AIR PRODUCTS

Steel Times International

EAF Steelmaking

Comparing oxygen/ carbon injection in a twin shell furnace

Steel Times International

EAF Steelmaking

Comparing oxygen/carbon injection in a twin shell furnace

In December 2001, Process Technology International Inc. (PTI)'s new JetBOx™ technology, marketed in Europe and Middle East by Air Products PLC, a subsidiary of Air Products and Chemicals Inc (NYSE: APD), was successfully set up at Gallatin Steel, KY, USA, one of the largest DC Arc Furnaces in the world.

Two JetBOx™ systems were installed in one of the twin Shell DC EAF, while the other one remained unchanged to allow for true comparison of the oxygen system (See Attachment 1: Furnace Parameters). Gallatin's initial requirement was to make the door lance pipe manipulator redundant, which was achieved 2 weeks after the JetBOx™ system went in operation.

Three months of successful operation have demonstrated sizeable results: (see Table 2 for more details)

- Increased foamy slag allows a reduction in arc current for better electrode savings and /or power input increase
- Energy costs savings (electrical consumption down 6%)
- Operating costs savings (Oxygen consumption down 25.7%, thus cutting the electrode consumption down 6.7%; carbon injected down 33%)
- Refractory savings
- Increased yield (up 1.6%).
- Increased safety.

"We expect even better results in the coming months, as a step-by-step approach is being taken to optimise oxygen consumption. For example, there is room to increase the oxygen consumption, which would reduce consumption in electrical energy," said Malcolm Coburn, VP technology, PTI.

"Our objective was successfully met and we now experience further benefits of the system: key costs savings and improved safety," said Willy McClintock, Meltshop Manager from Gallatin Steel.

In the last 12 months, Air Products and PTI have successfully installed JetBOx™ systems around the world, which are currently in operations in the USA, China, Poland and South Africa. (See Diagram 3: JetBOx™ profile diagram)

1- Furnace Parameters

- Ave electrical input 110 MW
- Furnace Tap weight 172 metric tons
- Twin shell single power source (switch from shell to shell)
- Copper water cooled panels
- Product – thin strip
- Ave. tapping carbon 0.03 %. Active oxygen about 850 ppm
- Single charge per heat using approximately 23 % pig iron and 15% HBI
- Average approximately 24 heats per day
- Typical Power on time (POT) 48 minutes
- Previous oxygen equipment – slag door manipulator with 2 consumable lances 3400 Nm^3/h each of oxygen flow.
- Installed now -two (2) PTI JetBOxes @ 4.5 MW capacity and 2550 Nm^3/h oxygen each.
- Carbon injection has two points - through JetBOx and through the roof.

About Gallatin Steel

Gallatin Steel is a joint venture between Dofasco, Inc. and Co-Steel, Inc., two of Canada's largest and most successful steel producers. Gallatin Steel produces steel of the highest quality, while emphasizing employee safety and care for the environment. Located in Ghent, Kentucky Steel Plant equipped with Twin-shell DC Powered Electric Arc Furnace (EAF), Ladle Metallurgy Facility (LMF), Single-Strand Thin Strip Caster, Tunnel Re-Heat Furnace, 6 Stand Finishing Mill and Coiler. Plant produce the Hot rolled coils of different grades including SAE and ASTM grades, High Strength and Low Alloy Grades, and API Line Pipe Grades. More information is available at web page: www.gallatinsteel.com

2- Table 2: Initial Results after 3 months of operation

Description	Unit	Before	After	diff.	diff. %
Tapping Weight	t	172	172	0	0,0%
Power Input	MW	110	110	0	0,0%
Tap to Tap Time	Min	52,2	50,8	-1,4	-2,7%
Power on Time	Min	47,4	45,9	-1,5	-3,2%
Secondary Voltage	V	865	865	0	0,0%
Electrical Consumption	Kwh/t	448	421	-27	-6,0%
Natural Gas Consumption	Nm^3/t	0	2,5	2,5	-
Oxygen Consumption	Nm^3/t	29,6	22,0	-7,6	-25,7%
Electrode Consumption	kg/t	1,79	1,67	-0,12	-6,7%
carbon bulk	kg/t	5,6	3,6	-2	-35,7%
Carbon injected	kg/t	9,1	6,1	-3	-33,0%
Yield	%	92,6	94,1	1,5	1,6%

Jetbox™[1]: lateral thinking improves EAF economics

Moving oxy-fuel burners further into an electric arc furnace (EAF) increases oxygen jet penetration and significantly cuts energy consumption. Such a simple-sounding idea has improved the performance of more than 16 EAFs in the past two years

A simple idea that improves the penetration of supersonic oxygen jets in electric arc furnaces (EAFs) has taken off in a big way. Since the JetBOx™ system was introduced to Europe two years ago, more than 16 other furnaces worldwide have been retrofitted with the technology.

Users find that the JetBOx™ system reduces electricity consumption, typically by around 9% compared to an EAF fitted with conventional oxy-fuel combustion, and increases steel production rates. The JetBOx™ system achieves these benefits without increasing the consumption of either oxygen or natural gas.

Air Products PLC markets Process Technology International, Inc. (PTI) JetBOx™ system and technology in Europe, Middle East and North Africa, and over the last eight years PTI has developed a series of unique water-cooled oxy-fuel burners for use on EAFs. Their applications include preheating and melting scrap, decarburising molten steel with a shrouded supersonic oxygen jet, post-combustion of CO, and injecting carbon to foam slag. The main benefits of PTI's oxy-fuel burners are lower electricity consumption and increased steel production. Since 1995 PTI burners, oxygen lances and integrated combustion systems have been installed on more than 40 EAFs in the USA, Canada, South Africa, Europe, China and Korea, giving an installed total of about 200 burners and lances. PTI systems are used by world leaders in EAF steelmaking, including Nucor Steel, Republic Engineered Technologies, IPSCO, Gallatin Steel, North Star-BHP Steel, POSCO, Dongkuk Steel and Gerdau Steel.

Air Products PLC is the UK subsidiary of Air Products (www.airproducts.co.uk), the world's only combined gases and Chemicals Company. Air Products serves customers in technology, energy, healthcare and industrial markets worldwide with a unique portfolio of products, services and solutions, providing atmospheric gases, process and specialty gases, performance materials and chemicals intermediates. The company is a longstanding innovator in many industrial markets, including coatings, adhesives and polyurethanes, the production and processing of iron and steel, ferrous metals casting, and the non-ferrous metals industry.

Big benefits for users of all sizes

PTI, in co-operation with Air Products PLC, installed Europe's first JetBOx™ system back in November 2000. On a 130 t electric arc furnace (EAF) at the Huta Zawiercie steelworks in Poland, a JetBOx™ system with four JetBOx™ oxy-fuel jet burners replaced three conventional burners and a slag door lance manipulator.

Following their successful co-operation on the Huta Zawiercie project, PTI and Air Products PLC agreed to market the new technology across Europe, the Middle East and North Africa.

In May 2002 a JetBOx™ system was installed on a 120 t DC EAF at Stahlwerk Thüringen (SWT), Germany. The unit was adopted after three months of successful trials, and has now become a standard part of the chemical energy package at SWT. "The unit has reduced electrical energy consumption and improved chemical energy efficiency, slag foaming consistency and refractory life of the adjacent EBT area," says Mr. Kleingärtner, melt shop superintendent at SWT.

Another German steel maker, Georgesmarienhütte (GMH), decided to install a JetBOx™ system on its 130 t DC EAF. This unit was commissioned in September 2002 and has now been running successfully for two months.

The reference list includes many Asian steelmakers, of which the latest is Dongkuk Steel, Korea. On a 100 t DC EAF at Dongkuk Steel, a JetBOx™ system with four JetBOx™ oxy-fuel jet burners have replaced a water-cooled slag door lance and four sidewall burners. This JetBOx™ system has reduced electricity consumption by 9% and power-on time by 11% resulting in more than a 10% increase in metal output.

The JetBOx™ technology has been successfully applied to smaller furnaces too. One example is Gerdau Courtice, a Canadian steelmaker with a 38 t EAF. Here, a JetBOx™ system with three JetBOx™ oxy-fuel jet burners replaced four sidewall burners and a slag door lance manipulator. The installation has cut electricity consumption by 10% and also reduced power-on time by 9%. These benefits were achieved with no increase in the consumption of oxygen or natural gas, clearly demonstrating that the JetBOx™ system can provide improved chemical energy efficiency.

Improved bath penetration

The JetBOx™ technology works so well because it uses a simple yet radical idea to solve an old problem: lack of penetration of the oxygen jet.

Conventional oxy-fuel burners and lances are mounted in the sidewall of the furnace. They provide an oxy-fuel flame, which helps to melt the scrap, and a supersonic jet of oxygen to decarburise the molten steel and supply chemical energy. Carbon is then injected near the oxygen jet to help with slag foaming and reduce FeO.

The big challenge is to keep the velocity of the oxygen jet high enough to provide good penetration through the slag and into the molten steel beneath. Higher jet velocity means faster decarburisation and more efficient use of oxygen.

With conventional burners and lances, the supersonic jet of oxygen has to travel a considerable distance before it strikes the molten metal. Over this distance it loses a significant part of its velocity, and this greatly reduces the penetration of the jet.

One solution to solve this problem would be to increase the flow of oxygen to. Unfortunately, would have significant implications for cost and efficiency. Excessive use of oxygen can cause panel flashback and increase both refractory wear and electrode consumption.

Another technique, which PTI have successfully used, is to shroud the supersonic core of the jet inside an outer flame. The fast-moving edges of an unshrouded jet entrain gas from the surrounding area, causing the jet to expand and lose velocity (Figure 1). Shrouding reduces turbulence at the edges of the jet, and so reduces entrainment. This technique is an effective method of maintaining a high velocity, and shrouded oxygen jets are now standard in many burner systems. Since 1995 more than 16 steel mills have decided to install JetBOx™ to their EAF.

Stay supersonic with lateral thinking

But shrouding and high oxygen delivery rates only go so far to preserve jet velocity. Significant velocity is still lost over the distance between the jet nozzle and the metal line.

Applying lateral thinking, PTI designers realised that the best way to preserve oxygen velocity would be to take their shrouded oxygen jet and

reduce the distance between the jet nozzle and the molten metal.

As Figure 2 shows, the JetBOx™ technology moves the supersonic oxygen nozzle closer to the molten bath, by mounting it in a special housing set away from the sidewall of the furnace. This approach generates three major benefits.

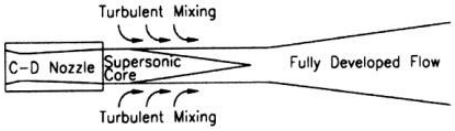
First, it reduces the distance to the metal line by as much as 50% compared to conventional mountings. This allows the oxygen jet to reach the molten steel while its core is still supersonic. The resulting increased penetration means faster decarburisation and more efficient oxygen usage.

Second, it means that the jet can be aimed at a more aggressive angle of attack without the risk of impinging on the refractory.

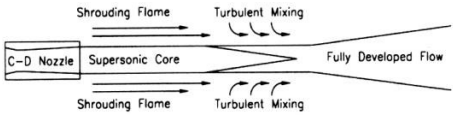
And third, it positions the JetBOx™ carbon injection pipe close to the molten bath for enhanced slag foaming. The close proximity to the burner also helps to prevent the injection port becoming plugged with slag.

[1] JetBOx is a trademark of Process Technology International Inc.

The PTI Jet burner in supersonic lance mode with shrouding flame around the supersonic jet



Non-Shrouded Supersonic Oxygen Jet



PT Shrouded Supersonic Oxygen Jet

Figure 1: At the edges of the supersonic oxygen jet, turbulence entrains the surrounding gas and causes the jet to spread. The result is loss of jet velocity and hence penetration. Shrouding the oxygen jet with an oxy-gas flame reduces turbulence and so increases jet penetration into the molten metal

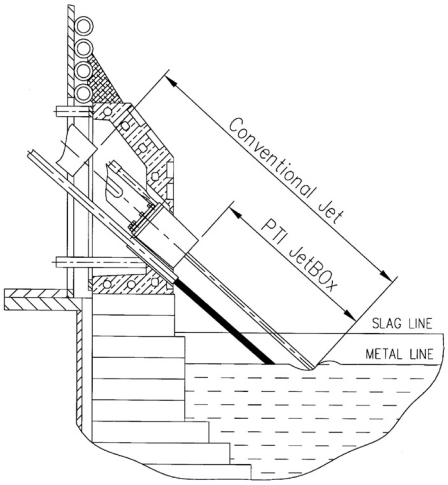


Figure 2: Key to the success of the JetBOx™ technology is the combination of a shrouded oxygen jet with a special mounting that places the jet nozzle much closer to the metal surface. Because the oxygen jet has to travel a shorter distance, it is still supersonic when it strikes the surface of the molten metal. Penetration is greatly improved, giving faster decarburisation and more efficient use of oxygen

About Air Products PLC

Air Products PLC is the UK subsidiary of Air Products and Chemicals, Inc. (www.airproducts.co.uk), the world's only combined gases and chemicals company. Founded more than 60 years ago, the business has annual revenues of $5.7 billion and operations in 30 countries. Air Products is a market leader in the global electronics and chemical processing industries, and a longstanding innovator in many industrial markets, including coatings, adhesives and polyurethanes, in ferrous casting foundries, the production and processing of iron and steel and the non-ferrous metals industry. The company distinguishes itself through its 18,000 employees around the world, who build lasting relationships with their customers and communities based on understanding, integrity and passion.

About PTI, Inc

During the last eight years Process Technology International, Inc. (PTI) (www.pticombustion.com) has developed an innovative combustion systems to introduce chemical energy into the EAF. The systems are based on PTI's uniquely designed water-cooled oxy-fuel burners that can provide all of the required functions for the modern EAF operation. These functions include preheating and melting scrap, decarburising molten steel with a shrouded supersonic oxygen jet, the post combustion of CO, and injecting carbon to foam slag. The main benefit of the systems is the reduction of electric power consumption and the increase in steel production. Since 1995 PTI burners, oxygen lances and integrated combustion systems have been installed on more than 40 EAFs in USA, Canada, South Africa, Europe and Korea with about 200 burners and lances in operation. PTI systems are operating at the plants of the world leaders in EAF steel making such as Nucor Steel, RTI, IPSCO, North Star Steel, POSCO, INI, Stelco , and Ameristeel.

For further information, please contact: Guenaelle Holloway, Corporate Communications, Air Products PLC, Hersham Place, Molesey Road, Walton-on-Thames, Surrey KT12 4RZ, United Kingdom
Tel: 01932 249 245
Email: hollowg1@apci.com

Shawn Lainchbury, Metals and Glass, Air Products PLC, Hersham Place, Molesey Road, Walton-on-Thames, Surrey KT12 4RZ, United Kingdom
Tel: 01932 249 398
Email: lainchs@apci.com

tell me more
www.airproducts.com

***Air Products PLC**, Hersham Place, Molesey Road, Walton-on-Thames, Surrey KT12 4RZ, UK, Internet www.airproducts.com. Contact: Shawn Lainchbury.