MINISTRY OF STEEL

CHAPTER IX

Steel Authority of India Limited.

Coal Dust Injection system in the blast furnaces

Highlights

The increasing cost of coking coal led the Steel Authority of India Limited (Company) to make all out efforts for increased use of non-coking coal in blast furnaces. The Company introduced Coal Dust Injection system (CDI) in six blast furnaces in its two Plants and has a Corporate Plan to introduce CDI in all the Plants in a phased manner. The Company, however, went ahead with its plans before ensuring availability of other infrastructural facilities for successful operation of CDI resulting in underutilisation of the capacity for CDI created.

The important points observed during audit were:

- The existing conditions of the blast furnaces were not conducive to coal injection of 150 kg/MTHM[♣]. Therefore, the supplier guaranteed an injection rate of 100 kg/MTHM only which was two-thirds of the installed capacity (150kg/MTHM).

  (Para 9.6)

- As a result of non-achievement of hot blast temperature of 1100^0C the anticipated reduction in coke consumption of 0.47 lakh MT valuing Rs.24.34 crore could not be achieved during 1999-2000 to 2004-05 in the blast furnace (BF-6) of Bhilai Steel Plant and the blast furnace (BF-4) of Bokaro Steel Plant. This also resulted in the blast furnace productivity not improving and had the effect of loss of hot metal production of 0.97 lakh MT valuing Rs.53.70 crore.

  (Para 9.8.3.4)

- As against the guarantee for an injection rate of 100 kg/MTHM the actual coal injection rate ranged between 42 kg/MTHM and 80 kg/MTHM across all blast furnaces during the period covered in audit.

  (Para 9.9.1)

- The shortfall in injection of coal dust of 4.45 lakh MT resulted in extra expenditure of Rs.64.56 crore since costly coke had to be consumed in place of proposed non-coking coal.

  (Para 9.9.2)

[♣] ***Metric Tonne of Hot Metal***

- The Management approved proposals for installation of CDI in five more blast furnaces of Bokaro Steel Plant, Durgapur Steel Plant and Rourkela Steel Plant at an estimated cost of Rs.406.08 crore. Before approval, the Company had not taken into consideration the factors responsible for the poor results achieved so far.

(Para 9.10)

Recommendations

- The Company needs to take measures for revamping or capital repair of all the blast furnaces before introducing CDI. The cooling system of the blast furnaces should be improved.
- Equipment should be installed to increase the availability of oxygen for oxygen enrichment. Refractory of the proper quality should be installed in blast furnace that is capable of withstanding the required higher temperature.
- The stoves should be modified to increase the hot blast temperature above 1100^0C.
- Before committing fresh investment in the new CDI system in other blast furnaces, commensurate infrastructure should be created to achieve the optimum utilisation of CDI system.

The Management accepted (November 2006) the recommendations.

9.1 Introduction

9.1.1 Steel Authority of India Limited (Company) operates 24 Blast Furnaces (BF) with an annual production capacity of 13.60 million metric tonnes (MMT) of hot metal. Metallurgical coke (Met coke or BF coke) forms a major portion (55 to 60 *per cent*) of the cost of hot metal production. Replacement of expensive metallurgical coke with non-coking coal is being attempted actively the world over due to increasing cost and depleting sources of coking coal, and high operational and capital cost of coke oven batteries. This is being achieved through Coal Dust Injection system (CDI), where certain amount of non-coking coal is injected into blast furnaces. This injection reduces the consumption of coke in blast furnace.

9.1.2 The Company installed CDI in BF-2 of Bhilai Steel Plant (BSP) on experimental basis in 1984 at a cost of Rs.11.59 crore. The system, however, could not achieve sustained injection rates above 30 kg/MTHM. The failure was attributed to low hot blast temperature, high ash content in coal, non-uniform distribution of coal dust in the tuyeres, poor coal injection technology, inadequate monitoring instrumentation, etc. CDI in BF-2 of BSP was abandoned in 1986.

Subsequently in 1995, the Management approved installation of CDI in BF-5 of Bokaro Steel Plant (BOSP) and BF-6 of BSP, with an installed capacity of coal dust injection of 150 kg/MTHM, in order to meet the shortages, replace the costly Met coke and improve the productivity of the blast furnaces. CDI was envisaged to replace coke in the ratio of 1:1 i.e., one kg of coal dust would replace one kg of coke. Later on, the Company extended the facility in some other blast furnaces. The details of CDIs, installed in the Company are summarised below:

Sl. No.	Location of BFs	Sanction by Board/original cost	Month of commissioning/commencement of operation	Actual cost (Rs. in crore)
1	BF-4 (BOSP)*	Board Approval in February 1995 for Rs.48.08 crore.	November 1998	55.66
2	BF-5 (BOSP)**	Initiated in May 2004 for Rs.17.31 crore.	August 2005	10.07
3	BF-6 (BSP)	Board Approval in December 1995 for Rs.48.85 crore.	September 1998	48.93
4	BF-7 (BSP)**	Initiated in July 2002 for Rs.9.69 crore.	December 2004	9.87
5	BF-1 (BSP)	BSP revived the old equipment of CDI in BF-2 (original value - Rs.11.59 crore) installed in 1984 on experimental basis.	October/November 2005	22.27
6	BF-5 (BSP)			
	Total			**146.80**
*	Board had approved CDI in BF-5. But due to long shutdown of BF-5, CDI was installed in BF-4.			
**	Due to lower rate of injection in BF-6 (BSP) and BF-4 (BOSP) i.e., 55 to 71 kg/MTHM during 2001-02 to 2003-04 as against the installed capacity of 150 kg/MTHM, surplus capacity was available for pulverised coal so CDI was installed in other BFs by sharing the common facilities already provided for CDI in BF-6 (BSP) and BF-4 (BOSP).			

Corporate Plan-2012 of the Company provides for installation of CDI across all the plants in a phased manner. The Company has already initiated action for installation of CDI in Durgapur Steel Plant, Rourkela Steel Plant and BOSP with an estimated capital cost of Rs.406.08 crore.

9.2 Audit objectives

The audit objectives were to examine:

(i) The operational efficiency of the CDI – to study the achievement against the capability created;

(ii) Reasons and limitations responsible for low performance;

(iii) Factors considered before committing fresh investments on CDI in other BFs.

9.3 Scope of Audit

The Performance audit review covers the performance of CDI during the period of six years from 1999-2000 to 2004-05. The review extends to the proposed CDI systems in the Company.

9.4 Acknowledgement

Audit is thankful for the co-operation received from the Management in furnishing information, records, data, and clarification with reference to the queries raised from time to time.

9.5 Audit findings

The Company was eager to modernise its blast furnaces for making them cost effective but it did not ensure availability of commensurate infrastructural facilities for successful operation of CDI. This resulted in underutilisation of the capacity for CDI created.

9.6 Guarantee for only two-thirds of the designed capacity

The design capacity of the CDI system selected by the Company for installation was for coal injection of 150 kg/MTHM. As the existing infrastructure of blast furnaces was not suitable for such high injection rates, the supplier of CDI at BF-6 of BSP, viz. M/s Babcock Materials Handling Process Technology GmbH, Germany, guaranteed coal injection rate of 100 kg/MTHM only (i.e., two-thirds of the installed capacity of 150 kg/MTHM). The Management, however, went ahead with the installation of CDIs with 150 kg/MTHM injection capacity.

The Management stated (November 2006) that with a view to introducing CDI technology on experimental basis, which was new to the Company in 1995, the Company's Board of Directors approved CDI in BF-6 with a performance guarantee of 100 kg/MTHM.

Reply of the Management is not tenable as the Company had earlier installed CDI on experimental basis in BF-2 of BSP in 1984; thus CDI technology was not altogether new to the Company.

9.7 Performance guarantee test

9.7.1 As per the results of the performance guarantee test (PG Test) conducted for CDI at BF-6 of BSP (12 to 27 April 1999), an injection rate of 101 kg/MTHM as against the guaranteed 100 kg/MTHM was recorded to have been achieved. However, analysis of the Daily Production Report of BF-6 in BSP for April 1999, made by Audit revealed that there was no consistency in performance and there were wide fluctuations in the injection rates. The injection rate was as low as 21 kg/MTHM (on 17 April 1999) and exceeded 100 kg/MTHM only for three days (out of 15 days of PG test), viz. on 14 April 1999 (108 kg/MTHM), 15 April 1999 (121 kg/MTHM) and 25 April 1999 (103 kg/MTHM).

The Management stated (November 2006) that CDI rate of more than 100 kg/MTHM was achieved during the period prior to PG test but this could not be demonstrated in the PG test. An injection rate of more than 100 kg/MTHM was achieved on a few occasions only in PG test.

9.7.2 Since blast furnace operates continuously, without any break, CDI should also be capable of continuous operation. However, it was observed that for PG Test, CDI was not operated continuously for 15 days. As a result, sustainability of CDI operation for 24 hours a day could not be confirmed.

The Management stated (November 2006) that PG test for CDI would be carried out as per agreed criteria in future.

9.8 Absence of adequate infrastructural facilities

Adequate infrastructural facilities such as proper cooling system, high blast temperature, oxygen enrichment, advanced monitoring and control gadgets, etc. are necessary to sustain a high injection rate. Due consideration was not given to the adequacy of the existing infrastructural facilities while introducing CDI, as discussed below.

9.8.1 Inadequate cooling system

9.8.1.1 The operation of CDI increases heat load on the wall and refractory of the blast furnace, which in turn, increases the possibility of damaging the refractory lining as well as the cooling system. Hence, a very effective and compatible cooling system in the blast furnaces is essential to protect the blast furnace shell and refractory lining. A combination of copper stave coolers and closed recirculation is considered to be the best for blast furnace cooling.

9.8.1.2 The cooling system in the blast furnaces of the Company had remained the same since inception and was inadequate for keeping the temperature of refractory linings at low level. The Management did not carry out necessary modification of cooling system in BF-6 (BSP) during shutdown for capital repair (June 2000 to May 2001); even though the price quoted for the job was Rs.3.62 crore only. In BOSP also, there was intermittent rise of wall temperature, which could not be controlled and 50 *per cent* of bosh & stack coolers were burnt.

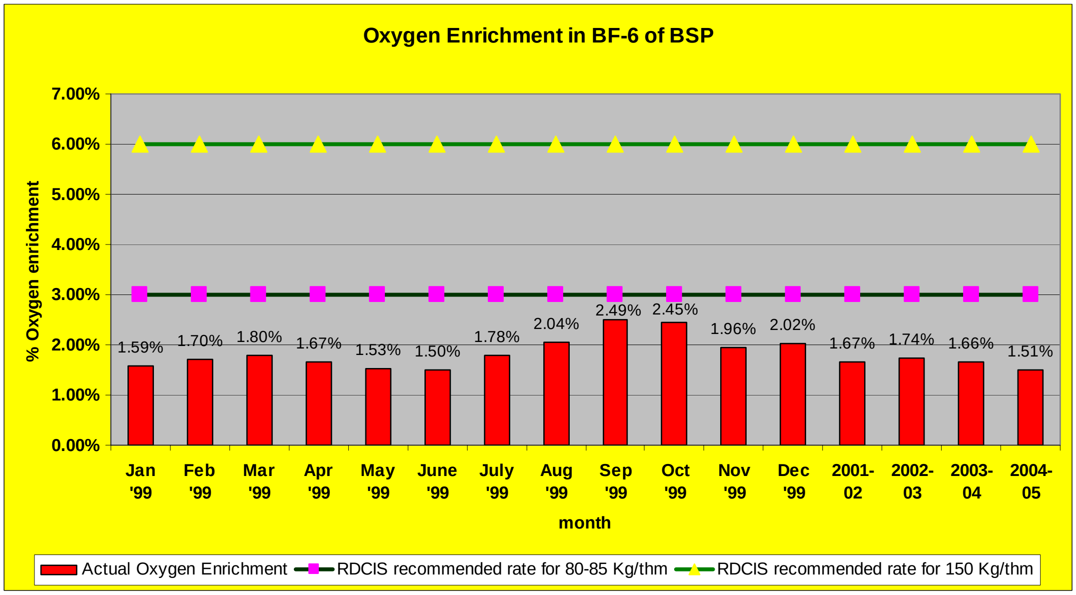
The Management stated (November 2006) that cooling system of BF-6 was not modified during capital repairs due to severe financial crisis. Further, modification of cooling system in BF-7 was already in progress and upgradation of BF-6 was planned shortly.

9.8.2 Inadequate oxygen enrichment facilities

Complete combustion of coal is necessary for smooth and efficient functioning of the blast furnace. Poor coal combustion results in operational problems like reduced permeability, undesirable gas and temperature distribution. These problems impair blast furnace productivity and coke replacement ratio. Complete combustion of coal could be achieved by a suitable rate of oxygen enrichment.

9.8.2.1 The Supplier of CDI had stated that two *per cent* oxygen enrichment was required to reach injection rate of 100 kg/MTHM and four *per cent* for injection rate of 150 kg/MTHM. The Research & Development Center for Iron and Steel, a unit of the Company, had recommended three *per cent* oxygen enrichment for injection rate of 80-85 kg/MTHM and six *per cent* for injection rate of 150 kg/MTHM.

9.8.2.2 In the initial period of CDI operation (1999), the actual oxygen enrichment in BF-6 of BSP ranged between 1.50 *per cent* (June 1999) and 2.49 *per cent* (September 1999). In subsequent periods also it remained in a lower range between 1.51 *per cent* in 2004-05 and 1.74 *per cent* in 2002-03.



Oxygen enrichment was even less than one *per cent* in BF-7 (BSP) and there was shortage of oxygen for enrichment of blast in BOSP.

9.8.2.3 Oxygen plants in BSP and BOSP were operating at much below the rated capacity mainly due to old and obsolete technology, which required regular and extensive revamping in order to sustain even the present level of production. The committee constituted to augment the oxygen supplies for injection system suggested (June 2004) regulation and maintenance of oxygen enrichment at 1.5 *per cent* in place of three *per cent* till long term measures could be taken. As a long-term measure, the installation of additional gas units at all plants of the Company by 2006-07 would require an investment of Rs.1200 crore.

The Management stated (November 2006) that the requirement of oxygen was otherwise high due to increase in the production of hot metal and crude steel and action was under way for installation of oxygen plant at BSP and BOSP to supplement oxygen requirement.

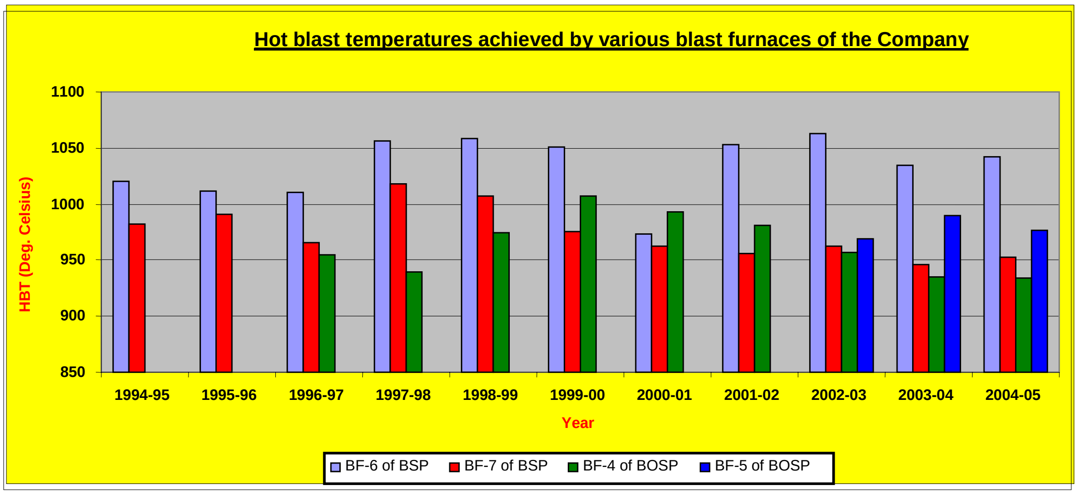
The Company should have ensured the required level of oxygen enrichment before installation of CDI.

9.8.3 Low hot blast temperature

Injection of coal dust causes a drop in the temperature in blast furnace. Inadequate hot blast temperature affects complete combustion of coal adversely. Required level of temperature needs to be maintained through hot blast temperature and oxygen enrichment.

9.8.3.1 Feasibility Report for CDI in BF-6 of BSP (April 1995) envisaged hot blast temperature of 1100^{0}C. The Company had also recommended (September 2002) that the success of CDI required higher hot blast temperature (1050-1100^{0}C). While selecting BF-6 for CDI, it was stated in the feasibility report that modified design of stoves provided in it could give hot blast temperature upto 1200^{0}C. Regarding BF-7 of BSP, the Centre for Engineering & Technology (CET), in their Report (May 1999) had mentioned that the stoves provided therein were thermally efficient in design and could provide hot blast temperature upto 1100^{0}C.

9.8.3.2 The actual hot blast temperature in different blast furnaces containing the CDI during 1994-95 to 2004-05 (both pre as well as post CDI period) were as follows:



9.8.3.3 Low hot blast temperature in blast furnaces was attributed to the inability of the refractory to withstand the hot blast temperature of 1100 ^{0}C. Old design of hot blast stoves and burners and the existing tuyeres were not able to withstand higher hot blast temperature. Low hot blast temperature was one of the reasons for poor performance of CDI system.

9.8.3.4 The hot blast temperature of 1100 ^{0}C, as provided in the feasibility report, was to increase the blast furnace productivity by 0.875 *per cent* and reduce the coke consumption rate by 0.875 *per cent*. It is estimated that failure to achieve 1100 ^{0}C hot blast temperature resulted in excess consumption of 0.47 lakh MT coke valuing Rs.24.34 crore during 1999-2000 to 2004-05 in BF-6 of BSP and BF-4 of BOSP. There was no improvement in blast furnace productivity either. Lower hot blast temperature resulted in less production of hot metal by 0.97 lakh MT valuing Rs.53.70 crore during the same period.

The Management stated (November 2006) that a range of hot blast temperature of 900-1100 ^{0}C in BF-6 and 900-1000 ^{0}C in BF-7 of BSP was given as the parameter in the contracts and the hot blast temperature was maintained in this range. While accepting that lower hot blast temperature was one of the factors affecting the success of CDI in BOSP, it was stated that capital repair of stoves to increase hot blast temperature in BOSP, were being carried out. In BSP too, effort was under way to rectify the problem of the health of the refractory in hot blast system, which would improve the hot blast temperature.

9.8.4 Inadequate numbers of tuyeres for CDI

For proper distribution and complete combustion of coal dust, adequate numbers of tuyeres were required to be installed uniformly in the blast furnace. The non-uniform distribution of coal dust causes increase in the consumption of coke and also affects adversely the productivity of the blast furnaces**.**

9.8.4.1 In BOSP, in BF-4 there were 20 tuyeres but coal was injected from 14 tuyeres only and in BF-5 out of 24 tuyeres, only 20 tuyeres were envisaged to be used for CDI. In BF-6 BSP, it was observed that the injection of coal was stopped in two tuyeres above the tap hole during tapping.

The Management accepted (November 2006) that injection was not done from all the tuyeres. It happened due to limitation in design of the tap hole and equipment to open and close the tap hole.

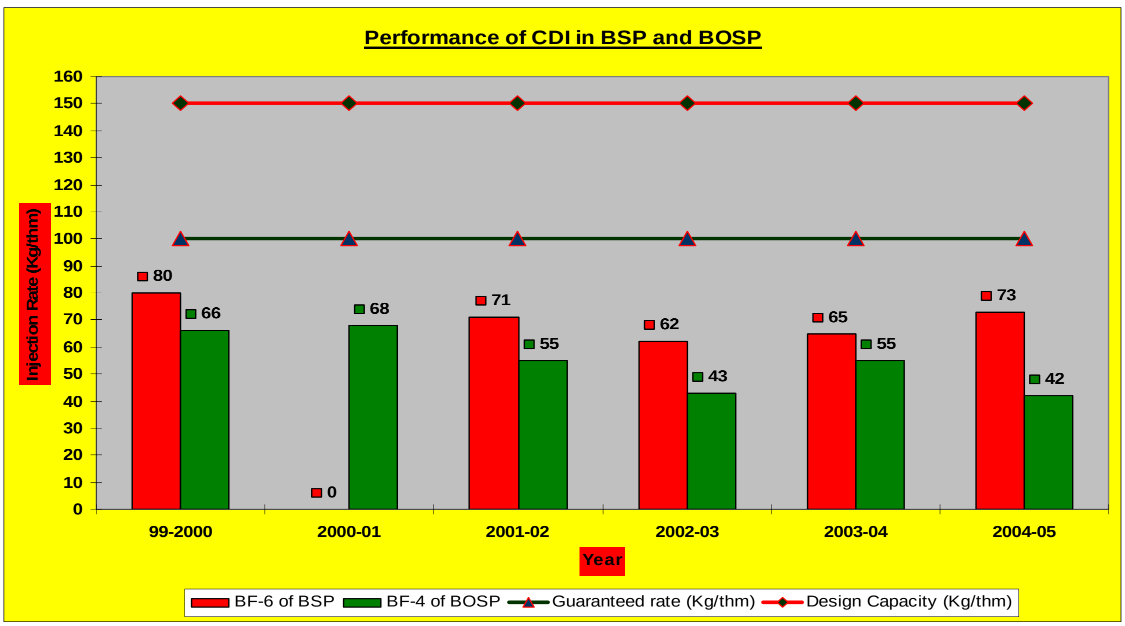
9.8.5 Lack of monitoring and control equipment

High rate of coal injection by CDI requires proper burden distribution[*] for optimum gas distribution. Measuring instruments are required for optimising gas flow for smooth furnace operation. However, while introducing CDI in blast furnaces, adequate consideration was not given to the level of instrumentation and monitoring system. Due to non-availability of that equipment, proper burden distribution was not ensured.

The Management stated (November 2006) that necessary care had been taken in respect of monitoring and control equipment in the upcoming CDI projects.

9.9 Operational efficiency of CDI

9.9.1 As against the guaranteed injection rate of 100 kg/MTHM, the actual injection rate of CDI of BF-6 (BSP) and BF-4 (BOSP) was much less, as shown below:



9.9.2 Based on the injection rate of 100 kg/MTHM and a coal-coke replacement ratio of 1:1, it was calculated in audit that there was a shortfall of coal dust injection of 4.45 lakh MT during 1999-2000 to 2004-05 in case of BF-6 of BSP and BF-4 of BOSP. This resulted in an extra expenditure of Rs.64.56 crore since costly coke had to be consumed in place of proposed non-coking coal.

[*] ***Burden distribution – charging of raw materials in the blast furnace such as iron ore, coke, sinter etc. It denotes the radial material distribution as well as the particle size distribution in a blast furnace.***

9.9.3 In BF-6 of BSP, with gradual increase in the injection rate of coal dust, the problems of burning of coolers and tuyeres and increased peripheral flow of gases (i.e., flow of gases towards the wall of blast furnace) were observed as reflected in the increased wall temperature. After taking remedial measures, an injection rate of 80-85 kg/MTHM was achieved during June-August 2003 but this could not be sustained due to excessive wall erosion in the blast furnace. The actual injection achieved subsequently on continuous basis was only 65-73 kg/MTHM (2003-04 to 2004-05).

The operation of CDI in BF-4 of BOSP was discontinued with effect from February 2005 due to bad condition of the furnace, burning of cooler and blast furnace reaching the last stage of its design life. It was put back into operation after completion of capital repairs in October 2006.

The Management while accepting the facts (November 2006) stated that higher injection rates could not be sustained due to operational problems and 65-73 kg/MTHM CDI was maintained in BF-6 of BSP to keep the furnace in good condition. Regarding CDI in BF-4 of BOSP, the poor performance was attributed to utilisation of different types of coal such as high ash indigenous coal and hard coking coal, fluctuations in the quality of raw materials and due to the operational difficulties.

9.9.4 Similarly, in BF-7 of BSP there was problem of peripheral flow of gases during CDI operation and erosion of furnace lining at different zones. To avoid breakdown of the blast furnace, the injection rate was kept on the lower side ranging between 25 and 40 kg/MTHM during December 2004 to March 2005. The injection rate through the newly created system in BF-5 of BOSP also ranged between 35 and 49 kg/MTHM during August 2005 to December 2005.

The Management accepted the facts and stated (November 2006) that capital repair of BF-7 had been taken up for change and modification in cooling system, refractory lining etc.

9.10 Action for installation of CDI in other blast furnaces

The Company approved proposals (between 2004 to 2006) for installation of CDI at BF-3 and BF-4 of Durgapur Steel Plant, BF-2 and BF-3 of BOSP and BF- 4 of Rourkela Steel Plant at a total estimated cost of Rs.406.08 crore.

9.10.1 The CDI facilities have again been designed to achieve an injection rate of 150 kg/MTHM with oxygen enrichment of six *per cent* in Durgapur Steel Plant and Rourkela Steel Plant. In case of BOSP, the injection rate has been designed to achieve 150 kg/MTHM with oxygen enrichment of five *per cent*. In the initial period, the CDI systems are proposed to attain an injection rate of 120 kg/MTHM with four *per cent* oxygen enrichment in case of Durgapur Steel Plant and an injection rate of 100 kg/MTHM in BOSP. To implement the project at Durgapur Steel Plant, an order valuing Rs.37.14 crore has been placed on M/s Shriram EPC Limited as the consortium leader in March 2006.

9.10.2 Before committing fresh investments on the installations of CDIs in other blast furnaces, the Management has not rectified or improved the condition of the selected blast furnaces nor created commensurate infrastructure to achieve the optimum utilisation (150 kg/MTHM) of CDI System. The sanction for installation of the CDI in other blast furnaces lacked justification in view of the Company's inability to achieve the performance parameters in the existing CDIs.

The Management stated (November 2006) that the limitations and difficulties experienced in the existing CDI were being taken care of gradually.

9.11 Conclusion

While the Company was eager to modernise its blast furnaces for making them cost effective it had not provided commensurate infrastructural facilities, which were essential for the successful operation of CDI. The Company went ahead without assessing the existing capability of their blast furnaces to cope with the CDI system. Such hasty action by the Company resulted in underutilisation of capacity created at a cost of Rs.146.80 crore and loss of Rs.142.60 crore due to fall in the targeted substitution of BF coke, non-reduction in coke consumption and non-increase in blast furnace productivity.

The Corporate Plan-2012 of the Company envisaged ambitious plans for even higher rates of CDI, and that too across all the plants under the Company. However, such plans would succeed only if the operational parameters of the blast furnaces and the supporting infrastructural facilities are adequately improved.

The matter was reported to the Ministry in December 2006; reply was awaited (January 2007).

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Countersigned

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