

# Application of on-line elemental analysis for control of sinter feed basicity

This application note describes the application 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. Sinter is created by mixing iron ore concentrate with several additives such as limestone and silica to control the chemistry and then igniting it 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 calculated chemical parameter composed of 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 the 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 on-line and provide minute by minute data to enable control of basicity in real time.

The CB Omni Agile for sinter (Fig. 1) provides accurate, reliable chemical analysis of material on conveyor belts with 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 on-line analysis 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.

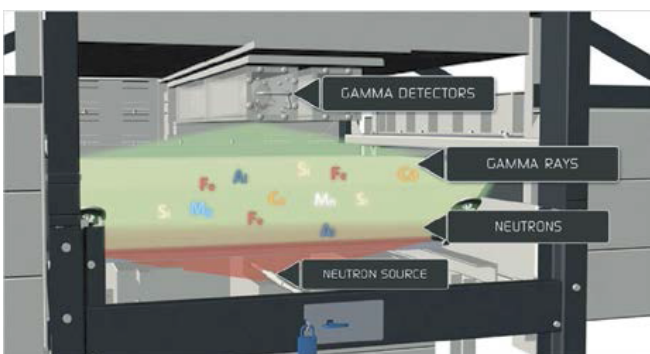
Sinter feed composition control is important because the various sinter feed materials are not perfectly characterized and their chemical make-up varies within a batch and between batches. Therefore the raw feed material chemistry changes and the additives feed rates should be adjusted to smooth out these 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 errors there is a lag of many hours between receipt of composite sample assays and current sinter feed chemistry. The sinter 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.

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 analysis of CaO, SiO<sub>2</sub> as well as other elements that affect basicity within a per-determined additives control strategy. The CB Omni Agile also provides a total moisture measurement. When combined with a free moisture measurement such as provided by the Thermo Scientific LFM3 the total moisture of sinter feed can be determined.

**Figure 2: 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 2). 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.

Table 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.

The analyzer is also shipped with a set of site specific reference standards that are used to verify both 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, this static calibration is further refined with a dynamic calibration in which the on-line 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 detection of process upsets and variability in the feed composition
- Entire sinter feed process volume is measured resulting in:
  - improved analysis
  - reduced errors normally associated with mechanical sampling methods
- Factory pre-calibration reduces commissioning costs leading to:
  - 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
- Calibrate to sinter product chemistry using existing sampling and composite analysis data
  - Eliminates 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

- Improve downstream sinter process through reduction in variability of basicity
- Includes a moisture measurement to assist in the implementation of a moisture control scheme
- Reduction in load on lab for analysis of control samples for chemistry and moisture determinations

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

	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	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

## 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 is designed to regulate certain target chemical values by 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 (CaO) bin weigh feeder feed rate onto the sinter feed belt to regulate the basicity to a pre-determined set point value.

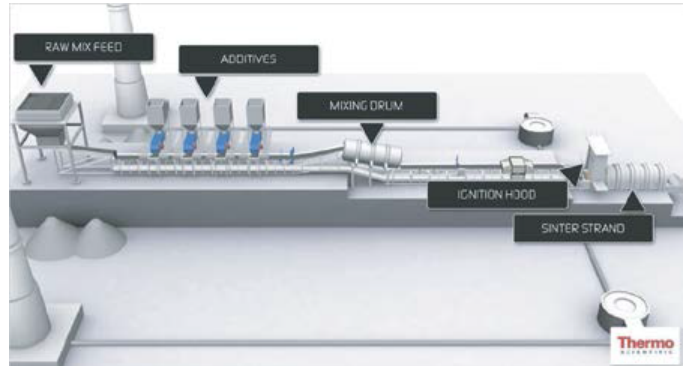
As the conveyor leaves the additives station it proceeds to a mixing drum where the iron ore concentrate and additives are blended to a homogenous mixture (Figure 3). Generally the chemistry of the additives must be known to a reasonable degree so that the control strategy can make a first pass attempt at determining the addition rate of each additive. Since the CB Omni Agile is measuring this mixture on a minute to minute basis, the control strategy can adjust the limestone weigh feeder set point to maintain the basicity set point.

To achieve such control, the additives bins must be equipped with weigh feeders that can accurately weigh and control the mass rate delivered to the sinter feed conveyor. Weigh belt feeders such as the Thermo Scientific Model 90-125 or 90-150 are commonly used for this purpose. Blending control using on-line analysis is beneficial because the incoming feed material and additives are not perfectly characterized and there is

variation of chemistry within each batch and between batches. Measuring the mixed product feeding the sinter furnace on-line on a minute by minute basis allows the additives feed rate 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

**Figure 3: CB Omni Agile analyzer provides input to the process control system.**



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).

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

Month	Strand #2 (Uncontrolled)	Strand #3 (Analyzer plus LDCS)	Strand #4 (Uncontrolled)
Sept.	0.04105	0.04382	0.04925
Oct.	0.04120	0.04226	0.04969
Nov. 1-15	0.04387	0.02333	0.04650

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 well implemented additives control strategy as seen on the trend graph in Figure 4.

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

## CB Omni Agile product key advantages

### Bulk material analysis

The CB Omni Agile uses Prompt Gamma Neutron Activation Analysis (PGNAA) to determine elemental concentration in bulk materials. The method is deeply penetrative and measures through many centimeters of material making it an ideal technology for real-time analysis of bulk materials on conveyor belts. Because the entire process stream is analyzed there are no errors normally associated with mechanical sampling. The combination of real-time analysis, full process stream analysis, accurate and reliable elemental analysis delivers a practical tool for sinter feed quality optimization.

### Factory calibration

The factory testing and pre-calibration of the CB Omni Agile on sinter calibration standards delivers accurate analytical results during and after the in-plant start-up phase. This eliminates costly and time consuming stop belt sampling campaigns requiring the acquisition of many calibration samples to develop and validate robust calibration models. Confidence in this initial CB Omni Agile sinter feed analysis is further deepened through the implementation of dynamic calibration using the sinter product composite sample chemistry.

### Automatic Belt Load Compensation (ABLC)

The automatic belt load compensation feature ensures analyzer accuracy over a range of changing production rates and belt loading. As the material loading on the belt changes so do the signals from the analyzed volume and the conveyor background. If not compensated for, these signal changes would increase the analyzer measurement error. This ABLC feature, unique to the Thermo Scientific CB Omni Agile, ensures that the Sinter feed chemical analysis remains accurate through the expected range of belt loading conditions found in typical sinter feed operations.

## Installation considerations

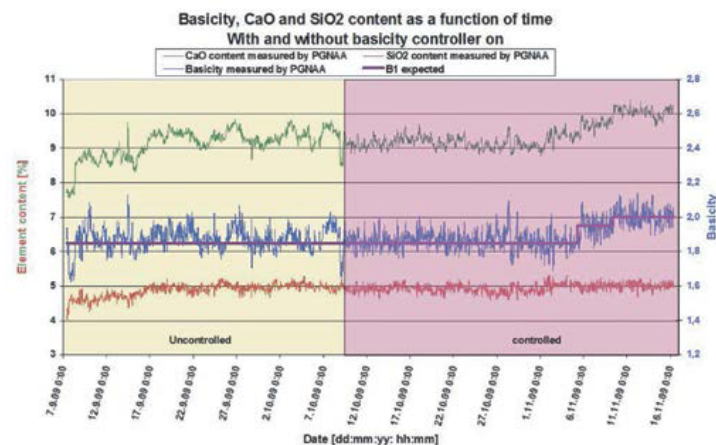
To achieve a successful installation, key criteria about the process and physical installation are required. This information is obtained in a pre-sales questionnaire. The data required includes the full chemical analysis (100% basis) of the sinter feed material including the expected

range of calibration for key analytes. The location chosen for the CB Omni Agile should be after the agglomeration drum, taking into account safe access for installation and maintenance as well as environmental protection for service personnel.

Other critical factors that will be used to design the CB Omni Agile for a specific sinter feed application include:

- Belt width and troughing angle
- Maximum and minimum feed rates
- Belt speed
- Range of belt loading
- Maximum burden height of material
- Location of existing sampling infrastructure
- Iron ore mineralogy
- Intended process control strategy

Figure 4: Graph of sinter feed chemistry with and without basicity control. B1 expected is the control set-point.



## Conclusions

Since 2007, through sinter plant installations across the globe it has been demonstrated that reliable and accurate on-line 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 on-line 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 precalibration feature of the CB Omni Agile has delivered meaningful benefit and return on investment.

### **A well implemented CB Omni Agile basicity control scheme can deliver the following benefits:**

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

### **CB Omni Agile advantages include:**

- Reliable and accurate with high availability and low maintenance requirements
- Variability of basicity in sinter feed can be reduced significantly and controlled
- Real time analysis of sinter feed chemistry
- Factory calibrated - lower commissioning costs and more rapid realization of return on investment
- Entire material on belt analyzed resulting in dramatic reduction of fundamental sampling error
- Automatic compensation for variable belt loading results in more reliable results



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