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An integrated approach to environment friendliness and energy conservation in foundries

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ABSTRACT

The paper highlights an integrated approach to pollution control in foundries through energy conservation, process modifications and application of cost effective and compatible pollution control devices. The results presented are based on data collected at the demonstration pollution control unit set up at M/s Crawley & Ray, Howrah, based on the design carried out by National Metallurgical Laboratory (NML), Jamshedpur.

INTRODUCTION

Machines have become essential in every sphere of our lives in this technological age and a machine can hardly be made without castings and forgings in it. Hence foundries and forgeshops cannot be neglected for the improvement of technological state of any country. Traditionally, foundries are considered to be hot dusty and dirty place where foundrymen toil hard with hot metal to produce shaped castings. Thus, in the early seventies there was a move in the developed western countries to level the foundries as smoke-stack and sunset industry. By then the awareness about the environment was growing and stringest laws were enforced which led to the closure of a significant number of foundries. Jerry Rogers of General Motors commented in AFS Environmental Conference held in 1995 that since 1980 one of every four foundries has shut down in US due to environmental regulations and non-competitive process. The result of such closure compelled the developed countries to source their requirement of castings from the developing nations such as Korea and Taiwan. As the economy became progressively stronger, these countries also became concerned about their environment and consequently the developed nations now are trying to source their casting requirements from China, Indonesia, Brazil and India. It is an opportunity the Indian foundries cannot afford to miss. But at the same time, proper care should be taken to avoid the environmental degradation. Fortunately, India is a vast country and does not face the problems as faced by Korea and Taiwan. Against these, one has also to consider the distribution of foundries in India which are concentrated in areas such as

Howrah, Agra, Batala, Coimbatore, Kolhapore, Bhavnagar etc. This type of concentrated distribution is worrying so far as environment is concerned. It, thus, follows that pollution control is necessary for Indian foundries for the protection of regional environment.

German workers [1] concluded in 1983 that the control of pollution in foundries is necessary — but bureaucratically exaggerated environmental laws led to increase in the cost of industrial products so much that they become unaffordable. This appears to be valid in the Indian context especially when India with her historical founding excellence can become a major supplier to the world market if quality — reliability and cost — competitiveness can be achieved. The position of Indian foundry industry with respect to that of other major producers of the world is shown in Table-1 [2].

Table-1 : World Casting Production Census 1993 (in million tonnes)

Country	F.G. Iron	S.G. Iron	Malleable Iron	Steel	Total
CIS	13.460	0.392	-	-	14.330
China	7.8585	1.132	0.418	1.538	11.615
U.S.	4.575	3.056	0.193	0.964	10.537
Japan	3.383	2.024	0.185	0.378	7.197
Korea	0.825	0.375	0.039	0.118	1.409
Taiwan	0.733	0.255	0.013	0.110	1.318
India	1.193	0.036	0.072	0.263	1.576

The foundry industry after some years of sluggishness is now experiencing a boom period, and the world casting production is expected to rise steadily due to economic turn around of developed nations. With this background, an analysis of Table-1 certainly indicates that India has enormous opportunity to emerge as a significant supplier of castings to the world market.

It is to be noted that any consideration of the environmental aspect of a technological process must be related to its energy requirement as well. A process which needs a minimum amount of energy is least polluting for the environment. Till date, fossil fuel is the major source of energy production and the combustion of the fuel will lead to various forms of environmental degradation such as increment of Suspended Particulate Matters (SPM), SO_2, CO and green house effect caused by excess CO_2 levels. Thus an integrated approach involving both pollution control and energy conservation is necessary for all technological processes.

Problems of Indian Foundries

There are about 5000 foundries in India with installed capacity of 3.4 million tonnes per annum[3]. Most of these are in the Small Scale Industry Sector. Reliable data about the foundries in India is virtually non-existent. However, one important but easily identifiable problem of Indian foundries is the technological obsolescence. In many cases, layout, equipment, process and manpower are totally inadequate to cater for the increasingly stringent quality and cost competitiveness demanded by the customers of the foundry product. The author who is associated with foundries for a long time also feels that many of the foundries are too small to employ professional managers for proper personnel and financial management. Added to these, many foundries are run by a peculiar system of hot metal sale to labour contractors which makes the product quality assurance virtually impossible. Apart from the above problems, the Indian foundries are perpetually plagued by poor quality input materials such as pig iron, coke, lime stone, sand etc. and acute shortage of funds both for equipment purchase and working capital due to reluctance of financial institutions to extend a helping hand to foundries of small and tiny scale. The banks complain about the lack of financial discipline in small and tiny sector of the foundry industry even though the Small Industries Development Bank agrees that a far bigger sum of money has to be written off as bad debt by the banks for large and medium scale sector of the industry than for the small tiny sector. Working with these constraints, the foundries have to produce quality castings at competitive price acceptable to the global market. This is not an easy task and compliance to strict pollution control norms will make the task far more difficult for most of these foundries with likely resultant closure.

THE INTEGRATED APPROACH

Presently, B.P.coke produced by coke-oven batteries, is not available in the market. Foundrymen are forced to use Beehive coke. Beehive coke is inferior compared to B.P. coke. It has more ash, more volatiles, more sulphur and less shatter resistance than those of B.P. coke. As it is, B.P. coke in India has an ash content of around 30% while Beehive may contain up to 40% ash. This high ash content is sometimes reduced by Beehive producers by mixing lower ash but higher sulphur content coal. As a result, a Beehive coke with lower ash content will have a sulphur content of more than 1% which will increase the SO_2 emission from the melting unit. The integrated approach will, in the first place, improve the energy efficiency of the Cupola, which means that less coke will be necessary to produce same quantity of molten iron of similar or even better quality. Such a cupola will be less polluting even before installation of any pollution control device and may need simpler and less costly devices to achieve the norm. It can again be remembered that any device installed to control the emission from the cupola will add to the cost of the product

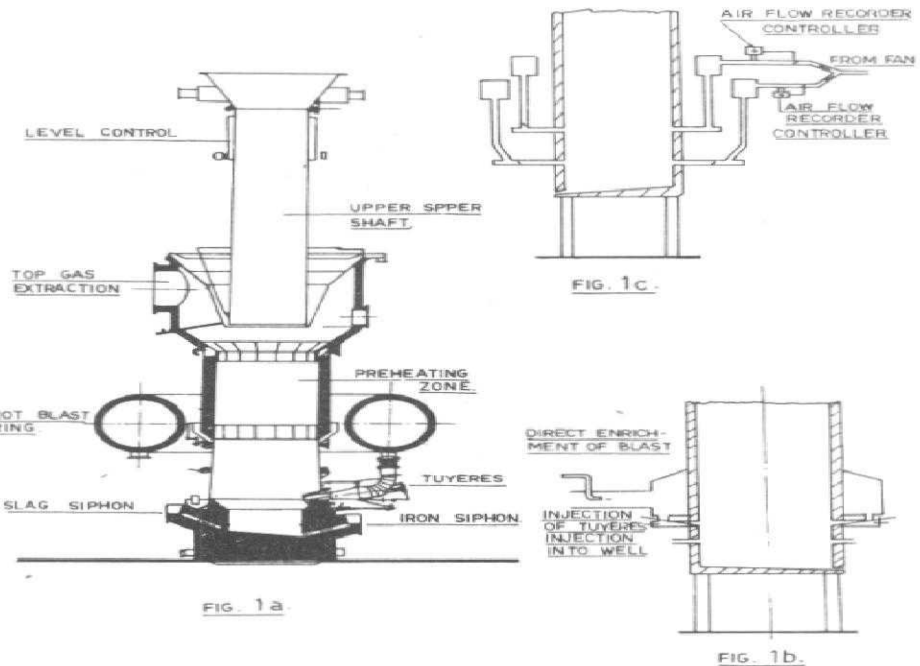

Fig.1 : Improved cupolas

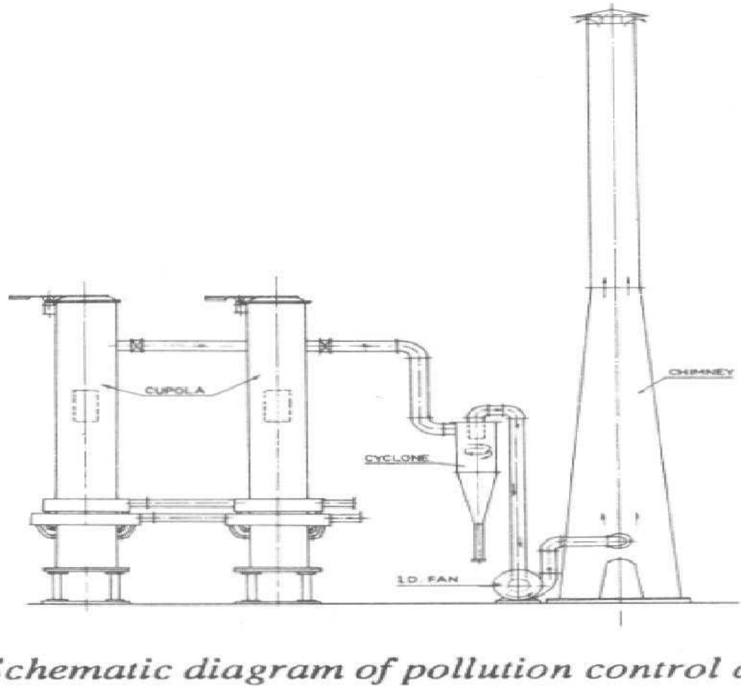

Fig.2 : Schematic diagram of pollution control device

and make the product less competitive. Stricter the norm, more costly will be the control devices.

Energy efficiency of a cupola will depend upon the combustion efficiency to a great extent. The recent survey on Howrah foundries carried out by National Metallurgical Laboratory (NML) showed the average value of combustion efficiency of an ordinary cupola under steady operating condition is of the order of 80 percent while that for a cupola of improved design is nearly 95%[4].

The combustion in the cupola is given by the following combustion equations :

$$C + O_2 = CO_2 \quad ... \quad (1)$$
$$2C + O_2 = 2CO \quad ... \quad (2)$$
$$C + CO_2 = 2CO \quad ... \quad (3)$$

While most of heat generated for melting is supplied by the equation (1), the equation (3) is highly endothermic. There are a number of improved designs of a cupola to get optimum melting condition such as (a) heating the input blast, (b) Oxygen enrichment of the blast and oxygen injection at tuyeres, and (c) dividing and proportionating the blast air.

Heating the air blast to 520°C will favour the reaction - (2) and improve the combustion (Fig.1a). Oxygen enrichment and injection to the extent 1 to 4% will intensify the heat liberating combustion equations with resultant increase of melting rates, temperature and carbon pick-ups (Fig.1b). Dividing the blast and directing it through two rows of tuyeres set at 915 mm apart will result in better combustion efficiency but more importantly the higher coke bed and two combustion zones result in improved heat transfer to the droplets of metals. It has been reported that[5] a reduction of coke consumption by 40 percent and an increase in melting rate up to 30 percent can be achieved by using a divided blast cupola.

The author is involved in the design and operation of divided blast cupolas to run under Indian condition since 1973. Very recently, the divided blast cupolas in the foundry with which the author is associated have been fitted with pollution control device with basic design and measurements done by NML, Jamshedpur. The cupolas of Crawley & Ray foundry have an internal diameter of 915 mm. These produce 5 tonnes/hour molten cast iron with tapping temperature of more than 1430°C using 7:1 metallics to currently available Beehieve coke ratio. The emission measurements were carried out a number of times on these cupolas before and after fitting the control device which is shown in Fig.2. The weighted average value of measurements is given in Table-2.

The study[4] conducted by the NML workers on Howrah Foundries indicated the SPM values ranging from 400 - 2650 mg/Nm^3 and SO_2 level from 200 to 2600 mg/Nm^3. These values when compared to those to Table-2 clearly shows the importance of the proper cupola design and operation. The SPM level is considerably lesser in a properly designed and operated cupola which allows a relatively less costly control device to achieve the norm.

Table-2 : Effect of Pollution Control Device on Emissions
(The values indicated are under steady state Cupola operation)

Measurement	Before control device	After control device
Flue gas temp. °C	96	62
Average SPM mg/Nm^3	212	135
Average SO_2 mg/Nm^3	43	72*
Average CO (%)	3	2.6
Average CO_2 (%)	11.3	3.3
Average particle size (μ)	460	125*
Combustion Efficiency %	95	93

* *The increase in SO_2 and reduction in average particle size may be attributed to change in coke quality*

The low value of SO_2 is perhaps due to proper charging operation compared to the cupola operational practice of other Howrah foundries. Hot gases have more chance of intimate contact with heated layers of lime stone which may absorb considerable amount of SO_2. Again from energy efficiency point of view, the advantage of the divided blast cupola can clearly be seen from Table-3.

Table-3 : Actual data of two foundries considering a production of 120 tonnes/ month or 1440 tonnes/year of molten metal

Measurement	Conventional	Divided blast
Melting rate in t/h	4.5 to 5	5.0 - 5.5
Size (melting zone ID in mm)	1220	915
Bed coke weight in kg.	1500	900
Metallics : Coke ratio	5:1	7:1
Charge coke weight in kg/t	200	140

The analysis of Table-3 reveals that 600 kg. and 900 kg. of coke is saved on 15 tonnes of molten metal per day in bed and charge respectively. This means that for every tonne of molten metal 100 kg of coke is saved. Thus for the production capacity of 1440 tpa, 144 tonnes of coke is saved. This, in terms of money at present, this will be 144 x 3000) = Rs. 432,000.

Better temperature of the metal is also likely to bring down rejection of casting and thus improving the yield. Even an improvement of 5% yield will result in saving of 14.4 tonnes of coke. Thus a considerable amount of energy can be saved for a typical foundry. The saving will be much more significant for a bigger country.

CONCLUSION

It is evident from the above, that when the air pollution from the cupola melting unit of the foundry is considered, the integrated approach to both environment friendliness and energy efficiency should be considered. Installation of any pollution control device will lead to increased production cost without increasing the productivity. But the integrated approach discussed above will largely offset the increased production cost due to savings in energy requirement. Control of pollution and the norm requirements should not be considered in isolation but should be considered in totality with energy conservation taking due account of social need, market opportunity and economic viability of the industry and indigenously available technology to achieve the level of control. The World Bank is now financing a project considering the relevance of social, technical and economic aspect of pollution control of six developing nations. Environment Protection Training Research Institute (EPTRI) has been entrusted to do the survey in India. It is hoped that some necessary but affordable systems may emerge from these studies.

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