Online Coal Analyzers Bring Benefits to the Utility Industry

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ABSTRACT

Online coal analyzers have been in commercial use for more than two decades now, with coal producers accounting for most of the units purchased. In the past three years or so, coal-fired power plants have shown an increasing share of the analyzers bought. This article explains the most common applications of analyzers at power plants, ranging from boiler optimization to compliance with emission regulations. The article also provides a brief overview of different analyzer types, their principles of operation, and typical performance achieved.

INTRODUCTION

Online coal analyzers were first introduced to the coal and utility industries in the early 1980's. Those units were products of research that had begun in the mid 1970's. As with most new technologies, it took some time for the products to mature and for the industry to embrace them. In the case of online coal analyzers, that wholesale acceptance did not begin until 1990 or so, but even then the usage varied widely. Coal producers bought these analyzers at four times the rate that utilities did. Geographically, the greatest use occurred in the United States, followed by Australia, perhaps owing to the fact that the manufacturers were located primarily in these two countries. Europe by notable exception accounted for less than 1% of the purchases of the elemental coal analyzers; this can be somewhat explained by the declining use of coal throughout the continent.

Now that we are in a new century the patterns of use of online coal analyzers are changing, and in fact major change has occurred in the past three years alone. The purpose of this paper is to explain what analyzers exist, how they work, and what changes are occurring within the industry. In particular, given the focus of this conference, the attention will be skewed toward the use of analyzers in power plants.

THE EARLY DAYS

It is ironic, given that power plants form a distinct minority in the use of analyzers, that the first elemental coal analyzers actually came about from research sponsored by the US utility industry, specifically from the Electric Power Research Institute. The Tennessee Valley Authority's Paradise plant and Detroit Edison's Monroe plant were the beta-sites for elemental coal analyzers from SAIC. Another analyzer supplier, MDH Motherwell, emerged in the early 1980's, with its beta-site at the prep plant at the Penelec Homer City power plant.

Despite the early utility interest in coal analyzers, it was the coal producers in the US and Australia that saw the promise and began purchasing these analyzers with some regularity. The analyzer producers who took over the leadership of this fledgling industry were Gamma-Metrics (now known as Thermo Electron) in San Diego, CA, USA, and Mineral Controls Instrumentation (now Scantech) in Adelaide, AUS. Thermo Electron dominated the elemental analyzer segment while Scantech led the way in ash

gauges. Today the coal analyzer industry produces annual revenues of about $10 million.

THE PRODUCTS

There are two types of analyzers which constitute the majority of coal analyzer usage throughout the world. Ash gauges which mount around conveyors account for about 75% of all online coal analyzers. These units are known sometimes as dual-gamma ash gauges, a designation arising from the fact that they use two different gamma isotopes to irradiate the coal. The relative attenuation of the two gamma signals can be used to infer the total ash concentration in the coal. However, these gauges rely on an assumption that the ash constituent composition doesn't change. Their accuracy is particularly vulnerable to shifts in the iron fraction of the ash, a limitation made worse by high levels of ash.

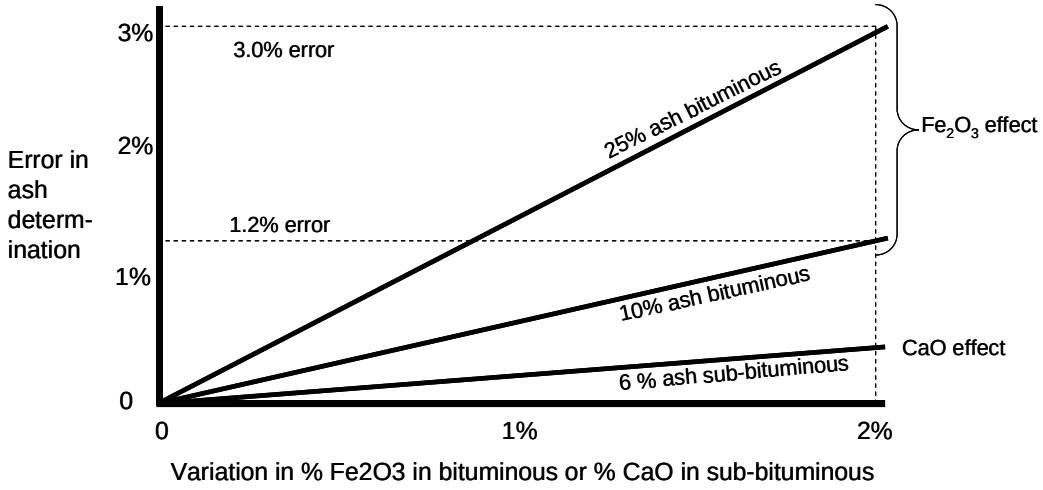

Figure 1. Ash error with Dual-Gamma Gauges

Typical prices for ash gauges are $50,000 US. Typical one sigma accuracies range from 1% to 4%. The vast majority of these analyzers are found at coal mines. Their application to utilities is limited by their accuracy and the fact that they measure only ash.

The second most common type of analyzer is also the most versatile and most accurate: the elemental coal analyzer. These analyzers account for more than half of the total money spent on analyzers each year by utilities and coal producers. The vast majority of these elemental coal analyzers employ a technology known as prompt gamma neutron activation, and the term PGNAA is well known. Unlike the dual-gamma ash gauges which must infer ash, these analyzers directly measure the major ash constituents (Si, Al, Fe, Ca, K, Ti, and sometimes Na) and sum them to determine total ash. Moreover, they measure sulfur, an element critical to the US coal industry for reasons associated with environmental regulations. Most applications of PGNAA technology use a californium neutron source to irradiate the coal and a sodium iodide scintillation crystal to detect the gamma rays given off in the process of neutron absorption.

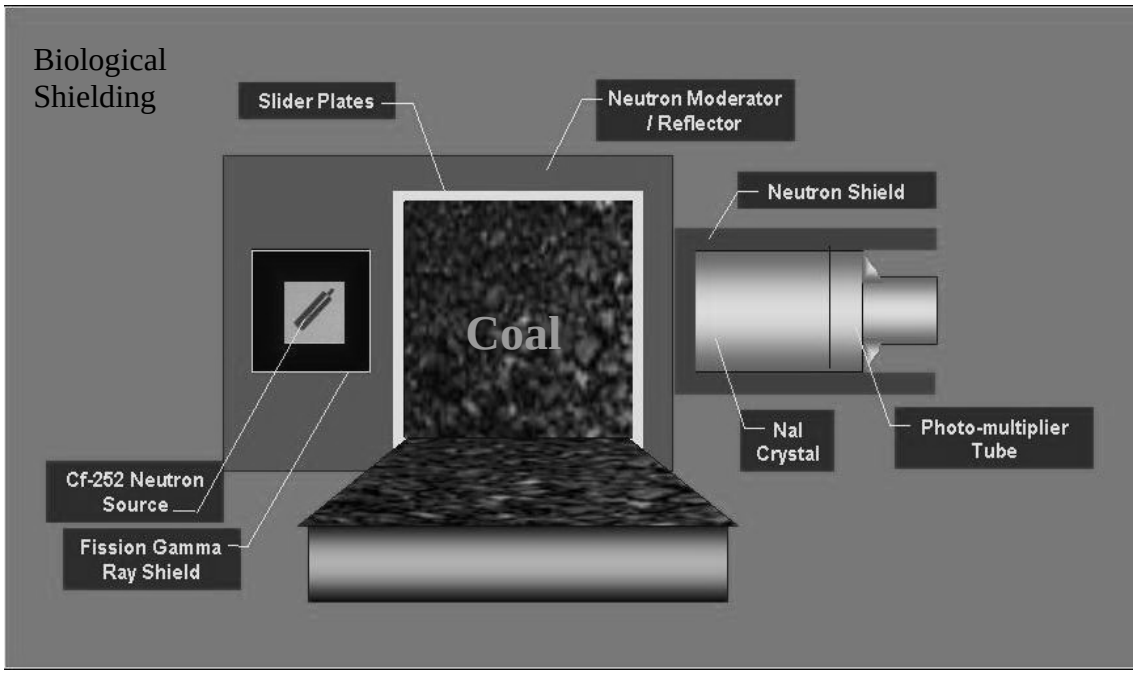

Figure 2. Thermo Electron's CQM Cross Section

Inasmuch as each element produces a different gamma ray energy spectrum when absorbing neutrons, the combined spectrum can be analyzed to infer the elemental composition of the coal.

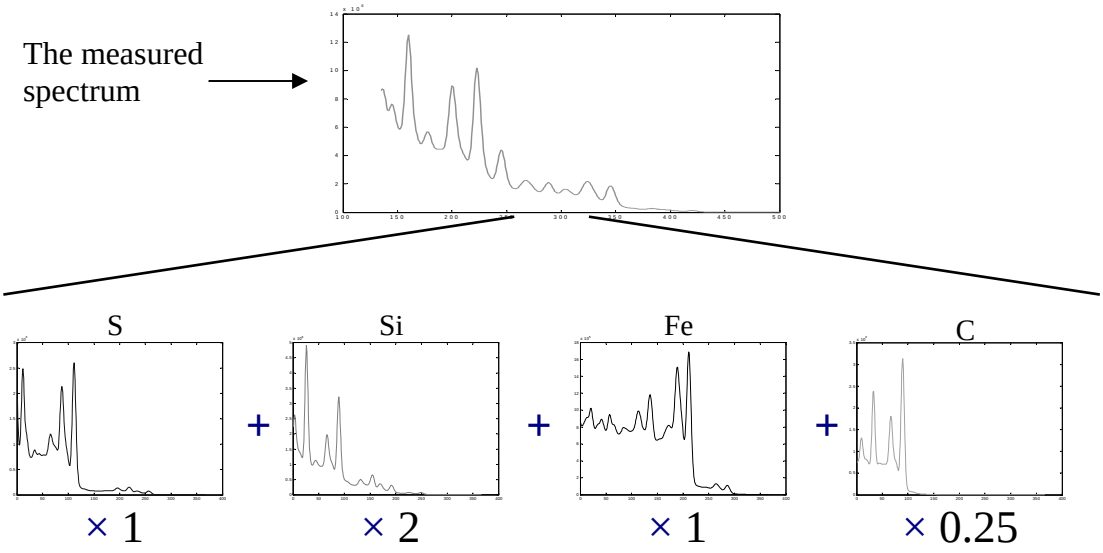

Figure 3. Principle of Library Least Squares Method of Spectral Analysis

Also, as expected, these analyzers must include significant shielding to ensure the safety of the users.

There are two types of elemental analyzers, one which analyzes a representative sample stream (usually primary saves or secondary rejects from a

multi-stage sampling system) and the other which mounts around a conveyor. The sample stream version is more accurate because of the consistent geometry presented to the analyzer and because the neutron source and the detector can be located closer to the coal stream.

Figure 4. Typical Sample Stream On-line PGNAA Coal Analyzer Installation

Typical prices are $270,000 US for belt type analyzers and $425,000 for sample stream versions, the latter including a built-in hopper, level sensor, belt conveyor, and flow control software. Elemental analyzers of both types are usually accompanied by a moisture meter to enable estimation of not only moisture, but also calorific value. Typical one sigma accuracies of elemental analyzers are 0.3 to 1.0% for ash, 0.03 to 0.08% for sulfur, 0.4 to 0.8% for moisture, and about 1% relative for calorific value.

THE APPLICATIONS

Coal producers have concentrated their use of online analyzers in a couple of areas. Many use the simple ash gauges to provide feedback to the mining operation. Ash gauges are also sometimes used to control the ash levels of product coming out of the prep plant.

Elemental coal analyzers tend to find their way into the more critical parts of the coal mining process. The most popular application is blending, with Thermo having automatic blending software to control more than one quality parameter. Furthermore, most elemental analyzers in the mine are found in the loadout tower, enabling the coal producers to do their utmost to control the quality of what is shipped to their customers.

At the power plant the uses are often quite different. The two most popular applications are blending to stay below emission limits and blending to keep ash fusion levels high enough to avoid fouling and slagging. In the US the lbs SO2/MMBtu limits often force utilities to blend different coal types in order to meet the regulations. With an on-line coal analyzer and software programs like Thermo's Coal Blending Optimization (COBOS) and Silo Tracking Software (STS), the power plant can safely blend two or more coal types and simultaneously satisfy sulfur targets as well those of other parameters such as calorific value. There are some power plants who exercise yet another level of control, blending coals with different ash fusions, striving to keep ash fusion levels in check. PacifiCorp has been a trendsetter in this use of analyzers.

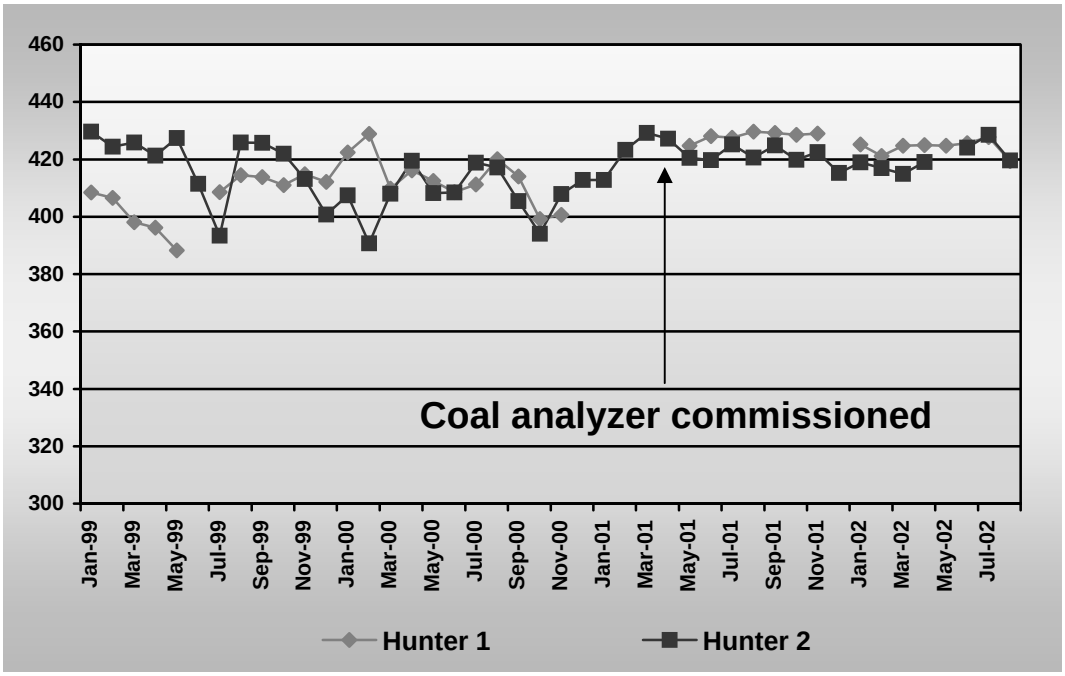

Figure 5. Average Monthly MWs Recovered using Thermo's CQM at Hunter Plant

TRENDS AND FUTURE POSSIBILITIES

Coal analyzers are beginning their second quarter-century of use. The acceptance of the products is at an all time high, owing to improvements in reliability, performance, and applications software over the past decade. What's particularly notable is that the prices of these products have remained fairly flat over time despite increasing component costs and despite the improvements made in performance and reliability. The current healthy state of the coal industry, at least in the major coal producing countries, has led to a rapid rise in the number of mines, prep plants, and coal-fired power plants. Not surprisingly there has been a steady increase in the number of new facilities incorporating online coal analysis as well.

What does the future hold? It's hard to say for certain, but ten years from now the industry of online coal analysis is likely to be larger, as products continue to improve and the payback periods for buyers decrease. Continued changes to electronics and detector technology offer promise for improved performance analytically. Neutron generators also offer potential as a neutron source, but the lifetime cost of this component is a deterrent to its acceptance. As the costs of these components fall with increased usage, they may become competitive in time.

Another area which may change in the future is the parameters being measured. There is increasing interest in measuring trace elements such as mercury or arsenic. The leading technology for elemental analysis, PGNAA, can measure these elements; the only problem is that they exist in concentrations below the threshold of detection. Whether the break-through that occurs will be a new technology or an improvement of the existing technology, online analysis of trace elements is not outside the realm of possibility.

Yet another area ripe for improvement is online moisture measurement. All moisture meters use microwaves for detection, and they suffer from not being able to measure the bound moisture in the coal. Having to assume that the bound moisture is constant limits the accuracy of these devices. The possibility of a new technology bringing better moisture accuracy to the user is real.

Other improvements may be found in the area of process control and applications software. An online coal analyzer has no value if it does not cause the owner to change the way he operates. In order for the user to derive maximum benefit there must be an easy-to-use, functional user interface and in many cases, application specific process control software as well. Thermo seems to be the major trendsetter in this area with automated blending, silo tracking, auger analysis, and automatic diagnostics.

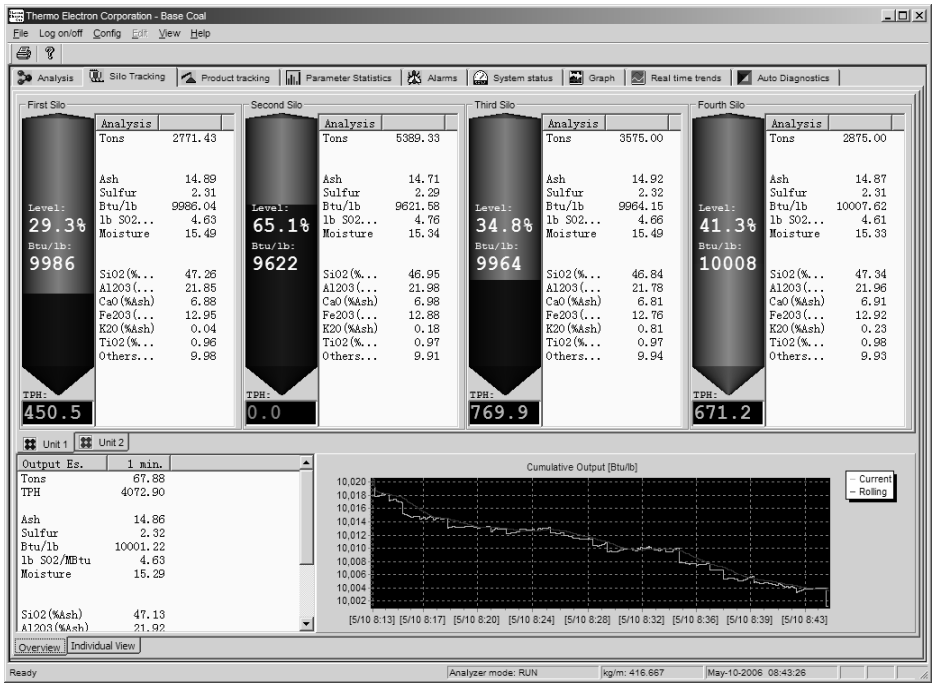

Figure 6. Thermo's Silo Tracking Software (STS)

SUMMARY

Online coal analyzers are growing in their use and their functionality. These trends are particularly noticeable among utility users striving for better boiler efficiency as well as insurance against excessive emissions. As the industry grows, users can expect better performing, more reliable instruments.

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