IRON CARBIDE PRODUCTION FACILITY

Description

November 1995

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1 INTRODUCTION

1.1 PRESENTATION OF THE IRON AND STEEL INDUSTRY :

World steel production is about 700 million tonnes per year, as shown in the following graph which shows crude steel production since 1987 by major geographical areas.

Crude steel production by major countries in thousands of tonnes

	1 987	1 988	1 989	1 990	1 991	1 992	1 993	1 994
ex USSR	161 935	163 037	160 092	154 286	132 666	117 953	97 785	77 741
Japan	98 513	105 681	107 909	110 331	109 649	98 100	98 100	98 100
USA	80 876	90 649	88 852	88 918	79 738	84 300	84 300	84 300
Canada	14 737	14 866	15 458	12 281	12 987	13 933	14 387	13 897
Asia	57 715	65 140	69 794	74 870	82 581	87 367	97 319	99 647
of uhich Gulf region	*10 001*	*11 424*	*11 346*	*12 606*	*12 652*	*13 603*	*15 444*	*16 153*
China	56 280	59 431	61 430	66 349	70 436	80 037	89 453	91 532
South America	39 518	42 194	42 547	38 582	39 445	42 171	43 334	45 746
FRG	36 248	41 023	41 073	38 434	42 169	40 800	40 800	40 800
Italy	22 819	23 762	25 216	25 472	25 084	24 842	25 717	26 057
France	17 432	18 598	18 692	19 021	18 401	17 961	17 109	18 031
UK	17 136	19 065	18 799	17 895	16 551	16 212	16 625	17 286
Spain	11 691	11 886	12 765	12 705	12 932	12 295	12 974	13 435
other EEC	20 632	23 092	22 033	23 045	22 385	20 289	18 956	23 201
total EEC	125 958	137 426	138 578	136 572	137 522	132 399	132 181	138 810
other Europe	13 281	14 035	14 073	13 088	12 427	12 555	13 762	13 588
total Europe	139 239	151 461	152 651	149 660	149 949	144 954	145 943	152 398
Africa	12 797	13 119	13 800	13 381	14 517	13 632	13 981	13 408
Oceania (Austr & NZ)	6 534	6 960	7 482	7 349	6 947	7 635	8 151	9 193
World steel total	778 271	778 271	784 720	768 742	734 423	721 391	729 432	723 410

About 2/3 of this quantity is elaborated via the so called conventional integrated route with hot pig-iron. This conventional route involves the following steps:

- Iron ore preparation (lumps, sintering and/or pelletizing)
- Reduction of iron oxide by carbon coke in a blast furnace with production of liquid iron saturated with carbon (hot pig-iron)
- Elaboration of steel of the required final chemical composition, in the oxygen converter (also called BOF: Basic Oxygen Furnace)
- transformation of steel into merchant products by rolling (bars, channels, coils and sheets)

These operations are performed in very large integrated steel complexes which involve many different plants and equipment, high capital costs, and a lot of labor. Because of the high capital and operating costs involved these complexes have to produce and transform great quantities of steel. The scale factor is of the order of 2 to 5 Mtpa of crude steel, which is then transformed into final merchant products, bars, channels or sheets. Because of the very high investment costs involved in the transformation (rolling) of steel, integrated steel plants specialise either in long products (bars and channels) or in flat products (hot rolled coils, colled rolled sheets).

Integrated steel plants are operated by very big steel companies, most of which were first established in Russia and Western Europe (UK, Germany, France, Belgium, Sweden, Italy) and in North America, during the Industrial Revolution of the 19th century and in the early 20th century. After world war II, the steel plants of Western Europe were rebuilt, modernised and expanded and they began to rely of imported iron-ore of high grades which gradually substitued to depleting local ores of low grade. Similar modernisation and expansion took place in North America. At the same time integrated steel plants were built in many developing countries, South America (Chile, Peru, Venezuela, Brazil, Argentina), in North Africa (Algeria, Nigeria) and in Asia (Japan, China, India, Pakistan).

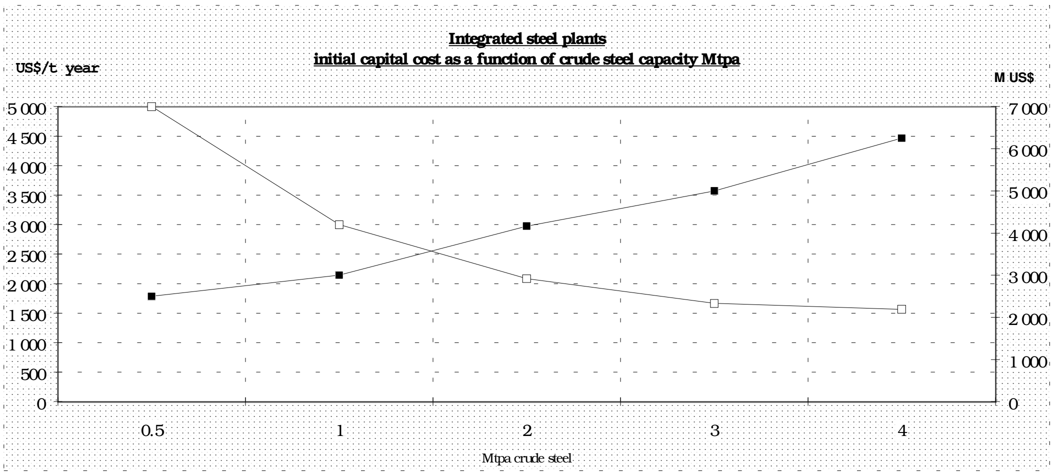
Large integrated steel complexes suffer from disadvantages which are related to their large size:

- Ore sintering plants, coke making plants and blast furnaces are heavy polluters. Most plant and equipment today in West Europe require major transformations or even rebuilding to comply with new and more stringent environmental regulations.
- The high investment costs required for any modification within an integrated steel plant makes it difficult to adopt new technologies that are emerging for steel making.
- The blast furnace is not a flexible unit. It is difficult to adjust output to demand when market conditions vary. In order to compensate to some extent for this lack of flexibility, the integrated steel complexes make efforts to melt in the BOF, metal from other sources such as scrap-iron and iron-carbide.

The other 1/3 of the steel production is elaborated via the so called mini steel mill route, where the source of iron raw material is mainly scrap-iron and steel is produced in electric arc furnaces.

Mini-steel complexes are much smaller than conventional integrated steel complexes, and consequently initial capital costs required are much lower.

For indication the following graph shows initial capital costs for an integrated steel complexe as a function of capacity Mtpa of crude steel.



It can be seen that the capital cost/t year of crude steel is of the order of 2 000 US$/t year for a capacity of 2Mtpa. This compares to 300-500 US$/t year for mini steel mills. However, the large scale factor of integrated steel complexes permit great economies in terms of operating costs, mainly energy and labour costs. Such economies are cannot be obtained in mini steel mills.

This being said, the advantages of mini steel plants are the following:

- The energy necessary to melt scrap-iron is much smaller than the energy required to produce steel starting from iron-ore.
- The electric arc furnace is a flexible unit the production of which can be easily adjusted to match demand.
- Minimills can be operated by relatively small companies.

There has been an marked evolution in Western Europe and North America from large integrated steel complexes to mini steel mills, in responding the need for new plants to meet increased demands in the quantity and quality of steel (forms, mechanical characteristics, anti-corrosion treatment). The lead in this evolution was taken by Italy, where such mills were established to produce bars and channels.

This is why, at the beginning, mini steel mills specialised in the manufacture of long products (mainly rod in coils and bars and thin section channels). Having to rely on scrap-iron as their main source of raw material, and because initially, the scrap-iron collected contained residual elements such as copper, tin, lead etc., which are detrimental to the quality of steel (its mechanical properties), mini steel mills first produced low quality steels. But with the improvement of scrap-iron collecting channels and the stripping of non ferrous metals, mini steel mills rapidly made progress to high quality steels, because of the advantage of the electric furnace.

Mini steel mills are very receptive to technological changes and are quick to adopt new methods which enable to diversify production, enter new markets and take significant market shares. This is why, after a first entry in the field of long products, a recent and remarkable example of the flexibility of mini steel mills is the development of the thin slab caster which enables to produce sheet steels. Nucor was the first mini steel company in the world to enter this market.

The conquest of new markets supposes that the chemical composition of steel can be adapted to meet final product specifications, which are more and more stringent in flat products, notably for the automotive industry (drawability, welding properties, phosporation, high mechanical resistance etc.). This requires, in particular, that residual elements be maintained within the tight limits by charging prime grade scrap-iron into the electric furnace, or by adding high quality primary iron-metal to secondary scrap.

NB: IndeedThis is because prime quality scrap-iron is scarce and its price is higher than ordinary scrap-iron.

Sources of primary iron-metal are the following:

- pig iron produced by blast furnaces in conventional steel complexes
- direct reduced iron in the form of sponge iron
- iron carbide, a more recent development.

The figure below shows depicts the different routes to steel that have just been mentioned.

In developing countries the alternative route to steel which has developed using the concept of the mini-steel mill, was with the process of direct reduction to produce the iron-metal as a raw material suitable for electric furnace operation. This was the case the case in Mexico (Sicartsa), Brazil (Salvador de Bahia), Argentina (...), Korea (....) and more recently in the Gulf region (Qatar, Abu-Dhabi and Saudi Arabia).

1.2 NEW IRON SOURCES :

<u>The need for new iron sources</u>

In order to make the chemically demanding grades of steel needed to serve those markets, minimills require a high proportion of their melt stock to be low in base metal residuals. Until recently, the supply of low residual steel scrap generated by integrated steel mills ("home scrap"), and new scrap generated by metalforming factories ("prompt scrap") was adequate. Integrated steel mills'efficiency improvements have caused integrated steel mills to become net scrap users. Increased use of galvanized and coated steels have resulted in contamination of the supply of prompt industrial scrap.

Against this declining supply, minimills have been increasing capacity at a rapid pace, especially in the highervalue steels. Integrated steel mills also need to extend their limited supplies of blast furnace iron.

Alternative ironmaking methods

Direct reduction is the best known of a number of nonblast furnace ironmaking methods. It reduces iron ore pellets or lumps to iron metal by exposing them to hot reducing gas in a kiln. Direct reduction is an effective means of making iron, however, it is more costly than the blast furnace and produces an inferior product. Direct reduction methods have high agglomeration costs.

Smeltingreduction methods of ironmaking involve the operation of a small blast furnace in connection with a coal gasifier. Since they produce hot metal, they must supply a nearby steel making facility. They produce excess energy, which must be marketed to make them economical.

Comparisons with iron carbide

Iron carbide has numerous advantages over the other ironmaking methods. The most important is cost. The cash cost of producting iron carbide is less by 20 % 40 % compared with the blast furnace or any alternative method. Iron carbide is higher in quality than all alternatives, and equivalent to better forms of blast furnace pig iron. Both iron carbide and hot briquetted iron ("HBI"), the highestquality form of DRI, are 90 % 92 % iron, the balance of iron carbide is favorable elements (mainly carbon), while the balance for HBI is adverse elements (mainly oxygen). Iron carbide is a merchantable product which can be readily stored or shipped, whereas hot metal must be used at the point of production, an direct reduced iron must be passivated.

1.3 DESCRIPTION OF THE IRON CARBIDE PROCESS :

Generalities

Iron carbide (Fe3C) is a metallic form of iron which has been carburized. Each molecule of iron carbide contains prereduced iron metal and fuel.

The iron carbide process uses a microprocessorbased control system to control the kinetics of a chemical process. From a designers' point of view, the iron carbide process seems like a petrochemical process for converting natural gas to water, using iron oxide as a reagent, and producing iron carbide as a byproduct. Most of the investment of an iron carbide plant is in gas handling machinery. While iron carbide is produced as one of several coproducts in most ironmaking processes, only the iron carbide process can make iron carbide as a saleable product.

The iron carbide process is a lowcost, environmentally benign means of producing high quality iron metal.

Technical description

The chemical formula which describes the manufacture of iron carbide from iron ore is :

$$3\ Fe_2O_3 + 5\ H_2 + 2\ CH_4 = 2\ Fe_3C + 9\ H_2O.$$

Natural gas is reformed into hydrogen and carbon monoxide in a package reformer similar to those used in hydrogenating vegetable oil. Fine unagglomerated iron ore is preheated in a rotary kiln or cyclone furnace to 800 deg. C. The hot iron ore is fed into the fluid bed reactor, and fluidized with a preheated, compressed, hydrogenrich stream of reducing gases.

The residence time of solids in the reactor is 1224 hours. The pressure of the reactor is 24 atmospheres. Solids are fed and withdrawn from the bed by gravity. Gas and solids compositions are sampled at frequent intervals, and the composition of fluidizing gases is altered to achieve the desired result. Finished iron carbide is tapped at regular intervals as sample data indicates it is ready. Spent gases are collected, cooled and scrubbed to remove water vapor and nitrogen, and makeup gas is added as necessary from the reformer. 100 % of valuable gases are used.

The iron carbide process is a lowtemperature process. Its operating temperature of 590 deg. C is far from the plastic range of any of the solids in the process, and can readily be handled by ordinary carbon steel, except in wear areas. Since iron carbide is magnetic and is not agglomerated, it can be further refined by dry magnetic separation to produce a premium quality product.

Development status

Since its initial application on a laboratory scale, the operation of the process has been scaledup four times. The latest operation was a successful sixmonth campaign of a demonstration plant at Wundowie, Western Australia, in 1989.

The first production plant is now operating in Point Lisas, Trinidad. Nucor, Inc., one of the largest and most profitable steel producers in the United States, has undertaken to build and operate an iron carbide plant for its own iron unit consumption requirement.

Nucor has announced that it intends to build three additional units soon, to build an additional four units when those are operating and to supply its virgin iron metal requirement of 2,500,000 metric tons per year. Nucor has also announced $ 40 million in refinements of its Hickman and Crawfordsville flat rolled steel mills to more fully exploit the properties of iron carbide.

Patent and copyright status

The iron carbide process is covered by US. Patent Re. 32,247. US Patent 5,073,194 covers the microprocessorbased process control system. US Patent 5,118,479 covers the design of the reactor. US Patent 5,137,566 covers the preheater system. A related process for reprocessing zincbearing electric arc furnace dust using the iron carbide process is US Patent 4,396,483. US Patent 4,398,945 describes a process for separating nickel, chrome, vanadium, manganese, tungsten and other valuable metals from laterite ores and other ores where those metals are found in compound with iron. All control software is copyrighted.

Commercialization

SOFRESID and AIC collaborate to commercialize the iron carbide process and build production plants.

American Iron Carbide Corporation ("AIC") was organized for the purpose of commercializing the patented process for making iron carbide. AIC is the exclusive manufacturing licensee for the Central United States. American Iron Carbide International Limited ("AICI") was formed as a tax advantaged offshore company for the purpose of exploiting the iron carbide process in certain countries ; is one of the two owners of Iron Carbide Development Corporation ("ICDC'), a research and development company which developed the process, and which controls the iron carbide technology. Iron Carbide Holdings, Ltd ("ICH"), a controlled subsidiary of ICDC, acts as the world licensing agent for the iron carbide manufacturing process.

SOFRESID is in charge of the engineering aspect and can provide all the services required by a new project, from the feasibility study, up to the erection and startup phases.

Process economics

A four unit iron carbide plant can be built in most locations in the Middle East for less than $325 million in capital costs. Iron ore is the largest component of delivered cost, with freight second, natural gas third, and electric energy a distant fourth. Labor, G&A, maintenance, and outside services are nominal. As a rule of thumb, it costs $45$55 per metric ton, exclusive of the cost of iron ore feed, to convert iron ore to iron carbide. The selling price of iron carbide is a function of the grade and the market into which it is sold. Selling prices between $110 and $200 per metric ton are anticipated, with an average of $120$160. A four unit plant generates $80$100 million per year.

Markets

The total world market for iron metal is $88 billion, $20 billion in the US and Canada. Iron carbide is lowcost, high quality input for both integrated and ministeelmaking, foundries, powder metals and other advanced materials. The immediate market for iron carbide in the US and Canada is estimated at $1.8 $3.8 billion, with annual iron carbide profit potential of $500$1,100 million. Steel producers are eager to use iron carbide. AIC can promptly book term sales for the entire output of 410 iron carbide plants. Ultimately, a market share of at least 20 % of total iron metal demand is achievable for iron carbide in the U.S.and Canada and more than 7% in the World.

2 THE PROJECT

2.1 GENERAL :

The project consists of building an iron carbide production complex aimed at supplying the world market for iron metal.

The complex shall comprise four discrete units of iron carbide production reactors and associated facilities, ore receiving and storage facilities, and product storage and shipping facilities. Total capacity is 1 270 400 tonnes per year.

Iron carbide shall be the finished product. Iron carbide is an advanced material which is used with steel scrap to make highvalue steel mill products. In this application, iron carbide replaces costly blast furnace pigiron, or scarce prime grade steel scrap.

The main production units of the complex will include storage, receiving and shipping facilities, gas reformers and gas conditioning machinery, ore preheaters and feeders, fluid bed reactors and product cooling and stacking facilities.

Details about the iron carbide process are presented in the chapter 10. A flowsheet of the process is presented in the chapter 3.3.

2.2 THE PRODUCTION UNITS :

Each of the four proposed production units includes ore handling and preheating equipment, flue gas treatment equipment for the plume from the ore preheater and feeders, a fluidbed reactor, a gas reformer with high temperature shift conversion and CO2 removal, gas heaters and heat exchangers; gas compressors; a packedbed gas scrubber for H2O removal, iron carbide removal and cooling facilities and a thickener for removal of particulate matter from discharge water.

The site itself includes offices, laboratory, locker and infirmary buildings, ship docking facilities, ship discharge and loading machinery, open ground storage for iron ore, and covered ground storage for iron carbide.

3 TECHNICAL DESCRIPTION OF THE SITE AND PRODUCTION UNITS

3.1 PRODUCTION CAPACITY

1 unit : 317,500 t / year

4 units :1,270,400 t / year

3.2 THE SITE.

- ground surface area :220,800 m2
- plant area each unit :15,000 m2
- buildings, parking, etc :15000 m2
- ship loading/discharge facilities :12,000 m2
- product ground storage (14,000 t) :38,000 m2
- iron ore ground storage (200,000 t) :60,000 m2
- contingency, expansion space :35,000 m2

Utilities

- electricals: installed power 50 MW
- natural gas :1,415,000 m3/day
- drinking water
- reformer makeup water450 m3/day

(can be condensed from plant water production)

- firefighting water network
- telephone service
- road access

3.3 IRON CARBIDE PRODUCTION FACILITIES.

The basic equipment is listed hereafter. The numbers refer to the attached flow sheet.

1.Ore reclaim system and conveyor

For ore storage and handling

2.Ore day silo facility

3.Ore preheater (kiln or cyclone)

To remove the ore moisture and input part of the heat required by the process. The bleed of reactor gas is burned in this equipment.

4.Ore preheat exhaust collector, with dust collectors (SO2 scrubber optional)

5.Refractory lined hot ore feed bins

Buffer equipped with lock valves to introduce the ore into the pressurized reactor atmosphere

6.Hot ore feeder

Supplies a controlled quantity of ore to the reactor

7.Fluid bed reactor

Iron carbide producing unit

8.Refractory lined cyclone

To recycle the ore transported by the reactor exhaust gas

9.Product cooler

To reduce the product temperature

10.Product let down valves

To counteract the reactor gas pressure

11.Product degassing vessel

Product atmosphere is replaced by air

12. Product weigh belt feeder

To control the system output

13. Product conveyor

14. Product storage and reclaim facilities

Iron carbide is stored under a covered area until its shipment

15. Off gas heat exchanger

Off gas temperature is reduced to allow the water removal in the scrubber

16. Recycle gas preheater

To supply part of the heat required by the process

17. Combustion gas stack

18. Process gas scrubber

Removes the water produced by the chemical reaction and cleans the circulating gas

19. Thickener

20. Gas recycle compressors

To force the gas trough the circulation loop

21. Gas reformer

To produce the hydrogen required for the reaction

4 SITE LAYOUT DRAWING

5 INVESTMENT BUDGET

The prices shown in the following chart are :

net prices, free from any tax and custom duties,

based on construction estimated prices (DECEMBER 1993).

They include :

- construction studies, training of operating and maintenance personnel, assistance to commissioning,
- building construction, supply of equipment, erection and testing,
- a provision for spare parts for commissioning and one year of operation,
- a provision for soil tests and basic topographical surveys.

They do not include :

- consumable such as : steel raw materials, fuels, power, products,
- the production of electric power,
- the sea water desalting unit if required,
- special foundations if required,
- land purchase

It has also been considered that :

the land would be free from any obstacle and levelled at the height adopted,

the utilities (water, electricity, gas...) would be available near the site (battery limits)

the aisles would be heat insulated by a double wall siding, and ventilated,

all offices and technical rooms will be air conditioned.

Detailed Data for Investment Budget

Civil	**$ 4,300,000**

Concrete	**$ 8,300,000**
Structural	**$ 11,100,000**
Buildings	**$ 9,900,000**
Mechanical	**$ 187,000,000**
Piping	**$ 15,400,000**
Electrical	**$ 9,900,000**
Instrumentation	**$ 7,100,000**
Site	**$ 27,000,000**
TOTAL	**$ 280,000,000**

6 OPERATING COSTS

6.1. SITE TOTAL YEARLY CONSUMPTION.

Main consumable only.

♦Fine iron ore: 1,727,000 t.

♦Energygas:495 Mm3/year.

electrical: 295,000 MWh/year.

6.2. MANNING

	1 unit	**4 units**	**Shifts/day**
Supervisory	**9**	**36**	**3**
Laboratory	**5**	**20**	**3**
Operators	**20**	**80**	**3**
TOTAL	**34**	**136**	

* To confirm during feasibility study.

6.3 Example of costs estimates

Typical Arab Gulf project

Operating cost estimates 1,270,000 metric tons/year iron carbide plant

	Number	USD/year	Production costs USD/tonne	G & A Other costs USD/tonne	Total cost USD/tonne
I. LABOR COST					
Supervision	36	876 000	0,69		
Chemical/Analytical	20	324 000	0,26		
Plant Force	80	896 000	0,71		
Fringe Benefits (25% of base)		524 000	0,41		
TOTAL LABOR COST		***2 620 000***			***2,06***
II. ORE COST	Units				
Dol/tonne of ore	25,20				
Iron units/tonne of ore	66				
Iron units/tonne Fe3C	90				
Tonnes of ore/tonne Fe3C	1,36				
TOTAL ORE COST		***43 641 818***	34,36		***34,36***
III. NATURAL GAS COST					
Dol / 1000 cu.ft.	0,80				
cu.m./1000 cu.ft.	28,32				
cu.m./tonne Fe3C	390,76				
TOTAL GAS COST		***14 018 791***	11,04		***11,04***
IV. POWER COSTS					
kwh/tonne Fe3C	210				
Dol/kwh	0,015				
TOTAL POWER COST		***4 000 500***	3,15		***3,15***
V. WATER COSTS					
cu.m./tonne Fe3C	0,834				
Dol/cu.m.	0,388				
TOTAL WATER COST		***410 900***	0,32		***0,32***
VI. OPERATING SUPPLIES		***700 000***	0,55		***0,55***
VII. MAINTENANCE		***7 000 000***	5,51		***5,51***
VIII. GENERAL & ADMINISTRATIVE					
General and Administrative		1 950 000		1,54	
Management Fee		4 200 000	3,31		
Local Taxes & Insurance		4 875 000		3,84	
TOTAL GENERAL & ADMINISTRATIVE		***11 025 000***			***8,68***
IX. ROYALTIES					
License Royalty		4 200 000	3,31		
Sublicense Royalty		4 200 000	3,31		
TOTAL ROYALTIES		***8 400 000***			***6,61***
X. MATERIAL TRANSFER		***0***			***0,00***
XI. TOTAL CASH COST **(depreciation excluded)**		***91 817 009***	***66,92***	***5,37***	***72,30***

7 ECONOMIC VIABILITY

Four units starting operations in 1996, 1997, 1998, 1999.

Selling price:$ 132/ metric tonne.i.e $ 120/ net ton

Annual production: 1,270,400 t.

Annual sales: $ 167,693,000

Annual net income: $ 68,770,000

Annual cash generation: $ 74,270,000

Internal rate of return: 21.2%

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8 STUDIES

The studies are intended to specify the technical, economic and financial conditions for the construction and operation of the project.

The study will cover the following matters :

8.1. MARKET STUDY.

The aim of the study is to assess the world market for iron metal for use by steel mills and foundries. This market study will evaluate the following products:

- Prime Grades of Steel Scrap,
- Dealer Grades of Steel Scrap,
- Blast Furnace Pig Iron,
- Direct Reduced Iron,
- Iron Carbide.

The study will estimate the relative values of all of the above products, and their delivered cost from the proposed site, as well as from competing regions. A forecast of demand and price for iron carbide demanded by world markets from the region will be provided.

The market study will estimate past, present, and future requirements and price of each product by market segment.

A survey will be conducted of possible competing projects in the region.

A survey will also be conducted of possible supply sources of iron ore, by price and quality points.

8.2 FEASIBILITY STUDY

Given the results of the market study, a feasibility study will be conducted, which will:

- work out preliminary equipment sizing,
- draw up general flow diagrams
- draw up the plant layout
- specify the general construction techniques,
- compute the investment,
- plan the plant general organization,
- draw up the implementation schedule, and
- set forth an estimated production schedule

The Market Study and the Feasibility Study shall be complemented by an economic evaluation which will be submitted along with a schedule which sets forth investments, operating costs, sales revenues, profits, and financial charges, and will compute the following economic indicators:

- pay back period
- net present value at various discount rates
- internal rate of return
- sensitivity analysis to key variables

The indicators will enable the project sponsors to:

- complete the technical evaluation
- generate detailed designs

- ensure that the proposed project is economically viable.

9 GENERAL SCHEDULE

Two stages must be considered:

- That of the market and feasibility studies, after which a decision to invest can be made.

The duration of that first stage is estimated to 8 MONTHS, out of which 1.5 MONTH for allowing the Client to make his decision on the investment.

- The project performance stage.

That phase will begin with a consolidation of the basic data resulting from the feasibility study. Its duration is estimated to 17 MONTHS till the commissioning of the plant FIRST PRODUCTION UNIT.

In those conditions the overall construction time can be estimated to **25 MONTHS** approximately (see attached general schedule).

- AS regards the other three production units the construction time required for each unit is 14.5 months.

The total duration of the project, including the erection of 4 production units, will depend on the decisions which will prevail regarding the staggering of the investment.

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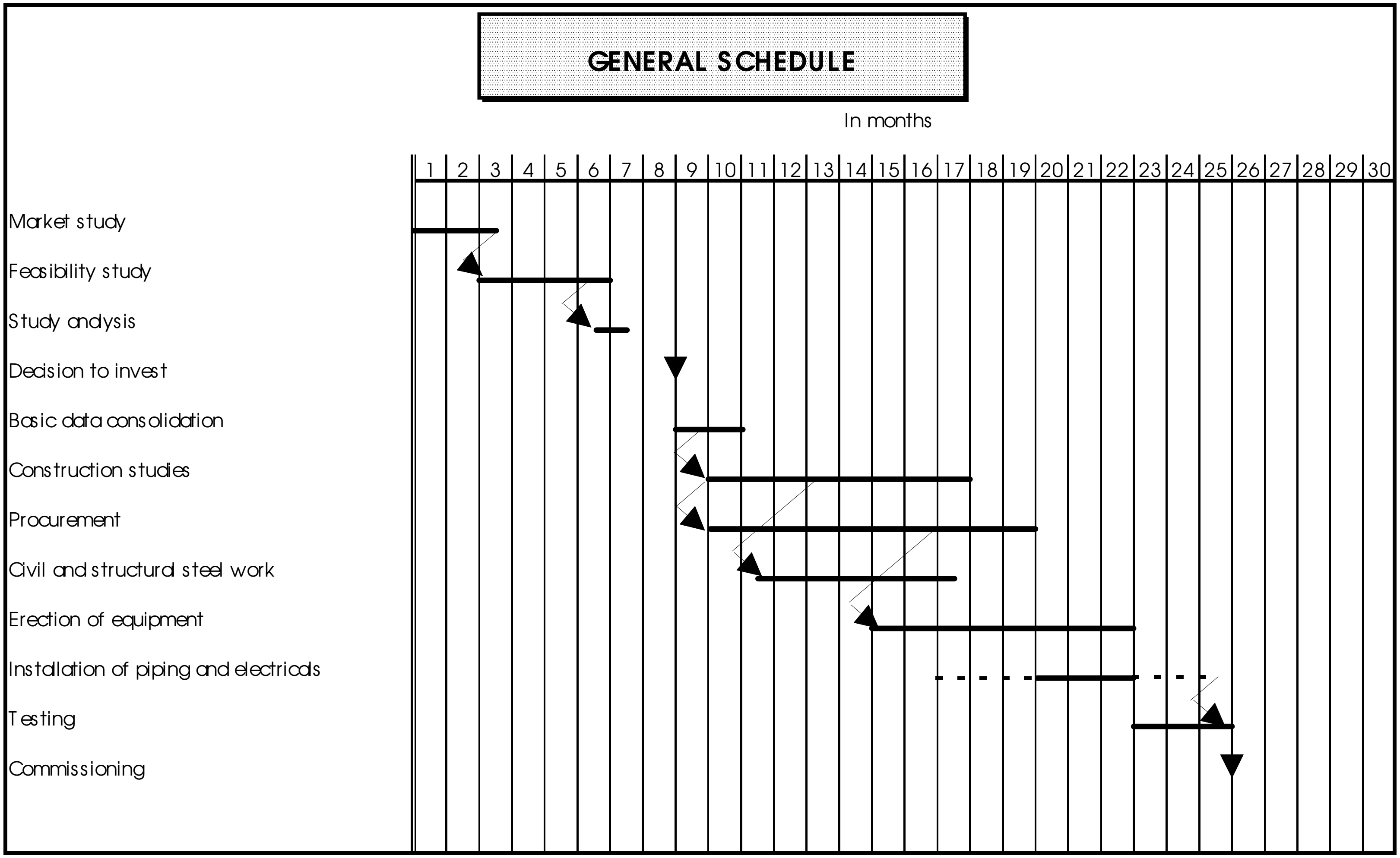

10 LITERATURE

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THE IRON CARBIDE MARKET

Most of the market of iron ore can be found in the steelmaking sector. The following sheets show examples of savings which can be obtained thanks to the use of iron carbide.

ELECTRIC FURNACE

The problem is to produce a steel grade with a maximum content of residuals of 0.15%.

Two solutions can be envisaged :

Dilution of the residuals by prime quality scrap (Factory Premium Bundles)

Dilution of the residuals by iron carbide.

Even the prime scrap contains some residuals (0.12%), so that to achieve the same dilution, a much smaller quantity of iron carbide is needed.

In this example, savings of $ 11.10/MT are achieved.

INTEGRATED STEEL MILL

The problem lies in the hot metal supply. The plant operates several blast furnaces. Most of the hot metal is produced by a modern, efficient furnace. The balance is produced by an old furnace which is kept working at high costs.

Iron carbide contains some carbon which is a source of energy during the converter blowing. It is then possible to replace the scrap and a part of the hot metal in the charge. Metallurgical trials proved the feasibility of this solution. By replacing scrap by iron carbide, the charge of a BOF can be reduced from 75 : 25 hot metal to scrap to 60 : 40 hot metal to iron carbide.

In the following example, savings of $12.75/MT are obtained.

For some demanding steel grades, the problem of residuals exists, even in BOF shops. Iron carbide can then be justified for the same reasons as in EAF plants.

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STEEL MILL SAVINGS FROM IRON CARBIDE USE

(Electric furnace illustration)

A steel mill desires to make 100 000 tonnes of steel with a specification of 0,15% maximum "residuals".

AVAILABLE RAW MATERIALSQUALITY (% residuals)**PRICE** ($ / tonne)

Premium scraps0,12135

Standard scrap 0,18100

Iron carbide0,02132

STD. SCRAP PREMIUM / IRON CARBIDE TOTAL $ / TONNE

Present*tonnes (000)* 5050 100

Practice*cost (million $)* 5,00 6,75 11,75 117,50

Iron carbide*tonnes (000)* 8020 100

Practice*cost (million $)* 8,00 2,64 10,64 106,40

Savings (million $) 1,110 11,10

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STEEL MILL SAVINGS FROM IRON CARBIDE USE

(Integrated seel mill illustration)

An integrated steel mill is presently using blast furnace hot metal and scrap to supply a melt shop with 3 000 000 tonnes per year of iron metal.

AVAILABLE RAW MATERIALS	**PRICE** ($ / tonne)
Blast furnace hot metal	**180**
Premium scrap	**135**
Iron carbide	**132**

		BF HOT METAL	**PREMIUM / IRON CARBIDE**	**TOTAL**	**$ / TONNE**
Present	***tonnes (000)***	**2 250**	**750**	**3 000**	
Practice	***cost (million $)***	**405**	**101,25**	**506,25**	**168,75**
Iron carbide	***tonnes (000)***	**1 500**	**1 500**	**3 000**	
Practice	***cost (million $)***	**270**	**198,00**	**468,00**	**156,00**
Savings	***(million $)***			**38,25**	**12,75**

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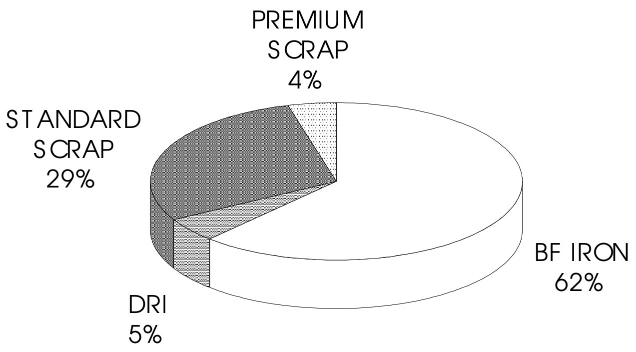
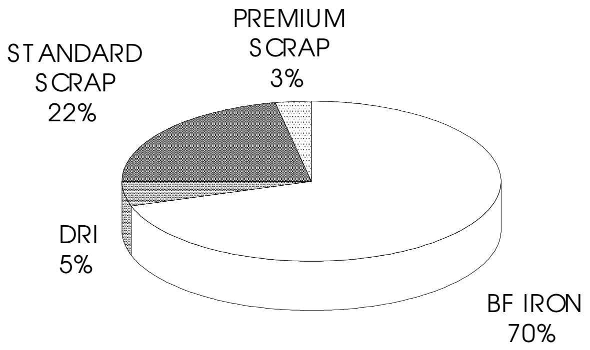
WORLD IRON METAL MARKET

The Total Market Available to Iron Carbide Exceeds 550 Millions Tonnes and $78 Billion



TOTAL PRODUCTION = 775 MTONNES



VALUE = $100.8 BILLION

GROWTH IN THE WORLD IRON METAL MARKET

		1990	2005
IRON CARBIDE	■	**0**	**65**
DIRECT REDUCED IRON	░	**36**	**100**
PREMIUM SCRAP	▒	**27**	**27**
STANDARD SCRAP	░	**222**	**346**
BLAST FURNACE IRON *	▥	**490**	**361**

* Blast Furnace includes Direct Smelting Sources

IRON CARBIDE IS EXPECTED TO CAPTURE 7.25% OF THE WORLD IRON METAL MARKET BY 2005