EAF Off-Gas Optimization Technology

The cornerstones of Tenova’s ‘Intelligent EAF’ process control and optimization strategy include:

- A full complement of sensors providing real-time measurements. This avoids control errors when using assumptions.
- Fundamental thermodynamic, kinetic, mass and energy balances for process control models. This avoids control errors with statistical models that rely on past events for future control predictions.
- Advanced analytics to improve and retrain process models. This avoids control errors stemming from changes in operating practices.

This paper discusses Tenova’s ‘Intelligent EAF’ solution, provides actual plant results confirming reduced energy, lower fume system maintenance, increased yield and productivity, and gives a view to the future, where efficient use of DRI and hydrogen will play an increasingly important role in EAF steelmaking.

Author: Doug Zuliani Ph.D.
Tenova Goodfellow Inc.

INTELLIGENT iEAF® PROCESS CONTROL SOLUTION

Tenova’s iEAF® software and NextGen® sensor technology represent the steel industry’s only complete EAF process control package (the ‘i EAF® solution’) utilizing a full complement of measurements to close a precise real-time mass and energy balance. This provides heat specific, dynamic control and optimization of both the quantity and timing of chemical and electrical energy inputs based on the net energy actually received by the scrap and bath, after deducting actual energy losses. This solution comprises a blend of proprietary sensors and software, including:

- Advanced Next Generation hybrid laser/extractive technology, NextGen®, providing full spectrum off-gas analysis.
- Specialized, low maintenance, highly reliable sensors to measure off-gas flow velocity, temperature and static pressure.

© Fig 1 Not all off-gas technologies provide a full-spectrum analysis
Tunable Diode Laser Absorption Spectroscopy (TDLAS) systems offer faster response, self-calibration and lower installation costs, but suffer from missing data from random signal interruptions and partial analysis (covering CO, CO₂ & H₂O). Such missing information requires assumptions to be made, which means imprecise control and reduced savings. Approximately 20 in situ EAF systems have been installed since this technology was first commercialized in 2000.

Recognizing the limitations of these two traditional methods, Tenova has developed a new class of hybrid off-gas analysis technology combining the best features of extraction and lasers, to provide a low maintenance, highly reliable, fully functional off-gas analysis solution. More than 30 systems have been sold in the five and half years since the launch of NextGen®, confirming that it is now the technology of choice for the steel industry.

Figure 2 lists the performance advantages of the NextGen® hybrid laser/extractive technology. The patented NextGen® innovation is a true breakthrough technology exceeding the capabilities of pure extraction and in situ TDLAS systems. It has:

- Approximately 100% availability because Tenova’s industry-proven extraction and filtration technology eliminates random laser signal blockage. Side by side tests confirm that the availability of off-gas analysis technology employing extraction far exceeds in situ...
TDLAS, on a per heat basis.

- Fast response, multipoint analysis provides continuous, simultaneous full-spectrum analysis at multiple locations and furnaces in eight seconds, or less.
- Full-spectrum analysis eliminates assumptions, thereby enabling precise, real time mass and energy balances, and dynamic control of burners, lances, injectors, electricity and draft.
- The technology has reduced maintenance. Improvements include fully self-calibrating technology, filtered gas that reduces the cleaning requirement for laser optics, only one probe to maintain compared with two for TDLAS, a central cabinet that requires no maintenance and a new probe design currently being tested which further reduces maintenance by 50% (Figure 4).
- Operating costs are reduced due to the elimination of calibration gases, use of reusable filters, a guaranteed one year life for the probe and no need for continuous nitrogen purging on two probes as with TDLAS.
- The system is Industry 4.0 ready, with a built-in computer that enables on line performance monitoring, system diagnostics, supports process control and model re-training over the internet.

**OFF-GAS SENSORS**

Tenova’s ‘Intelligent EAF’ includes additional proprietary low maintenance, highly reliable sensors (Figure 5). These sensors are:

- An Optical Velocity Sensor that uses optically detected radiation patterns to measure EAF off-gas velocity. It is used to convert the percentage of each gaseous species in the analysis to mass flow.
- An Optical Temperature Sensor that uses the two-colour method. This minimizes the effect of dust on the optic lens and is used for determining sensible heat loss of the EAF.
- A Static Pressure Probe that uses a proven, gas sampling probe design to reliably measure static pressure in the EAF for dynamic draft control.

**FUNDAMENTAL: EAF® PROCESS CONTROL MODELS**

Statistical models rely on the past to predict the future. However, unless the data set of past events is sufficiently comprehensive to properly capture all possible process outcomes, statistical models can suffer from poor predictions, especially when process excursions occur. Also, major practice changes to the scrap mix, electrical and chemical profiles, or draft control, pose serious difficulties, since new practice data will be insufficient to properly train the statistical model. For these reasons, statistical models have significant process control limitations.

Alternatively, thermodynamic, kinetic and real-time mass
and energy balance models provide a more fundamentally sound representation of the EAF process, which means the frequency of model retuning is significantly reduced. Hence, fundamental models offer the promise of being more robust, requiring less retuning and being capable of providing better control predictions over a broader range of operating conditions, with the proviso that model precision will improve when assumptions are replaced with actual process measurements. As noted previously, fundamental models supported by actual process measurements form the backbone of Tenova’s iEAF® solution.

Traditional EAF control bases both electrical and chemical energy delivery on kWh per ton and as such, is essentially static control. It runs every heat fundamentally on the same process clock fixed by the transformer size and a relatively constant change weight (Figure 6). Alternatively, a precise, real-time mass and energy balance (Figure 7) provides a much more powerful EAF process control tool, because it accounts second by second for actual mass and energy changes on a heat specific basis.

Figure 8 illustrates the iEAF® solution employing...