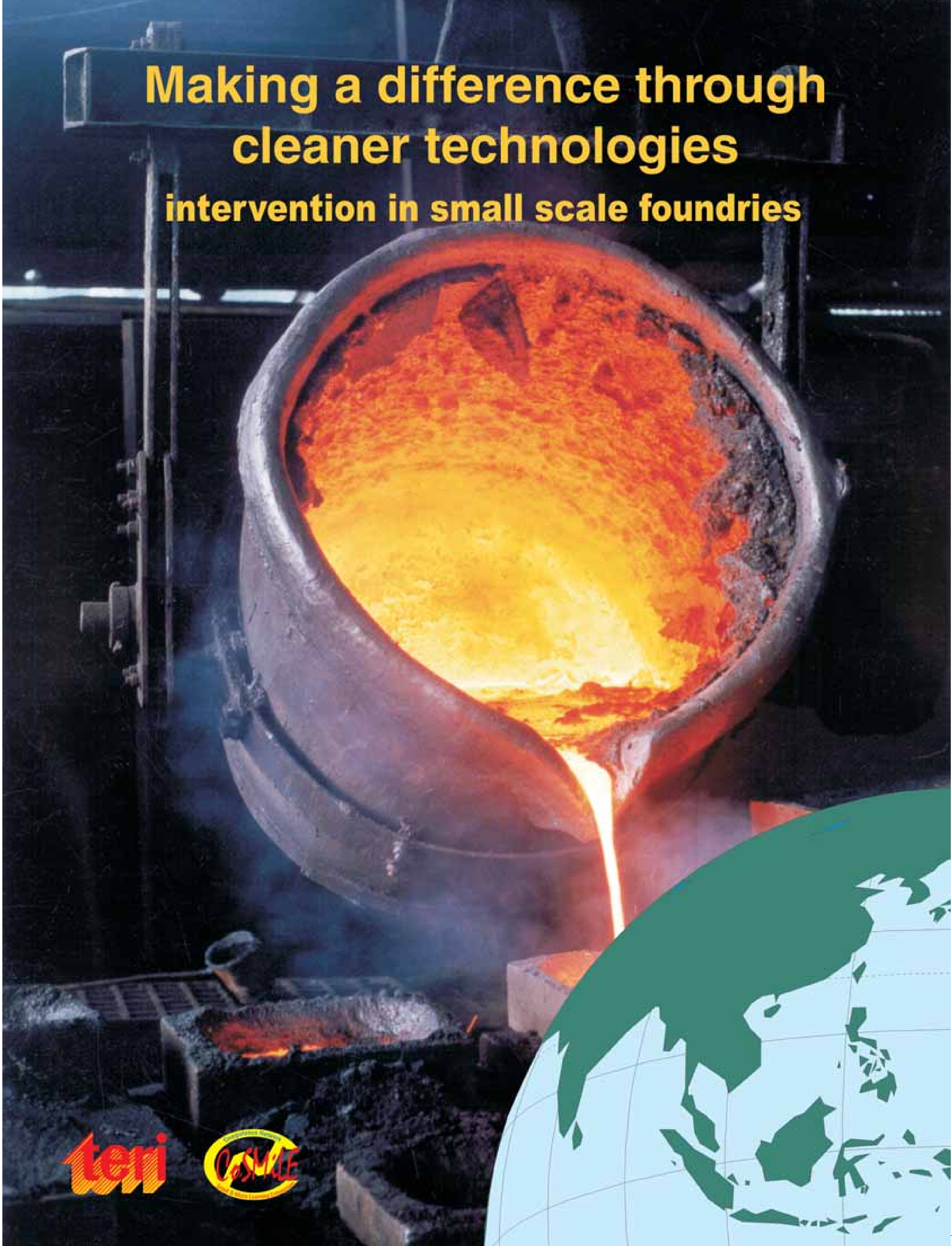
Making a difference through cleaner technologies

intervention in small scale foundries



Background

The Indian foundry industry faces new challenges as well as opportunities in today's globalized market. The demand for high-quality castings is rising in both domestic and international markets, even as units face increasing competition from overseas. Energy costs are on the rise, making it vital for foundry units to find ways to increase the energy efficiency of their melting furnaces. At the same time, stricter enforcement of environmental standards is forcing the foundry industry to become more conscious about emissions control during operations. All in all, there is an imperative and growing need for foundry units to improve the quality of their products and to increase the efficiency of their operations in terms of energy as well as environmental performance.

The cupola is the most common type of melting furnace used by foundries to produce grey iron castings. Cupolas use coke as fuel. Most cupolas operating in India today are based on designs that were developed at a time when energy and environmental concerns were not as important as they are today. Hence, their performance is sub-optimal in regard to energy efficiency as well as cupola stack emissions.

In this backdrop, TERI has developed clean, energy-efficient technologies for adoption by the small-scale foundry industry under an initiative titled CoSMiLE (Competence network for Small and Micro Learning Enterprises) supported by SDC (Swiss Agency for Development and Cooperation). TERI provides technical assistance to foundries that wish to improve the energy and environmental performance of their cupolas.

The services provided by TERI fall under two broad areas.

- Reducing coke consumption through improved cupola design and best operating practices.
- Reducing cupola stack emissions by recommending a suitable pollution control system that meets the most stringent emission norms prevailing in India. ■

Reducing coke consumption

Initial diagnosis

Cupola is the most common type of melting furnace used for the production of grey iron castings in foundries. In the mid-1990s, TERI conducted energy audits of a range of cupolas in Howrah and Agra foundry clusters. The most energy-efficient cupola audited by TERI used 13.6% charge coke (coke : metal ratio of 1 : 7.5). The figure for the least energy-efficient cupola was found to be as high as 26.5% (coke : metal ratio of 1 : 4).

Some of the contributing factors that were identified for this poor energy performance are listed below.

- Incorrect blast rate
- Lower blast air pressure
- Incorrect distribution of air between the top and lower tuyeres
- Turbulent (non-linear) entry of air into the cupola
- Incorrect sizing of cupola parameters such as tuyere area, well depth, and stack height among others
- Poor operating and maintenance practices
- Poor control of feed materials (shape, size, weight, sequence)

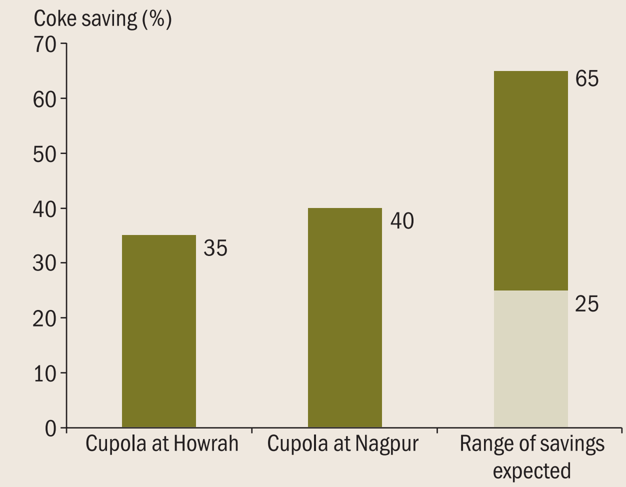
Commissioning of the demonstration plant at Howrah

Divided blast cupola

Divided blast cupola (DBC) or twin blast cupola is a proven technology for improving the energy performance at a modest investment. As is evident from its name, a DBC supplies blast air to the cupola furnace at two levels through a double row of tuyeres. The advantages of a DBC, compared to a conventional cupola, are as follows.

- A higher metal tapping temperature and higher carbon pick-up are obtained for a given charge-coke consumption.
- Charge-coke consumption is reduced and the melting rate is increased, while maintaining the same metal tapping temperature.

Coke saving with TERI design



The design being promoted by TERI captures the above advantages by optimizing the design parameters.

- Optimum blower specifications (quantity and pressure)
- Optimum ratio of the air delivered to the top and bottom tuyeres
- Minimum pressure drop and turbulence of the combustion air
- Separate wind-belts for top and bottom tuyeres
- Correct tuyere area, number of tuyeres, and distance between the two rows of tuyeres
- Optimum well capacity
- Higher stack height
- Mechanical charging system
- Stringent material specifications.

Energy savings and other benefits

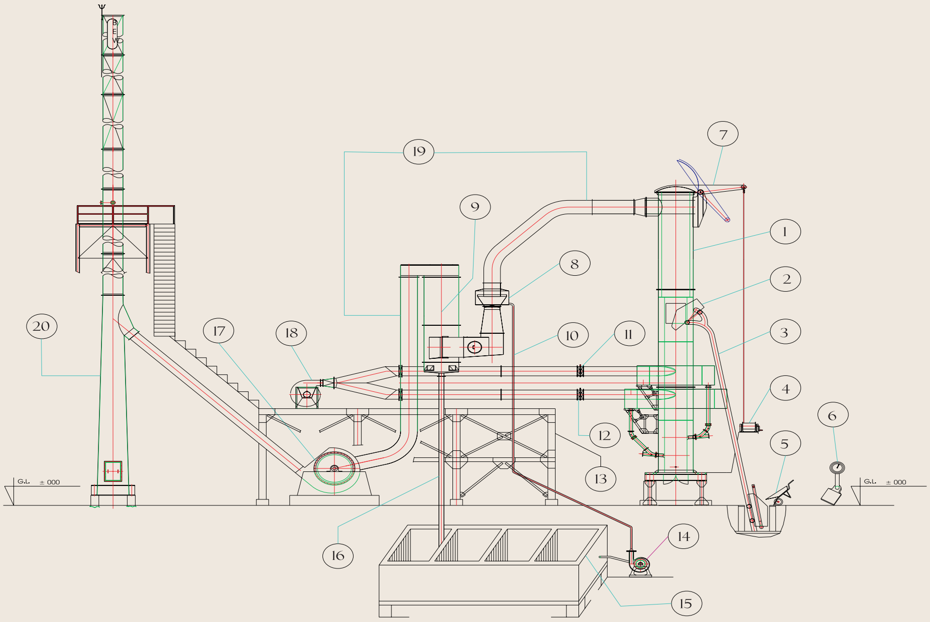
To showcase the benefits of an optimal DBC design, a demonstration plant was installed at Bharat Engineering Works, Howrah, a unit nominated by the IFA (Indian Foundry Association), in 1998. The TERI-designed DBC has brought down the charge-coke percentage from 13.6% to 8%, thereby achieving an energy saving of about 35% compared to the earlier cupola used by the unit. On an average monthly melting of 430 tonnes, the yearly saving in coke is 270 tonnes. It also yields an increase in metal tapping temperature and reduces silicon and manganese losses.

Encouraged by the success of the demonstration plant, a foundry unit located in Nagpur set up a DBC in 2000 with technical assistance of TERI. The unit has achieved a coke saving of 280 TPA (tonnes per annum) on a monthly melting of around 300 tonnes. Three more TERI-designed DBCs were set up in 2002 by a foundry unit in Hooghly (West Bengal). These DBCs have enabled coke savings of 28% compared to the hot blast cupolas earlier used by the unit. Replications of the TERI-designed DBC have been proceeding at a brisk pace since 2003. This was the year when one of the most prominent units in the Rajkot foundry cluster—Shining Engineers and Founders—set up two DBCs with assistance from TERI. The new cupolas have reduced charge coke percentage from 9.1% to 7.8%.

Taking into account the reduced silicon and manganese losses, and the lower rejection

Divided blast cupola installed at a foundry in Rajkot

Schematic diagram of a typical melting plant being offered by TERI



Legend
1 Cupola
2 Skip charger bucket
3 Skip bucket rail
4 Hand-operated winch
5 Wheel barrow
6 Weighing scale
7 Top cap with lever
8 Venturi scrubber
9 De-watering cyclone
10 Water delivery pipeline
11 Venturi meter - upper
12 Venturi meter - lower
13 Support structure - pollution control system
14 Water circulation pump
15 Water reservoir
16 Slurry drain pipe
17 Induced draft fan
18 Cupola blower
19 Flue ducts
20 Free standing chimney

levels, each DBC enables a saving of around Rs 1000 per tonne of molten metal. For a typical foundry producing 250 tonnes of molten metal each month, this amounts to a saving of over Rs 30 00 000 per annum.

The capital cost of a new DBC (inclusive of civil work, platforms, bucket charging mechanism, and other auxiliary systems) is around Rs 10 00 000 rupees (2007 prices).

Buoyed by the experience of Shining Engineers and Founders, many other foundry units in Rajkot and elsewhere have been setting up DBCs with technical support from TERI. As of December 2007, there are around 40 TERI-designed DBCs in operation in foundry units across India. ■

Pollution control

Initial diagnosis

TERI carried out environmental measurements in various foundry units in different locations to assess the emission level of cupola stack gases. During this exercise, the SPM (suspended particulate matter) emissions without any gas cleaning device were found to vary between 1300 and 3940 mg/Nm^3. The measurements also showed that the emissions from cupola were much higher than the statutory limits. Therefore, the installation of a pollution control device was found to be necessary to comply with the environmental regulations (*see Box*).

Existing emission standards for cupola melting furnaces in India

Type	*Pollutant*	*Concentration* (mg/Nm^3)
Cupola capacity (melting rate)		
• less than 3 tonnes/hour	Particulate matter	450
• 3 tonnes/hour and above	Particulate matter	150

Note It is essential that a stack is constructed over the cupola beyond the charging door and the emissions are directed through the stack, which should be at least six times the diameter of cupola.
Source EPA Notification, G.S.R. 742 (E), 30 August 1990

The emission standard for sulphur dioxide from cupola furnace is prescribed as 300 mg/Nm^3 at 12% carbon dioxide correction as referred in the Ministry of Environment and Forests' notification dated 2 April 1996, New Delhi. To achieve the standard, foundries may intake scrubber, followed by a stack of height six times the diameter of cupola beyond charging door. In case, due to some technical reasons, the installation of scrubber is not possible, the value of sulphur dioxide to the ambient air has to be effected through the stack height.

TERI also analysed the particle size distribution of cupola stack gas in order to choose the right pollution control system for foundries.

Pollution control system

Cupola stack gases contain a significant percentage of fine particulates. Therefore, TERI used a venturi scrubber to bring down the emissions below the more stringent particulate emission limit of 150 mg/Nm^3.

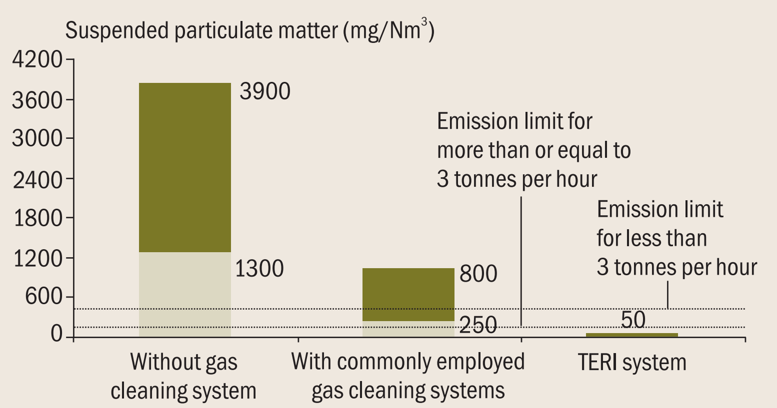
Some of the salient features of the venturi scrubber are listed below.

- Variable venturi throat to clean the gas by binding the particles to water droplets
- Optimum gas velocity at the throat, liquid : gas ratio, and throat geometry for maximum efficiency
- Dewatering cyclone after venturi to retain water droplets in the gas stream
- Induced draft fan to ensure sufficient pressure drop
- Stainless steel construction to prevent corrosion
- Closed circuit recirculation to minimize water requirement
- Lime dosing to maintain the pH of the recirculating water
- Explosion doors and gas-tight construction to prevent explosion.

Environmental Excellence Award
2000-2001
West Bengal Cleaner Production Centre
a collaborative effort of
West Bengal Pollution Control Board
Indian Chamber of Commerce
confers the Environmental Excellence Award, 2000–2001
on
M/s. Bharat Engineering Works
Kona, Howrah, West Bengal
for their proactive and appreciable environmental management practices during the year, 2000-2001
A. V. Lodha
President
Indian Chamber of Commerce
Manabendra Mukherjee
Minister-in-Charge
Environment and Information Technology
and
Chairman, West Bengal Pollution Control Board

The demonstration plant of TERI bags the Environmental Excellence Award

Comparison of emission levels



Environmental performance

TERI measured the SPM and sulphur dioxide emissions of the outlet gas from the pollution control device installed at a foundry in Howrah. The SPM was found to be about 50 mg/Nm^3 and sulphur dioxide was about 40 mg/Nm^3. The results have been validated by the monitoring conducted independently by the pollution control authorities. The capital investment required for the pollution control device is around Rs 15 00 000, which includes the costs of chimney and other associated structures. ■

Demonstration plant at Howrah

Cleaner technologies developed by TERI for small- scale and rural industries

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