Ferro Alloy Industries in the Liberalised Economy
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Technology of Ferro Alloys Making in India — A status and Recent Developments

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ABSTRACT

The ferro alloy industry in India has grown over the years and has built in a production capacity of more than 1 million tons for various ferro alloys. The industry has employed world class production technology and is playing a vital role in the sustained growth of the steel industry. Under the liberalized economy it has huge potential for earning valuable foreign exchange through export, besides meeting indigenous demand. Liberalization of economy, decontrol of iron and steel prices and delicencing of steel industry are likely to give a boost to the demand for ferro alloys. The dynamics of demand and supply pattern of crude steel and major ferro alloys upto the end of the century have been highlighted. The technology of bulk ferro alloy processing in general and recent Research and Development activities carried out in particular have been discussed in detail. The constraints facing the ferro alloy industry have been critically analysed with suggested measures for improvement.

Keywords : Ferro alloy technology, Indian ferro alloy industry.

INTRODUCTION

The ferroalloy industry in India has matured and is playing a vital role in the sustained growth of the steel industry. The country is now self sufficient in respect of bulk ferroalloys produced by carbo-thermic and alumino-thermic reduction processes. However, some raw materials for production of special ferroalloys not available in India, are to be imported. Significant amount of tonnage ferroalloys produced by electrothermal smelting are also exported, thus earning valuable foreign exchange.

In Spite of the continued growth of the ferroalloy industry, the non-availability of proper raw materials, shortage of reductants, interrupted power supply and high tariff rates have all contributed towards higher cost of production and as a result decline in exports.

The industry has already completed more than three and half decades of its existence. Its performance in both domestic and international markets was quite satisfactory till the mid seventies but gradually its performance started deteriorating and its operations became uneconomical due to higher production cost. Thus, the Indian ferroalloy industry lost its competitiveness in the international market. Wild fluctuations in demand and product mix in addition to the surplus installed capacity has further aggravated the situation.

Production of good quality ferroalloys is vital for steel industry since no steel can be made without the addition of one or more of ferroalloys. Ferroalloy industry has huge potential for earning valuable foreign exchange through export, besides meeting increasing indigenous requirements. Liberalizations of economy, decontrol of iron and steel prices and delicencing of steel industry are likely to give a boost to the ferroalloy industry. SAIL is the biggest consumer of bulk ferro alloys. It consumes about 1,80,000t of different ferroalloys costing more than 550 crores.

DYNAMICS OF DEMAND AND SUPPLY

The Iron and Steel Industry in India is growing at a very faster rate as demand and supply pattern shown in Table 1. The different surveys have indicated that the demand of steel by 2005–06 would be about 45 m.t. and by 2010–11 about 57 m.t.

Table 1 : Demand and supply of steel

Item	1996–97 (Projected)	2001–02 (Projected)
Domestic Demand	20.74	30.66
Export Demand	3.40	6.00
Total Demand	24.14	36.66
Domestic Supply	—	—
SAIL	8.75	10.85
TISCO	1.97	1.97
VSP	2.41	2.41
Secondary Producers	7.04	8.77
Total Projected Supply (from Existing Units only)	20.17	24.00
Projected Gap	3.97	12.66

Therefore future of ferroalloys industries in India which is totally dependent upon the growth of Iron & Steel Industries is very bright. The present installed capacity of ferroalloys is capable of meeting the demand of 25–30 m.t. of steel. Presently there are nearly 30 units operating in the country with an installed capacity of plus 1.0 m.t./yr. of bulk ferroalloys. The ferroalloy industries are mainly situated in Maharashtra, Andhra Pradesh, Orissa and Karnataka because of the availability of input materials in nearby vicinity.

With the faster growth of iron and steel industries, the demand of FeMn is increasing day by day. The FeMn industries in this country are self sufficient to meet the demand. The production and consumption pattern of the FeMn has been shown in Table 2.

Table 2 : FeMn production and consumption pattern in India (tonnes)

Year	Product	Import	Export	Consum.
1991–92	248856	145	3600	245401
1992–93	294401	155	3650	290906
1993–94	339946	165	3700	336411
1994–95	385491	175	3750	381916
1995-96e	431036	185	3800	427421
1996–97e	476581	195	3850	472926
2000–01e	546888	233	3850	543270
2004–05e	627566	277	3850	623993

HCFeCr occupies preeminent position among all other ferroalloys produced in the country and accounts for more than 80% of the export turn over of the ferroalloy industries which has been shown in Table 3.

Table 3 : Production and consumption pattern of HCFeCr/Charge chrome in India (tonnes)

Year	Production	Import	Exports	Domestic
1991–92	1,83,126	1,05,593	3600	77,533
1992–93	2,39,701	1,27,037	3650	1,12,664
1993–94	2,51,689	1,28,762	3700	1,22,927
1994–95	2,39,765	1,17,000	3750	1,22,765

The production of HCFeCr/Charge chrome during 94-95 was about 2,40,000 t as given below:

	Capacity (MT)	Production (MT)	Capacity Utilisation, %
HCFeCr/Charge Chrome	4,13,500	2,39,765	58

The FeSi production in the country is 60,000 t/annum against installed capacity of 1,25,000 t. The difference in demand and supply is met by import.

THE TECHNOLOGY

High Carbon Ferro Alloys

Generally high carbon ferro alloys and FeSi are made through carbothermic processes in Submerged Arc Furnace (SAF). The technology adopted by the industry has been based on the conventional method of utilising high grade ores, reductants and fluxes.

Unlike Mn ore, 70–80% of the chromite ore available after mining is in the form of fines. Therefore improvements have been made in conventional processes by adopting agglomeration method i.e., by pelletising/briquetting followed by preheating and prereduction before use in SAF. For production of FeMn/SiMn use of sinter, pellets, preheated and pre-reduced materials are also day by day gaining momentum. Computerised control of smelting process has helped to increase productivity still further.

Medium/Low Carbon Ferroalloys

Medium carbon ferro alloys are made in EAF by dilution method. Starting material is SiMn/SiCr. Predetermined amount of ore and flux are added to carry out the reactions. In case of low carbon ferro alloys alumino–thermic/silico–thermic reduction is followed. In some of the plant prereduction/reduction roasting is carried out with coal followed by alumino–thermic reduction.

MEL has developed a unique method of producing MCFeMn through CLU converter of 15 t capacity. In this process liquid HCFeMn is poured into the converter and refining is carried out by passing a gas mixture consisting of O_2, N_2 and steam from the bottom of the converter in varying proportion in different

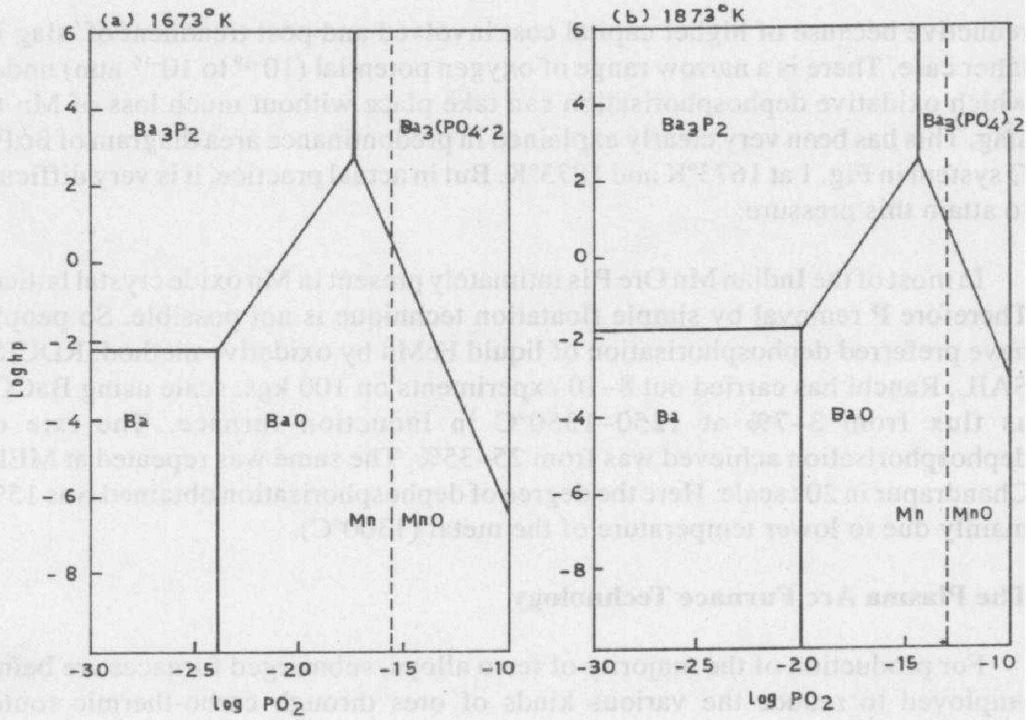

Fig. 1 : Predominance diagrams for Ba–P–O and Mn–O

periods. The total duration of heat is about 3–4 hrs. MEL has consistently produced 1.3–1.5% C FeMn for a long time. However, its production was discontinued due to lack of market.

In similar way HCFeCr may be refined in a ladle/furnace by passing a mixture of oxygen and inert gas.

Dephosphorisation of HC FeMn/Mn Ore

On one side steelmakers put stringent limit on P content of FeMn and on other side day by day the quality of Mn ore goes on deteriorating. Among all ferro alloys, maximum amount of P is coming from FeMn to steel. Therefore, dephosphorisation either at ore stage or of liquid FeMn is essential. Extensive laboratory works on dephosphorisation have been carried out in Japan, USA and China. On the basis of these works, dephosphorisation of liquid FeMn is possible either by oxidative or reductive route. For oxidative dephosphorisation BaO based fluxes are found to be more effective and for reductive dephosphorisation Ca or Mg based fluxes are preferred. Oxidative dephosphorisation is preferred to reductive because of higher capital cost involved and post treatment of slag in latter case. There is a narrow range of oxygen potential (10^{-19} to 10^{-16} atm) under which oxidative dephosphorisation can take place without much loss of Mn to slag. This has been very clearly explained in predominance area diagram of ßαP–O system in Fig. 1 at 1673°K and 1873°K. But in actual practice, it is very difficult to attain this pressure.

In most of the Indian Mn Ore P is intimately present in Mn oxide crystal lattice. Therefore P removal by simple floatation technique is not possible. So people have preferred dephosphorisation of liquid FeMn by oxidative method. RDCIS, SAIL, Ranchi has carried out 8–10 experiments on 100 kgs. scale using $BaCO_3$ as flux from 3–7% at 1250–1350°C in induction furnace. The rate of dephosphorisation achieved was from 25–35%. The same was repeated at MEL, Chandrapur in 20 t scale. Here the degree of dephosphorisation obtained was 15% mainly due to lower temperature of the metal (1300°C).

The Plasma Arc Furnace Technology

For production of the majority of ferro alloys, submerged furnaces are being employed to reduce the various kinds of ores through carbo-thermic route. Despite being an efficient route, there exist several rigid conditions with regards to raw materials and reductants characteristics which put limitations on their use in SAF. Not much of flexibility is available for changing of process parameters such as basicity due to operational restrictions like electrical resistivity. Also cheaper sources of reductants are not considered for use in SAF due to their electrical and physical properties.

An investigation was carried out jointly by RDCIS, SAIL and RRL(B) in a 35 KW transferred arc plasma reactor at Bhubaneshwar. The major aspects which were chosen for the studies included the kinetics of manganese oxide reduction, influence of slag basicity, production of MCFeMn, dephosphorisation and desulphurisation during smelting. The following conclusions were drawn from these experimentation:

i. Good quality FeMn having 75–80% Mn was produced

ii. An increase in Slag basicity resulted in decrease in Mn loss to the slag.

iii. The degree of dephosphorisation was independent of basicity and P removal achieved from 30–60% was only due to vaporisation.

iv. The desulphurisation was influenced by basicity and varied in the range of 50–70%.

Therefore at recent days attempts are being made for plasma smelting of ore fines with cheaper grades of reductants (coal/coke fines). Many companies in the world have tried commercial exploitation of the plasma technology either for smelting ore fines with cheaper grade of reductants or melting of metallic fines as shown in Table 4.

Table 4 : Commercial plasma F.A. Installations

	Capacity, t/hr.	Plant	Power level, MW
FeCr	80,000	Sweden	48
FeCr	50,000	South Africa	12–14
FeMn	50,000	South Africa	8

In view of the surplus capacity and large capital employed in Indian SAF furnaces, in near future it is very difficult to replace conventional technology by plasma processes. However, it does open exciting possibilities for the future.

New Technique of Sintering

The Table 5 shows that good quality metallurgical grade Mn ore will hardly last for 11 years. Therefore, there is urgent need for conservation of lumpy Mn ore as suggested below:

i. Government should restrict the export of Metallurgical grade ore

ii. Beneficiation technique should be applied in mines for upgradation of inferior grade of Mn ores.

iii. Maximum utilisation of fines for sintermaking for its use in SAF..

Table 5 : Estimated life of Mn Ores Reserves

Category	Reserves as on 1.4.90 m.t.	Reserves life as on 1.4.90 yrs.	Reserves life as on 1.4.90 yrs
Proved	28.567	16.92	11
Probable	41.794	24.76	19
Possible	106.116	62.86	57
Total	176.477	104.54	87

In this connection, it is to be informed that RDCIS, SAIL, Ranchi has developed a high pressure sinter (HPS) technology for Mn ore fines. On the basis of this technology a commercial plant of 100 tpd has been installed at MEL, Chandrapur and working successfully.

In HPS technique compressed air is passed from the top at a pr. of 0.75 Kg/Cm^2 and suction is applied through bottom of 650 mm thick bed. The charge mix consists of Mn ore fines, coke, lime stone and return sinter mixed with water. The speed of sintering is very high because of high pressure gradient across the charge bed. The hourly production is about 5 t and quality of the sinter is better than conventional one.

Alternate Reductant for FeSi Production

Charcoal is the best reductant for FeSi production. Day by day Government is imposing restriction on cutting of the trees. Days are not far away when total ban will be imposed on it. Therefore, search for alternate reductants substituting charcoal has become essential.

There are several alternate reductants which can substitute charcoal namely imported coal/coke, indigenous coal/coke, LECO etc. LECO is more advantageous because its P content is very low (0.0003%). Indigenous coal from Talcher belt or from other sources which has low P and ash content can be washed and used alone or in combination with imported coal. If we are going for imported coal, we must find out some solution for using –5 mm fraction which constitutes about 60–70%.

RDCIS, SAIL, Ranchi along with VISL, Bhadravati has successfully replaced charcoal by LECO and imported coal upto 30% each for ferro silicon production. Many FeSi producers are substituting charcoal by LECO, coke and coal along with wood chips in different proportions.

Special Ferro Alloys (FeNi, FeNb, FeV, FeMo, FeTi etc.)

Among the special ferro alloys, nickel and its alloys occupies the top position in terms of quantity required (12000–15000 t Ni/annum) and cost. The entire requirement is met by imports. The requirement of other special ferro alloys are being partly met by imports, the balance being procured from indigenous sources. The raw material requirements for the production of these ferroalloys are met by indigenous sources as well by import. The demand for special ferro alloys is on the increasing trend due to increase in steelmaking capacity as well as demand of special and alloy steels.

CONSTRAINTS FACED BY FERRO ALLOY INDUSTRY

Production of ferro alloys through electrothermic route is power intensive. It constitutes about 40% of the cost of ferro alloys. One of the main reasons for low capacity utilisation is insufficient and interrupted supply of electric power coupled with high tariff. For survival of the ferro alloy industries, government should supply power at NTPC rate and also big manufacturers should go for captive power plant utilising waste heat recovery from outgoing gases.

The second constraint is the deteriorating quality of input materials. To overcome this problem industry should adopt beneficiation/upgradation and agglomeration of ore/raw materials.

Since the future of ferro alloy industry is very bright due to faster growth of iron and steel industry, people should pay more attention on local R&D efforts resulting in reduction in power consumption and cost of production.

CONCLUSIONS

1. The future of ferro alloy industry is bright due to faster growth of iron and steel industry. The demand for steel is estimated at 37 mt by the end of the century.

2. The present installed capacity of more than 1 mt of various ferro alloys can meet the demand of 25–30 mt of steel in the country and has huge potential for exports.

3. RDCIS, SAIL, Ranchi has carried out lot of research activities in the area of dephosphorisation of HCFeMn and Plasma smelting of FeMn. It has successfully developed, installed and commissioned a commercial plant of 100 tpd HPSU at MEL, Chandrapur and has established the use of Leco and LAM coal upto 30% as a substitute of charcoal for FeSi production.

4. Insufficient and interrupted power supply coupled with high tariff and deteriorating quality of raw materials are major constraints for low capacity utilisation and higher cost of production.