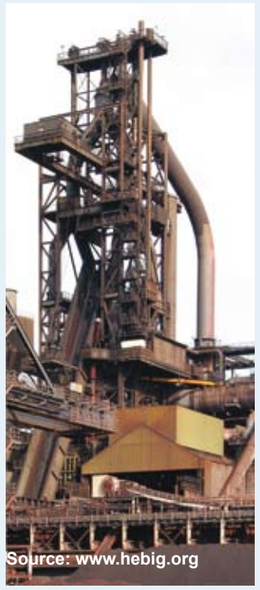
# Gases in the steel industry - *intensity continues to increase*

In the light of increased demand for metals and growing environmental pressures, Ian Salusbury looks at the prospects for gas supply to the ferrous metal industry.

**BOF versus EAF**
The BOF process uses up to 30% recycled steel, whereas the EAF process relies on the use of scrap material. The World Coal Institute says that 43% of total world crude steel production comes from recycled steel, making it the most recycled material in the world. But the growth in the industry and the long-term use of steel has resulted in a lack of availability of steel scrap, which will limit the expansion of EAF facilities. Also, the quality of the steel produced in the EAF process is restricted by the quality of the scrap input.



Source: www.hebig.org

FERROUS METALS are those containing iron and the most significant one by far is steel. It has been estimated by the EU that two-thirds of the turnover of the European metals industry comes from ferrous metals. There are also around 40 non-ferrous metals in production (the most common being aluminium, lead, copper, tin and zinc) and alloys such as brass. Supplying these industries generates a substantial proportion of the major gas suppliers' revenues. Praxair attributes 17% of its sales revenues to the metals industry, second only to manufacturing's 22% share.

Dr Joachim von Schéele, Marketing Manager for the Metals & Glass Industries division at Linde, explained why the market for gases in the metals industry is growing, "In addition to growing steel and metals production, there are a couple of drivers out there that are on our side – the environment is one of them and fuel prices are also supporting us...There are even more advantages where raw materials prices are high. So we have a pretty good situation."

Oxygen is the key gas used in metals manufacturing processes, and is added by means of oxygen enrichment, injection or oxy-fuel burners. Paul Grohmann, Head of the Technology Management department in Messer's metallurgy division, explained how using oxygen helps the industry reduce energy costs, "Air has the disadvantage of carrying nitrogen and this diminishes the combustion efficiency. So with the exhaust you get lots of heat lost, if you have no heat recovery system for preheating the combustion air, for example." He went on, "You have much better radiation in using oxygen – the radiation of the flue-gas consists only of the radiation from carbon dioxide and water. Nitrogen does not take part in gas radiation at all (like all other gases with two atoms) within the temperature scope of furnaces."

Better use of oxygen also helps to reduce the industry's other environmental impacts. Using oxy-fuel burners reduces the volume of flue gases and those that are produced consist mainly of water vapour and carbon dioxide, which can then be sequestered. Reducing the input of nitrogen also reduces emissions of nitrogen oxides (NOx).

**Ferrous metals**
Steel production has seen huge growth in recent years. Between 2000 and 2007, the total output of the industry increased by 54% and now stands at around 1300 million tonnes per annum.

There are two main processes for steel making: the basic oxygen furnace (BOF) and the electric arc furnace (EAF). According to UK Steel (the trade association for the steel industry in the UK), basic oxygen steelmaking delivers 65% of global steel production, electric arc processes provide 32%, and other processes makes up only 3% of production.

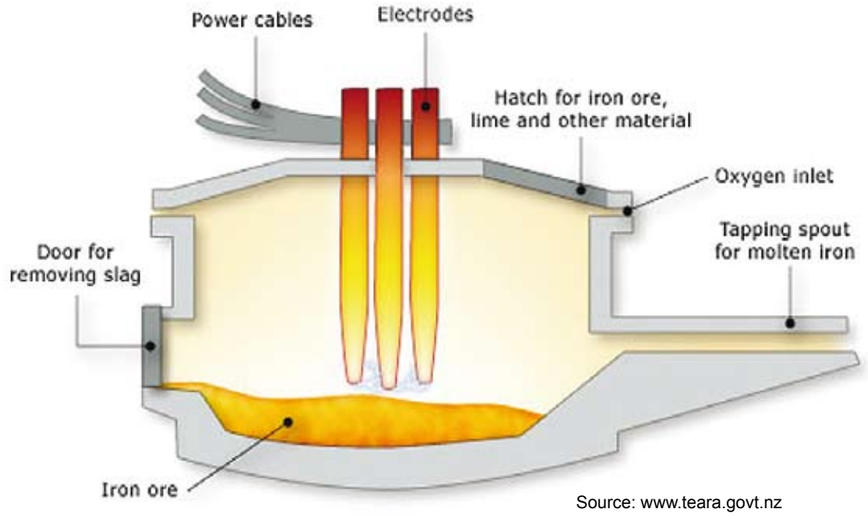
> **"There are a couple of drivers out there that are on our side"**

In the BOF process, iron ore, coke, and limestone are heated in blast furnaces, into which oxygen-enriched air (typically 30% oxygen) is blown, via nozzles called tuyeres. Typical oxygen consumptions for large blast furnaces are around 1000 tpd. This process produces the molten pig iron that feeds the BOF. Its lining of alkaline refractory materials (calcium oxide and magnesium oxide) gives the furnace its name of "basic". High purity oxygen is injected into the BOF to oxidise the excess carbon, to bring the percentage down from around 5% to 0.05-2.0%, depending on the type of steel being made. Low carbon steels (typically used in automobile body panels) contain at most 0.10% carbon while high carbon steels (used in spring materials and high strength wires) contain between 0.60 and 1.0% carbon. Steel makers using this process generally require 800-1300 tpd of oxygen.

In the EAF process, which is used in installations known as mini-mills, the input is scrap metal. This is loaded into the furnace with some iron ore and then subjected to high intensity electrical power to melt the contents. Oxygen is input via oxy-fuel burners. Praxair has a particular expertise in this area and in 2007 announced the 100th license for its CoJet gas injection system. As the EAF process operates on a smaller scale than the BOF, anything from 10 to 250 tpd of oxygen are required.








Source: www.teara.govt.nz

**The Electric Arc Furnance**
The electric arc method of melting metal is becoming more popular in use. By using a fuel-efficient oxy-fuel flame at the beginning of the melting process, a greater overall melting efficiency is achieved with a faster melt rate, according to Air Products. Further temperature homogeneity benefits can be achieved by using these burners to direct thermal energy at cold spots caused by uneven energy distribution from the electrode arcs.
Additionally, the burners can be positioned in front of the slag door to enable early, efficient oxygen lancing, or over the tap hole area to promote quick, trouble-free tapping. Electrical savings of 80kWh/tonne and 20% production increases have been achieved.

Oxygen is involved in steel making as a reactant or a combustant and is now being applied in an increasing number of processes, as Paul Grohmann of Messer noted, "There is a trend now in steel mills to enrich the air for reheating processes. Blast furnaces have already done this, and now reheating furnaces are being converted. This has generated a big increase in demand for $O_2$ for steel mills from our customers."

Dr Pravin Mathur, Director of Business Development at Praxair, confirmed that oxygen is by far the most significant gas in terms of tonnage supplied, but also pointed to the other key gases used, "Oxygen is most important, but if you look at stainless steel, argon plays a huge role. And nitrogen is used as a carrier gas and for miscellaneous uses."

> **"Powdered coal injection can become more and more important"**

Although nitrogen is usually suitable to use as an inert gas in other industries, in the metals industry, argon often has to be used instead. Argon is used to protect those metals or alloys, such as chromium, vanadium, aluminium and magnesium, which would react with nitrogen or incorporate it within the material. Nitrogen is used for cooling, stirring (such as when alloying elements are added to the steel) and as a carrier gas for powder injection. Hydrogen is used for annealing high alloy steels and in DRI production.

Although the basic oxygen and electric arc furnace processes are predominant, there are other steel-making processes in use:

- Pulverised Coal Injection: this process has been used since the early 1960's. It involves direct injection of coal into the blast furnace and allows for a wider range of coals to be used. Pravin Mathur explained the benefits of this process: "There's an environmental benefit as well as a cost saving benefit with our gas application technologies – for example, powdered coal injection in blast furnaces can become more and more important because today the cost of coke has gone through the roof."
- COREX: this can also produce molten iron without using coke.
- FINEX: the first working example of this technology has been established by Posco in South Korea. It uses a fluidised bed reactor, and so can process non-coking coal and iron ore fines. It began operations in April 2007 and has achieved large reductions in pollutant emissions: the amount of NOx emitted is 4% that of a blast furnace.

Most of these new processes require the use of oxygen at even greater intensities, to the satisfaction of industry figures such as Pravin Mathur: "If anybody puts a COREX or any of these newer ironmaking processes in, we're happy!"

It's no surprise that China is now the world's leading steel producer, but the scale of its production is startling. According to figures from the International Steel and Statistics Bureau, China now accounts for 37% of all steel produced; its output has equalled that of the next six biggest producers combined (Japan, USA, Russia, South Korea, Germany and India).

Recent announcements by the major gas suppliers of new projects reflect this dominance. For example, last year Air Liquide revealed an agreement with Shagang, the leading private steel company in China, for two new air separation units (ASUs), which will produce 2000 tpd of gaseous oxygen, while Air Products signed a deal with Tangshan Guofeng Steel for a third ASU at their steel mill in Hebei Province in Northern China. Announcements by Linde of major investments for ASUs to supply the Austrian company Voestalpine and Corus in The Netherlands serve as a reminder of the health of the steel industry in the EU though.

So the future looks very promising – the combination of high energy prices, more stringent environmental legislation, and a growing demand for its products, makes the metals industry an excellent market for gas suppliers. Oxygen will continue to be the main gas supplied, but the development of new processes could result in more diverse requirements in future.

**Challenging $CO_2$ emissions**
In the EU the steel industry has become so efficiently run that there is no prospect of significantly reducing $CO_2$ emissions by increasing recycling or saving energy by switching from coal to natural gas fuelling. Therefore, more radical steps are being considered in the ULCOS project – Ultra Low $CO_2$ Steelmaking. Forty-eight companies (including Air Liquide), research institutes and universities are working in this EU-funded project with the aim of reducing $CO_2$ emissions by 50% by 2050. The options being considered include new designs for blast furnaces, $CO_2$ capture and storage and the use of hydrogen or natural gas to reduce iron ores. The latter produces direct reduced iron (DRI). In contrast to a blast furnace which melts all the material input and then separates out non-ferrous material such as slag, the DRI process does not include this separation step and so must use much purer ore. The use of DRI in conjunction with EAF technology already accounts for up to 5% of overall steel production, but is only practised in one steel mill in Europe, that of Mittal Steel in Hamburg.