Cement analysis

Application of online elemental analysis for control of sinter feed basicity

Introduction

This application note describes the implementation and benefits of using the Thermo Scientific™ CB Omni™ Agile Online Elemental Analyzer for sinter as a primary sensor for basicity control in the iron ore sintering process.

Sinter is the primary feed material for making iron in a blast furnace. It is created by mixing iron ore concentrate with several additives such as limestone and silica to control the chemistry, and then igniting the mixture at 1200 °C in a continuous belt-fed furnace.

The basicity of sinter feed material is an important parameter in the efficient operation of the sintering and iron-making process. Basicity is a chemical parameter that plays an important role in determining the formation of different mineral phases in the sinter. It is calculated from the ratio of two or more elements that are known to affect the alkalinity of the material. Stabilization of the basicity of the sinter product delivers benefits not only to sinter operations but to the downstream iron-making process. With the Thermo Scientific CB Omni Agile for sinter, it is now possible to measure sinter feed chemistry online and provide minute-by-minute data to enable control of basicity in real-time.

The CB Omni Agile for sinter provides accurate, reliable chemical analysis of material on conveyor belts, and features high availability and minimal maintenance. In installations around the world, the CB Omni Agile configured specifically for sinter feed applications has proven to be a valuable tool for optimizing sinter feed basicity by providing the essential online data needed to control sinter feed chemistry. The resulting control and stabilization of sinter feed has delivered significant economic benefits both for the sintering process and the blast furnace.

The importance of sinter feed control

Sinter feed composition control is important because the various sinter feed materials are often imperfectly characterized, and the chemical make-up can vary between batches and even within a batch. Therefore, changes to the raw feed material chemistry and the additives' feed rates should be adjusted to smooth out such variations in the sinter strand feed chemistry.

In a typical sintering operation, the control of the sinter feed chemistry is based on composite samples of the final sinter product. In addition to errors normally associated with sampling and analytical lab analyses, there is a lag of many hours between receipt of composite sample assays and the receipt of actionable results; the sinter feed chemistry quite possibly will change in the meantime. The operation may also lack sampling equipment on the sinter feed conveyor.

Sinter product composite samples are typically obtained by incremental sampling. If the sampling frequency is too long, short-term variability in sinter composition will be missed. Composite samples tend to smooth out and hide true process variability so are not on a short enough time scale to achieve optimum sinter feed chemistry control. Consequently, process upsets and missed chemistry targets in the sinter product will unknowingly be passed along to the blast furnace.

Advantages provided by CB Omni Agile analysis

Through the use of real-time chemical analysis data from the CB Omni Agile, the sinter feed basicity can be controlled to provide a more consistent feed to the sinter strand. Control is made possible by using the CB Omni Agile's analysis of CaO, SiO_2, and other species that affect basicity within a pre-determined additives control strategy. The CB Omni Agile also provides a total moisture measurement. When combined with a free moisture measurement, such as that provided by the Thermo Scientific™ LFM_3 Moisture Analyzer, the total moisture of sinter feed can be determined.

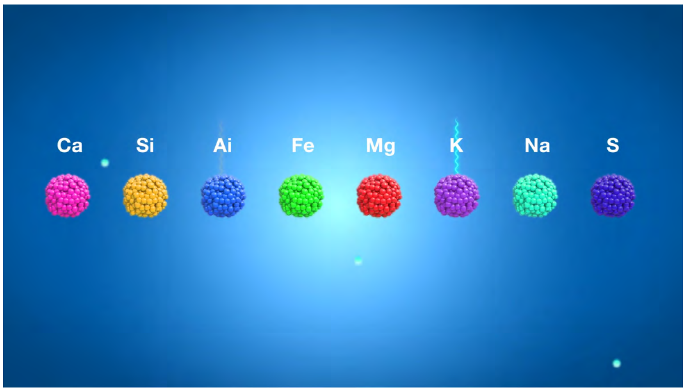

Figure 1. CB Omni Agile measured the full volume of material passing through the instrument.

The CB Omni Agile is a true bulk material analyzer. It uses deeply penetrative radiation to excite and measure all of the material on the conveyor as it passes through the analyzer (Figure 1). This enables accurate and consistent analysis independent of particle size or surface effects, with no sampling errors. The CB Omni Agile analyzer is located over the sinter feed conveyor (after the agglomeration drum), where it sees a homogenous presentation of material on the feed conveyor. This location is the preferred choice for installation, enabling automatic feedback control of the additives.

Because of these unique characteristics, the CB Omni Agile can be factory-calibrated using reference standards. These standards are manufactured from high-quality industrial-grade materials to match the elemental composition over the expected range of the process material. During the factory calibration process, these standards are configured within the CB Omni Agile tunnel to simulate the range of belt loading that the CB Omni Agile will encounter in the process plant as specified in the pre-sales questionnaire. Each CB Omni Agile is factory tested and calibrated with these standards (Table 1) so that when it arrives on site it is ready to provide useful analytical results as soon as it is commissioned.

	SiO_2	Al_2O_3	CaO	MgO	MnO
Static guarantees (RMSD) %	0.30	0.60	0.40	n/a	n/a
Onsite static performance (RMSD) %	0.27	0.29	0.14	0.19	<0.01

Table 1: Typical CB Omni Agile for sinter static calibration guarantees.

The analyzer is also shipped with a set of site-specific reference standards that are used both for verification of the static calibration of the instrument as part of the commissioning acceptance process and for periodic health checks post-commissioning. After the CB Omni Agile is put into operation, the static calibration is further refined with a dynamic calibration in which the online chemical analysis of the sinter feed is adjusted to agree with the sinter product chemistry. The factory configuration process includes an implementation within the analysis software routines to calculate basicity from the analyte values, using the sinter plant's specific formula obtained from the pre-sales questionnaire.

Benefits

- Rapid analysis time allows for early detection of process upsets and variability in the feed composition
- Entire sinter feed process volume is measured resulting in improved analysis and reduced errors normally associated with mechanical sampling methods
- Factory pre-calibration reduces commissioning costs leading to multiple benefits:
  - Elimination of protracted and expensive stop-belt calibration sampling campaigns
  - Quicker adoption and acceptance of the analytical results
  - Timely realization of process improvements and quicker return on investment
- Calibration to sinter product chemistry using existing sampling and composite analysis data eliminates the need to invest in sinter feed composite sampling equipment in order to optimize sinter additives
- Accurate and reliable analysis allows better control of additives to stabilize feed chemistry
- Downstream sinter process is improved through reduction in variability of basicity
- Moisture measurement is included to assist in the implementation of a moisture control scheme
- The load on a laboratory for analysis of control samples for chemistry and moisture determinations is greatly reduced

Blending control

In order to achieve a set point value or permitted range of values for the basicity, the sinter plant control system must be configured with a process control strategy that can regulate certain target chemical values through controlling the additives' feed rates.

The CB Omni Agile basicity reading is a primary process input for an additives control strategy. A typical additives strategy will include adjustment of the limestone (in CaO form) bin weigh feeder feed rate onto the sinter feed belt to regulate the basicity to a pre-determined set point value.

As the conveyor leaves the additives station it proceeds to a mixing drum where the iron ore concentrate and additives are blended to a homogenous mixture (Figure 2). The chemistry of the additives must be known to a reasonable degree so that the control strategy can make a first-pass attempt at determining the addition rate of each additive. Since the CB Omni Agile is measuring this mixture on a minute-by-minute basis, the control strategy adjusts the limestone weighfeeder set point to maintain the basicity set point.

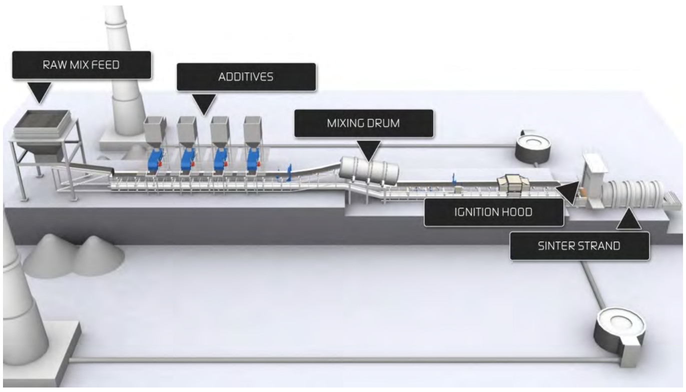

Figure 2: CB Omni Agile analyzer provides input to the process control system.

To achieve such control, the additives bins must be equipped with weigh feeders that can accurately weigh and control the rate of mass delivered to the sinter feed conveyer. Weigh belt feeders such as the Thermo Scientific™ Model 90-125 or 90-150 are commonly used for this purpose. Blending control using online analysis is beneficial because the incoming feed material and additives are not perfectly characterized and there is variation of chemistry between batches and even within each batch. Measuring the mixed product feeding the sinter furnace online on a minute-by-minute basis allows the additives' feed rates to be adjusted to compensate for these variations and thereby provide a more stable feed chemistry to the downstream process.

Sinter feed analysis and blending

Results from at least one iron ore sinter operation employing limestone additive control system have shown that variability of basicity can be reduced by 50% (Table 2).

Month	Strand #2 (uncontrolled)	Strand #3 (analyzer plus LDCS)	Strand #4 (uncontrolled)
September	0.04105	0.04382	0.04925
October	0.04120	0.04226	0.04969
November 1–15	0.04387	0.02333	0.04650

Table 2. Example of reduction in standard deviation of basicity in sinter feed using a CB Omni Agile based basicity control strategy.

The blending strategy for sinter feed additives based on the mixed product chemistry measured by the CB Omni Agile should take into account the plant objectives for control of costs and any process and material handling constraints that are unique to each industrial site. Control strategies are created by in-house or contracted process control engineers in consultation with process specialists and are implemented by process control specialists through the appropriate configuration of the plant control system.

Meaningful improvements in the stability of sinter feed can be realized within a properly implemented additives control strategy, as seen on the trend graph in Figure 3.

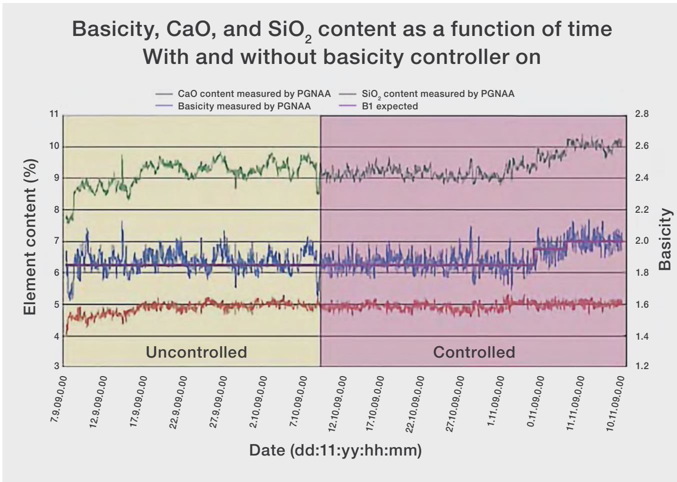

Figure 3. Graph of sinter feed chemistry with and without basicity control. B1 expected is the control set-point.

Not only can variability be reduced, but set point targets can be quickly reached and verified. This allows greater operational flexibility for both the optimization of additives usage and stabilization of sinter feed.

Conclusions

Since 2007, through sinter plant installations across the globe, it has been demonstrated that reliable and accurate online elemental analysis of sinter feed can be achieved using a factory-calibrated CB Omni Agile that has been configured for the sinter feed application.

From the constituent elements, online basicity can be accurately determined and used for automatic control of sinter feed basicity resulting in meaningful economic benefits for the downstream iron-making process. Interestingly, it has been found that sinter plants do not commonly have sinter feed conveyor belt sampling stations from which validation or dynamic calibration samples could be obtained.

This would pose a challenge for a lesser analytical technology. It has been shown that the CB Omni Agile can be dynamically calibrated against the sinter product composite sample chemical data that historically has been used to control the sinter feed additives feed rates prior to installation of the CB Omni Agile.

In several cases, plant operators were reluctant to incur capital or lost production costs to implement sinter feed sampling systems or even a stop-belt calibration sampling campaign.

In these cases, the unique pre-calibration feature of the CB Omni Agile has delivered meaningful benefits and return on investment.

CB Omni Agile Online Elemental Analyzer.

A well-implemented CB Omni Agile basicity control scheme can deliver the following benefits

- More consistent sinter product—improved sinter quality and stabilized feed to the blast furnace
- Increased sinter strand and blast furnace throughput due to reduced sinter product variability
- Decreased return fines, which lowers material handling costs
- Reduced load on testing laboratories, allowing capacity to be used elsewhere without incurring additional costs
- Net reduction in cost per ton of sinter production

CB Omni Agile provides multiple advantages:

- Reliable and accurate analysis, with high availability and low maintenance requirements
- Significantly reduced and more easily controlled variability of basicity in sinter feed
- Real-time analysis of sinter feed chemistry
- Lower commissioning costs and more rapid realization of return on investment, due to factory calibration
- Dramatic reduction of fundamental sampling error because the entirety of the material on the belt is analyzed
- Automatic compensation for variable belt loading, making results more reliable

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