8.0 Uses, Specifications, Consumption and Trade

8.1 INTRODUCTION

Iron (Fe) has been known since antiquity. Iron objects dating from the third millenium B.C. have been found although the international smelting of iron ores probably dates back to only about 1300 B.C. The prototype of the modern blast furnace was developed in the 14th century.

Iron is ubiquitous in the lithosphere as either a major constituent or in trace amounts. It is in almost every material in the earth's crust in which it constitutes about 5.1 percent or 51 kg/metric ton. In abundance, it ranks fourth, behind oxygen, silicon and aluminium.

Iron and iron ore are fascinating materials and have contributed greatly to the service of man. Early record shows occurrences of iron way back in 2000 B.C., during the Bronze Age, when copper was the most popular metal. This marked the beginning of the early Iron Age, when iron was first found in meteoric state. Native iron is rare but not unknown. It was a rare metal and was used only in small items of jewellery. Later, applications were made in dagger blades and swords. History of iron making appears to have begun around 1000 B.C. in Asia Minor, where the first record of smelting of iron ore appears. This knowledge of iron smelting travelled throughout the world between 1000 and 400 B.C., spreading the Iron Age. Smelting was done in primitive bowel furnaces which were no more than a hole in the ground. These furnaces were followed by bloomery furnaces to be later replaced by the shaft furnaces of today.

Early applications of iron continued to remain for swords, daggers, rods, etc. for quite some time till the advent of beams and structurals for use in construction. Early records show use of large wrought iron pillars and beams; these applications are recorded even in India. We have the famous wrought iron pillar in Delhi dated A.D. 300. Wrought iron beams were used in Konark dated the 13th century. Most early applications were confined to wrought iron to which was later added cast iron[1].

Iron is an essential component of the human body. A 70 kg adult male contains about 4 gm, 70 percent in the form of hemoglobin and about 26 percent in storage compounds ferritin and homosiderin.

By far, the most important use of iron is in the making of steel which is essentially an alloy of iron with small and carefully controlled amounts of carbon, plus many other elements, depending on end-use. Some steel is made from so-called sponge iron, obtained by direct reduction of beneficiated iron ores, thus bypassing the blast furnace.[2]

8.2 INDIAN HISTORY OF IRON AND STEEL

India is one of the earliest manufacturers and users of iron and steel in the world. This is indicated from a number of references available in the annals of metallurgical history. Literature survey reveals many documentary evidences, such as making of various surgical instruments in the 3rd/4th century B.C. by Sushrut, presentation of a gift of 30 lb of Indian iron by King Porus to Alexander the Great on the bank of Jhelum (around 326 B.C.) and the use of different weapons in various shapes and sizes in the ancient times. The famous Iron Pillar (A.D. 300) in Delhi is a glorious example of wonder

work of the past and challenge to the modern metallurgists of the present world. Another skilled achievement of Indian iron makers is the famous Damascus blades produced and exported from India over 1,000 years ago. Massive iron beam used in the construction of the Sun Temple, Konark in the latter half of the 13th century is another splendid example to confirm the early expertise.

Till the 18th century, iron and steel making in India was at par with that of Europe in the form of village crafts. The scene totally changed with the invention of the Bessemer Process in 1856 and the Basic Open Hearth Process in 1878. These developments led to significant increase in the world steel production from 0.5 Mt in 1870 to 28 Mt in 1900. In 1875, the Bengal Iron Works Co. constructed a blast furnace at Kulti for the manufacture of iron with coke.

The modern Indian steel industry owes to J.N.Tata who made pioneering efforts in setting up steel plant in 1907. The plant had a designed capacity to produce 125,000 tonnes of saleable steel per year. Pig iron and ingot steel were produced for the first time in 1911 and 1912, respectively. The plant achieved its rated capacity in 1916 and catered to the needs of steel during the World War I in a big way. The capacity was increased with the introduction of Duplex Process of steel making in 1924. The plant achieved peak production in 1942 when 839,000 tonnes saleable steel was produced.

In 1936, Indian Iron & Steel Company acquired Bengal Iron & Steel Co. The initial capacity of 2,70,000 tonnes/year was doubled with the addition of two basic Bessemer converters. These two companies merged in 1953 to become an integrated steel plant. In 1981, the Company started production at Hirapur near Asansol with two blast furnaces of 500 t/day.

Mysore Iron & Steel Works came into existence in 1918 with a charcoal blast furnace at Bhadrawati to produce 20,000 t/year of pig iron. This plant became a steel-making unit in 1936 when a 25-t open hearth was added with the introduction of one more open hearth. The plant achieved a capacity of 30,000 tonnes of saleable steel per year.

With these three plants, India produced around 1 Mt per year of finished steel and attained more or less self-sufficiency just prior to Independence in 1947.

After the Independence, in the First Five-Year Plan (1951-56), the finished steel production marginally increased from 1.07 Mt in 1951 to 1.25 Mt in 1955 by expanding the existing plants. In the Second Five-Year Plan (1956-61), the Government of India decided to raise the ingot steel capacity from 1.5 to 6.4 Mt by installing three integrated steel plants each with a capacity of 1 Mt/year of ingot steel, and by increasing the capacity of TISCO to 2 Mt per year and IISCO to 1 Mt per year. Accordingly, three public sector plants were erected with the foreign finance and technical assistance equipped with the latest technologies, under the company name Hindustan Steel Ltd.

These three steel plants were set-up to cater to different product needs of the country. Rourkela Steel Plant was the first with the West German collaboration for flat products. Bhilai was the second with Russian assistance for the production of rails, structurals and billets. Durgapur was the third with the aid of British Consortium for wheels and axles production.[3]

The present annual capacity of steel production from the integrated steel plants is placed at 17.45 Mt from the main producers and 7.78 Mt in the secondary sector by various processes.

8.3 USES

Iron ore is used mainly for making pig iron, sponge iron and steel. Iron and steel together form the largest manufactured products in the world and each of them enters into every branch of industry and is a necessary factor in every phase of our modern civilization.[4] Pure iron has relatively few and quite specialized uses. Ingot iron is galvanized for roofing, siding and tanks. In the form of corrugated pipe, it is used for culverts. Because of its relatively high purity, it is suited to oxyacetylene welding, both as material to be welded and as welding rod. It is used in vitreous enameling. Its good ductibility makes it suitable for deep-drawing operations as in the

manufacture of appliance parts, e.g. washing machine tub; relatively low electrical resistance and high magnetic permeability lead to its use in many types of electrical equipment, generator fields, magnetic parts of relays, magnetic brakes and clutches.

Iron ore is also used in ferro-alloy, cement, foundry, vanaspati and glass factories.

8.4 PROPERTIES

Iron is a part of the Eighth Group of the Periodic Table of elements. Its atomic number is 26 and atomic weight 55.847 $\pm$ 0.003. Pure iron is a white metal and it is one of the chemical elements. It must never found in nature in the form of the metal.

The physical and chemical properties of iron are difficult to define precisely because even small traces of other elements may have profound effects on these properties.

8.4.1 Physical Properties

The mechanical properties, e.g. tensile and yield strengths are particularly dependent on the presence and amount of minor impurities and for most purposes should be considered approximations.

One of the most distinguishing properties of iron is magnetism. In its strong magnetism in the presence of the magnetic field or an electric current, iron is superior to all other elements. With high quality iron, the magnetic influence produced through induction by the presence of the magnetic field of either a permanent magnet or an electric current disappears almost entirely upon removal of the magnet or the current. The presence of other elements in iron alloys, such as carbo, cobalt and nickel results in substantial increase in magnetic relativity. Iron when heated loses its magnetism and becomes paramagnetic at about 770° C.[2]

8.4.2 Chemical Properties

The Eighth Group of the Periodic Table of the elements consists of three trials: iron, cobalt and nickel comprised the first trial and the other two are made up of the six platinum group metals. This classification tends to overemphasis the similarity of the elements in the group. With the exception of a few compounds of ruthenium and osmium, none of the Group VIII elements exhibits the group valency and in fact the resemblence of iron, cobalt, nickel trial to the platinum group metals is more formal than real; the chemistry of iron is more like that of manganese, which precedes it in atomic number to ruthenium.

Iron exhibits five valencies of which 2^+ and 3^+ are by far the most important.

Valency 0 : In iron pentacarbonyl, $Fe(CO)_5$, the iron atom is assigned the formal valency of zero.

Valency 2 : Ferrous hydroxide is slightly amphoteric; it dissolves readily in acids, but also in concentrated sodium hydroxide. In ionic compounds, bivalent iron is somewhat more stable than trivalent. In the form of complexes, the trivalent state is more stable.

Valency 3 : Ferric hydroxide is basic and slightly acidic, the later giving rise to the ferrites.

Valency 4 : Iron non-acarbonyl, $Fe_2(CO)_9$; and the ferrates (IV), Sr_2FeO_4 and Ba_2FeO_4 represent this rare valency state.

Valency 6 : Under strongly oxidizing conditions, ferrates (IV) M_2FeO_4 (M = Monovalent) can be formed. They are isomorphous with the sulphates and are very strong oxidizing agents, but of little practical importance.

The metal dissolves readily in dilute mineral acids, very strong oxidizing media, such as concentrated nitric acid, or acids containing dichromate, passivate iron.

Iron reacts with the hologen to form ferric fluoride, chloride or bromide, the reaction with iodine proceeds only as far as ferrous.[2]

8.5 DIFFERENT TYPES OF IRON

Iron, as such-pure iron, does not exist as an article of commerce but in service and in the market, only in the form of cast iron, steel or wrought iron that is when contaminated with carbon and other impurities.

Iron and steel together form the largest manufactured products in the world and each of them enters into every branch of industry and is a necessary factor in every phase of our modern civilization.

8.5.1 Cast Iron

Cast iron, because of the ease with which it can be melted, is produced in final form. Cast iron is impure, weak and must be brought to its desired size and form by melting and casting in the mold. A typical mold contains about 94 percent iron, 4 percent carbon and 2 percent other ingredients or impurities.[4] Cast iron is usually made by melting steel scraps, cast iron, scraps, pig iron and ferro alloys.[2]

8.5.2 Malleable Cast Iron

It is the iron which when first made in cast in the condition of cast iron and is made malleable by subsequent treatment without fusion.[4] Malleable irons are cast as hazard and brittle white cast iron and then rendered tough and ductile by heat treatment. They are strong, tough, ductile, corrosion resistant, machinable and castable and find wide use in automotive and many other basic industries.[2]

8.5.3 Pig Iron

Pig iron is a raw form of cast iron and malleable cast iron is a semi-purified form.[4] Most pig iron is refined to make steel; some is used for the production of cast irons. Pig iron is the hot metal and main product of the blast furnace.

Cast iron which has been cast into pigs is different from that obtained in the blast furnace. This name is also applied to molten cast iron which is about to be so cast into pigs; or is in a condition in which it could readily be cast into pigs before it has ever been cast into any other form.

8.5.4 White Pig Iron and White Cast Iron

These are pig iron and cast iron in the fracture of which little or no graphite is visible so that the fracture is silvery and white.[4] White cast iron, the primary product, contains up to 6 percent carbon in combined form, mostly as iron carbide.

8.5.5 Molted Pig Iron and Molted Cast Iron

These are pig iron and cast iron, the structure of which is molted, with white parts in which no graphite is seen and gray parts at which graphite is seen.[4]

8.5.6 Gray Pig Iron and Gray Cast Iron

These are pig iron and cast iron in the fracture of which iron itself is nearly or quite concealed by graphite so that the fracture has the gray colour of graphite.[4]

8.5.7 Ductile Iron

Ductile iron, also called spheroidal graphite or S.G. iron or nodular iron, contains graphite in the form of rounded particles or spheroids instead of flakes or plates, characteristics of other graphite cast iron. Its properties make it useful in engine parts, such as crankshafts, wheels, and gears and many other applications requiring good castability, wear resistance, machinability and easy control of properties.[2]

8.5.8 Wrought Iron

Wrought iron is almost the same as the very low carbon steels except that it is never produced by melting and casting in the mold but is always forged to the desired size and form. It usually contains less than 0.12 percent carbon. Its chief distinction from the low carbon steels is that it is made by a process which finishes it in a pasty, instead of in a liquid form and leaves about 1 or 2 percent of slag, mechanically disseminated through it.[4]

It is slag-bearing, malleable iron which does not harden materially when suddenly cooled.[4]

The manufacture of steel is more centralized for economical reasons but is several times as great as that of cast iron. Wrought iron is less in amount than either of the others, but has its own importance and uses. These three products cast iron, steel and wrought iron together comprise the whole of so-called "ferrous" group of metals. They have two characteristics in common: first that iron is present in all to the extent of at least 92 percent and second that carbon is their next most important ingredient which regulates and controls their chief qualities.[4]

8.5.9 Sponge Iron

The manufacture of sponge iron requires non-coking coals or natural gas as reducing agents. Sponge iron is a very good substitute for scrap which is required by the electric arc furnaces or mini-steel plants.

Scraps are to be imported to meet the demand of secondary steel plant and it is hardly feasible due to paucity of forgein exchange.

Sponge iron has been used in electric arc furnaces of TISCO, HEC, ASP, Kulti Works and other places.[3]

8.5.10 Steel

Steel is more pure than cast iron, much stronger and may be produced in desired size and form either by melting and casting in a mold or by forging at a red heat. It usually contains 98 percent or more of iron and in different samples, from 1.5 percent down to almost no carbon, together with small amount of their ingredients or impurities.[4]

Steel is an iron alloy containing less than 2 percent carbon, it may contain major amounts of other metals added for specific purposes.[2] Broadly, three types of steels are categorized. They are Low, Medium and High Carbon Steels.

8.5.10.1 Low-Carbon Steel

These steels, sometimes referred to as mild steels, usually contain less than 0.25 percent carbon and therefore have microstructures that consist mostly of ferrite and small amounts of peartite. These steels are easily hot worked in the austerite condition and are produced in large tonnages for beams and other structural applications.

8.5.10.2 Medium-Carbon Steel

The medium-carbon steels contain between 0.25 and 0.70 percent carbon and are frequently used in the heat treated condition for machine components that require high strength and good fatigue resistance.

8.5.10.3 High-Carbon Steel

Steel containing more than 0.7 percent carbon is a special category because of its high hardness and low toughness. This combination of properties makes the high-carbon steel ideal for bearing application where wear resistance is important and the compressive loading minimizes brittle fracture that might develop on tensile loadings.

8.6 COMMERCIAL GRADES AND SPECIFICATIONS

8.6.1 Pig Iron

As the most important structural materials, iron and steel are the subjects of innumerable specifications that detail both the chemistry and physical and mechanical properties suitable for each end-use. The different grades of pig iron depend upon their contents of silicon, sulphur, phosphorus and manganese and further specify maximum limits for 16 additional elements.[2]

Depending upon grade and end-use, pig iron may contain from 0.5 to 3 percent silicon, sulphur up to 0.05 percent and manganese from 0.40 to 1.25 percent. Low phosphorus grades may carry 0.035 percent maximum while other grades allow phosphorus content up to 0.9 percent; carbon may be as high as 4.5 percent.[2]

8.6.2 Pure Iron

Ingot iron may be about 99.75 percent pure, its most important impurities are given below with the indication of typical concentrations.

Carbon	0.015 percent
Manganese	0.025 percent
Phosphorus	0.005 percent
Sulphur	0.025 percent
Silicon	Traces

Three specifications exist for reagent grade iron. The ACS specifies iron low in manganese and iron wire. The first has a manganese concentration of less than 0.002 percent while the iron content of the second (expressed as "reducing power") should be 99.90 percent minimum.

"Reduced iron" or ferrous reduction prescribes a minimum assay of 93 percent.[2]

Very pure iron is easily contaminated by handling and its investigation demands exacting precautions.[2]

TABLE 8.1 : TYPICAL COMPOSITION OF CAST IRON

Composition	White Iron	Malleable Iron	Gray Iron	Ductile Iron
Carbon, wt %	1.8-3.6	2.0-3.0	2.5-3.8	3.2-4.2
Silicon, wt %	0.5-2.0	0.6-1.3	1.1-2.8	1.1-3.5
Manganese, wt %	0.2-0.8	0.2-0.6	0.4-1.0	0.3-0.8
Phosphorus, wt %	0.18	0.15	0.15	0.08
Sulphur, wt %	0.10	0.10	0.10	0.02

element into the finished steel. They include

TABLE 8.2 : TYPICAL COMPOSITION OF HEAT-RESISTANT ALLOY CAST IRON

Composition	High-Si	High-Cr	High-Ni	High-Al
Carbon, Wt %	1.6-2.5	1.8-3.0	1.8-3.0	1.3-1.7
Silicon, wt %	4.0-6.0	0.5-2.5	1.0-2.7	1.3-6.0
Manganese, wt %	0.4-0.8	0.3-1.5	0.4-1.5	0.4-1.0
Nickel, wt %	--	0.5	14.30	--
Chromium, wt %	--	15-35	1.7-5.5	--
Copper, wt %	--	--	0-7	--
Molybdenum, wt %	--	--	0-1	--
Aluminium, wt %	--	--	--	18-25
Maximum service temp, °C	895	980	950	980

TABLE 8.3 : TYPICAL COMPOSITION OF CORROSION-RESISTANT CAST IRON

Composition	High-Si	High-Cr	High-Ni
Carbon, wt %	0.4-1.0	1.2-2.5	1.8-3.0
Silicon, wt %	14-17	0.5-2.5	1.0-2.7
Manganese, wt %	0.4-1.0	0.3-1.0	0.4-1.5
Nickel, wt %	--	0-5	14-30
Chromium, wt %	--	20-35	0.5-5.5
Copper, wt %	--	--	0-7
Molybdenum, wt %	0-3.5	--	0-4

8.6.3 Cast Iron

Typical composition of the various types of cast iron are listed in Tables 8.1, 8.2 and 8.3.

Because of their many end-uses, iron and iron alloys are the subjects of numerous specifications. Many of them specify only physical and mechanical properties and sizes.[2]

8.7 IRON ALLOYS

Iron is a major or minor constituents of countless alloys of industrial importance. The so-called ferro-alloys considered here are used in steel making to introduce the desired alloying ferro-silicon, ferro-manganese, ferro-chromium, ferro-vanadium, ferro-tungsten, ferro-molybdenum, ferro-titanium and ferro-boron. The most important iron alloy is steel.[2]

8.8 SPECIFICATIONS

As the raw materials of iron ore are used for different purposes, i.e. for making sinters and pellets or used in blast furnace or for making steel, the specifications depend on the users and on the basis of chemical analysis and sieve analysis. However, Table 8.4 gives the general idea of the approximate specifications of iron ore used by different steel industries.

TABLE 8.4 : GENERAL SPECIFICATIONS OF IRON ORE USED IN IRON & STEEL INDUSTRY

Unit	B.F.	S.M.S.	Fines (for sintering)	Source of Supply
1. Bhilai Steel Plant	Size = 10 to 50 mm. -10 mm = 10% max. (for Dalli mechanised mine 5% max) Fe = 63.0 ± 1.0%; Fe consistency = mean ±0.5% = 60% min. P per rake = 0.15% max. (As P content for the month should not exceed 0.1%)	Size = 50 to 100 mm -50 mm = 5% max. +100 mm = 5% max. Fe = 68.0 ± 1.0% P per consignment = 0.10% max SiO_2 = 3.0%	Size = 0 to 10 mm +10 mm = 5% max -3 mm = 55 to 65% -1 mm = 40% max Fe = 61.0 ± 1% SiO_2 = 4.0 ± 0.5% Fe consistency = mean ± 1% = 60% min P per rake = 0.18% max.	Rajhara, Dalli, Captive mines, M.P.
2. Bokaro Steel Ltd.	Sieve Analysis +60 mm = 0.28% -60 mm +40 mm= 12.65% -40 mm +25 mm= 24.04% -25 mm +10 mm= 50.51% -10 mm +5 mm= 12.52% Chemical Analysis Fe = 62.04%; SiO_2 = 1.85%; Al_2O_3 = 3.08%; Al_2O_3/SiO_2 = 1.66%	Size = 25 to 50 mm Fe = 63% SiO_2 = 1 to 2% Al_2O_3 = less than 3% P_2O_5 = 0.05% max. S = 0.03%	Size = 0.1 mm Fe = 60.5 + 1% SiO_2 = 2.5 ± 0.3% Al_2O_3 = 4.9 ± 0.5%	Captive mines, Kiriburu, Meghahatuburu
3. Durgapur Steel Plant	Size = 10 to 50 mm mesh Tolerance + 10%, with penalty 10.1 to 20%, and beyond 20% rejection. Fe: 60-65% P: 0.015% max Moisture: 3% max Al_2O_3/SiO_2 = 1.5% max $Al_2O_3+SiO_2$ = 6.5%	Size = 50 to 125 mm Tolerance +125 mm 10% -50 mm, 7 mm mesh, 2.5% Fe : 65% min. P = 0.5% Moisture dry basis: SiO_2 = 3% max; S = 0.02% max.	Size = 0 to 10 mm square Tolerance 10 mm = 10% Fe = 56% min. Al_2O_3 = 6% max. SiO_2 = 6% max. P = 0.15%	Bolani Ores Ltd.
4. Indian Iron & Steel Co. Ltd.	Size = -12 mm 16.66% Fe = 60.52% SiO_2 = 2.61% Al_2O_3 = 5.12%	---	---	Captive Mines from Gua, Manoharpur.
5. Kalinga Iron Works	Size = 10 to 40 mm Fe = 65% and above	---	---	
6. Rourkela Steel Plant	Size = 12 to 100 mm Fe = 58 to 60%; Al_2O_3 = 6% max.; SiO_2 = 6% max.; Al_2O_3 + SiO_2= 10% max. P = 0.15% max. Moisture = 3% max.	Size = 12 to 100 mm Fe = 63 to 65%; P = 0.05%; Al_2O_3 + SiO_2 = 7% max. S = 0.02% Moisture = 5%	Size = -9 mm Fe = 50 to 55%	Captive mines Barsua, Kalta.
7. Sandur Manganese & Iron Ores Ltd.	Size = 5 to 60 mm Fe = 66 to 68%	---	---	Bellary district, Karnataka
8. Tata Iron & Steel Co. Ltd.	Size = -50 to +10 mm; -10 to 100 mm; -50 mm Fe = 63.75 to 66.88%; SiO_2 = 0.82 to 1.69%; Al_2O_3 = 2.02 to 3.93%; P = 0.076 to 0.150%; Moisture = 4.13 to 8.54%	Size = -100 + 150 mm, -100 + 50 mm, +50 mm Fe = 67.71 to 68.60; SiO_2 = 0.68 to 0.79% Al_2O_3 = 0.69 to 1.39% P = 0.040 to 0.063%	N.A.	Noamundi, Joda East and Katamati.
9. Visvesvaraya Iron and Steel Co. Ltd.	Size = 10 to 25 mm. Fe = 62 to 63% max. Si = 5% max. Alumina = 2.5% max. The ore should be almost free from sulphur and titanium oxide.	Fe = 62 to 66% Al_2O_3 = 2 to 3.5% SiO_2 = 1 to 3%	N.A.	Mysore Minerals Ltd.

Source[9] : B.F. = Blast furnace
S.M.S.= Steel Melting Shop

P = 0·15
S = 0·02

Coal washeries use magnetite ores of 80% Fe_3O_4 min. specific gravity 4.75 min. and size -13 to 76 mm.[5] Magnetite content is 75 percent min. by weight and size -1.25 to 5.00 cm.[6] Moisture is less than 10 percent.[7]

8.8.1 Role of Impurities in Iron Ores

Cost-saving techniques of steel making require iron ores which are quite different from what were needed fifty years ago. Today, almost all blast furnace operators want tailored ore, such as sinters, pellets and calibrated lumps as furnace feed, mainly to effect economy in fuel consumption and to increase the productivity.

The broad specifications of the ores used by steel mills are discussed below:

8.8.1.1 Iron Content

Iron ore used should be as high a grade as possible. Experiments have proved that for an increase of 1 percent Fe in the burden, productivity increased by 2 percent while coke rate decreased by 3 percent. This is due to the smaller amount of slag formed.

Haematites are easier to reduce than magnetites in spite of the greater amount of oxygen combined with iron in haematite. Ores with high contents of iron silicate minerals have a low degree of oxydation and are difficult to reduce in the blast furnace.[8]

8.8.1.2 Silica

Silica is the most important gangue component in iron ore. Together with alumina, it is the main constituent of the acid slag produced during smelting. The amount of silica permissible in the ore is determined by the proper slag volume which in turn is determined primarily by sulphur in the charge and by the necessity of having a slag fluid enough to recover the molten iron.

It has been established that a decrease of about 1.5% in the silica content of the ore will produce a drop in slag volume of about 65 kg per tonne of pig iron. It has been estimated that an increase of 100 kg in the amount of slag per tonne of pig iron increases fuel consumption by about 40 kg of coke per tonne of pig iron.[8]

8.8.1.3 Alumina

The alumina content of the slag of a coke blast furnace should not be very low. About 10-15 percent alumina in the slag increases the fluidity of basic blast furnace slags and thus makes it possible to use a higher basicity, which facilitates the removal of sulphur.

If the ore is high in alumina, its content in slag may be as high as 25-30 percent. Such a slag requires a high temperature in the furnace to ensure the right fluidity and produces high-silicon pig iron for foundry and Bessemer processing as is the Indian practice. It is estimated that for every one percent reduction in the alumina content of the ore, the coke and flux rates decrease by 40 and 60 kg per tonne, respectively, and the consequent increase in production of pig iron would be about 2 to 2.5 percent.[8]

8.8.1.4 Alumina-Silica Ratio

More important than the above is the alumina-silica ratio which should be 1:1 to 1:1.5 with silica predominating; together they should be less than 5-6 percent and Al_2O_3 should not exceed 3 percent to provide an ideal blast furnace feed. Alumina percolates and segregates more into the fines when the aluminous ore is crushed and washed. Thus, the inherrent aluminosity of the fines gets enhanced instead of satisfying the siliciousness needed in the fines usable for pellet or sinter feed.

8.8.1.5 Size of Lumps

The current practice is to use closely sized lumpy ore, generally 10-50 mm. Studies carried out have shown that a percent decrease in the proportion of lumps larger than 35 mm in the burden corresponds to a decrease in the coke rate of approximately 2 kg/tonne and a percent decrease in fines of less than 6 mm leads to a decrease in the coke rate of 1 kg/tonne. Larger furnaces in Japan now use more than 8 mm and less 25 mm ore.[8]

8.8.1.6 Sinter Grade Fines

Sinter constitutes the bulk iron material in the blast furnaces. The quality of sinters depends mainly upon the quality of iron ore fines used

for making the sinters. Both the physical and chemical characteristics of fines are important criteria. Generally, fines with -10 to -100 mm with 10 percent 100 mm are required. The -5 mm tolerance is kept at 3 percent. The iron content is specified at -63 percent with tolerance limit of ±0.5 percent. Silica and alumina each should be 3 percent with a tolerance limit of ± 0.3 percent in each case. Phosphorus is expected to be around 0.05 percent.

8.8.1.7 Pellet Grade Fines

Pellets form the bulk iron material in the blast furnace in the USA and Canada. Its use in the Direct Reduction (DR) Process is on the increase. Pellets with iron content of around 65 percent are used in the blast furnaces whereas in DR Process such higher grade pellets called super-pellets are needed. These are basic pellets with high iron content plus 66 percent, low gangue, SiO_2 + Al_2O_3 3 percent; low sulphur and phosphorus 0.05 percent each and low alkalies. The pellet grade fines should be 100 mesh 95 percent and minus 325 mesh 60-75 percent. The iron content of the fines should be very high and gangue low to conform to the quality of pellets given above.[8]

8.8.1.8 Iron Ore Lumps

Over the years, the use of lumps in the blast furnaces has declined to the extent of about 20-25 percent of the blast furnace charge, the rest being sinters and pellets. The size of the lump ore feed has progressively narrowed down, 10-25 mm in case of Japanese steel mills to facilitate reaction and gas permeability. The -5 mm tolerance in lumps is around 3 percent although it is targeted at one percent in Japan. The iron content of the ore is 64 percent with a tolerance limit of ±0.05 percent. The permissible content of SiO_2 and Al_2O_3 is 3 percent each with a tolerance limit of ±0.3 percent in each case. Phosphorus should be particularly low, around 0.05 percent. Low decrepitation index (- 5 mm 3 percent) and low reduction degradation index (-5 mm 30 percent) are being demanded by the steel mills. If the lumpy ore does not meet such quality, it is crushed and fed to the sintering plant.

High grade calibrated ore contains less than 3 percent of gangue (SiO_2 + Al_2O_3) and SiO_2/Al_2O_3 ratio is uniform. Such ore found to be suitable for DR process using either coal or natural gas as reductant. The metallization obtained through DR process has been of the order of 94 to 95 percent and partial substitution of costly pellets may be achieved by using such ores.

8.8.1.9 Direct Use of Fines Iron Ores

Fines and super-fines are directly used without agglomeration in the Inred, Elred and plasmasmelt processes of iron making.

Specially calibrated iron ore fines have been found to be useful as high density aggregate for pipe coating. Such coated pipes are essential for the transport of crude oil from offshore wells.[8]

Micaceous haematite iron ore is used for welding rod and electrodes.[9] Micaceous iron ore is generally soft unctuous.[7]

The specifications of iron ore used for pipe coating and vegetable oil are given below :

(a) High density aggregates for pipe coating

(i) Proctor density - 200 lb/ft^3, with 2.5 percent tolerance

(ii) Specific gravity - 4.8 min. (specific gravity of fine ore of +67 percent Fe)

(iii) Moisture - 4 percent

(iv) Size -10 mm (max.) (75 to 95 percent below 5 mm)

(b) Hydrogenation of vegetable oil

i) Type of iron ore - Spathic iron ore ($FeCO_3$)

ii) Spongy structure

iii) Light yellow colour

iv) Should not sinter at below 1000^{0}C

v) Analysis-

LOI	-	27 to 29 percent
Fe_2O_3	-	60 percent
SiO_2	-	0.36 to 10 percent
CO_2	-	40.27 to 34.88 percent
Ca	-	Up to 1.29 percent

Mg - Up to 3.34 percent

vi) Size - 1 to 2.5"

vii) Should be strong and hard and free from lamination

8.8.1.10 Concentrates and Pellets

Soft and weathered ore containing on an average 38 percent Fe.

8.8.1.11 Export

i) Goan ore - lumps - 56 to 62 percent Fe
fines - 60 to 64 percent Fe

ii) Other than Goan Ore
Lumps - High grade - 65 to 67 percent Fe
Low grade - 63 to 65 percent Fe

8.8.1.12 Steel Making

There are no definite specifications of iron ore required by the steel-making industries. It entirely depends on the end-use. However, the requirements of the steel-making industries are given below plantwise.[10]

Steel Plant	Fe%	SiO_2 %	Al_2O_3 %	Size(mm)
DSP	62-63	2.5-3.5	4.5-5	10-50
IISCO	60-62	2.5	4.6	12-75
TISCO	64-65	SiO_2 + Al_2O_3	6% max	10-40
RSP	62-63	2.0-2.5	4.0-4.5	10-80
BSP	64-65	3.5-5.0	3.25-3.75	10-50
BSL	63-64	1.5-2.0	3.5-4.0	10-40

8.9 CONSUMPTION

Iron ore is mainly consumed in iron and steel industry for making pig iron and steel. In recent years, significant quantities are consumed by sponge iron units. Iron ore is also consumed by cement, alloy steel, ferro-alloys, etc. industries. Small quantity of iron ore (magnetite) is utilized by coal washeries for preparing the medium for gravity separation.

During 1989-90, total iron ore consumed by various industries was 20,146,000 tonnes. Out of this, about 95 percent, i.e. 19,106,000 tonnes iron ore was consumed by various iron and steel industries. But there was a slight decreasing trend continuously year after year which brought down the consumption to 87.64% only during 1993-94. Second main consumer of iron ore is sponge iron industry which consumed 2.7 percent of the total consumption or 554,000 tonnes during 1989-90. The consumption of iron ore in sponge iron industries is indicating a rising trend. It was 6.7 percent in 1990-91, against 2.7 percent during the previous year. In 1992-93, the consumption of iron ore was 2,364,000 tonnes which increased to 2,613,000 tonnes in 1993-94, constituting 9.63 percent of the total consumption. Cement industry was the third main consumer of iron ore accounting for about 2 percent of the total consumption or 392,000 tonnes. The consumption of iron ore in cement industry also gradually increased from 2 to 2.4 percent of the total consumption in 1993-94. In the year 1993-94, iron ore consumed by cement industry was 652,000 tonnes. Other consumers are coal washeries, ferro-alloys industry, alloy steel industry, foundries, etc.

During the year 1990-91, the consumption of iron ore in all industries at 22,235,000 tonnes was 10 percent above the consumption level during 1988-89.

The consumption of iron ore during 1992-93 at 25,785,000 tonnes was 5 percent more than consumption of 1991-92. The consumption of iron ore was 24,389,000 tonnes during 1991-92. The consumption of iron ore increased to 27,148,000 tonnes in 1993-94 which was again around 5 percent more than the consumption during 1992-93.

In Table 8.5, industrywise, yearwise consumption of iron ore is given.

The production capacity of India in case of iron ore is 84 Mt whereas only 67 Mt of iron ore was produced in 1995-96. The industry is heavily dependent on export orders. The production of iron ore mines from Bihar, Madhya Pradesh and Orissa meets the need of export as well as domestic steel plants, whereas the production from Goa and Karnataka is mainly exported.[11]

Details of the consumption of iron ores are given below for the prime three consumers, i.e. iron and steel, sponge iron and cement industries.

TABLE 8.5 : CONSUMPTION OF IRON ORE[1] FROM 1988 TO 1993-94 (BY INDUSTRIES)

(Qty in tonnes)

Name of Industry	1988	1989-90	1990-91	1991-92	1992-93	1993-94(P)
All Industries	19,331,000	20,146,000	22,235,000	24,389,000	25,785,000	27,148,000
Iron & Steel	18,679,000(9) [96.63]	19,106,000(9) [94.84]	20,221,000(9) [90.94]	21,521,000(9) [88.24]	22,805,000(9) [88.44]	23,794,000(9) [87.64]
Sponge Iron	301,000(3) [1.55]	554,000(5) [2.75]	1,509,000(6) [6.79]	2,287,000(6) [9.18]	2,364,000(7) [9.17]	2,613,000(9) [9.63]
Cement	275,000(65) [1.42]	392,000(61) [1.94]	408,000(59) [1.83]	486,000(57) [1.99]	523,000(54) [2.03]	652,000(62) [2.40]
Coal Washery[2]	50,000(17) [0.26]	53,000(16) [0.26]	60,000(16) [0.27]	60,000(16) [0.25]	60,000(15) [0.23]	60,000(15) [0.22]
Ferro-alloys	11,000(9) [0.06]	27,000(9) [0.13]	23,000(9) [0.10]	19,000(13) [0.08]	20,000(9) [0.07]	16,000(11) [0.06]
Alloy-Steel	5,000(16) [0.02]	4,000(14) [0.02]	4,000(14) [0.02]	3,000(11) [0.01]	3,000(10) [0.01]	3,000(11) [0.01]
Others (foundry, non-ferrous, metallurgy, electrode,etc.)	10,000(19) [0.05]	10,000(21) [0.05]	10,000(20) [0.04]	13,000(21) [0.05]	10,000(21) [0.04]	10,000(21) [0.04]

Figures rounded off. [] indicates the percentage.
Figures in parentheses denote the number of units in organised sector reporting consumption.

[1] Does not include magnetite concentrates 1,642,000; 1,918,447; 1,877,000; 2,664,000 ; 2,026,000 and 2,585,000 tonnes consumed in the production of pellets during 1988 to 1993-94, respectively, which are mainly exported.

Despatches of pellets to one sponge iron plant during 1990-91 and 1991-92 were 170,000 and 424,000 tonnes , respectively.
(P) - Provisional [2]Magnetite.
Source - Indian Bureau of Mines.

TABLE 8.6 : PLANTWISE CONSUMPTION OF IRON ORE IN IRON AND STEEL INDUSTRY

(Quantity in tonnes)

Sl.No.	Unit	1988	1989-90	1990-91	1991-92	1992-93	1993-94(P)
1. Bhilai Steel Plant, Bhilai	BF	2,309,000	2,787,000	2,599,000	3,048,000	3,140,000	3,277,000
	SMS	155,000	133,000	95,000	102,000	87,000	97,000
2. Bokaro Steel Plant, Bokaro	BF	1,969,940	2,034,595	1,733,579	1,573,869	1,641,803	1,506,758
3. Durgapur Steel Plant, Durgapur	BF	1,101,549	1,032,399	1,032,399	847,855	574,956	637,000
	SMS	134,164	110,059	110,059	106,373	63,736	39,000
4. IISCO, Barhanpur	BF	1,208,700	1,028,049	1,047,604	1,227,671	1,275,943	1,211,904
	SMS	36,798	55,404	42,971	46,231	43,357	38,070
5. Kalinga Iron Works, Orissa.	BF	177,929	162,763	177,005	178,988	182,871	182,871
6. TISCO, Jamshedpur	BF	2,283,074	1,612,314	1,582,719	1,582,719	1,410,000	1,478,494
	SMS	154,644	102,101	129,859	129,859	130,000	154,026
7. Rourkela Steel Plant, Rourkela	BF	1,362,478	1,244,355	1,097,830	1,018,380	1,126,004	938,295
	SMS	698	221	81	--	25	10
8. VISL, Bhadravati	BF & SMS	5,026	77,354	68,323	76,567	25,694	261
9. V.S.P., Vishakha-patnam, A.P.	BF & SMS	--	14,800	207,300	460,670	680,220	895,840

BF - Blast Furnace SMS - Steel Melting Shop (P) - Provisional
Source : Indian Bureau of Mines.

8.9.1 Iron and Steel Industry

In India, consumption of steel per capita is 20 kg; however, a study on the steel consumption by a group of experts in India, has shown that nearly 90 percent of steel consumed in India is directly or indirectly consumed by about 15 percent population. It is derived that 129 million Indians consumed 13.5 Mt steel during 1992-93 which makes the steel consumption 105 kg per capita. The balance 85 percent population did not have purchasing power to go in for steel consuming activities like housing or for steel-based industrial items.[12]

Iron ore is mainly consumed in iron and steel industry for making pig iron and finished steels. In recent years, significant quantities are consumed by sponge iron units. During 1989-90, about 20 Mt iron ore was consumed in different industries. The share of iron and steel was 95 percent during the year.[13]

There are nine main industries of iron and steel in India. Table 8.6 shows the iron ore consumption during 1988 to 1993-94 by these industries. From the Table, it is derived that Bokaro Steel Plant, Bhilai Steel Plant, Tata Iron & Steel Co. Ltd. and Vishakhapatnam Steel Plant consumed the major part of the total consumption of iron ore during 1992-93. The total consumption of iron ore during 1992-93 at 25 Mt was 33 percent more than consumption during 1988 and 28 percent more than that during 1989-90. The consumption of iron ore increased to 27,148,000 tonnes in 1993-94 which was 5 percent more than the consumption during 1992-93.

The iron ore was mainly used in blast furnaces, and sintering and pelletizing plants.

8.9.1.1 Pelletization

Pellets were first commercially introduced when the rich iron deposits of the Mesobi range in America were exhausted in the sixties and inferior grades of iron ore had to be used.[1]

The use of pellets as feed in the blast furnace has several advantages because of their uniform size, known composition and strength.

In India, there are four pelletization plants which produce BF grade pellet. A plant located at Naomundi in Bihar is owned by TISCO and two are located in Goa, one owned by M/s. Chougule and Co. and other by M/s. Mandovi Pellets Ltd. The fourth pelletization plant located at Mangalore is owned by M/s. Kudremukh Iron Ore Co. Ltd.

Out of these, only pelletization plant of M/s. Kudremukh Iron Ore Ltd. is working presently. The other three are closed mainly due to increase in prices of furnace oil required by them.

A pelletization plant of M/s. Mandovi Pellets Ltd., which is 100 percent export-oriented, is to be reopened due to great demand of B.F. grade pellets.

The pellet plant of KIOCL completed in 1987 has a capacity of 3 Mt per year to produce DR grade pellets suitable for making sponge iron. These pellets have an excellent export market and are being regularly exported to different countries of the world. During the year 1989-90, Kudremukh plant exported about 3.4 Mt of concentrates and 1.95 Mt of pellets valued Rs. 174 crores.[13]

8.9.1.2 Sintering

Pellets along with sinter resulted in growth of grade of iron ore fines and blue dust.

In India, there are nine integrated steel plants; all plants have their own sintering plants except The Indian Iron and Steel Co. The total sintering capacity during 1995 was 26.21 Mt.[13] These plants received the raw material mostly from their captive mines.

The list of the sintering and pelletization plants along with their capacity is given in Table 8.7.

8.9.1.3 Sponge Iron

Manufacture of iron requires non-coking coals and natural gas as reducing agents. Sponge iron is a very good substitute for scrap which is required by the electric arc furnaces or mini-steel plants in the country. The scrap has to be imported which can be substituted by sponge iron to a large extent.

There are nine sponge iron operating units. Table 8.8(A) shows the list of sponge iron units along with their capacity. Eleven new sponge

TABLE 8.7 : CAPACITY OF SINTERING AND PELLETISING PLANTS

Sl.No.	Name of the Unit	Installed Capacity
1.	Bhilai Steel Plant	5,177,000
2.	Bokaro Steel Plant	6,914,000
3.	Chowgule & Co.Ltd., Pale (Pellet)	550,000
4.	Durgapur Steel Plant	1,500,000
5.	Kalinga Iron Works (Sinters)	18,000
6.	Kudremukh Iron Ore Co.Ltd.	3,000,000
7.	Mandovi Pellets Ltd. (Pellets)	1,800,000
8.	Rourkela Steel Plant	1,200,000
9.	Tata Iron & Steel Co.	800,000
10.	Visvesvaraya Iron & Steel Co.(Ordinary sinters)	5,256,000

Source : Indian Minerals Year Book 1994
Vol II, Indian Bureau of Mines, Nagpur.

iron units are coming up in near future. Table 8.8(B) shows the unitwise consumption of iron ore in sponge iron plants.

8.9.2 Cement Industry

Iron ore used in cement industry improves burning properties, imparts colour and balances the composition of the mix. Iron ore lumps, powder and blue dust used by cement industry have Fe contents +58 percent.

During the year 1989-90, sixty-one units consumed about 392,000 tonnes of iron ore (1.94 percent of the total consumption) which increased to 652,000 tonnes in 1993-94. (2.4 percent of the total consumption).

8.9.3 Coal Washeries

Iron ore (magnetite) is used in coal washeries for the preparation of heavy media.

There are nineteen coal washeries which include four owned by the Bharat Coking Coal Ltd., two by TISCO, four by Central Coal Fields Ltd., two by Western Coal Fields Ltd., four by Central Coal Washing Organisation, and one each by Durgapur Steel Plant, IISCO and Durgapur Project Ltd. On an average, 555 g magnetite is required for a tonne of coal washed.[7]

The consumption of iron ore in coal washeries during the year 1980 was 40,000 tonnes which reached in 1989-90 to 53,000 tonnes. There were total sixteen coal washing units in 1989-90. In the year 1993-94, there were fifteen coal washing units which consumed 60,000 tonnes iron ore and it was only 0.22 percent of the total consumption.

8.10 IMPORT AND EXPORT

India produced 67 Mt iron ore during 1995-96. The domestic consumption was less and thus the remaining production is exported after meeting the domestic requirement.

8.10.1 Import

Occasionally, iron ore pellets are imported from Behrain and Malaysia. Such imports were 81,000 tonnes during 1989-90 which increased to 114,000 tonnes in 1990-91. It was considerably decreased thereafter to 74,000 tonnes in 1991-92 and further down to 27,000 tonnes in 1992-93. The imports of iron ore pellets were 164,000 tonnes during 1993-94 which increased to 1,523,000 tonnes in 1994-95.

During the years 1987-88 and 1988-89, there were no imports of iron ore pellets. Iron and steel scraps imported during 1985 were 1,600,000 tonnes which increased to 2,225,000 tonnes during 1988.[14]

8.10.2 Export

After meeting the domestic requirement, the remaining production of iron ore is exported to various countries. The important centres from which iron ore is marketed for internal consumption and for exports apart from the captive sources of the steel plants are Hospet (Karnataka), Redi(Maharashtra), Marmugao (Goa) and Barajamda-Barbil-Banspani (Bihar-Orissa).

In the year 1988-89, iron ore export was 33 Mt; 17 percent higher than the previous year. This further rose by 6.9 percent, i.e. up to 35.34 Mt during 1989-90. But during next three years, the export of iron ore came down to 22.16 Mt during 1992-93, which was the lowest in the decade. However, during 1993-94, the export of iron ore at 26.85 Mt showed 21 percent rise over the previous year. During 1994-95, exports at 26.06 Mt was 3 percent less than that in the previous year.

TABLE 8.8(A): SPONGE IRON PLANTS

Name	Location	Type	Capacity in tonnes	Remarks
1. Essar Gujarat	Hazira Gujarat	Gas	1,760,000	Operating
2. Grasim India Ltd.	Raigad (M.S.)	Gas	600,000	-do-
3. Sponge Iron India Ltd.	Kothagudem	Coal	60,000	-do-
4. Orissa Sponge Iron Ltd.	Orissa	Coal	100,000	-do-
5. Bihar Sponge Iron Ltd.	Chandit	Coal	300,000	-do-
6. Ipitata	Joda, Orissa	Coal	120,000	-do-
7. Sunflag	Bhandara (M.S.)	Coal	300,000	-do-
8. Bellary Ispat*	Bellary (Karnataka)	Coal	60,000	-do-
9. Hindustan Electro Graphite	Borai (M.P.)	Coal	450,000	-do-
10. Jindal Strips Ltd.	Raigad (M.S.)	Coal	400,000	-do-
11. Nippon Denro Ispat Ltd.	-do-	Gas	1,000	Under erection
12. Usha Rectifier Ltd.	Jagdishpur	Gas	1,000	-do-
13. Kalinga Steels	Raigad (M.S.)	Gas	750,000	-do-
14. Tamil Nadu Sponge	Salem (T.N.)	Coal	30,000	-do-
15. Gold Star	Vizianagaram (A.P.)	Coal	440,000	-do-
16. Prakash Industries Ltd.	Champa (M.P.)	Coal	375,000	-do-
17. Nova Iron Steel	Champa (M.P.)	Coal	150,000	Under developing stage
18. Monnet Ispat Ltd.	Raipur (M.P.)	Coal	300,000	-do-
19. Kumar Metallurgical Corpn.	Nalgonda (A.P.)	Coal	60,000	-do-
20. Raipur Steels	Raipur (M.P.)	Coal	30,000	-do-
21. Vandana Ispat Ltd.	Raigarh (M.P.)	Coal	75,000	-do-

* Presently not in operation

Source : Indian Bureau of Mines, Nagpur

TABLE 8.8(B): UNITWISE CONSUMPTION OF IRON ORE IN SPONGE IRON PLANTS

(in tonnes)

Unit	1989-90	1990-91	1991-92	1992-93	1993-94
1. Bihar Sponge Iron Ltd., Singhbhum	145,420 (26.26)	145, 420 (9.63)	145,420 (6.36)	145,420 (6.15)	145,420 (5.61)
2. Ipitata Sponge Iron Ltd., Joda Distt.Keonjhar.	98,477 (17.78)	89,762 (5.95)	133,761 (5.85)	143,295 (6.06)	160,380 (6.19)
3. Orissa Sponge Iron Ltd., Distt.Keonjhar	132,000 (23.84)	129,221 (8.56)	142,184 (6.21)	137,794 (5.83)	149,083 (5.75)
4. Sponge Iron India Ltd., Paloncha, Distt. Keonjhar	102,743 (18.55)	100,423 (6.65)	99,600 (4.35)	80,682 (3.41)	95,318 (3.68)
5. Sunflag Iron &Steel Co.Ltd. Distt. Bhandara	75,100 (13.56)	157,527 (10.44)	189,478 (8.28)	189,478[e] (8.02)	189,478[e] (7.31)
6. Essar Gujarat Ltd., Dist. Surat Gujarat	--	886,880 (58.76)	1,577,000 (68.94)	1,577,000[e] (66.72)	1,577,000[e] (60.85)
7. HEG Ltd.	--	--	--	89,846 (3.80)	89,846[e] (3.47)
8. Jindal Strips Pvt.Ltd.	--	--	--	--	184,924 (7.13)
Total	553,740	1,509,233(6)	2,287,443(6)	2,363,515(7)	2,591,449(8)

(e) : Estimated

Figures in parentheses indicate the percentage in the total consumption.

Source : Indian Bureau of Mines, Nagpur.

Table 8.9 shows the total iron ore exported during 1987-88 to 1994-95.

(i) Export of Iron Ore Lumps (below 60% Fe including black iron ore containing up to 10% Mn): A quantum of 2.4 lakh tonnes of this grade of iron ore was exported in 1988-89, which decreased to 1.9 lakh tonnes during 1989-90 but in 1990-91 the export of this grade increased to 2.1 lakh tonnes. However, this rising trend could not continue further in 1991-92 and it again decreased to 1.9 lakh tonnes. During 1992-93, export of this grade was 2.6 lakh tonnes which slightly decreased to 2.2 lakh tonnes in 1993-94. The record exports of 7.4 lakh tonnes was achieved in 1994- 95 (Table 8.10).

(ii) Export of Iron Ore Fines (62% Fe and above): Table 8.11 shows that export of this grade of iron ore was 10.17 Mt to 13.42 Mt, during 1990-91 to 1994-95 period. The highest export of this grade was in 1990-91 when 13.42 Mt was reported but it decreased to 10.97 Mt in 1991-92. There was rise in 1992-93 and 1993-94 when the exports were 11.88 Mt and 12.03 Mt, respectively. In the year 1994-95, the export of this grade was 10.17 Mt.

(iii) Export of Iron Ore Fines (below 62% Fe) : Table 8.12 shows the countrywise export of this grade during 1990-91 to 1994-95. It is seen that the export of this grade was ranging between 2.03 Mt and 2.45 Mt. In the

TABLE 8.9 : EXPORTS[16] OF IRON ORE (TOTAL) FROM 1987-88 TO 1994-95

(Qty. in '000 tonnes Value in Rs.'000)

Year	Quantity	Value
1987-88	28,226	554,48,78
1988-89	33,041	673,09,02
1989-90	35,341	927,57,03
1990-91	32,492	1,049,13,29
1991-92	29,514	1,435,38,59
1992-93	22,168	1,104,08,65
1993-94	26,857	1,373,67,46
1994-95	26,062	1,297,63,18

TABLE 8.10 : EXPORTS[16] OF IRON ORE LUMPS FROM INDIA (BELOW 60% Fe INCLUDING BLACK IRON ORE CONTAINING UP TO 10% Mn

(Quantity in Tonnes; Value in Rs. '000)

Country	1990-91		1991-92		1992-93		1993-94		1994-95	
	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value
China, Republic of	--	--	--	--	24,973	100,67	--	--	--	--
Italy	--	--	--	--	--	--	--	--	--	--
Japan	192,500	387,52	144,801	582,97	203,984	595,59	221,642	10,84,53	726,738	25,81,02
Korea, Dem. Rep.	--	--	--	--	--	--	--	--	--	--
Korea, Rep. of	--	--	7,231	40,64	31,718	106,69	--	--	--	--
Malaysia	--	--	11,960	59,84	--	--	--	--	23,000	1,11,48
Romania	26,182	93,60	--	--	--	--	--	--	--	--
Spain	--	--	34,000	49,75	--	--	--	--	--	--
Total	218,682	481,12	197,992	733,20	260,675	802,95	221,642	10,84,53	749,738	26,92,50

year 1990-91, the export was 2.2 Mt which decreased slightly to 2.03 Mt in 1991- 92. In 1992-93, the export of this grade was 2.18 Mt which rose to 2.45 Mt but again fell to 2.05 Mt in 1994-95.

(iv) Export of Iron Ore Lumps (60% Fe and above) : The countrywise export of this grade during the period 1990-91 to 1994-95 is given in Table 8.13 which shows that the export of this grade during 1990-91 was 11.4 Mt but export decreased to 10.39 Mt in 1991-92. There was a sudden fall in export of this grade of iron ore in 1992-93 when only 3.1 Mt was exported. However, there was a rise in 1993-94 and 1994-95 when 6.8 Mt and 8.1 Mt were exported.

(v) Export of Agglomerated Iron Ore Pellets : Table 8.14 showing countrywise export during 1990-91 to 1994-95 indicates that it was almost steady during the period and not with much fluctuations. In the year 1990-91, the export was 1.29 Mt which slightly rose to 1.35 Mt in 1991-92, a record export. But the export decreased to 1.23 Mt in 1992-93 and in 1993-94 it remained almost at the same level, i.e. 1.22 Mt. There was a marginal rise in 1994-95 when it was 1.27 Mt.

(vi) Export of Iron Ore Concentrates : Total export of concentrates in the year 1990-91 was 3.89 Mt which rose to 4.47 Mt in the year 1991-92. In the year 1992-93, the export of concentrates at 3.41 Mt was 24 percent less than that in the previous year. However, the export rose to 4.10 Mt in the year 1993-94. The export of concentrates was 3.65 Mt in 1994-95. The countrywise export of iron ore concentrates is shown in Table 8.15.

8.11 TRADE

World production of iron ore grew at about 3.7 percent per annum from 1960-75, stagnated between 1975 and 1979 and decreased by about 7.9 percent per year between 1979 and 1983.

There is presently substantial excess world iron ore capacity. The world's production of iron ore during 1983 was 739 Mt which reached 970 Mt in 1994.

In India, the production of iron ore was 41 Mt in 1981, which gradually rose to 44 Mt in 1985 and further to 50 Mt in 1990. During the year 1994-95, the production of iron ore was 64.5 Mt in India.

Total world apparent consumption of iron ore grew at an annual average rate of 3.9 percent per year from 1960-70. Growth slowed to 1.2 percent per annum from 1970-80 and consumption declined by 2.9 percent per annum between 1980 and 1983. However, in India and other developing countries, the rising trend was recorded from 1988 to 1992-93.

Iron ore is not traded on commodity exchanges and most of the trade is by way of long-term contracts. Nearly 85 percent of the international trade is covered by such long-term

TABLE 8.11 : EXPORTS[15] OF IRON ORE FINES FROM INDIA (62% Fe AND ABOVE)

(Quantity in Tonnes, Value in Rs. '000)

Country	1990-91		1991-92		1992-93		1993-94		1994-95	
	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value
Australia	--	--	--	--	67,000	345,62	--	--	--	--
Belgium	--	--	100,000	333,05	185,000	670,63	108,500	396,22	167,618	655,57
Chinese Taipei	76,996	222,17	--	--	38,500	164,11	38,500	162,44	--	--
China, Republic of	--	--	163,802	720,36	1,101,566	48,04,47	1,368,678	58,95,33	1,563,694	68,08,79
Cyprus	--	--	10,043	22,60	--	--	--	--	--	--
France	36,500	155,00	345,741	15,82,14	155,709	602,02	104,695	400,52	--	--
German Dem.Rep.	--	--	--	--	--	--	--	--	--	--
German Fed.Rep.	--	--	--	--	--	--	--	--	53,820	232,25
Hong Kong	--	--	--	--	--	--	--	--	--	--
Hungary	--	--	--	--	--	--	--	--	--	--
Iraq	--	--	--	--	--	--	--	--	--	--
Italy	327,000	678,27	125,000	355,15	109,471	412,65	195,719	624,96	98,831	318,50
Japan	9,009,724	252,46,39	7,57,2,433	31,73,87	8,147,435	422,32,14	7,617,243	362,46,19	5,774,992	26,469,89
Jordan	--	--	--	--	--	--	--	--	--	--
Korea Dem.Rep.	199,536	647,38	93,984	503,04	--	--	264,550	14,41,48	--	--
Korea, Rep of	1,687,802	62,10,54	1,420,338	65,09,75	1,301,364	56,22,34	1,317,516	60,63,15	1,916,453	93,83,59
Kuwait	--	--	--	--	--	--	--	--	--	--
Liberia	--	--	--	--	--	--	--	--	--	--
Malaysia	--	--	--	--	--	--	26,500	141,95	--	--
Nepal	1,378	2,80	2,883	7,38	1,450	3,19	1,969	4,33	2,503	22,36

Table 8.11 (Concld.)

Netherlands	743,501	18,07,40	491,602	17,08,03	426,471	16,40,50	300,348	10,10,48	245,074	760,55
New Zealand	--	--	--	--	--	--	--	--	--	--
Norway	--	--	--	--	--	--	--	--	--	--
Oman	--	--	--	--	--	--	--	--	--	--
Pakistan	345,757	11,35,34	334,716	16,75,91	188,910	928,01	494,146	26,55,37	17,29,14	790,88
Panama Rep.	--	--	--	--	--	--	--	--	--	--
Philippines	--	--	42,360	95,31	--	--	--	--	--	--
Portugal	--	--	56,000	184,14	51,812	205,30	124,988	373,33	45,140	147,97
Romania	957,450	19,12,12	50,873	109,48	83,145	347,43	--	--	--	--
Thailand	--	--	--	--	--	--	--	--	95,970	517,06
Turkey	--	--	--	--	--	--	45,592	199,63	--	--
United Arab Emirates	44,305	150,92	52,500	278,78	31,587	243,54	27,371	159,13	37,211	359,77
United Kingdom	--	--	116,000	274,44	--	--	--	--	--	--
USSR	--	--	--	--	--	--	--	--	--	--
Total	13429949	3816833	10978275	1753343	11889420	5822195	12036315	5577451	10174220	4646718

TABLE 8.12 : EXPORTS OF IRON ORE FINES (BELOW 62% Fe) FROM 1990-91 TO 1994-95

(Qty in tonnes)
(Value in Rs. '000)

Country	1990-91		1991-92		1992-93		1993-94		1994-95	
	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value
Belgium	--	--	--	--	--	--	--	--	--	--
China, Republic of	--	--	--	--	55000	20676	33577	13910	491	184
Cyprus	--	--	--	--	--	--	--	--	--	--
France	--	--	--	--	--	--	138980	48442	36555	10166
Italy	1044000	231991	855461	274657	902164	335793	1317349	448159	796394	272633
Japan	1096900	253251	882945	287214	763345	282651	395199	148169	491242	177593
Kenya	--	--	--	--	--	--	--	--	19805	5481
Korea, Dem.Rep.	--	--	--	--	--	--	--	--	--	--
Korea, Rep.of	--	--	--	--	403055	154706	205759	75381	19818	8405
Kuwait	--	--	--	--	--	--	--	--	--	--
Netherlands	--	--	--	--	--	--	--	--	148500	50705
Liberia	--	--	--	--	--	--	--	--	--	--
Nepal	--	--	--	--	127	45	--	--	--	--
Philippines	--	--	--	--	--	--	--	--	--	--
Portugal	--	--	--	--	--	--	--	--	45405	13776
Romania	--	--	--	--	--	--	103727	38014	393918	127948
Singapore	--	--	110000	28970	--	--	--	--	--	--
Spain	--	--	102290	44837	33508	10241	82132	16508	--	--
United Arab Emirates	60400	11836	85595	26131	22832	6679	175880	51994	101431	29358
United Kingdom	--	--	--	--	--	--	--	--	--	--
USSR	--	--	--	--	--	--	--	--	--	--
Yugoslavia	--	--	--	--	--	--	--	--	--	--
Total	2201300	497078	2036291	661809	2180031	81071	2452603	839577	2053559	696249

contracts with duration extending from two to three years up to ten to fifteen years. Many steel producing countries have also chosen to invest in mines in ore producing countries; for example, Germans owning mines in Brazil and the Japanese in Australia.

There are also short-term contracts of one year duration but these are more prevalent amongst the European consumers. A very small proportion of trade is conducted on on-spot basis only to take care of some sudden additional demand.

During the last few years, counter trade is featuring in the iron ore trade and there has been particular interest to trade among the Eastern Europe, Russia and the rest of the western world. With the opening up of trade between Eastern Europe and Russia, it is expected that some new developments will take place especially, as the ore quality in Russia and Eastern Europe is relatively poor, average Fe content, being only 45-46 percent, will be sought to be improved.

Commercial services are extremely important in a long-term relationship between the seller and the buyer. These services cover a number of activities, such as correct contract negotiation, administration, provision of efficient and flexible delivery programmes, smooth handling of claims, arising from quality variations or other deviation from the agreed contract and fair negotiating practices.

TABLE 8.13 : COUNTRYWISE EXPORTS OF IRON ORE LUMPS (60% Fe AND ABOVE) FROM 1990-91 TO 1994-95

(Qty in tonnes)
(Value in Rs. '000)

Country	1990-91		1991-92		1992-93		1993-94		1994-95	
	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value
Australia	83877	42329	--	--	36000	31266	81000	65797	137940	114203
Austria	--	--	23000	18117	--	--	41000	34870	--	--
Belgium	--	--	--	--	--	--	--	--	--	--
Chinese Taipei	655105	211085	722015	414588	44425	23529	160155	129166	333140	199690
China, Republic of	695	253	92367	43592	356960	161394	453191	279805	733933	479777
Cyprus	--	--	--	--	--	--	--	--	--	--
Czechoslovakia	27936	16114	--	--	--	--	--	--	--	--
German Dem.Rep.	--	--	--	--	--	--	--	--	--	--
German Fed.Rep.	105483	37982	--	--	--	--	--	--	--	--
Greece	3220	1341	--	--	--	--	--	--	--	--
Hungary	179240	92769	56936	40677	--	--	--	--	--	--
Indonesia	82316	50587	41410	31866	--	--	101580	97114	60000	57350
Iraq	--	--	--	--	--	--	--	--	--	--
Iran	--	--	--	--	--	--	129200	72668	49009	44596
Italy	86500	28469	114000	48201	413061	205444	534183	240511	307321	129694
Japan	7886545	2987440	7196193	4149322	2225563	1206701	4416104	2728655	5387426	3015631
Korea Dem.Rep.	492855	196502	422619	239850	--	--	147774	88772	--	--
Korea, Rep.of	1375694	545862	1344167	770245	24174	9352	322170	190145	640042	334516
Kuwait	29000	9123	--	--	--	--	--	--	--	--
Malaysia	52000	22901	13421	6715	54275	26185	66307	34662	72500	35946
Nepal	--	--	53	12	2028	446	--	--	--	--

Table 8.13 (Concld.)

Netherlands	--	--	47500	21611	--	--	--	--	--	--
Oman	--	--	--	--	3500	1474	--	--	--	--
Pakistan	72624	25291	71512	40177	--	--	61100	32739	146000	74368
Panama Rep.	--	--	--	--	--	--	--	--	--	--
Philippines	--	--	--	--	--	--	--	--	--	--
Qatar	--	--	--	--	--	--	--	--	--	--
Romania	155281	34486	27946	9991	--	--	--	--	27416	12174
Singapore	--	--	95983	59969	24453	9491	71816	29342	--	--
Thailand	--	--	--	--	--	--	--	--	134231	82899
Trinidad	--	--	--	--	--	--	--	--	--	--
Turkey	113495	62625	129305	98247	--	--	226000	187551	125000	103327
United Arab Emirates	21000	5562	--	--	--	--	--	--	--	--
USA	--	--	--	--	--	--	--	--	--	--
Total	11422866	4370721	10398427	5993180	3184439	1675282	6814580	4212096	8153985	4684179

TABLE 8.14 : EXPORTS OF IRON ORE & CONCENTRATES AGGLOMERATED IRON ORE PELLETS

(Quantity in tonnes) (Value in Rs. '000)

Country	1990-91		1991-92		1992-93		1993-94		1994-95	
	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value
Australia	197,459	10,78,01	238,014	18,32,99	85,708	650,35	113,000	960,01	113,698	94,067
Austria	--	--	--	--	39,862	332,77	--	--	--	--
Chinese Taipei	--	--	161,617	13,28,48	134,926	10,59,60	202,500	15,37,90	88,156	87,534
China, Republic of	--	--	52,828	399,82	316,585	22,27,67	465,419	38,17,56	52,17,40	430,286
Czechoslovakia	89,500	516,24	27,750	228,12	--	--	--	--	--	--
Egypt	17,000	90,53	--	--	--	--	--	--	--	--
France	--	--	--	--	--	--	--	--	--	--
German Fed.Rep.	--	--	--	--	--	--	--	--	--	--
Hong Kong	36,000	188,16	--	--	--	--	--	--	--	--
Hungary	284,266	15,77,75	118,898	764,35	--	--	--	--	--	--
Indonesia	127,243	850,25	189,080	16,69,35	234,617	21,83,31	175,070	16,50,56	113,000	106,239
Iran	--	--	41,948	169,29	42,000	261,41	84,000	473,19	61,087	48,565
Iraq	--	--	--	--	--	--	--	--	--	--
Japan	239,513	997,68	175,714	12,35,84	119,040	819,76	60,000	246,63	42,000	38,218
Korea,Rep.of	--	--	--	--	--	--	--	--	24,609	24,495
Malaysia	--	--	66,000	563,17	--	--	--	--	--	--
Mexico	--	--	--	--	--	--	--	--	--	--
Qatar	32,975	218,18	--	--	--	--	--	--	--	--
Turkey	275,909	16,03,54	281,436	21,86,68	266,603	22,38,62	126,999	10,38,95	306,043	238,698
USA	--	--	--	--	--	--	--	--	--	--
Yugoslavia	--	--	--	--	--	--	--	--	--	--

TABLE 8.15 : EXPORTS OF IRON ORE CONCENTRATES

(Quantity in tonnes) (Value in Rs. '000)

Country	1990-91		1991-92		1992-93		1993-94		1994-95	
	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value
Austria	--	--	14,576	58,67	--	--	--	--	--	--
Australia	28,108	71,74	106,708	415,89	37,220	360,09	35,936	311,83	--	--
Behrain	158,099	455,60	58,885	275,45	88,681	439,02	327,685	15,65,54	164,522	7,04,93
Belgium	--	--	--	--	--	--	--	----	80	32
China	76,322	207,65	288,630	1,131,58	479,083	2,772,67	429,535	25,45,52	388,324	17,37,46
Chinese Taipei	--	--	204,825	841,74	263,790	1,147,03	85,850	5,66,88	--	--
Czechoslovakia	91,436	237,08	--	--	--	--	--	--	--	--
Hong Kong	39,003	140,58	--	--	--	--	--	--	--	--
Hungary	--	--	26,022	157,11	--	--	--	--	--	--
Indonesia	--	--	86,320	660,41	--	--	--	--	--	--
Iran	324,104	1,164,73	1,014,544	5,531,45	552,954	3,427,90	1,072,331	63,37,97	1,244,895	64,95,08
Japan	3,176,914	8,112,49	2,670,849	10,133,97	1,964,985	838,823	2,127,159	87,08,72	1,858,568	71,82,42
Singapore	151	2,82	--	--	--	--	--	--	--	--
Turkey	--	--	--	--	26,000	21,459	25,966	2,30,41	--	--
USA	--	--	--	--	--	--	--	--	8	2
Total	3,894,137	10,392,69	4,471,359	19,206,27	3,412,713	1,674,953	4,104,462	2,02,66,87	3,656,397	1,61,20,23

Source: Indian Bureau of Mines, Nagpur

The major exporting companies/countries generally have a sales network with their own sales offices in important markets to provide commercial services through experts who normally represent the same mine for several years.

8.12 PRICES

Prices are influenced not only by the intrinsic prices of the ore (FOB price), but freight rates. Freight rates demonstrate a more volatile behavier composed to the base price of the ore.

The prices of iron ores of different grades are given in Table 8.16 (A). From the Table, it can be seen that price of +63 percent fines has gone up by 34 percent during the year 1992-93 as compared to the price in 1988-89. But it decreased by 11 percent in the year 1993-94 and further by 20 percent in the year 1994-95 compared to price during 1992-93.

The price of iron ore lumps of +63 percent during the year 1992-93 has also risen by 34 percent in comparison to the price in the year 1988-89. But in the year 1993-94, it decreased by 10 percent and further by 15 percent in 1994-95 compared to price in the year 1992-93.

8.12.1 Goa Mineral Ore Exporters Association, Panjim, Goa

Tables 8.16 (A) and 8.16 (B) show standardized grades of iron ore fines and lumps FOBT prices loaded at Berth No. 9 from 1988-89 to 1995-96.

It is seen that the prices of iron ore have not been raised considerably due to strong competition among the producers of iron ores.

Marketing of iron ore is assuming greater complexity due to increasing pressure for lower prices and improved quality of ore.

8.13 FUTURE SCENARIO IN INDIA

8.13.1 Resources

India is fortunate to be endowed with abundant iron ore. Ores occur as haematite, magnetite and siderite. Total reserves of in situ iron ore in India, including magnetite have been estimated at approximately 17.0 billion tonnes. Fortunately, ores are of a fairly good quality.

TABLE 8.16(A) : FLOOR PRICES OF IRON ORE

(In US Dollars)

Grade	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96
Fines								
63/63%	11.67	13.19	15.30	16.51	15.70	13.97	12.64	13.37
62/62%	11.33	12.80	14.84	16.02	15.24	13.56	12.27	12.98
61/61%	11.00	12.43	14.41	15.55	14.79	13.16	11.91	12.60
60/60%	10.78	12.18	14.12	15.24	14.49	12.90	11.67	12.35
Lumps								
63/63%	12.73	14.38	17.31	18.34	17.17	12.62	14.70	15.86
62/62%	12.39	14.0	16.69	17.68	16.56	15.07	14.18	15.30
61/61%	11.94	13.49	15.92	16.87	15.80	14.38	13.53	14.60
60/60%	11.47	12.96	15.30	16.21	15.18	13.61	13.00	14.03
60/59%	10.96	12.38	14.61	15.48	14.75	13.19	12.41	13.39

India's prime markets are Japan, South Korea, Taiwan and Eastern Europe.

Considering the large deposits, India should not be over concerned and panicky about export, which is dependable source of earning foreign exchange. Superior quality ores required for direct reduction may be preferred for use in India. India has large reserves of blue dust, over 500 Mt, which should also be exploited for exports.

8.13.2 Development in Steel Industry

Work has progressed in the manufacture of iron carbide which is expected to replace some of the steel scrap as feed for electric furnaces. Attempts are being made in America, Japan and Australia to develop a process for producing steel directly from iron fines and coal fines, and when established, it would eliminate a whole series of steps that encounter today in steel making.

-The existing and future steel-making routes clearly indicate that :

- Selection of appropriate technology is vital for any industry for its survival in the ever-competitive market.

TABLE 8.16 (B) PRICES OF IRON ORE, 1988-89 TO 1994-95

Grade	Market	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95
Basic Lumps +65% Fe	Export Hospet (Karnataka)	Rs.81	Rs.101	Rs.108	Rs.210	Rs.183	Rs.183-191	Rs.146-153
JSM Lumps	--"--	Rs.81	Rs.137	Rs.147	Rs.226	Rs.197	Rs.190-205	Rs.156-163
JSM Fines	--"--	Rs.81	Rs.86	Rs.92	Rs.152	Rs.140	Rs.140-143	Rs.100-102
Lumps, 59/60% Fe	FOBT Marmugao (Goa)	$10.96	$12.60	$14.61	$15.48	$14.75	$13.19	$12.41
Lumps 63/63% Fe (No.9 berth)	--"--	$10.11	$11.63	$17.31	$18.34	$17.17	$15.62	$14.70
Fines 60/62% Fe (No.9 berth)	--"--	$11.33	$12.80	$14.12	$15.24	$14.49	$12.90	$11.67
Fines 63/63% Fe (No.9 berth)	--"--	$10.44	$11.80	$15.30	$16.51	$15.70	$13.97	$12.64

Source : Indian Bureau of Mines

- Cleaner production technologies, which utilise the by-products/scrap, are receiving more attention, and effective waste management will remain as one of the thrust areas in future.

- Demand for better quality steel by consumers will increase due to more and more use of automation in processing technology. Hence, present and future steel-making processes will have to ensure close chemistry, low residual and gaseous content, high degree of cleanliness with inclusion of morphology control to achieve desired consistency in properties and performance during service.

- Recycling technologies are receiving importance all over the world. Secondary steel producers in mini-steel sectors shall continue to grow in the overall steel scenario with its increasing share in production.

- Liberalization of economy, flow of international technology, and delicensing of steel sector including iron and steel in the high priority industries with attractive facilities for foreign investments will contribute significantly in upgrading the rank of India among the front line steel producers of the world in the coming years.

8.13.3 Export and Import Policy

8.13.3.1 Import Policy

The general policy procedure for importing iron and steel, ferro-alloys and ferrous scraps is decided by the Ministry of Commerce like for other non-ferrous items. MMTC continued to be the canalizing agency for importing iron and steel. However, direct imports are allowed under supplementary licensing, replenishment (REP) licensing and flexibility provisions in the Import Policy.

A close watch is maintained on import and domestic availability to ensure that the industrial requirements are met to the maximum extent possible and industrial activities do not get adversely affected due to non-availability of iron and steel. Thus, imports of pig iron, in particular, increased substantially in 1992 as there were shortages.

8.13.3.2 Export Policy

The export policy for iron ore was as under :

Iron and steel industry has been completely exempted from the provisions of compulsory licensing. Deregulation of prices and distribution of iron and steel became effective from 16.1.1992.

As per the National Mineral Policy, 1993, out of 13 minerals dereserved, iron ore (both haematite and magnetite) figures in the list as one more step towards to the liberalisation policy.

According to the new Industrial Policy, automatic approval will be given for investments up to 51% foreign equity to cover the foreign exchange requirement for imports of capital goods. These include industries

producing iron ore pellets, sponge iron, pig iron, ferro-alloys and steel of all categories.

As per the Export Policy as on the 31st March, 1993, iron ore is canalised through MMTC. However, exports of the following types of iron ore are not canalised:

i) Iron ore of Goa origin when exported to China, Japan, Europe, South Korea and Taiwan.

ii) Iron ore of Redi origin to all markets.

Exports of iron ore concentrates produced by beneficiation or concentration of low grade ore containing 40% or less iron produced by KIOCL and export of iron ore pellets manufactured by KIOCL out of concentrates produced have also been deleted from the list of exports permitted through canalising agencies.

8.13.4 Conclusions

Though improvement has been achieved by the Indian Steel industry in productivity, labour value productivity, capital value productivity and total value productivity indices of Indian plants during the last 5 years, the levels attained (with the exception of material value productivity) are nowhere near the industry's best. There is a tremendous scope for improvement by enhancing capacity utilization, yield, quality, energy consideration and development of value-added products. Greater attention is needed to generate more revenue from by-products and wastes. There is a need to reduce inventories, work-in-progress and stock levels. (15)

Although the Indian plants are not modern, the capital intensive per tonne of steel is already higher than those in most other countries. New investments should therefore be made with utmost care and should be managed. More emphasis should be given on low cost investments to improve equipment availability, extend the life of existing assets towards process intensification measures to enhance the capacity further. In view of the distinct advantage of low raw material and wage costs, Indian steel companies have the potential to perform their competitors by fully harnessing the existing assets and human resources.

Taking the present conditions of the iron and steel industry into consideration, the following conclusions can be derived:

i) More emphasis should be given to low cost investments to improve equipment availability, extend the life of existing assets and towards process intensification measures to enhance the capacity further.

ii) It is desirable to augment the capacities of existing units before creating new assets.

iii) European and American companies have been steadily improving Labour Value Productivity and Employee Productivity over a long period. A similar approach is warranted in India to forge ahead.

iv) The full competitive potential of Indian firms will be realised only when their productivity indicators match the highest level attained by the industry.

v) Capacity utilization in India is less than the world average thus providing a major opportunity to enhance competitiveness by making full use of production facilities.

vi) The investment should generate surpluses to final growth.

REFERENCES

1. Kashyap, Aditya : Iron & Iron Ore 2000, - Iron & Steel Review, April 1993.

2. McGraw Hill : Encyclopedia of Science & Technology, Vol. 15.

3. Sinha, SN : Kundu AL ; Muthuswamy C : Iron and Steel Industry in India : Past, Present and Future, Iron and Steel Review, September, 1993.

4. Bradley, Stoughton : The Metallurgy of Iron and Steel.

5. McGraw Hill : Encycolpedia of Science & Technology, Vol.17.

6. Indian Minerals Year Book 1993.

7. Sinha, RK ; Industrial Minerals.

8. Export Potentialities of Iron Ore from India - Market Survey Series - MS : 9, May, 1986.

9. Compendium of Lecture Notes on Training Programmes on Requirement of Mining Plan - End-Use Grades of Important Minerals, 30th & 31st Aug. 1988, Course No. 93

10. Khuntia, GS ; Panigrahi, AT; and Panda, PK; Iron Mining Practice in India- Now and Beyond 2000 AD, Indian Mining - 1993, Annual Review, Journal of Mines, Metals & Fuels, Nov. - Dec. 1993.

11. Sheshadri, GR ; Mining Journal, Annual Review, 1994.

12. Charlu, JS ; Banerjee Sushim ; Banerjee Somdeb ; Growth of Steel Consumption in India and Abroad, Iron and Steel Review, March,1994.

13. Indian Minerals Year Book - 1992

14. Annual Report 1990, Iron & Steel Scrap, USBM, April, 1992.

15. Singhal, LK : Productivity in Indian Steel Industry - International Comparisions - Productivity, Vol. 34, Oct. - Dec.1993, No. 3.

16. Director General of Commercial Intelligence & Statistics, Calcutta. Monthly Statistics of Foreign Trade of India (Annual Number, 94-95), Vol. II, Imports, March 1995.