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Tubarao Steel Works Project and Its construction

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The body can be viewed from the next page.

Tubarão Steel Works Project and Its Construction*

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Coke oven: 49 ovens × 3 batteries
Blast furnace: Inner volume of 4 415 m^3 × 1 unit
Steelmaking plant: 280 t converter × 2 units
Slabbing mill: Universal types rolling mill × 1 unit.

This report describes the outlines of the progress of the project and the equipment and operational conditions of the works.

1 Introduction

On November 30, 1983, the inaugurating ceremony of Tubarão Steel Works was held with splendor in the honorable presence of the President of the Federative Republic of Brazil and many distinguished representatives from Brazil, Italy and Japan, to start the operation of No. 1 blast furnace (**Photo 1**). The tripartite international project involving Brazil's SIDERBRAS (Siderurgia Brasileira S.A.), Italy's FINSIDER (Societa Finanziaria Siderurgica) and Japan's Kawasaki Steel group has been completed, and the modern steelworks having an annual production capacity of 3 000 000 t slabs and provided with the largest blast furnace in North and South Americas has been put into operation.

Photo 1 Opening ceremony of Tubarão Steel Works

In the early 1970s, the Brazilian Government made it a fundamental policy to export iron ores and secure stable markets, with steady efforts promoted to export value-added products. Spurred by an increase in demands for steel worldwide including in Brazil in those days, a project was contrived to build an integrated steelworks for manufacturing semi-finished products to meet overseas and domestic demands, as a part of the long-term steel policy of the Brazilian Government, and Kawasaki Steel Corporation was sounded out in early 1973 as to the possibility of participation in the present project. After deliberate consideration, Kawasaki Steel decided to take part, and a tripartite joint venture project was formed with Brazil's SIDERBRAS and Italy's FINSIDER, which all had already expressed their will to join. The project was started in May 1973 with a preliminary feasibility study.

The particular novelty in the basic concept of this project was to aim at manufacturing not ordinary steel mill products such as plates, coils and sheets, but semi-finished products as slab, in an integrated steelworks starting with iron-making. The reason for formulating

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** Technical Division

this concept was that the making of semi-finished products would not only open the market for steel supply sources but also to reduce financial and technological burdens. The significance of Kawasaki Steel joining in the present project lies in the promotion of economic cooperation between Brazil and Japan in the long-term perspective, ensuring a new type of steel sources, and a new step in the company's international activities by effective utilization of technologies and manpower resources accumulated in the company.

The following report describes the Tubarão Steelworks, covering the circumstances up to the construction, outline of equipment, and results of the initial operation.

2 An Outline of Project

2.1 History

Following the sounding out in 1973 for participation and the subsequent preliminary feasibility study made in 1973, a pilot company was founded in March 1974 on the basis of tripartite agreement among Brazil, Italy and Japan. In accordance with stockholders' consensus, the following five targets were set up as the activities of the pilot company:

Act. 1: Execution of feasibility study and preparation of reports.

Act. 2: Negotiations about the supply of raw materials, petroleum, electric power and water, and investigation on utilization and capacity of local service providers.

Act. 3: Estimation of construction cost and examination of financial matters.

Act. 4: Investigation and checking of labor force and infrastructure.

Act. 5: Execution of basic engineering.

In the pilot company, five technical committees for five respective fields of activities were organized, and persons assigned by each stockholder began to execute the business. As the basic engineering underlying the feasibility study involved an enormous amount of work, the business was shared by Brazil, Italy and Japan. An engineering contract was established between the pilot company and tripartite stockholders, and the business was initiated in March 1974. At the same time, investigation and examination for various matters such as procurement of funds, materials and equipment, organization and personnel of the new company, etc. were started under the stockholders' agreement.

The feasibility study was completed in November 1974, immediately followed by a study among stockholders whether or not the project was to be executed. Unfortunately, the so-called first oil crisis occurred at this moment, making it inevitable to review the equipment installation plan and financial plan. After a drastic revision of basic concept and reconsideration of construction plan by participants from Brazil, Italy and Japan, a new fundamental strategy was established. At last, in March 1976, three stockholders agreed in putting the present project into execution. In June 1976, the pilot company was replaced by a new company–Companhia Siderurgica de Tubarão (CST). Lumbering work at the construction site was started in September 1976, boring work in November, and land preparation in April 1978, thus, putting the construction work at site into full swing.

On the other hand, the basic specifications for equipment were established on the basis of basic engineering conducted in the feasibility study, followed by the preparation for contract. The contract for equipment supply was concluded in October 1978 and came into force in May 1979. The foundation work for blast furnace was initiated in May 1980, with the civil construction attaining its peak. On the other hand, the manufacture of equipment proceeded smoothly, the first ship left Japan in October 1980, and installation work of blast furnace started in January 1981. In parallel with the construction at site, the preparation for operation was advanced steadily involving employment and training of operators. In this way, Tubarão Steelworks successfully started its operation on November 30, 1983.

2.2 An Outline of Companhia Siderurgica de Tubarão (CST)

Tubarão Steel Works is an integrated steel mill for semi-finished products, having an annual production capacity of 3 000 000 t slabs at the end of the first phase construction, which may be expanded to 6 000 000 t/year at the end of the second phase, and 12 000 000 t/year in future. Some slabs produced in this plant will be exported to the third countries, with some sold to stockholders. While this project is a tripartite joint venture enterprise by Brazil, Italy and Japan, the majority of shares is in the hand of Brazil, assuming the form of Brazil-dominated company. The composition of capital formation is as shown below.

SIDERBRAS	: 72% (51% of which voting stock)
Kawasaki Steel Group:	14% (24.5% of which voting stock)
FINSIDER Group	: 14% (24.5% of which voting stock)

The total construction funds amounted to 3 130 million dollars (comprising construction cost of 2 360 million dollars and preparation cost and interest of 770 million dollars). Of this amount, Brazil financed 1 480 million dollars, FINSIDER group 830 million dollars, and Kawasaki Steel group 820 million dollars. Brazilian financing owes much to the cooperation by Japanese

Table 1 Partition of the work

No.	Plant	Engi-neering	Equip-ment	Civil & erection
1	Ore yard	J, B	J, B	B
2	Sinter plant	J	J	B
3	Blast furnace	J	J	B
4	Power & blower	J	J	B
5	Air separation	J	J	B
6	Utility center	J	J	B
7	Power distribution system	J, B	J, B	B
8	Sea water system	J, B	J, B	B
9	Water system	J, B	B	B
10	Fuel distribution system	J, B	J, B	B
11	Business computer system	J	J	B
12	Mould & stool making plant	J	J	B
13	Coal yard	I, B	I, B	B
14	Coke oven plant	I	I	B
15	Steel making plant	I	I	B
16	Slabbing mill	I	I	B
17	Maintenance shop	B	B	B
18	Car dumper	B	B	B
19	Transportation equipment	B	B	B
20	Lime plant	B	B	B
21	BOF process computer	J, I	I	B

Note; J: Japan, B: Brazil, I: Italy

consortium, such as "700 million dollars financing contract" by Japanese banks and "purchase/sales contract on an installment basis for coke oven plant (500 million dollars)" by Japanese syndicates.

Tubarão Steel Works employed about 6 000 persons in the first phase operation, of which about 5 000 engaged in production and engineering activities. About 40% were experienced workers from various steelworks in Brazil.

In the present project, the concept of work sharing among the three parties was also put into practice to the best possible extent in the case of the construction-related business. After repeated negotiations based on the technological potential and domestic circumstances in Brazil, Italy and Japan, it was finally agreed upon to execute the construction according to the division of work shown in **Table 1**.

3 Siting and Raw Materials Conditions

3.1 Siting

Tubarão Steel Works is located in the suburbs of Vitória, capital of Espirito Santo State, lying about 500 km north-east of Rio de Janeiro, former capital of Brazil (see **Fig. 1**). Facing the Atlantic, and characterized by warm climate, Vitória has a population of about 240 000 (about 870 000, if peripheral cities are included). It is a large base for export, with a leading commercial harbor of Brazil, and at the same time, a city of long history having prospered as a political, economic and cultural center of Espirito Santo State.

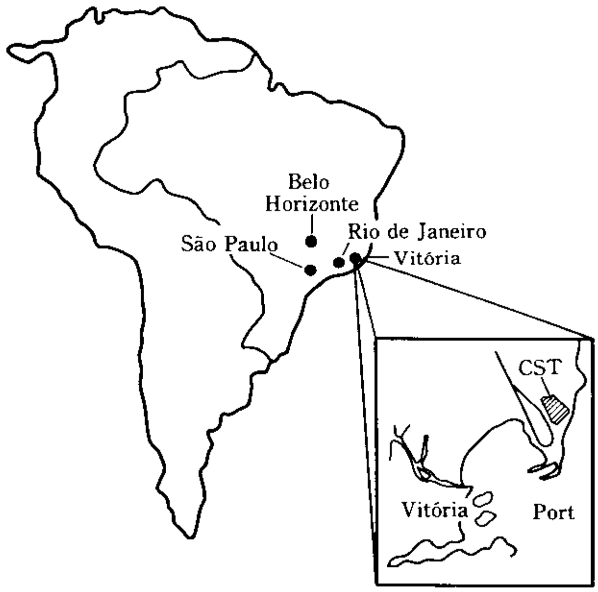

Fig. 1 Location of the site

In the suburbs of Vitória, there is a largest base for iron ore export in Brazil, where iron ores mined from the so-called "iron quadrangle" of Minas Gerais State are collected in and exported to various countries in the world. Tubarão Steelworks is built in the neighborhood of the iron ore export base. The site is located on a hill about 18 m above sea level, facing the Atlantic in the front and enjoying very favorable siting conditions.

While the site was chosen by Brazil from the beginning, the subsequent detailed investigation by the Brazil-Italy-Japan partners proved that it had most suitable conditions for steelworks site, and finally it was selected as the construction site mainly on the following reasons.

(1) Dominant warm climate, off the course of tropical cyclones, with hardly any natural disasters.
Annual rainfall: 1238 mm
Atmospheric temperature: 13-37°C (average 24°C)
Mean wind speed: 4.6 m/s (maximum wind speed 18 m/s)
(2) Excellent soil conditions, with no record of earthquakes.
(3) A large export base for iron ore of Vale do Rio Doce Co. in the neighborhood, with great ease of ore acquisition.
(4) Good availability of ample industrial water and electric power.
(5) Proximity to Vitória, the political and economical

center of Espirit Santo State, with adequate levels of infrastructures such as housing, medical facilities, roads, railways, port facilities and so on.

(6) Ample supply of high quality labor resources.

(7) Agreement with the Brazilian government's policy for inviting steelworks in an industrially-dormant Espirit Santo State as leverage for local industrial development.

Tubarão Steelworks owns a total compound of about 13 600 000 m^2, of which about 7 000 000 m^2 (includig 2 000 000 m^2 for the second phase construction) was used after preparation in the first phase.

3.2 Raw Materials and Utility Supplies

3.2.1 Iron ore

Iron ore, main material for steelworks, is supplied from the neighboring Tubarão base of Vale do Rio Doce Co. Its principal mines comprise CAUE, CONCEIÇÃO, CAPANEMA and TIMBOPEBA mined in Minas Gerais State. These ores are carried in by existing railways and received by the car dumper. The planned iron ore materials for the first phase production consist of 85% of sintered ore and 15% of sized ore.

3.2.2 Coal

Since Brazil yields little hard coking coal suited for iron-making, it was inevitable to use imported coal in high proportion. In view of the current policy of the Brazilian Government to diversify sources of coal supply, coals from U.S.A., Poland, Canada and Australia are mainly used with Brazilian coal.

3.2.3 Auxiliary materials

Auxiliary materials such as limestone, manganese ore and serpentine are supplied from Minas Gerais and Espirit Santo State, Brazil.

3.2.4 Electric power

Planned power consumption in the first phase operation of Tubarão Steelworks is 930 000 MWH/year, of which 580 000 MWH/year is generated in the works and 350 000 MWH/year supplied by Espirit Santo Centrais Electricas S.A. (ESCELSA).

Electric power supplied by ESCELSA has a 60 Hz frequency and a 138 kV voltage. Operating voltages in the works are 13.8 kV, 330 V, 440 V, 220 V and 110 V, except for the control systems.

3.2.5 Industrial water

In Tubarão Steelworks, both sea water and fresh water are used for industrial water. Sea water is used mainly for cooling at a rate of about 39 700 m^3/h. It is taken from the Atlantic and distributed to various plants for use. The quality of sea water used is mean SS 10 ppm, and maximum temperature 28°C.

Fresh water for industrial use is taken from Santa Maria River flowing in the vicinity of the steelworks and supplied by Companhia Espirito Santense de Seneamento (CESAN). The planned water consumption in the first phase is 71 000 m^3/d (potable water 11 000 m^3/d and industrial fresh water 60 000 m^3/d). CESAN supplies untreated raw water, which is treated by the water treatment equipment installed in Tubarão Steelworks and distributed to various areas. The quality of raw water is pH 5.8-8.6, SS 20 ppm or less and turbidity 20 deg. or less.

3.3 Port

Port facilities to be used for receiving coal and shipping products are being constructed by the Brazilian Government in Tubarão area adjacent to the steelworks. This port is constructed as a public port to supplement the existing Vitória commercial port, under the plan to handle mainly steel products and raw materials for steelmaking. Its specifications at the end of the first phase construction are given below.

Coal berth: wharf length 728 m, water depth 18 m, unloading crane 1800 t/h × 2 units (1 unit currently in operation)

Steel product berth: wharf length 638 m, water depth 14.5 m, loading crane 35 t × 4 units (2 units currently in operation)

4 Outline of Steelworks

4.1 General Layout and Materials Flow

As shown in **Fig. 2**, Tubarão Steel Works is so laid out organically that materials can flow most rationally from the Atlantic coast side along the production line, in the order of coal yard, coke oven plant, ore yard, sinter plant, blast furnace, steel making plant and slabbing mill.

The compound lies about 18 m above sea level in average. Iron ore and auxiliary materials are carried by freight cars from inland, while coal brought in by ship. When planning the general layout, the following points were taken ito consideration.

(1) Expansion for the future
The layout was so designed from the beginning that the steelworks could be readily expanded not only to annual output 6 000 000 t/year in the second phase plan, but also to 12 000 000 t/year in future. Moreover, sufficient consideration was made on the space and materials flow, considering the future need of installing various type of rolling mills to meet diversified demands.

(2) Materials flow requirements
As mentioned above, the Steelworks compound is about 18 m above sea level, and about 14 m higher than the port facilities area. The railways to carry

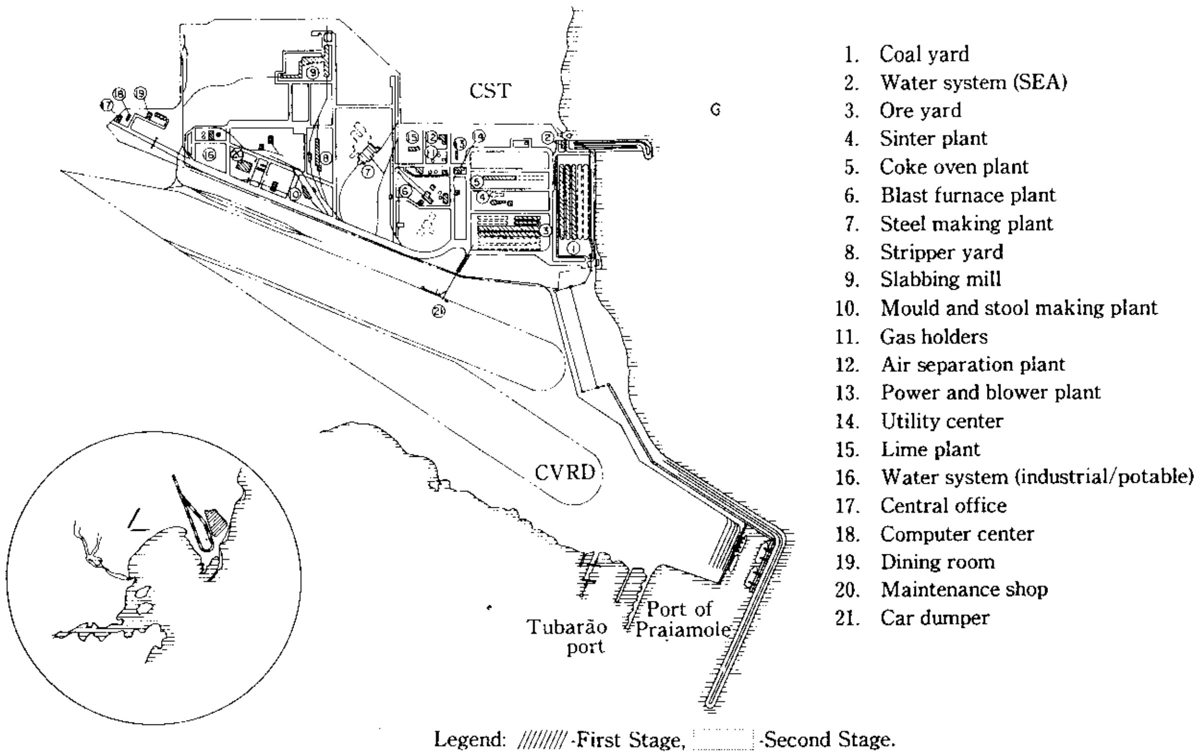

Fig. 2 General layout

slabs to the port are required to be about 4 km long to cope with 14 m level difference in view of allowable gradient for railroad. On the other hand, a long hauling of a large amount of coal from the port raises the freight cost problem. Taking these two factors into consideration, a layout was adopted, whereby materials will flow sequentially from the Atlantic coast side to inland yards.

(3) Topography and bearing capacity of soil
The Tubarão Steelworks compound was made not by reclamation but by reshaping natural terrain. Therefore, some area of the compound used to be hills, riverbeds, and marshes, resulting in a large difference from place to place in soil bearing capacity. When deciding on the general layout, the main equipments having large foundation load were placed at cut-off ground having greater bearing capacity. It was also attemped to reduce the construction cost by considering smooth connections between plants and shortening of materials flow distances.

The materials flow underlying the equipment plan was designed as shown in **Fig. 3**. Scrap to be used in the steel-making is all supplied by return scrap.

4.2 Outline of Production Facilities

4.2.1 General

Tubarão Steel Works is equipped in the first phase with a blast furnace, two basic oxygen furnaces and a slabbing mill. It is the most modern integrated steelworks for semi-finished products, with an annual capacity of 3 000 000 t slab. Each production unit was designed taking into consideration various conceivable phases including operation, maintenance, environmental control, reduction in production cost and space for future expansion. On the other hand, the technological level of steel making in Brazil and multiple sales routes of slab were also considered. The basic concepts of production facilities are described below.

(1) While each operating unit was to be designed on the basis of modern equipment and technology, those having been established at the time of planning are to be used in consideration of difficulty of the first phase operation.
(2) Equipment are to produce slabs of diversified properties and dimensions.
(3) Equipment are of high production efficiency and excellent labor productivity.
(4) Adequate consideration is to be paid to environmental conservation.

Principal specifications of plants are shown in **Table 2**.

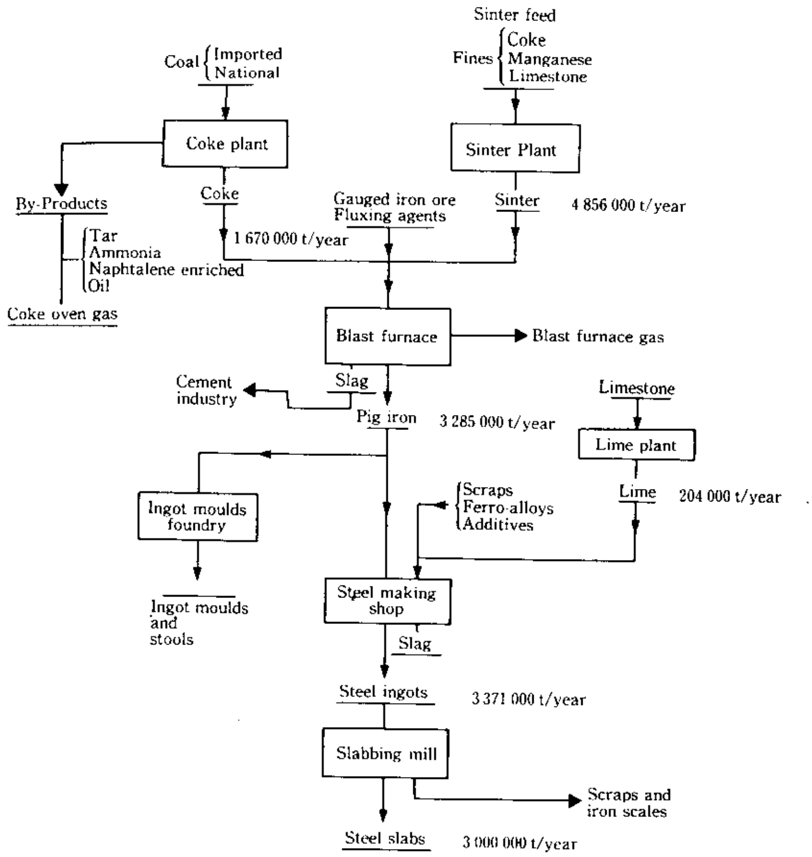

Fig. 3 Materials flow

Table 2 Principal specification of the plant

Plant	Main specifications
Coal yard	Number of yard: 3 yards Stacker: 2 500t/h × 2 units Reclaimer: 750t/h × 2 units
Ore yard	Primary yard: 2 yards Blending yard: 2 yards Stacker/reclaimer: 3 600t/h/2 500t/h × 2 units Blending stacker: 2 500t/h × 1 unit Blending reclaimer: 1 500t/h × 1 unit
Coke oven	49 ovens × 3 battery Height: 6.5 m Quenching equip.: dry quenching
Sinter	Type: Lurgi DL sinter strand Effective grate area: 440m² Pallet width: 5 m Productivity: 33 − 37t/m²/d
Blast furnace	Inner volume: 4 415m³ Hearth diameter: 14 m Height: 110 m Production capacity: 3 285 000t/year Casting machine: 3 000t/d Torpedo car: 450 t
Steel making	Converter: 280 t/ × 2 units Inner volume of converter: 490 m³ each Desulfurization equip.: torpedo car desulfurization type
Slabbing mill	Production capacity: 3 371 000 t/year Soaking pit: 140 t × 30 pits Rolling mill: universal type Production capacity of slab: 3 000 000 t/year
Power & blower	Blower: 49 000 kW × 2 units Generator: 54 000 kW × 2 units Turbine: 66 000 kW × 2 units Boiler: 250 t/h × 2 units
Air separation	Air separation unit: 2 units Production capacity of oxygen: 21 000 Nm³/h each Production capacity of nitrogen: 18 000 Nm³/h each
Mould & stool making	Type: Furan process type Production capacity: 4 000 t/m (ingot, mould) 12 000 t/m (stool)
Others	Computer: FACOM M160 AD type × 2 units Lime plant: rotary kiln type × 2 units Gas holder: 150 000 m³ × 1 unit 40 000 m³ × 1 units

4.2.2 Coal yard and coke ovens

The coal yard includes three yards each 800 m long and 45 m wide. Coal carried from the port through belt conveyors is received by two stackers to be stored in the yard, and then delivered by two reclaimers, blended in blending bins to give uniform quality, and sent to coke ovens.

The coke ovens are of largest size in the world with 3 battries each with 49 ovens, consisting of 6.5 m high and 16.9 m long ovens of Carl Still type. The dry quenching system is adopted so as to utilize sensible heat of coke effectively and improve the quality of coke. For the waste water treatment system, the activated sludge method is adopted.

4.2.3 Ore yard

The ore yard consists of two yards each 640 m long and 50 m wide. While the ore storage capacity is much smaller than that in Japanese steelworks, this is adequate for the location where stable supply of high quality iron ore is always available. Iron ores are blended in seven blending bins and two blending yards to obtain uniform composition, and sent to the sinter plant.

4.2.4 Sinter plant

The sinter machine of DWIGHT-LLOYD type is as large as 440 m^2 in effective grate area, allowing a 33–37 $t/m^2 \cdot d$ productivity and a high layer depth operation of 500 mm maximum. Two main blowers are provided. Hot sintered ore is cooled by a pressure circular type cooler, and an electric precipitator is adopted for waste gas cleaning. A process computer is provided for the operation control, so as to ensure stable operation.

4.2.5 Blast furnace

The blast furnace of a 4 415 m^3 inner volume is the largest in North and South Americas, and the 12th in the world. The designed pig iron output is 3 285 000 t/year. There are four tap holes. The furnace is cooled by stave cooling system. The furnace top charging system is of a two-bell one-valve seal type with continuous revolving chute. Four hot stoves of Koppers external combustion type are provided. As auxiliary equipment, a slag granulation system and a casting machine are provided. For the control of operation, a Go-Stop system developed by Kawasaki Steel is introduced, in addition to a process computer, contributing extensively to stabilizing operation.

4.2.6 Steel-making plant

The steel-making plant can turnout 3 371 000 t/year steel with two units of 280 t basic oxygen furnace (LD converter). Besides, a hot metal desulfurization equipment in torpedo car through ATH process and a process computer for operation control and blowing control in furnace are provided so as to ensure high quality and efficient production. For dust collection, a primary dust collector of BAUMCO type and a secondary dust collector of bag filter type are instablled.

4.2.7 Slabbing mill plant

The slabbing mill plant includes a universal type rolling mill, with an annual capacity of 3 000 000 t, maximum slab width of 2 m and maximum slab weight of 35 t. The conditioning equipment consists of a slab cooler of chain conveyor type with water spraying nozzle connected with a scarfing conveyor 117 m long, so as to handle slab continuously. The possibility of adopting direct charge is incorporated in the layout, in preparation for installing a hot strip mill in future.

4.2.8 Computer

Two units of large computer (FACOM-M160 AD) are provided for the production and administrative control of the steelworks.

5 Construction Work

5.1 Manufacturing and Shipping

The contract for equipment supply was signed on October 31, 1978, in the presence of the President of Brazil, and after being approved by governmental agencies in the nations concerned, came into force in May 1979. As mentioned above, Kawasaki Steel took over the supplies of blast furnace, sinter plant, power and blower plant, air separation plant, mould and stool making plant, business computer system, fuel distribution system, power distribution system, sea water system, ore yard, utility center, and software of process computer for steel-making plant. After concluding the contracts with CST, the operation of making contracts with manufacturers was initiated. The manufacture of plant equipment was started as soon as the contract came into force, and the first ship left Japan in October 1980. Manufacturing in Japan proceeded smoothly, and all shipping was completed in August 1982, sending from Japan about 244 000 freight tons of plant equipment (about 87 000 mt) in this period.

In order to reduce handling cost through centralized control and ocean freight, goods to be shipped from Japan were concentrated at Chiba and Mizushima Works of Kawasaki Steel, and shipped on full-load basis by liners. This allowed not only to save freight cost, but also to make efficient transportation on the part of shipping companies, thus giving sizable benefits to CST and shipping companies. In designing and manufacturing plant equipment, particular attention was paid to peculiar conditions (weather, environment, and so on) at the site, and selecting spare parts and consumables available in Brazil as much as possible.

5.2 Civil Works

The timber felling work at the steelworks site was started in September 1976, followed by survey, subsoil investigation by boring and loading test at blast furnace site. On the basis of these invetigations, the final positions of main equipment and details of land preparation work were established. With the land preparation work started in April 1978, and the blast furnace foundation work in May 1980, the civil engineering works went into the full swing.

The hilly areas where main equipment were located consisted of weathered Tertiary layer with sporadic clayey soil layers, and were characterized by very high bearing capacity. The foundtion structures for the main equipment affect not only the construction time schedule but also the economy. The Kawasaki Steel's engineers deliberately examined the foundation structures on the basis of detailed analysis of boring data, load test data, water tank loading test data, etc. and decided finally to adopt pile-less structures, so as to shorten the construction time and minimize the cost. For the blast furnace foundation, in particular, the use of post-tension method and the execution control through the observational construction control system (OCC system) having the feedback function made it possible to achieve great effect in safety, construction time and economy. The settlement of blast furnace foundation in the blast furnace plant constructed by this method is shown in **Table 3**. The relative settlement between foundations of blast furance proper and hot stove was at most 3 mm or less, indicating excellent state of foundation.

Civil engineering is Brazil's speciality, with its technical and executing capability at fairly high levels. For the work management technology, however, the assistance by Japanese engineers was required. Since any delay in the civil engineering works would greatly affect the

Table 3 Settlement of blast furnace plant's foundation

	Foundation of blast furnace proper		Foundation of hot stove		Relative settlement (mm)
	Intensity of load (t/m^2)	Settlement (mm)	Intensity of load (t/m^2)	Settlement (mm)	
Mar. 1982	19.0	1.6−2.6	14.9	1.7−2.3	0.1−0.9
Sept. 1982	22.4	3.7−5.4	20.8	3.9−5.3	0.2−1.6
Nov. 1983	25.9	5.3−7.9	23.2	6.0−7.1	0.2−1.9
Jan. 1984	28.6	5.0−7.9	23.2	5.3−7.1	0.3−2.6

Note: Basic level (zero point) for the above settlement is foundation level of erection work starting date.

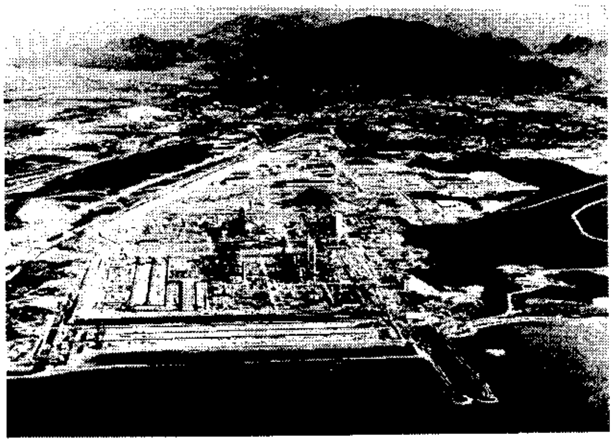

Photo 2 General view of Tubarão Steel Works

overall schedule of construction, engineers dispatched to civil engineering division and schedule control division from Kawasaki Steel made detailed schedule control. Consequently, the main construction work was completed approximately as scheduled. The civil engineering work in the first phase dealt with about 14 000 000 m^3 earth in land preparation, and placement of about 710 000 m^3 concrete in foundation and structures.

5.3 Erection Work

The erection of plant equipment was initiated in December 1980 for coke oven plant, and in January 1981 for blast furnace, and took about three years. The steelworks was put into operation in November 1983. **Photo 2** shows a general view of the completed steelworks. The erection work required 7 300 000 man-days, and the total weight of installed plant equipment amounted to 350 000 t, which were broken down as follows:

Equipment	:	104 000 t
Refractories	:	116 000 t
Electric and instrumentation equipment	:	15 000 t
Steel structures	:	89 000 t
Piping materials	:	26 000 t
Total	:	350 000 t

Plant equipment delivered by Kawasaki Steel were erected smoothly without any appreciable troubles. The no-load test for sinter plant was completed in February 1983, and that for blast furnace plant in March 1983. Subsequently, load test was restarted after some work interruption, and plants were put into operation sequentially. All the plants have been operating very smoothly since then. Some characteristic events concerning the progress and contents of erection works are described below.

5.3.1 Work control and erection supervision

The erection work was conducted by Brazilian constructor under the technical guidance by erection supervisors dispatched by Brazilian, Italian and Japanese equipment suppliers. The constructors participated in the first phase work were mostly of major enterprises in Brazil and at fairly high level in respect of execution technology. Kawasaki Steel cooperated mainly in the fields of work management and schedule control. Since Kawasaki Steel engineers and supervisors dispatched to CST assisted on the basis of schedule and work control technologies accumulated in Kawasaki Steel through its own previous constructions, plant equipment in charge of Kawasaki Steel was erected as skillfully as those in Japan. The number of supervisors sent from Japan amounted to 490 and 4049 man-months in total. The contract for erection work was concluded not on the basis of cost-plus-fee system, as generally adopted for the construction of steelworks in Brazil, but on the basis of unit price system, in which the work was divided into a number of steps and unit price was decided for each step. This system makes it possible to reduce the installation cost by imposing a wide-ranged responsibility to the constructors, but requires a large quantity of drawings and data before bidding. Kawasaki Steel provided intensive backup on the basis of many years' experience of its own in construction and accumulated data, so as to realize the contract based on the system mentioned above.

5.3.2 Erection work schedule

The actual schedules of plant erection work are shown in **Fig. 4**. Plant equipment under the charge of the Kawasaki Steel was completed as scheduled up to test run through the close cooperation between engineers and supervisors dispatched from Kawasaki Steel and CST engineers in charge of erection, as well as appropriate guidance in the fields of schedule and work control. It is considered that the following achievements made by those engineers mentioned above and related manufacturers contributed effectively to the progress of erection work.

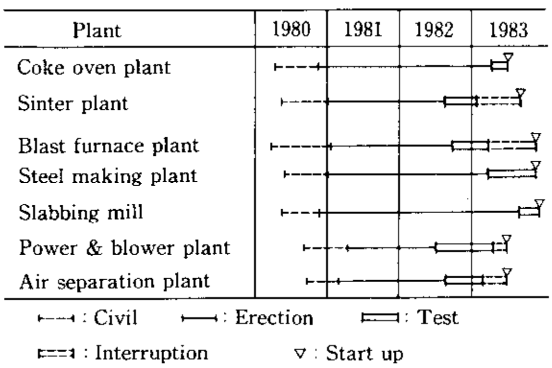

Fig. 4 Construction time schedule

(1) Strict control of manufacturing process to eliminate delay in delivery.
(2) Taking adequate care in loading and transporting to minimize damages in shipping.
(3) Proper adjustment of foundation, erection and manufacturing schedules.

6 Operation

6.1 Personal Dispatch for CST Operation

Companhia Siderurgica de Tubarão (CST) started as a pilot company of only five executives, with its employees increased step by step. Because of its non-productive nature as a newly-built company, however, it is imperative to limit the employment of personnel, and it is also difficult to recruit experienced persons. At the stage of equipment planning and construction, it is necessary to examine basic specifications for equipment and fundamental policy of operation, thereby implementing CST's intention and reviewing equipment specifications provided by the equipment suppliers. However, with a limited number of manpower including experienced persons, it was anticipated that the performance would fall short of expectation, leaving some problems unsolved. In order to promote the construction and operation smoothly under such circumstances, it was urgently required to dispatch from stockholders employees having adequate knowledge and experience in construction, operation and management of steelworks. For this reason, it was decided to dispatch personnel from stockholders to CST, and put them into key positions as CST members. They were required to instruct and advise CST's employees, and attack and solve problems quickly for themselves. In March 1977, a basic agreement was concluded for employing foreigners (personnel loan agreement), who were seen sent to various sections in no time.

Among CST executives, president and those in charge of finance and construction came from Brazil, those in charge of production and technology from Japan and those in charge of accounting from Italy. The executive in charge of construction supervises four Divisions each for schedule planning, design engineering, construction and purchase contract, with each Division overseeing two departments. To each Division, one member was sent from each of Japanese, Brazilian and Italian parties, sharing posts of one General Superintendent and two Chiefs of Department in the form of so-called troika. From Kawasaki Steel, four members consisting of one General Superintendent and 3 Chiefs of department were sent, contributing to making an efficient construction management. In the Production and Technology Division under the supervision of execu-

Table 4 Loaned employee from Kawasaki Steel and FINSIDER to CST

	78/E	79/E	80/E	81/E	82/E	83/E
From Kawasaki Steel						
Construction division	5	10	13	14	14	10
Production & technical division	2	6	11	14	16	17
Personnel & general affairs dept.	1	1	2	2	2	2
Accounting dept.	2	2	2	2	2	2
Total	10	19	28	32	34	31
From FINSIDER	6	6	16	20	19	15

tives sent from Kawasaki Steel, Kawasaki Steel officials were assigned in every section to assist Brazilian manager for better communication and information collection.

On the other hand, in order to solve specific problems, a contract was concluded in April 1977 on the duty of specialist engineer (part-timer contract) so that specialists could be dispatched for a short period whenever any problem occurred, to assist CST in the business. Up to now, 300 man-months part-timers have been dispatched from Kawasaki Steel. The numbers of loaned employees from Kawasaki Steel to CST from 1978 to 1983 are shown in **Table 4**.

6.2 Training

In order to ensure a smooth start-up and stable operation, CST made efforts to employ persons experienced in steel-making and related businesses, and planned and executed a large-scale training within the firm, in Brazil and overseas. Consequently, 4946 persons (as of April 1984) adopted by Production and Technology Division were composed of

(1) 619 persons formerly worked in three major mills (USIMINAS, CSN and COSIPA)
(2) 1320 persons of previous experiences in steel-making companies other than three major mills
(3) 1623 persons experienced in steel-related businesses.

The number of unexperienced persons was 1384.

Training in Brazil for 1400 persons in the categories (2) and (3) above was mostly conducted at three major mills for 3 months in respect of working operation and maintenance of plant equipment. This was highly effective in turning unexperienced persons into useful workers in the integrated steelworks.

Training overseas was conducted for 4 months in Kawasaki Steel and Italy in accordance with division of equipment supply to improve technical skills of core engineers in each field of work. Kawasaki Steel accepted 114 trainees, and Italy 132.

Training at Kawasaki Steel was held at Chiba Works and Mizushima Works on jobs concerning blast furnace, sinter plant, power and blower plant, instrumentation, and production control system, under a training service agreement signed in October 1978. The trainees consisted of 24 managers, 53 engineers and 37 foremen, of whom 75% were recruited from the three major mills. The main purpose of the training was to make unexperienced trainees acquainted with large-sized plant equipment, covering technologies of operation and maintenance, and those of control. Owing to the high morale of the trainees to learn, training proved to be effective and satisfactory. The trainees brought back to Brazil all the fruits of trainig compiled in the technical standards, which laid the foundation in promoting the preparation of various technical standards before start-up. Moreover, as instructors in this training session were sent as key-persons of operation guidance supervisors to be mentioned later, the operation guidance was brought about smoothly.

6.3 Operation Guidance

In order to ensure successful operation of the new steelworks, discussion was made on the need of operation guidance, in addition to the said training, with co-operation from stockholders. Contract for operation guidance between CST and stockholders was concluded in June 1983. For some plant equipment, it was agreed to dispatch part-time engineers whenever necessary. The guidance by part-time engineers was started in January 1983, followed by operation guidance under the contract.

The purpose of the operation guidance was to give instructions so that Tubarão Steelworks could make successful start-up, operation and maintenance. Before concluding the contract for operation guidance, the assignment of guidance work was discussed, and the assignment to stockholders and the number of engineers to be dispatched were decided as shown in **Table 5**, in consideration of their responsibility for equipment supply and operation experience. Kawasaki Steel took charge of instructing operation and maintenance technology for coke dry quenching equipment (CDQ), ore yard, sinter plant, blast furnace, power and blower plant, water system, power distribution system, fuel distribution system and production control system, and operation technology for steel-making. While the coke dry quenching equipment was supplied by Italy, they were assigned to Kawasaki Steel because only Kawasaki Steel had operation experience in coke dry quenching equipment. The total number of engineers dispatched for operation guidance was 279 in total (118 from Brazil, 53 from Italy and 108 from Kawasaki Steel). The disptach period covered a few months before and 8 months after the blowing-in of the blast furnace. Kawasaki Steel engi-

Table 5 Number of engineers for operation guidance

No.	Plant	KSC	FIN	SID
1	Coal yard and coke oven	–	9	7
2	Coke dry quenching	7	–	–
3	Ore yard sinter	6	1	8
4	Blast furnace	22	–	19
5	Steel making plant	23	9	24
6	Slabbing mill	–	17	15
7	Maintenance shop	–	–	11
8	Refractories	–	–	7
9	Mould and stool making plant	–	–	4
10	Power & blower plant	11	–	–
11	Air separation plant	–	–	11
12	Water systems	5	–	3
13	Power distribution system	2	–	–
14	Fuel distribution system	6	–	–
15	Production control	10	–	5
16	Instrumentation and others	15	16	3
17	Chief superintendent	1	1	1
	Total	108	53	118

KSC: Kawasaki Steel
FIN: FINSIDER
SID: SIDERBRAS

neers were sent beginning in January 1983, to be engaged in guidance for preparation of starting up operation.

The crucial target of the guidance immediately after start-up was to prevent fatal accidents in plant equipment. This was achieved in a month or so. After the second month, the target was shifted to securing output and improving product quality. Consequently, the test rolling of slab at USIMINAS and CSN, Brazilian steelworks, gained reputation for top-level quality in Brazil. Cost reduction was set as the subsequent target, and it is expected that the effect of the new target will soon become apparent. As for the maintenance work for electrical, instrumentation and mechanical equipment, which required long-term steady efforts, the basic concept and details of execution methods were taught emphatically. Difference in languages and habits provided an enormous barrier to the guidance. While both CST and Kawasaki Steel paid great efforts to overcome this barrier, the continued endeavor toward mutual understanding from both parties solved the problem and brought the operation guidance to completion without troubles.

6.4 Status of Operation

Since its inauguration, Tubarão Steelworks has continued the operation smoothly. A general view of the blast furnace is shown in **Photo 3**. The actual operation data for April and May 1984 are given in **Table 6**. It must be added that the production was suppressed in April because of performance test for a part of plants and a quality assurance test of slabs by the customer. The test rolling conducted before starting sales achieved good results to satisfy various standards and specifications, proving the excellent quality of the slabs produced. In view of smooth operation of plant equipment and satisfactory aquisition of technological know-hows, Tubarão Steelworks may be expected to keep the operation at the top level in the world.

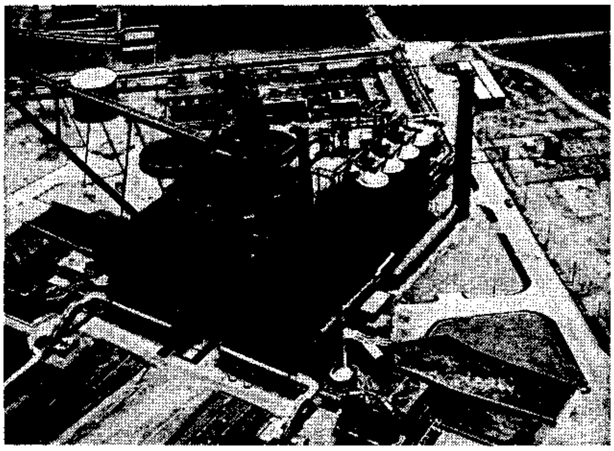

Photo 3 General view of No. 1 blast furnace

Table 6 Actual operation data

	Items	April '84	May '84
Production volume	Coke	105 503t	131 318t
	Sinter	340 183t	380 455t
	Hot metal	193 926t	220 923t
	Ingot	177 228t	201 558t
	Conditioned slab	154 768t	182 922t
Main data	Productivity of iron	1.5t/d m³	1.6t/d m³
	Si in hot metal ($\bar{x}$)	0.44 %	0.53 %
	S in hot metal ($\bar{x}$)	0.023%	0.027%
	Mn in hot metal ($\bar{x}$)	0.78 %	0.66 %
	P in hot metal ($\bar{x}$)	0.103%	0.099%
	Hot metal desulfurization ratio	91.2 %	98.5 %
	Hot metal ratio	89.9 %	90.3 %
	Steel yield	94.5 %	94.9 %
	Slabbing yield (after scarfing)		
	Open rimmed steel	86.8 %	87.4 %
	Capped steel	90.3 %	91.5 %
	Semi-killed steel	90.9 %	83.6 %

7 Conclusion

With its magnitude of construction cost amounting to

US$3.1 billion dollars and its characteristics of multinational joint venture involving Japan, Brazil and Italy, it might be deemed only natural that the project came to see some unexpected hindrances, thus taking longer time than originally planned.

After all, however, the spirit of cooperation and dedication demonstrated by all parties to full extent from the beginning up to the start-up of the steelworks is considered to be the key to the success of the project. Admittedly, it was at the time of unfavorable market condition that Tubarão Steelworks was put into operation, but spurred by a sign of recovery in the world economy, there is something of a bright hope seen in the steel market. We would like to expect continuing satisfactory operations and the stable management of Tubarão Steelworks.

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