

Enhancing Energy and Environment Performance in Foundries

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The Energy & Resources Institute (TERI), with help from Swiss Agency for Development & Cooperation (SDC) has embarked upon an initiative to address the issues of energy efficiency and environmental compliance in the foundry sector. The issues are being addressed through the process of demonstration and replication of the divided blast cupola (DBC) and the venturi-scrubber based pollution control system (PCS) technologies. Results of two cases, one of replication of DBC technology and the other of the PCS technology are presented. The implementation of these technologies not only addresses the two issues but also makes business sense.

Keywords : Foundries; Energy efficiency; Environmental pollution; Divided blast cupola; Pollution control system.

INTRODUCTION

The Indian foundry industry comprises more than 5000 units spread across more than 20 clusters. A sizeable proportion of units also fall outside of these clusters. Most of the units are small-scale family owned and run operations. They mostly cater to local markets in the clusters. Thus, while foundries in a cluster might be predominantly manufacturing pump-set castings in a pump-set cluster, in another the units would be mostly manufacturing automotive castings. While the local markets have an influence on the type of castings made they also have an influence on the quality of castings.

Energy performance has been a low priority for the foundry owners and managers for historical reasons. The foundry industry had its roots in the industrialisation that started in the 19th century. After independence, the steel sector and the coal-mining sector being mostly under government control, the availability and prices of the raw materials were ensured. The scenario changed, however, since the opening up of the economy in early 1990s. Competition has forced the large integrated steel plants to decrease the quantum of pig iron production, causing the prices to rise. The advent of numerous, geographically distributed mini-blast furnace based pig iron plants has not been able to completely offset the shortfall. Also the assured availability of coal for the small-scale entrepreneurs has come into question with the removal of licences and permits to obtain the same. As a measure to reduce costs and enhance energy performance thus optimising coke consumption is an attractive proposition.

Another important development in the industrial sector has been the increasing focus on the environmental compliance. The foundries, grappling over the last several years with cutting down costs and streamlining operations, have not been in a position to implement the environmental standards. Compounding the

problem is the lack of effective and economical technological solutions to the problem.

BACKGROUND

The Energy & Resources Institute (TERI), with support from the Swiss Agency for Development & Co-operation (SDC) has undertaken an effort to address the problems of energy efficiency and environmental compliance in the small-scale foundry sector.

To demonstrate an energy efficient and environment friendly technology in the small-scale foundries a demonstration plant was set up in the Howrah foundry cluster in 1998. The divided -blast cupola technology, which is an energy efficient option to the conventional or modified conventional cupola technology, has been demonstrated in this plant along with a venturi-scrubber based pollution control system as the end of the pipe pollution control system. Figure 1 presents the sketch of an integrated DBC and venturi-scrubber based pollution control system.

The effort, initially anchored in the Howrah foundry cluster, is now being taken to different foundry clusters in India. A number of replications, in Maharashtra, West Bengal and Gujarat are already up and running. Replications are ongoing in Tamil Nadu.

The paper presents two cases to illustrate the cost benefit analysis of employing a properly designed energy efficient divided-blast cupola and a venturi-scrubber based pollution control system. The case for the divided-blast cupola technology is illustrated for foundry A that is a small-scale foundry manufacturing sanitary fitting. The case for venturi scrubber based pollution control system is illustrated for a foundry B that is a medium-scale foundry manufacturing pipes.

DIVIDED BLAST CUPOLA (DBC): FOUNDRY A

The Technology

The divided-blast cupola (DBC) technology has been demonstrated by BCIRA more than 20 years back. The divided blast cupola is different from the conventional cupola technology

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Legend

01 cupola; 02 skip charger bucket; 03 skip bucket rail; 04 hand operated winch; 05 wheel barrow; 06 weighing Scale; 07 top cap with lever; 08 venturi scrubber; 09 de-watering cyclone; 10 water delivery pipe line; 11 venturi meter – upper; 12 venturi meter – lower; 13 support structure – PCS; 14 water circulation pump; 15 water reservoir; 16 slurry drain pipe; 17 induced draft fan; 18 cupola blower; 19 flue ducts; and 20 free standing chimney.

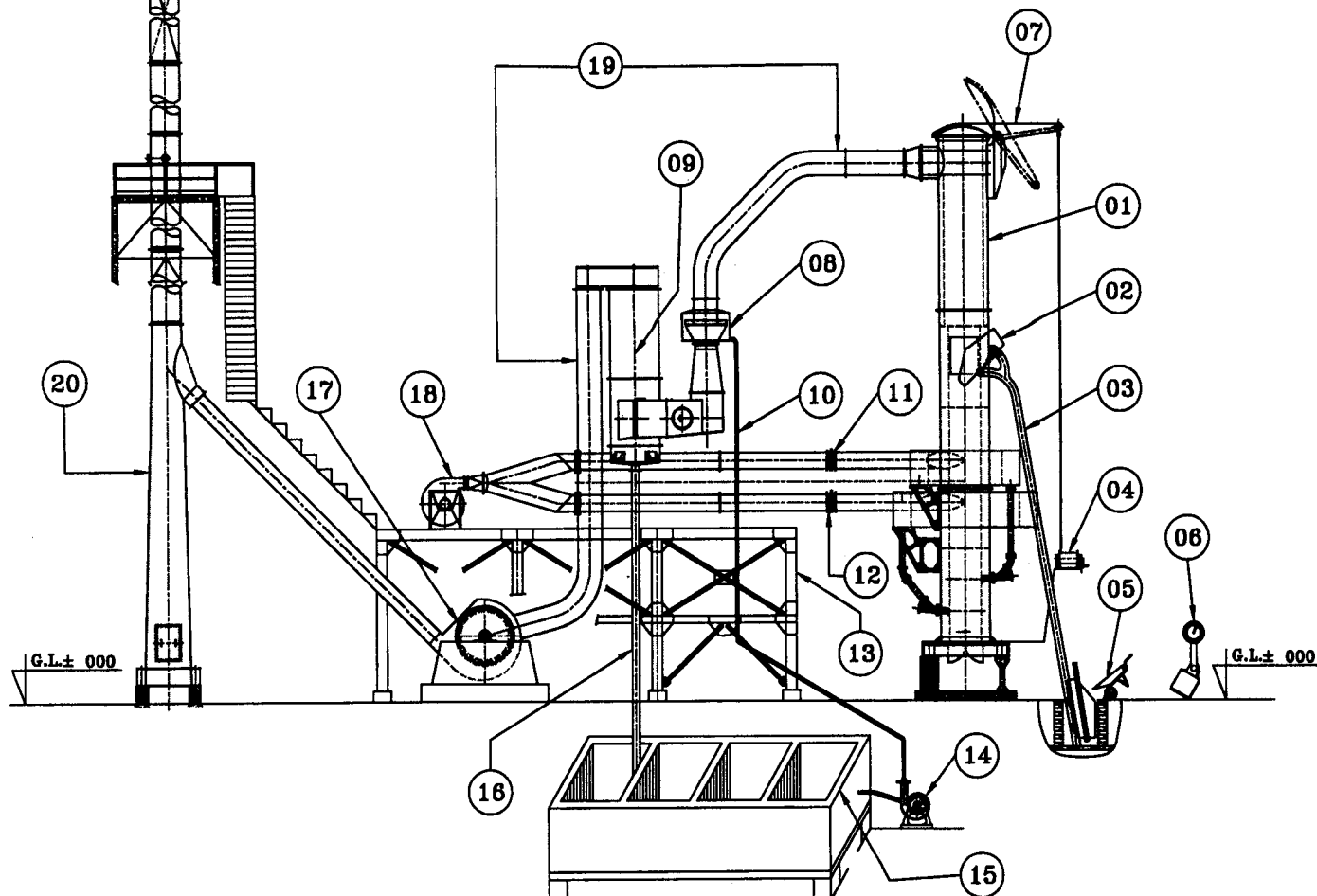


Figure 1 Sketch of DBC and venturi-scrubber based PCS

in that the blast air is directed into the cupola through two separate rows of tuyeres as opposed to one in the conventional design. The two rows of tuyeres are connected to two separate windbelts as opposed to one windbelt in the conventional cupola design. In the modified conventional cupola, however, the rows of tuyeres could be two to three in number but still the delivery of air being through one windbelt it does not facilitate proper division of air blast.

The TERI designs of DBC are adapted to suit the Indian conditions of raw materials. Thus, high ash coke is as suitable for the DBC as a low ash coke. Suitable modifications are also made in the shaft and the stack height in order to fine-tune the adoption. The blower specifications are another area where the DBC is very different from a conventional cupola. While most of the conventional cupolas deliver the requisite amount of air, they do not provide the desired pressure. The specifications for

the TERI designed DBC ensure a higher delivery pressure to ensure proper penetration of combustion air into the coke bed.

Replication at Foundry A

The foundry is a small-scale unit manufacturing pipes and sanitary fittings. This foundry is different from a normal unit in two respects:

- (a) the foundry is new unit, been set up only 5-6 years ago
- (b) the entrepreneurs, though not having foundry experience are foundry technologists.

The foundry had experimented with some designs of cupolas that had not proved to be effective. The coke consumption was high and at the same time the quality of the metal obtained was not consistent. The temperatures obtained using the cupola were also not consistent (consistently high temperatures are a requirement

for casting thin walled pipes and sanitary fittings). Apart from these three factors, the earlier cupola had not been fabricated to strict specifications, was in a rickety shape, having given way more than once.

The entrepreneurs were looking for a dependable design of cupola that could provide a consistent metal quality at high temperatures. In addition, cost-cutting being one of the important considerations, the entrepreneurs were also looking for coke savings.

An energy audit was conducted at the plant to establish the baseline performance for the then existing cupola. The results obtained are summarised in Table 1.

It can be observed from Table 1 that the foundry had not been performing well on the energy indices. Moreover, the inconsistent temperatures and high rejections were only increasing the difficulties for the foundry.

Upon deliberations with the unit it was decided to give the foundry a design for a 690 mm (27") ID cupola that would have a melting rate of about 3.5 t/h. In the fabrication strict adherence to the specifications was advised. The key specifications are detailed in Table 2.

The foundry was provided with detailed drawings for the cupola and the supporting structure to facilitate the fabrication by a local fabrication firm. In addition the manual charging system was

Table 1 Key baseline parameters

Key parameters	Units	Magnitude
Cupola ID	mm (inches)	560 (22)
Melting rate	t/h	1.2
Metal temperature	°C	1360-1454
Coke quality	% ash	26
Charge coke	%	22.4
Total coke	%	27.0
Rejections	% (tonnage)	12.5

Table 2 Key specifications for the 3.5 t/h DBC

Key Parameters	units	Magnitude
Cupola ID	mm (inches)	690 (27)
Melting rate	t/h	3.5
Recommended blower capacity	m ³ min	51
Fan discharge pressure	kPa	10.7
Cupola shell	mm	10 (thick) mild steel
Windbelt	mm	6 (thick) mild steel

Table 3 Performance parameters for 3.5 t/h DBC

Key Parameters	Units	Magnitude
Cupola ID	mm (inches)	690 (27)
Melting rate	t/h	3.5
Metal temperature	°C	1413-1443
Coke quality	% ash	26
Charge coke	%	13.4
Total coke	%	16.2
Rejections	% (tonnage)	10.9

replaced with skip bucket charging system to provide the requisite charging rate. The foundry was able to fabricate and erect the cupola in six months time.

The foundry adhered to the specifications and sourced the blower from a reputed manufacturer though the cost was higher. Also the skip charger was sourced from a reliable supplier. Meeting all the specification made the fabrication a costlier (than usual) exercise but as further analysis will illustrate the benefits far outweigh the costs.

The cupola was commissioned in September 2001. On all the parameters, of energy indices as well as operating indices, the cupola met the specifications. Over the period September 2001 to January 2002 the plant operations stabilised further. The details of the cupola performance averaged for the month of January 2002 are given in Table 3.

Costs and Benefits

The foundry incurred an expenditure of about Rs 1 million on the project to install the DBC at the unit. The expenditure included fabrication of the cupola shell, cast iron bricks, cupola base plate and tuyere inserts, erection of the casting bay facilities, cupola support structure, blower and skip bucket charging system.

However, as asserted earlier the benefits far outweigh the costs. The foundry could save about 25 t of coke every month on a monthly melting of 250 t. At the cost of Rs 4500 /t of coke, the savings amount to a massive Rs 1.35 million per annum (at the 2001-2002 prices). This implies that the payback on the investment is less than a year.

Additional advantages of consistent metal quality, consistent temperature and reduced rejections multiply the attraction of the DBC technology.

VENTURI SCRUBBER BASED PCS AT FOUNDRY B

The Technology

The venturi scrubber based PCS is an accepted technology for pollution control. However, this has not found much usage in the foundry industry because of two reason:

- (a) there are several low cost (and low performance) options available
- (b) there has not been much focus on environmental performance of foundries

The venturi scrubber based pollution control system at the foundry B is equipped with

- (a) a variable throat which allows for the pressure drop across the throat to be varied in order to adjust the PCS for optimised performance
- (b) dewatering cyclone which dries the exit gases after they have been scrubbed by water
- (c) stainless steel fabrication which allows for a longer life of the system. The system being a wet system is to be able to withstand the attack of acids formed in the process of trapping gases like SO_x and NO_x .
- (d) safety devices : the design has an explosion door and gas tight connections with machined flanges incorporated because of the presence of high amounts of carbon monoxide in the flue gases.

Replication at Foundry B

The foundry B is a manufacturer of grey iron spun pipes. The foundry had a pollution control system installed but due to the stringent environmental norms in the state it was facing a tough challenge in meeting the norms. After weighing a number of solutions on cost benefit terms the foundry chose to use the venturi scrubber based PCS.

Considering the fact the foundry had existing ducting for flue gas offtake and a site for installing a PCS the implementation became an easier task. The design was tuned to meet the most stringent environmental norms with certainty. The specifications to which the venturi scrubber based PCS was designed are given in Table 4.

Designed to meet the most stringent environmental norms (SPM: 150 mg/Nm³ max), the PCS commissioned in August 2003 produced satisfactory results. The state pollution control board checked the emission levels itself to ascertain that the PCS was working properly. The SPM was observed to be only 39.4 mg/Nm³ while the SO₂ content at 12% CO₂ correction was found to be 62.2 mg/Nm³.

Table 4: Specifications for design of venturi-scrubber based PCS

Key Parameters	Units	Magnitude
Gas flow	Nm ³ /h	24 000
Gas temperature	°C max.	150
Gas pressure (static)	mm wg	-0.1 to -0.6
Inlet dust concentration	mg/Nm ³ , max.	2500
CO ₂ in flue gas	%	9.5
CO in flue gas	%	4
O ₂ in flue gas	%	12
Moisture in flue gas	kg/Nm ³	0.0252
Density of flue gas	kg/Nm ³	1.352

Costs and Benefits

The venturi-scrubber based pollution control system is an end-of-the-pipe solution to the environmental emissions from foundries. This coupled with the inherent energy-efficiency of the divided blast cupola presents a technological option which can go a long way in ensuring environmental compliance and enhanced energy and environmental performance of the foundry industry. At foundry B the cost of installing the PCS was close to Rs 1.8 million. This, however, is a rough estimate. A payback for this option has not been worked out. It needs to be stressed that investment in meeting environmental standards are enabling investments in nature and a simple calculation of payback is not possible.

CONCLUSION

The initiative has successfully demonstrated that substantial coke savings are possible through a properly designed divided blast cupola. The replications have further proved that the design is energy efficient and thus environment friendly. Also the demonstration and replication of venturi-scrubber based pollution control system presents a viable option for foundries which are looking for solutions to the environmental problems.

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