

Tenova is a worldwide supplier of advanced technologies, products and services for the metal and mining industries. Its innovative integrated solutions combine process automation and metallurgical know-how to enhance the value delivered to the customers. At the same time, Tenova is committed to develop its technology in the areas of greatest significance for the future of the industries it serves: product quality, energy saving and environmental sustainability.

Tenova Goodfellow is the Tenova Melt Shops' Center of Excellence for process control technology. As the world leader in real-time off-gas process control, Tenova Goodfellow provides the highest quality and most technologically advanced industrial equipment and process control technology for the markets it serves. Through R&D partnerships with government, universities and industry leaders, Tenova Goodfellow works at the cutting edge in developing next-generation optimization control strategies.

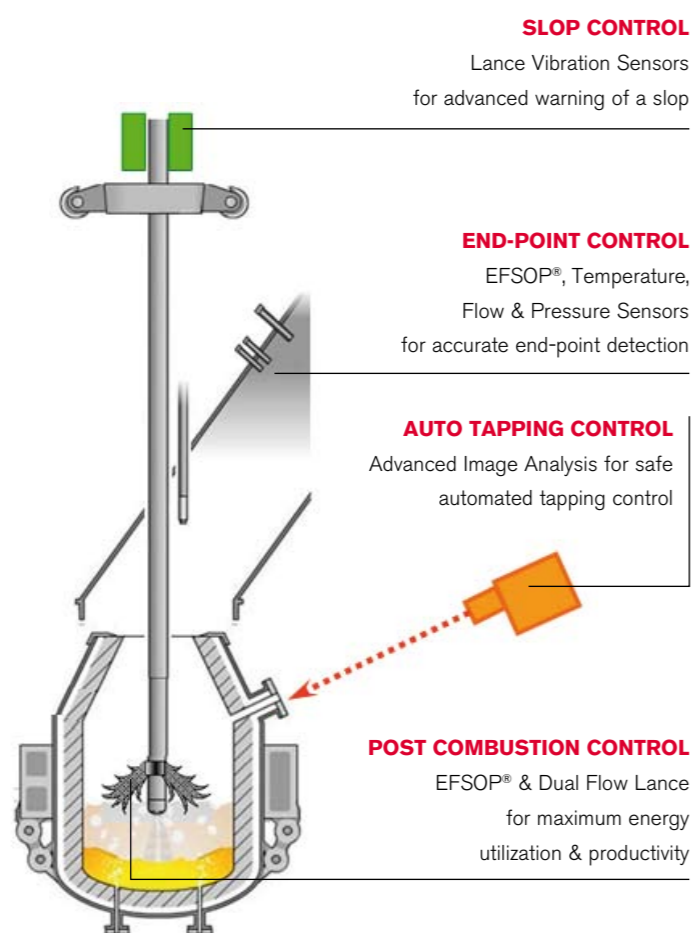
iBOF® TECHNOLOGY

iBOF® is a breakthrough technology designed to reduce GHG emissions while improving yield, productivity and scrap-melting capability and cutting operating costs. iBOF® technology delivers unprecedented value and an unparalleled level of customized control by employing a combination of reliable off-gas analysis, novel sensors and process models linked by a comprehensive automation system.

iBOF® is a modular solution available as a unified package or as standalone systems designed to meet specific customer needs.

iBOF® BRINGS PROVEN BENEFITS SUCH AS:

- Reduced Tap Alloys
- Reduced Consumables
- Increased Productivity
- Increased Yield
- Reduced GHG Emissions
- Improved Safety
- Reduced Maintenance & Repair



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Tenova iBOF® Technology

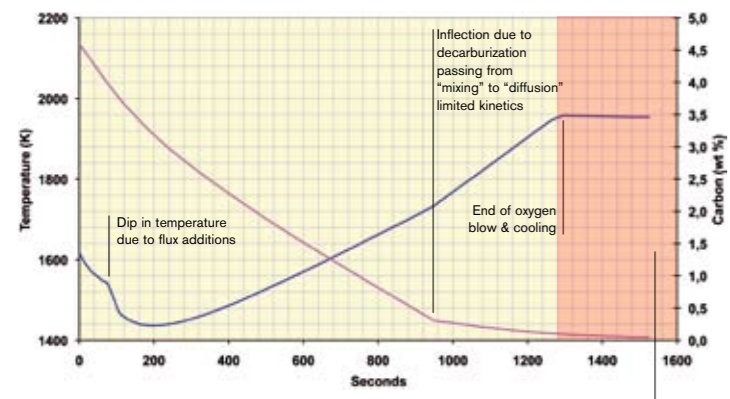
The innovative modular solution
for BOF steelmaking optimization

iBOF® TECHNOLOGY

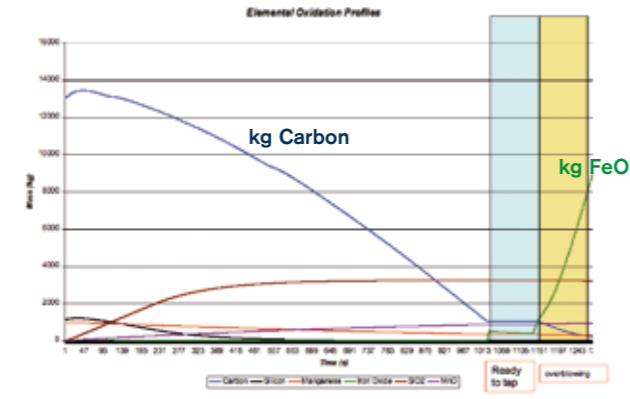
iBOF® is a modular technology, available either as an integrated technology package or as independent standalone modules to meet the specific needs of each melt shop. The technology consists of:

- Module 1, Improved End-Point Detection to reduce conversion costs, improve yield and increase productivity, without costly sub-lance technology;
- Module 2, Intelligent Slopping Detection System to warn operators in advance of an impending sloop to increase productivity and yield;
- Module 3, Optimized Post-Combustion to increase productivity from enhanced scrap melting;
- Module 4, Auto-Tapping Control to improve safety and minimize slag carry-over and tap alloy additions.

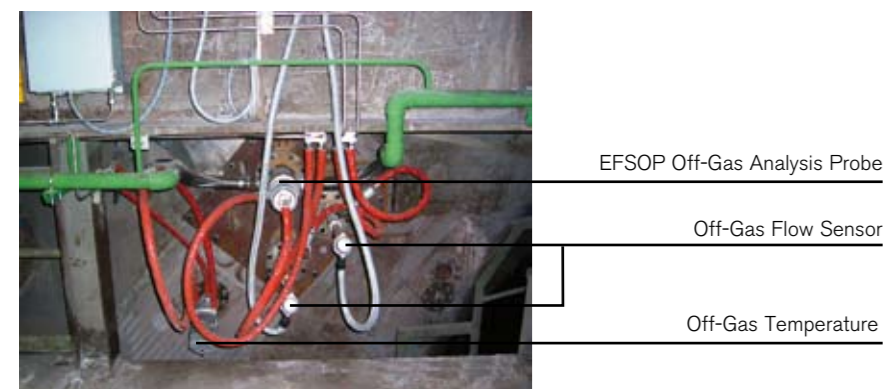
iBOF® technology employs key sensors and comprehensive process models to predict slag & bath chemistry and temperature from start to end of blow, for accurate end-point determination.



— Temperature (K)
— Carbon Concentration (wt%)



Effect of the overblowing with respect to liquid steel oxidation with consequent decrease of the yield



A typical installation of the novel sensors on the fume duct.



Analyzer room installation.

MODULE 1: END-POINT DETECTION

iBOF® End-Point Detection technology is based on industry-proven EFSOP® off-gas analysis, proprietary off-gas sensors to measure temperature, flow and pressure, and BOF process control models designed to enable "Blow & Tap" practice without the additional cost and delays associated with Sub-Lance technology. Thanks to its innovative features, iBOF®:

- predicts slag & bath chemistry and temperature from start of blowing;
- alerts operators of the correct time to drop in-blow Celox;
- alerts operators when to pull the lance based on aim Carbon & Temperature.

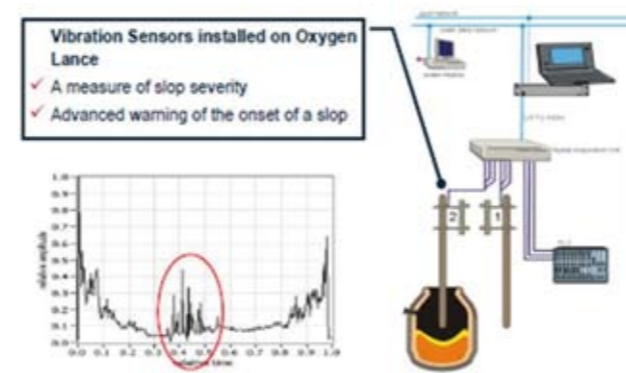


iBOF® operator screen for comprehensive process control

iBOF® End-Point Control Steel Plant Verified Benefits	
Factor	Benefit
End-point C, 90% of heats	± 0.010%
End-point C, 97% of heats	± 0.015%
End-point Temperature	± 12 C
Catch Carbon, reduction in standard deviation	60%
Oxygen, saving	0.7% SAVINGS
Ladle Carbon, saving	2.7%
Tap Ferro Alloys, saving	1.6%
Tap Aluminum, saving	4.0%

MODULE 2: INTELLIGENT SLOPPING DETECTION SYSTEM (ISDS)

iBOF® sloop-detection technology uses lance vibration analysis with real-time alerts to give operators advance warning of the onset of a sloop and a measurement of sloop severity. The system is designed to provide direct feedback control of lance position and oxygen flow rate, for rapid mitigation of the effects of a sloop.



ISDS schematic configuration and slopping on set visualization.



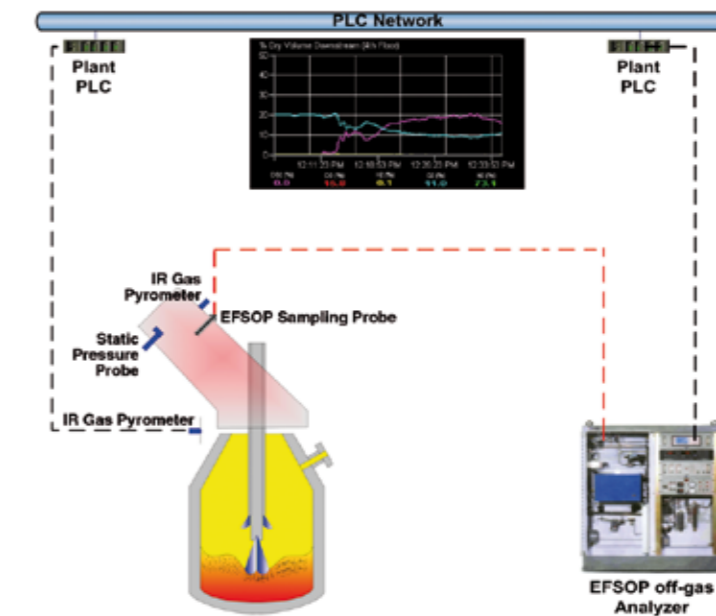
iBOF® Intelligent Slopping Detection System main screen.

iBOF® Sloop Detection Steel Plant Verified Benefits	
Detection Capability	> 95% sloop events detected
Advance Warning	20 – 40 seconds

MODULE 3: OPTIMIZED POST-COMBUSTION

iBOF® post-combustion uses EFSOP® off-gas analysis together with temperature, flow and pressure sensors and a dual-flow lance with independent control of primary and secondary

oxygen to control secondary oxygen flow-rate, penetration and timing. The result is optimal post-combustion efficiency and scrap-melting capability with minimal refractory or lance wear.

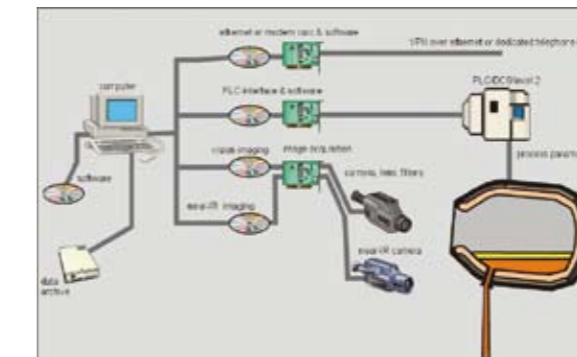


With typical BOF blowing practice, 85%-90% of gas exiting the converter remains as uncombusted CO. This CO represents a significant amount of process energy, since full combustion of C to CO₂ generates 3.5 times more heat than partial combustion to CO. Controlled injection of secondary O₂ above the lance tip promotes in-converter combustion of CO to CO₂, providing additional energy for higher productivity from increased scrap melting.

iBOF® Post-Combustion Benefits	
■ 3 - 6% increase in scrap melting	
■ Slop mitigation from slag reheating	
■ Reduced lance and mouth skulls	

MODULE 4: AUTOMATIC TAPPING CONTROL

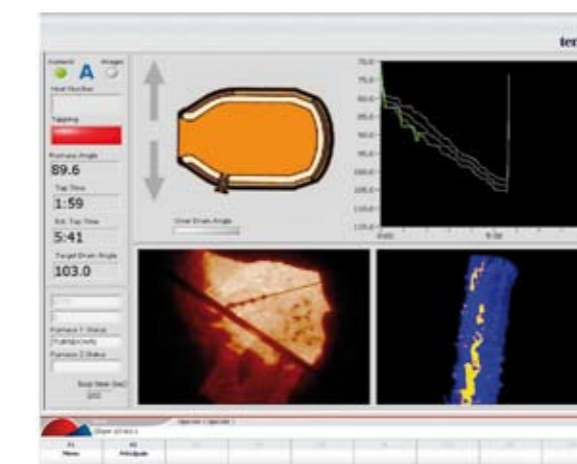
iBOF® auto-tapping technology employs advanced image analysis together with process models to control tapping practice, in either an operator-assist mode or a fully automatic mode.



iBOF® tapping control: schematic configuration.



Typical installation of the iBOF® tapping camera.



iBOF® tapping control main screen.

iBOF® Auto-Tapping Benefits	
■ Decreased tap time and variability	
■ Reduced slag carry-over	
■ Reduced ferroalloy and aluminum consumption	
■ Up to 0.5% increase in yield	
■ Improved operator safety	