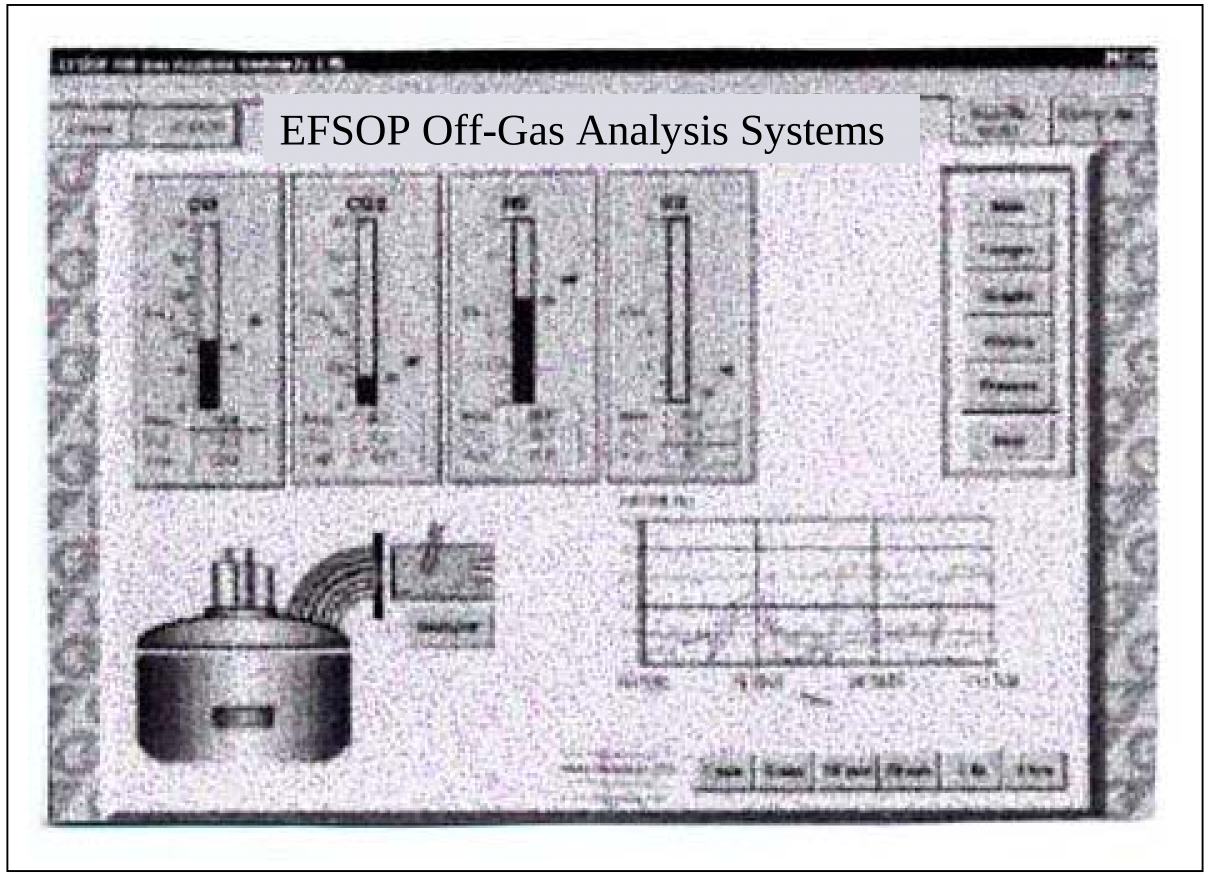

Figure 2: A typical off-gas computer screen for the Goodfellow EFSOP™ system.

Your Invitation to Work with Us

We are interested in collaborating with you. Please contact the Business Office to discuss your particular needs.
☐ (613) 996-8693
✉ cetc-bdo@nrcan.gc.ca

For Further Information Please Contact:

Jacques Guérette PEng
Manager, Industry Group
☐ (613) 943-2261
✉ jguerett@nrcan.gc.ca

CANMET Energy Technology Centre - Ottawa
Natural Resources Canada
1 Haanel Drive
Nepean,Ontario, K1A 1M1
Canada

cetc.nrcan.gc.ca

Natural Resources Canada   Ressources naturelles Canada

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INDUSTRY ENERGY RESEARCH AND DEVELOPMENT PROGRAM

CLEAN ENERGY TECHNOLOGIES

EXPERT FURNACE SYSTEM OPTIMIZES STEELMAKING PROCESS

Summary

Stantec Global Technologies Ltd. has developed the Expert Furnace System Optimizing Process (EFSOP™) and has demonstrated this system at Co-Steel Lasco in Whitby, Ontario. Combining continuous fume analysis with realtime process data, this system can lead to an increase in furnace productivity, a decrease in production costs, improved performance of environmental systems and insight into electric arc furnace (EAF) steelmaking metallurgy. Other benefits to EAF operators include combustion optimization, metallurgical understanding, and fume system design and operation.

Highlights

- Electrical energy savings
- Maximizes combustion efficiency and process benefits
- Payback period less than a year
- Reduces polluting emissions

Goodfellow EFSOP™ gas sampling probe.

Canada

CETC – OTTAWA
CANMET Energy Technology Centre - Ottawa
Natural Resources Canada
1 Haanel Drive, Ottawa, Ontario K1A 1M1
Tel : (613) 996-8693 **FAX :** (613) 995-9584
www.cetc.nrcan.gc.ca

Aim of Project

An increase in production through use of an EAF has led to a corresponding increase in the amount of energy being lost to fume control systems. The expansion in the use of chemical energy sources and oxygen injection practices in EAFs has served to decrease heat times. However, too often EAFs are not operated to optimize combustion efficiency and maximize process benefits. The aim of this project was to develop a system, which provides off-gas analysis as a process control and interpretation tool to optimize operation of EAF steelmaking operations.

The Principle

The combustion environment within an EAF determines the effectiveness of chemical energy additions. The oxidation of carbon in an AF occurs in two stages:

$C + ½ O_2 \rightarrow CO$
$\Delta H = -110.6$ kJ/gmol
@ 1650°C (3000°F) (1)

$CO + ½ O_2 \rightarrow CO_2$
$\Delta H = -282.1$ kJ/gmol
@ 1650°C (3000°F) (2)

The first stage of this reaction (C to CO) occurs very readily using decarburization oxygen lancing. Frequently, the more exothermic second reaction (CO to CO_2) does not occur in the freeboard above the molten metal and much of the CO leaves the furnace in the exhaust gases, carrying with it large amounts of potential energy. Measurements reveal that significant additional energy can be lost in the form of hydrogen from incomplete combustion or cracking of burner gases and equilibrium dissociation of water at high temperatures.

The Situation

With modern furnace practices, over 30% of the total energy input to the furnace can be lost to the off-gas handling system. Much of this heat is in the form of chemical potential energy from the incomplete combustion of hydrocarbons in the furnace shell. At the same time, environmental regulations have become increasingly stringent. Meeting environmental standards and accommodating the high off-gas heat loads can require a substantial capital investment in additional baghouse capacity and/or water-cooled ductwork. Some plants are now facing productivity limits imposed by air pollution control systems.

The Goodfellow EFSOP™ system uses sophisticated instrumentation to measure off-gas composition, and also ties in plant programmable logic controller parameters in real time. The system analyses the furnace exhaust to quantify the availability of carbon monoxide and hydrogen in the off-gas (the result of incomplete combustion of oxygen and fuel in the furnace shell). Together, these combustible gases can make up over 50% of the furnace offgas, representing a tremendous amount of energy. The total energy content of the off-gases can be over 200 kWh/t (182 kWh/tonne) of which more than 100 kWh/t (91 kWh/tonne) can be chemical energy. Oxygen and carbon dioxide are also measured in the gas sample to complete the combustion analysis. The key parameters for the Co-Steel Lasco furnace are summarized in Table 1. The system highlights the usefulness of continuous off-gas chemistry analysis as a process control and interpretation tool. The continuous analysis gives the EAF operator the information needed to save energy by injecting additional oxygen. Maximizing combustion in an EAF should include optimizing burners' ratios, timing and type of carbon addition, and the effect of lancing rates and angles.

EAF steelmaking is a highly dynamic metallurgical process. The furnace reactions and energy balances change dramatically over the course of the heat as the cold charge material is heated to a molten metal bath. During the period of meltdown and prior to flat bath conditions, very few parameters are available to show which metallurgical events are occurring.

Tap Size	137 tonnes (125 tons)
Charge Weight	154 tonnes (140 tons)
Transformer	120 MVA
Shell Diameter	6.25 m (20'6")
Electrode Diameter	61 cm (24")
Tapping mode	eccentric bottom tapper into ladle on tapping turret

Table 1: Co-Steel Lasco EAF description.

The Goodfellow EFSOP™ process provides continuous feedback on bath chemistry. Off-gas chemistry profiles can be used to identify the carbon endpoint for the heat. Analysis results can also lead to improved oxygen efficiency in the furnace and can minimize excessive yield losses associated with excessive lancing.

In addition to process energy and metallurgical benefits, the system's accurate characterization of the furnace exhaust gas chemistry is very valuable in the design of primary direct evacuation systems (DES), which capture emission fumes from an EAF. The DES for an arc furnace must be designed to cool the hot furnace exhaust to meet the air pollution control system temperature limits, typically 135°C (275°F) for a typical baghouse. The temperature of the gas is controlled using various techniques such as water-cooled ducts and evaporative cooling. Dilution air must be introduced at the combustion gap to fully combust the unburned CO and H_2 in the off-gas, critical to preventing downstream explosions. Proper mixing of the combustion air with the furnace exhaust is also important to ensure the complete destruction of the combustible gases and minimize pollutant formation.

The permanent Goodfellow EFSOP™ installation at Co-Steel Lasco became fully operational in February 1996 and has been operating on a continuous basis for over 6,000 heats with minimal maintenance requirements. Off-gas analysis and process data, valuable in the evaluation of process changes over time, were logged for this period.

Since this first installation at Co-Steel Lasco, the Goodfellow EFSOP™ system has been installed in steel plants in the USA and the United Kingdom.

The Goodfellow EFSOP™ performance has received Environmental Technology Verification (ETV), a program designed to support Canada's environmental industry by providing credible and independent verification of technology performance claims. In October 1998, EFSOP™ was awarded a silver medal by the Financial Post in the Environmental Technologies field.

The Company

Stantec Global Technologies Ltd. is a technology company with offices located in Mississauga, Ontario. The parent company, Stantec Consulting Ltd., is located in Edmonton, Alberta. Through their R&D efforts they developed a prototype of this innovative technology.

Economics

The differences between steelmaking practices at Co-Steel Lasco in 1996 and those of 1997 with Goodfellow EFSOP™ are impressive. Electrical consumption has been reduced by 35 kWh/t while power-on times were reduced by 4 minutes per heat. These changes are substantial and, on the basis of plant specific costs, result in an annual savings in excess of CAD 1 million. Payback through direct savings was slightly less than one year.

Awards

In 1999, Dr. Howard Goodfellow was the recipient of an Energy Efficiency Award for his work on the Expert Furnace System Optimization Process for Stantec Global Technologies.

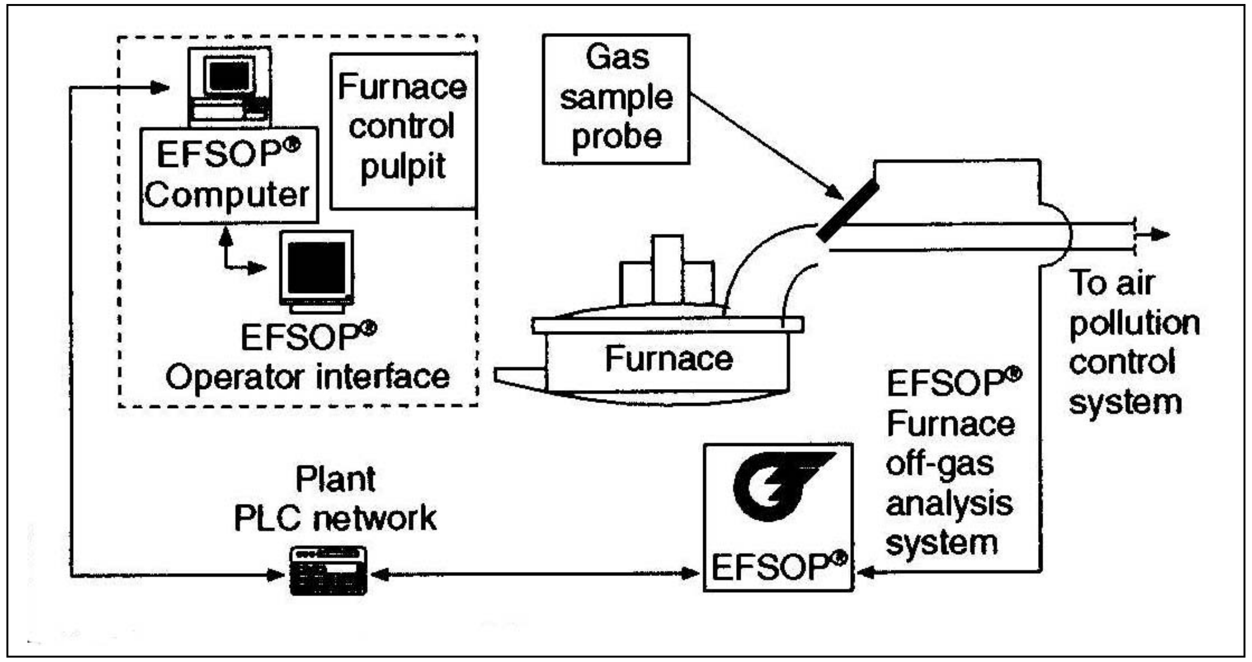

Figure 1: Schematic of the Goodfellow EFSOP™ instrumentation.