Special Address

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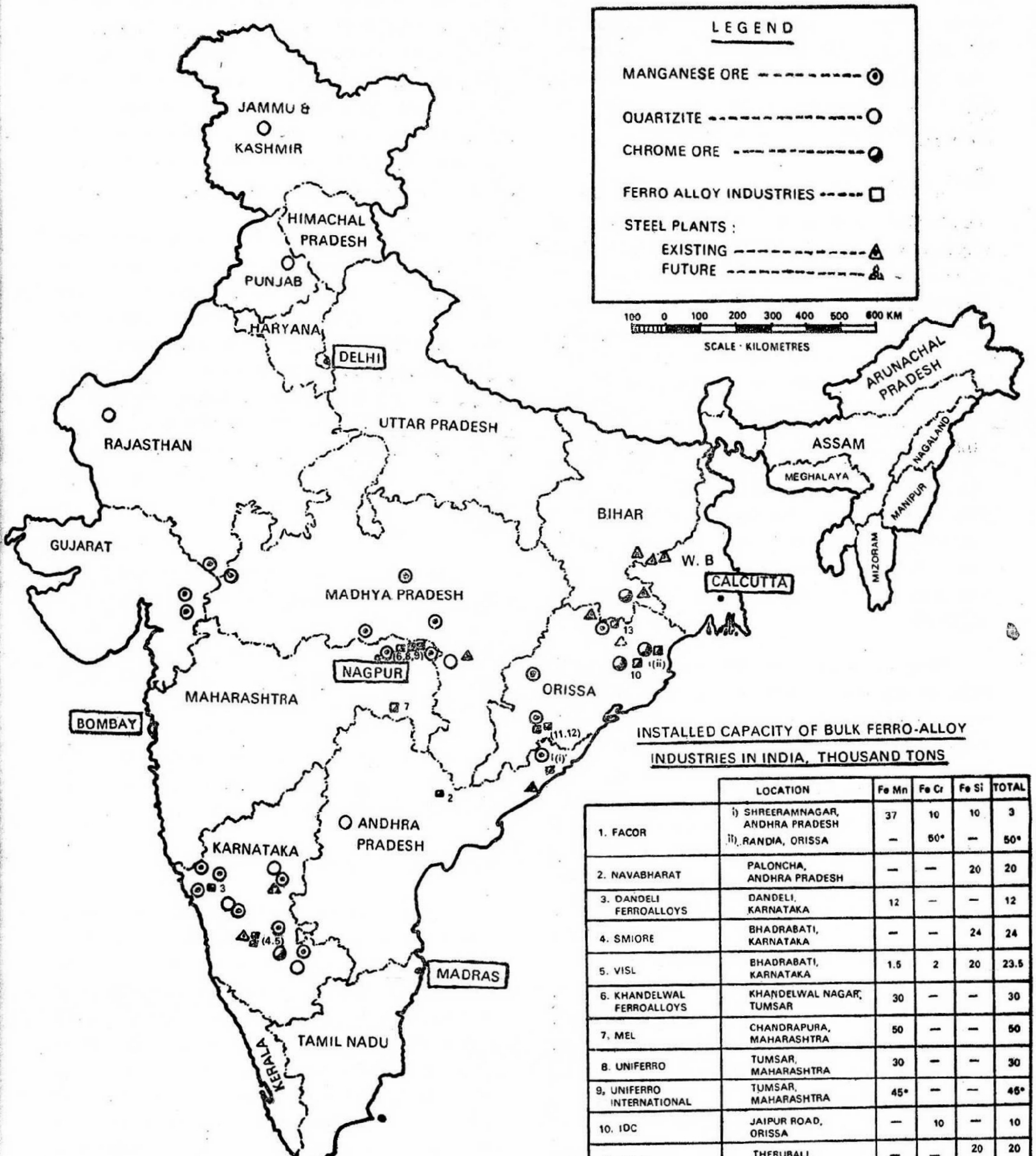
FERRO-ALLOY INDUSTRY IN INDIA - PERSPECTIVES AND TECHNOLOGICAL TRENDS

I am grateful to Dr. V. A. Altekar for inviting me to this National Seminar on the Problems and Prospects of Ferro-alloy Industry in India. The fortunes of the ferro-alloy industry are closely linked with the progress and prosperity of the steel industry world-wide. As you all know, the steel industry the world over has been experiencing a severe recession for sometime now, closely following in the wake of the global energy crisis. With the steel development programme in the advanced countries almost at a standstill and the international market situation not too rosy, the Indian ferro-alloy industry is at present passing through a difficult phase of dwindling foreign markets. In addition, the raw materials, power and energy costs have increased. This calls for special efforts on the part of the Government, the ferro-alloy industry, the technologists and others concerned in finding solutions to the industry's major problems and for providing a more congenial and promising environment for its healthy and sustained growth in the years ahead. This National Seminar is, therefore, most opportune and crucial, and the National Metallurgical Laboratory and the Indian Institute of Metals (Iron and Steel Division) deserve our congratulations for organising this Seminar at this juncture.

Growth of the ferro-alloy industry in India

Since independence, the crude steel capacity in India has grown substantially and is poised for further growth. According to present indications, it is expected to grow to over 35 million tons per year by 2000 A. D. As the ferro-alloy industry is inextricably linked with the steel industry, its continued development and prosperity are totally dependent on the planning and development of the steel production in the country.

The production of ferro-alloys in an appreciable quantity was taken up in India only about 25 years ago. Prior to that, ferro-alloys like



INSTALLED CAPACITY OF BULK FERRO-ALLOY INDUSTRIES IN INDIA, THOUSAND TONS

	LOCATION	Fe Mn	Fe Cr	Fe Si	TOTAL
1. FACOR	i) SHREERAMNAGAR, ANDHRA PRADESH	37	10	10	3
	ii) RANDIA, ORISSA	—	50*	—	50*
2. NAVABHARAT	PALONCHA, ANDHRA PRADESH	—	—	20	20
3. DANDELI FERROALLOYS	DANDELI, KARNATAKA	12	—	—	12
4. SMIORE	BHADRABATI, KARNATAKA	—	—	24	24
5. VISL	BHADRABATI, KARNATAKA	1.5	2	20	23.5
6. KHANDELWAL FERROALLOYS	KHANDELWAL NAGAR, TUMSAR	30	—	—	30
7. MEL	CHANDRAPURA, MAHARASHTRA	50	—	—	50
8. UNIFERRO	TUMSAR, MAHARASHTRA	30	—	—	30
9. UNIFERRO INTERNATIONAL	TUMSAR, MAHARASHTRA	45*	—	—	45*
10. IDC	JAIPUR ROAD, ORISSA	—	10	—	10
11. IMFA	THERUBALI, ORISSA	—	—	20 23*	20 23*
12. JAIPUR SUGAR	RAYGADA, ORISSA	18	—	—	18
13. TISCO	JODA, ORISSA	30	—	—	30
TOTAL		253.8	72	117	442.8
					118*

*EXPORT ORIENTED

FIG. — 1 MAP OF INDIA SHOWING LOCATIONS OF MAJOUR FERRO-ALLOY PLANTS AND SOURCES OF RAW MATERIALS FOR FERRO-ALLOY PRODUCTION high carbon ferro-manganese and low grade ferro-silicon used to be made in the blast furnaces for a short period before the furnaces were shut down for relining. The bulk of the higher grade ferro-alloy requirements were met by imports, though the country had been exporting premium grade ores for the production of ferro-alloys for the past several decades. Even today, some of these ores are being exported.

Early beginning

During the Second Five Year Plan, great emphasis was laid on increasing the steelmaking capacity in India. The installation of three new integrated steel plants at Bhilai, Durgapur and Rourkela was taken up during this period along with the expansion of TISCO and IISCO. This was closely followed by the installation of the Alloy Steels Plant at Durgapur. Simultaneously, to cater to the domestic demand for ferro-alloys, a number of units came to be established during 1957 to 1961. From 1961 to 1967, however, there was no new addition in the ferro-alloy industry and thereafter, again some new units were installed; the latest two units were commissioned in 1983, which are totally export-oriented.

Figure 1 shows the location of the ferro-alloy plants, their installed capacities and the major raw materials deposits. It will be noted that most of the ferro-alloy units in India are located in forest areas near the mines, and were installed at a time when power was available in abundance. The forests provided adequate wood to produce charcoal which was and is still today the principal reductant for the ferro-silicon plants. For the production of ferro-manganese and ferro-chromium, however, a mixture of charcoal and low ash coke was used.

Development and growth

Since its inception, the ferro-alloy industry has seen many ups and downs. The golden period was between 1967 to 1970, when the production of bulk ferro-alloys (FeMn, FeSi and FeCr) rose to 220,000 tons from a meagre 29,000 tons per year just after independence During this period, the best grade of raw materials were exploited, leaving large quantity of unutilised fines and low grade ores in the mines; charcoal was freely used for the production of ferro-silicon unwittingly depleting the forest reserves, and best quality coke with lowest ash content was also used. Needless to say, adequate and continuous supply of power which is essential for successful operation of the ferro-alloy industry, was then available.

During the period 1970 to 1974, there was a comparative lull in the ferro-alloy industry, but after 1974 the demand again picked up. By 1978-79, the industry had attained a production level of 300,000 tons per year and during the following period 1978 to 1983, there was further substantial addition to the installed capacity of ferro-alloys, particularly in the chrome and the manganese sectors, raising the total installed capacity to 442,800 tons per year, out of which 118,000 tons per year were earmarked for exports only.

Recently, Letters of Intent have been issued to three more parties for the production of 145,000 tons per year ferro-chrome and ferro-manganese. Thus, if the new projects are implemented in accordance with these Letters of Intent and also the licensed capacities hitherto untilised are installed, the ferro-alloy industry may well have a total installed capacity of about 600,000 tons per year by 1986-87 out of which 258,000 tons will be for exports only.

Domestic demand for ferro-alloys

As stated earlier, the future of the ferro-alloy industry is tied up with the growth of the steel industry. This is specifically significant in the context of the prevailing worldwide recession in the steel industry. At present most of the growth in the steel industry is actually taking place only in the developing countries, while the developed countries have shelved many of their steel expansion plans. In India too, it is planned to raise the crude steel production capacity to 22.5 million tons by 1990 and 35 million tons (including the mini steel sector) by 2000 A. D. This is a very modest target, the achievement of which is well within the capabilities of the country. On the basis of this probable steel production, the estimated domestic requirements of bulk ferro-alloys in 1990 and 2000 and the present installed capacity for bulk ferro-alloys are presented in Table 1.

TABLE - 1

Domestic requirements of bulk ferro.alloys in 1990 and 2000 A. D. and the present installed capacity for bulk ferro-alloys.

Year	Projected crude steel production	Requirement of ferro-alloys ('000 tons)			
		FeMn	FeSi	FeCr	Total
	mill tons				
1981-82 (1)	10.414	177(2)	53(2)	30(2)	260
1990	22.500	332	108	72	512
2000 A. D.	35.000	506	183	129	818
Installed capacity(3) for bulk ferro-alloys (1983)	—	253.8	117	72	442.8
Licensed capacity(3) (1982)					
—Domestic use	—	224.8	94.0	22	340.8
—Export oriented	—	90.0	23.0	145	258.0
Total		314.8	117.0	167	598.8

NOTES :

(1) Actuals

(2) Indigenous production plus imports of low carbon ferro-alloys

(3) Includes export oriented plants.

From a comparison of installed capacity of the bulk ferro-alloys, namely FeMn, FeSi and FeCr, given in Figure 1 and the requirement of ferro-alloys given in Table 1, it will be obvious that there is at the moment some surplus capacity in these ferro-alloys. After meeting the domestic demand, therefore, it would be essential to find export outlets for the excess production. The industry is well aware of this situation and has already taken steps to build export markets for Indian ferro-alloys.

Power Scarcity and Under-utilisation of Capacity

Due to various constraints, of which the principal one is erratic power supply, the ferro-alloy units in the country are not in a position today to utilise their installed capacities adequately. As a result of this low capacity utilisation which is much below the optimum level, the production costs of the Indian ferro-alloy industry have risen much higher than those at the international level.

The Sixth Five Year Plan has laid great emphasis on improved power generation with a view to ensuring uninterrupted power supply to various core sector industries. Even if all the licensed capacities are fully utilised and the power position improves considerably, there will be substantial shortfall in all the categories of bulk ferro-alloys by 1990, if exports are allowed according to present planning. By 2000 A. D., the shortfall will further increase. On the other hand, if exports are curtailed then in 1990 there will be marginal shortfall in FeMn only. By 2000 A. D. there will be substantial shortfall for FeMn and FeSi even if export is totally stopped. However, stopping of exports may not be a wise policy from the viewpoint of long term interests of the industry and the economy. Whatever way we look at it, if crude steel production of 35 million tons materialises by the year 2000 A. D., to meet adequately the domestic ferro-alloys demand, the ferro-alloy industry will need to create additional capacity over and above the new capacity that will materialise from the on going projects and those under planning or in the process of implementation.

Minor Ferro alloys

As regards other ferro-alloys such as ferro-molybdenum ferro-tungsten and ferro-vanadium, these are required in small quantities and are being produced by small units. As molybdenum oxide is not produced indigenously, some 600 to 800 tons per year of molybdenum oxide containing 500 to 600 tons per year of molybdenum metal are being imported. Around half of the amount of this oxide is converted into ferro-molybdenum in some 15 small plants scattered all over the country, while the rest is directly charged into the steelmaking furnace. Imports of ferro-molybdenum, ferro-tungsten and ferro-vanadium as such have apparently been banned, though it would appear that imports of ferro-colombium is allowed, as this is not produced at present in the country.

Raw Materials Resources

The major raw materials required for the production of bulk ferro-alloys are manganese ore, chromite and quartzite. Of the above, quartzite of good quality is available in adequate quantities in many places in India. However, in the case of manganese and chromite ores, unrestricted exports in the past have depleted our stocks of good quality ore. In the present context, therefore, it is essential to increasingly utilise the low grade ores and fines adopting beneficiation, agglomeration, pelletisation, briquetting and sintering techniques as may be appropriate, so that we can stretch our raw materials resources for maintaining our production level as required.

The present estimates of the available raw materials for the bulk ferro-alloys in the country are given in Tables 2, 3 and 4. It will be noted from Table 2 that the reserves of quartzite are quite extensive in the country, but it is not known how much of these quartzites will be useful for the production of ferro-silicon alloys.

The reserves for higher grade manganese ores (+45% Mn) are only 17.28 million tons compared to the total deposit of about 79.50 million tons as shown in Table 3. The reserves of the chromite ores (Table 4) have been estimated around 111 million tons. A good deal of these chromite and manganese ores will have to be upgraded for use by the ferro-alloy industry.

As regards raw material requirements for other ferro-alloys, namely ferro-molybdenum,

TABLE—2

Reserves of quartz/quartzite
(Million tons)

State	90-99% Silica	Others	Total
Andhra Pradesh			
Mahboobnagar	7.14	—	7.14
Karnataka			
Raichur	5.00	—	
Dharwar	—	30.00	
Mandhya	—	0.34	
Tumkur	—	2.50	37.84
Tamil Nadu			
Coimbatore	0.04	—	
Dharmapuri	—	0.22	0.26
Madhya Pradesh			
Durg	—	21.34	21.34
Punjab			
Hoshiarpur	—	2.83	2.83
Rajasthan			
Jaisalmer	12.00	—	12.00
Jammu & Kashmir			
Anantnag & Doda	—	2.78	2.78
Total	24.18	60.01	84.19

Source : Indian Minerals Yearbook 1978-79.

TABLE—3

Reserves of manganese ore in India

	Gradewise recoverable reserve (Mill tons) as on 1-1-1975)			
	+45%Mn	35-46%Mn	25-35%Mn	Total
Bihar Orissa	4.62	8.41	17.96	30.99
Madhya Pradesh Maharashtra	12.66	6.32	1.65	20.63
Andhra Pradesh	—	—	1.25	1.25
Karnataka	—	4.90	12.75	20.13
Goa	—	—	3.28	3.28
Others	—	3.03	0.19	3.22
Total	17.28	22.88	39.34	79.50

Source : Indian Minerals Yearbook 1978-79.

TABLE—4

Reserves of chromite in India
(Million tons)

State	Measured	Indicated	Inferred	Total
Orissa	24.1	39.5	43.3	106.9
Karnataka	—	1.0	1.4	2.4
Others	—	1.3	0.7	2.0
Total	24.1	41.8	45.4	111.3

Source : Indian Minerals Yearbook 1978-79

ferro-tungsten, ferro-vanadium and ferro-colombium, the available raw materials for the production of ferro-tungsten and ferro-vanadium are just adequate as the present demand is small. In respect of ferro-molybdenum, since molybdenum oxide is not produced in India at present vigorous exploration is necessary to locate molybdenum ores as molybdenum oxide is essential for the production of certain grades of alloy steel. Similar is the case of ferro-colombium which is now allowed to be imported.

Power Requirement

The ferro-alloy industry is power-intensive and the bulk of the production of ferro-alloys is carried out in electric smelting furnaces which require continuous supply of large quantities of power. In the past too, the ferro-alloy industry had suffered badly, due to restricted supplies or non-supply of power. The present situation is even worse and some of the export oriented units have had to be completely shut down for lack of power. As the ferro-alloy industry depends on purchased power from the various State Electricity Boards, the assured supply of this essential input is beyond its control. Since SEBs are often reluctant or helpless, the Central and State Governments should intervene and ensure that continuous and adequate quantity of power is given to the ferro-alloy industry. This will enable them to meet fully their commitment both for internal and external markets.

In this context, it is to be noted that with the entry of South Africa and Brazil as major exporters of ferro-alloys, competition in international market has become very keen. Both Brazil and South Africa have an edge over India, because they are advantageously placed in respect of power availability at lower cost. The Government should, therefore, seriously consider effective measures whereby power at a reasonable cost to the ferro-alloy industry can be supplied. This will help reduce the production costs and increase in turn the industry's competitive strength in the international market.

Reductants

The reductants available to the ferro-alloy industry are pearl coke, charcoal and coal. The coke available to ferro-alloy production in India has high ash and phosphorous content. This has an adverse effect on ferro-alloy quality and production costs as the resultant chemical composition fails to meet the specification requirements, particularly in respect of the phosphorous content in the alloy. Also, the high ash content raises the power consumption due to large slag volume, which in turn is reflected in the higher production cost.

In the case of ferro-silicon and silicon metal, which involve a slagless process, the use of coke is practically ruled out. All the producers mostly use charcoal as the reductant. With the rapid depletion of our forest reserves, the continued availability of charcoal at reasonable prices is fast becoming a problem. It is reported that the prices have also abnormally gone up over the last few years due to the scarcity of charcoal. Though coal has been successfully used in other countries for production of ferro-silicon, Indian coking coal with its high ash and high phosphorous contents, is unsuitable for ferro-silicon production. On the other hand, Indian non-coking coal is generally found to have low phosphorous but high ash contents. The modern trend is to use washed coal directly as a reductant for ferro-alloy production. Since India's non-coking coal reserves are much higher than those of coking coal, the installation of coal washery for the non-coking coal of suitable grade, which could be utilised directly by the industry may be considered.

Technological Developments

Recent technological developments in ferro-alloys production have been primarily in the areas of beneficiation of raw materials, optimisation of recovery and computerised process control. The control of production and plant operations are being increasingly taken over by computers not only to improve the quality of the products but also to raise the productivity and plant availability. Increased attention is also being paid to the environmental aspects and pollution control.

Preheating and pre-reduction of raw materials

Physical and chemical pre-treatment of raw materials such as crushing, screening, beneficiation, agglomeration, drying, preheating, pre-reduction, calcining, sintering etc. are now considered essential for the production of ferro-alloys. The introduction of large size furnaces is demanding better and safer operations and the possibilities of the increased use of ore concentrates and fines have become important to achieve the operational economy.

From the operations viewpoint, if the granulometry of the raw materials is not appropriate, it may either cease the furnace operation or else the specific power consumption may go very high, both of which are not desirable. Hence, physical pre-treatment of raw materials is becoming more important in this context. Pre-heated and/or pre-reduced hot burdens for smelting are only practicable in closed furnaces and this will reduce the specific energy consumption. However, the use of cold sinters or pre-reduced burdens in conventional furnaces has also indicated substanial improvements in productivity and unit power consumption rates.

Upgrading inferior quality managanese ores and sintering have become a common feature of the operations of all large-scale ferro-manganese and silico-manganese units. The metal content in the ore is thus increased, while the flux load decreases in the furnace and consequently the slag volume to be melted or handled. For instance, the Tasmanian Electro Metallurgical company Pvt Ltd (TEMCO), Tasmania, Australia is currently using 65% sinter in the total ore input. This has resulted in an increase of production per kwh consumption with a high manganese recovery in the ferro-alloy. A characteristic feature of this plant is the use of acid slag.

The Nippon Kokan research group has established the feasibility of using cold-bonded carbon composite pellets for the manufacture of silico-manganese from ore fines. Apart from the use of ore fines, inexpensive coke fines were utilised in pellet making and thus a saving of 115 kg coke/ton of hot metal could also be effected.

In India too, the use of manganese ore sinters from fines has begun in a modest way at the plant of Maharashtra Elektrosmelt Ltd in the recent past It is expected that the existing ferro-manganese plants will soon exploit the possibility of using their ore fines and other Mn-dusts in the plants.

Ferro Alloys Corporation of India Limited is beneficiating its run of mine chromite ores essentially by hydrocyclones and concentration tables and then making them into bonded briquettes for charging into the smelting furnace for the production of charge chrome.

For the production of ferro-nickel, preheating of the charge is an established technology which has been in use for quite sometime. For the production of ferro-manganese, the practice and the results achieved vary from plant to plant, depending on the raw materials and on the varying power consumption between 2,000 kWh /ton to 3,500 kWh/ton.

In the case of ferro-chromium, some interesting developments have taken place in recent years. Outokumpu in Finland has been using sintered chrome concentrate pellets since 1968 and reports stable operations and good results. The plant claims to have achieved a specific power consumption of 2,700 to 2,800 kWh/ton for the production of ferro-chrome with 50-52% chrome content. It is also claimed that by the use of furnace gas in the rotary kiln the plant has been able to obtain substantial economy in preheating.

Based on the Outokompu technology, a plant has been already commissioned in the Philippines. Another plant is under installation/commissioning in Turkey, while a third project is under implementation in India. In Japan, Showa Denko's SRC process, which is based on the pre-reduction of carbonised chromium oxide pellets in the rotary kiln, is gaining importance. The process, it is claimed, has lowered the specific power consumption and improved the productivity in the smelting furnace even further. So far, two plants based on this process for the manufacture of ferro-chrome have been built in Japan.

Energy optimisation and recovery

With the rising price of energy, increased efforts to improve upon the specific energy consumption are being made basically in three complementary sectors :

a) **Optimisation of raw materials** including agglomeration, sintering, screening, use of more reactive raw materials etc

b) **Optimisation of process** including pre-heating, pre-reduction, higher metal gangue ratio etc and the use of best possible smelting equipment having low reactance and high operating efficiency, and

c) **Optimisation of operations** through better process control, improved instrumentation and the use of process computers.

Apart from employing energy efficient techniques to lower the specific power consumption, it is now necessary to recover and utilise the waste heat from the stack gases emanating from the ferro-alloy furnaces.

Specific power consumption

The specific power consumption in the production of the major ferro alloys is given in Table 5 below :

TABLE—5

Specific power consumption in kWh for production of bulk ferro-alloys

Product	Specific power consumption (kWh)
FeSi 75	9000 — 10000
FeMn 75	2700 — 3000
HCFeCr	4000 — 4500
Charge chrome	4200 -- 4500

It will be noted that specific power consumption is the highest in the case of ferro-silicon. Therefore, it is of immediate importance to recover energy from the stack gases generated during the production of ferro-silicon or silicon metal.

Energy recovery from waste gases

Figure 2 shows the simplified heat balance for a 45 MVA FeSi furnace (kWh values per ton metal) and Figure 3 presents the typical energy flow in a 32 MVA FeSi furnace and the general mode of utilising this energy from a semi closed furnace. It will be observed from these figures that the energy content of the furnace gas corresponds to about 82 to 100 per cent of the electrical energy input. The major portion of this can be recovered in a steam boiler and the steam can be utilised for the generation of electrical energy. Elkem A/S of Norway claims that about 20 to 25 per cent of the electrical energy to the furnaces can be recovered in this way. It is reported that at CUAEM's 50 MW ferro-silicon furnace in Dunkerque, about 20 per cent of the electric energy input to the furnace is being recovered by developing steam and utilising it for the generation of power. Similarly, JMC's Nagagawa plant in

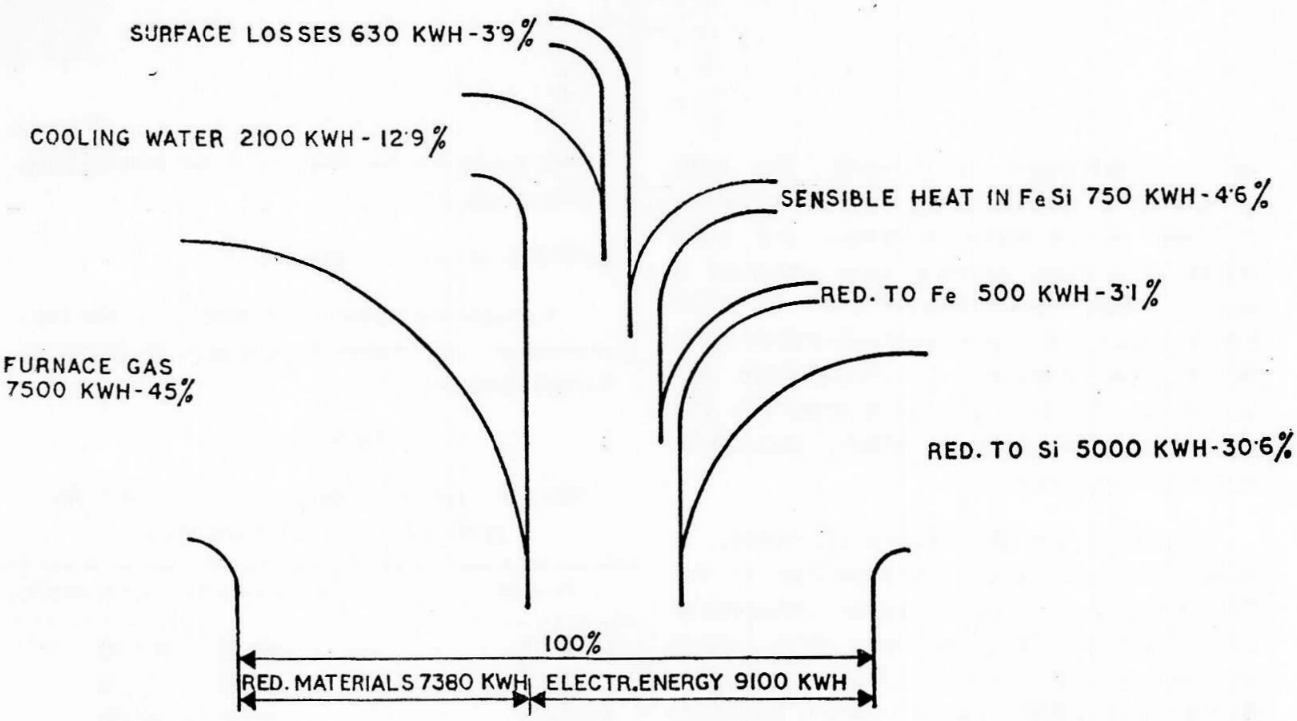


FIGURE 2 — SIMPLIFIED HEAT BALANCE FOR 45 MVA FeSi FURNACE
(KWH-VALUES PER TON METAL)

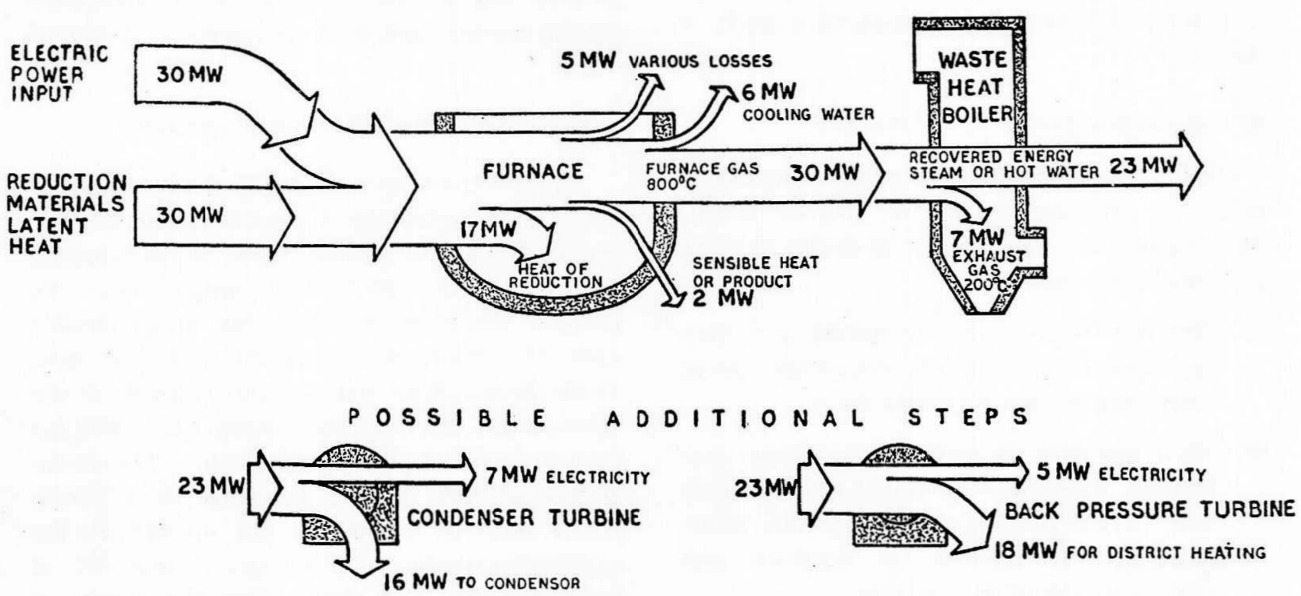


FIGURE 3 — TYPICAL ENERGY FLOW FOR FOR A 30 MW 75% FeSi FURNACE

Japan is generating 5 MW power from a 32 MVA ferro-silicon furnace. Sooner or later, the waste gas energy recovery systems are expected to be adopted by all the major ferro silicon producers.

Energy recovery systems

Until now, all the systems for energy recovery from the stack gases have been based on so-called semi-closed furnaces which allow sufficient inlet of air so that complete combustion of the furnace gases can take place under the furnace hood. This has certain operational advantages, but then the energy recovery is not so pronounced in this case. On the other hand, if the furnace could be completely covered and no air inlet or combustion takes place, the furnace gas can be used as a raw material for chemical synthesis or burnt in a steam boiler to generate steam and power. From the viewpoint of energy recovery, the closed furnace system has the following advantages :

i) Cheaper gas cleaning plant,
ii) Cheaper boiler installation, and
iii) Higher energy recovery factor.

The difficulty encountered earlier in respect of closing the ferro-silicon furnace has been effectively overcome with the development of split furnace body concept by Elkem. An 8.5 MW split furnace based on this concept is being successfully operated by Elkem at their Bremanger Smeltverk plant in Norway. However, Elkem so far has not reported the use of split furnace body for larger capacity furnaces of 45 MVA and above.

One of the major disadvantages of a closed furnace is the use of wet scrubbing of gas and the need to purify the water and the problems associated with handling and disposing of large quantities of sludge. These problems could be solved, but it would be easier and also cheaper if a dry gas cleaning system capable of withstanding the high temprature of the gases from closed furnaces could be utilised.

For the past several years, Elkem has been working for a successful solution to dry gas cleaning at elevated temperatures. It is reported that suitable filters for elevated temperature gas cleaning have already been developed, but commercial application of these filters in elevated temperature gas cleaning is yet to be established.

Another possibility of utilising the recovered energy is to use it directly in the form of heat without transferring it with low efficiency for generation of power. However, such installations like hot water supply are more applicable to cold countries and are, therefore, not likely to be of much interest to the ferro-alloy industry in India.

Computerised Process Control

Ferro-alloy production through electric smelting operations is not only power-intensive but also sensitive to input materials quality as well as to any variations of the operational parameters. For this reason, manual controls of the operational parameters are now being replaced by computer control which measures the parameters continuously or on a pre-determined basis, signalling the corrective steps through automatic controls for the inputs, power supply and other operational parameters on an overall basis fo optimise the production at the minimum cost input.

With consistent process control efforts, it has been possible to reduce the power consumption per ton of ferro-manganese by 20 per cent or so. This could be achieved not only by minimising the direct energy losses in the furnace proper, but also by concentrating or upgrading the input raw materials in the form of pre-reduced sinter, correcting for optimum slag volume/wt per ton of ferro-alloys and other operational parameters.

The typical inter-relationships between the basic control parameters for furnace control, the weighing computer, the furnace computer etc are indicated in Figure 4. The programme details will naturally depend on the input

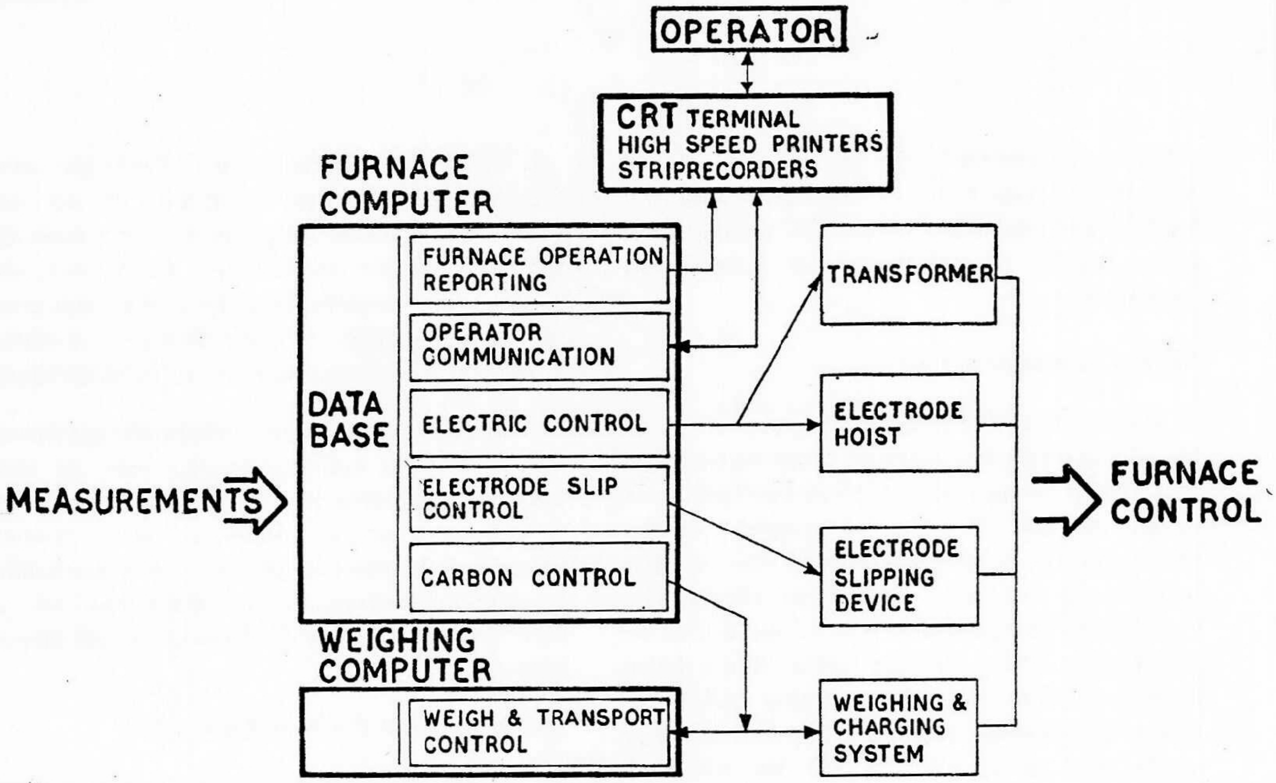


FIG. 4 — INTEGRATED COMPUTER CONTROL SYSTEM FOR ELECTRIC SMELTING FURNACES

materials, furnace characteristics, the type of ferro-alloys to be produced and host of other variants and will have to be developed and test run on a plant to plant basis before implementation.

It will be noted that the control functions have been divided into measurements of variants (data base) and control demands. The computer records the relevant data on operation, power delivering systems, input raw materials weighments, chemical analyses etc. Once these data are analysed and assimilated, the control demands are given to the operations through high speed printers, recorders etc. These commands can be made more effective through automation in charging, operational control, power delivery systems etc through different software programmes based on micro-processors. Thus, the computer control system is not only effective for on-line monitoring and operations control but also for minimising the personnel effects on the productivity and quality of the product, which otherwise would have been extremely laborious and error-prone.

Pollution control

In recent years, environmental aspects with respsct to air and water pollution have assumed special significance in ferro-alloy smelting operations in the developed countries. The stringent environment pollution control legislation in these countries have necessitated the development and adoption of appropriate pollution control systems in the plants. There is also greater awareness in developing countries of the need for pollution control and countries like India are also planning statutory measures to control industrial pollution.

The pollution hazards from the ferro alloy industries were discussed in the INFACON-80. In particular, it was emphasised that the silicon dioxide particulates in the furnace emissions were extermely hazardous to the workers of the ferro-alloy industry. There are many sources of dust emission in a ferro-alloy plant. The major source of dust is of course the furnace fumes, but considerable air pollution also takes place due to the dust generated during raw materials and finished product handling. During the raw materials preparation and handling operations, substantial amounts of dust are generated at various points such as the crushers, conveyors, rail-road car or truck unloading, screens, silos etc. Similarly, during the handling of finished products in the crushers, screens etc as well as at storage, dust pollution problems arise. However, the abatement or control of dust in these areas is not very difficult, whereas the control of pollution created by the furnace stack emissions is more complicated. The gas emissions from the ferro-alloy smelting furnaces contain, in addition to fine particles much larger size particles of dirt, dust and incompletely combusted wood and/or coal and coke. The gas may contain harmful sulphurous products, toxic metal-oxide vapours, carbon monoxide and other organic gases. The most harmful ingredients in these gases are the silicon dioxide particulates. These particulates vary in size from 0.02 to 10 microns depending on the alloy; fine particles predominate in silicon / ferro-silicon plants, whereas the ferro-manganese and ferro-chrome plants give rise to coarser particulates.

The quantity of particulates varies greatly depending on the condition of the charge material, frequency of tap, furnace design and operating practice. In a covered furnace, the concentration ranges from 10 to 70 gm/cu m, while in open furnaces the same gets diluted to 0.5 to 5 gm/cu m.

The air pollution control in the ferro-alloy industry today is carried out by adopting the following methods, either singly or in combination, depending on the plant and other considerations :

a) Wet scrubber
b) Electrostatic precipitator
c) Fabric filter bag house

Of these, the use of fabric filters has gained popularity over the others for the ease of operation and maintenance as well as effectiveness in obtaining the desired level of particulate control in the environment. The wet scrubber technique, though very effective, poses the problem of water pollution and disposal of sludges from the settling tank or filters etc. The wet scrubbers are also expensive in operation compared to the fabric filter bag house. Although electrostatic precipitators are very commonly used for gas cleaning, these have not been popular at all in ferro-alloy industries using submerged arc furnaces. Earlier, the statutory requirement for the environment protection was not so stringent in India. Recently, the Government of India has adopted statutory measures for pollution control and is enforcing them in the new projects being set up. In this context, it is gratifying to note that MEL, Chandrapur and FACOR, Randia have taken steps for the control of pollution from the furnace gases.

Emerging Technology—Plasma-Arc

The raw materials resources are dwindling and their quality progressively deteriorating all over the world. The older technologies which were primarily based on prime quality raw materials are now becoming increasingly inadequate to sustain operations at an economic level. One of the recent technological innovations which may eventually provide a satisfactory answer to some of the nagging problems is the application of plasma-arc technology for the production of ferro-alloys.

The potential advantages of the plasma-arc technology are :

a) Unrestricted choice to some extent in the selection of feed materials including reductants which are relatively cheap and can be used directly without upgrading/ beneficiation in quality. The size of the feed materials may also vary from fines to lumps,

b) Better utilisation of the electrical energy employed, and

c) Considerable savings in consumable electrodes through the use of water-cooled plasma guns or electrodes.

The plasma-arc technology which is yet to emerge as an industrially viable pyrometallurgical process is being vigorously pursued in several important research centres and some successful pilot plant operations have also been reported. The results obtained so far have already successfully demonstrated the technological superiority of this new route for the processing of ferro-alloys. SKF has patented a 'PLASMA SMELT' type process for the production of ferro-manganese; fine manganese oxide ore is injected together with powdered coal and fluxes, into the reaction zone of the coke-filled shaft furnace and a range of ferro-manganese alloys, including those with silicon over 5 per cent could be produced by this process. The power consumption for high carbon ferro-manganese has been reported to be about 3000 kWh/ton at 0.5 slag-to-metal ratio, while for silico-manganese, the power consumption is 4500 kWh/ton. SKF have also patented another 'PLASMA SMELT' process for the manufacture of chromium iron alloys and stainless steel. These chromium-iron alloys can be used in stainless steelmaking by AOD route. Stainless steelmaking via the SKF process is expected to be about 25 per cent more favourable in respect to energy balance.

Demag, in a recent patent, has described their process for smelting of high carbon ferro-chrome in an electric reduction furnace. In this process, the ore fines and other feed materials are fed through hollow electrodes as in the conventional submerged arc furnace. Strictly speaking, this system may not be classified as a transferred arc plasma system, since the power supply is alternating current, and the bath of the furnace is shrouded with the burden.

Many other plasma-arc systems are on the anvil in various research centres all over the world. A good deal of work has been done in South Africa by the Council for Mineral Technology (MINTEK), Realising the potential of plasma technology for ferro-alloys some years ago, MINTEK set up their first experimental facility with an 100 kVA three phase, AC diffuse-plasma system, similar in design to that at Toronto. The system proved quite amenable to the melting and the smelting of various ferro-alloys. However, because of the use of inclined electrodes in this system, the scale-up potential is limited by the operational problems.

In view of this, MINTEK has opted for the installation of a transferred arc pilot plant furnace with three hearth anodes and vertical raw material feed as in the TRD (Tetronics Research and Development Limited, U K.) system. This pilot plant furnace was expected to be commissioned by September 1983. Extensive test work is planned with this pilot plant facility, in particular for processing various types of ferro-alloys

With the amount of research and development effort being put into plasma technology for pyrometallurgical operations today, it is becoming apparent that in the not too distant future, appropriate plasma-arc technology will overcome the difficulties of the contemporary technologies in the field and establish itself as the most efficient energy saving process route to be used for various kinds of raw materials which are becoming difficult to be used in today's technology system at an economic cost.

Plant Design and Engineering and Equipment Manufacture

Till 1958, most of these smelting furnaces have been imported. Thereafter, gradually several items of equipment, sub-assemblies and components came to be manufactured in India based on the designs, drawings and specifications furnished by plant design engineers and foreign equipment suppliers. With regard to self-reliance in this field, two areas need to be specifically referred to, namely (i) the overall plant design and engineering and (ii) equipment design and manufacture.

As regards the overall plant design and engineering, adequate expertise and technical capacity have been built up and Indian consultancy engineering organisations are capable of planning, designing and engineering of all types of ferro-alloy plants. In fact, the bulk of the ferro-alloy capacity in the country has been designed and engineered by Indian consultants. As regards equipment design and manufacture, most of the equipment other than the furnace proper and the requisite computer controls, is available indigenously. For the auxiliary systems such as materials handling, power supply, water and other utilities adequate technical capabilities and facilities exist in the country for their design, manufacture and erection.

For the furnace proper, the electrode hoist and the slipping mechanism, high capacity transformer, secondary busbar system and the instrumentation and controls including computerisation of materials handling and process control need to be developed. While it is possible to manufacture many of these individual components and sub-assemblies of the furnace, it may be necessary to enter into collaboration agreement with a reputed foreign manufacturer in order to be able to offer the furnace as a composite production unit with performance guarantee.

Future Trends

The steel industry is the bulk consumer of ferro-alloys and therefore the demand and production of ferro-alloys are tied to the fortunes of the steel industry. Consumption of manganese and silicon alloys follows closely the volume and pattern of the overall steel production. The consumption of chromium alloys is, however, basically dependent on the production volume and pattern in the alloy and special steels sectors, in particular the production of stainless steels.

The recessionary trend in the steel industry and a compounding increase in the cost of energy have forced a natural reorientation of power-intensive groups of ferro-alloy industry in the world.

Ferro-chromium : The most pronounced shift in orientation has taken place in ferro-chromium industry with the dominance of production activities shifting from the major alloy consuming countries to those which are endowed with the basic input materials and the resources for generation of cheaper power. This pattern of the geographical shift of the industry started with the explosion of the oil crisis as far back as 1974. A number of new plants have since been built in South Africa, Greece, Philippines, Turkey, India and Albania, all sited close to ore reserves, while the production levels in USA, Japan have dropped considerably.

It is very likely that the future growth in steel sector in the developed countries will be largely in the area of high value alloy and special steels. In such a situation, it is logical to assume that these countries will find it more economical to import their ferro-chrome requirements, rather than venture into new ferro-alloy projects, due to the high cost of energy and the stringent pollution control requirements.

Ferro-manganese : The production of high carbon ferro-manganese requires less energy and it can be produced in the blast furnace. Therefore, there has not been any noticeable shift in the location or 'pull towards the ore producing region. By and large, the producing units continue to be based near the consuming centres. It is significant that both the USSR and Japan are the largest producers and South Africa the largest exporter of ferro-manganese.

The future technological advances in the ferro-manganese production will perhaps lie in the area of (i) utilisation of ore fines, sinters, pre-reduced burdens etc. and (ii) operation in larger furnaces utilising computer control, efficient energy balance etc.

Ferro-silicon : Although the production of ferro-silicon requires the maximum amount of energy compared to other major ferro-alloys, there has been little or no effort on the part of this industry to move towards any preferred geographical location; the main reason is the abundance of raw materials in almost all the countries which are major consumer of this ferro-alloy. Being power-intensive, its natural expansion will take place at locations where along with the major raw materials inputs, power is also available in abundance at an economic price.

The largest producer of ferro silicon is the USSR, with Japan occupying the second position. Both the countries are basically consumers of their own products, whereas in Norway, Iceland and South Africa where power is cheaper and the availability of raw materials assured, the production or future expansion will depend on the export markets and thus the future of the ferro-silicon industry is very much tied up with the world increase in steel production.

Other than the use of computer controlled, completely closed or semi-closed furnace with a view to improve upon the overall energy balance, no other technological breakthrough or development is envisaged for this ferro-alloy.

Minor ferro-alloys : Minor ferro-alloys like those of molybdenum, vanadium, niobium, titanium, tungsten, nickel and rare earth metals are all high value commodities. The costs for the production of these alloys constitute a relatively minor proportion of the overall production costs. These will tend to be produced near the consumption points unless the overall production costs become too unfavourable in the context of the international market prices. Some of these metals are classified as strategic materials also. Therefore, the future of these industries will tend to be governed not only by the cost and the price structure, but also by the political, national and international developments that may have their influence on a geographical region or country. Again, allowing the fact that during scarcity or price rise, substitution of one alloy with another is a common set pattern, the future growth of the minor ferro-alloy industries will continue to be governed by this trend. It may be mentioned here that the recycling of noble and precious metals from the wastes and scrap is becoming an important industrial activity and the future of the minor ferro-alloy industry is likely to be influenced also by the growth of such recycling industries.

The Indian Scenario

The estimated demand for the major ferro-alloys in India has been projected earlier, up to the years 1990 and 2000 A. D. The existing major ferro-alloy industries operate in a captive and protected home market. Moreover, the cost of production of most of these ferro-alloys is rising. While the cost of power contributes significantly to this high production cost, materials management in some sectors of the industry is equally responsible for the high cost. It is well known that sound materials management, namely optimum burden preparation which includes beneficiation of raw materials, selection of reductants etc, contributes significantly towards the reduction in the cost of production as well as lowering of the power consumption. This awareness of good materials management and operations the beneficiation and use of inferior quality raw materials, optimum process control, utilisation of process wates, dusts etc - is being created in the Indian ferro-alloy industry.

The Indian ferro-alloy industry is in an advantageous position in respect of the availability of raw materials, barring good quality reductants. However, adequate care and control with a view to conserving these resources for the future need to be exercised.

Regarding future installations for ferro-manganese and ferro-chrome production in the country, the industry should keep in view the emerging technologies such as the plasma-arc technology for the manufacture of ferro-alloys, and examine the possibilities of their adoption and adaptation to the Indian situation.

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