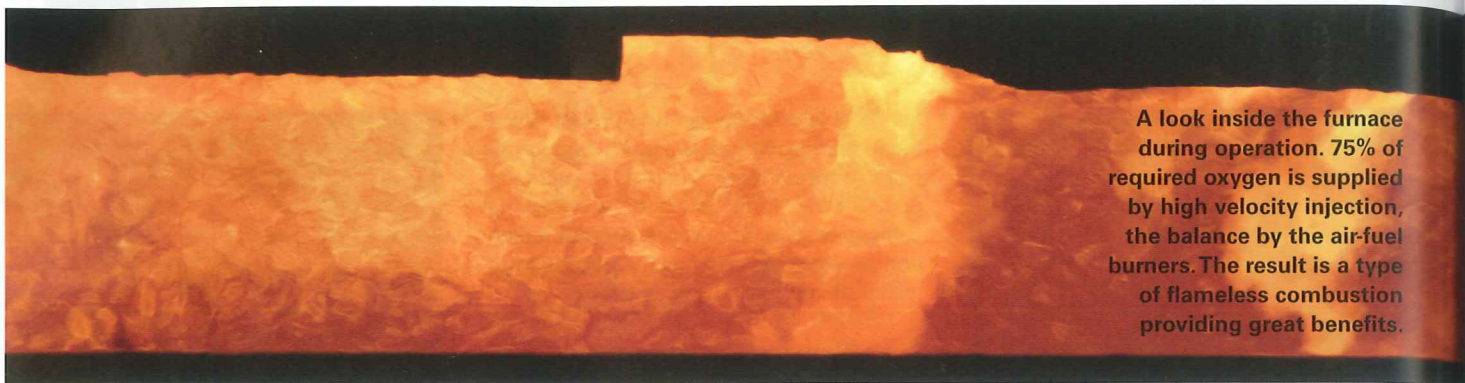


# Flameless Oxyfuel Reheating



A look inside the furnace during operation. 75% of required oxygen is supplied by high velocity injection, the balance by the air-fuel burners. The result is a type of flameless combustion providing great benefits.

For the past 18 years, Linde has been pioneering the use of oxyfuel in reheating and annealing furnaces and installed 115 of its REBOX® solutions in rolling mills and forge shops around the world. Recently, most installations have employed flameless oxyfuel systems; today 30 such installations are running at a total of 15 production sites. At SSAB, flameless oxyfuel is used for slab reheating.

*By Jonas Engdahl, SSAB, Anders Lugnet, Linde, Joachim von Schéele, Linde*

SSAB is global niche producer of high strength steel with a leading market position because of its productivity and its innovative solutions that help increase the competitiveness of its customers. SSAB's production capacity in Sweden and the US totals more than six million tonnes.

SSAB's mill at Borlänge, Sweden, produces sheet coiled products. The size of the slabs is 11,000 mm long by 1,500 mm wide by 220 mm thick. The reheating takes place in two 37 meter long by 12 meter wide walking beam furnaces, heating slabs from 20° C to 1,230° C. Designed maximum capacity was 300 tonnes/hour per furnace. The air-fuel combustion system uses a recuperation system to preheat air to 400° C. The fuel (oil is used) consumption is 440 kWh/t (1.58 GJ/t).

The new installation at SSAB uses the REBOX® HLL technology, which creates a type of flameless oxyfuel without replacing the existing air-fuel burners. By reducing the airflow and substituting high velocity oxygen injection into the combustion, great benefits can be achieved. Approximately 75% of the oxygen needed for the combustion is supplied with this technique. The flue-gas volume is less than 25% that of air-fuel. During trials in April and May 2008, the system was employed. The system start-up took only one day. As of February 2009, the system is running continuously.

## Risks eliminated

It is important to repeat that the technology continues using the existing air-fuel

burners. This means that installation of this technology is rather easy because it does not include any replacement of burners or installation of additional burners, which minimizes the installation down time. Also, the existing air-fuel system, at any time, can be brought back into operation as is was before. This eliminates any potential risk relating to the implementation, and it enables operation to be flexible and optimized in response to fluctuating fuel cost and production requirements.

With this flameless oxyfuel installation the following results have been achieved:

- No negative impact on the surface quality.
- A positive impact on the temperature uniformity of the slabs.
- The ideal heating curve suggested by the control system can be achieved more easily.

Less smoke emanating from the furnace, greatly improving the plant environment.

Based on the results of current installation in one zone, a full implementation would provide:

- A reduction of NO<sub>x</sub> emission by 45% (-14% by one zone).
- Fuel consumption can be decreased by 25%, leading to the same reductions in SO<sub>2</sub> and CO<sub>2</sub> emissions (-7% by one zone).
- Production throughput can be increased by 15-20% (+6% by one zone).

The installation of the REBOX HLL system was made in the upper preheating zone, originally equipped with eight 3.5 MW oil burners. The entire installation was done

during a normal production period, using some brief maintenance stops to drill the holes into the furnace. Oxygen flow trains were placed on top of the furnace to feed the zone with the required pressure and amount of oxygen. Oxygen lances connected with flexible hoses to the main supply piping completed the installation. No changes to the originally air combustion system were needed, which makes it possible to run the system "On" or "Off", dependent on the demands.

## Correct oxygen level

It was decided to have an operating range of the system corresponding to oxygen-enrichment levels of 25-85%. Most of the time, the operation ran with 75% of the total oxygen coming from the high pressure oxygen system. The control system is very important because it must control both the flow of air and oxygen to the zone to achieve a correct oxygen level and complete combustion. However, due to the very fast response time of the oxygen regulation system, a correct oxygen-fuel ratio was very easy to attain at all levels of power rates. Hence, the combustion performance improved so that lower set-points for oxygen-fuel ratios could be used without producing smoke or incomplete combustion.

From an operating point of view, the system was quite simple, the main parameters being oxygen-enrichment level and lambda for the oxygen-fuel ratio. The model used for controlling the heating of the slab was complemented with a gas composition factor, which



# of Slabs at SSAB

Zone 1	Air-fuel Zone 1&2	REBOX HLL Zone 1,2,4,6&9	REBOX HLL	REBOX HLL
Conversion to HLL of total installed power (HLL/Total)	0/152	28/152	56/152	105/152
Fuel consumption [kWh/tonne]	440	408 (-7%)	370 (-16%)	330 (-25%)
NO <sub>x</sub> [tonnes/year] at 1.6 million tonnes production	304	261 (-14%)	219 (-28%)	167 (-45%)
Maximum oxygen use [Nm <sup>3</sup> /h]	-	3,500	7,000	10,000
Production limit [tonnes/h]	300	320	340	350

reflects the higher gas radiation when having higher concentration of CO<sub>2</sub> and H<sub>2</sub>O.

## Excellent results

Implementation in the upper preheating zone has produced many interesting results and proven benefits. The first clear result is the lower fuel consumption. To reach the same temperature in the zone and the slabs as with all air-fuel, the fuel consumption using the new system is approximately 40% less. This is due to two main reasons: less nitrogen to heat; and a higher gas radiation factor. Overall, fuel consumption to operate the whole furnace was reduced by 7%.

It was possible to lower the oxygen/fuel ratio to provide complete combustion without producing smoke. This means that, not only is less fuel needed, less oxygen is required.

The temperature distribution within the zone was very even, producing a profile along the slab that is more uniform.

From an environmental point of view, there are also benefits: CO<sub>2</sub> and SO<sub>2</sub> emissions decrease by the same ratio as the reduction of fuel consumption. NO<sub>x</sub> emissions were tracked very carefully, due to the tight regulations in Sweden. The NO<sub>x</sub> content measured at the stack was lowered by 4-10%,

depending on the total load of the furnace and firing rate of the particular zone.

When evaluating these figures, we should also consider the change of total energy input per ton of produced steel. If taken this into account, on average the system in one zone gives a reduction of approximately 14% of total NO<sub>x</sub> per tonne of produced steel.

Due to the production logistic in the mill, it has not been possible to actually prove the productivity performance. However, it was obvious that with the system the heating rate increased and the potential to increase the tonnage throughput is substantial. For example, no limitations, which normally are present, such as low pressure of combustion air or not enough heat to the material, were reported during the test. Simulation shows that a productivity increase of 6% is achievable with the REBOX HLL installation in the single zone. A higher productivity rate is not the only benefit that comes with higher heating capacity; additional significant advantages are increased soaking time and a more flexible production unit for use as a stand-alone furnace.

## Many advantages

Flameless oxyfuel technology is a proven solution not only for improvement of heating efficiency and to increase reheating capacity, but also to significantly reduce emissions to environment and improve quality of product.

The successful results from REBOX industrial installations of flameless oxyfuel in 30 furnaces demonstrate clear advantages over other alternatives. Further optimization of the installation in the walking beam furnace at SSAB in Borlänge, Sweden grants additional benefits as to those already achieved. Production flexibility, capacity increase, energy efficiency and higher production limits with fewer furnaces are all achievable based on the mill demand. ■



The REBOX HLL installation in a 300 t/h walking beam furnace at SSAB, Borlänge.