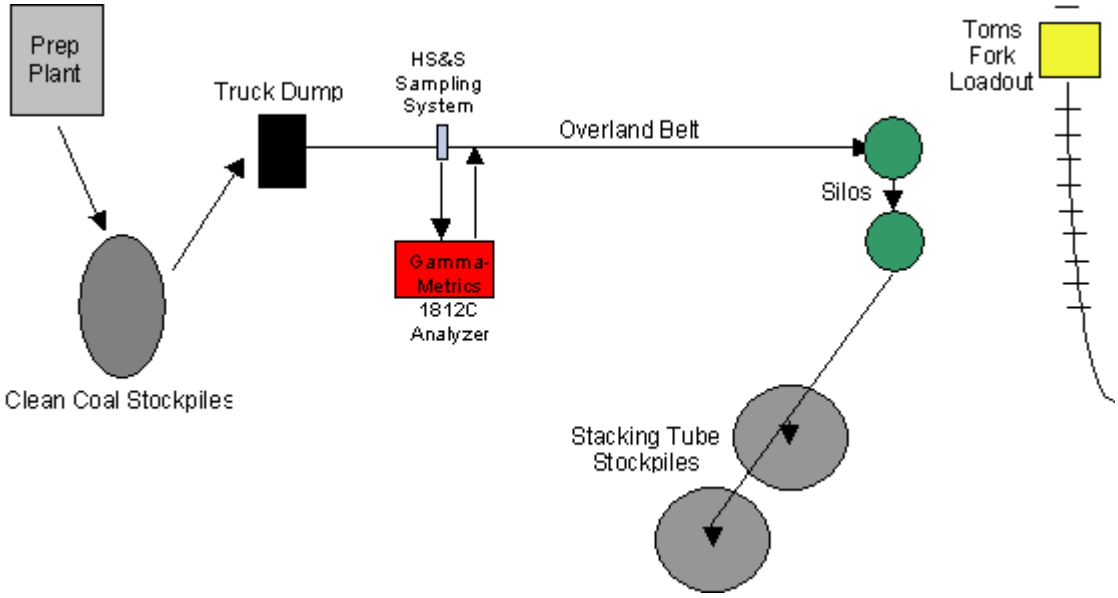


Figure 1. Layout of Catenary Coal Samples Mine

Use of Coal Analyzers to Improve Mine Operations

Arch began implementing on-line analysis here in 1993 with the addition of a Gamma-Metrics 1812C coal analyzer. This analyzer was used to monitor the quality of the coal being loaded into the silos, just before loadout, AND it was also used to give feedback to the mine to drive the quality consistent with the specifications required by its customers. The mine was unable to take full advantage of this analyzer because of railroad scheduling and limited storage. Therefore, they had to very conservative.

In 2002, the mine added two stacking tube stockpiles (Figure 2) with total storage capacity of 70,000 tons and with underground reclaim, in the vicinity of the loadout silos (Figure 3). Now they had the ability to draw from four sources in meeting their train targets: the two stockpiles and the two silos. This investment was accompanied by the addition of a CQM Coal Quality Manager coal analyzer (Figure 4) from Thermo Gamma-Metrics.

Figure 2. Stacking tube stockpiles at Toms Fork Loadout

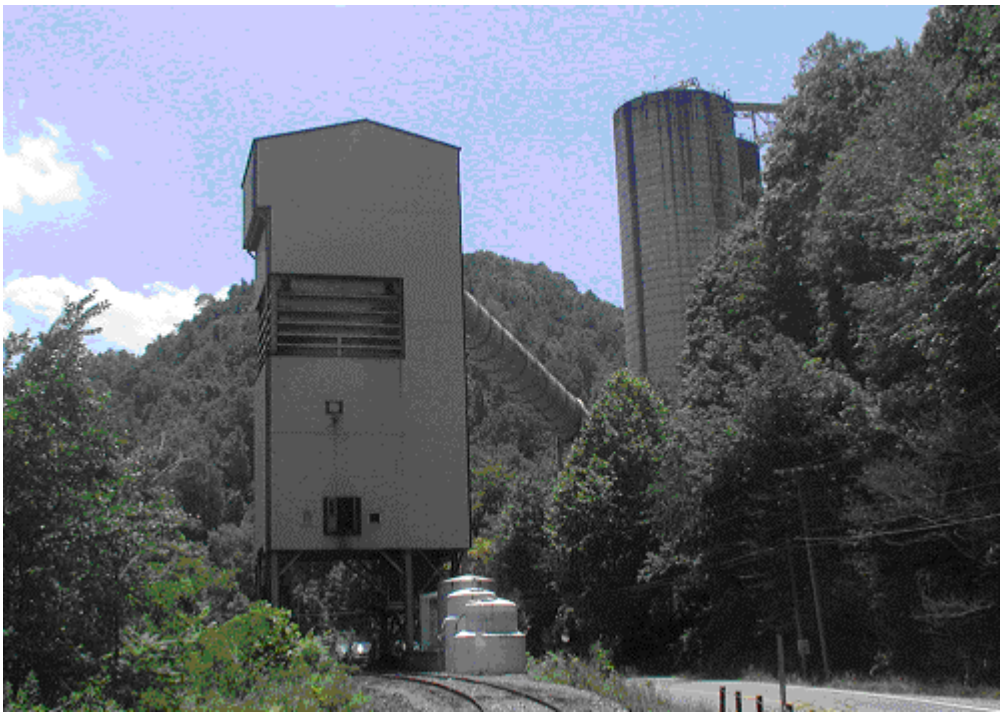


Figure 3. Loadout silos and loadout tower at Toms Fork.

Figure 4. Gamma-Metrics CQM Coal Analyzer in Loadout Tower

The operating philosophy changed considerably with these investments. Now they were able to drive very different qualities in each of the four sources, knowing that with the analyzer in the loadout they could detect changes from target quality and automatically revise the blend proportions to meet shipment specifications.

Analyzer Details

The Gamma-Metrics 1812C

This analyzer (Figure 5) is located adjacent the overland belt and is fed the primary save material collected by a 2-stage sampling system manufactured by Hebden, Shilbe & Smith. The flow rate through the 1812C is about 4 tph. The analyzer results are monitored locally and automatically fed to a scoreboard at the truck dump (Figure 6), to enable dozer operators and truck drivers to find the right coals from the clean coal stockpiles to achieve the qualities sought during that shift. The mine QC group also uses this information to make periodic changes in the destination of the coal being produced, in order to ensure distinct qualities in the four coal inventories (two silo, two stockpile) subsequently used to blend into the unit trains.

Figure 5. Gamma-Metrics 1812C Coal Analyzer near the overland belt.

Figure 6. Coal Quality Scoreboard at Truck Dump

The Gamma-Metrics Coal Quality Manager CQM Analyzer

The Gamma-Metrics CQM is located in the loadout tower, and as a sample stream analyzer, is fed the primary saves from a 3-stage HSS sampling system. The flow rate through the CQM is about 5 tons/hour. The analyzer produces analyses each minute and with the accompanying COBOS Coal Blending Optimization System software can make feeder adjustments as frequently as each minute to satisfy the quality requirements of the shipment. This analyzer is the only one in the world currently blending **automatically** on **two** control variables, in this case, sulfur and ash.

The Gamma-Metrics CQM was designed for accuracy, by maintaining a constant and optimal cross-sectional geometry in the analysis zone. It uses the Prompt Gamma Neutron Activation Analysis (PGNAA) technology to generate minute-by-minute elemental analysis results for sulfur, ash, and ash constituents. The CQM also includes a moisture meter to analyze moisture and allow the estimation of Btu/lb.

Gamma-Metrics Coal Blending Optimization System (COBOS)

Although Thermo Electron has been providing blending software to the coal industry for more than 15 years, a recent product enhancement satisfies well the combined goals of system performance and user friendliness. The optimization algorithm minimizes the cost of the blend, subject to satisfying the allowable range of values in the control parameters. While the system can accommodate up to six different sources on any train or barge, and up to five control parameters, realistically the number of control parameters will generally not exceed three, and often is just the two primary parameters of sulfur and ash.

With each train or barge, the operator merely selects the active sources (predefined by name, cost, and certain historic average qualities), selects the customer whose shipment is being loaded (these too are predefined by name and target quality), inputs the target batch size in tons, and COBOS does the rest. It automatically adjusts the assumptions on which the analyzer operates (MAF Btu/lb, bound moisture, and non-measurable ash fraction) based upon the blend proportions and the specific assumptions associated with each source. It also takes into account the different delay times from the feeders being controlled and the analyzer. The result is trains and barges on spec while minimizing the cost—allowing the mine to minimize the use of its most valuable coals. Figure 7 depicts the main COBOS screen on the Operator Console.

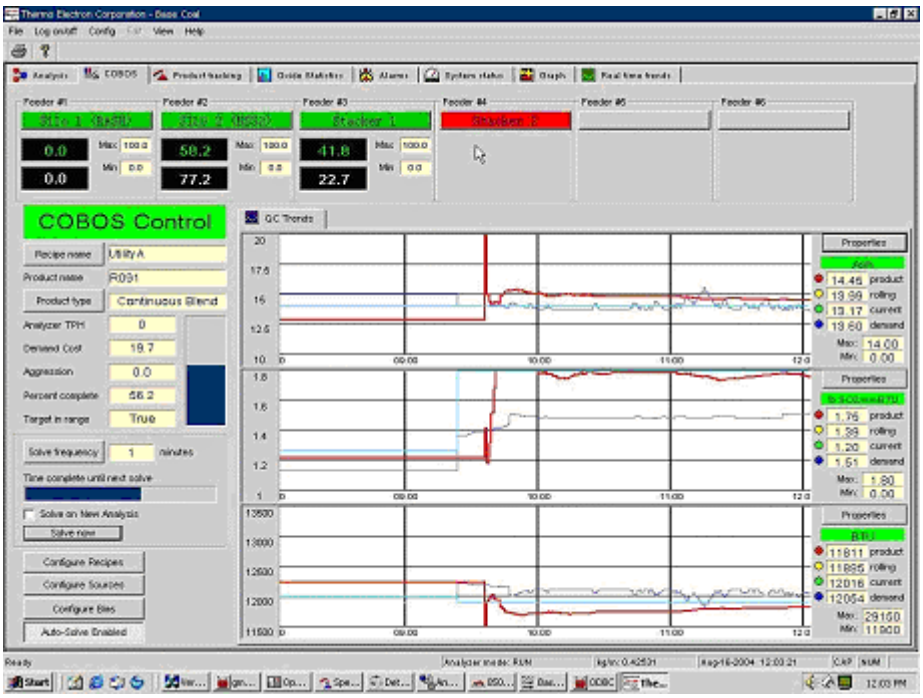


Figure 7. Main COBOS screen

The mine ships unit trains typically from 10,000 tons up to 16,500 tons, at a loadout rate of 4000 tph. The COBOS system tracks the cumulative quality of the train and automatically adjusts the feed proportions from the four sources to meet simultaneously the sulfur and ash targets. The benefits to Arch associated with the investment in the two stockpiles, and the analyzer with its blending software, are twofold: (a) with more consistent quality they are able to meet their customer's quality specifications, thus building on their reputation as a consistent, reliable supplier, and (b) 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.

Detailed assessment of COBOS performance at Toms Fork Loadout To get a glimpse of what COBOS does for Arch Coal we took a look at the June 2004 loadout activity at the Toms Fork Loadout. To understand their operating strategy, it helps to know the target qualities they had for each of the four sources:

Source	Ash	lbs SO2/MBtu	Btu/lb
Silo 1	30% (raw)	NA	9500
Silo 2	10%	<1.20	12,500
Pile 1	13.5%	1.60	12,200
Pile 2	12%	1.17	>12,500

It also helps to understand some of the operational practices of the mine. Arch relies on OPC software in the Operator Console to communicate over a DH+ line to their PLC. It alerts the loadout operator not to begin loading a train unless the analyzer and sampling system are ready, and the gates on the silos and stockpiles are locked out should either system not be ready.

It can be seen from Figures 8-10 that

- a majority of trains are the product of three or more sources
- yet more than half of the trains loaded had one dominant (>80% of total) source
- nonetheless, the source proportions change radically from train to train, suggesting the need for automation in the process

Figure 8. Number of sources used to satisfy a train quality target

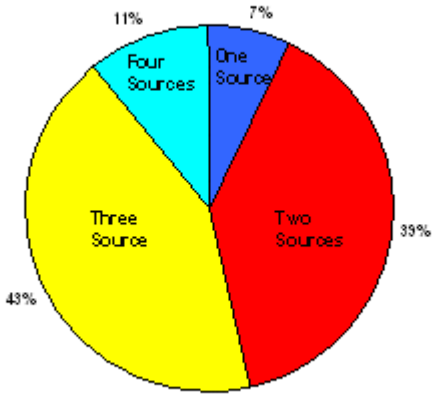


Figure 9. Percent of total blend tonnage represented by largest source

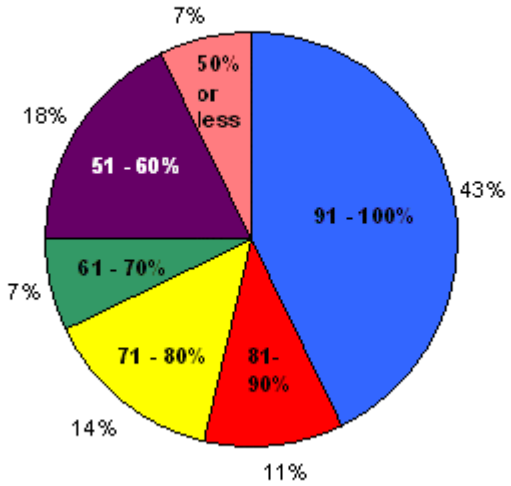
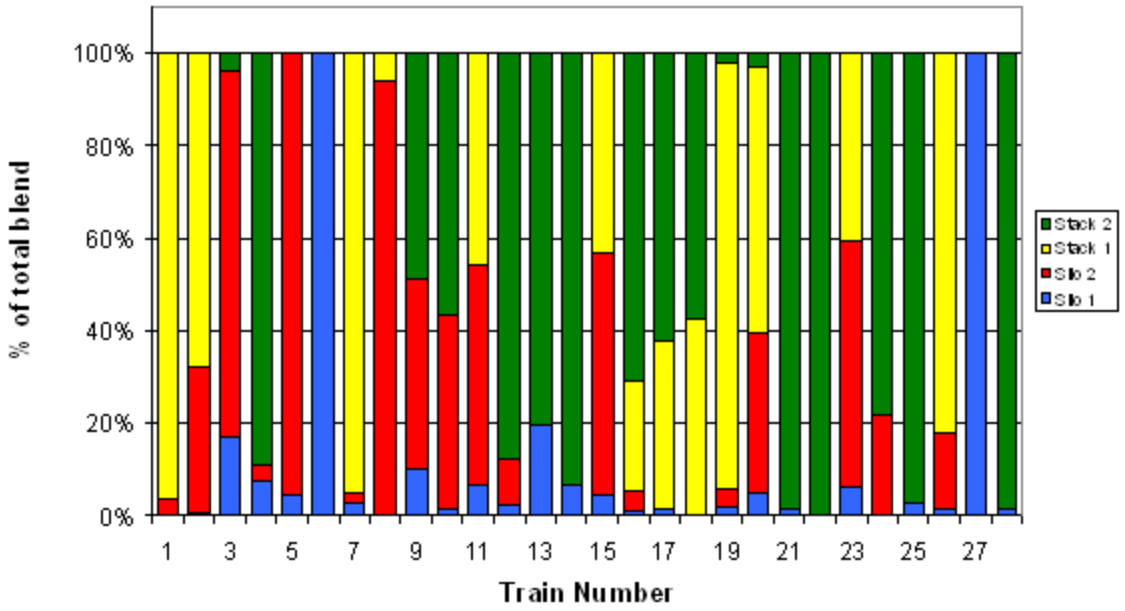


Figure 10. Blending proportions:
Toms Fork Loadout June 2004



When we zero in on control system performance (figures 11 and 12), we can see that in a vast majority of the cases, the ash target was satisfied very closely, and when the sulfur goal wasn't met, it was always because there wasn't sufficient mid-sulfur to meet the spec. In only two trains out of 28, did the actual ash exceed the target ash by more than 1%.

Figure 11. Control System Performance on Ash at Toms Fork Loadout

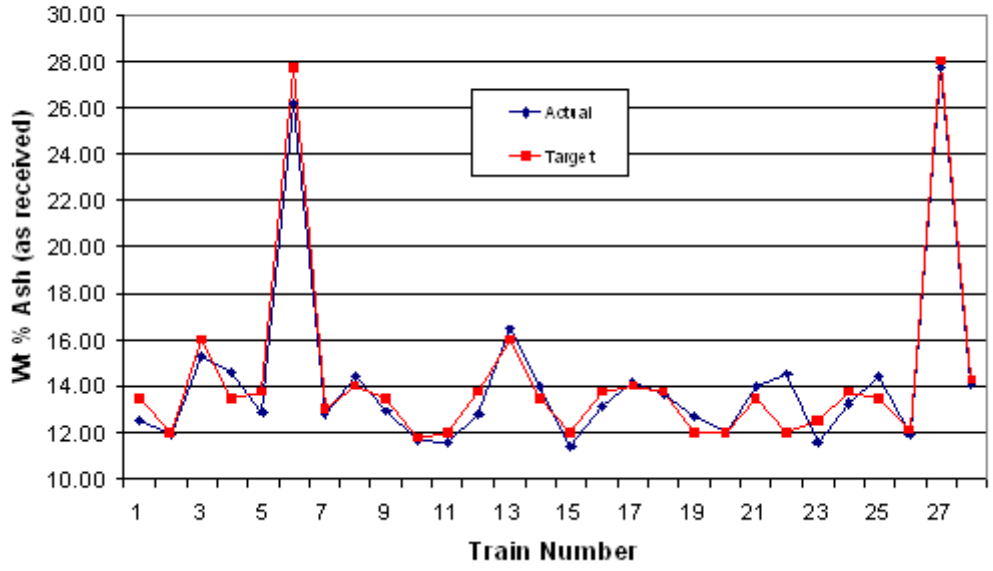
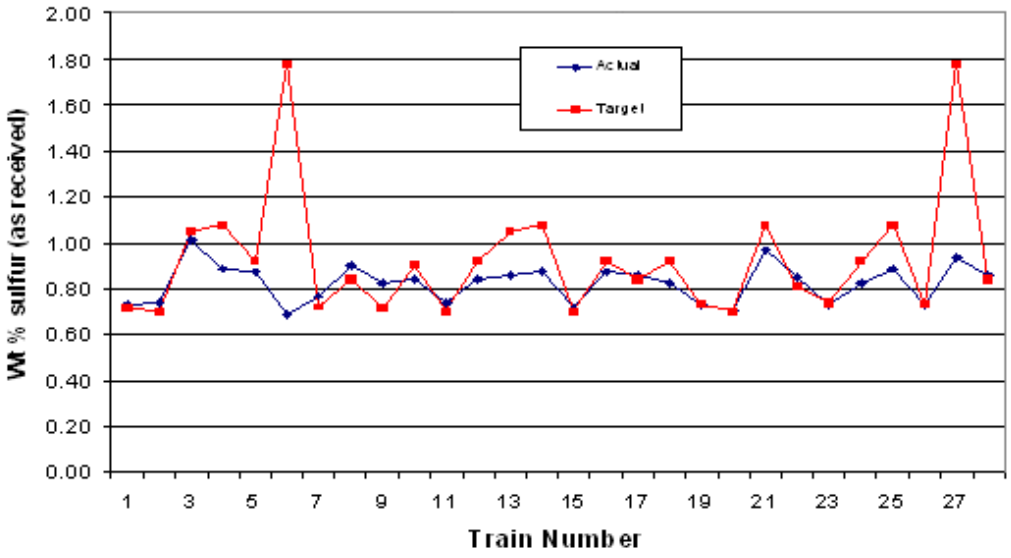


Figure 12. Control System Performance on Sulfur at Toms Fork Loadout



Conclusion

As evidenced by this use of Gamma-Metrics COBOS blending software at Arch Coal's Toms Fork loadout, today's automated coal blending systems are very sophisticated and capable of excellent performance. With capabilities of up to six sources and five control parameters, most blending situations today could be optimized by an automated blending system operating in conjunction with an online elemental analyzer.