

Our 118th year

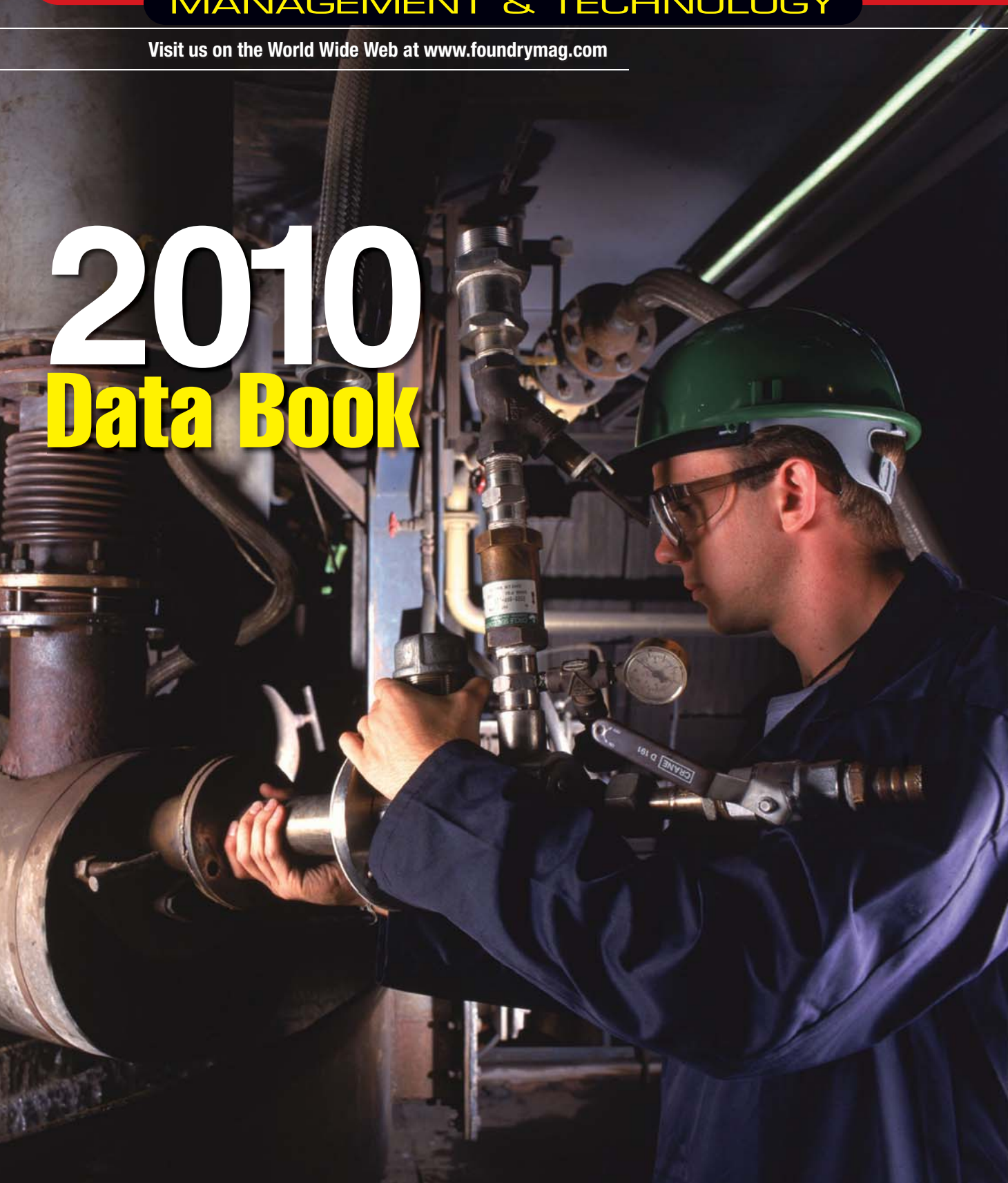
JANUARY 2010

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O₂ Technologies to Cut Coke Usage, Alloying Costs and Waste Generation

Since their introduction over 200 years ago, numerous improvements have been made to cupola furnaces and the cupola melting process, toward better environmental performance, increased efficiency, and a more flexible operation. One of the most significant improvements was the implementation of oxygen-enriched blast air in the 1930s.

Enrichment can be accomplished several ways, including diffuser enrichment in the air main and direct tuyere injection. Air Products introduced its modified tuyere injection method in the early 1960s, and has installed it at over 100 foundries worldwide.

Blast air normally contains 78% nitrogen and 21% oxygen, with the balance being other inert gases. Coke reacts with the oxygen in the blast air, creating heat that melts the charge material. But, the nitrogen — more than 75% of the volume — contributes nothing to the combustion reaction. Nitrogen in the blast air reduces the cupola's overall efficiency since it takes heat away from the melting process and is exhausted through the flue. Increasing the percentage of oxygen, via oxygen-enriched air, decreases the percentage of nitrogen, so the flame temperature, the available heat, and the heat-transfer rate increase, all leading to a much more efficient cupola.

Foundries typically use oxygen enrichment levels of 1-4%, which increases total oxygen to 22-25%. Some foundries use "super-enrichment," enriching their cupolas beyond 10%. The flexibility of adjusting enrichment levels allows the operator to control the melt rate (up or down), decrease the amount of time required to heat the cupola after it has been offline, and replace coke given the increase in available heat. One application of oxygen that is particularly attractive now is using higher oxygen enrichment levels to reduce coke usage at the same production rate.

Oxygen-natural gas (oxy-fuel) burners can be used to add energy to the melt zone, decreasing coke consumption, increasing operating flexibility, and improving overall efficiency.

In the early 1990s, Air Products introduced its patented APCOS™ (Air Products Cupola Oxy-fuel System) oxy-fuel burner. APCOS allows simultaneous injection of natural gas, oxygen, solids and metallurgical

powders through the cupola tuyeres. At the time of introduction, there were three main objectives for using APCOS: to increase fuel efficiency through the reduction of coke consumption; to increase and decrease melt rate quickly; and to inject solid materials without the associated cooling effect. These objectives remain, however now the focus is on increasing the efficiency of the cupola and decreasing the overall cost of operation. Of utmost concern is the increasing cost, declining quality and limited availability of foundry coke.

The APCOS oxy-fuel burner uses natural gas as its fuel, substituting heat energy supplied by foundry coke. Natural gas is one of the most abundant fossil fuels in the U.S., the distribution system is well established, and the current price is low compared to foundry coke. In fact, the price of coke is four times that of natural gas in some markets (evaluated on a \$/MMBtu basis). Foundries that have used APCOS have been able to reduce coke consumption by up to 40%. This makes it a very attractive option by providing significant savings and quick paybacks.

Natural gas also burns much cleaner than coke, greatly reducing particulates and other harmful emissions (e.g., SO₂, NO_x, etc.). In some cases, CO₂ emissions were reduced by 20% with APCOS.

Another characteristic of the APCOS system is its ability to inject waste dust and metallurgical powders (alloying materials) into the melt zone. Injecting solid particles (like dust) into the cupola is not new: An English patent from 1831 describes adding coal and additives to a blast furnace, and injection has been used to add materials such as silicon, cupola ash, coal dust and sweepings. In most cases, it was necessary to blow-in the material periodically because continuous injection caused operational problems by cooling the tuyere. Injecting these materials in the presence of an oxy-fuel burner eliminates the cooling effect and enhances alloy pick-up. Further, waste material can be injected, thus reducing the



Melt rate increase:	>20%
Coke reduction:	40%
Silicon yield improvement:	10%
SO ₂ reduction:	7%
CO ₂ reduction:	20%

A summary of results that could be achieved with the APCOS™ oxy-fuel burner system.

overall waste that a foundry generates.

Finally, the system is very flexible. The oxy-fuel burners are equipped with supersonic oxygen nozzles. So, the foundry can shut off the natural gas and still be able to enrich through the tuyeres. Also, the burners are designed to be installed and removed easily if maintenance is needed on the tuyeres.

AIR PRODUCTS 

North America
Air Products and Chemicals, Inc.
7201 Hamilton Boulevard
Allentown, PA 18195
Tel: 800-654-4567
Fax: 800-272-4449
E-mail: gigmrktg@airproducts.com
www.airproducts.com