Boosting Heating Capacity Using New Technology

'Growing through introducing new technology has been an exciting journey', says Sten Ljungars, Technical Manager at Outokumpu Stainless, Coil Products Nyby. 'Of course it has been challenging, but by continuously implementing new oxyfuel technologies we have achieved excellent results, strongly supporting our vision "Best in Stainless".'

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Outokumpu Stainless is a leading producer of stainless steel. Yet it is also a company with a wealth of experience of using oxyfuel in its reheat furnaces and annealing lines. At its production sites at Avesta, Degerfors and Nyby in Sweden, there are many excellent examples of this. Today Outokumpu Stainless has a total of 15 oxyfuel furnaces. The main reasons for converting these operations to all oxyfuel were:

- The need to increase production capacities
- The desire to minimise fuel consumption
- Stricter environmental legislation

The oxyfuel journey began back in the mid-1980s with oxygen-enrichment. AGA, who during the past 15 years has pioneered the use of oxyfuel in this field, constructed its first all-oxyfuel installation at Timken in the USA in 1990. Just two years later, in 1992, Outokumpu Stainless began to convert to all oxyfuel, when the new technology was installed at a comparatively large pit furnace at its Degerfors plant.

Doubled capacity

At the Avesta plant, stainless sheets are hot-rolled in the Steckel mill and cold-rolled in the Z-high mill. The catenary furnace for strip annealing is an enormous oxyfuel installation. In 2001, this furnace was refurbished and converted to oxyfuel operation. The total installed oxyfuel power is 39 MW – the biggest in the world in this context.

The old 24 m furnace had a 75 t/h capacity, but the requirement was to double this whilst at the same time meeting strict requirements for emissions. The refurbishment included a 10 m extension, yet production capacity was increased to 150 t/h. The conversion involved the removal of airfuel burners and recuperators and the installation of all oxyfuel. The oxyfuel technology used involved staged combustion. The conversion reduced fuel consumption by 40%.

Airfuel to DFI: tripling output

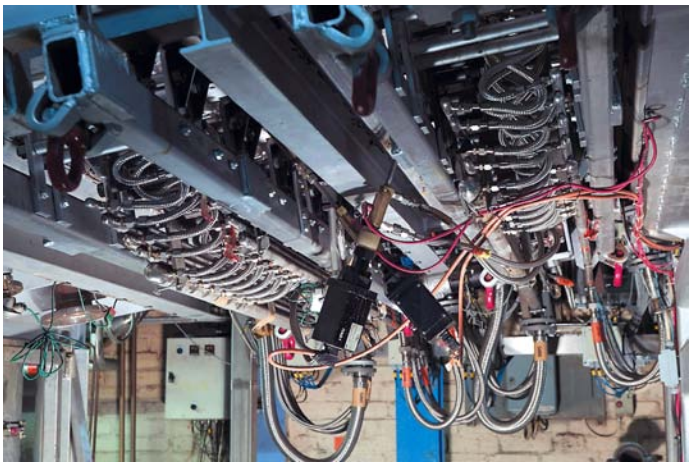
At the Outokumpu Stainless Nyby plant, there are two catenary furnaces, originally installed in 1955 and 1960 respectively. The Nyby plant has sufficient capacity to produce 150,000 t/a of stainless strips.

The catenary furnace on the first annealing-pickling line, for hot or cold rolled strips, was converted to all oxyfuel operation in 2003. Requirements for increased production combined with stricter requirements for low NO_X emissions led to this decision. The furnace, 18 m long, was equipped with REBOX-R burners for flameless oxyfuel combustion. The total power input, 16 MW, was not altered when converting from airfuel to oxyfuel, but with oxyfuel the heat transfer efficiency increased from 46 % to 76%. As a result, production capacity was increased from 42 to 65 t/h without any increase in the length of the furnace, and NO_X emissions were kept below 70 mg/MJ.

World's biggest oxyfuel installation, 39 MW in a catenary furnace in Avesta. At the conversion, the furnace was extended only 10 m, but production capacity was raised from 75 to 150 t/h.

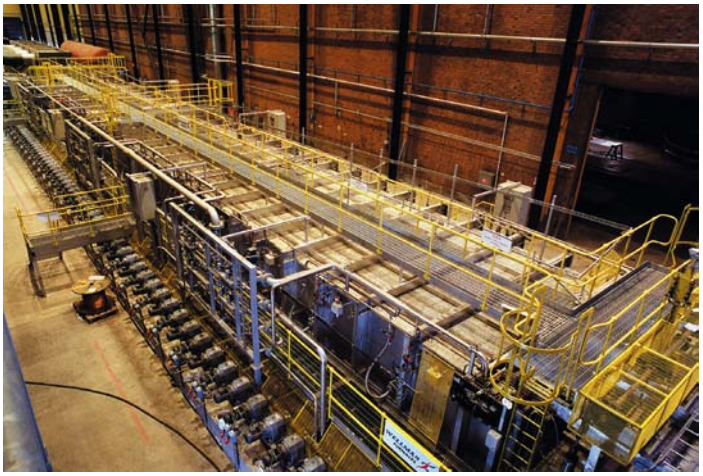
In the final annealing-pickling line at Nyby, the catenary furnace is 19 m long. When it was equipped with airfuel burners, it had a production capacity of 11 t/h. Oxygen-enrichment was then added, increasing capacity to 16 t/h. In 1995 this furnace was converted to all oxyfuel operation, enabling the output to reach 23 t/h.

Although these figures indicate fantastic improvements due to the use of new technology without extending the furnace, yet more was desired. In 2001 it became clear that higher



A Direct Flame Impingement (DFI) unit, with 120 nozzles in 4 cassettes, is used at the entry of a catenary furnace in Nyby to increase the heating capacity by 50 %. The photograph shows one of the DFI cassettes from below.

Catenary furnace in Nyby that has been converted to operation with REBOX-R flameless oxyfuel combustion technology. The furnace length remained unchanged, but production capacity was increased by 50 %.



Roller hearth furnace in Degerfors using staged oxyfuel combustion. Fuel consumption is 235 kWh/t.

Walking beam furnace in Degerfors that has been converted to operation with REBOX-S flameless oxyfuel combustion technology.

throughput capacity and flexibility were required. The authorities did not object to an increase in production but stipulated that NO_X emissions were to be reduced. Yet there was a further obstacle: there was very little space available to extend the furnace, so how could the production rate be increased, given that the furnace had already been converted to all oxyfuel operation?

AGA provided the solution to this very difficult problem. A completely new technology was brought in: Direct Flame Impingement (DFI). In 2002, DFI was installed at this catenary furnace. It was a very compact unit, being 1.8 m long, 2.4 m wide and 1 m high, and was installed at the entrance to the furnace. The unit contained 120 burner nozzles in 4 cassettes, in total 4 MW of oxyfuel. These small oxyfuel flames heat the moving steel strip directly, which has a huge impact on the heat flux (kW/m^2). This improved temperature control and also increased heating capacity by 50 % in the furnace. With a 1.8 m extension of the furnace, production capacity was raised from 23 to 38 t/h.

These two catenary furnaces are probably the world's most efficient of their kind considering their length (approximately 20m) and production capacities. An additional benefit is the impact the use of oxyfuel has had on the surface quality of the strips. As a result, there is no longer any need to use skin pass rolling on Cold Rolled 2B.

'We aimed for higher output, but we also reduced the number of process steps by one and reduced our costs by converting to oxyfuel', says Sten Ljungars.

Three generations

The Degerfors plant is an excellent showpiece for understanding the development of oxyfuel technology.

By 1995, the number of pit furnaces at Degerfors using oxyfuel had reached 8, and 2 box furnaces for batch annealing were also equipped in the same way. Two other larger oxyfuel installations followed: a new roller hearth furnace in 1998 and the conversion of a walking beam furnace in 2003. The latter employs flameless combustion, the so-called REBOX-S technology.

Among the benefits obtained from operating these furnaces with oxyfuel combustion are the short throughput time, which increases production capacity, and low fuel consumption and environmental impact.

It is actually possible today to see three generations of oxyfuel technology in operation in the same building at the Degerfors plant:

- The batch annealing furnaces using conventional water-cooled burners (1995)
- The roller hearth furnace with ceramic burners with staged combustion (1998)
- The walking beam furnace with flameless REBOX-S technology (2003)

Flameless combustion

As mentioned above, both a catenary furnace in Nyby and a walking beam furnace are operating at Degerfors using so-called flameless combustion. In fact, the other catenary furnace in Nyby will also soon be using this technology. Flameless combustion, or, to put it more scientifically, volume combustion, is a technique where the flame is diluted with flue gases. This is done to achieve a cooler but more widely spread flame. As a result of this, the flame becomes practically invisible. However, the aim is to substantially lower the production of NO_X and to produce a more even distribution of heat – a diluted flame still contains the same amount of heat.

Although all oxyfuel means combustion without any nitrogen (as compared with air fuel; air contains 78 % nitrogen), the very high flame temperature strongly encourages the production of NO_X; the nitrogen originates from air-ingress to the furnace. However, with flameless technology NO_X emissions are reduced to very low levels. During stable furnace operating periods, NO_X levels below 25 mg/MJ are achieved.

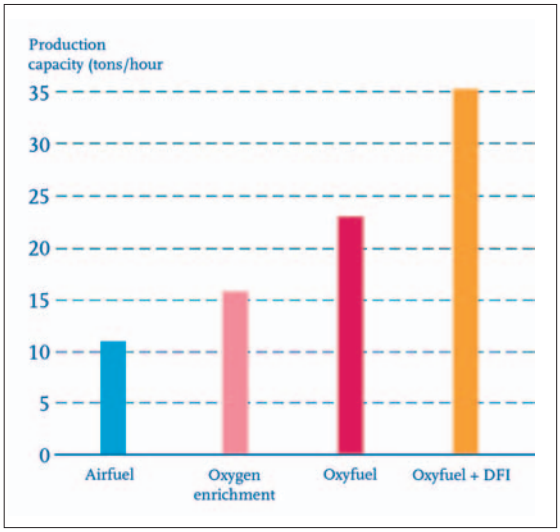
Flameless combustion has arrived and it is definitely here to stay. There are clear advantages and today there are few cases where this technology should not be the natural choice. This is also valid for other heating operations, such as ladle preheating.

Partnership provides more capacity

In total, there are now 15 furnaces operating with all oxyfuel within Outokumpu Stainless' Swedish operations. The combined oxyfuel power rating of these furnaces is about 150 MW.

Linde, the company of which AGA is a member, has now installed oxyfuel in more than 80 reheat furnaces and annealing lines over the past 14 years. Despite this, the use of oxyfuel in this context is still seen as a 'new technology' by many people. The key to introducing this technology has been, and still is, partnership with users.

The environmental and cost-saving drive to use new technology has to overcome the tendency to choose old 'proven' solutions. Working in close co-operation with selected key customers such as Outokumpu Stainless, AGA has been able to introduce new technology at full-scale production units. This joint commitment ensures a successful implementation and gives the customer access to highly cost-efficient state-of-the-art technology. This has been the key to the development of all oxyfuel firing in reheat furnaces and annealing lines, and it will provide the basis for successful developments in the future, both for the supplier and the customer. ■



Development of production capacity, from the 1980s until today, as a function of technology employed in the roughly 20 m long final strip annealing line in Nyby. Today, after further tuning, the capacity has reached 38 t/h.