An Overview Of The Ferro Alloys Industry In India

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1.0 Introduction

Ferro alloys are essential inputs in quality steelmaking and are used as deoxidizers and, more importantly, as alloying additions to impart desired properties. The growth of the ferro alloy industry as such is closely linked with the development of the steel industry.

Ferro alloys are classified broadly into two broad categories, the bulk and the noble (or special) ferro alloys. The bulk alloys are ferro manganese (Fe-Mn) silico manganese (Si-Mn), ferro chrome (Fe-Cr), charge chrome (Ch-Cr) and ferro silicon (Fe-Si). The noble ferro alloys include ferro vanadiun (Fe-V), ferro titanium (Fe-Ti), ferro molybdenum (Fe-Mo), ferro tungsten (F-W) and ferro niobium or columbium (Fe-Nb) . Ferro alloys are further sub-divided into grades with respect to their carbon (and sometimes silicon) contents.

This paper provides an overview of the ferroalloys industry in India, and attempts to identify the factors responsible for unutilized capacity and understand (a) why some ferro alloys, such as charge chrome are poised to overtake others, (b) the complexities of producing ferro nickel from indigenous minerals , (c) the prospects for better exports as well as the constraints due to high cost and inadequate supply of power. Later in the paper, the authors look at the technology base of the ferro alloys industry in India and point out the existing gaps in the technology used viz-a-viz that in more advanced countries, and make suggestions for bridging the gap through technology acquisition and/or development of appropriate R & D programmes.

2.0 Installed Capacity

The bulk ferro alloys industry in India presently has a licensed capacity of about 850,000 tonnes/year in the organised sector, shared by about 20 major producers as shown in Table I, [1]. An additional capacity of 100,000 tonnes/year is estimated in the small/unorganised sector. Within the organised sector, more than 93% of the capacity is designed for producing three main bulk alloys namely Fe-Mn/Si-Mn, Fe-Cr/Cr and Fe-Si, as shown in Figure 1, [2]. The Indian industry has not made a beginning yet in the commercial production of ferro-nickel.

The industry is capable of producing, and does produce in smaller quantities, noble ferro-alloys such as Fe-Ti, Fe-V, Fe-Mo, Fe-W as well as the calcium-silicon.

3.0 Production and Demand of Bulk Ferro Alloys

Production data on bulk ferro alloys for the past three years are given in Table II [3, 4] and shown in Figure 2. In comparison with a total production of 380,000 t reported for 1988-89 [1], the data in Table II indicate a steady rise in production during the past four years, esspecially in silico manganese, HC ferro chrome and charge chrome.

3.1 Ferro Manganese and Silico Manganese

The total capacity of manganese-based ferro alloys is 420,000 t.

Ferro manganese : In comparison with the production of high cabron Fe-Mn (1,92,000 t), that of medium carbon Fe-Mn is small (5,880 t). Ferro manganese has been the most widely used ferro alloy in steel making and its consumption exceeds that of all other ferro alloys combined. Present consumption of FeMn in India is reported to be 16 kg/tonne of steel produced as compared with 6 kg/tonne in industrially advanced countires [2].

In the integrated steel plants, FeMn has been used predominantly for producing low-Si rimmed steels and the bulk of the silico-manganese used for making Si-killed steels. With the increasing adoption of continuous casting technology, there is a trend in favour of the latter type of steels. As a result, there is a significant change in the structure of manganese consumption too, as illustrated by the following data [5].

	% Consumption for selected years			
Mn Consumed as	78	82	86	90
Si-Mn	23.6	28.6	33.5	32.7
Fe-Mn	76.4	71.4	66.5	67.3

3.2 Ferro Chrome and Charge Chrome

Ferro Chrome : The present capacity of 130,000 tpa is shared by six major ferrochrome plants which treat chromite ore in electic submerged arc furnaces in the presence of carbon or silicon or by the Thermic process. For the high carbon ferro chrome containing 67-75% Cr, used and desired for stainless steelmaking worldwide, the conventional processing requires a lumpy chromite ore with 48% Cr_2O_3 having a minimum Cr/Fe ratio of 3:1, [2]. India's ferro chrome demand is expected to reach 380,000 tonnes by 1995 [6].

Charge Chrome : Charge chrome is a low grade high carbon ferro chrome (50-55% Cr) with higher silicon content and can be produced from a chromite ore containing as low as 42-44% Cr_2O_3 with a Cr/Fe ratio of 1.6:1 in submerged arc electric furnaces by melting chrome ore lumps and briquettes and reducing agents like coke and non-coking coal and fluxes like quartz. The production cost of charge chrome is significantly lower than that of the high carbon ferro chrome.

The large scale adoption of processes such as the Argon Oxygen Decarburisation (AOD) and Vacuum Oxygen Decarburisation (VOD) has made it possible to produce stainless steel using charge chrome (having 50-55% Cr)instead of the high carbon ferro chrome containing 67-75% Cr.

The use of charge chrome is now rapidly gaining ground at the expense of high carbon ferro chrome. As a result, the whole scenario of the industry has changed with the utilization of low grade chromite in the manufacture of charge chrome.

Presently, there are four charge chrome plants, in operation with a total capacity of 208,000 tpa, and are entirely export oriented.

Recent Developments and Future Outlook : Due to a price rise in international markets, the chrome ore has found an export market, but there is no shortage for domestic eonsumption. The current demand for charge chrome and ferro chrome is fully satisfied by the capacities presently existing despite the fact that production is lower than the capacity, mainly due to power cuts and high power costs.

TISCO has reportedly converted one of its ferro manganese furnaces at Joda for the production of ferro chrome with a capacity of 18,000 tpa.

The Indian Metals and Ferro Alloys (IMFA) Group is reported to have put-up a new complex, Indian Charge Chrome Ltd., in Choudwar, Orissa with the installation of a 48 MVA furnace supplied by Elkem a/s Norway. The unit is fully export oriented and has foreign participation.

India's charge chrome demand is forecast to increase rapidly to 546,000 tpa by 1995 [6].

3.3 Ferro Silicon

Used as an excellent deoxidizer, silicon can be added into liquid steel without any problem of carbon pick-up. Presently, there are six large ferro silicon plants in operation in India with a total capacity of 122,000 tpa. Anthor 14 units are in operation in the small sector with an estimated capacity of 35,000 tpa [2].

3.4 Ferro Nickel

Presently, there is no commercial production of ferro nickel in India. The current demand of about 20,000 tpa is met by imports. Much developmental work was done to produce nickel from the lateritic ores of Sukinda in Orissa (which possesses about 95% lateritic reserves in India [1]. IDCOL gave serious thought to producing ferro nickel at its Jajpur Road plant for ferro chromium in from a blend of imported and indigenous (limonitic) ores using a rotary kiln - smelting furnace route.

In 1982, Elkem, Norway conducted a pilot plant test using 40 t ore from Sukinda's Kansa section (1.12% Ni, 51% Fe) and produced a ferro nickel of good grade (17.8% Ni). However, the slag produced was very corrosive (78% FeO, 0.1%

NiO) as a result of the high iron content of the Sukinda ore. In view of above results, IDCOL has put up a proposal to use their 6.5 MVA furnace for producing ferro nickel by treating an ore blend comprised of (a) 15% Sukinda ore and (b) 85% Japanese ore assaying 2.4% Ni, 13.4% Fe. Their projected production capacity is 8000 tpa of crude ferro nickel (20% Ni, 77% Fe, 0.12% C); the slag will assay 0.12% NiO, 19.3% FeO [7].

3.5 Noble Ferro Alloys

There are about ten units, led by the Mishra Dhatu Nigam, engaged in the production of noble ferro alloys, with a reported tonnage of 185, 57, 112 and 66 for FeMo, FeNb, FeTi and FeV, respectively for the year 1989-90 [2].

4.0 Exports

As mentioned earlier, the present installed capacity (totalling about a million tonnes) of bulk ferro alloys is much higher than the domestic demand. During 1992-93, the Indian industry exported more than 1,50,000 thousand tonnes of ferro alloys valued at Rs. 256 crores (representing more than 25% of total production) and registered a significant improvement over its performance during 1990-91 as shown in Table III. The Indian ferro alloys industry has a much higher export potential whose realization, however, depends on the availablity of power at international prices.

The industry faces a significant gap between costs and international prices, especially for more energy intensive ferro alloys, not withstanding the full convertibility of Rupee. The power tariff in India remains many times higher than that in other ferro alloys producing countries, thus pushing its products out of the export competitiveness as shown below [3] :

	Rs./kWh
Canada	0.20
Venezuala	0.20
Norway	0.45
S. Africa	0.60
Brazil	0.75
Bhutan	0.35
India	1.50-2.00

The average price of power supplied by the NTPC comes out to Rs.0.52/kWh; the ferro alloys industry has made a strong plea to the government to supply power at this average rate for the production of ferro alloys meant for exports.

The new policy of delicensing and decontrolling the iron and steel industry and allowing the private sector to set up new projects is viewed as a big confidence booster and should help increase the country's steel production and the ferro alloy demand. Until then, export is the only way to make use of surplus capacity in ferro alloys.

With regard to the export of raw materials, the policy of the government is to promote export of value added products and preserve mineral resources. During 1991-92, the export ceiling for chrome ore was 470,000 tonnes and for manganese ore 400,000 of which 100,000 tonnes was fines.

Due to increase in exports as well as domestic demand of manganese ore, and stagnant production, there has been an acute shortage of required grades of the ore. The manganese ore reserves in India are limited and there is a need for new explorations.

5.0 Status of Ferroalloys Technology in India

Raw Materials Treatment : Most plants in India follow conventional methods of producing ferroalloys using high grade basic ores, reductants and fluxes. In the case of manganese and chromium, the ore grade is assessed in terms of the metal content, the M:Fe ratio (which may be as high as 5:1 for Fe-Mn and as low as 1.6 : 1.0 for charge chrome), the phosphorus level and the slag forming constituents. For making ferro silicon, on the other hand, the ore (quartzite) is assessed in terms of it SiO_2 content (normally > 98%) and various impurity levels (Al_2O_3, Fe_2O_3, CaO each normally < 0.2%) with very little tolerance for phosphorus or arsenic. In order to keep the furnace charge permeable enough to allow the reaction gases to escape the charge, fines are normally rejected to avoid chocking and/or eruptions in the furnace. In general, as a result of the deteriorating raw materials base, the industry will have to utilize and develop efficient methods of beneficiation, agglomeration and smelting along with efficient waste heat recovery and pollution control [9].

Productivity : For carbothermic reduction of ores for making standard ferro alloys of Mn, Si and Cr, sub-merged arc furnaces are used. The average specific furnace productivity is relatively low and varies widely as seen in Table II.

Energy : Typical smelting energy requirements are shown in Table V and Fig. 3. This energy input accounts for 30-50% of the production cost for ferro alloys. Therefore, savings and conservation of energy is crucial to improve process economics. The energy consumption can be reduced through suitable pre-treatment of the basic ore. As shown in Table V pre-heating can save upto 1400 kWh/tonne whereas pre-reduction could accomplish a saving of as much as 2600 kWh/tonne.

Enviroment : Most plants let out the off gases through stacks or chimneys without cleaning it from toxic impurities and dust particles. Some of the newer plants have adopted modern technologies in order to use low grade ores, after appropriate beneficiation and agglomeration. Some have installed filter bags for gas cleaning. The operating cost of (fans, blowers, etc.) for pollution control is reported to be large (Rs. 7 Cr/yr for a 50,000 t/yr plant) and they have appealed for a reduction in import duty on the fibre-glass bag houses used [1]. Charcoal has been used as the major reductant; however, due to environmental concerns about deforestation, metallurgical coke is being increasingly used.

5.1 Research and Technology Development in Ferroalloys Industry

As can be seen in Table VI, much of the R&D effort in India as well as abroad has been directed at pre-treatment of basic ores (mineral beneficiation, agglomeration, pre-reduction) in order to utilize low grade ores and fines, reduce power consumption and allow the use of cheaper energy sources.

Paramount Sinters Ltd., is reported to have conducted extensive work on sintering of manganese ores and have successfully enhanced the Mn/Fe ratio from about 3 to above 5. A 15,000 tpa. Mn-ore sinter plant is under operation at Maharastra Electrosmelt Ltd., (MEL's) plant in Chandrapur since 1981. MEL is reported to be setting up a 3.3 MVA arc furnace and another 5.5 MVA furnace as an R & D facility to develop ferro nickel and noble ferro alloys [3].

The technology development in Europe and Japan has advanced to the pilot scale and beyond in the areas of open slag smelting and reduction smelting.

The Swedes are reported to be successfully operating a 78,000 tpa plant using plasma smelting technology. The advantages result from the utilization of cheaper raw material fines and coal fines. Even though there is no saving in specific power consumption the process allows an efficient heat recovery from the waste gases [1].

With regard to the treatment of high phosphorus manganese ores, the process developed by the Russians at their Nikopol works employs a 6-electrode rectangular furnace and produces a high-phosphorus pig iron under the first two electrodes the MnO rich slag overflows into the second compartment comprised of 4 electrodes and yields a low-phosphorus high-carbon ferromanganese [1]. However, in the opinion of the authors, this method is likely to (a) incur a heavy loss of manganese in the pig iron, (b) be more energy consuming and (c) require a major process/furnace change in existing plants. There exists a need to develop processes for removing phosphorus from manganese ores as well as from liquid ferro manganese, as discussed by Chaudhary and Goel [10] in this volume.

5.2 Major Areas of Technology Gaps

In order to improve the technology base of the ferroalloys industry in India, the DSIR-study has earmarked the following thrust areas :

- Process metallurgy
- Production facilities
- Productivity and capacity utilisation
- Process control and automation
- Raw materials conservation, dust recovery and slag utilization
- Energy conservation and pollution control
- Product quality and diversification of product-mix
- Captive power generation

5.3 Suggestions to Bridge Technological Gradient

The main suggestions for improving performance and technology base are :

- Selection of the right process and production facilities
- Employment of high powered furnace, on-load tap changers and capacitor banks
- Improvement of furnace utilisation factor
- Reduction of heat losses from the furnaces
- Moisture control of raw materials
- Computer process control
- Use of agglomerated feed,
- Utilisation of sensible heats of hot metal and hot slag
- Product granulation.

5.4 Suggestions for Technology Acquisition

Following is a list of technologies which may be adopted by individual plants with a view to modernise their operations. However, these technologies must be proved with Indian raw materials and tailor made to meet individual requirements. These are :

- Open slag bath operation utilising 100% ore fines and/or prereduced pellets
- Fluidised bed operation
- Shaft type smelting furnace
- Waste heat recovery
- Ladle metallurgy

5.5 Suggestions Towards an Indigenous R & D Programme

The following R & D work is recommended :

- Open slag bath operation utilising ore fines and/or prereduced pellets
- Production of ferroalloys in DC furnaces
- Treatment of high-phosphorus manganese ores
- Development of alternative reductants.

6.0 Summary and Conclusion

The ferro alloys industry in India has steadily grown with the steel industry. India has large reserves of important minerals used for producing ferro alloys, such as manganese ore, chromite and quartz.

Much of the technical know-how is available in the country. There is a greater recognition of R & D efforts for developing indigenous technology.

There is a surplus capacity which could be utilized for increasing exports. However, the average power tariff in India remains 2-3 times higher than in Norway, Brazil, S. Africa. With power input constituting 35-45% of the cost of production, ferro alloys industry is highly energy intensive. Thus, there exists a definitive need to reduce power tariff to make the industry competitive and brighten the export prospects for ferro alloys.

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TABLE - I
LICENSED CAPACITIES OF FERROALLOY PLANTS IN INDIA [1]

No.	Plant	Licensed Capacity (t/yr)		
1.	Dandeli Steel & Ferro Alloys (P) Ltd.	FeMn	:	15,000
2.	Visvesvaraya Iron & Steel Ltd., (VISL)	FeSi	:	20,000
		Others	:	3,800
3.	The Sandur Manganese & Iron Ores Ltd.	FeMn	:	36,000
	(SMIORE)	FeSi	:	24,000
4.	Ferro Alloys Corporation Ltd.	FeMn	:	50,000
	(FACOR-FAW)	FeSi	:	5,000
		SiMn	:	8,500
		LCFeCr	:	12,000
		HCFeCr	:	2,000
		SiCr	:	2,000
5.	Nava Bharat Ferro Alloys Ltd.,	FeSi	:	20,000
	(NAVFAL)	CaSi	:	2,500
6.	VBC Ferro Alloys Ltd., (VBC)	FeSi	:	10,000
7.	The Tata Iron & Steel Co. Ltd., (TISCO)	FeMn	:	30,000
8.	The Jeypore Sugar Co. Ltd., (JEYSUCO)	FeMn	:	24,000
9.	Indian Metals & Ferro Alloys Ltd., (IMFA)			
	Domestic	FeSi	:	20,000
		Si-metal	:	4,900
	Export	FeSi	:	25,000
		Si-metal	:	10,000
		ChCr	:	45,000
10.	The Industrial Development Corporation of Orissa Ltd., (IDCOL)	LCFeCr	:	10,000
11.	Ferro Alloys Corporation Ltd., (FACOR-CCP)	ChCr*	:	50,000
12.	OMC Alloys Ltd., (OMCAL)	ChCr*	:	50,000
13.	Ispat Alloys Ltd., (IAL)	CaSi	:	2,500
14.	Indian Charge Chrome Ltd., (ICCL)	ChCr*	:	62,500
15.	Universal Ferro & Allied Chemical Ltd.,	FeMn	:	45,000
16.	Khandelwal Ferro Alloys Ltd.,	FeMn	:	53,750
17.	Maharashtra Electrosmelt Ltd., (MEL)	FeMn	:	1,00,000
18.	Uniferro International	FeMn*	:	65,000
		HMnO-slag	:	40,000
				8,50,000

* Targeted for Export

TABLE - II

PRODUCTION OF BULK FERRO ALLOYS IN INDIA [3, 4]

Ferro Alloys	Production (tonnes)	
	1990-91	1992-93
HC Ferro Manganese	200,010	1,91,827
MC Ferro Manganese		5,880
Silico Manganese	62,846	92,672
Ferro Silicon	71,889	74,013
HC Ferro Chrome	48,679	90,846
LC Ferro Chrome	8,536	6,626
Silico Chrome	21,132	5,886
Charge Chrome	85,628	1,17,127
	479,811	5,84,877

TABLE - III

EXPORT OF BULK FERRO ALLOYS FROM INDIA [3, 4]

Ferro Alloys	Exports		Value in
	1990-91	1992-93	Rs. lakhs
HC Ferro Manganese	13,544	8,331	1,106
MC Ferro Manganese	-	-	-
Silico Manganese	N/A	15,516	2,549
Ferro Silicon	1,469	-	-
HC Ferro Chrome	3,630	22,575	4,140
LC Ferro Chrome	-	-	-
Silico Chrome	-	-	-
Charge Chrome	68,426	1,04,462	17,809
	87,069	1,50,884	25,604

TABLE - IV
SPECIFIC FURNACE PRODUCTIVITY [1]

Product	Range of Specific furnace Productivity (t/MVA-day)	
FeMn	4.66	9.13
M/L/ELC FeMn	4.80	12.50
SiMn	2.66	5.43
FeSi	1.83	3.45
FeCr	2.66	4.00
LCFeCr	-	3.69

TABLE - V
SAVINGS IN SMELTING POWER CONSUMPTION FROM PRE-TREATMENT CHROME ORES [1]

Sl. No.	Ore/Furnace Chrage Pre-treatment	Average Power Consumption, kWh/t	Expected Savings, kWh/t
i.	Unscreened lumps	4,000-4,600	Base
ii.	Fines briquettes	3,850-4,400	250 - 200
ii.	Screened lumps	3,600-4,000	400 - 600
iv.	Fines sinters	3,300-3,700	700 - 900
v.	Fines pellets	3,400-3,600	600 - 1,000
vi.	Hot briquettes	3,300-3,600	700 - 1,100
vii.	Preheated pellets	2,700-3,000	1,300 - 1,600
viii.	Prereduced pellets	1,700-2,000	2,300 - 2,600

TABLE - VI

MAJOR R & D ACTIVITIES CONDUCTED IN INDIA AND ABROAD

Activity	Benefits expected/derived
INDIA	
a) Beneficiation of Cr and Mn Ores, agglomeration of ore fines (NML, RRL/B)	Reduction in furnace charge cost and power consumption, conservation of high grade ores
b) Sintering of ore fines before smelting (MEL, Paramount Sinters Ltd., RRL/B)	-do-
c) Preheating and Pre-reduction of fines and agglomeration	-do-
d) Dephosphorization of high phos Mn-Ores	Low impurity in the product
e) Production of Vanadium-rich slag, low Si pig iron from titano-magnetites; Removal of Al from Fe-Si(NML); Production of Fe-Zr and Fe-Ti (MEL)	Value-added product
ABROAD	
i. Pre-reduction of pellets and open slag bath smelting (Mannesmann Demag) along with lumpy ore	Lower power consumption, better yield
ii. Open slag bath smelting utilizing 100% fines	Lower power, better thermal efficiency
iii. Smelting reduction following fluidized bed operation (Kawasaki)	Use of cheaper energy sources, use of fines
iv. Two-stage smelting, for treating high phosphorus Mn-Ores to produce a high Pig iron (discarded) and a (MnO) rich slag treated in the 2nd stage	Low phosphorum in the product
v. Smelting of ore fines using plasma reactors (6 x 8 MW), Swede Chrome, Melmo, Sweden (32 MW), Palmiet Ferrochrome, Krugersdorp, S. Africa.	Use of cheaper ore fines and coal fines; possible heat recovery from waste gases

Fig. 1 : Existing Capacity of Various Ferro Alloys in India

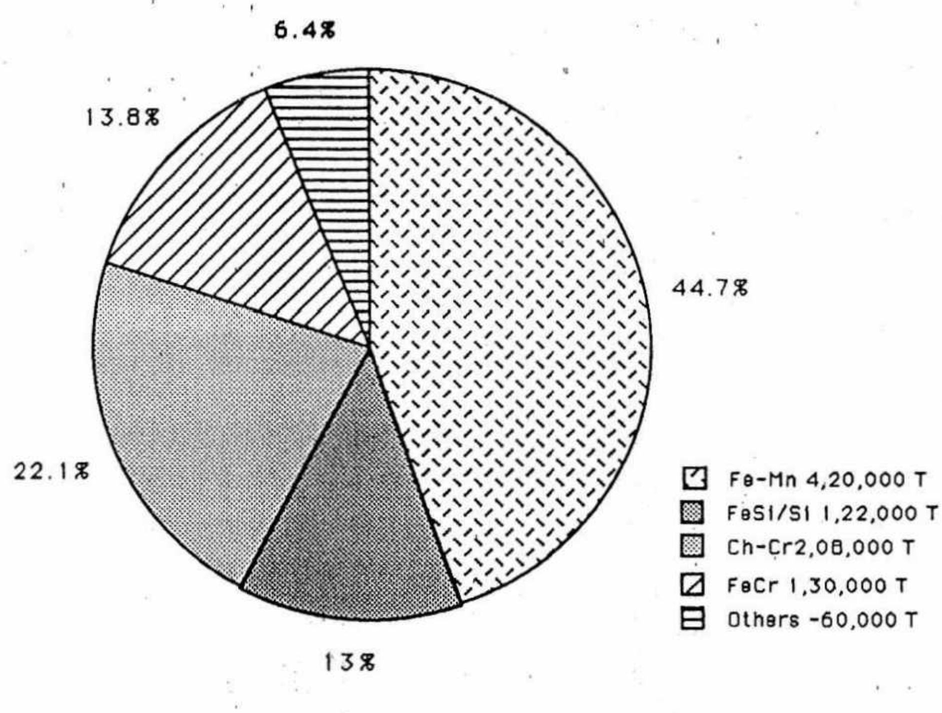

Fig. 2: Licensed Capacity & Production of Bulk Ferro Alloys In India

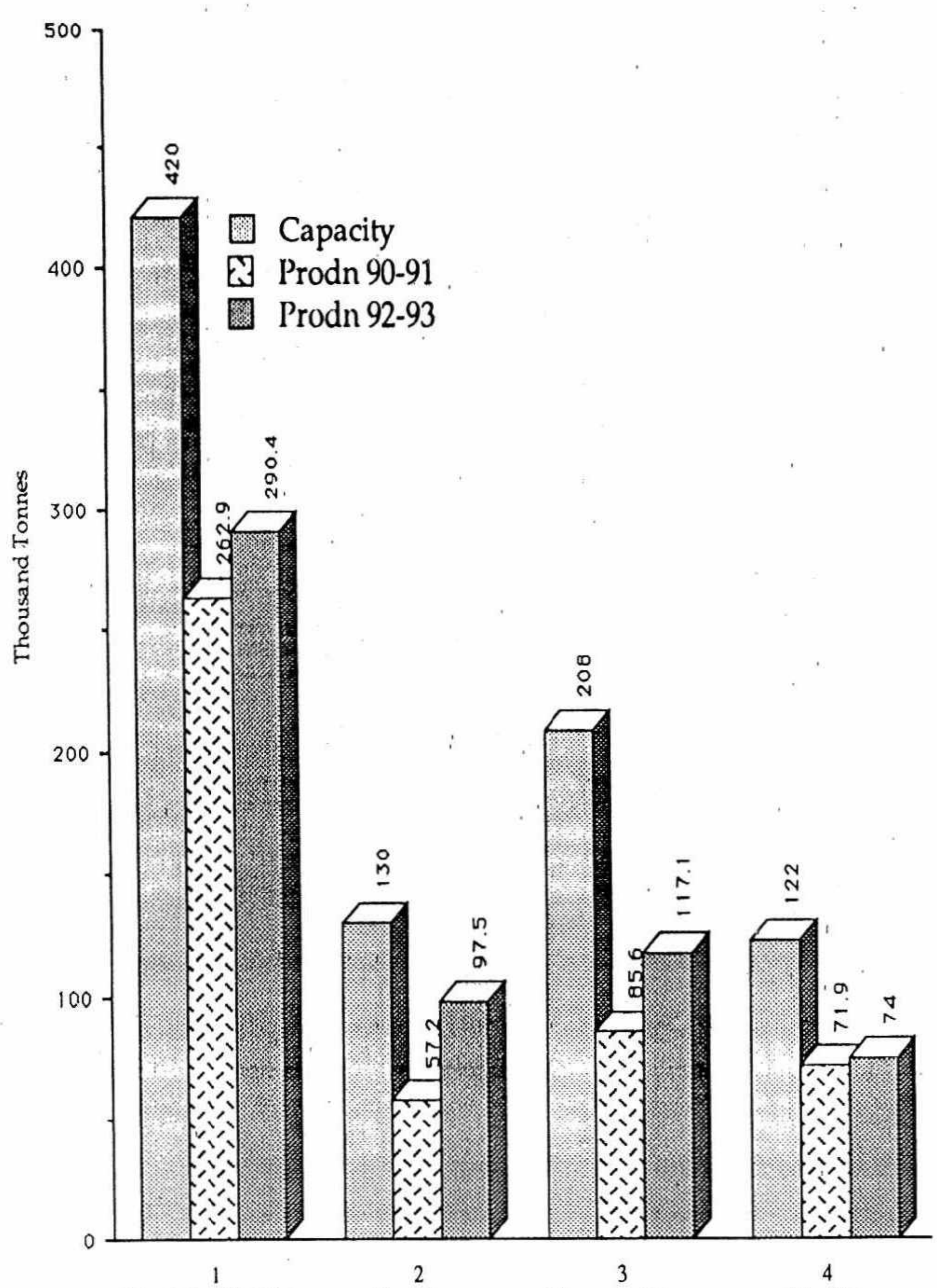

Fig. 3 : Smelting Energy Requirement for Bulk Ferro Alloys