# CHAPTER 4

# PRODUCTION PLAN

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The crude steel production scale of this integrated steelworks is to be $1.5^{mil.t/y}$ for stage I, and $3.0^{mil.t/y}$ for stage II, based on the estimation of the future steel demands in the Philippines stipulated in the preceding chapter. The main plants and the production configuration are considered based on the following concepts:

1) The B.F.-B.O.F. process is adopted as the main production process.
2) The molten steel produced by the B.O.F. shall be all processed by the continuous casting machine.
3) As the final products, the hot-rolled products mainly of coils and sections are planned to meet the domestic demands (foreseen values) as mentioned before.
4) As the basis of this planning, special consideration shall be given to enabling stable maintenance and stable operation of this integrated steelworks, which is to be the first integrated steelworks in the Philippines.
5) The layout is planned with provision of the future expansion, considering the possible site area.

The concreate details are given in the subsequent paragraphs.

## 4-1 Production Process

### 4-1-1 Stage I production process

The new steelworks is an integrated production system capable of producing $1.5^{mil.t/y}$ of crude steel, by one blast furnace of inner volume of $2,600^{m^3}$

This integrated steelworks will produce hot coils, billets, slabs, and blooms and become a major supplier of steel materials to the domestic steel manufactures and finished products to consumers. Based on the production plan previously stated, the production process is planned as a modern steelworks to suit the conditions in the Philippines.

The ratio of agglomerate for the blast furnace is rated at 80%; and the sintered ore which is rated at 60% is to be processed and supplied by P.S.C.. Approximately 20% of the pellets is to be imported.

The Ore-sizing equipment is installed to feed the sized ores to the blast furance.

A coke oven plant is installed to supply the necessary quantity of coke to the blast furnace as a self-supplying system.

The blast furnace is capable of supplying the required quantity of molten pig iron to the steelmaking plant steadily throughtout the year.

As for steelmaking process, two basic oxygen furanace (nominal $160^{t/heat}$) are to be installed, and the hot metal ratio is set at approximately 85% for optimum operation. However, the purchase of the scrap will be necessitated because the scrap produced within the steel-works becomes insufficient.

As for billet manufacturing, the continuous casting method suitable for modern steelworks is adopted; continuous slab and bloom casters are to be installed.
The casters are capable of processing all molten steel from the B.O.F.
However, some consideration shall be given in the equipment so that a certain amounts of ingots can also be produced by an ingot-making process, in order to balance the B.O.F.-C.C. production at the start-up and for emergency. The basic process flow is that C.C. slabs are supplied to the hot strip mill after conditioning and C.C. blooms to the billet mill, but some of the slabs and blooms are sold out to the domestic steel manufactures.
The hot strip mill produces hot coils by the continuous rolling process and the billet mill produces billets by the reversible rolling process from the supplied materials, to meet user's requirements in quantities and qualities.
*Figure 4-1-1* outlines the process flow and production balance, which shows the production mix based on the processes mentioned above.
*Figure 4-1-2* shows the material balance of the raw materials, by-products, and final products.

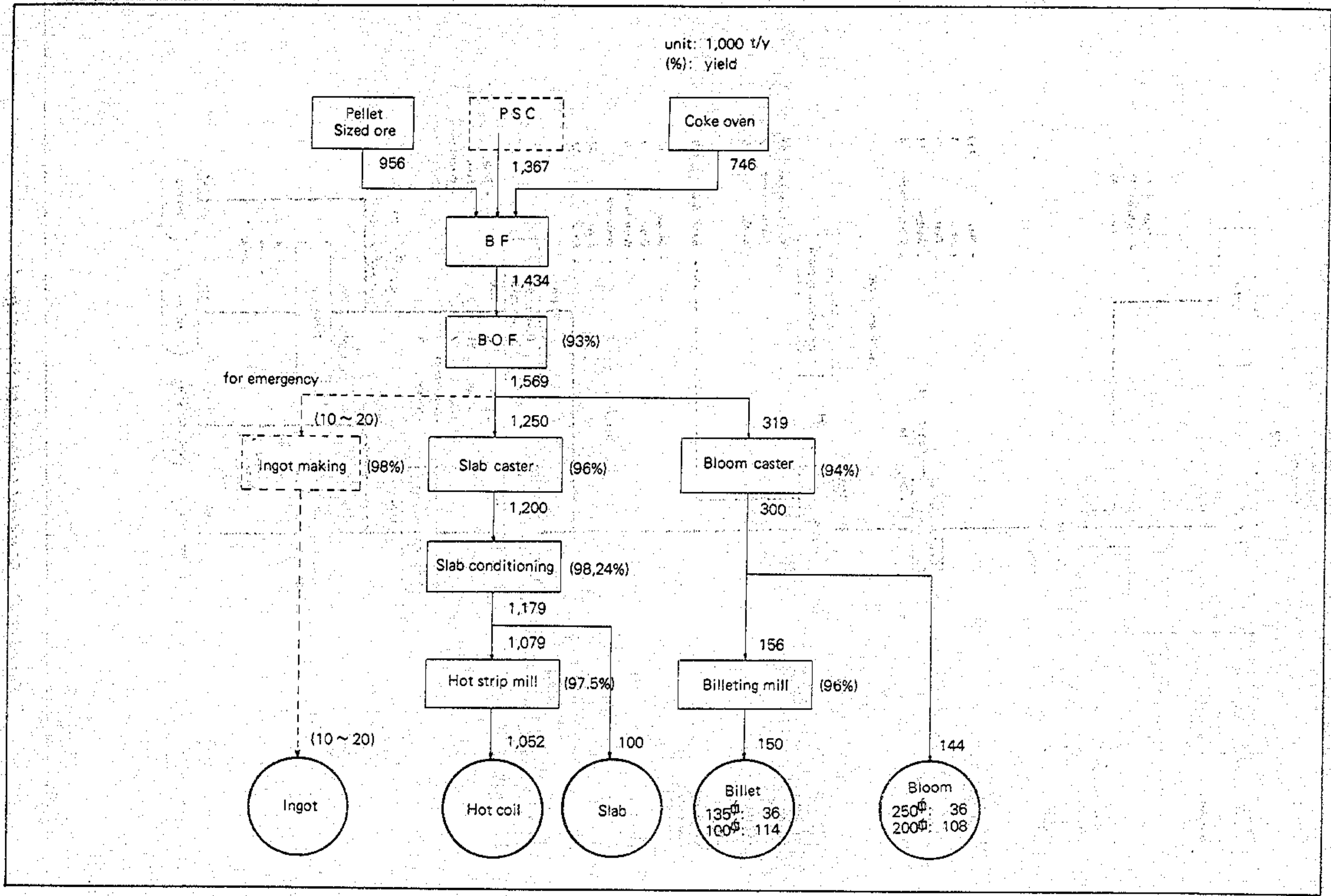


Fig. 4-1-1 Process flow and production balance at the stage I

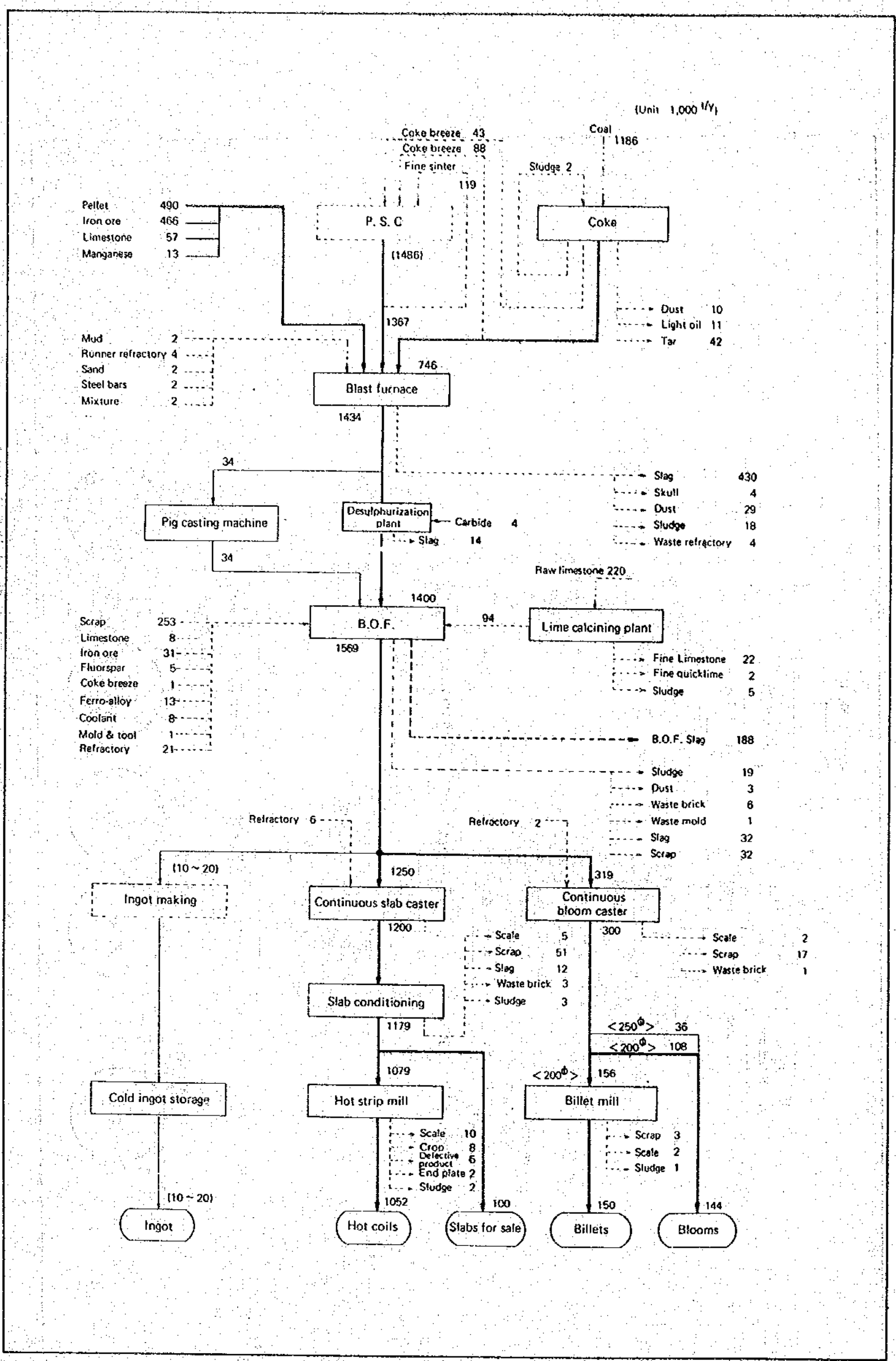


*Fig. 4-1-2 Material balance at the stage I*

### 4-1-2 Stage II production process

One blast furnace of inner volume 2,600$^{m^3}$ is added to be the. two blast furnace system, and one basic oxygen furnace is also added to enable 2/3 B.O.F. operation. The annual crude steel production is to be 3.0$^{mil.t/y}$.

The burden supply conditions to the blast furnaces is to be the same as in the stage I; since the material supply quantity will be doubled, each of the related equipment must be expanded in capacity. Though the sinter supply system is not clear so far, it seems that P.S.C. will be required to build No. 2 sinter plant.

Pig iron is to be continously and steadily supplied from the blast furances to meet the steelmaking capacity, where the hot metal ratio is set at around 85% in stage I. All amount of molten steel is to be processed by the continuous casting process.

As for the continuous casting equipment, continuous slab and bloom casters of the same capacity as for stage I are added. C.C. slabs are supplied to the host strip mill after conditioning. Now consideration is given to the plant layout so that the direct sending method for energy-saving can be adopted in future. Some of the C.C. slabs are to be shipped to heavy plate manufacturers.

The C.C. blooms are to be supplied to the medium-section mill or new billet mill.

In the hot strip mill, one re-heating furnace, one roughing mill and one coiler will be added. Some of the hot coils is to be supplied to the hot coil shearing line for hot-strip processing. In the medium-section mill, continuous finishing mills and finishing equipments for shaped-steel production will be newly installed behind the billet mill which is installed in stage I. A new billet mill will also be installed to meet the demands for billet.

*Figure 4-1-3* outlines the process flow and production balance, under stage II.

*Figure 4-1-4* shows the material balance of the raw materials, by products, and final products.

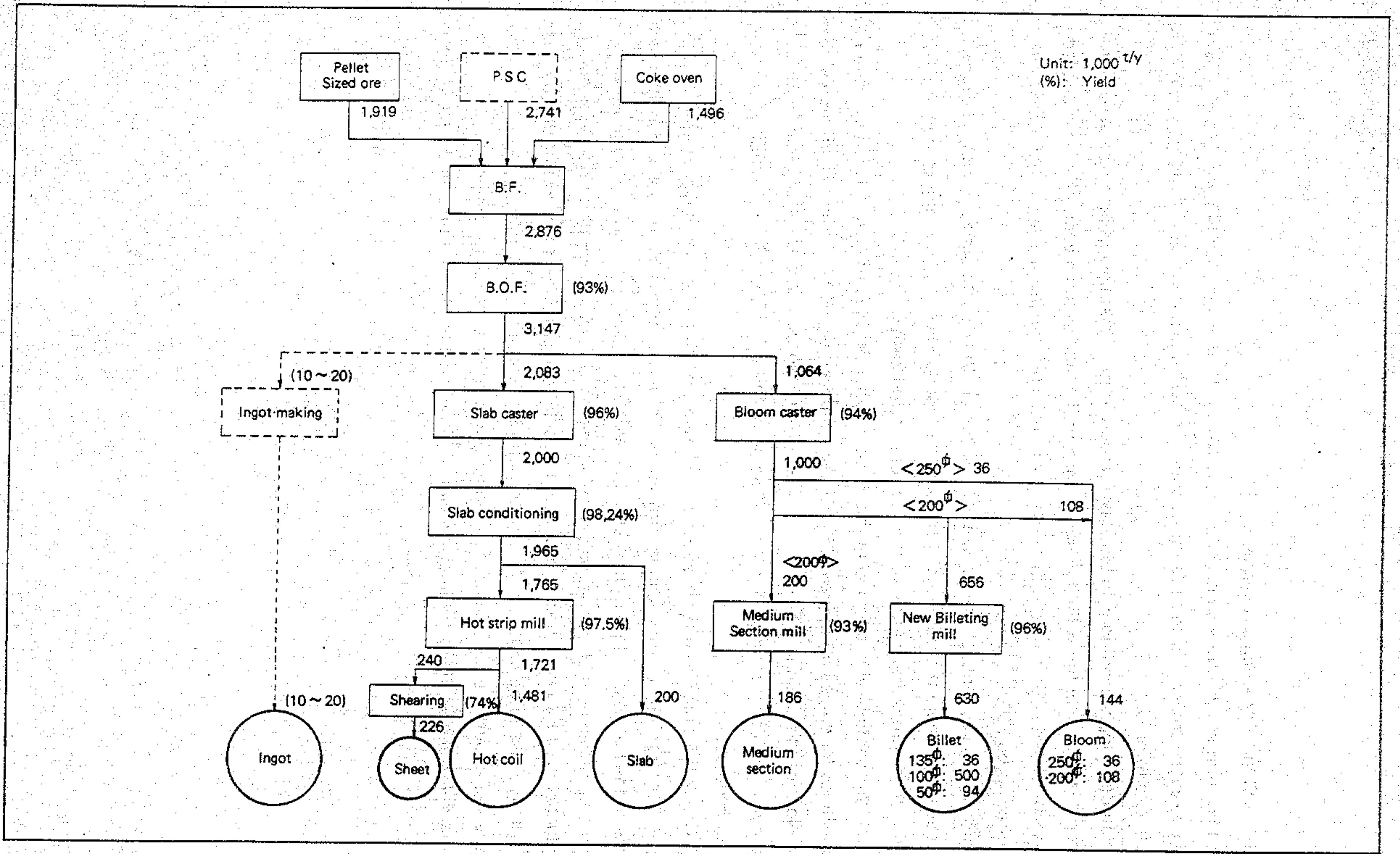


*Fig. 4-1-3 Process flow and production balance at the stage II*

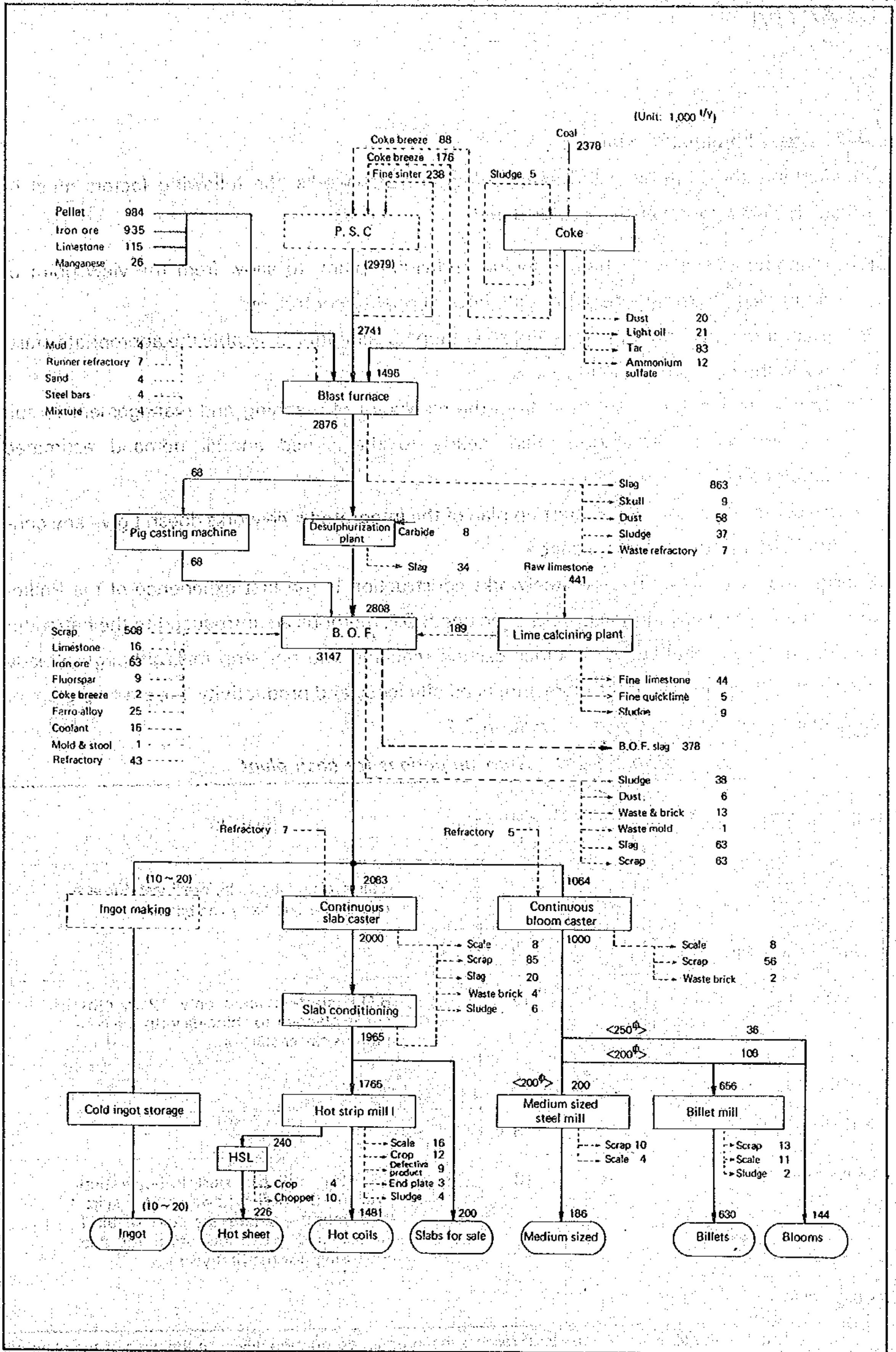


*Fig. 4-1-4 Material balance at the stage II*

### 4-2 Stage I production start up

In planning the start-up of the entire integrated steelworks, the following factors must be organicly and comprehensively considered.

(1) Planning of start-up schedule for the individual plant, to allow from the view point of equipment capacity, operation skill, level of quality control, etc.

(2) Planning of the optimum iron- and steel-tapping schedule, to enable the appropriate start-up of the final production process.

(3) Some consideration and effort from the viewpoint of planning and management to suit the scheduled production plan nearly to the aimed annual demand estimated beforehand.

(4) To confirm that the overall start up plan of the integrated steelworks doesn't give any contradiction to the utilities balance.

Considering that this integrated steelworks construction is the first experience of the Philippines, and that the blast furnace, coke oven and B.O.F. methods are introduced to the nation for the first time, and that the continuous casting machine and hot strip mill, although already used in the Philippines, involve more enhanced efficiency and productivity, the start-up plan for each plant is made as outlined in *Table 4-2-1.*

*Table 4-2-1 Start-up periods for each plant*

| Plant | Start-up periods (month) | | Remarks |
|---|---|---|---|
| | A | B | |
| Coke oven plant | 7 | 7 | Starts one month before blast furnace operation. (Half an oven battery) |
| Blast furnace plant | 7 | 7 | |
| B.O.F plant | 12 | 16 | B.O.F start-up takes only 12 months, but is planned to coincide with the continuous caster start-up. |
| Continuous slab caster plant | 16 | 16 | |
| Continuous bloom caster plant | 5 | 5 | |
| Hot strip mill plant | 16 | 18 | Hot strip mill can start full-operation level in 16 months; however, it is started 2 months before the start of blast furnace and B.O.F operation for slab processing, for the first year. |
| Billet mill plant | 11 | 11 | |

A: The period (months) when each plant reaches its normal production level on the basis of the planning made in its particular conditions not being constrained by those of other plants.

B: The period (months) when each plant reaches its stable production level according to the workswise comprehensive operation plan adopted in the present study.

*Fig. 4-2-1* shows the main production estimation during start-up periods.

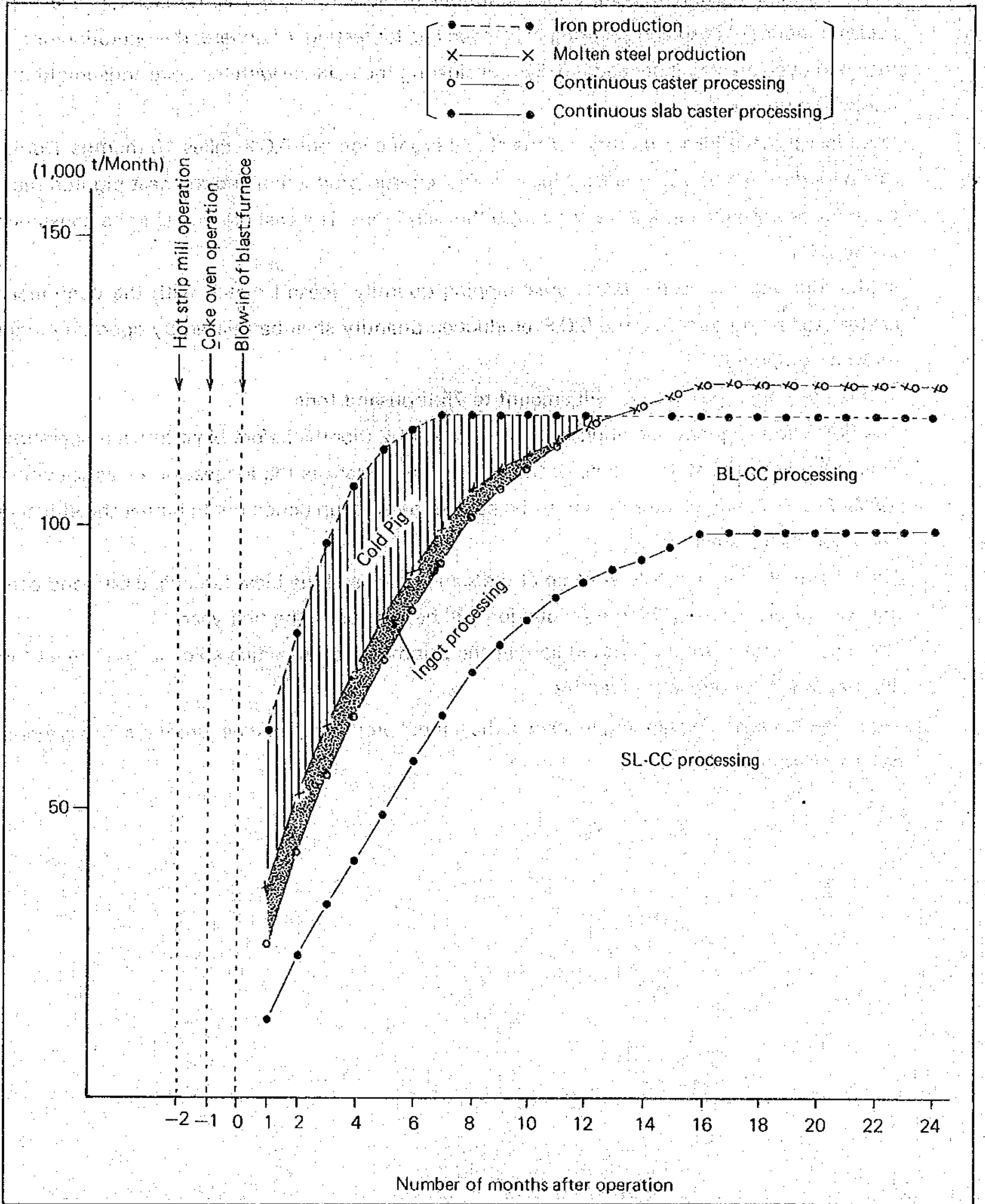


*Fig. 4-2-1 Production during start-up period*

Although the coke oven start-up period is considered seven months, the coke oven (half a battery) operation is planned to start one month before blow-in of the blast furnace for securing a certain amount of coke and securing coke-oven gas for testing. Afterward, the operation rate of the coke-oven plant will be made to rise, considering the balance with the coke consumption in the blast furnace.

The blast furnace take 7 months for the stable production but B.O.F. takes 16 months. During this period 15 months will cause excessive molten iron production and the cast pig iron must be produced, which aggregates about 380 thousand tons. The cast pig iron is to be consumed in the B.O.F.

In the first year, since the B.O.F. steel-tapping quantity doesn't match with the continuous caster processing quantity, the B.O.F. production quantity shall be utilized by operating ingot making equipment.

In this case ingot production will amount to 75 thousand tons.

The hot strip mill plant operation is planned to start 2 months before blast furnace operation. This is because the start-up time of the hot strip mill plant is the longest of all, as shown in *Table 4-2-1,* and much attention must be paid in the start-up period not to hinder the effective operation of the steel works.

The billet mill operation is to start-up at the same time as of the blast furnace, B.O.F., and continuous caster; however, bloom production will be surplus in the first year.

The bloom surplus will be stocked so that the shipment can be adjustable, so as to meet the fluctuations in bloom sales quantity.

Totalizing the start-up planning in stage I, the annual production of main products in this works can be seen in *Table 4-2-2.*

*Fig. 4-2-2 Stage I production start-up plan (unit: $1,000^t$)*

| | Iron | | | Molten steel processing | | | Crude cast steel | | | Semi-finished products for sale | | Products production | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Production | Destination | | | | | | | | | | | |
| | | B.O.F. | Shaping | Ingots | Slab - CC | Bloom - CC | Ingots | Slab - CC | Bloom - CC | Slab | Bloom | Hot coil | Billet |
| First year | 1,295 | 978 | 317 | 76 | 702 | 292 | 75 | 674 | 275 | 100 | 198 | 534 | 74 |
| Second year | 1,434 | 1,361 | 73 | 0 | 1,170 | 319 | 0 | 1,123 | 300 | 100 | 144 | 976 | 150 |
| Third and subsequent years | 1,434 | 1,400 | 34 | 0 | 1,250 | 319 | 0 | 1,200 | 300 | 100 | 144 | 1,052 | 150 |
| Production for balancing basic productions (Stage I) | 1,434 | – | – | (10~20) | 1,250 | 319 | 0 | 1,200 | 300 | 100 | 144 | 1,052 | 150 |

(  ): For emergency

4-3 Future plan

According to the information from the Phillippine side, approximately $643^{ha}$ of land can be reserved for the integrated steelworks.

The final future plan concering the production scale of the steel works to be constructed on this site shall be decided by the following conditions:

1) The final products mix planned by the steelworks.
2) The equipment specifications of each plant based on the product mix.
3) Layout plan of each plant under conditions 1) and 2).
4) The overall layout plan of the steel works, based on the conditions of 1), 2), 3) and others.

In case of the integrated steelworks of the philippines, the plants which can be installed in the given area in future will be made clear by furthering the stage I and II process and estimating the stage III one.

An example of stage III can be illustrated as follows.

1. Iron-making area: No. 3 and 4 coke ovens and No. 3 and 4 blast furnaces
2. Steel-making area: No. 2 steel-making plant (B.O.F and C.C)
3. Rolling area: No. 2 hot strip mill, cold strip mill and a certain surface treatment plant, No. 2 billet plant, steel bar and wire rod plants, etc.

In this case, annual crude steel production of this steelworks will amount to $7.0-8.0^{mil.t/y}$.

Exapnsion of prot, material yard, and area for available utilities, maintenance shop etc. will be also acquired to meet this production scale.

However, the actual planning of stage III must be decided in consideration of the steel-demand in market and the desire of the steel-works in terms of the facilities configuration. Our experience shows that the annual productivity of area is about $1^{t/y}$ per square meter. This justifies our estimation above of the final crude steel production scale for stage III.

# CHAPTER 5

## RAW MATERIALS

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## 5-1 Iron ore

### 5-1-1 Domestic iron ore

With respect to iron ore resources, no remarkable changes have occurred since the Pre-Feasibility Study was carried out in 1977. Santa Ines mine is still being studied for feasibility; however, it seems to be difficult to determine future development at the present because the quality of the iron ore produced by the mine is low-grade with a high sulfur content, and so is a problem in preprocessing.

Mining the domestic iron sand is suspended from the viewpoint of environmental protection, but it can be permitted, to meet the demand for ironmaking in integrated steelworks. In the study, only the iron sand is to be domestically procured, in the same way as in the Pre-Feasibility Study. All other iron ores are to be imported.

### 5-1-2 Iron ore imports

With respect to iron ore matters in the world, no remarkable changes have occurred since 1977. Accordingly the same attitude towards the Pre-Fesibility Study still applies to the importation of iron ore.

*Table 5-1-1* and *5-1-2* show the amounts of ores used according to uses.

*Table 5-1-3* shows chemical analysis of iron ores.

*Table 5-1-1 Iron ore consumption by uses (stage I)* (Unit: 1,000 t/y)

| | Sintering (Undersizes) | Blast furnace (Lumps) | Steel making (Lumps) | Total | |
|---|---|---|---|---|---|
| | | | | (dry) | (wet) |
| Pellets | 26 | 490 | – | 516 | 527 |
| Lump ore | 406 | 466 | 31 | 903 | 931 |
| Fine ore | 603 | – | – | 603 | 637 |
| Imported iron ore | 1,035 | 956 | 31 | 2,022 | 2,095 |
| Sinter | 119 | 1,367 | – | 1,486 | |
| Sinter + pellets | | 1,857 (80%) | | | |
| Ore for BF charge | | 2,323 (100%) | | | |

*Table 5-1-2 Iron ore consumption by uses (stage II)* (Unit. 1,000 t/Y)

| | Sintering (Undersizes) | Blast furnace (Lumps) | Steel making (Lumps) | Total | |
|---|---|---|---|---|---|
| | | | | (dry) | (wet) |
| Pellets | 52 | 984 | | 1,036 | 1,057 |
| Lump ore | 814 | 935 | 63 | 1,812 | 1,868 |
| Fine ore | 1,203 | | | 1,203 | 1,268 |
| Imported iron ore | 2,069 | 1,919 | 63 | 4,051 | 4,193 |
| Sinter | 238 | 2,741 | | 2,979 | |
| Sinter + pellets | | 3,725 | | | |
| Ore for BF charge | | 4,660 | | | |

*Table 5-1-3 Chemical analysis of iron ores*

| | Chemical analysis (%) | | | |
|---|---|---|---|---|
| | Fe | $SiO_2$ | $Al_2O_3$ | $TiO_2$ |
| Australian pellets | 63.8 | 4.93 | 2.99 | 0.13 |
| Australian lump ore | 64.8 | 3.15 | 1.67 | 0.07 |
| Brazilian lump ore | 66.4 | 2.18 | 0.95 | 0.07 |
| Indian lump ore | 63.0 | 3.01 | 3.29 | 0.14 |
| Australian fine ore | 61.4 | 6.25 | 2.89 | 0.12 |
| Brazilian fine ore | 65.4 | 4.67 | 0.88 | 0.12 |
| Indian fine ore | 61.3 | 3.95 | 3.56 | 5.86 |

### 5-1-3 Production of sinter

The Philippine Sinter Corporation manufactures sinter for blast furnace on commission. Since the existing plant of P.S.C. is unable to supply the amounts required by stage II of the project, it is necessary to study the construction of a sinter plant exclusively for use by integrated steel-works.

## 5-2 Coal resources

### 5-2-1 Domestic coal resources

With respect to coal resources, no changes have occurred since the Pre-Feasibility Study in the Philippines. The Lumbog mine is believed to have ample reserves of soft coking coal. Since the quality is still unknown, it is difficult to tell the feasibility of the development of that coal mine. Therefore all coals are to be imported.

### 5-2-2 Coking coal imports

With respect to coal matters in the world, no remarkable changes have occurred since the Pre-

Feasibility Study. Accordingly, the attitude towards the Pre-Feasibility Study still applies to the purchase plan of coal. *Table 5-2-1* and *5-2-2* show a blending schedule for coking coals.

*Table 5-2-1 Coking coal blending schedule (at the stage I)*

| | Blending ratio % | Annual consumption (1,000 t/y) | | Ash content % | Sulfur content % | Volatile matter % |
|---|---|---|---|---|---|---|
| | | Dry | Wet | | | |
| U.S. (LV) | 8 | 95 | 103 | 7.0 | 0.69 | 18.9 |
| U.S. (MV) | 15 | 178 | 193 | 7.3 | 0.82 | 30.0 |
| Australian (Hard) | 25 | 297 | 322 | 10.5 | 0.40 | 19.5 |
| Australian (Semihard) | 40 | 474 | 516 | 8.8 | 0.68 | 32.0 |
| Australian (Soft) | 12 | 142 | 155 | 9.1 | 0.63 | 38.0 |
| Total | 100 | 1,186 | 1,289 | 8.9 | 0.63 | 28.2 |

*Table 5-2-2 Coking coal blending schedule (at the stage II)*

| | Blending ratio % | Annual consumption (1,000 t/y) | | Ash content % | Sulfur content % | Volatile matter % |
|---|---|---|---|---|---|---|
| | | dry | wet | | | |
| U.S. (LV) | 8 | 190 | 207 | 7.0 | 0.69 | 18.9 |
| " (MV) | 15 | 357 | 388 | 7.3 | 0.82 | 30.0 |
| Australian (Hard) | 25 | 595 | 646 | 10.5 | 0.40 | 19.5 |
| " (Semihard) | 40 | 951 | 1,034 | 8.8 | 0.68 | 32.0 |
| " (Soft) | 12 | 285 | 310 | 9.1 | 0.63 | 38.0 |
| Total | 100 | 2,378 | 2,585 | 8.9 | 0.63 | 28.2 |

## 5-3 Other raw materials

### 5-3-1 Limestone

P.S.C. is responsible for limestone supplies for sintering. Accordingly, limestone for sintering is not included in the raw material schedule for the new steelworks.
Domestic lump limestone shall be used for blast furnaces and steelmaking.

### 5-3-2 Other iron-making materials

(1) Manganese ore

There are manganese ore reserves throughout the Philippines. The data submitted by the Bureau of Mines and the Board of Investment reports five of the existing twenty mines are mining manganese ore and new large-scale maganese ore deposits are said to have been found. Under these conditions it is desired to use domestic manganese ore. However the annual production of domestic manganese ore at the present is approximately 20,000$^t$, and approximately 9,000[1] are imported annually. Since the relationship between domestic manganese ore's grade and price is not definite, this study calculates the original cost presupposing the importation of manganese ore from India.

| | Indian Mn Ore | Domestic Mn Ore |
|---|---|---|
| Mn % | 28.4% | Not informed |
| Fe % | 24.5% | " |
| Landed Cost | $43.25 | $85.20.....₱622.00 |
| | (March 1979) | (1977) |

(2) Serpentine, dolomite, and quartzite

There are great reserves of these ores which would be easy to mine, throughout the Philippines. In fact, serpentine has never yet been mined in the Philippines. Serpentine is a source of MgO and $SiO_2$ and is suitable as an ironmaking auxiliary raw material. Since there is no record of mining serpentine, the present study presupposes that dolomite is used as a MgO source, while guartzite is used as a source of $SiO_2$.

5-3-3 Other steelmaking raw materials

(1) Ferroalloys and calcium carbide

The manufacturers of ferroalloys are the established MCCI (Maria Cristina Chemical Industries Inc.) and EAC (Electro Alloys Corporation) which started operations recently.

MCCI and EAC are able to supply enough ferroalloys to meet the demand of new steelworks, so the steelworks shall be able to depend on domestic sources for ferroalloy supplies. Also they shall use domestic calcium carbide to desulfur hot metal.

(2) Fluorite

Fluorite is to be imported from Thailand, because it is not produced in the Philippines.

(3) Scrap

If home scrap does not suffice, scrap requirements are supplemented by imports.