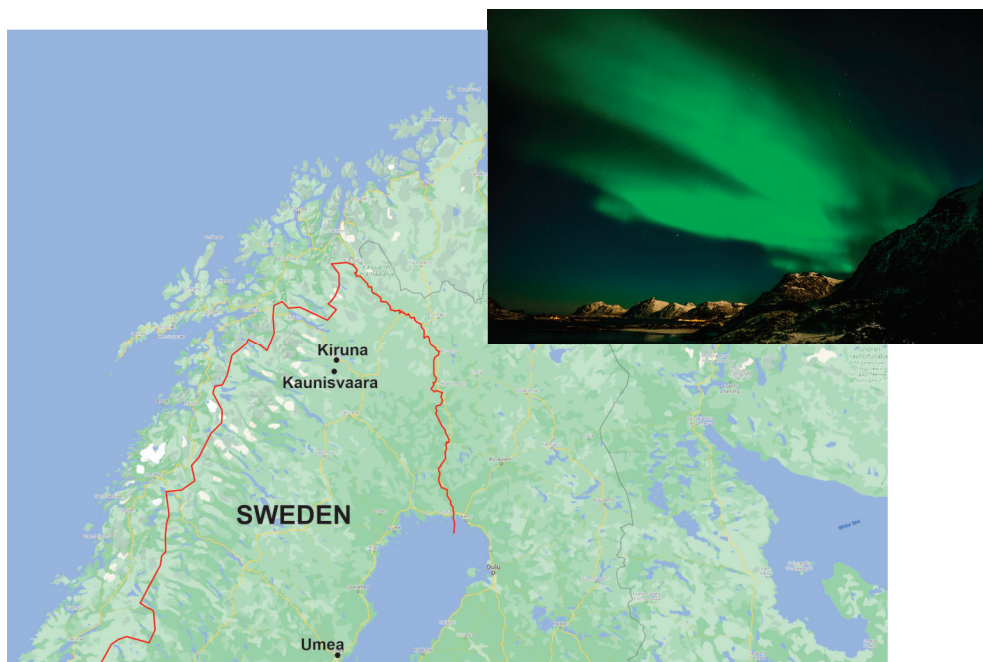


Quick Determination of Moisture in Iron Ores with a Primary Method

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Introduction

Iron ore mining is one of the biggest industries in Sweden. The mines are located far north in the land of midnight sun and dark, cold winters. One of them, the Kaunis Iron Mine, started just three years ago and produced about 2.6 million tons of iron ore in the first year, which was shipped all over the world. Analysis of the iron takes place over the entire production process, from the ore through to the concentrate. A major concern in iron ore is the moisture content. After being crushed, the ore has about a 7% moisture content. To be able to accurately analyze the ore, it must first be dried and measured for moisture. The main methods used for iron ore analysis are wavelength dispersive x-ray techniques for main and trace elements, and combustion techniques for sulphur and carbon. The ore samples are dried, divided, ground, and pressed into suitable samples and/or fused to glass beads and analyzed in vacuum conditions.



Northern Sweden where Kaunis Iron Mine is located



Degerfors Laboratory AB www.degerforslab.se

Quality Control by a Routine Lab

When the mine opened, several contractors were hired for different tasks. Degerfors Laboratory (D-LAB) was found to be the best laboratory for chemical analysis. D-LAB is an accredited contract laboratory which specializes in inorganic samples such as: all types of steels, Cu and Cu alloys, Ti, Ni-base and other base metals, and raw material for the steel industry such as ferro alloys, scrap, and ores. One of D-LAB's key abilities is fast sample processing. More than 95% of samples sent to D-LAB are analyzed within a day. Once contracted, D-LAB had only seven weeks to start up, get adequate instruments, move on-site, hire and train laboratory personnel, and calibrate their instruments and methods to fit the ore mixture. One of the most important parts in this process was reducing the time spent on each sample. For example, when they began, their initial method to determine moisture used a moisture balance that could handle one sample at a time. This greatly slowed down the process, as the technicians needed to reload the next sample every five minutes. They decided to try a new approach with the LECO TGM800 moisture analyzer.

Methods Existing

The "official" ISO 3087:2020 method for moisture determination uses sample weights between 1 and 10 kg to compensate for the sample homogeneity. Unfortunately, sample runs using these methods in most cases take more than 5 hours to complete, which makes production control quite difficult. Fast-drying moisture balances, on the other hand, can have run times closer to 10 minutes, but they can only analyze one sample at a time, so the sample throughput is limited. In addition, these fast-drying moisture balances use much higher, not always constant temperatures that can cause some systematical errors.

Description TGM800 (TGA801)

The LECO TGM800 system is a thermogravimetric analyzer for determination of moisture content of different materials using a mass-loss-on-drying technique. Mass loss of the sample is measured as a function of the oven temperature and the drying time. Up to 16 samples can be analyzed simultaneously in one run. The instrument is equipped with a built-in balance and a carousel that holds up to 16 aluminum foil crucibles and one reference crucible for buoyancy correction. The weight of each sample is determined by lowering the sample carousel for placement on the balance. Furnace atmosphere and ventilation rate can be adjusted. The maximum temperature is 175 °C. The TGM800 consists of a Windows® 10 PC, the four-place balance and the ventilation system. Everything is controlled by a touch screen driven LECO Cornerstone® software.



TGM800 System – Cover Open

Some key features:

- Supports 1.5 in/3.8 cm diameter aluminum foil crucibles
- Supports 2.4 in/6 cm diameter aluminum foil crucibles
- Analysis can be performed in air or nitrogen atmosphere
- Automated crucible and sample mass recording
- Optional fixed time or constancy method parameters



TGM800 Large Crucibles



TGM800 Small Crucibles

Measurements

2 kg to 3 kg of the iron mineral from the mine is crushed down to a particle size of about less than 250 mesh, homogenized and then a portion of 2 g to 4 g is used for moisture determination, without further sample preparation.



Iron Ore - Sample Loading into LECO TGM800

The routine setup for the work in the D-LAB is 120 °C temperature and drying time with usual constancy criteria.

Typical Results From Daily Routine Analysis of Iron Ore

Iron/Ore Name	Sample Weight	Moisture	Number of Replicates
Sample A	~ 2 g	7.25 ± 0.17	4
Sample B	~ 2 g	7.49 ± 0.19	4
Sample C	~ 2 g	7.02 ± 0.09	4
Sample D	~ 2 g	7.14 ± 0.11	4

For further evaluations in LECO's labs in St. Joseph, Michigan, and Berlin, Germany, tests were performed with another iron ore with 1 g and 4 g sample weights. The 1 g samples were put in the small, 3.8 cm crucibles, and the 4 g samples were put in the larger, 6 cm crucibles. The applied drying temperature was 120 °C in normal air atmosphere with an air flow of 5 L/min. The samples were thoroughly mixed without special sample preparation. The constancy criteria was 0.0005 g, which meant the sample was declared as being weight constant when the weight was within the constancy criteria for 9 minutes.

Results with 4 g Sample Weights

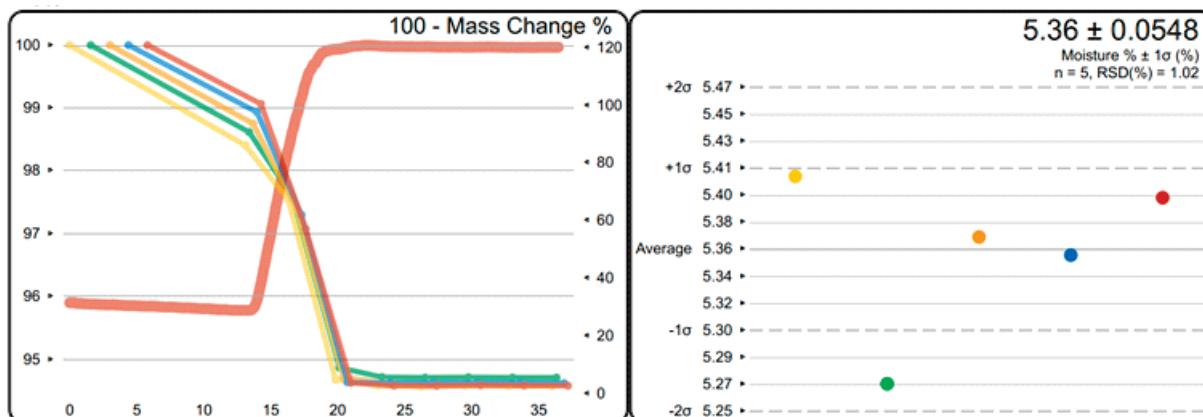
Bottle 1		Bottle 2	
Mass [g]	Moisture [%]	Mass [g]	Moisture [%]
4.0373	5.41	4.0318	5.28
4.0614	5.27	4.0666	5.27
4.0123	5.37	4.0467	5.25
4.0142	5.36	4.0186	5.32
4.0542	5.39	4.0491	5.23
Average	5.36	Average	5.27
Standard Deviation	0.05	Standard Deviation	0.03

Results with 1 g Sample Weights

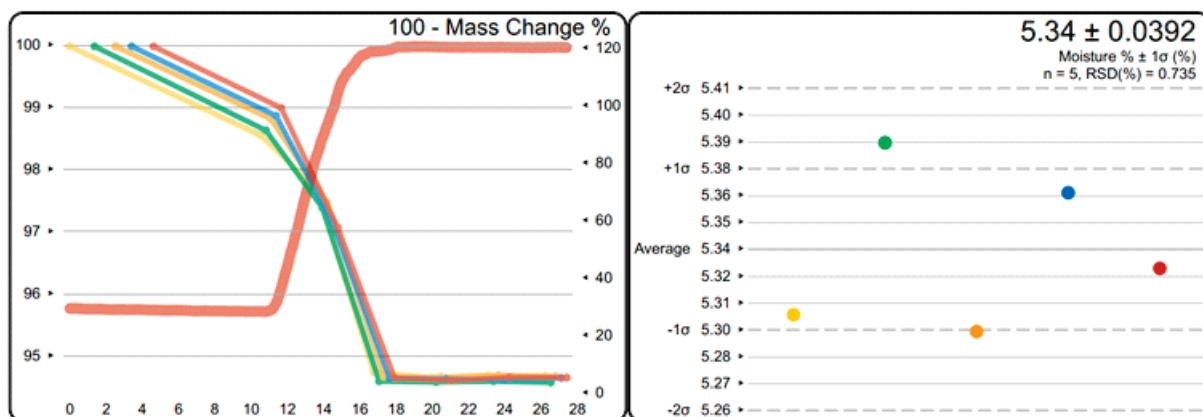
Bottle 1		Bottle 2	
Mass [g]	Moisture [%]	Mass [g]	Moisture [%]
1.0049	5.30	1.0164	5.18
1.0247	5.39	1.0227	5.14
1.0066	5.30	1.0361	5.31
1.0182	5.36	1.0501	5.51
1.0120	5.33	1.0098	5.34
Average	5.34	Average	5.30
Standard Deviation	0.04	Standard Deviation	0.14

The same iron ore sample was delivered in two bottles. As seen in the tables on the previous page, the results matched each other, both between the two bottles and the two sample weights of 1 g and 4 g. The 4 g samples seemed to have slightly better precision, which was expected due to the larger samples' homogeneity.

As seen in the weight loss curves below, the typical analysis time is around 20 to 25 minutes for the 4 g samples and slightly shorter for the 1 g samples. These are the simultaneous analysis times for all 10/16 samples of one run.



Analysis time / weight loss curves for the 4 g samples – the red curve is the temperature



Analysis time / weight loss curves for the 1 g samples

Conclusion

The TGM method for quick determination of iron ore moisture content is accurate, precise, and fast. 16 results can be obtained simultaneously within 25 minutes, including time spent on sample introduction. Compared to standard moisture balances and other quick tests, this provides a big advantage in sample throughput, especially when compared to the > 5 h moisture determination time needed for ISO 3087:2020. The mass loss-on-drying method is a primary and well-accepted method. In addition, the sample masses used are smaller than those needed for ISO 3087:2020. All of the results from the TGM800 are well-documented and can be exported and handled by any LIMS system.

At D-LAB, the LECO TGM800 handles up to 16 samples at a time, saving time and accelerating the throughputs. A validation of the TGM800 was done against the standard moisture balance. The result was that even when compared with sample weights of up to 10 g on the moisture balance, the TGM800 gave the same results and standard deviation. D-LAB has the manual moisture balance as a backup, but it has not been used as the TGM800 has had 100% uptime so far. D-LAB is now analyzing more than 30,000 samples per year. (As the number of samples continue to increase, we are in the market for another one.)