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Production of ferro Manganese Through Blast Furnace Route

RANJAN SEN
Tata Korf Engineering Services limited, Calcutta, India

ABSTRACT

High carbon ferro manganese is produced entirely through submerged arc furnace route in India. This route has the greatest disadvantage of high electrical energy consumption. The manufacturers of ferro alloys are facing difficulties to stay competitive due to the increasing tariff of electric power. Ferro manganese can be manufactured in blast furnaces much more economically compared to submerged arc furnaces with co-generation of electric power using the BF off-gas. Some modifications will be required in the design of conventional blast furnaces for producing ferro manganese. Tata Korf mini blast furnaces can be conveniently used for the manufacture of FeMn, since most of these modifications have already been incorporated in the design of these furnaces.

Keywords : Ferro manganese, Blast furnace route, Submerged arc furnace.

INTRODUCTION

Bulk Ferro Alloys such as ferro manganese, ferro silicon and silico manganese are required for deoxidation and alloying of steel. Demand of the ferro alloys are likely to go up in keeping with the rising trend of consumption and production of steel in India. Production of Ferro alloys being energy intensive and Submerged Arc Furnaces (SAF) being the only route for manufacture of ferro alloys in India, the competitiveness of ferro alloys manufacture in India is increasingly being put into tight corners. However, ferro manganese is the type of ferro alloy which is also produced through Balst Furnace route. The scope of production of ferro manganese through BF route in Indian context is discussed in this paper.

FeMn PRODUCTION THROUGH SAF ROUTE

In India 100% of FeMn is produced thourgh SAF Route, although TISCO and IISCO are reported to have produced FeMn in their blast furnaces just before taking them down for relining. SAF route offers the following advantages,

- o Low capacity furnace with low capital cost,
- o Flexibility, i.e., switching of alloy from one to another.

However, under Indian condition the process has the following disadvantages:

- o High cost of electric power
- o Non–availability of power throghout the year

The capacity utilisation of the Indian ferro alloy manufacturing units is fairly low due to the above mentioned disadvantages and therefore, production is not cost competitive.

FeMn PRODUCTION THROUGH BF ROUTE

Mizushima Ferro Alloy Co. Ltd., a group company of Kawasaki Steel Corporation (KSC) started producing high carbon ferro manganese satisfactorily through Blast Furnace route since June 1985. There is another company named STE DU FERROMANGANESE DE PARIS OUTREAU in France which is manufacturing high carbon ferro manganese every year to the extent of 400,000 tonnes through small blast furnaces. The process offers specific advantages under Indian conditions since it does not consume electric energy as the main fuel and therefore, has no uncertainity in operations. It is rather possible to generate electricity from the blast furnace off gas. Overall cost of production is low. Mn yield is also higher compared to SAF route. However, no ferro alloy other than FeMn can be manufactured in blast furnace. Coke rate is higher compared to SAF route, since the coke replaces the electric energy consumption as applicable for SAF route.

Therefore, the advantages of the process are

- High Mn yield
- Low cost of production
- Producer electric energy

EXPERIENCE OF FeMn PRODUCTION IN KAWASAKI STEEL CORPORATION

In 1984 Kawasaki Steel Corporation started construction of a 398 m^3 blast furnace which was blown in during June 1985 to produce high carbon ferro manganese. The main features of the blast furnace are given below :

Furnace Proper

Carbon brick was used to encounter erosion effect of manganese slag. Eccentric type high flow rate water cooled tuyere was adopted to cope with the higher blast temperature.

Recuprator

Recuprator was adoped instead of hot stove for blast furnace to reduce the installation cost, which preheated both cold blast and combustion air in the flue pipe of recuprator to increase thermal efficiency.

Furnace Top Equipment

Centre feed type bell less charging equipment was adopted, however it is not an exclusive requirement for FeMn production. Bell type charging system can also render satisfactory service. Because of the temperature rist at the furnace top, a water cooling system was adopted to cool the stationary armour.

Gas Cleaning System

A dust catcher, cyclone and a venturi scrubber were adopted to get dust content of the gas at the exit of the gas cleaning system as less than 5 mg/Nm^3.

The major operational data of Kawasaki Steel Corporation (KSC) are presented below :

Inner Volume	:	398 m^3
Production	:	240 t/day
Blast volume	:	550 Nm^3/min
Oxygen enrichment	:	5%
Blast temperature	:	800°C
Coke rate	:	1500 kg/t
Productivity	:	0.6 t/m3/d
Slag rate	:	600 kg/thm
Top gas generation	:	4800 Nm^3/thm
Manganese yield	:	91%
Mn content of HCFeMn	:	75%

QUALITY OF HCFeMn

A comparison of the quality of the Ferro Manganese produced in SAF and BF route is given below :

Element	SAF (%)	MBF (%)
Mn	75	74.7
Si	1.5	0.26
C	6–8	6.9
P	0.35	0.13
S	0.05	0.003

SPECIFIC CONSUMPTION OF RAW MATERIALS

The specific consumption of the raw materials for the two routes are given below:

Item	SAF	MBF
Manganese Ore, kg	2500	1725
Coke, kg*	650	1500
Fluxes, kg	100	500
Oxygen for enrichment of blast, Nm^3	–	265
Electric energy, kWh	2670**	1300 (Generation)
Mn yield, % ***	60–62	88–90

* For SAF 20% ash pearl coke and for BF 12% ash coke is required.

** After taking credit of 330 kWh/t power generation.

*** Through slagless process.

MINI BLAST FURNACE FOR FeMn PRODUCTION

A review of the design features of the blast furnaces used by KSC for FeMn production leads to the realisation that the Mini Blast Furnaces of Tata Korf in use in India for production of Pig Iron are suitable also for production of HCFeMn. Except the modified design of the top equipment of the blast furnace used by KSC, all other features are already incorporated in these Mini Blast Furnaces. This can be seen from the following Table 1.

Table 1 : Comparison of design features of KSC Blast Furnace with Tata Korf MBF

Item	KSC	Tata Korf	Remarks
Furnace proper			
a) Furnace support	Fee standing type	Free standing type	Similar in design
b) Coooling system	Colling plates and spray cooled	Spray cooled	Partially similar Cooling plates can be provided if required
c) Refractories	High alumina and carbon bricks	High alumina	Can be modified
Furnace charging			
a) Charging pattern	Standard charging pattern (COCO)	Standard charging pattern(COCO)	Same
b) Top equipment	Single hopper, bell less top	Double bell system	Modification not required
Hot blast generator			
a) Type	Recuperator instead of stoves	Recuperator instead of stoves	Similar in design
b) Blast temperature	Nominal 860ºC, Maximum 900ºC	Nonimal 860ºC Maximum 900ºC	Similar in design
Gas cleaning system	Dust catcher, cyclone and venturi scrubber	Dust catcher, cyclone and venturi scrubber	Similar in design
Blower	Electric blower– 550 Nm^3/min at 1.3 kg//cm^2 pressure	Series of fans– 550 Nm^3/min at 1.5 kg/cm^2 pressure	Blast volume same. Standby advantage is available with fans

ECONOMICS OF FeMn PRODUCTION

The operating costs and financial status for the two routes have been prepared and presented in Annexure 1 to Annexure 4. Largest TATA KORF blast furnace of 250 m^3 volume has been considered for the purpose of preparation of the estimates. The average productivity has been taken as 0.6 t/m^3/day. This is established in plants producing FeMn through blast furnaces with 12% ash coke. The annual plant availability is assumed as 340 days. Accordingly the daily production and annual production of HCFeMn shall be 150 tons and 51,000 tons respectively. The SAF project for manufacturing 51,000 tones of HCFeMn per year shall require one no. of 33 MVA submerged arc furnace. The other sassumptions made are given below :

1) Selling price of FeMn is Rs. 19,000 per MT exworks exclusive of excise duty. With 15% excise duty, price comes to Rs. 21,859 per MT.
2) Other manufacturing expenses in BF at Rs. 1200 per ton have been taken as 1.5 times the expenses being incurred by the existing mini blast furnace plants in India.
3) The gross power generation from the off gas of BF will be 1300 kWh/t. Out of this about 200 kWh will be consumed internally for BF operation. Thus the net power available for sale will be 1100 kWh/t.
4) Sale price of electricity has been taken as 85% of purchase price of Rs. 2.50 per kWh.

The production cost and gross and net profits for production of 51,000 tons of HC FeMn per year is given in Table 2 below. It may be noted here that the comparison is made on a like to like basis to arrive at the status of the two routes.

Table 2 : Salient financial data for FeMn production

	Item	SAF Route	MBF Route
1.	Production cost, Rs./ton	16,752	12,280
2.	Gross profit before interest and depreciation, Rs. in crores	11.47	34.27
3.	Net profit/loss after interest and depreciation, Rs. in crores	(2.22)	13.88

CONCLUSIONS

1. Production of Fe–Mn through BF route is environment friendly and techno–economically feasible.
2. Blast furnace of TATA KORF design with suitable modifications in furnace top equipment shall be adequate for production.
3. Product through BF route would always remain competitive due to 35% lower cost of production compared to SAF route.

Annexure – I

Cost of production through SAF route

Input	Specific consumption kg/T	Unit rate Rs/T	Amount Rs.
Mn Ore	2500	2460	6150
Coke	650	2480	1612
Dolomite	100	400	40
Other manufacturing expenses	—	—	2500
Power, kWh	2670	2.50/kWh	6675
Gross ex-works cost per tonne of alloy			16,977
Credit for high MnO slag @Rs.300/t of slag for 750 kg of (225) slag per tonne of alloy			
Net ex-works cost per tonne of alloy		16,752	

Annexure – II

Cost of production through BF route

Input	Specific consumption kg/T	Unit rate Rs/T	Amount Rs.
Mn Ore	1725	2460	4244
Coke	1500	5125	7687
Dolomite	160	600	96
Oxygen (for 5% O_2 enrichment), Nm^3	265	5.25	1391
Other manufacturing expenses	–	–	1200
Gross ex-works cost per tonne of alloy	–	–	14,618
Credit for sale of power @Rs.2.125 per kWh for 1100 kWh per tonne of alloy			(2338)
Net ex-works cost per tonne of alloy			12,280

Annexure – III

FeMn project through SAF route

1.	Cost of project @Rs.10,000 per annual tonne to 51,000 t	...	Rs, 51.00 crores
	Shareholders fund	...	Rs. 17.00 crores
	Term loans	...	Rs. 34.00 crores
2.	Working capital		
	Raw materials for 15 days @Rs.7802 for 2250	...	Rs. 175.50 lakhs
	Other manufacturing expenses for 30 days @ Rs.2500 for 4500 t	...	Rs. 112.50 lakhs
	Finished goods stock for 15 days @Rs.16,752 for 2250 t	...	Rs. 377.00 lakhs
	Credit on sale for 30 days @ Rs.21,850 for 4500 t	...	Rs. 983.00 lakhs
			Rs. 1648.00 lakhs
	Add : 25% Margin money	...	Rs. 412.00 lakhs
			Rs. 2060.00 lakhs
			Say, Rs. 21 crores
3.	Total borrowing Rs.34 crores + Rs. 21 crores = Rs.55 crores.		
	Total net sales relisation @Rs.19,000 t for 51,000 t	...	Rs. 96.90 crores
	Total cost of production @Rs.16,752 t for 51,000 t	...	Rs. 85.43 crores
	Gross profit	...	Rs. 11.47 crores
	Interest @20% on Rs. 55 crores	...	(Rs. 11.00 crores)
4.	Profit/Loss after interest	...	Rs. 0.47 crores
	Depreciation @5.28% SLM on Rs.51 crores	...	(Rs. 2.69 crores)
5.	Profit/Loss After Interest & Depreciation	...	(Rs. 2.22 crores)

Annexure – IV

FeMn project through BF route

1.	Cost of project 1 x 250 m^3 Mini Blast Furnace for production of 51,000 tons/yr	...	Rs.	60.00 crores
	Power plant of 6.5 MW @Rs.3.5 crores/MW	...	Rs.	22.75 crores
	Add: MBF Modifications	...	Rs.	4.25 crores
			Rs.	87.00 crores
	Shareholders fund	...	Rs.	29.00 crores
	Term loans	...	Rs.	58.00 crores
2.	Working capital			
	Raw materials for 15 days @Rs.13418 for 2250 t	...	Rs.	301.90 lakhs
	Other manufacturing expenses for 30 days @RS.1200 for 4500 t	...	Rs.	54.00 lakhs
	Finished goods stock for 15 days @Rs.14,618 for 2250 t	...	Rs.	328.90 lakhs
	Credit on sale for 30 days @ Rs.21,850 for 4500 t	...	Rs.	983.30 lakhs
			Rs.	1668.10 lakhs
	Add: 25% Margin money		Rs.	417.02 lakhs
			Rs.	2085.12 lakhs
			Say, Rs.	221 crores
3.	Total borrowing Rs.58 crores + Rs.21 crores = Rs.79 crores			
	Total net sales relisation @Rs. 19,000/t for 51,000 t		Rs.	96.90 crores
	Total cost production @RS.12,280 x 51000 t	...	Rs.	62.63 crores
	Gross profit	...	Rs.	34.27 crores
	Interest @20% on Rs.79 crores	...	(Rs.	15.80 crores)
4.	Profit after interest	...	Rs.	18.47 crores
	Depreciation @5.28% SLM on Rs.87 crores	...	(Rs.	4.59 crores)
5.	Profit after Interest & Depreciation	...	Rs.	13.88 crores