Coal Analyzers Applied to Coal Cleaning: The Past, the Present, and the Future

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R. Woodward
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Presentation Outline

- A brief review of online coal analyzers
  - Ash only analyzers
  - Elemental analyzers
  - Choosing the right analyzer
  - Prep plant control methods
- Case Study
  - Operational environment
  - Process control approach
  - Results
- Conclusion
Ash Gauges

- Dual-gamma gauges (also known as LET and DUET)
  
  Scantech’s Coalscan 2100
  
  GTA 1000 from Indutech
  
  Scantech’s Coalscan 2800
  
  - Operate on the assumption that ash composition does not change
  - One gamma compensates for changes in belt loading
  - The other gamma distinguishes high atomic number elements (ash) from low atomic weight elements (C, H, O)
Measurement error of dual-gamma ash gauges arising from variations in Fe$_2$O$_3$

![Graph showing error in ash determination versus variation in Fe$_2$O$_3$ as a percent of ash.]

- 3.0% error for 35% ash
- 1.2% error for 25% ash
- 0.0% error for 10% ash
Ash Gauges (continued)

- Natural Gamma Gauge

  - No radioactive source
  - Detects natural gamma radiation from potassium or thorium
  - Relies on the assumption that the $K_2O$ percentage of ash does not change

Scantech’s Coalscan 1500
History of ash gauges in prep plant application

- Approximately half of all online ash gauges are used in prep plants.
- About 20% of those monitor the raw coal entering the plant.
- A majority of those analyzers, numbering more than 50, were a waste of money for the coal producer.
- More importantly, they created a negative image for analyzers in general, an image that persists today among some coal producers and throughout certain countries.
Most use the technology known as PGNAA (prompt gamma neutron activation analysis)

Two types of PGNAA analyzers exist

- Sample stream
  - Typically flow rates of 2-10 tph
  - Most accurate analyzer in industry
  - Constant analysis geometry

- Full flow
  - Effective on belt sizes up to 60 inches
  - Accuracies best when belt loading variations are small
How does an elemental coal analyzer derive ash?

From Elemental Coal Analyzer

Si  Al  Fe  K  Ti  Ca  Na

Common oxide form

SiO₂  Al₂O₃  Fe₂O₃  K₂O  TiO₂  CaO  Na₂O

Key Assumptions

Constant non-measurable fraction of ash

Total Ash

= \frac{\sum \text{ (6 or 7 ash oxides)}}{1 - \text{non measurable ash fraction}}
Accuracy comparison: sample stream vs. full flow

Arch Mountain Laurel CQM: Lab vs. Analyzer Ash
Comparison
August 2007

Arch Mountain Laurel ECA: Lab vs. Analyzer Comparison
August 2007

When flow is consistent and belt is fully loaded, the accuracy difference is slight; in this example

• 10% worse RMSD
• 20% worse Std Error of the Estimate
Historic patterns of analyzer use

Percent of analyzers sold into prep plant applications

- Dual-gamma attenuation
- PGNAA sample stream 1984-1999
- PGNAA belt 2001-present
- PGNAA sample stream 2000-present

Analyzer brand & type:
- Scantech
- Thermo Scientific
In the US today coal producers have a better understanding of what coal analyzers can and cannot do
- Few ash gauges are bought to monitor prep plant feed
- Most analyzer purchase decisions are based upon projected ROI rather than hope

However, more than 80% of today’s new prep plants are being built in China and India
- Most do not have analyzers
- Those that do still chose predominantly dual-gamma ash gauges
What does the future hold?

- 25 years of online analyzer history does not suggest an imminent breakthrough in performance
- However, incremental improvement is likely in several areas
  - Auto diagnostics
  - Detectors
  - Electronics
  - Process control
- Trace element detection will still be problematic
When do you really need an analyzer?

- When the pressure to meet contract specs is high, either to foster a reputation for quality, or because the penalties for off-spec shipments are severe
- When there is a reasonably convenient means of varying the product ash
  - Raw coal bypass
  - Heavy media plant
- When the contract ash limits are close to the target ash
When can you do without?

- When there is a downstream means for correcting variations in product ash
- When the contract penalties for shipping out-of-spec product are not severe
Recommended analyzer selection process

- Tight
  - PGNAA sample stream analyzer
  - Dual-gamma ash gauge

- Moderate
  - PGNAA belt analyzer

Accuracy Requirement

- 5% (Moderate)
- 15% (Moderate)
- 45% (Tight)

* subject to iron variability
** subject to belt loading variability
How does the prep plant take advantage of online analysis to control ash?

- Change gravity setting
  - Alliance Pontiki

- Change raw coal bypass fraction
  - Alliance Gibson County
  - Cumberland Coal
  - Howick (Australia)
  - Catherine Hill Bay (Australia)
  - United Collieries (Australia)
  - An Tai Bao (China)

- Adjust refuse gate height on some jigs
  - Monterey Coal

- Change the middlings fraction sent to rewash
  - Arch Mountain Laurel
Recent case study

- **Gibson County Coal**
  - The mine
    - Underground mine in southern Indiana
    - November 2000 start up
    - Produces low-sulfur coal
    - 100% steam product
  - The preparation plant
    - a capacity of 700 tons of raw coal an hour
    - Uses heavy media cyclones
    - Two ash target levels: 7% and 10%
- Raw coal passes through diverter entering the plant
- Raw coal bypass fraction ranges from
  - 0 – 5% for low ash customer
  - 15-25% for 10% ash customer
- Online coal analyzer positioned on product side of prep plant monitoring the raw/clean blend
- Raw coal bypass fraction controlled by control room operator based upon analyzer rolling average ash value
Raw Coal Handling

Continuously variable diverter

Raw Coal plant feed

Raw Coal Bypass
Regular, minor adjustments made in raw coal bypass fraction

% of Raw Coal Bypassing the Gibson County Plant over a 4-hour period

0% 5% 10% 15% 20% 25%

% of raw coal bypassing the plant

8 pm 10 pm midnight
Ash quality maintained close to target

Figure 7. Gibson County Prep Plant Ash from one day in February 2006
Real-time plots taken off of Analyzer Operator Console

- Plant Feed (tph)
- Product Tons (tph)
- Product Ash (Wt. %)
- Raw Coal Bypass (tph)
Gibson County’s Online Coal Analyzer

- Product is Gamma-Metrics CQM (Coal Quality Monitor) from Thermo Scientific (formerly Thermo Electron)
- Analyzes primary sample stream from a 2-stage mechanical sampler
Since the analyzer and the diverter were installed, prep plant product consistency has improved considerably.

Raw coal bypass approach has inherent advantages
  • no need to adjust gravities
  • raw coal bypass fraction can be controlled either automatically or by control room operator
A large percentage of coal analyzers are used in prep plant applications. Most of them are simple ash gauges, but those applied to the measurement of raw coal are generally inaccurate. Not all prep plants can justify the purchase of an analyzer, but those that do should focus on analyzers located on the product stream. The choice of analyzer type depends primarily upon the degree of accuracy required. There are several ways to exploit online analysis data, one of which is to control a continuously variable diverter to adjust the raw coal bypass fraction.
Questions and Comments