

THE LATEST SAMPLING TECHNIQUES AND TESTING PROCESSES USED IN COAL QUALITY MANAGEMENT

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ABSTRACT

Advancements in quality control at the mine site, and throughout the entire quality chain from production to consumption, have been made in technology and automation. These have improved sample collection and analysis processes. However, the basic purpose of quality and quantity monitoring, control and verification, which is ultimately to provide information for risk management, has not changed.

MECHANICAL SAMPLING SYSTEMS

Over the past 20 years, materials handling facilities have become larger, with higher throughput capacity and faster conveyor belt speeds. This fact, coupled with the increased emphasis on accuracy and precision, has led to a proliferation of mechanical sampling systems throughout the quality chain. Many systems have been installed and are being used regularly at minesites, washing plants, load-outs, terminals, and plants where coal is consumed.



Cross-belt cutter entering coal stream

Partly because of this rapid growth in mechanical sampling, standards organizations have been very busy developing new guidelines to cope with this phenomenon. This has resulted in the publication of the eight-part ISO 13909, Hard coal and coke- Mechanical sampling in 2001.

Mechanical sampling systems have existed for many decades, though they have not always been used correctly. However, in recent years improvements in the design and control of the cross-

belt sampler have made this type of mechanical sampling device as commonplace worldwide as the more traditional cross-stream samplers, which are installed at conveyor belt transfer points.

Another major component of a mechanical sampling system is the crusher. Since most mechanical sampling systems include some degree of preparation of the coal sample, the downstream processing of the sample material within the system is an extremely important function.

Although it is necessary for all parts of the mechanical sampling system to operate properly and in sync, the crusher is one of the more critical mechanisms. This is the reason why the latest SGS systems utilise a 'toothed' double-roll crusher with cast alloy steel liners for the rolls. Wear characteristics are improved and maintenance costs are thereby reduced.

Other advances include a touch screen control unit. This allows the operator to update the system's parameters by inputting new password-secured operating information whenever required,



The cross-belt 'sweep arm' sampler

without the need for additional programming. The touch screen is also an easy way to monitor the status and performance of the sampling system. In addition, the most up-to-date mechanical sampling systems are designed to accommodate the installation of an online coal analyser within its subsystem.

ONLINE ANALYSERS

The advent of the new breed of online analyser (OLA) more than a decade



Double-roll crusher outside

ago did not have the same impact as the innovations in mechanical sampling during this period. This is because initially the use of the OLA was extremely limited, due to a lack of standardization of the calibration process, which is essential for an OLA to produce meaningful results. OLA instrumentation has improved over the years as have the calibration procedures. OLAs are now routinely installed and operated at mines, washing plants, load-out facilities and elsewhere, but specifically as process control devices.

The following questions should be asked to determine if an OLA is suitable for a particular installation:

- Do the economics of the process control at this site justify the cost of an OLA?
- What are the parameters that can be controlled? For example, ash or sulphur.
- If blending is a goal, are the feeders responsive and scales installed for each blend source, as well as the final product stream?
- Which parameters are for contract purposes, but do not have to be analysed in real-time?
- What degree of accuracy is needed for the process control?

Corollaries to the process control accuracy include the following:

- Is it well known that the calorific value, volatile matter and sulphur dioxide are not directly measured, but calculated from other elements?
- Are the limitations of microwave technology for moisture determination understood, particularly regarding inherent moisture changes or differences?

- If calorific value is the main parameter to be measured, does the dry ash-free calorific value remain fairly consistent?

SGS provides a guide for planning the calibration test procedure, verifying the calibration itself and conducting an OLA performance test. The source document is ASTM D6543. Key elements are the reference methods for sampling, sample preparation and analysis, which must be established and used consistently. One additional key aspect is that the laboratory used for routine quality assurance should also be used for calibration.

During normal use, an OLA can be compared to various routine samples, such as shift samples or other samples collected by the sampling system. These routine samples can be used to construct control charts that provide an indication of the status of the OLA calibration. However, when needed, the one hour reference method is used to make calibration adjustments.

ONE HOUR REFERENCE METHOD

CALIBRATION TESTING

The coal flow, moisture variations and other conditions that can have an effect on the coal stream or coal characteristics must be reviewed. The number of seams, coal types or blends to be used in the test must be established, and the widest range of ash and sulphur values must be selected. The mechanical sampling system should be inspected and its bias test data must be reviewed. Additionally, the suitability of the onsite sample preparation facilities must be evaluated and corrective action taken if necessary.

The one hour sample collection period must be synchronised with the OLA computer clock. This should take into consideration the lag time for the mechanical sampling system to process the sample (the one hour collection period must be a full hour of coal flow). The sampling system should be set to collect at least the sample mass specified in the standard during one hour test periods. All of the proper protocols for sample preparation and analysis must

be used and documented, and the OLA data collection must be in accordance with the manufacturer's procedures. During sample collection the actual coal source, seam mineralogy, etc. should be recorded and compared with the optimal or design conditions. In general, calibration samples are collected after a period of time established in conjunction with OLA manufacturer. During this initial period, the manufacturer confirms that the OLA and related software are fully operational.

VERIFICATION TESTING

Once the calibration parameters are installed in the analyser, verification samples are collected in the same manner as outlined above, in order to confirm that the calibration parameters are correct. Once the verification is complete, the OLA is ready for performance testing.

PERFORMANCE TESTING

Performance test samples are collected in the same manner as the calibration and verification samples. One of the recommended methods for performance testing (in ASTM D6544) is the Grubbs test, which requires the collection of 60 test sets. This test also required an independent sample to be collected from the coal flow, which can be extracted from one of the reject streams within the mechanical sampling system.

DATA EVALUATION

Calibration data must be reviewed and calibration parameters established by the manufacturer. The manufacturer must also review verification data. However, the performance test data should be calculated and reviewed independently.

REFERENCE BLOCK TESTING

A routine evaluation method for OLA utilises 'reference blocks'. This eliminates the effect of comparison to routine sample analysis or the reference sampling and analysis method. The reference blocks, provided by the manufacturer, are comparative tools that are placed in the analyser's path (between the source and detector). The analyser is set up to interrogate the block with a 'raw' calibration, which does not change when it is re-calibrated.

The interrogation period is usually four hours or as directed by the OLA manufacturer. or as directed by the OLA manufacturer. It is advisable to read the calibration blocks before and after source refreshment to provide a temporary analyser calibration adjustment prior to its updating via the reference method. The objective of reference block testing is to determine whether the analyser is stable with respect to the last block reading and/or historical information. The reference blocks are not used to calibrate the analyser. Optimal use of the reference block should be verified with the OLA manufacturer.

PERFORMANCE OF MECHANICAL SAMPLING SYSTEMS

Particle size and particle size distribution affects the development of the sampling programme for any material. In general, the more quality variation among the particles, the more difficult it is to sample the material and the more intricate the sampling scheme becomes. Therefore, it is obvious that the various sizes, shapes and densities of coal particles have an enormous impact on the design of the mechanical sampling system, as well as how it is operated.

As indicated, there is an abundance of mechanical sampling systems installed around the world, with online analysers utilizing coal streams from many of these systems. Therefore, it is crucial that mechanical sampling systems function properly. Consequently, performance tests (bias tests) are necessary to document the accuracy of these systems.

Although bias testing of mechanical sampling systems have been conducted for many decades, it is fortunate that ISO, ASTM and other international standards bodies have discussed and documented the latest bias testing techniques. The most notable standards for the bias testing of coal mechanical sampling systems are as follows:

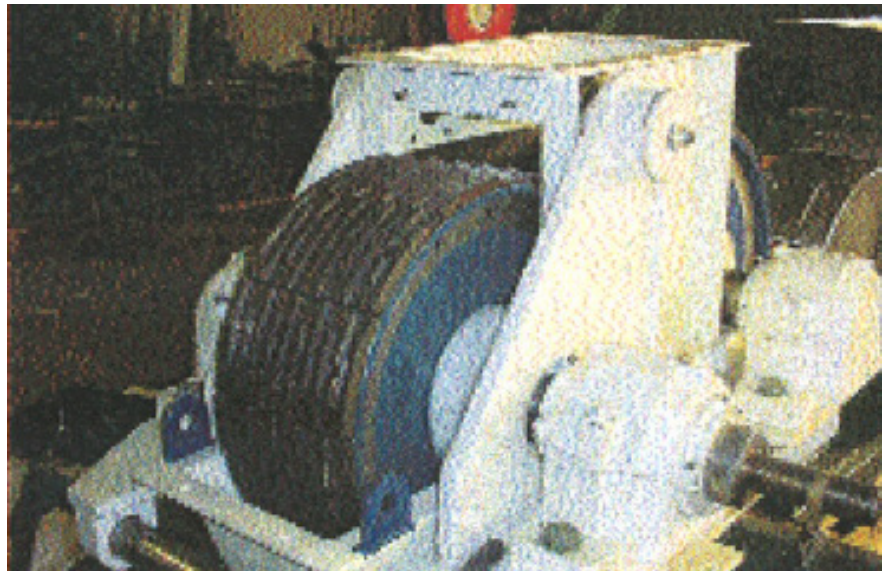
- ISO 13909: hard coal and coke - Mechanical sampling - Part 8: Methods of testing for bias.

- ASTM D6518: Standard Practice for Bias Testing a Mechanical Coal Sampling System.

It is impossible to design an effective mechanical sampling system (MSS) without knowing detailed information about the characteristics of the material to be put through the system and where the system is to be installed. The following points are some general rudimentary requirements for the design of MSS:

- Apertures of cutters, chutes, etc. must be at least 2.5 times the top-size of the material.
- There must not be any choke points within the system. The construction

Conceptually, a bias test on a coal mechanical sampling system is a simple comparison of the material extracted by an MSS to the material from which it was extracted. However, in practice the bias test is complicated by the existence of various statistical models, experimental designs, and interpretive techniques. However, in this instance it is inappropriate to itemise the various options available for bias testing programmes. During a bias test, the samples collected by the mechanical sampling system are compared to reference samples, which are typically collected from a stopped conveyor belt ('stopped-belt' samples).



Double-roll crusher inside

material should be as resistant as possible to the material being sampled.

- The entire system should be compact and airtight, but with access doors through which cutters chutes, conveyors, etc. can be inspected.
- Overall, the system must comply with the pertinent international standard being employed, e.g. ISO, ASTM.

BIAS TEST

A bias test is usually conducted at the time the MSS is commissioned in order to document its suitability for use at that particular site. Bias testing can also be part of an ongoing quality assurance programme.

CRITICAL INSPECTION AND SPC CHARTS

A bias test is usually preceded by a 'critical inspection' of the mechanical sampling system. This is performed in order to identify any obvious areas that need corrective action before the actual bias test is conducted. However, critical inspections can also be used in ongoing quality assurance programmes.

Mechanical sampling systems are subject to wear and require regular maintenance. They also require regular verifications of their continued capability to operate as designed. Once put into service and shown to be capable, the MSS must undergo frequent surveillance to monitor and control its performance

and demonstrate that the device is consistent from day to day. A common method for monitoring and controlling the MSS performance on an ongoing basis is the critical inspection together with statistical process control (SPC) charts.

Since there are many different types and designs of mechanical sampling systems, which utilize a variety of different components, it is not possible to provide a critical inspection procedure that will be universally appropriate. However, the following general requirements are offered:

- An experienced inspector must be perform the critical inspection.
- There must be a report that records each critical inspection.
- Corrective action (or preventive action) requests must be prepared when problems are encountered.
- Maintenance requests must also be part of the critical inspection report.
- All corrective, preventive or maintenance requests must be followed-up to ensure compliance.

During critical inspections, measurements are made of the speed and opening of the cutters, and historical records are reviewed for feed rates, lot sizes, etc. The theoretical extraction ratio is determined and compared to the actual extraction ratio. If the two values are not within 10% of each other, then at the outset there is reason to question the measured values or the operation of the MSS.

SPC charts are used in conjunction with periodic critical inspections. They are employed to document whether

the mechanical sampling system is operating in the same manner as during its last bias test. Conventional wisdom indicated that if there are no changes to the extraction ratio, then it is reasonable to assume that there is no fundamental change in the operating or bias condition of the MSS. Individual and moving range SPC charts are used for this purpose.

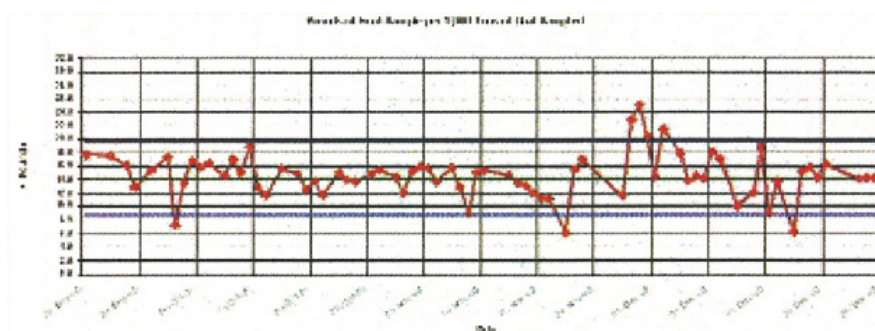
Where there is a deviation beyond a pre-determined action limit, an investigation in to the cause of the excursion is conducted.

Plotting and monitoring individual and moving range SPC charts allows the control of the two fundamental characteristics of any process distribution; its centre and its range.

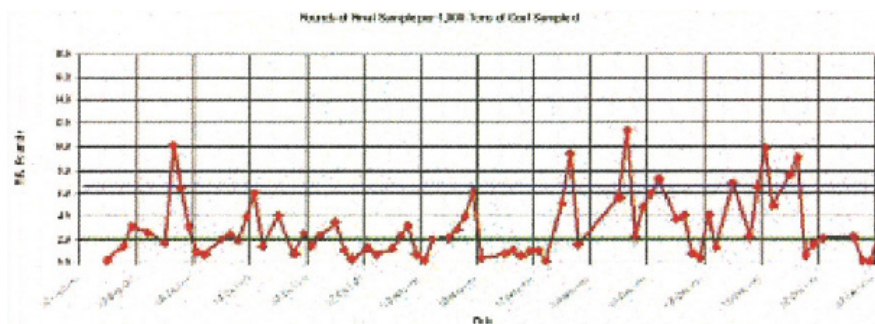
This is the reason the weight (mass) of the sample produced by the mechanical sampling system for every 1000 t of coal should be routinely determined and plotted on SPC charts. This promotes the continual real-time monitoring of the MSS performance.

CONCLUSION

Clearly, there have been advancements in technology, automation and standardization involved with coal quality monitoring, control and verification. These improvements have been significant and provide better information on which to base risk management decisions.



An SPC 'individual' chart, sample mass per 1000 t



An SPC 'moving range' chart, sample mass per 1000 t

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