Ferrosilicon industry faces demand and cost constraints

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ABSTRACT

The ferrosilicon industry is caught in a vortex of demand recession, power shortage, and escalating cost of both power and charcoal — the two crucial inputs. Against an installed capacity of 91,200 tonnes, the demand is about 52,000 tonnes. Because of power cuts in Karnataka (40%) and Orissa (50%), the demand is just met at an overall capacity utilization of 54%. However, at 80% utilization under fortuitous power situation, a surplus production of 40% could result. India has successfully exported to Japan in the past. Export was banned in 1979. Therefore, power shortage and inflationary costs, not technology, are constraints on export today. Cost-competitiveness can be realised by controlled cost of inputs, liberalised credit and subsidy. As a typical case, the situation in Karnataka is cited. Power tariff in Karnataka has risen from 5.75 p/kWh (1977) to 25.95 p/kWh (1981), an increase of 351% in five years. Power cost per tonne of ferrosilicon is Rs. 2371, representing 28% of the current price; charcoal cost is Rs. 2131, representing 26% of price. The diminishing availability of charcoal owing to ecological compulsions continues to push the cost up. But more seriously, it is compelling a search for alternative reductants. Quality preference is discussed. Import of a suitable reductant seems inevitable. Under crisis ridden circumstances, it is vital that the Government takes an integrated approach to pull the industry out of its present malaise so that it can continue to support the iron and steel industry.

Introduction

In the present state of technological development there does not seem to be an immediate alternative to electric furnace smelting of tonnage ferro alloys in general and ferrosilicon in particular. Although ferromanganese is still being produced in blast furnaces in some countries such as Russia and USA because of favourable raw material situation, ferrosilicon production depends entirely on electrothermics to attain process temperature and quality product.

The ferro alloy industry, a continuous process industry, is both capital and power intensive. It caters to the very important capital intensive steel industry. It is vital, therefore, that the linkage between the two industries is strengthened for national growth. With the introduction of advanced technology such as ladle metallurgy, greater demand on supply of ferrosilicon to closer specification will arise.

However, the present climate of demand recession, power shortages, and escalating costs of both power and charcoal—the two crucial

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inputs—is not exactly favourable for quality production at cost-competitive prices. The diminishing availability of charcoal in an ecology-conscious society is another important factor that is going to pose a serious problem, particularly to the ferrosilicon industry.

How dose the industry respond to such challenges ? Unless immediate stock is taken of this situation and the Government intercedes in a major way, the future of ferrosilicon looks bleak. All factors seem to conspire toward discouraging its production. The industry is lurching from crisis to crisis.

When the basic criteria of good demand, cheap and stable inputs are denied, no industry can be expected to survive. This paper, therefore, raises these vital issues to highlight the gravity of the situation and, hopefully, to find tangible solutions to the industry's problems in the near future.

Uncertain Demand

Figure 1 shows the pattern of production, and exports from 1975-76 to 1982-83. The apparent consumption matched production in 1980-81 only, because it was a bad year for power availability.

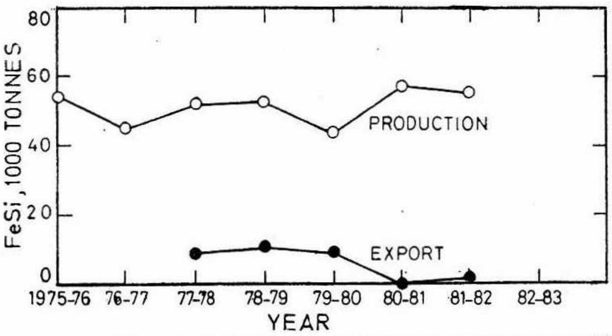

FIG. 1. FERROSILICON PRODUCTION AND EXPORT[1,2]

For clearer understanding of the relationships that exist, it is worthwhile to review the ferrosilicon scene with respect to supply and demand. Today, there are five producers spread over three States : Karnataka, Andhra Pradesh and Orissa. Table 1 shows their installed capacity with furnacewise ratings. Karnataka, the largest ferrosilicon producing State, and Orissa are predominantly dependent on hydro-electric power. Hence, they are vulnerable to the vagaries of the monsoon. Whereas, Andhra Pradesh is self-sufficient with a strong thermal backing.

Home Demand

Although the annual installed capacity is 91,200 tonnes, the realistic availability under an endemic power shortage situation needs to be projected. Considering an average power cut of 50% in Orissa, 40% in Karnataka, and 'nil in Andhra Pradesh, as in 1982-83, the capability strictly could be 62,000 tpy. But, owing to lowered operational efficiency during power cuts, an 80% capacity utilization would be reasonable to assume. Thus, the overall utilization factor could drop to 54% with a production of 49,600 t.

At this level of production, a narrow gap of 2500 tonnes could exist against the apparent demand of 52,100 tonnes (Table 2). Only by appropriate variation of either production or demand, or both, the irony of importation, despite surplus capacity, could be averted. It is noteworthy that at 80% utilization under fortuitous power situation, a surplus production of 40% could result.

Today, the demand from the tonnage steel industry accounts for only 47%; with alloy steel it goes up to 65%. If the ferrosilicon demand is to increase to 80% of installed capacity, the major consumers would have to increase their production by 40%. Alternatively, the ingot steel capacity of the integrated steel plants alone, must increase by 258% or 21 million tonnes.

The second alternative, in particular, is too much to expect in the near future. It is well recognised that the growth of steel industry is a slow process in a developing country. However, at the same time, the limited resources already employed in capital intensive industry

TABLE—1

Installed capacity of ferrosilicon in India

Company	Location	State	Furnace No.	Furnace MVA	Capacity tpy
Visvesvaraya Iron & Steel Ltd.	Bhadravati	Karnataka	1	9	5,000
			2	12	15,000
Sandur Manganese & Iron Ores Ltd.	Hospet	Karnataka	2	20	24,000
Indian Metal & Ferro-alloys Ltd.	Therubali	Orissa	1	10	7,200
			1	24	16,000
Nav Bharat Ferro-alloy Ltd.	Paloncha	Andhra Pradesh	2	16.5	18,000
Ferroalloy Corporation	Garividi	Andhra Pradesh	1	7.5	6,000
		TOTAL	10	147.5	91,200

TABLE—2

Apparent demand of ferrosilicon (1981-82)

Industry	Production Mt	Sp. Consn. Kg/t	FeSi t	Demand %
Main Steel Plant (ingot)	8.15	2.5	20,377	39
Mini Steel Plants (ingot)	1·60	2.5	4,000	8
Alloy & Special Steels	0.90	10.8	9,720	19
Foundry	3.50	3.5	12,810	24
Miscellaneous (@ 10%)	—	—	5,212	10
TOTAL	—	—	52,119	100

should not be wasted by allowing the surplus capacity to remain idle.

Given the possibility of improved power generation, it is not inconceivable to obtain over-production. In such a situation, the domestic demand should be stimulated by pragmatic measures. Reduction of excise duty (10% of selling price, Tariff item No. 68) is a distinct possibility. Besides, finding an export market is a must.

Japanese Market

In the years 1978 and 1979, a favourable export market developed by the closure of old and uneconomical ferrosilicon plants in Japan which were seriously affected by the oil crisis. The ferrosilicon industry in Japan was subjected to the "Specific Depressed Business Stabilization Act" and under close control of the Ministry of International Trade and Industry. This situation gave impetus for export to Japan.

However, the boom period was short-lived when the monsoon failed, and the Government clamped a ban on exports in 1979. Overnight, India became an importing country. The demand-supply situation went off-balance. By the time 12,000 tonnes of imported ferrosilicon could arrive, the country had good monsoon and the producers were operating at full capacity, leading to glut in the home market.

As a result of these fluctuations, export to Japan dropped from 8278 tonnes in 1979-80 to nil in 1980-81. India's position thus dropped from the third place, with about 10% share, to the last among twelve countries exporting ferrosilicon to Japan[3]. Only in 1982, a partial relaxation on export ban was allowed because of slump in the Indian market.

Incentive Needed

Today, there can be no doubt that cost— not technological capability — is a serioos constraint on exports. When over production takes place either as a result of fortuitous energy situation or demand recession within the country, the product must be cost-competitive in the international market.

Notwithstanding the passing phenomenon of depressed prices owing to world-wide steel recession, which results in dumping on the nearest available market, the genuinely low-priced product sets the competitive standard.

For example, a country like Norway which purchases energy at 14-16 p/kWh from the utility company, has a tremendous cost advantage over a country whose tariff is twice as much. Apart from agreed rates, the Norwegian producer has the option to make short-notice purchase of energy at high or low rates depending on generative capacity at a given point of time. The rate can change from an incredible low of 0.62 p/kWh (0.4 ore) to an exorbitant rise of hundred-fold.

Hence, cost comparisons should be made on equal footing to avoid abberations that are not created by the producer, but caused by factors beyond his control. Spiralling power tariff is a good example. When authorities such as the International Monetary Fund (IMF) and the World Bank (IBRD) rightly advocate economic generation of power, the same principle is applicable to the user industry. Profitability, after all is the major criterion for survival of any industry in general, and capital intensive industry in particular. Faced with an uncertain demand, industry in India is asking precisely what the Third World is asking the affluent countries : more aid.

It is imperative, therefore, that the Government takes a serious view of the situation and formulates an export policy that will encourage export of surplus production to our traditional markets at least. Liberalised packing credit and export subsidy itself, can ease tight financial positions of companies, enabling them to meet export commitments. Assured power supply would restore the confidence of foreign buyers. The fact that industrial licences embody export obligations to the extent of 25% of the output clearly reveals the economic logic. But, the force of Government's will is necessary to clear the way toward exploiting the export potential.

In due course, as indigenous requirements increase with implementation of various planned projects, exports can gradually decrease to establish an equilibrium between demand and supply. For a favourable balance of trade, however, a shift toward exports through overproduction is obviously preferred.

Power Problem

In 1976-77, the hydel share of the installed capacity in the respective ferrosilicon producing States was : 100% of 1056 MW in Karnataka, 72% of 923 MW in Orissa, and 39% of 1200 MW in Andhra Pradesh[4]. Thermal power, more or less, constituted the remaining capacity. Since then, the installed capacity has improved to 1875 MW in Karnataka, 1134 MW in Orissa, and above 2000 MW in Andhra Pradesh. Andhra Pradesh, with its strong thermal power support, is less dependent on the monsoon.

Karnataka was a power surplus State more than a decade ago. It attracted electro-metallurgical industries with long-term agreements and special concessional tariffs. In 1968, the power rate was 3.43 p/kWh and the State Duty was 0.25 p/kWh, totalling 3.68 p/kWh.

Tariff Impact

Even by 1977, when SMIORE installed its first 20 MVA furnace for ferrosilicon production, power was reasonably priced at 5.75 p/kWh, inclusive of State Duty. The power cost per tonne of ferrosilicon was Rs. 525, or 13% of the selling price of Rs. 4000 per tonne of FeSi 73 (Rs. 5.48/Kg Si).

Over the years the power tariff increased dramatically, as shown in Fig. 2. By the introduction of Central Excise Duty of 2 paise in March 1978, the increase was 35%. But when the rate changed to 14.96 p/kWh in January 1980, the heaviest impact was felt : 93% increment. Special concessions were withdrawn. Subsequently, two more changes were made in quick succession, with increments of 29% and 35%. The concept of special treatment to power-intensive metallurgical industries disappeared when they were brought under the general high-tension category on 1 Feb. 1981. The tariff rose to 25.95 p/kWh. (Orissa was at 18.5 p/kWh, which has now touched 30.5 p/kWh ; Andhra Pradesh stands at 35 p/kWh).

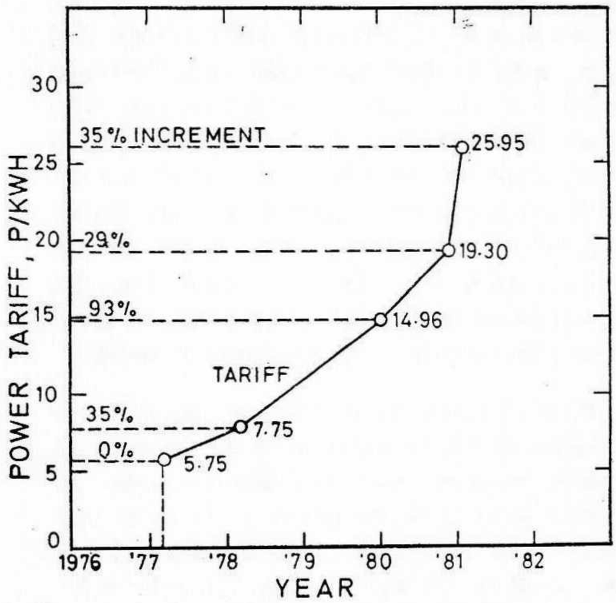

FIG. 2. POWER TARIFF CHANGES IN KARNATAKA

During the four years that witnessed drastic changes in the power situation, the cost of power went up to Rs. 2371, representing 28% of the ferrosilicon price. Figure 3 shows the relative increase of power cost and ferrosilicon prices over the corresponding levels of Rs. 525 and Rs. 4000 prevailing in the base year 1977. Over the years, while the power cost increased by 351%, the price had increased by 112% at Rs. 8500 per tonne (1980-81). By September 1982, the relative price increase had dropped to 83%.

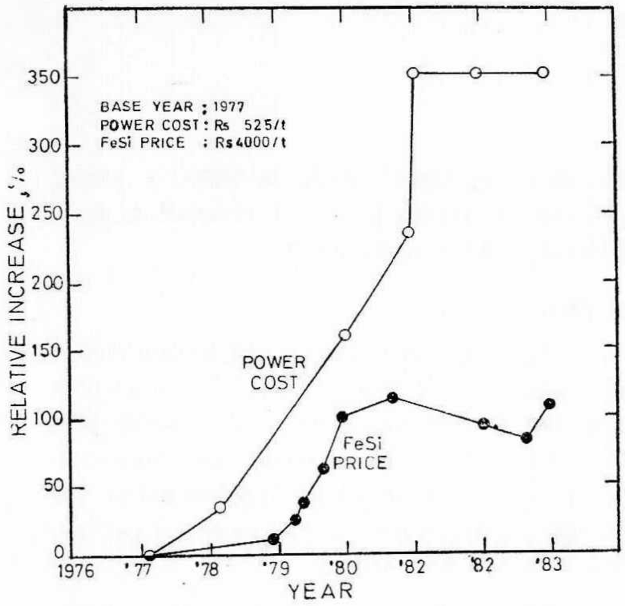

FIG. 3. RELATIVE INCREASE OF POWER COST AND FERROSILICON PRICE

This signified that the ferrosilicon market could not absorb the changes in tariff, thus imposing a severe burden on the producer already reeling under the stress of power cuts, affecting productivity.

Mathematically, the average fixed cost on an installation increases by 100% if capacity use drops by 50%. In real terms, the increase could be as much as Rs. 1000 per tonne for a new installation.

To obviate such hardships in a shrinking market, to facilitate pay-back of heavy borrowings, and to develop long-term corporate plans, it is of paramount importance that a rational and stable power tariff policy is evolved. Tariff revisions should take place every five years at the minimum, and ten years at the maximum. The latter period is especially desirable for continuous process industries which are capital and power intensive.

Power Paucity

On the basis of 6.3 GWh/MVA and 147.5 MVA installed capacity (Table 1), the Industry's requirement is 930 GWh per year. Of this Karnataka requires 50%; Orissa 23% and Andhra Pradesh 27%.

In October 1972, power cut of 25% was imposed for the first time in Karnataka. Ever since, power cuts have been the bane for the process industry in particular. Poor rainfall and, more importantly, demand outstripping supply are the major causes for paucity of power.

The severity of power shortage is evident from Fig. 4, which shows the effective power cuts, based on installed capacity, imposed on the author's company from 1972 1982. While the overall average for the period was 37%, the peak cuts varied anywhere from 25% to 79%, and generally for periods of 3 to 6 months. The prevailing power cut (Oct. '82 - June '83) for the company has matched the previous record of 79% in 1980.

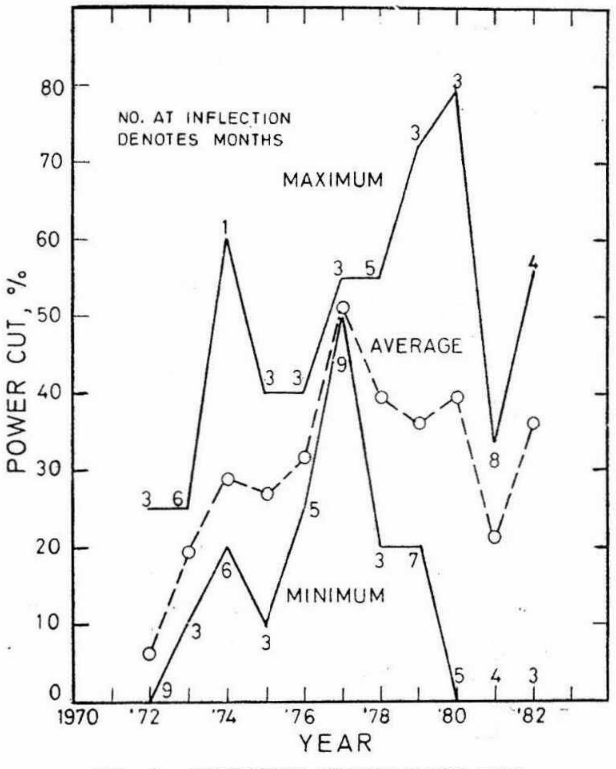

FIG. 4. EFFECTIVE POWER CUTS FOR SMIORE (KARNATAKA)

Owing to favourable monsoon since 1980, nil power cuts for periods of three to five months have been also experienced. However, when power cuts are reimposed, they are not based on installed capacity, but on average performance during nil cut periods or some other period convenient to the State Electricity Board. This arbitrariness, naturally, deprives the producer from considering alternative products or evolving production strategies consonant with market conditions.

Operational Difficulties

If non-availability of power, a crucial input for ferroalloy production, can fluctuate as widely as 79% (1980) and average as high as 51% (1977), the constraint on the operational efficiency and productivity are self-evident. For every GWh of energy denied 112 tonnes of ferrosilicon production is lost.

Operations at reduced load of 10 MW, representing 64% of full load, primarily inhibits the use of furnace rotation. Below 12 MW the rotation mechanism cannot function without breaking electrodes or the safety pin. It is well known that by rotation or oscillation of the furnace, development of hot spots in the lining is prevented and throughput is increased.

As a result of low-load operations and frequent shutdowns, not only the costs of consumables such as oxygen and lancing pipes go up but the lives of expensive lining, electrodes and equipment come down. Thermal shocks, in particular, can play havoc on electrode life. In any case, sudden interruption of power and prolonged shutdowns are not the best conditions for quality production.

Elyutin et al[5] point out that specific power increases as the number of shutdowns during the same period increase. When producing 45% ferrosilicon, the specific power is reported to have increased from 4848 to 5159 kWh/t as the shutdown increased from 7 to 12.

With severe power cuts, it becomes necessary to phase out the energy consumption over the month, specially to avoid expensive and time-consuming furnace dig-out following, say, a 15-day shutdown. Indeed, power cut yielding less than 70% of the peak load affects furnace operations to the detriment of productivity, cost and quality.

Charcoal Problem

The carbon requirement for ferrosilicon is about 128% more than that required for electric pig iron and about 103% more than that required for ferromanganese. Hence, voluminous high-conductivity material is contra-indicated.

The Indian coke, which also has high ash content and in turn high Al_2O_3, is therefore precluded from use. Whereas charcoal, which has high resistivity and lower Al_2O_3, is well suited for ferrosilicon production. Today, it is the chief reductant in the Indian context.

Nevertheless, since charcoal is likely to disappear from the scene owing to ecological compulsions, the urgency to look for alternatives assumes great importance.

Appropriate Reductant

Factors that have a significant influence on the technical choice of reductants are (i) Al_2O_3 content, (ii) size fraction, (iii) fusion temperatures, and (iv) SiO-reactivity. While laying down purchase specifications, it would be worth-while considering these aspects.

Al_2O_3 limit

The Indian Standard stipulates 1.25% Al for FeSi 73 grade. The main sources of Al_2O_3 (%) in the charge are : quartz (0.85%), iron ore (1.1%), and charcoal (1.0-1.5%). Although a marginal reduction of Al_2O_3 can be had by using millscale instead of iron ore, the former is not preferred because of its poor availability coupled with extensive crumbling tendency during storage. Mild steel turnings and borings have been ruled out on account of high cost. Thus, for a given set of raw materials, if Al_2O_3 contents in quartz and ore are assumed to be constant, the Al_2O_3 that can be tolerated from charcoal (or any other reductant) depends on the recovery and limit of Al in the alloy.

Figure 5 shows such a relation. Generally, recovery ranges from 60 - 70% depending on operational conditions. Typically, at 60% recovery, charcoal should contain 1.4% Al_2O_3 to obtain 1.2% Al in the alloy. The Al_2O_3 limit decreases with increased recovery of Al or decreased content in the alloy.

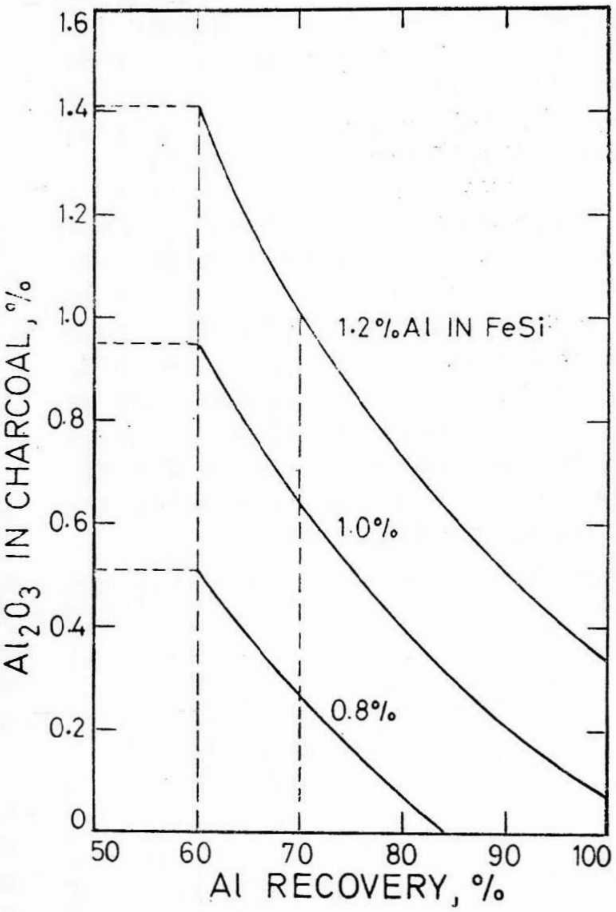

FIG 5. DEPENDENCY OF ALUMINA IN CHARCOAL ON RECOVERY AND CONTENT OF Al IN FeSi 73

It would, however, be impractical to specify below 1.5% Al_2O_3. The very primitive mode of carbonization in the jungles, by burning a variety of woods and covering them with clay, contaminates and makes the composition erratic. Added to this, the friability of charcoal results in high fines during handling. The situation is further aggravated during the monsoon when moisture absorption is as high as 40%; the screens are rendered ineffective by blinding. The Al_2O_3 control can thus go haywire. Since Al_2O_3 in charcoal cannot be specified at will, it is necessary to search for alternatives.

A quick test of suitability would be the Al_2O_3 to fixed carbon (F.C.) ratio. For example, to obtain 1.25% Al in FeSi 73 at 60% recovery, the following expression may be used :

$$(\% Al_2O_3)_r = \frac{2.78\% Al_2O_3}{100\% F.C.} (\% F.C.)_r \quad \cdots (1)$$

where subscript 'r' represents the reductant. The factor of 2.78 is valid for a given set of raw materials and reductants not susceptible to burn-off at the furnace top. Thus, if the F.C. in say, 'Leco' (lignite briquette) is 75.85%, the Al_2O_3 in it should not exceed 2.11%. Since Leco has 1.4% Al_2O_3, it is suitable chemically at least.

The utilization of substitute with higher Al_2O_3 is constrained somewhat by the Indian Standard IS : 1110—1969, which specifies maximum of 1.25% Al for FeSi 73 grade and 1.5% Al for FeSi 78. The German Standard DIN 17560 provides for 1.0 to 2.0% Al in their FeSi 75 (73 to 79% Si). The Japanese also stipulate up to 2% Al when importing FeSi 78 from India. At such times, pearl coke (70.26% F. C., 7.53% Al_2O_3) has been blended with charcoal to the extent of 20% of the carbon required in the charge.

If, therefore, the consumer, particularly the steel plants, takes a closer look and shows relaxation on aluminum, it would certainly help the producer to blend high-Al_2O_3 reductants with charcoal.

Size fraction

Fines below 6 mm increase resistivity but affect permeability of the charge. This can cause non-uniform descent of charge, channelling of gases, loss of SiO gas and "sticky top" condition. As a result, power and raw material consumptions increase. Oversize, on the other hand, has the reverse effect. But, notwithstanding improved porosity of the charge, the increased conductivity could lift the electrodes, inhibiting adequate power input. Once again throughput and efficiency drops. An optimum size for a given reductant is, therefore, very important.

Figure 6 shows a plot of typical results obtained in a 24 MW furnace while operating on gas coke at Orkla Industries, Norway[6]. This clearly demonstrates that by optimum sizing the power and raw material consumptions are reduced by more than 5%. It is generally accepted that the size granulometry should be quite close.

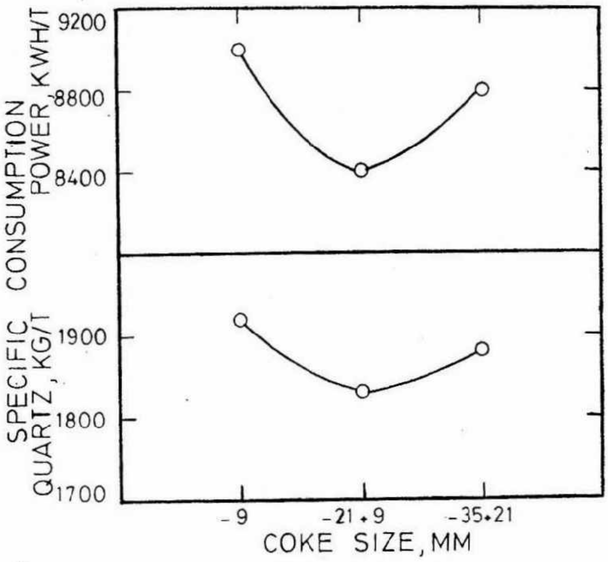

FIG. 6 POWER AND QUARTZ RATE AS A FUNCTION OF COKE SIZE

Besides size, carbonization temperature and resultant structure of coke influences resistivity. A relatively porous structure gives higher resistivity. Cokes typically used in Europe have resistivity ranging from 20 - 27 ohm cm. Australian char, a substitutional candidate, has 25 ohm cm with a porosity of 33%.

Fusion temperature

Coals soften at a particular temperature. To avoid the problem of 'sticky top' which would affect permeability and steady descent of charge in the furnace, coals with high ash-fusion temperature, say, above 1300°C would be suitable. Australian char (2-3% Ash, 2-5% V. M. 91-95% F.C.) for example, has an ash fusion temperature of 1460°C in oxidising atmosphere and 1400°C in reducing atmosphere.

SiO-reactivity

In a ferrosilicon furnace the atmosphere is both oxidizing and reducing according to the reaction taking place above 1818°C in the smelting zone :

$$1.5\ SiO_2 + SiC = 0.5\ Si + 2\ SiO + CO \quad \text{.. (2)}$$

One mole of the ascending SiO gas is reduced by carbon in the upper zone according to :

$$SiO + 2C = SiC + CO \quad \text{... (3)}$$

The second mole of SiO thus gets a chance to condense at a relatively low temperature in the outer most zone. Since the recovery of Si is important to optimise consumption of raw materials and power, the reactivity of the reductants needs to be compared systematically.

The Technical University of Trondheim, Norway, has developed a meaningful method for determining the reactivity of coke. Essentially, the test measures the amount of unreacted SiO gas passing through a 20 cu cm coke bed, heated to slightly above 1650°C. The ability of carbon in the reductant to react with SiO can thus be compared against a reactivity scale.

A typical scale is shown in Fig. 7. Next to charcoal, reductants such as Australian char and low-temperature carbonised semi-coke have reactivities that are suitable for ferrosilicon production.

Rising Cost

The ferrosilicon industry's dependency on charcoal is threatened. Ecological pressures of restricting and, perhaps, totally banning the use of charcoal seems to be on the increase. In fact, conservation of forest resources through legislative action is foreseen. Because procurement of charcoal is becoming more and more difficult, the escalating price is bound to push the price of ferrosilicon upwards.

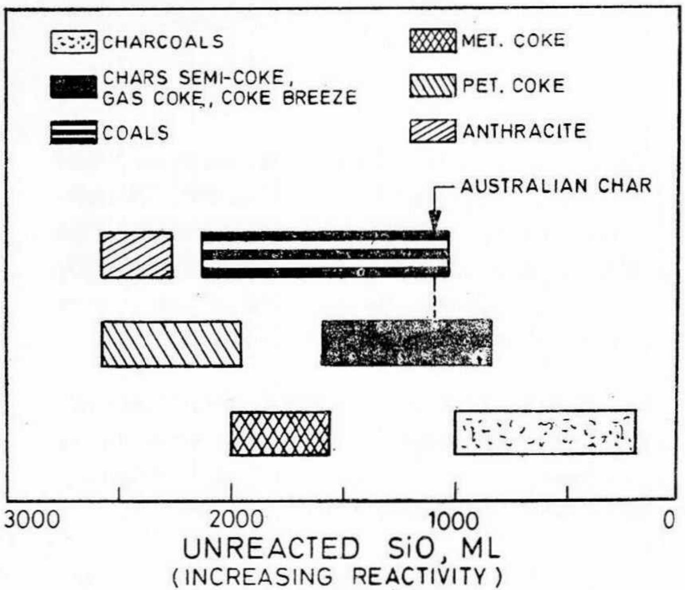

FIG. 7. SiO REACTIVITY SCALE

In the last six years (1977-83), the charcoal price per tonne has increased three-fold, from Rs. 512 to Rs. 1556, and the railway freight has increased more than two-fold, from Rs. 128 to Rs. 276. With an average landed cost of charcoal at Rs. 1556, the cost per tonne of alloy works out to Rs. 2131, representing 26% of the current selling price.

Even if the market adjusts to price changes, what concerns all ferrosilicon producers is how to find a substitute for charcoal. Is import the answer ? At current prices ranging from Rs. 1600 to Rs. 1900 per tonne of charcoal (63% F.C.), the equivalent landed cost at plant of imported coke or char with, say, 80% F.C. would have to be Rs. 2390 to Rs. 2838. After deducting inland freight with 5% transit loss the landed cost at port would have to be Rs. 2001 to Rs. 2428.

Since import of reductants seems inevitable in the absence of suitable indigenous substitute for charcoal, the Government should arrange duty-free import to make the commodity available at reasonable cost. It would also help in alleviating the burden of high inventory because of bulk imports.

Summary

The ferrosilicon industry is constrained by falling demand, poor productivity and escalating costs of both power and charcoal. Because of severe power shortage, the supply just meets the domestic demand. However, surplus production could arise under fortuitous power situation, requiring export. But more urgently, the fast diminishing availability of charcoal necessitates finding an appropriate substitute for sustaining production.

At this juncture the survival of the industry depends upon relief measures that the Government is prepared to grant. Hence, the latter should consider the following aspects with a sense of urgency :

i) Reduction of excise duty to stimulate the domestic demand.

ii) Stable power tariff for a fixed period of 10 years to avoid frequent price movements.

iii) Assured power supply to meet export commitments.

iv) Liberalised packing credit and export subsidy for full utilisation of installed capacity.

v) Duty free import of suitable reductant as a substitute for charcoal, and supply at a reasonable price to stabilize product price.

It is of vital importance that the Government takes an integrated approach to cure the industry's malaise and to ensure that it plays its destined role in supporting the country's iron and steel industry.

Acknowledgment

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References

1 Indian Iron & Steel — Statistical Bulletin Annual Volume 1981, Indian Institute of Metals.

2 The Indian Ferro Alloy Producers' Association (Private Communication).

3 Heinz H. Pariser, Ferro Alloy Statistics 1975 — 1980, Vol. I, 288.

4 N. K. De Sirkar, Seminar on Captive Power Generation, National Productivity Council, Calcutta, (1979).

5 V. P. Elyutin, Yu. A. Pavlov, B. D. Levin, E. M. Alekseev, Production of Ferroalloys — Electrometallurgy 2nd ed. (revised), The Israel Program for Scientific Translations Ltd. Jerusalem, (1961), 77.

6 Egil Ullebo, ILAFA — Int. Congress on Ferroalloys, Acapulco, Mexico, (1978).