Precision sorting

Richard Woodward, Thermo Electron, US, explains how to use an online analyser to perform sorting.

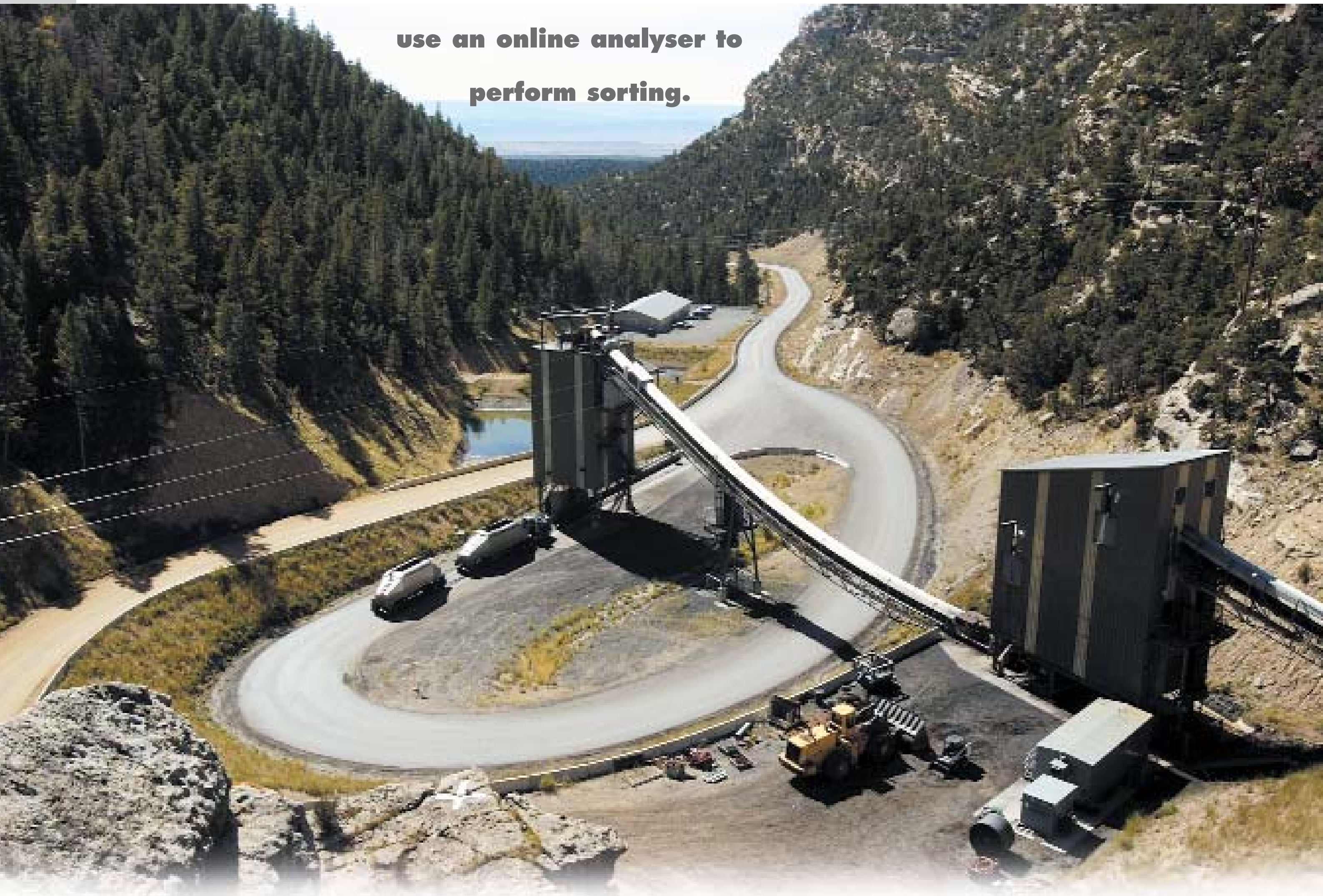

Figure 1. The coal handling system at the loadout includes a crusher tower, a coal analyser, a loadout conveyor, a two-stage sampling system and the truck loadout tower.

A large western US underground mine has experienced significant short-term variability in sulphur and ash as a function primarily of the location of the longwall within the mine. In order to meet the different coal qualities required in its contracts, the mine had to be able to sort the ROM coal coming out of the mine. Only by proper sorting would the mine be able to subsequently blend the coals to meet contract specifications.

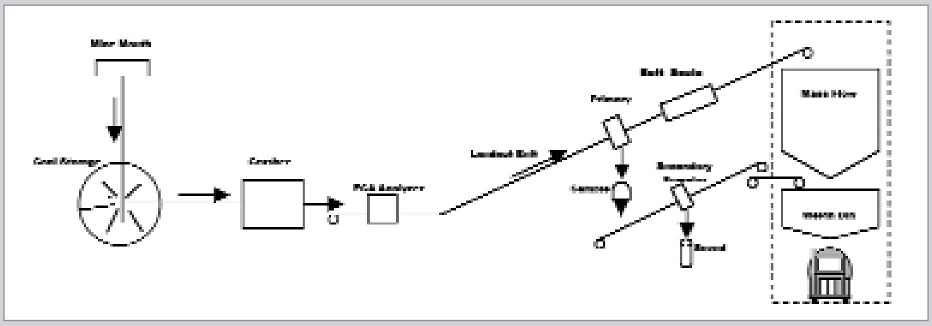

Figure 2. Schematic diagram of the mine and truck loadout.

The mine undertook a revolutionary approach to solve this problem by installing an online analyser around the belt conveyor just ahead of the truck loadout. The company also had to devise a process for taking the information from the analyser and making the proper sorting decision. It developed its own process control system, which takes minute-by-minute coal quality information, passes it through an algorithm and then sends information to a scoreboard (at the truck loadout), which tells the driver which destination he should use, as a function of the sulphur and ash readings from the analyser.

The system has performed reliably since it was installed in 2002. In conjunction with analysers installed at the downstream rail loadouts, the company has consistently met its contract quality targets.

In detail

This western US mine began commercial production in 1999. The mine produces approximately 2.5 million tpa using longwall mining techniques. High Btu coal is mined and is currently sold in markets ranging from the eastern US to the Pacific Rim.

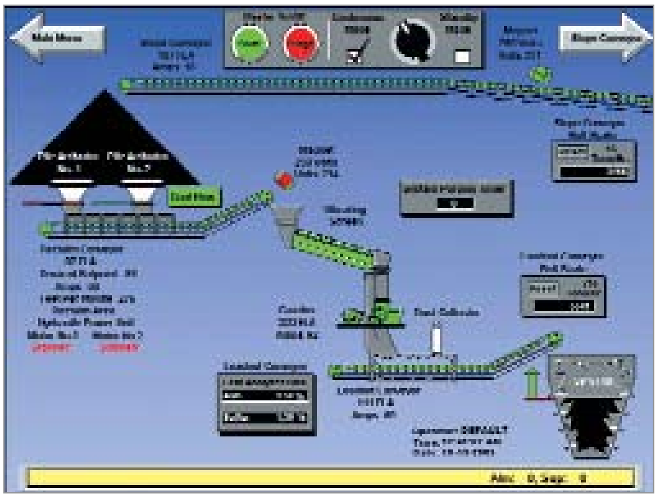
Figure 3. Plant schematic as shown on company's control system.

The mine is an underground mine employing a single longwall. As the coal exits the mine, it goes onto a 50,000 t conical stockpile. The pile has an underground reclaim leading to a nearby crusher building, which reduces the topsize to 2 in. Another short belt conveyor takes the coal to the top of the truck loadout tower. Trucks transport the coal to one of two nearby rail loadouts, the south loadout 20 miles away serving one railroad, and the north loadout 30 miles away serving another railroad. The trucks load in approximately three minutes and carry approximately 43 t. As many as 350 trucks can be loaded in a single day. (Figures 1 to 3).

Project description

Because of the intermittent, almost unpredictable, high sulphur pockets in the mine, as well as normal ash variations arising from in-seam and out-of-seam dilution, the company wanted some way of segregating the high sulphur and high ash coal so that it did not jeopardise the limits in any of its contracts. The only realistic way of doing so was to use an online elemental analyser. When the mine was being developed, almost all elemental coal analysers were designed to analyse a sample stream, with low flow rates leading to analysis time delays of five to ten minutes. The company would not be able to tolerate any analysis time delays because the distance in time between the crusher and the coal entering the loadout truck could be less than five minutes.

Figure 4. The Gamma-Metrics ECA coal analyser fits around existing conveyor and provides minute-by-minute analysis of sulphur and ash.

Fortunately, a couple of years after the mine began, the coal analyser industry introduced full-stream elemental analysers, which was just what this mine required. The company was able to procure an over-the-belt elemental analyser from Thermo Electron, which it installed in 2002, as the mine was still coming up to full production. (Figure 4). The Gamma-Metrics analyser, however, was only one part of the solution. The mine had to devise a method for taking the minute-by-minute analysis information and using it to advise the truck drivers as to which destination they should use for that truck.

To do this the minute-by-minute analyses had to be time-aligned with the coal being loaded into the trucks, which presented something of a challenge. The mine had procured a mass-flow loadout bin, which simplified this challenge. By knowing the speed on the belt where the analyser was mounted, the distance from the analyser to the loadout tower and the capacity of the loadout bin, the mine was able to synchronise analysis information from the analyser with the 43 t batches being loaded into the trucks.

The mine wanted to achieve this process objective without having to add personnel. It was clear that the time-aligned analysis information had to be passed in real-time and automatically to a computer (actually a PLC). This PLC would employ an algorithm that would equate the coal quality to a desired destination (Figure 5). The control system would then communicate that destination to the truck driver. The latter was accomplished by installing a simple scoreboard just forward of the truck while it was being loaded (Figure 6).

Additional analyser considerations

Coal analysers have been commonplace in the US coal industry since the late 1980s. There have always been certain necessary steps to derive optimal performance. Foremost among these steps was onsite calibration, to ensure that the analyser and the local laboratory were in agreement. The mine planned well for this necessity with a two-stage automatic sampling system on the same belt as the analyser. Another requirement for the analysers mounted around the conveyor was a nearby belt scale to allow the analyser to know how many t were represented in each minute's analysis to permit batch averaging. This tph information was also necessary for belt

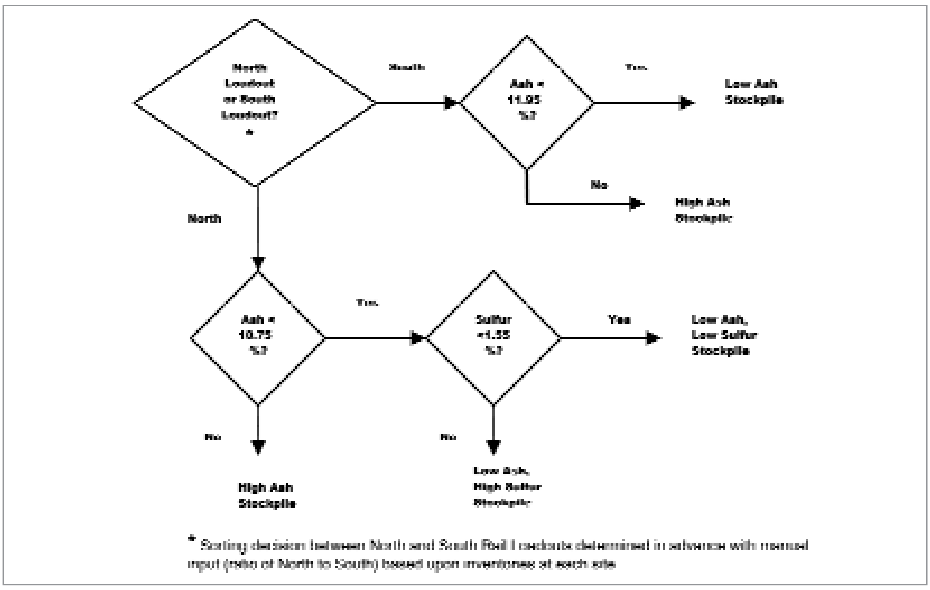

Figure 5. Sorting algorithm used by the mine to determine truck destination.

Figure 6. Up to 350 trucks/day haul 43 t each to one of two rail loadouts, with their actual stockpile destination at each loadout determined by the real-time analyser results. The scoreboard (inset) provides this information immediately upon completion of the truck loading.

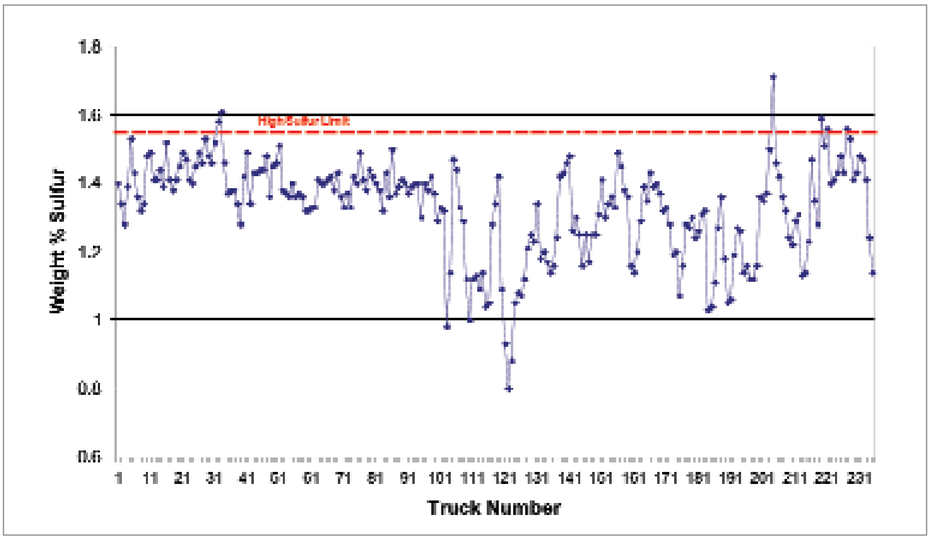

Figure 7. Truck-by-truck sulphur concentration, as determined by the analyser.

analysers because the changing belt loading would affect the raw analysis information. However, the analyser can make corrections by knowing the belt loading.

Beyond these normal preparations for online coal analysis, there were two additional complications unique to this application.

The first complication arose because usually the belt scale is located upstream of the analyser, but this was not possible at this mine. This meant that rather than having a tph figure to send to the analyser to match with each five second batch of spectral information, the analyser had to archive its spectral data and wait for the tph value some seconds later.

The second complication arose because the reclaim from the conical stockpile was intermittent and driven by the levels in the truck loadout bin. This in turn related to the rate at which trucks were arriving to be loaded. Typically the reclaim system would operate for three minutes and then shut off. The Thermo Electron analyser was usually programmed to begin gathering spectral data at the beginning of each minute. However, if that practice were to occur here, in a three minute period of flow the analyser might have two full minutes and two 'partial' minutes worth of spectra. Since the spectrum derived from an empty belt is not useful, the analyser's PLC had to be reprogrammed to begin a one minute analysis only when the coal is flowing and also to cease gathering spectral data when the belt becomes empty.

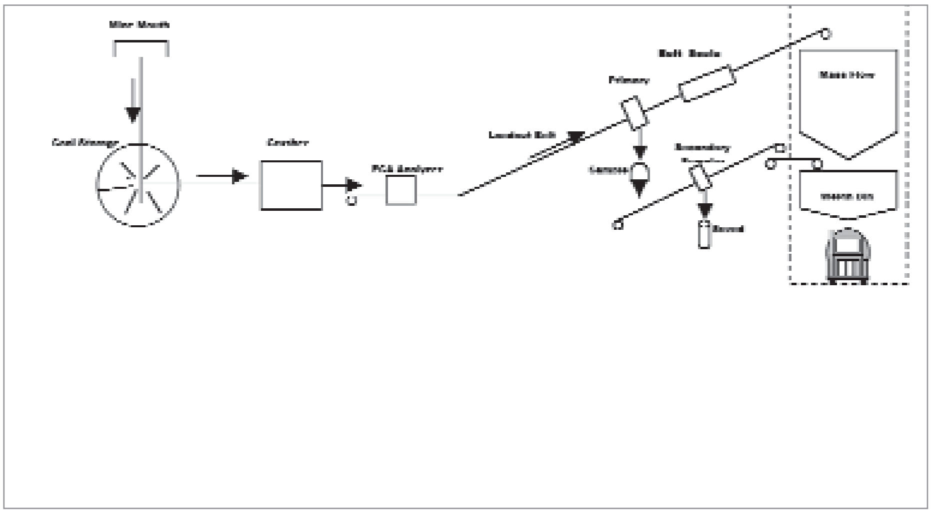

Figure 8. Truck-by-truck ash concentration, as determined by the analyser.

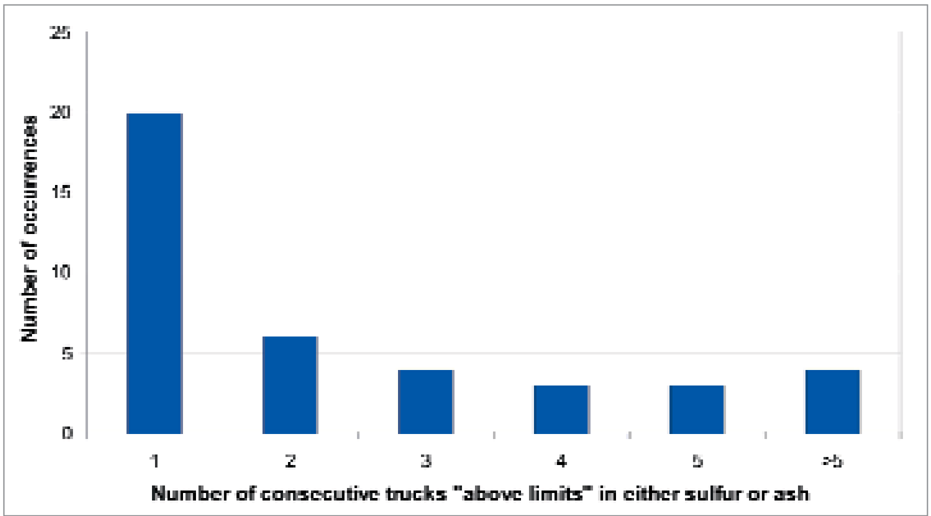

Figure 9. Adverse excursions in coal quality are short lived, necessitating the need for online analysis.

Figure 10. The north rail loadout capitalises on the sorting ability of the mine coupled with another coal analyser on the loadout conveyor.

Experience to date

The analyser and truck sorting system has now been in operation for more than three years. The analyser and the control system have operated almost flawlessly. There have been no significant periods of unavailability. Furthermore, the company has been able to consistently meet its contract quality targets. Contract penalties from the north rail loadout have been eliminated, as have the SO_2 penalties from the south rail loadout. This satisfactory outcome can be attributed to the sorting analyser at the mine, coupled with additional analysers at the loadouts, which control the quality of the railed product.

A truck-by-truck depiction of sulphur and ash concentration from the 6 October 2005 shipments (Figures 7 and 8) shows high short-term variability, particularly toward the end of the day. Without the analyser (Figure 9) it would be impossible to identify those trucks whose sulphur and ash levels were in excess of the contract limits. Good blending at the rail loadout (Figure 10) is contingent upon good sorting in the first place and the analyser and the control system ensure effective and reliable sorting.

Conclusion

Across-the-belt elemental analysers are ideally suited for sorting decisions based on short-term variations in coal quality coming out of the mine. This western US mine has successfully used a Thermo Electron ECA coal analyser to direct each truck to the correct downstream stockpile at two different rail loadouts. The net impact has been a virtual elimination of out-of-spec rail shipments. ■