INNOVATIONS IN FERRO ALLOYS TECHNOLOGY IN INDIA

C.N. Harman

FACOR Alloys Limited,
Shreeramnagar-535 101, Dist.Vizianagaram. A.P.
e-mail: cnharman@hotmail.com

ABSTRACT

Steel is the most versatile material which has made the progress in every aspect on this earth possible. There are hundreds of varieties of steel because for each application it has to be made with specific properties to get the most optimum usage. It is well known that the basic constituent of steel is iron. But it is the proportion of other elements in it, which give each type of steel certain specific properties. These elements are added in liquid iron in form of Ferro alloys to get the desired composition and properties. Thus, Ferro alloys are important additives in the production of steel. It can be said that no steel can be made without use of one or more of the several Ferro alloys.They form the backbone of steel. Thus, the Ferro alloys industry is vitally linked for its growth and development to that of the steel industry.

Ferro alloys industry in India has never been globally competitive, despite its rich ore deposits and low-cost manpower, essentially due to

a) Insufficient availability and high cost of electric power
b) Increasing ores and reductants cost
c) Non-availability of low ash, low phos. coking coal in the country for the production of desired coke with low ash, and low phos. contents, making import of such coke at a high cost imperative
d) High-cost and insufficient infrastructural facilities (both road and rail) for rapid transportation of ore from mines to plants
e) Stiff competition from producers and exporters of Ferro alloys in other countries like South Africa, Kazakhstan, China, Russia, Australia etc. due to global trade agreement which has made drastic reduction in customs duty on imports necessary.
f) Wide fluctuations in the International price of Ferro alloys depending on demand versus supply.

To over come these challenges plus adhering to stringent pollution control norms innovations are inevitable in the process technology, and plant equipment design, along with frequent changes in product mix, to be more cost-effective. An attempt is made in this paper to address the innovations that took place in the past and those that further need to be made, considering the future of this industry.

1. HISTORICAL PERSPECTIVE

Ferro alloys production in India through submerged arc furnace (SAF) route made a beginning in late 1950s. After the invention by Soderberg of self- baking type electrodes, during 1920s, this became the most preferred way for making bulk ferro alloys of Silicon, Manganese & Chromium.

1.1 First Phase of the Industry

The initial/first phase of the industry is marked by the installation of small capacity furnaces mostly for the production of Mn-alloys. The status of the Indian ferro alloy industry by mid-sixties is given in table-1. With the starting up of the first furnace at VISL, Bhadravathi, a total of 18 furnaces were commissioned by the mid-sixties.

Table 1: Status of Ferro Alloy industry by the mid sixties

Sl. No.	*Name of the Plant*	*Furnace No.*	*Capacity In MVA*	*Year of Start-up*
1	Visveswaraya Iron & steel Co, Ltd (VISL)	1	1.5	1950
		2	1.5	1950
		3	9.0	1950
		4	12.0	1962
		5	12.0	1962
2	Dandeli Ferro Alloys Ltd	1	4.6	1956
3	Ferro Alloys Corporation Ltd(FACOR)	1	7.5	1957
		2	7.5	1958
		3	7.5	1962
4	Tata Iron & steel Co, Ltd (TISCO)	1	9.0	1958
		2	9.0	1958
5	Jeypur Sugar Co. Ltd (JEYSUCO)	1	3.6	1958
		2	7.5	1959
6	Universal Ferro Alloys Ltd(UFA)	1	9.0	1959
		2	9.0	1963
7	Khandelwal Ferro Alloys Co. Ltd.	1	9.0	1961
		2	9.0	1962
	TOTAL	18	129.4	

1.2 Second Phase Expansion

With the advent of production of stainless steel and alloy steels in India, of which Cr is the most important ingredient, the chromium alloys production with totally indigenous raw materials, in view of restrictions on imports then, was innovated through research and developmental studies during sixties. Ferro Alloys Corporation Ltd., after successfully proving its production with Indian chrome ores, Giridhi low phos coke and non-coking coal in the 600 KVA pilot SAF at National Metallurgical Laboratory, Jamshedpur, started industrial scale production of chrome alloys in 1967.[1]&[4].

First, they commissioned their 12 MVA, SAF for production of High carbon ferro chrome and Silico Chrome, then after installation of rotary kilns for pre-heating of ore fines and for calcination of lime-stone, to be fed to an 8 MVA tilting type open arc furnace, the production of Low carbon ferro chrome was started.

Thus the second phase of expansion of the industry took place between late sixties and late seventies, when thirteen more moderately sized furnaces were added to undertake production of Si and Cr alloys. The brief details of capacity additions are given in table-2.

Table 2: Capacity additions in late sixties and seventies

Sl. No.	*Name of the Plant*	*Furnace No.*	*Capacity In MVA*	*Year of Start-up*
1	Indian Metals and Ferro Alloys Ltd.(IMFA)	1	10.0	1967
		2	24.0	1974
2	Ferro Alloys Corporation Ltd. (FACOR)	4	12.0	1968
		5	8.0	1968

Table 2: Capacity additions in late sixties and seventies (Continued)

Sl. No.	*Name of the Plant*	*Furnace No.*	*Capacity In MVA*	*Year of Start-up*
3	Sandur Manganese & Iron Ore Ltd,(SMIORE)	1 2	15.0 20.0	1968 1977
4	Ind. Development Corp.of Orissa Ltd.(IDCOL)	1 2	9.0 6.5	1969 1979
5	Dandeli Ferro Alloys Ltd	2 3	1.2 2.5	1969 1969
6	Maharashtra Electro Smelters Ltd.(MEL)	1 1	33.0 16.5	1977 1975
7	Nav Bharat Ferro Aloys Ltd. (NAVFAL)	2	16.5	1979
	Total	13	174.2	

1.3 Third Phase of Expansion

The third phase of expansion in the country was prompted by product diversification, availability of advanced technology and encouragement from Government by way of incentives for setting up 100% export oriented plants, to earn valuable foreign exchange.

FACOR again for the first time in the country have pursued a strategy to utilize the disseminated ores, run of mine ore rejects and waste dumps containing on an average about 20% Cr_20_3 in their Boula Mining lease. They sponsored beneficiation studies on these in Regional Research Laboratory, Bhubaneswar, and with the process flow-sheet developed on these studies, they set up a pilot plant for chrome ore beneficiation at their plant in A.P. and achieved excellent results by up-gradation of such ore rejects and fines to concentrates containing more than 40% Cr_20_3 with Cr/Fe ratio 1.7 and SiO_2 4 - 6%. The development work was also carried out to mix these concentrates along with naturally occurring ore fines to form into briquettes which have the required crushing strength for being fed to the smelting furnaces.[2][4]. The feasibility for production of charge chrome (Cr 58-60%) using low grade lumpy chrome ores along with these briquettes was established in April 1979, in one of their sub-merged arc furnaces at Shreeramnagar. About 500 tonnes of charge chrome was produced and exported to consumers abroad. Their acceptance of this charge chrome as per international standard, enabled FACOR to obtain the industrial licence to set up with their own technology, the first "100% Export Oriented Unit" for production of 50,000TPA of charge chrome in India.[3]. Thus, the era of charge chrome production began in 1983. Subsequently, two more export oriented units for ferro chrome with similar capacity were installed but with foreign technical collaboration, One with Outokumpo and other with Elkem A/s, during 1980s, 13 more furnaces were started with the already developed technology of briquetting to adopt to the prevailing raw material conditions. The details of capacity additions during eighties are given in table-3

1.4 Fourth Phase of Expansion

M/s. Electrokemish A/S of Norway who supplied most of the SAFs to India, on the basis of their pilot scale studies in a 2000 KVA furnace had expressed that there will be 10-20% reduction in specific power while smelting in large size furnaces compared to small size furnaces. But it is surprisingly not found to be correct in India! Smelting power and other usage norms reported by producers in small furnaces are found to be al-

Table 3: Capacity additions during eighties

Sl. No.	*Name of the Plant*	*Furnace No.*	*Capacity In MVA*	Year of *Start-up*
1	Sandur Manganese & Iron Ore Ltd.(SMIORE)	3	20.0	1980
2	Maharastra Electro Smelters Ltd.(MEL)	2	33.0	1981
3	Ferro Alloys Corporation Ltd.(FACOR)Garividi	6	16.0	1981
4	Indian Metal & Ferro Alloys Ltd.(IMFA)	3	48.0	1983
5	Navbharat Ferro Alloys Ltd.(NABFAL)	3	16.5	1983
6	VBC Ferro Alloys Ltd	1	16.5	1984
7	Ferro Alloys Corporation Ltd. (CCP) (FACOR)	1	45.0	1984
8	OMC Alloys Ltd. (OMCAL)	1	30.0	1986
9	Ispat Alloys Ltd.(IAL)	1	10.5	1986
10	Indian Charge Chrome Ltd	1	48.0	1989
11	Universal Ferro Allied Chemicals Ltd.	3	4.0	1987
	(UNIFERRO)(LC FeMn)	4	16.5	1989
		5	16.5	1989
	Total	**13**	**320.5**	

most equal to those obtained in large furnaces! More over the smaller furnaces of 1.5 to 6 MW have been found to have better flexibility in change over from one ferro alloy to another and they can utilize ore fines without any eruptions!. Use of pin vibrators, avoid bridging of charge! This gave the scope for establishing many small furnaces at comparatively low initial capital cost with the announcement by Govt. of liberalized de-licencing and broad banding policy in addition to incentives like concessions in power tariff and excise tax exemptions to small scale industries in selected industrially backward areas in some states for promoting industrialization. This resulted in mush-room growth of small scale producers of ferro alloys during the fourth phase of expansion in India.[4]. About 45 plants with low furnace capacities ranging from 1 MVA to 7.5 MVA were established. List of such small scale ferro alloy units is given table-4.

Table- 4: Small Scale Ferro Alloy Units

Sl.No	*Particulars*	*Location*	*MV Rating*
1	Aloke Ferro Alloys	Raipur, M.P.	2 x 4 .5
2	Andhra Ferro Alloys	Kothavalasa, A.P.	1 x 3.6
3	Bansal Ferro Alloys	Bhalgaru, Haryana	1 x 3.5
4	Deepak Ferro Alloys	Raipur, M.P	1 x 4
5	Haryana Ferro Alloys	Haryana	1 x 2.5
6	Hindustan Ferro Alloys	Hamirpur, U.P.	1 x 3.6
7	Mandsour Ferro Alloys	Mandasour, M.P.	2 x 4
8	Monnet Ferro Alloys	Raipur, M.P.	1 x 7.5
9	Monnet Ferro Alloys	Durgapur, W.B.	1 x 7.5
10	Pooja Ferro Alloys	Goa	1 x 4.5
11	Srinivasa Ferro Alloys	Raipur, M.P.	2 x 5
12	Syam Sundar Ferro Alloys	Malanpur, M.P.	2 x 3.5
13	V.K. Ferro Alloys	Vizag, A.P.	1 x 1.25
14	Amit Ferro Alloys	Raipur, M.P.	1 x 3.6
15	Anjaney Ferro Alloys	Mihijam,Bihar.	1 x 3.6

Table- 4: Small Scale Ferro Alloy Units (Continued)

Sl.No	*Particulars*	*Location*	*MV Rating*
16	Balaji Electric Chemicals(P) Ltd.	Yeotmal,	1 x 3.6
17	Bhaskar Ferro Alloys	Durgapur, W.B	1 x 6
18	Bhubaneswar Ferro Alloys	Pondichery	1 x 1.8, 1 x 0.5
19	Cochin Ferro Alloys	Cochin	1 x 2
20	Cresent Alloys (P) Ltd	Seoni, M.P.	1 x 2.5
21	Gemeni Electro Chemicals (P) Ltd.	U.P.	1 x 3
22	Golden Ferro Alloys	Karaikal, T.N.	1 x 2
23	Goutam Ferro Alloys	Ranchi, Bihar.	1 x 5
24	Grima Alloys Pvt. Ltd.	Uroi, U.P.	1 x2.5
25	Hindusthan Ferro Alloys	Hamirpur, U.P.	1 x 3
26	Hindustan Melleables	Dhanbad, Bihar.	1 x 2.5
27	Hira Ferro Alloys	Raipur, M.P.	1 x 7, 2 x 2.5, 1 x 5
28	Hitech Electro Thermics Ltd.	Palakad	1 x 1, 1 x 2.5, 2 x 7.5
29	Jain Carbide & Chemicals	Raipur, M.P.	2 x 2.5, 1 x 3.5
30	K.R. Alloys (P) Ltd.	Palakad	1 x 0.5, 1 x 1.5
31	Karthik Alloys	Goa	1 x 5
32	Karthi Ferro Alloys	Durgapur, W.B.	1 x 5, 1 x 3.6
33	Maithan Ferro Alloys	Asansol, W.B	2 x 5
34	Muscan Ferro Alloys	Pitampur, M.P.	1 x 5
35	Navchrome (Navbharat)	Raipur	1 x 3.6, 1 x 6.5
36	Sai Chemicals	Raipur, M.P.	1 x 3.6
37	Shri Ganesh Ferro Alloys	Raipur, M.P.	1 x 7.5
38	Shyam Ferro Alloys	Burdwan, W.B.	1 x 7.5
39	Silcal Electro Met. Ltd.	Avanash, T.N.	1 x 2.5
40	SNAM Ferro Alloys	Pondichery	2 x 3.5
41	Srinivas Ferro Alloys	Durgapur, W.B.	1 x 6.5, 2 x 7.5
42	Standard Ferro Alloys	Raipur, M.P.	1 x 7.5
43	Standard Ispat Ltd.	Raipur, M.P.	1 x 3.5, 1 x 3.0
44	SUN metals & Alloys (P) Ltd.	Palakad	2 x 1.5
45	Thesiblal Met. Ltd.	Pondichery	1 x 4.5
	Total		68 furnaces

Then the down turn in ferro alloys demand started in 1990s and further accelerated in 1997-98 due to over all recession in steel industry. This caused a crash in price of ferro alloys. In addition to this because of increased demand for ores from China, there was sudden rise in price of ores. Also there was increase in power cost due to withdrawal of some of the earlier concessional tariffs given in some areas. This resulted in closure of many ferro alloys plants in the country. Only those who had captive mining leases and/or captive thermal power generation plants or were located in such backward areas where concessional power tariff was extended, survived.

Again in 2002, with the increase in demand of steel, the ferro alloys market started improving and some more plants were added for the production of manganese and chrome alloys.

2. CURRENT STATUS OF THE INDUSTRY

The current production capacity of bulk ferro alloys in India is about 3.36 million tonnes per annum, contributed by 118 plants operating total 229 furnaces. 63 plants with 144 furnaces have capacity for 1.98 million tonnes of HC FeMn & SiMn, 29 plants with 38 furnaces have capacity for 0.212 million tonnes of FeSi and 26 plants with 47 furnaces have capacity for 1.164 million tonnes of HC FeCr. The details of the plants are given in tables-5, 6 & 7. (source : IFAPA)

Table 5: Ferro-Manganese & Silicon-Manganese Producing Plants

Sr.	*Name*	*Plant Location*		*Capacity*	
No.		*Site*	*State*	*No.of*	*Install.*
				Furnaces	*MVA*
1	Adhunik Meghalaya Steels P.Ltd	Byrnihat	Meghalaya	2	15.00
2	Alok Ferro Alloys Ltd	Raipur	Chhattisgarh	2	6.10
3	Amit Ferro Alloys Ltd.	Raipur	Chhattisgarh	2	7.20
4	Anjaneya Ferro Alloys Ltd.	Mihijam	Jharkhand	3	13.25
5	Balaji Electrosmelters Ltd.	Yavatmal	Maharashtra	1	3.60
6	Balmukund Sponge & Iron Ltd.	Giridih	Jharkhand	1	9.00
7	Bhaskar Shrachi Alloys Ltd.	Durgapur	West Bengal	2	13.50
8	Castron Technologies Ltd.	Bokaro	Jharkhand	1	5.00
9	Chhattisgarh Electricity Co.Ltd	Raipur	Chhattisgarh	5	45.00
10	Corporate Ispat Alloys Ltd	Durgapur	West Bengal	1	7.50
11	Cosmic Ferro Alloys Pvt.Ltd.	Bankura	West Bengal	2	18.00
12	Crescent Alloys Pvt.Ltd.	Seoni	Madhya Pradesh	1	2.50
13	Dandeli Ferro Pvt. Ltd	Dandeli	Karnataka	3	7.80
14	Dayal Ferro Alloys Ltd	Ramgarh	West Bengal	2	13.50
15	Deccan Ferro Alloys Ltd.	Kotthavalasa	Andra Pradesh	1	6.00
16	Deepak Ferro Alloys Ltd.	Raipur	Chhattisgarh	2	7.50
17	Gautam Ferro Alloys Ltd	Ramgarh	Jharkhand	2	10.00
18	Haldia Steels Ltd.	Burdwan	West Bengal	3	15.50
19	Hira Ferro Alloys Ltd.	Raipur	Chhattisgarh	3	9.70
20	Hi-Tech Electrothermics Ltd.	Palakkad	Kerala	1	2.50
21	Impex Ferro Tech Ltd.	Burdwan	West Bengal	4	25.00
22	Indsil Electrosmelts Ltd	Palakkad	Kerala	2	10.80
23	Indsil Energy & Electro Chemicals Ltd	Raipur	Chhattisgarh	3	15.50
24	Ispat Godavari	Raigarh	Chhattisgarh	2	10.00
25	Jain Carbide & Chemicals Ltd.	Raipur	Chhattisgarh	3	8.00
26	Jalan Ispat Castings Ltd	Meghnagar	M.P.	1	7.50
27	Kartik Alloys Ltd	Goa	Goa	2	7.20
28	Kartik Alloys Ltd	Durgapur	West Bengal	2	7.20
29	M.B.Smelters Ltd.	Hindpur	Andhra	2	1.50
30	M.S.P. Power	Raigarh	Chhattisgarh	2	10.00
31	Maharashtra Elektrosmelt Ltd	Chandrapur	Maharashtra	2	66.00
32	Maithan Alloys Ltd	Burdwan	West Bengal	4	25.00
33	Maithan Smelters Ltd	Byrnihat	Meghalaya	1	7.50
34	Manganese Ore India Ltd	Balaghat	Madhya Pradesh	1	5.00
35	Meghalaya Sova Ispat Ltd		Meghalaya	2	16.00
36	Modern India Con-cast Ltd.	Bishnupur	West Bengal	3	15.00

Table 5: Ferro-Manganese & Silicon-Manganese Producing Plants (Continued)

Sr.	*Name*	*Plant Location*		*Capacity*	
No.		*Site*	*State*	*No.of*	*Install.*
				Furnaces	*MVA*
37	Monnet Ispat Ltd	Raipur	Chhattisgarh	4	24.50
38	Nagpur Power & Ind.Ltd (earlier KFA Ltd)	Kanhan	Maharashtra	4	20.80
39	Natural Sugar & Allied Industries Ltd.	Osmanabad	Maharashtra	2	12.00
40	Nava Bharat Ferro Alloys Ltd	Paloncha	Andhra	4	77.10
41	Orion Ferro	Raigarh	Chhattisgarh	2	10.00
42	Prakash Industries	Raigarh	Chhattisgarh	3	22.50
43	Puja Ferro Alloys Ltd, Cuncolim	Salcette	Goa	1	5.00
44	Raghubir Ferro Alloys Ltd.	Raipur	Chhattisgarh	2	9.00
45	Sai Chemicals Pvt Ltd	Raipur	Chhattisgarh	1	5.50
46	SAL Steels Ltd.	Gandhidham	Kutch,Gujarat	1	24.00
47	Sandur manganese & Iron Ores Ltd.	Sandur	Karnataka	3	55.00
48	Saturn Ferro Alloys	Raipur	Chhattisgarh	2	9.00
49	Sharp Ferro Alloys Ltd.	Durgapur	West Bengal	2	15.00
50	Shivam Iron & Steel Co.Pvt.Ltd.	Giridih	Jharkhand	2	12.00
51	Shri Gayatri Minerals Ltd.	Bishnupur	West Bengal	2	19.00
52	Shri Girija Smelters Ltd.	Raipur	Chhattisgarh	2	8.60
53	Shyam Century Ltd		Meghalaya	2	16.00
54	Shyam Ferro Alloys Ltd	DSP/Burd-wan	West Bengal	8	70.50
55	Sova Ispat Alloys Ltd	Durgapur	West Bengal	3	24.00
56	Sri Ganesh Ferro Alloy P Ltd	Raigarh	M.P.	1	3.00
57	Srinivasa Ferro Alloys Ltd	Durgapur	West Bengal	3	18.50
58	Srinivasa Ferro Alloys Ltd	Raipur	Chhattisgarh	2	8.60
59	Tata Iron & Steel Co.Ltd.	Joda	Orissa	2	24.00
60	Tirumala Balaji Alloys Pvt.Ltd	Raigarh	Chhattisgarh	2	18.00
61	Universal Ferro Alloy & Allied -	Tumsar	Maharashtra	5	53.50
62	Vandana Global Ltd	Raipur	Chhattisgarh	2	18.00
63	VBC Ferro Alloys Ltd (earlier Jeypore Sugars)	Rayagada	Orissa	1	5.00
	Total			144	1043.50

Table 6: Ferro-Silicon Producing Plants

Sr.	*Name*	*Plant Location*		*No. of Furnaces*	*Capacity*
No.		*Site*	*State*		*MVA*
1	Akshay Ispat & Ferro Alloys P.Ltd.	Namchi	S.Sikkim	1	7.50
2	Bharat Alloys & Energy Ltd.	Kurnool	Andhra	1	16.50
3	Bimala Ispat Alloy		Meghalaya	1	3.60
4	Byrnihat Ferro		Guwahati	1	7.50

Table 6: Ferro-Silicon Producing Plants (Continued)

Sr.	*Name*	*Plant Location*		*No. of Furnaces*	*Capacity*
No.		*Site*	*State*		*MVA*
5	Gita Ferro		Meghalaya	1	3.60
6	Hindustan Malleable & Forging	Dhanbad	Bihar	1	3.00
7	Hi-Tech Electrothermics	Alwaye	Kerala	1	1.00
8	Indian Metal & Ferro Alloys Ltd.	Therubali	Orissa	2	58.00
9	J.K.Alloys		Jammu	1	3.60
10	Jayantia Alloys		Meghalaya	2	11.10
11	Lakshmi Industries	Nellore	Andhra	1	1.50
12	Maithan Smelters		Meghalaya	1	7.50
13	Meghalaya Steel		Meghalaya	1	5.00
14	Nala Hari Ferro		Meghalaya	1	9.00
15	Pioneer Carbide		M.P.	1	5.00
16	Quality Castings		Gujarat	1	5.00
17	RNB Carbide		Meghalaya	1	5.00
18	Sai Megha Ferro		Meghalaya	1	3.60
19	Satya Megha Ispat P.Ltd.	Byrnihat	Meghalaya	1	5.00
20	Shree Sai Smelters (I) P.Ltd.	Byrnihat	Meghalaya	2	5.00
21	Shri Guru Kripa		Jammu	1	2.50
22	Silical Metallurgic P.Ltd	Palakkad	Kerala	1	12.00
23	SMS Smelters Ltd	Lekhi	Arunachal	2	15.00
24	Snam Alloys	Nettapakkam	Pondicherry	2	5.00
25	Sri Lakshmi Electrosmelters	Aluva	Tamilnadu	1	2.50
26	Sri Sitaram Industries		Jammu	1	2.00
27	Tecil Power Ltd	Chingavanam	Kerala	1	7.50
28	VBC Ferro Alloys	Medak	Andhra	1	16.50
29	Visvesaraya Iron & Steel Ltd	Bhadravati	Karnataka	5	36.00
				38	266.00

Table 7: Ferro-Chrome Producin g Plants

Sr.	*Name*	*Plant Location*		*No.*	*Capacity*
No.		*Site*	*State*	*of*	*MVA*
				Furnaces	
1	Andhra Ferro Alloys	Vizianagaram	Andhra	2	6.80
2	Balasore Alloys Ltd	Balasore	Orissa	5	75.00
3	Corporate Ispat Alloys Ltd.	Durgapur	W.B.	1	7.50
4	Ferro Alloys Corporation Ltd	Garividi	Andhra	6	58.50
5	Ferro Alloys Corporation Ltd	Randia	Orissa	1	45.00
6	GMR Technologies & Ind.Ltd.	Srikakulam	Andhra	2	15.00
7	IDCOL Ferro Chrome Plant	Jajpur Rd	Orissa	2	15.00
8	Indian Charge Chrome Ltd	Choudwar	Orissa	1	48.00

Table 7: Ferro-Chrome Producin g Plants (Continued)

Sr. No.	*Name*	*Plant Location*		*No. of Furnaces*	*Capacity MVA*
		Site	*State*		
9	Indian Metal & Ferro Alloys Ltd.	Theruballi	Orissa	1	24.00
10	Jindal Stainless Ltd.	Duburi	Orissa	2	120.00
11	Jindal Stainless Ltd	Kothavalasa	Andhra	2	23.50
12	Jindal Steel & Power Ltd	Raigarh	Chhattisgarh	1	24.00
13	KC Minerals		Jammu	1	3.00
14	Mandsaur Ferro Alloys Ltd	Mandsaur	M.P.	2	7.90
15	Nava Bharat Ferro Alloys Ltd	Denkenal	Orissa	2	45.00
16	Pee Ell Alloys	BariBrahmana	Jammu	1	3.125
17	Prakash Industries	Raipur	Chhattisgarh	1	7.50
18	Rawmet Ferro Alloys	Cuttack	Orissa	2	36.00
19	Rohit Ferro Tech P.Ltd.	Bihnupur	W.B.	2	15.00
20	S.A.L. Steel	Kutch-Bhuj	Gujarat	1	24.00
21	Sri Vasavi Industries Ltd	Bishnupur	W.B.	2	28.00
22	Standard Chrome Ltd.	Raigarh	Chhattisgarh	2	10.00
23	Tata Iron & Steel Co.Ltd.	Bamnipal	Orissa	1	30.00
24	Tawi Chemicals Industries		Jammu	2	1.45
25	Tawi Industrial Enterprises	BariBrahmana	Jammu	1	4.50
26	Utkal Manufacturing Services Ltd.	Choudwar	Orissa	1	27.00
				47	704.775

2.1 Raw Materials

The country has adequate reserves of ores to meet the needs of the bulk ferro alloys industry if the policy of control on export of ores and conservation of minerals by using beneficiated low grade ores is followed. Table-8 gives the data on recoverable reserves of ores and fluxes.

Table 8: As per IBM (As on 01/04/2000)

Sl.No.	*Minerals*	*Total Recoverable Reserves (in Million tones)*
1	Chromite	97.000
2	Manganese ore	191.457
3	Quartzite	864.710
4	Bauxite	2527.167
5	Magnesite	287.535

2.2 Reductants

The high ash and volatile matter contents of the reductants have marked adverse affect on the furnace operation. The resistivity and reactivity of the reductants also has very significant effect on productivity of the furnaces. The high sulphur and phosphorous contents of the reductants adversely affect the quality of ferro alloys produced.

- Charcoal is considered as an ideal reductant in the manufacture of silicon alloys.
- Metallurgical coke from steel plants and other coke making plants along with non-coking coal are used for the production of manganese alloys.
- Imported low ash & low phos. coke along with non-coking low phos. coals and Anthracite coal are used in the production of chrome alloys.

In India coal reserves are about 202 billion tonnes but only about 15% of this is coking coal.[5]. Most of the coals are very high in ash and not amenable to known methods of washing because the shell rock is finely distributed in coal. In the absence of low ash & low phos. coking coal/coke in the country, production of chrome alloys has to depend on imported coke. The Indian ferro alloy producers have substituted 50 to 70 percent of the requirement with low phos. non-coking coal though high in ash and imported low ash anthracite coal from Vietnam. Typical analysis of reductants used in ferro alloy industry are given in table-9.

Table 9: Typical Analysis of Reductants used in ferro alloy industry

Ash Analysis

S.No	*Materials*	*Ash %*	*VM %*	*FC %*	*P %*	*S %*	*SiO2 %*	*FeO %*	*Al203 %*	*CaO %*	*MgO %*
1	Steam Coal	38.20	30.10	31.70	0.058	0.340	62.80	4.96	19.80	1.82	5.54
2	CIL Coke	33.54	4.46	62.00	0.013	0.540	66.24	4.79	22.95	0.84	1.01
3	Low Ash Met. Coke	12.90	4.80	82.30	0.020	0.560	56.92	6.68	22.30	1.82	6.65
4	Anthracite Coal	7.20	5.70	87.10	0.009	0.700	45.20	10.35	29.20	2.52	5.34
5	Met. Coke	32.00	1.90	66.10	0.079	0.980	31.20	9.23	22.82	2.66	8.87
6	Durgapur Pearl Coke	22.65	2.30	75.05	0.040	0.850	54.40	8.55	23.71	1.96	4.43
7	Charcoal	8.57	21.12	70.31	0.061	0.370	43.60	3.99	10.33	32.0	5.00

Performance of the Indian ferro alloy industry in the year 2005-06 is highly significant as it has registered the highest ever production of 1.64 million tones as compared to 1.48 million tones in the year 2004-05, due to increased domestic consumption and exports. Table-10 gives the figures of production and exports during the last two years.

3. REVIEW OF TECHNOLOGY ADOPTED

Some of the recent plants have incorporated latest technologies to use both lumps as well as fines after necessary beneficiation and agglomeration. Also they have installed effective pollution control measures in the form of bag filters for gas cleaning after waste heat recovery.

Although the basic technique of ferro alloy production in submerged arc electric furnace has not undergone any major change, the design, the size, automation and control features of ferro alloy furnaces have undergone substantial changes in the recent past in order to meet the changing raw materials conditions and to achieve higher productivity, and better economy of operation and conservation of energy.

Table 10: Production & Exports during 2004-05 & 2005-06 (source: IFAPA)

Particulars	2005-06 (Million tones)	2004-05 (Million tones)	Increase (in %)
PRODUCTION			
- Ferro Alloys	1.65	1.48	11.48
- HC FeMn & SiMn	0.89	0.77	15.58
- HC FeCr	0.66	0.59	11.86
- FeSi	0.09	0.099	-9.00
Export of Ferro Alloys	0.45	0.39	15.38

There are some well known processes which have been developed and adopted on large scale elsewhere in the world. For instance

- SRC process (Showa Denko, Japan)[6][7].

In this process pellets made from chrome ore fines are pre-reduced in solid state and are fed to submerged arc furnaces in hot condition. Depending on the extent of pre-reduction of the chromium oxide in pellets obtained in the rotary kiln which utilizes the heat of the furnace exhaust gases, the specific power consumption can be reduced to 50% of the normal.

- Outo Kumpu Process from Finland [6][7]

In this process pellets are made from chrome ore fines/concentrates and are preheated and fed to the furnace in hot condition along with other charge materials. In this process the power consumption for smelting is brought down by about 25%.

This process has been adopted by Tisco at their Bhominipal plant in India. Because of several problems in filtration after wet grinding and in the pellet sintering shaft furnaces, the plant could not be operated with full capacity. Now they are using pellets along with briquettes after installing a briquetting plant to achieve full production capacity. However, several plants in South Africa have successfully adopted Outokumpu process.

FACOR, at its Shreeramnagar plant carried out R&D work on pelletisation of high grade chrome ore fines. About 1500 tonnes of sintered pellets of chrome ore fines were produced and fed to furnace using 80% of the ore requirement in the form of these pellets.[7]. The results are encouraging. Very stable and smooth furnace operation was achieved with very good flame distribution over the whole surface area of the charge in furnace. The height of the flames was found to be very small, say few inches compared to few feet otherwise, particularly in the center of the furnace. It was further observed that fumes had extremely low content of flue dust. The specific power for smelting was lower by about 12% and the fixed carbon requirement was also lower by about 10%. Further studies are being made in this regard to use sintered pellets on regular basis.

Chrome ores are mostly friable in nature and necessitate some form of agglomeration before being charged into the furnace along with other raw materials. Most of the chrome alloy producers in India have adopted the briquetting process towards agglomeration of fines.

- There has been developed the D.C arc furnace process [8][9] where fines are charged through a pre-baked carbon hollow electrode but problems have been found with furnace cover parts and other equipments due to very high heat radiation. Recently some improvements have been reported by better cooling of parts by copper panels etc. But the energy consumption is still higher than conventional process. So unless sensible heat and latent heat in the exhaust gases is fully recovered by generating power, the process may not be economically attractive.
- FACOR has planned R&D work on solid state reduction of chrome ore fines in a fluidized bed reactor using natural gas and hope to get positive results.

Regarding Mn ore fines, they are being directly used along with lumps in small furnaces without affecting the specific power required for smelting. However, Research and Development work were carried out on the sintering of Mn ore fines by Paramount Sinters Limited for Maharastra Electrosmelt and by Regional Research Laboratory, Bhubaneswar for FACOR.

FACOR had set up a 15000 tonnes per year capacity Manganese ore sinter plant at their Shreeramnagar works with the collaboration of Regional Research Laboratory, Bhubaneswar in 1985. The sinters produced were used at the rate of about 15% of the ore charge for production of ferro manganese. All minus 6 mm fines in ores were utilized. MEL are also sintering and using all the minus 6mm fines in a pressurized pan sintering plant where apart from suction below, pressure is applied by use of compressed air over the top of the sinter pan, thereby increasing the production of sinter.

4. FUTURE OUT LOOK

The Indian Chrome & Manganese Alloys Industry has a lot of potential to meet the domestic and export demand, but has been all along facing abnormal fluctuations in their price. India has rich mineral resources as it stands 2nd to South Africa in chrome ores and 7th in the world in Manganese ore production. It has the third largest pool of technical manpower and has low cost labour to face competition. Although the performance and operating norms in some of the Indian plants are comparable to those in foreign plants, because of higher power cost, higher raw materials cost etc., much higher efficiencies in operations of Indian plants are required to face the future competition for which the following innovations need to be applied to expansion of existing plants or for new ones.

1. Increase Productivity by having large size Furnaces with higher Transformer Capacity

Small furnaces have very low out put per man. The wages which are comparatively low now would soon shoot up with inflation and improved standards of living. Thus it is very essential to increase labour productivity. It is desirable to employ single furnace having high transformer capacity instead of operating several small furnaces. Together with employing large size furnaces, the raw materials preparation and handling systems must be modernized with adequate control systems.

2. Employment of auto furnace control with auto on-load tap changers and HT capacitor banks to obtain effective power utilization

Employment of auto furnace control equipment coupled with auto on load tap changers and H.T Capacitor banks are today's common feature of modern furnaces which contribute towards increased productivity through higher "effective power" utilization.

3. Reducing heat losses from furnace

Several open furnaces are in operation in the country today. Closed furnaces should be envisaged during modernization/expansion or new projects for manufacture of Mn and Cr alloys. This will reduce the heat losses from the furnace and enable recovery of sensible and latent heat in exhaust gases, as well as bring down the size of gas cleaning units since it will require handling of smaller volumes of gas. In addition to energy recovery from waste gas, it ensures cleaner environment.

4. Control of Moisture in Raw materials

In our country due to long rainy season and lack of sufficient sheds, the moisture content of various raw materials including reductants goes beyond acceptable limits and increases specific power and reducer requirement. For low moisture level in raw materials, drying operation is imperative since it will help not only to bring down the specific power consumption but also reduce the specific consumption of reductants, besides giving steady slag and metal composition.

5. *Use of agglomerated feed*

Agglomerates, being consistent in size and uniform in chemical composition, are better than natural lumps in their reducibility and therefore use of agglomerates lowers the specific power consumption, as well as helps to attain smooth furnace operation.

In India ore sinters are used in the production of Mn alloys in a couple of plants, while briquettes are used in the production of chromium alloys in most of the plants.

There is scope to implement the scheme of utilizing more and more agglomerated feed in the manufacture of Cr and Mn ferro alloys. Since pellets have an advantage over briquettes, pelletization process has to be eventually followed by the Indian plants to reduce their costs by bringing down the specific power consumption. There is need for suppliers to offer lower cost smaller capacity pelletisation plants, considering the existing small and medium size furnaces in use.

REFERENCES

[1] ."Status of Ferro alloy Industry in the Liberalised Economy" by C.N.Harman at National Workshop, Jamshedpur – 2 - 21st August 1996.

[2] ."Agglomeration of Chrome ore fines by Briquetting and the performance of Briquettes in the smelting of High Carbon FerroChrome& Charge Chrome at FACOR" by C.N..Harman, M.Subramanian, and O.Seetharamayya.

[3] "Production of Charge Chrome in 45 MVA Submerged arc electric furnace at FACOR, Randia using a mix of Briquettes and lumpy Chrome ore" by C.N.Harma, M.Subramanian, and Manoj Saraf.

[4] . "Ferro Chrome Industry in India" by C.N..Harman at International Chromium Development Association, meeting at Jaipur in 1998.

[5] ."Stamp Charged Coke Making Technology". P.K.Banerjee., S.H.Krishnan and A.D.Baijal, Trans, Indian Inst. Met., - Vol.59, No.5

[6] "Some Technical Issues in Ferro Chrome Smelting of Interest to Tata Steel'' by Amit Chatterjee, Tata Steel, Jamshedpur in National Seminor on Ferro Alloys in 2003 at Kolkata.

[7] ."Innovations in Ferro Alloys Technology" by C.N.Harman, FACOR, in 2nd Ferro Alloys India in 2005 at New Delhi.

[8] ."D-C Arc Single Electrode Smelting Furnace" by B.Kjellberg and B.Orrling (Asea Metallurgy, Sweden) in INFACON 86.

[9] "The Control and Operation of a Pilot plant D.C. Plasma Furnace" by K.C. Nicol, M.S. Rennie and A.B. Stevart (Council for Mineral Technology, South Africa) in INFACON 86.