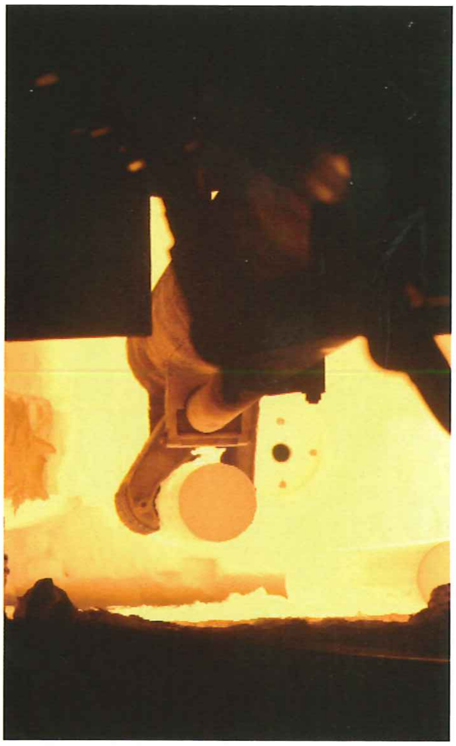
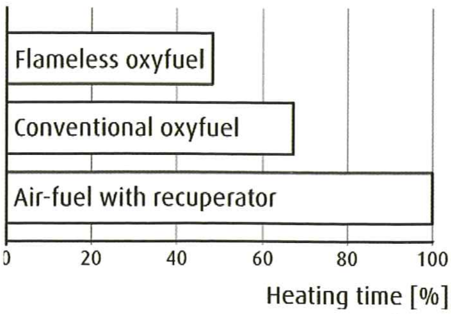
Wide-ranging benefits of flameless oxyfuel combustion

With ever rising fuel and energy costs, could Linde Gas' claims of increased production, decreased fuel consumption and the added bonus of reduced emissions gained from their REBOX® oxyfuel solutions, be the answer to your reheat furnace and annealing needs? Iron & Steel Today looks at an extensive list of references in search of the answer.

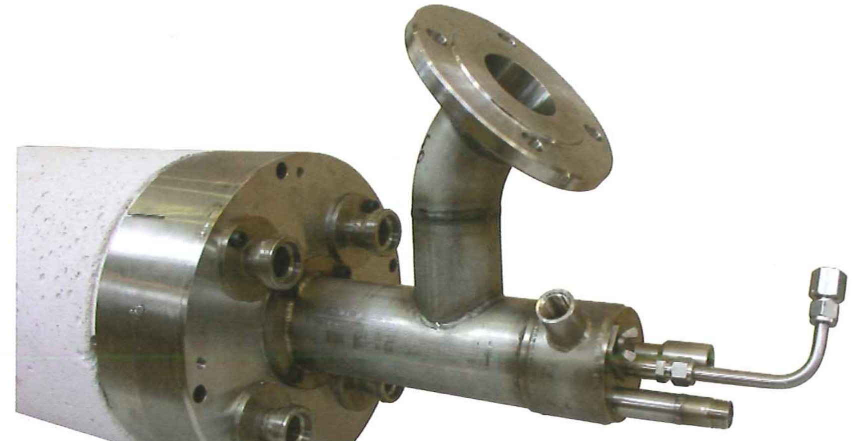


A look through the door into the flameless oxyfuel fired rotary hearth furnace at ArcelorMittal Shelby

Prompted by rapidly rising fuel prices in the 1970s, ways of reducing fuel consumption in reheat and annealing furnaces were first considered within the steel industry. This in turn, laid the foundations that led to the use of oxyfuel solutions in rolling mills and forge shops. By the mid-1980's, Linde began to equip the first furnaces with oxygen enrichment systems. These systems increased the oxygen content of the combustion air to 23-24%. The results were encouraging: fuel consumption was reduced and output, in terms of tonnes per hour, increased. In 1990 Linde converted the first furnace to operation with 100% oxygen, that is, full oxyfuel combustion, at Timken in the USA and has been pioneering the use of oxyfuel ever since.



Comparison of total heating time at Ovako's Hofors Works using different combustion technologies



Flameless oxyfuel burner for low calorific fuels

Today there are more than 110 reheat furnaces and annealing lines in operation using Linde's REBOX® oxyfuel solutions. Increased throughput and flexibility, reduced fuel consumption and decreased emissions of CO_2 and NO_X, both of which are considered greenhouse gases, are the main reasons that these solutions have become increasingly popular. The results can be summarised as:

- Capacity increase of up to 50%
- Fuel savings of up to 50%
- Reduction of scaling losses
- Reduction of CO_2 emissions by up to 50%
- Reduction of NO_X emissions (guaranteed level below 70mg/MJ).

Introduction of flameless oxyfuel combustion

In recent years, flameless oxyfuel combustion has been successfully applied and the technology has been proven to deliver outstanding results. It has such major advantages, that Linde feel it is likely to be installed for most applications. The advantages of conventional oxyfuel combustion are combined with those of flameless combustion, to produce improved and more uniform heating whilst reducing NO_X emissions. Combustion with low NO_X emissions, is normally important in large, continuously operating reheat and annealing furnaces, but is also relevant to other heating processes, for example, the drying and pre-heating of ladles and other vessels.

An example of the impact of flameless oxyfuel can be found at Ovako's Hofors works in Sweden. The first use of oxyfuel in reheating operations dates back to1994. Since then, a large number of soaking pits and rotary hearth furnaces have been converted to conventional oxyfuel. However, in 2006, flameless oxyfuel began to be used, and installations with conventional oxyfuel were then converted to flameless operation. These included ladle preheating facilities. In addition to further decreasing the total heating time by 15%, the flameless oxyfuel also delivered more uniform heating and an additional fuel saving of 17%, as well as 5-20% less scaling.

Close co-operation

The development of flameless oxyfuel combustion, has been brought forward in close co-operation with steel producers in order to meet their needs. It builds on the proven advantages of oxyfuel over air-fuel, which have been demonstrated for many years. In commercial installations since 2003, it has been clearly proven that flameless oxyfuel has taken this a step further, with even higher production rates, decreased fuel consumption, reduced CO_2 emission, very low NO_X emission and uniform heating.

Over the past five years, Linde has established flameless oxyfuel in the steel industry and today, can claim installations either up and running or in progress, at a total of 14 production sites such as: Acerinox, ArcelorMittal, Ascométal, Böhler-Uddeholm, Dongbei Special Steel, Kanthal, Outokumpu, Ovako, Sandvik, and Scana Steel.

Outokumpu, Sweden: Walking beam and catenary furnaces

In 2003, a walking beam furnace in Degerfors was rebuilt and refurbished in a Linde turnkey project with performance guarantees. It entailed replacing the air-fuel system (including recuperator) with flameless oxyfuel, and the installation of essential control systems. The resultant 40-50% improvement in heating capacity, provided increased loading of the rolling mill, a reduction of over 25% in fuel consumption, and NO_X emissions below 70mg/MJ.

At the Nyby plant, there are two catenary furnaces, originally installed in 1955 and 1960 respectively. Led by the need for an increase in production, combined with stricter demand for low NO_X emissions, the catenary furnace on the first annealing-pickling line – for hot or cold rolled strip – was converted to all oxyfuel operation in 2003. The 18 metre long furnace, was equipped with flameless oxyfuel burners. The total power input of 16MW was not altered when converting from air-fuel to oxyfuel, but with oxyfuel the heat transfer efficiency increased from 46% to 76%. The replacement of the air-fuel system, combustion blowers and recuperators, resulted in a 50% increase in heating capacity without any increase in the length of the furnace and a 40% reduction in specific fuel consumption, with NO_X levels below the guaranteed level of 70 Mg/MJ.

At the Avesta works, stainless sheets are hot-rolled in the Steckel mill and cold-rolled in the Z-high mill. Avesta has the world's largest oxyfuel fired furnace, of 40MW. The old 24 metre furnace had a capacity of 75 tonnes per hour, but the challenge was to double this whilst meeting strict emissions requirements. The refurbishment included a 10 metre extension, yet production capacity was increased to 150 tonnes per hour. The conversion involved the removal of air-fuel burners and recuperators, followed by the installation of all oxyfuel equipment. The oxyfuel technology involved staged combustion. This conversion reduced fuel consumption by 40%, and NO_X levels are now below 65mg/MJ.

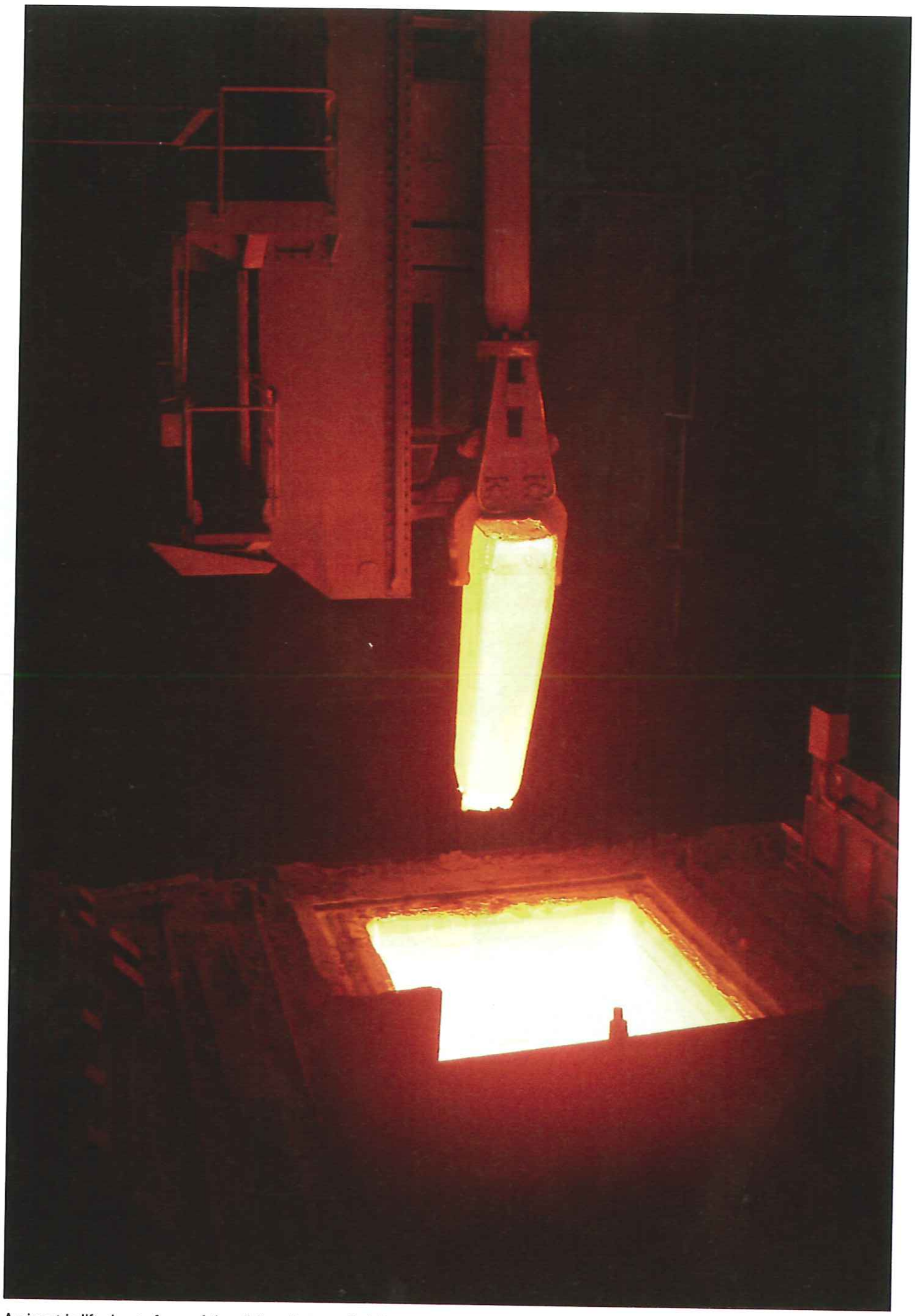
This furnace is an example of another route to flameless, with conversion from conventional oxyfuel to flameless oxyfuel in the past year. Flameless oxyfuel is also used for drying and preheating of ladles and converters at the Outokumpu plant.

Ascométal, France: Soaking pit furnaces

In 2007, Linde also undertook flameless oxyfuel installations at two sites belonging to the bearing steel producer Ascométal, part of the Severstal Group. At Fos-sur-Mer, a turn-key delivery in 2005-2007 converted nine soaking pit furnaces into all flameless oxyfuel. The delivery included a combustion system with flameless burners, furnace upgrade, new flue gas systems, a flow train and a control system. The furnace sizes are 80 to 120 tonne heating capacity each. The results include 50% more heating capacity, 40% fuel savings, NO_X emission reduced by 40%, and scale formation reduced with three tonnes per 1000 tonnes of steel heated. In a second and similar project in France between 2007-2008, four soaking pit furnaces at the Les Dunes plant were also converted into all flameless oxyfuel operation.

ArcelorMittal Shelby, USA: Rotary hearth furnace

In 2007, Linde delivered a turnkey conversion of a 15 metre diameter rotary hearth furnace at this seamless tube producer. It included a combustion system with flameless burners, a furnace upgrade, new flue gas systems, a flow train, and a control system. The former air-fuel fired furnace was converted in two stages, first using oxygen-enrichment for a period of time and then implementation of the flameless oxyfuel operation. Excellent results have been achieved, meeting all performance guarantees. These included 25% more throughput, 50% fuel savings (from enrichment), reduced NO_X emission below 70mg/MJ and 50% reduced scale formation.



An ingot is lifted out of one of the all flameless oxyfuel fired soaking pit furnaces at the Fos-sur-Mer plant

Power in a small package – and also for poor fuels

Oxyfuel burners have always been powerful and compact. The new generation of flameless oxyfuel burners, have maintained a compact design to facilitate both the exchange of existing oxyfuel burners and also easy retrofit in air-fuel installations. A 5MW water-cooled burner for example, has a diameter of less than 15cm and weighs less than 20kg.

The steel industry also demands an ever increasing need to burn low calorific fuels. For fuels containing below 2 kWh/m^3, use of oxygen is an absolute requirement. Flameless oxyfuel can be successfully employed here. In integrated steel mills, the use of blast furnace top gas (less than 1 kWh/m^3), alone or in combination with other external or internal fuels, is becoming increasingly important. This type of fuel not only has a low energy density, meaning that large volumes have to be transported, but by frequently being flue-gases, they are also at low pressure which is costly to increase.

The all-round solution

Flameless oxyfuel combustion has such major advantages that there is no longer any reason to apply conventional oxyfuel in pre-heating (of ladles and other vessels), re-heating and annealing processes. The only exception would be Direct Flame Impingement (DFI), for example, for boosting capacity in metal coating lines. The ability to also use it for combustion of low calorific fuels is an added advantage. With 30 installations worldwide over the past five years, Linde Gas can claim flameless oxyfuel as a proven and leading technology in this field.

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