Part 15 Product Transportation and Logistics

Section 1 Product Transportation and Logistics

Contents

1. Basic concept of transportation system for the new steelworks in 2010

Along with the modernization and industrialization of Viet Nam, the steel products delivery system must be modernized. The production quantity as well as quality in 2010 in Viet Nam is expected to be quite different from the present situation. The delivery system of steel products from the new integrated steelworks to each customer, therefore, must be considered under the new concept developed for the new situation.

The delivery system planned for the new integrated steelworks in the year of 2010 will consist of :

1) Mass transportation system from the new steelworks to the customers namely by ship to the discharging port near the customers and subsequently by truck
2) Delivery service to customers' shop at the appropriate time
3) Securing the products during transportation to prevent damage
4) Intermediate secondary processing of steel products to meet the customers' requirements
5) Lowest transportation cost

2. Steel demand by area in Viet Nam

Present steel demand in Viet Nam by area is projected approximately:

- North area : 30%
- Central area : 5%
- South area : 65%
- Source : VSC

This ratio is assumed to be unchanged in 2010.

3. Delivery system from the new integrated steelworks

3.1 Present transportation cost

3.1.1 Transportation cost

Assuming the present cost is unchanged in 2010, the transportation cost in 2010 is as follows:

Truck : US$ 0.11/ton-km
Rail way : US$ 0.025/ton-km
Sea : US$ 0.01/ton-km

3.1.2 Loading and unloading operation cost

Loading/unloading cost is US$ 2.5/ton at present for one operation. Assuming it is unchanged in 2010, the total loading/unloading cost for various delivery types is calculated as shown in Table 1-1.

Table 1-1 Total loading and unloading cost

Delivery case	Transportation measures	Number of times loading/ unloading *	Total loading/ unloading cost (US$)
(A) Truck	Delivery truck	1	2.5
(B) Railway	Works truck + Railway + delivery truck	5	12.5
(C) Sea	Works truck + Ship + delivery truck	5	12.5

*: Loading from the workshop to a truck is made by the shop's crane, and this cost is not counted.

3.1.3 Total transportation cost

The total transportation cost (loading/unloading cost + transportation cost) is illustrated in Figure 1-1. (In this calculation, the transportation costs for the railway case and the sea case include the truck transportation cost of 20km and 50km, respectively.)

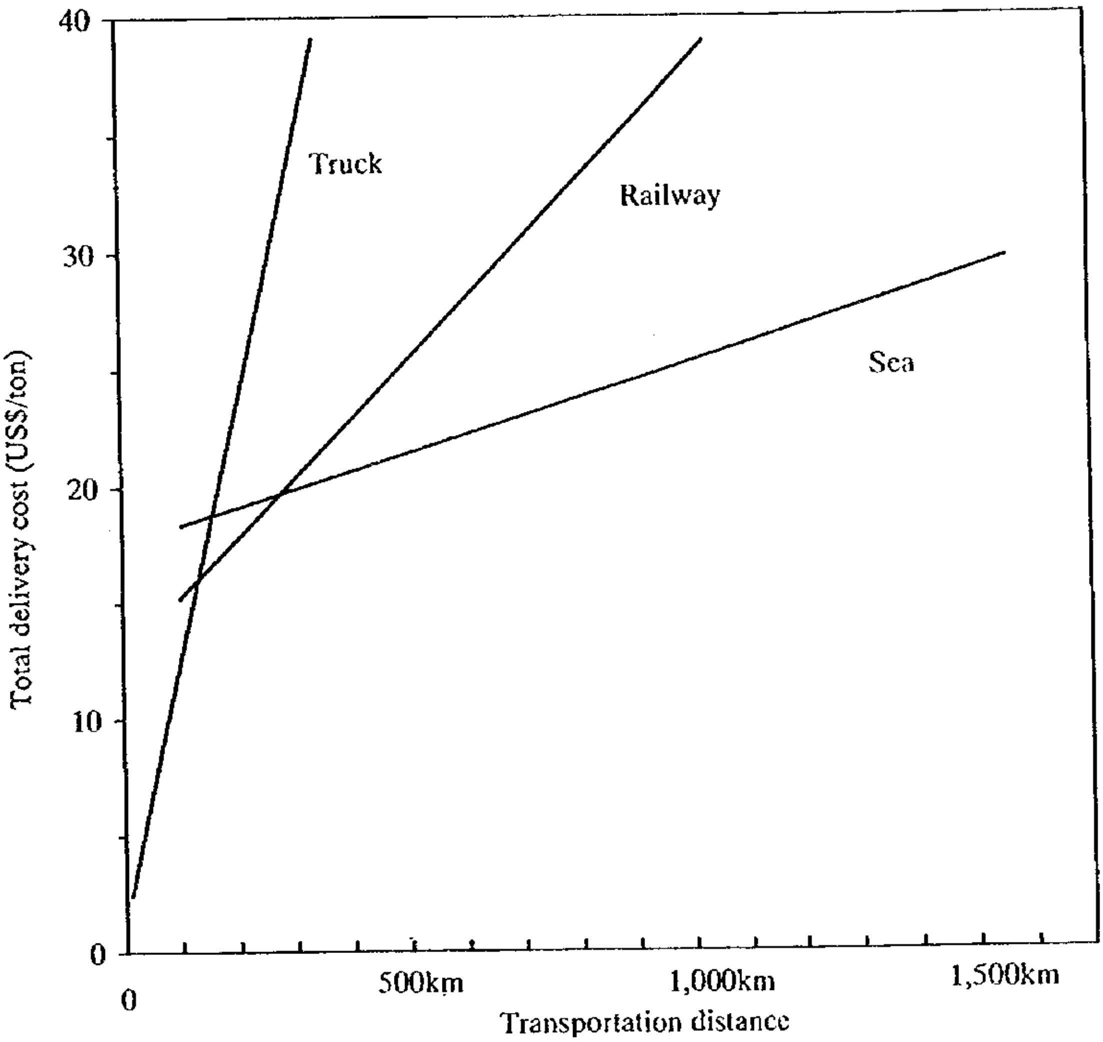


Figure 1-1 Total delivery cost

3.2 Transportation system for the new integrated steelworks

Table1-2 shows the total transportation costs from the new steelworks to customers by delivery type.

Table 1-2 Delivery type and costs for two candidate sites of new integrated steelworks

(Unit: US$/ton)

Site	Location of customers	By truck	By railway *	By sea **
Case (A) Mui Ron area	Ha Noi/Hai Phong area (400km)	n.a.	24.2	21.5
	HCMC area (1,400km)	n.a.	49.2	31.5
Case (B) Dung Quat area	Ha Noi/Hai Phong area (850km)	n.a.	35.5	26.0
	HCMC area (950km)	n.a.	37.9	27.0

* :including truck transportation cost (20km) from the railway stations to customers.

** :including truck transportation cost (50km) from the discharging ports to customers.

Source: VSC

Judging from the above Table1-2 and the present situation of the railway and road sectors, the main delivery method should be sea transportation in both cases (A) or (B). The Truck transportation method is to be applied for the customers close to the steelworks (about 100-200km).

The present railway has problems with rails, communication facilities, maintenance etc., and so can not transport sufficient volume of products.

In the road sector, existing roads and bridges between the discharging ports and the customer's areas need renewal and rehabilitation.

4. Port and port facilities for unloading of steel products

Assuming that the present ration of steel demand by region will be unchanged in 2010, the transportation volume of steel products from the new integrated steelworks to north and south areas in 2010 is estimated as shown in Table 1-3.

Table 1-3 Transportation volume of steel products to north and south areas

(Unit: 1,000 t/y)

	To south area	To north area
Volume of transportation	2,700	1,200

1) Class of ship to be utilized for transportation

Judging from the availability of ships, effectiveness of transportation, transportation distance, and weather conditions such as storms in Viet Nam, 2,000DWT class ships are to be mainly utilized.

2) Suggestions to port and port facilities expansion plan for unloading of steel products

To meet the increasing volume of handling cargoes at Saigon and Hai Phong, which are regarded as major ports in south and north regions respectively, both ports are under way of expanding their handling capability based on proper expansion plans. A sharp increase of handling amount of steel products is projected after the completion of the new integrated steelworks construction. However, this sharp increase does not seem to be reflected in the expansion plan of Saigon and Hai Phong ports. Accordingly, a comprehensive port plan is suggested to cope with the problem of handling to meet the increasing volume toward 2010 taking into account not only Saigon and Hai Phong ports but adjacent or peripheral ports in south and north areas.

For unloading steel products, 30t level crane is normally utilized. This type of unloading facilities is not sufficiently installed at present. So reinforcement of this type of crane is a pressing need.

5. Intermediate processing facilities

Steel products shipped from the new integrated steelworks will be mainly rolled coils. Due to their weight and size, they are not easily accepted by most customers. The new integrated steelworks will be located far from the steel market areas and the delivery service will not be satisfactory for the customers. So the coil center together with the warehouse will need to play the role of the intermediate processor to solve these problems.

5.1 Warehouse

A warehouse is a facility to stock the steel products, ready for delivery at the appropriate time and amount to customers. Along with the industrialization of Viet Nam, many customers will seek to control stocks based on an efficient and rationalized operation. As a result of this trend, a steel delivery service based on the customer's production schedule is considered to be the appropriate system. The system is commonly applied in most industrialized countries. As described in 3.2, the transportation of steel products to customers in 2010 should be mainly by ship from the steelworks to the main discharging ports (Hai Phong, HCM, Vung Tau, etc.) and further by truck from the ports to customers. Each ship will transport about 2,000 ton aiming for the lowest delivery cost. The steel production schedule in the steelworks will be based on the most efficient program for production, independent of the delivery schedule. In addition to that, the transportation schedule may be disturbed by weather conditions such as storms which come to the coast area every year. Under such a situation, the installation of warehouses having a certain storage capacity will become necessary for the delivery service. The most suitable location of such warehouses is considered to be close to the discharging port area. Their main functions are:

1) The stocking of steel products mass-transported by ship from the steelworks until the time of the delivery to customers.
2) Delivery of the appropriate quantity of steel at the appropriate time to the customers.

Figure 1-2 is a schematic illustration showing the function of the warehouse together with the coil center. They are tightly related to each other in their functions. The warehouse, therefore, is preferably located close to the coil center. Steel quality must be kept in good condition in the warehouse, and especially flat steel products should absolutely be stocked indoors and not outdoors.

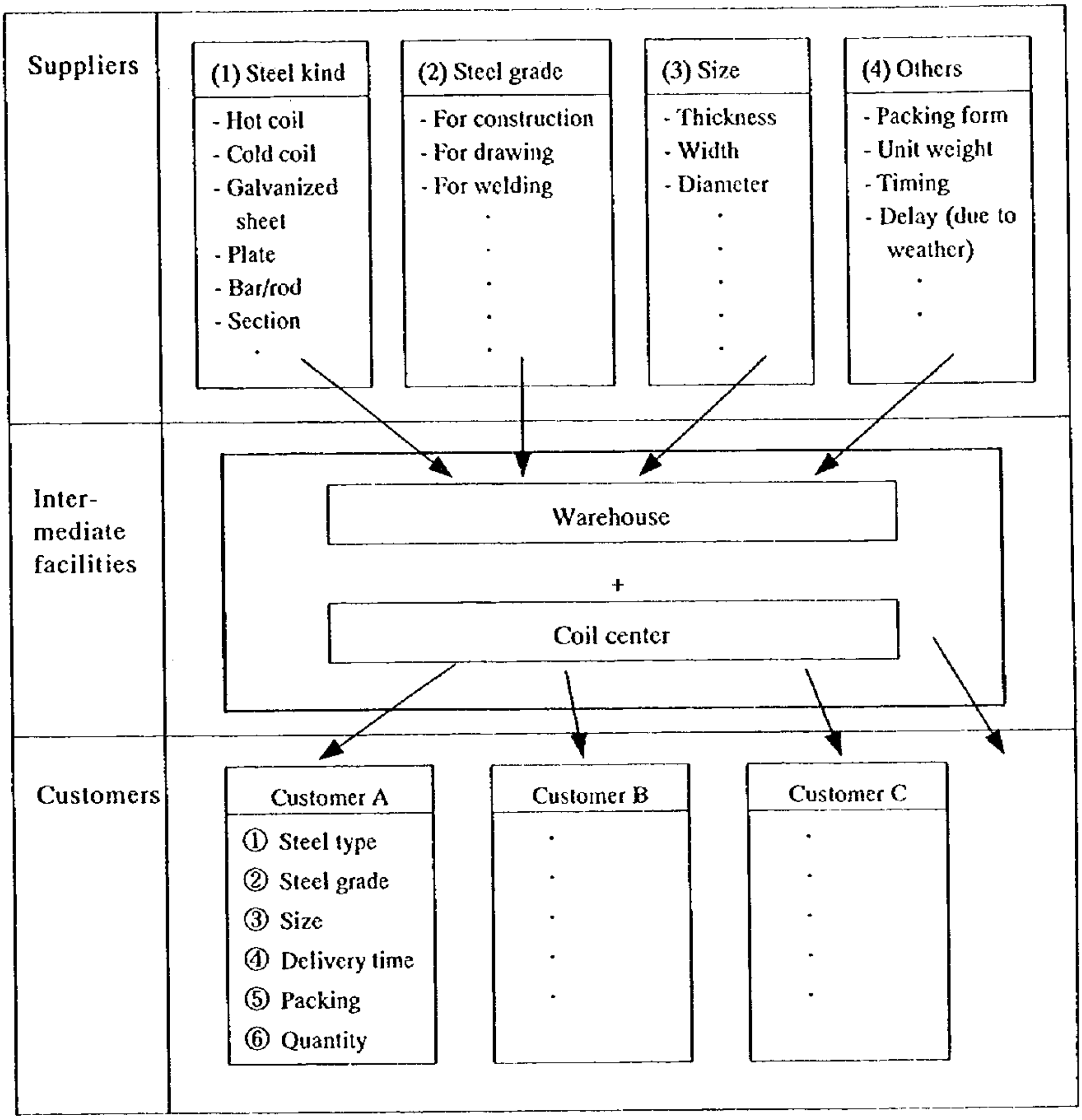


Figure 1-2 Function of intermediate facilities

5.2 Coil center

With the industrialization and modernization, it has been observed that delivery of steel products will become more complicated and should be customer-orientated. Steel suppliers and/or traders will be obliged to respond to their requirements in detail, which consists of specific requests for quantity, size, packing, etc. Installation of such facilities for customer service in the new integrated steelworks is not practical, and the most suitable location is considered to be at the intermediate area between supplier and customers.

The coil center plays the above roles, and its main functions are :

1) Secondary processing of steel products, such as the slitting and cutting of steel
2) Proper packaging deliveries according to customers' requests

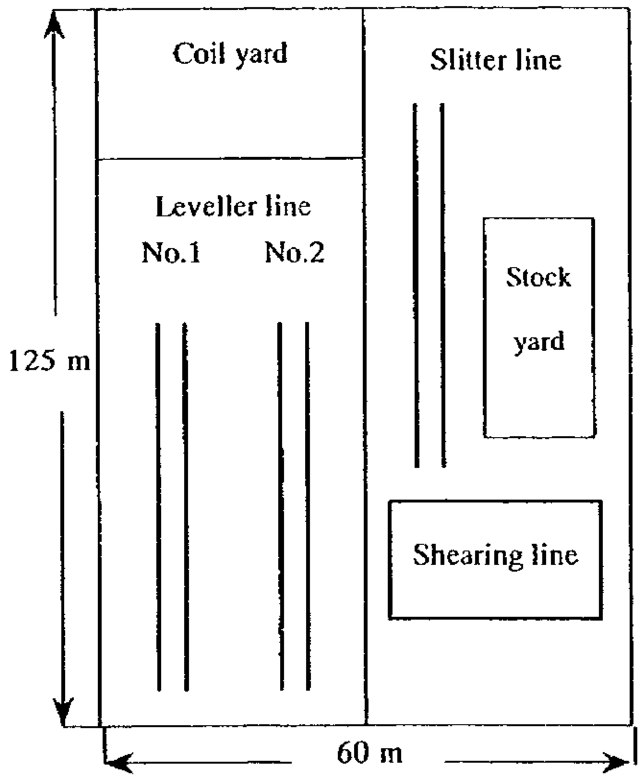
5.2.1 Facilities of coil center

Reference specifications (main facilities and capacity) as well as layout drawings of existing coil centers in Japan are shown in Table 1-4, 1-5, Figure 1-3 and Figure 1-4.

In future, it seems to be more practical that the coil center will increase it's storage to partly substitute for the function of the warehouse.

Table 1-4 Coil center for hot rolled coil

Items		Slitter line	Leveller cutting line		Shearing line (6 units)
			No.1	No.2	
Coil/sheet size	Thickness (mm)	1.2 - 6.5	3.2 - 12.0	1.6 - 6.0	max. 16.0
	Width (mm)	600 - 1,350	750 - 2,000	600 - 1,600	max. 3,100
	Weight (ton)	max. 25	25	25	
Products size (mm)		min. width 50	Length		customer's required size
			1,500 ~ 12,200	600 ~ 10,000	
Production capacity (t/y)		about 120,000			



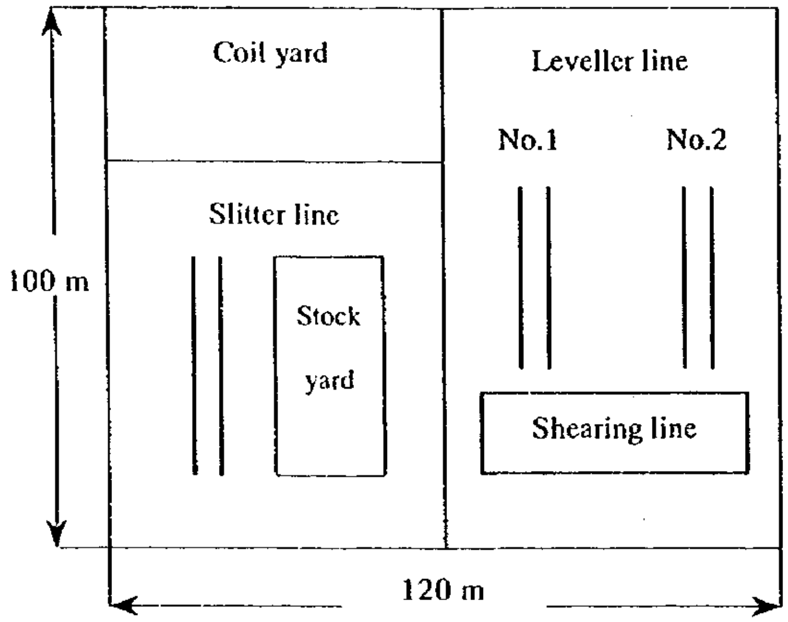
: Number of employee

worker	18
office staff	22
Total	40

Figure 1-3 Layout of a coil center for hot rolled coil in Japan

Table 1-5 Coil center for cold rolled coil

Items		Slitter line	Leveller cutting line		Shearing line
			No.1	No.2	(7 units)
Coil/sheet size	Thickness (mm)	0.4 - 4.5	0.4 - 3.2	0.4 - 1.6	max. 4.5
	Width (mm)	600 - 1,550	600 - 1,550	100 - 600	max. 2,000
	Weight (ton)	max. 15	15	15	
Production size (mm)		15mm (for 950mm coil) 25mm (for 1,550mm coil)	Length: 800 ~ 6,000	Length: 300 ~ 4,000	customer's required size
Production capacity (t/y)		about 70,000			



: Number of employee

worker	35
office staff	17
Total	52

Figure 1-4 Layout of a coil center for cold rolled coil in Japan

5.2.2 Recommendation for coil center in Viet Nam in 2010

Based on the market survey result as well as the equipment capacity of the steel works, the quantity of steel products necessary to be handled in the coil center in Viet Nam is tentatively calculated under the following precondition, and is summarized in Table 1-6.

Precondition

1) Ratio of quantity of flat products to be handled in coil center to the total flat steel demand : 30% *
2) Capacity of one coil center : 100,000t/y

* Present ratio in Japan is about 78%. The balance of 22% steel is delivered directly to the customers in coil; mainly automobile companies, pipe manufacturers, drum manufacturers, etc. In the past, however, customers did the slitting/cutting job mostly in their own shops. After this stage, the number of coil centers in Japan gradually increased and the ratio went up to the present level of 78%. Considering this history in Japan, the ratio in Viet Nam is assumed to be 30% in 2010. The quantity of flat products handled in coil center in 2010, therefore, will be $0.30 \times 2,550 \times 10^3$ t/y = 770×10^3 t/y.

Table 1-6 Projection of steel to be handled in coil center in Viet Nam in 2010

Items	Area			
	North area	Central area	South area	Total
Quantity of flat products necessary to be handled in coil center * (1,000 ton/y)	230 (30%)	40 (5%)	500 (65%)	770 (100%)
Required number of coil center	2	0	5	7

* For hot coil, cold coil and galvanized sheet

6. Dealers/traders of steel in Viet Nam

Main dealers/traders of steel are listed in Table 1-7.

Table 1-7 List of dealers/traders of steel in Viet Nam

Category	Name of company	Remarks
1. Trading company	(1) VINAMETAL Co.	Main dealer of VSC products
	(2) ANPHU IMP-EX Trading Co.	
	(3) VANLOI Co.	
2. Importer	(1) ANPHU IMP-EX Trading Co.	
	(2) Seaprodex Co.	
	(3) Vegetex Co.	
	(4) Protimex, Thanh Hoa Co.	
	(5) Artex Thang Long Co.	
3. Distributor	(1) Nam Vang Co.	
	(2) Daiwam steel pipe Co.	
	(3) THEP VIET Co.	

Part 16 Non-flat Rolling Mill Plant (Reference)

Section 1 Master Plan for Long Product Production

Contents

1. Demand and supply forecast of long products

Steel demand in 2005 and 2010 is estimated from an analysis of steel consumption of long products in developing countries in Asia. Long products consumption in Thailand and Malaysia is shown in Figure 1-1 and Figure 1-2. The demand and supply balance in Viet Nam in 2005 and 2010 is shown in Table 1-1 and summarized as follows.

1) Bars and wire rods
   - In 2005
     A shortage of about 150 thousand tons of bars and wire rods is expected.
   - In 2010
     A shortage of about 400 thousand tons of bars is expected.
     A shortage of about 200 thousand tons of wire rods is expected.

2) Small and medium sections
   - In 2005
     A shortage of about 160 thousand tons is expected.
   - In 2010
     A shortage of about 250 thousand tons is expected.

Table 1-1 Demand and supply forecast in Vietnam
(Long products)

Steel products		Demand and supply (1,000 tons / year)						
		1997	2005			2010		
		Capacity A	Demand B	Import C	Balance B-C-A	Demand B	Import C	Balance B-C-A
Bars & Rods	Bars	1,035	1190	60	95	1,520	80	405
	Rods	515	600	30	55	770	40	215
	Total	*1,550*	*1,790*	*90*	*150*	*2,290*	*120*	*620*
Sections & Others	Small & Medium	150	310	0	160	400	0	250
	H-beam	0	70	70	0	90	90	0
	Others	0	70	70	0	90	90	0
	Total	*150*	*450*	*140*	*160*	*580*	*180*	*250*
Total		**1,700**	**2,240**	**230**	**310**	**2,870**	**300**	**870**

Remark;
1) Others are sheet piles, rails and its accessories.

Assumption;
1) Demand for bars and wire rods is assumed about 80% in total long products, and ratio of wire rods to bars is assumed 1 to 2.
2) Demand for small and medium sections is assumed about 14% of total long products, and H-beam, sheet piles and rails are about 6 % in total.
3) Import of bars and rods is assumed five percent (5%) of demand from the quality, steel grade and size requirement.
4) H-beams, sheet piles and rails are assumed 100% import item why the demand is not enough for construction of one mill.

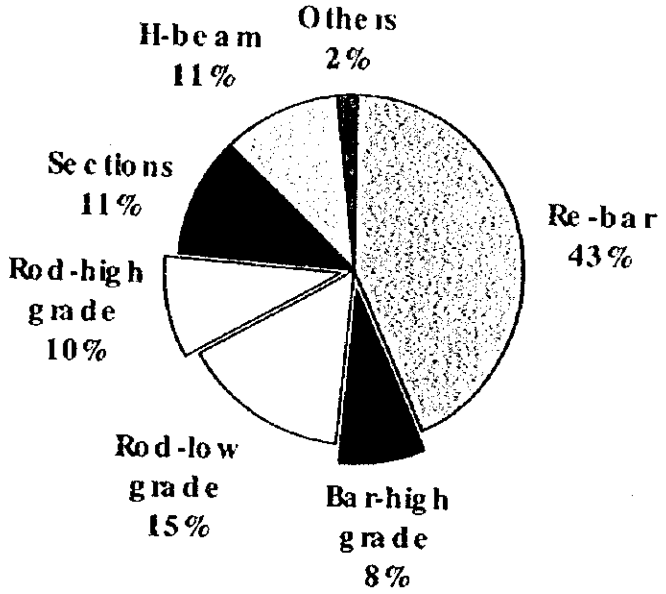


Figure 1-1 Long products consumption in Thailand
(Total 3.7million, Average in 1993/1995)

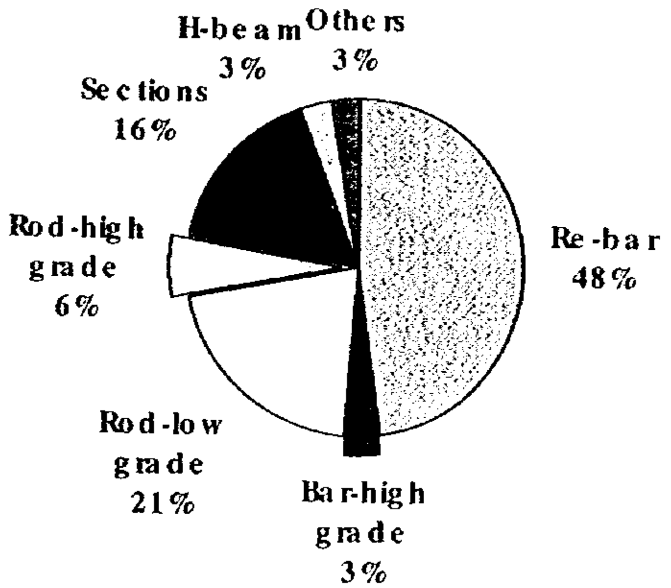


Figure 1-2 Long products consumption in Malaysia
(Total 2.8million, average in 1993/1995)

2. Site for long products mill

The site for long products mill is studied. Table 1-2 to Table 1-4 show examples of case studies according to the location of integrated steel plant where bar mill and wire rod mill is expected as one of the sites. Construction of bar mill and wire rod mill in the integrated steel plant is recommended because it has many advantages for the production of the quality steel. However, after the discussion, it is concluded that all long products mills are excluded from the pre-feasibility study of the integrated steel plant for minimizing the investment cost of the integrated steel plant. These long products mills will be constructed at the site near the market by the independent company.

1) Bar mill and wire rod mill

The site for bar mill and wire rod mill is depend on which is a priority in the following two points. When the total quality control of the quality steel is considered, the construction in integrated steel plant is preferable.

- In the integrated steel plant considering the future provision of material source for high grade steel.
- In the site near the market

2) Section mill

For the site of section mill, there is not a need to be in the integrated steel plant and the priority is near the region of demand. The site for section mill is recommended as follows considering the balance of demand by reason in Viet Nam.

- In the south, new section mill shall be constructed.
- In the north, existing section mills shall be utilized.

* In Viet Nam, the plan for upgrading of Nha Be No.1 and the construction of Bienhoa No.3 for an angle production are under way. Instead of these two projects, the construction of one big mill is recommended as the centralization to one mill is especially important for the section mill as the market of section is not big enough.

Table 1-2 Study for investment for long products mill
< Case A Integrated steel plant in north >

1,000 tons/year

Area	Products	1997	2005			2010		
		Capacity	Adjust.	Invest.	Capacity	Adjust.	Invest.	Capacity
North	Bar	500			500		370	870
	Wire rod	200			200	-80	325	445
	Sction	60			60	60		120
	Total	760			760	-20	695	1,435
Central	Bar	45			45	20		65
	Wire rod	20			20	-20		0
	Section	0			0			0
	Total	65			65	0	0	65
South	Bar	490	-55	150	585	-80		505
	Wire rod	295	55		350	-65		285
	Section	90	-90	250	250	30		280
	Total	875	-90	400	1,185	-115	0	1,070
Total		1,700	-90	400	2,010	-135	695	2,570
(Imports)					230			300
(Total supply including imports)					2,240			2,870

< Premise for Case A >

- Two section mill projects under planning in the south, up-grading of Nha Be No.1 and construction of Bien Hoa No.3 for production of angle is combined to one bar & section mill.
- Small mills shown as "Others" in Table 3.3 will be closed down in the course of time, and production of these mills is replaced by new bar mill.
- Old or small wire rod mill will be closed down in the course of time, and production of these mills is replaced by new wire rod mill.
- Wire rod production in Luu Xa No.1, Giasang and Danang is absorbed by new wire rod mill, and these mills are utilized for bar and section production.
- Balance of bars and rods is adjusted by products mix of existing bar & rod combination mills.

< Investment for plants >

- One bar & section mill (400,000ton/year) in the south by 2005
- One bar mill (400,000ton/year) in the north by 2010
- One rod mill (350,000ton/year) in the north by 2010

Table 1-3 Study for investment for long products mill
<Case B Integrated steel plant in central region>

1,000 tons/year

Area	Products	1997	2005			2010		
		Capacity	Adjust.	Invest.	Capacity	Adjust.	Invest.	Capacity
North	Bar	500			500			500
	Wire rod	200			200	-80		120
	Sction	60			60	60		120
	Total	760			760	-20	0	740
Central	Bar	45			45	-45	400	400
	Wire rod	20			20	-20	360	360
	Section	0			0			0
	Total	65			65	-65	760	760
South	Bar	490	-55	150	585	-45		540
	Wire rod	295	55		350	-100		250
	Section	90	-90	250	250	30		280
	Total	875	-90	400	1,185	-115	0	1,070
Total		1,700	-90	400	2,010	-200	760	2,570
(Imports)					230			300
(Total supply including imports)					2,240			2,870

< Premise for Case B >

- Small mills in the central region will be closed in step with the construction of new mills in the central region.
- Other conditions are the same as in Case A

< Investment for plants >

- One bar & section mill (400,000ton/year) in the south by 2005
- One bar mill (400,000ton/year) in the central region by 2010
- One wire rod mill (350,000ton/year) in the central region by 2010

Table 1-4 Study for investment for long products mill
< Case C Integrated steel plant in south >

1,000 tons/year

Area	Products	1997	2005			2010		
		Capacity	Adjust.	Invest.	Capacity	Adjust.	Invest.	Capacity
North	Bar	500			500			500
	Wire rod	200			200	-80		120
	Section	60			60	60		120
	Total	760			760	-20	0	740
Central	Bar	45			45			45
	Wire rod	20			20			20
	Section	0			0			0
	Total	65			65	0	0	65
South	Bar	490	-55	150	585	-80	370	875
	Wire rod	295	55		350	-65	325	610
	Section	90	-90	250	250	30		280
	Total	875	-90	400	1,185	-115	695	1,765
Total		1,700	-90	400	2,010	-135	695	2,570
(Imports)					230			300
(Total supply including imports)					2,240			2,870

< Premise for Case C >

- All conditions are the same as in Case A, and only the location of new mills is different.

< Investment for plants >

- One bar & section mill (400,000ton/year) in the south by 2005
- One bar mill (400,000ton/year) in the south by 2010
- One rod mill (350,000ton/year) in the south by 2010

Remarks;

1) Adjustment means adjustment of production by closing of old mills or changing of products mix of existing mills.
2) Sections include small and medium sections only, and do not include H-beam here.
3) Adjustment of production is made under the tentative premise of equal production tons/hour in all products.

3. Mill type and capacity

In any case of site, the construction of the following three types and capacities of mills is recommended for the world wide competitiveness. One bar mill and one wire rod mill should be given preferences for the high quality steel production considering future provision.

- Wire rod mill 350,000 ton/year
- Bar mill 400,000 ton/year
- Bar & section mill 400,000 ton/year

4. Material for long products

4.1 Material route

Table 1-5 shows the recommended process for typical steel grade. At present, plants in Viet Nam can produce construction grade only. For the production of a wide range of high grade steel products in the future, material from BF & BOF process is recommended. As far as a caster concerns, there is a choice of a billet caster or a bloom caster. A billet made through the route of bloom caster and break down mill is preferable for making high grade steel. However, a production cost of billet made from bloom is much higher compared to the billet directly cast. Considering the balance of products mix in Viet Nam and the production cost, the continuous cast billet is chosen here.

4.2 Billet size

The billet size recommended is 150 mm because it is a minimum size for the powder casting for high grade steel. The billet size related to the each mill is shown in the articles in Section 2.

Table 1-5 Typical steel grade and recommended process for long products

Remark; A: Possible — ^{L}: Ladle furnace

B: Restricted applications only — ^{V}: Vacuum degassing

Blank: Impossible — SBQ: Special Bar Quality

EAF or BF & BOF		EAF				BF & BOF		
Material		Scrap Low grade	Scrap High grade			Iron ore		
CCM		Billet	Billet		Bloom	Billet		Bloom
Casting method		Open	Open	Powder	Powder	Open	Powder	Powder
SBQ Low alloy	Automobile			B^{LV}	A^{LV}		B^{LV}	A^{L}
	Others		B^{V}	B^{V}	A^{V}	B^{V}	B^{V}	A
SBQ Carbon	Automobile			B	A		B	A
	Others		B	B	A	B	B	A
Spring steel				B^{L}	A^{L}		B^{L}	A^{L}
Free cutting steel					A			A
Bearing steel								A^{LV}
Valve spring wire					B^{LV}			A^{LV}
High carbon wire	Tire-cord							A^{LV}
	Spring			B	B	B	B	A
	PC wire			B	B	B	B	A
	Wire rope		B	B	B	B	B	A
Cold heading wire	Low-alloy			B^{L}	A^{L}		B^{L}	A^{L}
	Carbon			B	B		B	A
Welding wire			B^{V}	B^{V}	B^{V}	B^{V}	B^{V}	A^{V}
Low carbon wire			B	B	B	B	B	A^{V}
Chain		B	B	A	A	B	A	A
Cold finish bar		B	B	A	A	B	A	A
Bar & rod for construction		A	A	A	A	A	A	A
Re-bar		A	A	A	A	A	A	A
Sections	Small/Middle	A	A	A	A	A	A	A
	Large				A			A

Section 2 Non-flat Rolling Mill Plant

Contents

1. Wire rod mill

1.1 Products mix

1) Size mix

Mill capacity is designed on the basis of size mix in Table 2-1. In Viet Nam, 6.0 mm is a popular size and 5.5 mm is no demand so far. However, considering the much demand of 5.5 mm in the world for the drawing quality, 5.5 mm is included in products. Production amount of small size affect much to the mill capacity. Small size ratio is estimated about 50% from the production in Japan and market survey in Viet Nam. The productivity of the sizes bigger than 7.0 mm is almost same and no need to consider the content of each size for mill design.

Table 2-1 Size mix for wire rod mill

Products	Size (mm)	%
Wire rod & Re-bar coil	5.5	20
	6.0 and D6	20
	6.5	10
	7.0 to 18 and D10	50
	Total	100

2) Steel grade mix

Mill shall be designed for production of the steel in the Table 2-2 considering the future possibility.

Table 2-2 Steel grade mix for wire rod mill

Products	Typical grade (JIS)	Typical use	Production (%)
Re-bar in coil	SD295	Construction	5
Low carbon steel	SWRM 8 to 22	Concrete reinforcing, Nail, Barbed wire, Galvanized wire Fastener etc.	75
High carbon steel	SWRH62 to 72	Wire rope, PC wire, Spring	10
Cold heading steel	SWRCH10 to 50	Fasteners, Machine parts	5
Spring steel	SUP6, 9	Coil spring	5
Low alloy steel	SCM435, SCr4440	Fasteners	0
Welding wire steel	SWRY11 to 21	Welding wire	0

1.2 Billet

1) Billet size
The billet size of 150 mm square is recommended from the following reason.
- The minimum size for the powder casting for high grade wire rods.
- The maximum size for keeping entry speed 0.1 m/sec at wire rod mill with maximum rolling speed 100 m/sec.
- Billet size in common with another long products mill

2) Billet weight
The billet weight in 2 tons is recommended from the following reasons.
- World wide standard billet weight for wire rod
- Coil weight 2 ton might be too heavy for Viet Nam market now. For the demand of small coil, the finishing facilities to divide the coil shall be considered.

1.3 Design basis of mill

1) Operation basis
- 3 shift by 3 crew
- Operation hours : 7200 hours/year
  (365 - 52 - 13) days/ year x 24 hours/day
- Yield : 96%
- Mill efficiency : 0.65
  (Ratio of actual ton / hr and theoretical ton / hr)

2) Main specification
Main specification is shown in Table 2-3.

Table 2-3 Main specification of wire rod mill

Item	Specification
Production capacity	350,000 ton/year
Wire rod size	5.5mm to 18mm
Coil weight	1 ton/coil, 2 ton/coil
Billet	150mm square x 12m, 2 ton
Mill capacity	Max. 100 ton/hour
Rolling speed	Max. 100m/sec
Number of stands	28 stands (2-Hi mill 18, Block mill 10)
Strands	1 strand
Provision	Pouring line for 16 to 50mm bar-in-coil in future

1.4 Equipment list

Equipment list is shown in Table 2-4.

Table 2-4 Equipment list for wire rod mill

Equipment	Type	Number
1. Mill equipment	(Mechanical & Electric)	
1.1 Billet charging skid		1 set
1.2 Billet weighing machine		1 set
1.3 Billet charging table	Inside roller table	1 set
1.4 Reheating furnace	Walking beam, 100 ton/hour	1 set
1.5 Billet discharging table	Inside roller table	1 set
1.6 Descaler	High pressure water	1 set
1.7 Rougher stands	Horizontal & Vertical	6 stands
1.8 Crop and cobble shear	Flying shear	1 set
1.9 Intermediate stands		
- No.1 train	Vertical & Horizontal	6 stands
- No.2 train	Vertical & Horizontal	6 stands
1.10 Loopers	Side loopers	5 sets
1.11 Stand changing car		2 sets
1.12 Crop and cobble shear	- in Intermediate	1 sets
1.13 Water cooling before block	about 10 m	1 set
1.14 Crop shear before block mill		1 set
1.15 Chopping shear		1 set
1.16 Looper before block mill	Side looper	1 set
1.17 Finishing stands	10 stands block mill	1 set
1.18 Water cooling zone	about 50 m	1 set
1.19 Pinch roll		1 set
1.20 Laying head		1 set
1.21 Air cooling conveyor	Roller table, about 90m	1 set
1.22 Dividing shear	Tub shear	1 set
1.23 Reforming tub	Two mandrel	1 set
1.24 Hook conveyor	Power and free	1 set
1.25 Conditioning station	Lifting car	1 set
1.26 Strapping machine	Hoop strapping	2 sets
1.27 Weighing machine		1 set
1.28 Unloader		2 sets
2. Utilities		1 set
2.1 Sub station		1 set
2.2 Air compressor		1 set
2.3 Water treatment		1 set

Equipment	Type	Number
3. Inspection & testing facilities 3.1 Up setting machine 3.2 Steel grade checking machine 3.3 Tensile testing machine		1 set 1 set 1 set 1 set
4. Maintenance facilities 4.1 Welder 4.2 Lathe 4.3 Drilling machine 4.4 Bearing chock changing 4.5 Block mill maintenance table 4.6 Lathe for iron roll 4.7 Lathe for WC roll		1 set
5. Auxiliary 5.1 Paging system 5.2 TV monitor system		1 set
6. Computer system 6.1 Production management		1 set

1.5 Layout of mill

Mill layout is shown in Figure 2-1. Layout is considered for the future provision of pouring line for the production of 16 to 50 mm bar-in-coil.

1.6 Feature of mill

The feature of this mill is one strand high speed mill for the production of the quality wire rod. The problem of this mill is limited productivity of small size because of the limited rolling speed. Even now, the rolling speed is limited to about 100 m/sec from the difficulty of control of ring pattern at high speed. In order to get the high productivity for 5.5mm, the two strands mill can be applied. However, considering the investment cost and expecting the development of technology in feature, the one strand mill is applied here. The main features of the mill are as follows.

- Walking beam reheating furnace with inside roller table for the production of the quality wire rod
- Descaler for the prevention of scale defect
- Vertical and horizontal mill arrangement for the quality wire rod
- High speed rolling for the high productivity
- Pre-block cooling for the control of rolling temperature
- Tub shear for the 1 ton coil
- Enough length of hook conveyor for the finishing and inspection work

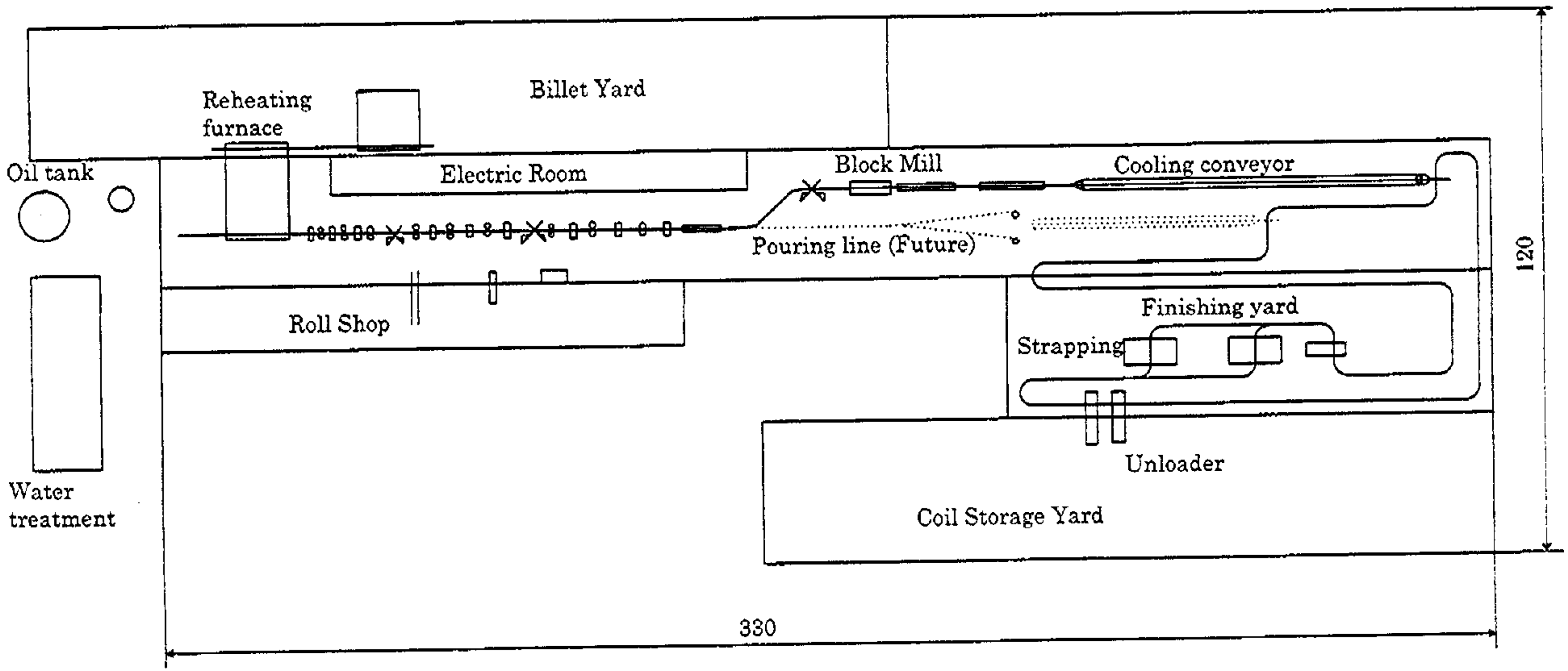


Figure 2-1 Wire rod mill layout

2. Bar mill

2.1 Products mix

1) Size mix
Mill capacity shall be designed on the basis of size mix in Table 2-5. The productivity of sizes bigger than 19 mm is almost same and no need to consider the detail content of it.

Table 2-5 Size mix for bar mill

Products	Size	Production (%)
Re-bar	10	10
	13	10
	16	10
	19 to 32	40
	Sub-total	70
Round bar	13	5
	16	5
	19 to 50	20
	Sub-total	30
Total		100

2) Steel grade mix
Mill shall be designed for the production of steel grade in Table 2-6 considering the future possibility.

Table 2-6 Steel grade mix for bar mill

Products	Typical grades (JIS)	Use	Production (%)
Re-bar	SD295 to 345	Concrete reinforcing	70
Steel for general structure	SS400 to 490	Construction	5
Chains	SBC300 to 490	Chains	5
Cold finish	SGD2 to 4	Machine parts	5
Carbon steel	S25C to S55C	Hot forged machine parts	5
Low alloy steel	SMn443, SCr420 SCM415, 435	Machine parts, Gears	0

2.2 Billet

1) Billet size
Billet size in 150 mm square is recommended from the following reasons.
- The minimum size for powder casting for high grade steel
- The minimum size for making 50 mm quality bar.
- Common billet size with wire rod mill

2) Billet weight
Billet weight in 2 ton is recommended from the following reasons.
- The heavier billet the higher yield
- Common billet with wire rod mill

2.3 Design basis of mill

1) Operation basis
- 3 shift by 3 crew
- Operation hours : 7,200 hours / year
  (365 - 52 - 13) days / year x 24 hours
- Yield : 96%
- Mill efficiency : 0.65
  (ratio of actual ton/hour and theoretical ton/hour)

2) Main specification
Main specification of bar mill is shown in Table 2-7. For the run-in roller table line, the maximum rolling speed is limited to 16 m/sec. for keeping stable rolling.

Table 2-7 Main specification of bar mill

Item	Specification
Production capacity	400,000 ton/year
Bar size	Re-bar D10 to D32
	Round bar 13 to 50mm
Bar length	6 m to 12 m
Billet	150 mm square x 12 m, 2 ton
Mill capacity	Max. 110 ton/hour
Rolling speed	Max. 16 m/sec (Roller table line)
	Max. 20 m/sec (Trough line)
	Slit rolling for D10 and D13
Number of stands	20 stands

2.4 Equipment list

Equipment list is shown in Table 2-8.

Table 2-8 Equipment list for bar mill

Equipment	Type	Number
1. Mill equipment	(Mechanical & electric)	
1.1 Billet charging skid		1 set
1.2 Billet weighing machine		1 set
1.3 Charging table	Inside roller table	1 set
1.4 Reheating furnace	Walking beam, 110 ton/hour	1 set
1.5 Billet discharging table	Inside roller table	1 set
1.6 Descaler	High pressure water	1 set
1.7 Rougher stands	Horizontal & Vertical	8 stands
1.8 Stand changing machine		1 set
1.9 Crop and cobble shear	Flying shear	1 set
1.10 Intermediate stands	Vertical & Horizontal	6 stands
1.11 Loopers	Side looper	6 sets
1.12 Stand changing car		1 set
1.13 Crop and cobble shear	Flying shear	1 set
1.14 Finishing stands	#15 V / H combination	1 stand
	#16 Horizontal	1 stand
	#17 to #20 Block mill	2 sets
1.15 Dividing shear	- Flying shear	1 set
	- Disc shear for D10 and D13	2 sets
1.16 Chopping shear		2 sets
1.17 Run-in roller table		1 set
1.18 Run-in trough		2 sets
1.19 Pinch roll		4 sets
1.20 Cooling bed	Walking beam type 120m x 10m	1 set
1.21 Products cut shear		1 set
1.22 Shear for random- bar-ends		1 set
1.23 Inspection table		1 set
1.24 Bundling machine	- for small bundle	4 sets
	- for 2 ton bundle	2 sets
1.25 Weighing machine		1 set
1.26 Unloading table		2 sets
2. Utilities		1 set
2.1 Sub station		1 set
2.2 Air compressor		1 set
2.3 Water treatment		1 set

Equipment	Type	Number
3. Inspection & testing facilities 3.1 Magnetic particle tester 3.2 Steel grade testing equipment 3.3 Bending machine 3.4 Tensile testing machine		1 set 1 set 1 set 1 set 1 set
4. Maintenance facilities 4.1 Welder 4.2 Lathe 4.3 Drilling machine 4.4 Bearing chock changing 4.5 Lathe for iron roll 4.6 Lathe for WC roll		1 set
5. Auxiliary 5.1 Paging system 5.2 TV monitor system		1 set
6. Computer system 6.1 Production management		1 set

2.5 Layout of mill

Example of mill layout is shown in Figure 2-2.

2.6 Feature of mill

The feature of this mill is a production of both of the quality bar and Re-bar from small size to medium size. For the production at high productivity of small Re-bar, the slit rolling with finishing block is applied. The main features of this mill are as follows.

- Walking beam furnace for the quality steel bars
- Descaler before the roughing stand for the prevention of scale defect
- V/H arrangement for the rolling of quality bar
- Slit rolling for the small Re-bar, D10 and D13
- Vertical and horizontal combination stand at #15 stand for easy slitting
- Four stands block mill for easy operation of slit rolling
- Tungsten carbide roll for finishing stands for high speed rolling

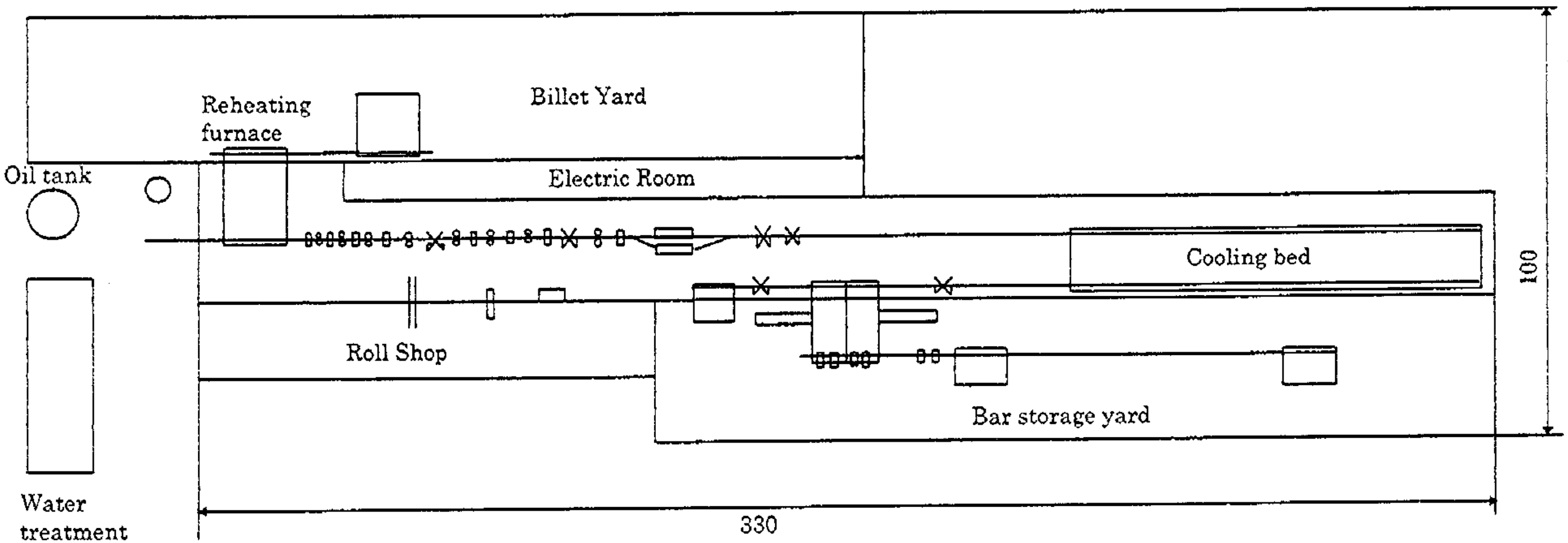


Figure 2-2 Bar mill layout

3. Bar and section mill

3.1 Products mix

1) Size mix
Ratio of section including a flat bar is 60% in this mill from the forecast of demand in 2010. Small angles, 30 mm and 25 mm is not included because demand for these small angles are not much, but affect much to the equipment cost and mill productivity. Flat bar with thickness 3.0 mm is also not included because demand for this thin size is small but affect much to the mill equipment cost and mill productivity. The ratio of angle, channel and flat bar is estimated from the production statistics in Japan.

Table 2-9 Size mix for bar and section mill

Products	Size	Production(%)
Re-bar	16 to 32 (6 sizes)	40
Angle	40 x 5 to 100 x 13 (10 sizes)	30
Channel	75 x 40 to 125 x 65 (4 sizes)	10
Flat bar	4.5 x 44, 6x32 to 100x19 (61 sizes)	20
Total		100

2) Steel grade mix
The steel grade is construction steel only as shown in Table 2-10.

Table 2-10 Steel grades for bar and section mill

Products	Typical grade (JIS)	Use	Production (%)
Re-bar		Concrete reinforcing	40
Sections	SS400	Construction	60

3.2 Billet

1) Billet size
Billet size in 150 mm square is adapted from the view point of common billet with another long products mill. The maximum channel size by this size is 125 mm. For the production of 150 mm channel, 180 mm billet is needed.

2) Billet weight
Billet weight in about 2 ton is adopted from the view point of common billet with another long products mill.

3.3 Design basis of mill

1) Operation basis

- 3 shift by 4 crew
- Operation hours : 7,920 hours / year
  ((365 - 24- 11) days / hour x 24 hours / day)
- Mill efficiency (Ratio of actual tons/hour and theoretical tons/hour)
  - Re- bar : 0.65
  - Angle, Channel : 0.50
  - Flat bar : 0.45

  * Mill efficiency of sections is lower compared to Re-bar because of difficulty of rolling. Mill efficiency of flat bar is much lower than Re-bar because of many size changes.

2) Main specification

Main specification of mill equipment is shown in Table 2-11.

Table 2-11 Main specification of bar & section mill

Item	Specification
Production capacity	400,000 ton/year
Products size	Re-bar D16 to D32
	Angle 40x5 to 100x 13
	Channel 75x40 to 125 x 75
	Flat bar 4.5x44, 6x32 to 100x19
Products length	6 m to 12 m
Billet	150mm square x 12m, 2 ton
Mill capacity	Max. 130 ton/hour
Rolling speed	Max. 16 m/sec
Number of stands	19 stands

3.4 Equipment list

Equipment list is shown in Table 2-12.

Table 2-12 Equipment list for bar and section mill

Equipment	Type	Number
1. Mill equipment	(Mechanical & electric)	
1.1 Billet charging skid		1 set
1.2 Billet scale		1 set
1.3 Reheating furnace	Pusher, 130 ton / hour	1 set
1.4 Billet discharging table	Inside roller table	1 set
1.5 Descaler	High pressure water	1 set
1.6 Rougher stands	#1 to #4 Horizontal & Vertical	4 stands
	#5 to #7 Horizontal	2 stands
1.7 Stand changing equipment		1 set
1.8 Crop and cobble shear	Flying shear	1 set
1.9 Intermediate stands	Horizontal	6 stands
1.10 Loopers for intermediate	Up-looper	1 set
1.11 Stand changing car		1 set
1.12 Crop and cobble shear		1 set
1.13 Finishing stands	Vertical & Horizontal	6 stands
1.14 Loopers for finishing stands	Up & side combination	5 sets
1.15 Dividing shear		1 set
1.16 Run-in-table		1 set
1.17 Cooling bed	100 m x 12 m	1 set
1.18 Straightener	In-line before shear	1 set
1.19 Products shear		1 set
1.20 Shear for Random-ends		1 set
1.21 Inspection table		1 set
1.22 Stacking machine		1 set
1.23 Bundling machine		2 sets
1.24 Unloading table		2 sets
2. Utilities		1 set
2.1 Sub station		1 set
2.2 Air compressor		1 set
2.3 Water treatment		1 set
3. Inspection & testing facilities		1 set
3.1 Tensile testing machine		1 set
3.2 Bending machine		1 set

Equipment	Type	Number
4. Maintenance facilities 4.1 Welder 4.2 Lathe 4.3 Drilling machine 4.4 Bearing chock changing 4.5 Lathe for roll dressing		1 set
5. Auxiliary 5.1 Paging system 5.2 TV monitor system		1 set
6. Computer system 6.1 Production management		1 set

3.5 Layout of mill

Example of mill layout is shown in Figure 2-3.

3.6 Feature of mill

The feature of this section mill is a wide range of products including the many sizes of flat bars. Therefore, the consideration is given especially for minimizing the size change. The mill arrangement of the mill is also well considered from the balance of investment cost and the effect for the mill efficiency. The main features of mill are as follows.

- Pusher type reheating furnace as construction grade only
- Descaler for the prevention of scale defect for larger size of sections
- Mill arrangement for the production of many kinds of products from the view point of the balance of investment cost and productivity. The mill here is an example of mill arrangement without the H/V combination stand for minimizing the investment cost. When easy operation is considered, the application of combination stands is preferable.
- Sizing stand for channel
- Stand quick changing car for many size changes
- In-line straightener before the products shear
- Stacking equipment for flat and sections

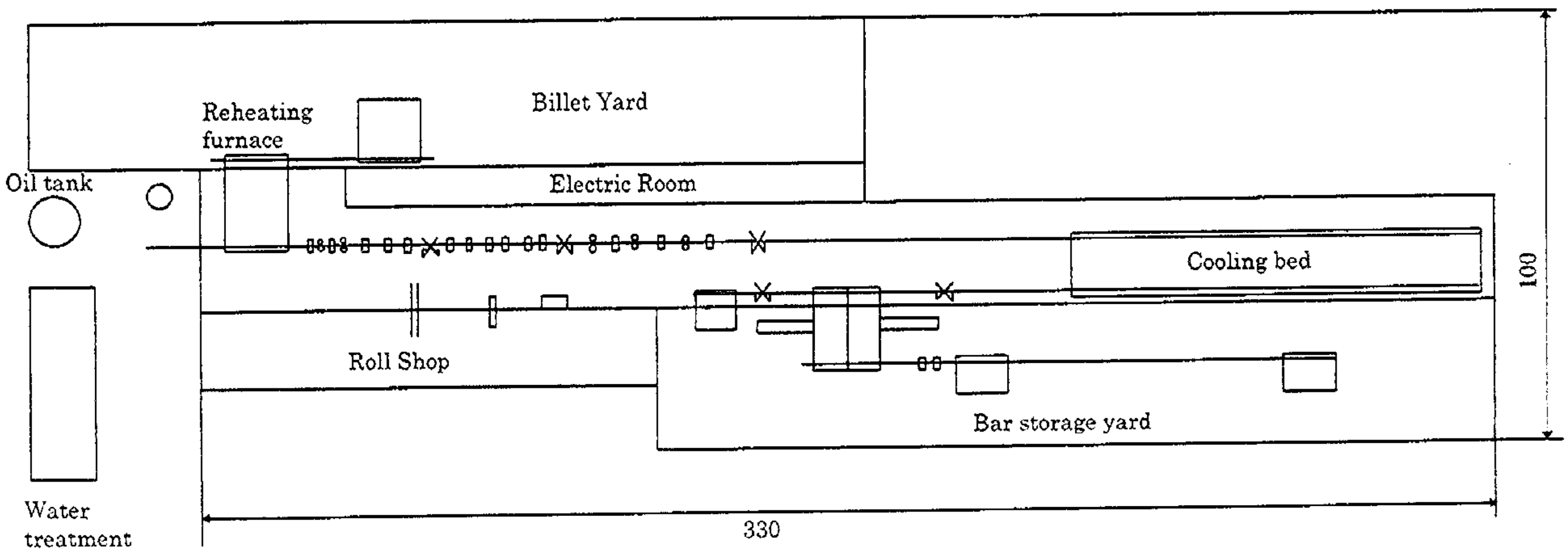


Figure 2-3 Bar & section mill layout

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Appendices

List of Appendices

Part 1

Section 1 Study of Ironmaking Processes

Contents

1. Blast furnace - Converter process

The blast furnace process is shown in Figure1-1.
The blast furnace process needs agglomerated or lump ore and coke as raw materials.
So this process generally requires coke ovens and sintering plants.
The blast furnace produces hot iron which is refined at the basic oxygen furnace.

In the blast furnace process, pre-treated sinter, pellets which are made of fine ores, lump ores are used as raw ferrous materials and cokes which are made of coking coal are used as reducing agent and fuels. These materials are charged from top of blast furnace.

The hot air is blown through the upper bottom of blast furnace, then burns the reducing agent. Ascending in the blast furnace, the generated gas reduces the ferrous oxide materials and rises the temperature of the charged materials. Descending in the blast furnace, the ferrous materials are softened and melted at the middle to lower part of the blast furnace. The hot metal is stored in the blast furnace hearth and is tapped at the several hour intervals.

Being removed dust by the gas cleaning facilities, the top gas of blast furnace is used as the fuel of heating in the works. The remained gas is used for the fuel of the power plant.

The blast furnace - the basic oxygen process is adopted at major steelworks in the world, is the most popular and technologically established.

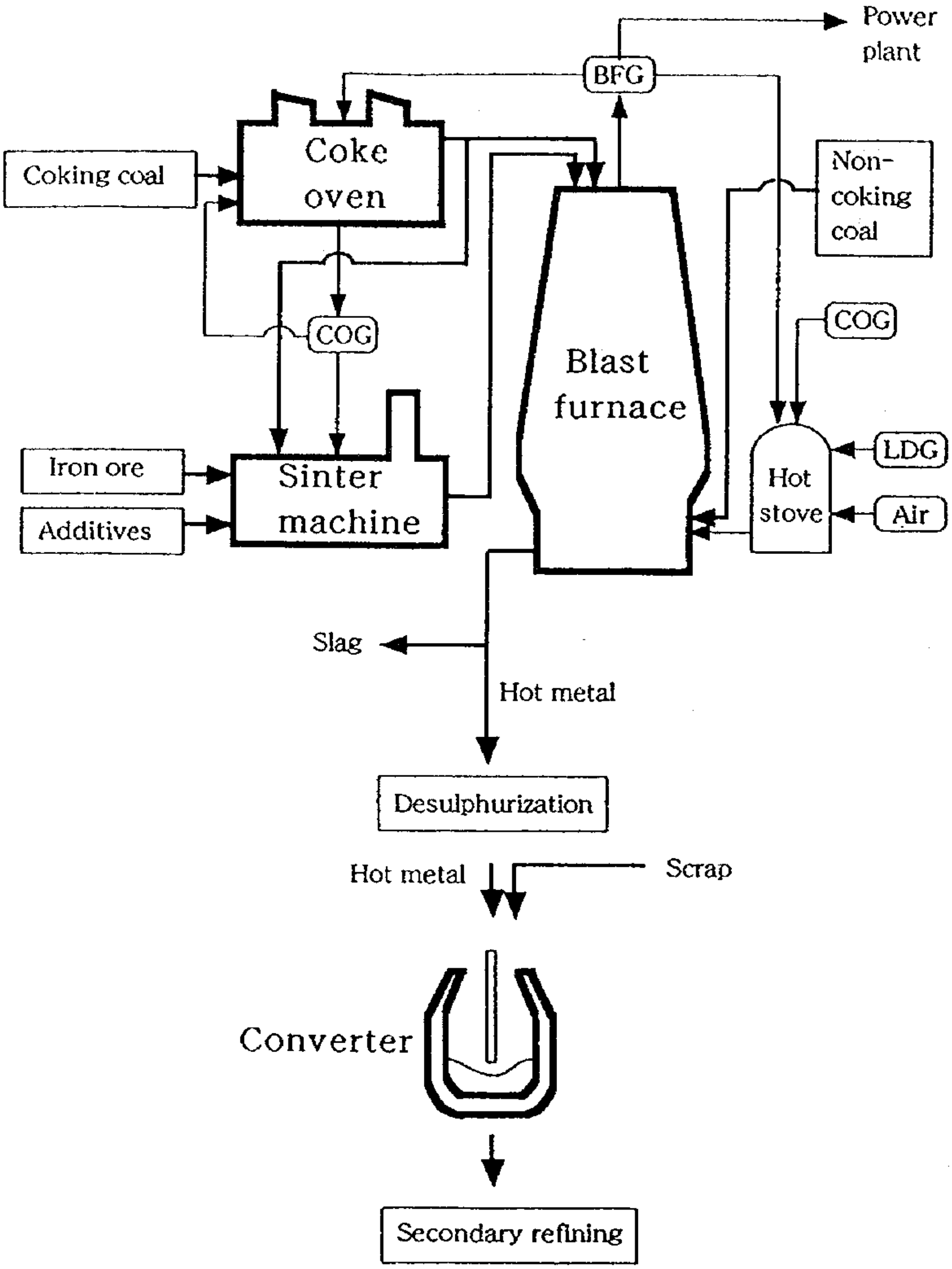


Figure 1-1 Blast furnace process flow

2. Direct reduction - EAF

The steel making processes by the direct reduction - EAF route presently occupy the second largest share in operation throughout the world. Among the direct reduction processes, the following are the representative processes industrially proven or commercially available.

Natural gas based process:
- MIDREX process
- HYL-III process
- FINMET (former FIOR) process
- IRON CARBIDE process

Coal based process:
- SL/RN process
- FASTMET process

2.1 MIDREX process

The first MIDREX plant was built in Portland, Oregon, USA in 1969 by Midrex Division of Surface Combustion Company which had been purchased by the Midland Ross Corporation, USA. In 1974, the Korf Group purchased the division and formed Midrex Corporation. In the early 1980s, the Korf Group experienced financial difficulties and in 1983 sold Midrex to Kobe Steel.

The MIDREX process (Figure 1-2) converts iron oxide pellets or lump ore to high purity direct reduced iron (DRI) or hot briquetted iron (HBI). The direct reduction of iron oxides proceeds on a continuous basis: the iron oxides are fed to the top of the shaft furnace, flow downward by gravity and are then discharged from the bottom of the shaft furnace in the form of DRI or HBI.

Reducing gas is generated in a stoichiometric CO_2 reformer which reforms a mixture of fresh natural gas and recycled top gas from the shaft furnace at approximately 920℃. As the reducing gas leaves the reformer in near equilibrium conditions, containing 90 to 92 percent hydrogen plus carbon monoxide, the gas does not require quenching; it is fed directly to the shaft furnace where reduction takes place at about 850℃.

Part of the shaft furnace offgas is used to fire the reformer burners; the remainder is recirculated to the reformer. Thermal efficiency of the reformer is greatly enhanced by a comprehensive heat recuperation system. The heat exchangers recover the sensible heat from the reformer flue gas to preheat combustion air (used in the reformer burners) up to 650℃ and to preheat the process gas (mixture of top gas and natural gas) fed to the reformer up to 540℃.

The DRI produced can be discharged at ambient temperature or hot briquetted. The briquettes are cooled in a quench tank or with water sprays. The shaft furnace is operated at low pressure and has a number of internal mechanical devices and flow aid devices to facilitate solid/gas contact.

A major feature of the MIDREX process is its stable product quality. The uniform gas distribution in the shaft furnace ensures uniform product metallization even when the ore supplies change.

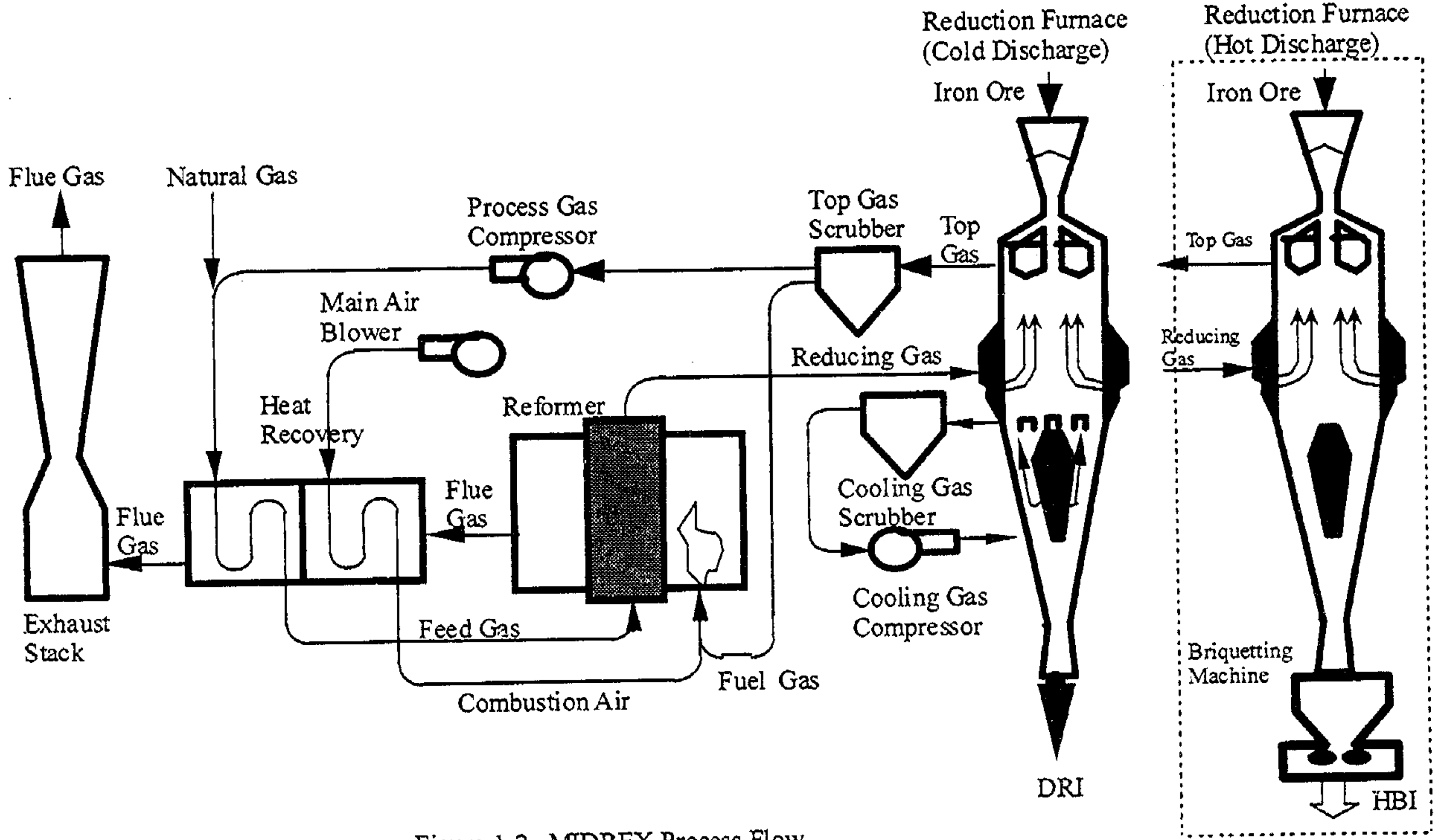


Figure 1-2 MIDREX Process Flow

2.2 HYL-III process

The first HYL plant was built in 1957 in Puebla, Mexico. This technology, known as HYL-I, uses four fixed bed reactors, operated in a batch mode. In 1969, development of HYL-II, an improved batch process, was began. Simultaneously, HYL began working on HYL-III, a continuous process using a shaft furnace. The first commercial HYL-III plant, 2M5, was started up in 1979.

The HYL-III process (Figure 1-3) reduces iron oxide pellets or lump ore in a shaft reactor. Reducing gas is generated in a steam reformer to produce the hydrogen plus carbon monoxide required as make-up for the reduction process. The reformed gas is quenched to remove excess steam, then reheated.

Reducing gases are made up of a mixture of make-up and recycling gases. The basic components of the reduction circuit, aside from the reactor, are (1) a gas heater to increase the reducing gas temperature up to 925℃, (2) a scrubbing unit for dedusting, cooling and H_2O elimination from the top gas, (3) the recycle gas compressor and (4) the CO_2 removal unit. Here CO_2 is selectively eliminated from the system for a more efficient reuse of the recycle gas.

The zero kWh option uses steam turbines to produce electricity; steam for the turbines is generated using heat from the reformed gas quenching step. The shaft furnace is operated at high pressure; it has no internal mechanical devices or flow aids except for a "cluster breaker" at the furnace outlet.

After CO_2 is removed, reactor offgas is circulated to the reactor. The DRI produced can be discharged at ambient temperature or hot briquetted. The briquettes are cooled in a quench tank.

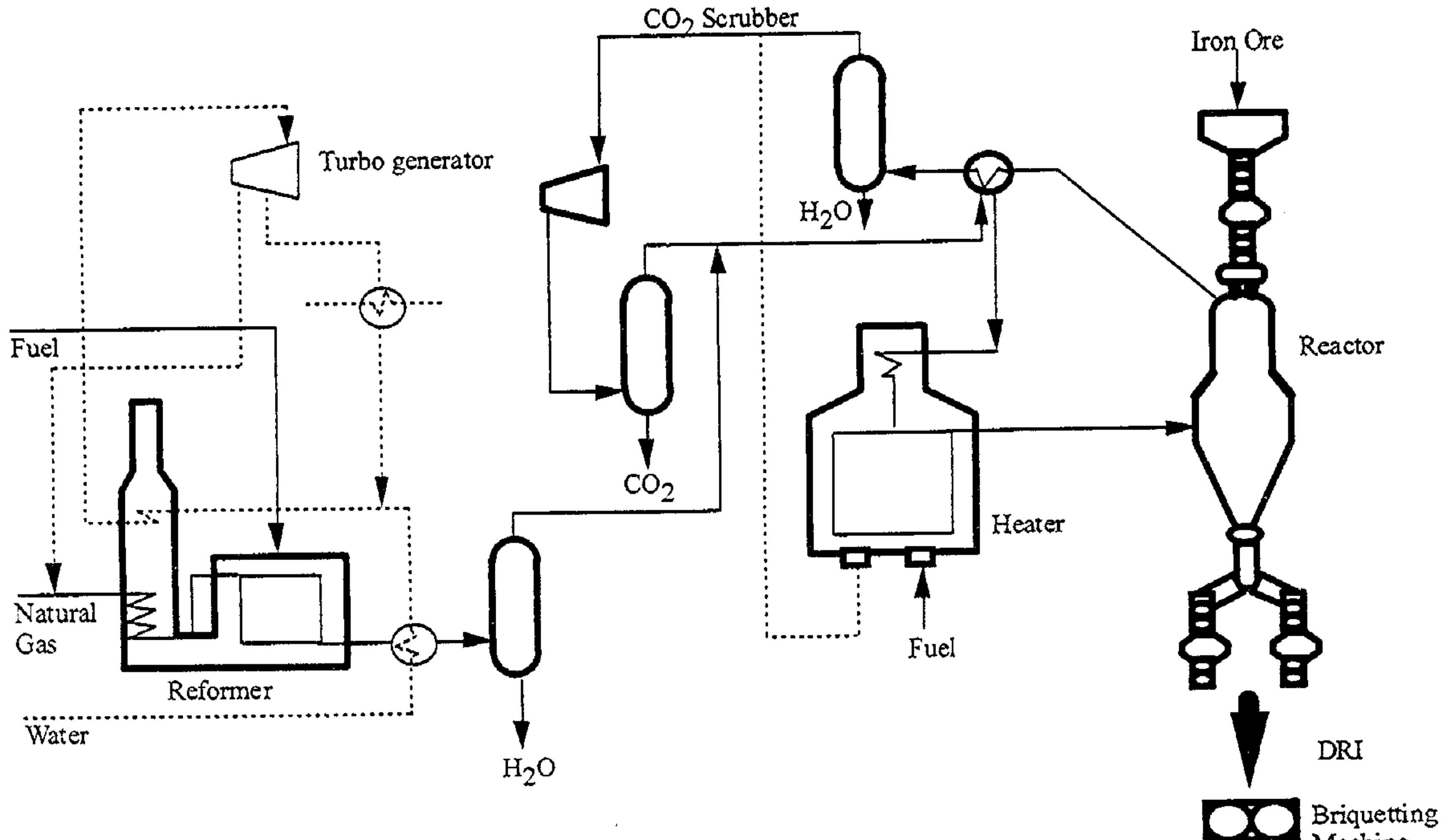


Figure 1-3 HYL-III Process Flow

2.3 FINMET (former FIOR) process

The concept for the Fluidized Iron Ore Reduction process (FIOR) was developed by A. D. Little and Esso Research and Engineering Co. in the 1950s. The A. G. McKee Co. acquired the rights to sub-license the FIOR Technology in 1971 and sold a license to FIOR de Venezuela where the 400,000 t/y plant started up in 1976. Later, rights to the technology were sold to Davy International.

The FIOR process (Figure 1-4) uses four bubbling bed fluidized reactors to reduce iron ore fines. The fines are charged to the first reactor, where they are preheated, and flow sequentially through the other three. Reducing gas is generated in a steam reformer. The product is discharged hot, briquetted, then air-cooled.

An improved version of the FIOR process is now marketed as the FINMET process which is often termed "FIOR II" process. The FINMET process is designed to correct deficiencies in the FIOR process in the area of ore preheating, CO_2 removal, cyclone life, solids transfer and recycle of remet material.

The FIOR preheating reactor uses natural gas to preheat the iron ore. In the FINMET process, this step was eliminated and the heat is provided instead by offgas from the reducing reactors.

The CO_2 removal system can scrub both recycle gas as well as reformed gas. In the FIOR plant, only the reformed gas is scrubbed, which limits the amounts of CO which can be used in the reducing gas. The FINMET process will use higher percentages of CO to improve the process heat efficiencies.

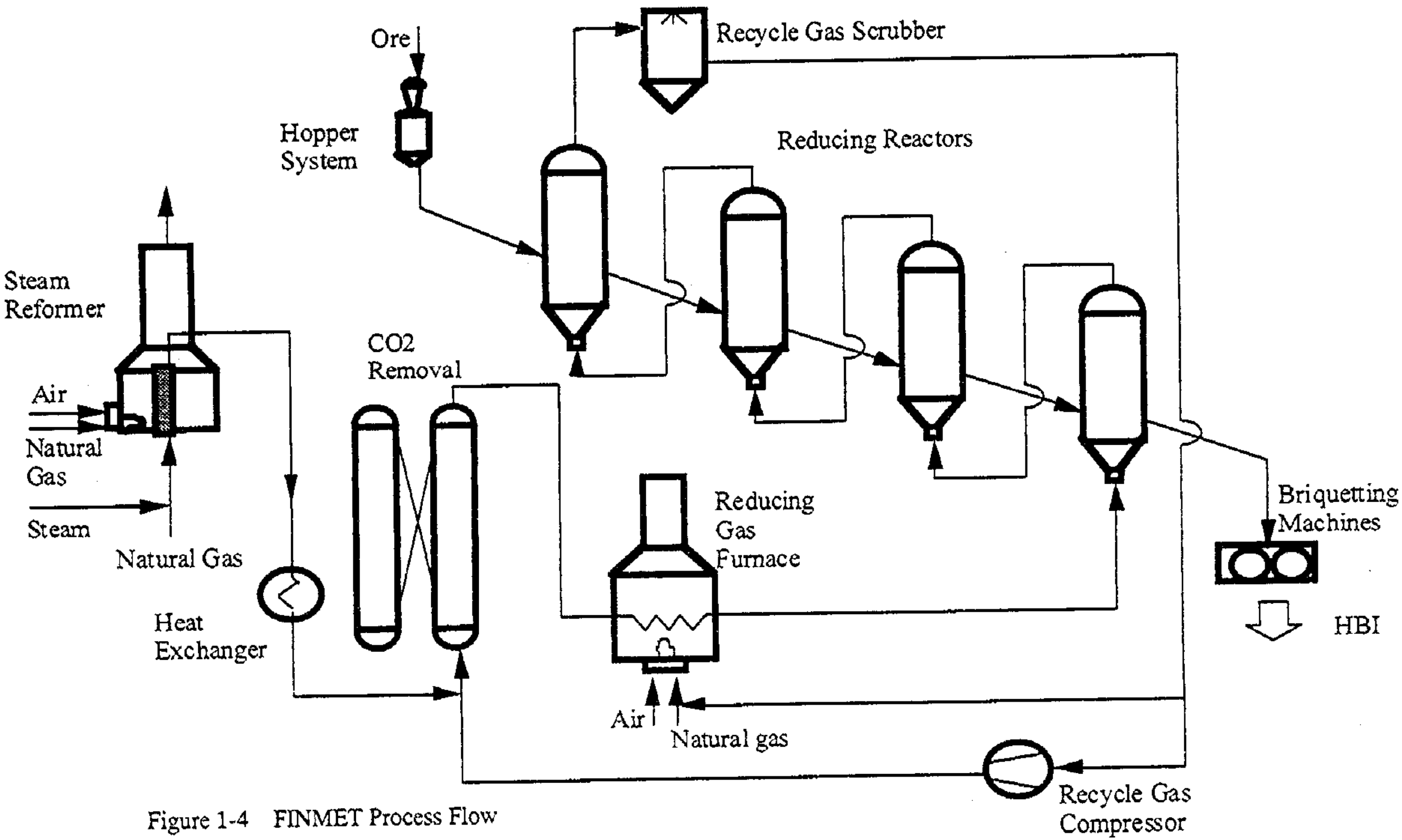


Figure 1-4 FINMET Process Flow

2.4 IRON CARBIDE process

In 1994, the first commercial Iron Carbide process plant having a 0.3 million t/y capacity was started up in Trinidad to supply the products to Nucor, USA.

The Iron Carbide process uses one bubbling fluidized bed reactor to reduce iron ore fines. The reactor has a series of internal baffles that create intimate contact between the ore and the gas. Hydrogen is used as the reducing gas; it is produced from natural gas by steam reforming, then shifting the gas and removing CO_2.

Iron carbide is made by a single step, gas solids reaction. Iron oxide is fed into a fluid bed reactor at a temperature between 550℃ and 600℃ and a pressure of about 1.8 atmospheres. A preheated process gas containing a mixture of carbon monoxide, carbon dioxide, methane, hydrogen and water vapor, is introduced to form the iron carbide. The typical chemical reaction for the process is as follows:

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

Reactor offgas is returned to the reactor. The product is cooled in a heat exchanger that preheats incoming ore. Product is in the form of iron carbide (Fe_3C) fines which contain about six percent carbon.

A diagram of the system for the production of iron carbide (Figure 1-5) reveals its essential elements.

First, the screened and classified iron or concentrates are preheated and introduced into the fluid bed reactor, where a hot stream of a mixture of gases is forced up through the bed of ore, interacting to strip the oxygen from combination with iron (forming water), while carbonaceous gases provide one carbon atom for every three iron atoms, thus forming iron carbide - Fe_3C.

Second, the water laden offgas (top of the reactor) is relieved of much of its dust burden in the cyclone on top of the reactor, thence to the heat exchanger for cooling, and into the scrubber where the water vapor is condensed out of the stream along with any remaining small particles of dust.

Third, the scrubbed gas, partially depleted of carbon and hydrogen, is reconstituted with make-up gas, and is re-pressurized, passed through the heat exchangers to boost the temperature, and finally pre-heated to the reactor temperature for re-entry at the bottom of the fluid bed reactor to repeat the cycle.

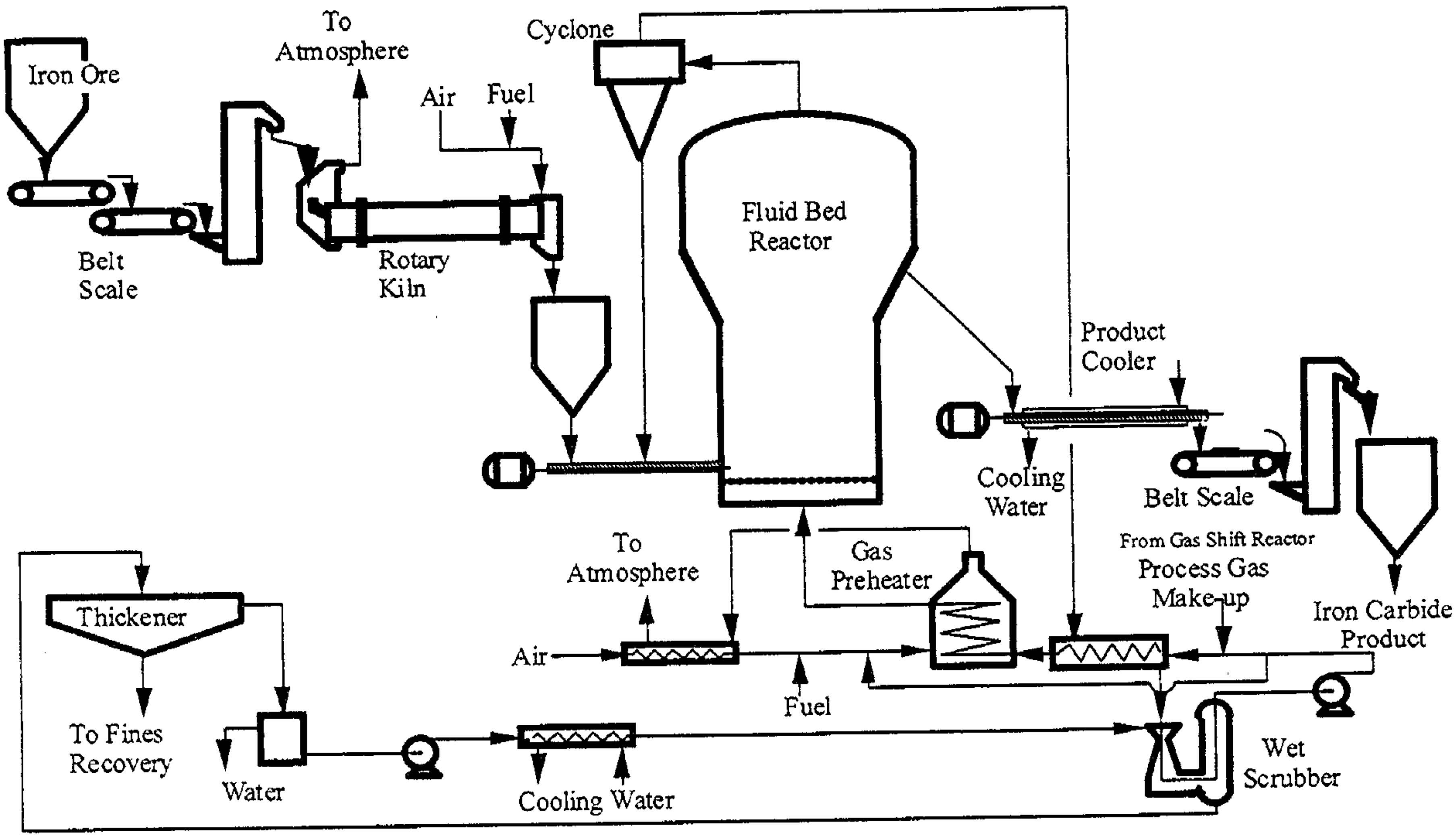


Figure 1-5 IRON CARBIDE Process Flow

2.5 SL/RN process

The SL/RN process was developed as a combination of the Republic Steel and National Lead (RN) processes, developed between 1920 and 1930, and the Stelco and Lurgi (SL) processes, developed around 1960. Between 1968 and 1984, the Highvelt Steel and Vanadium Corporation of South Africa installed 13 SL/RN kilns for pre-reduction of iron ore. In addition to the plants making DRI, there are a number of plants used for production of ferroalloys.

In the SL/RN process (Figure 1-6), iron oxide in pellet or lump form is fed to a rotary kiln. Coal is introduced at the tail end of the kiln, is gasified, and reduces the iron oxide. Air is introduced to the kiln at several places.

The product is discharged from the reactor, cooled in a rotary cooler, magnetically separated from the coal ash, and discharged in pellet or lump form. The offgas is burned in a combustion chamber and cooled, then dust is removed. The gas can then be used to generate electricity.

In terms of the use of different reductants, the SL/RN process is characterized by great flexibility as it can process all coals from non-coking coals such as lignite to anthracite/coke breeze.

An additional feature of the SL/RN process is the possibility of recovering considerable amounts of energy by utilizing a waste heat boiler for production of high pressure steam for subsequent electric power generation.

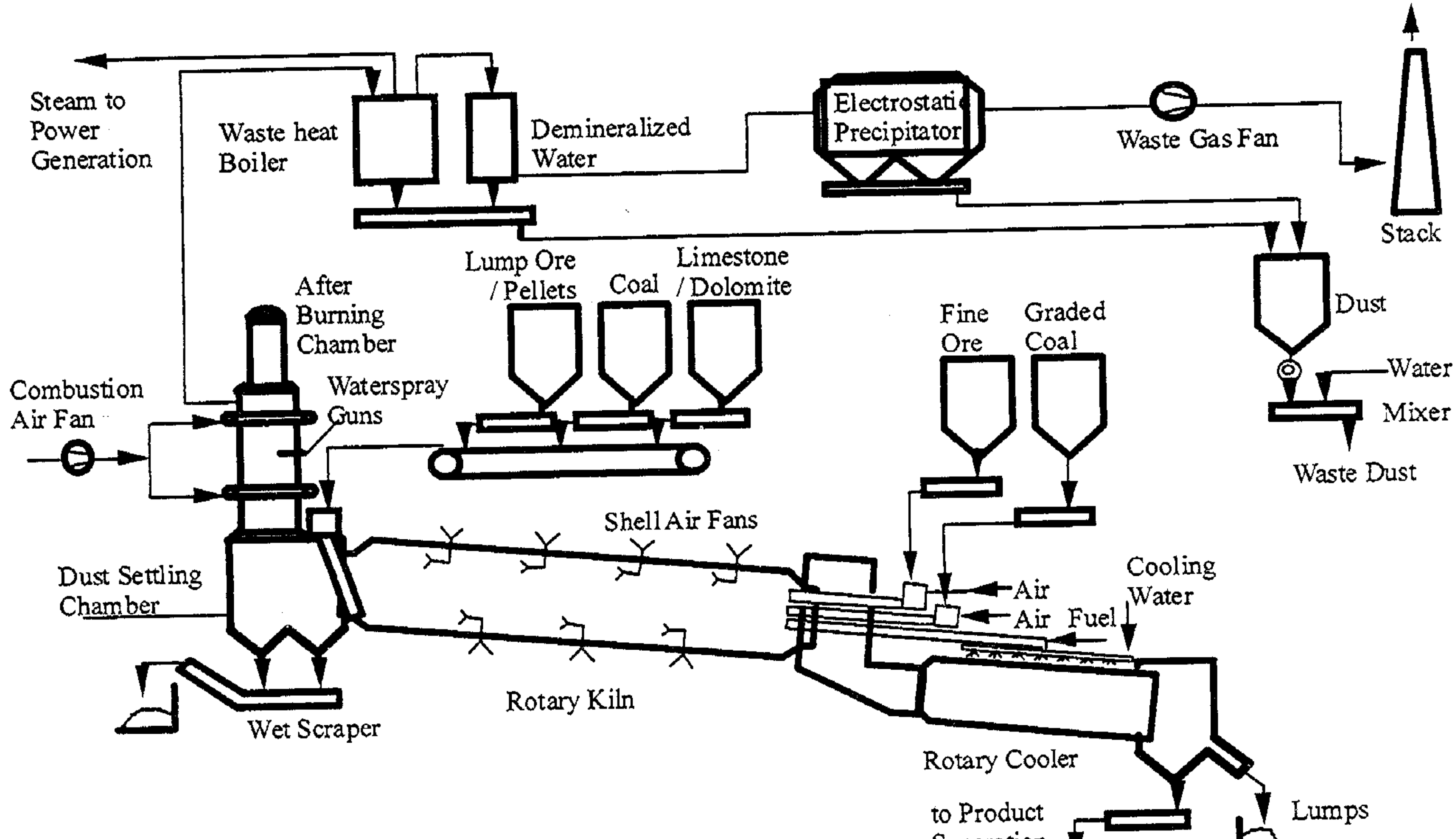


Figure 1-6 SL/RN Process Flow

2.6 FASTMET process

Bench scale tests on FASTMET process were started in 1991 at the Midrex Technical Center in Charlotte, NC. In December 1995, Midrex and Kobe Steel started up a 2.9 t/h demonstration plant at Kakogawa Works in Japan.

The FASTMET process (Figure 1-7) mixes iron ore fines, coal fines and binder to produce pellets that are dried at low temperature, then charged in a layer one or two pellets deep to a rotary hearth furnace (RHF). Burners located in the RHF heat the pellets, which gasifies the coal within the pellets and reduces the iron ore. As the RHS rotates, the pellets are heated to 1250-1350℃ using gas, oil, coal-fired burners. Residence time on the furnace hearth is typically 6-10 minutes.

In the FASTMET process, generation of reducing gas and reduction both occur within the pellets. As the pellets are heated, carbon from the reductant is converted to carbon monoxide (CO), which then reduces the iron oxide (Fe_3O_4 or Fe_2O_3) to metallic iron (Fe). The intimate contact of the iron oxide and carbon, as well as the high reduction temperature, results in a very rapid reduction rate. The offgas is conditioned to remove combustibles, used to preheat combustion air, scrubbed to remove sulfur, then discharged to the atmosphere.

After one revolution of the RHF (less than 10 minutes), the pellets are discharged hot (at approximately 1000℃). They can be loaded into refractory-lined transfer containers

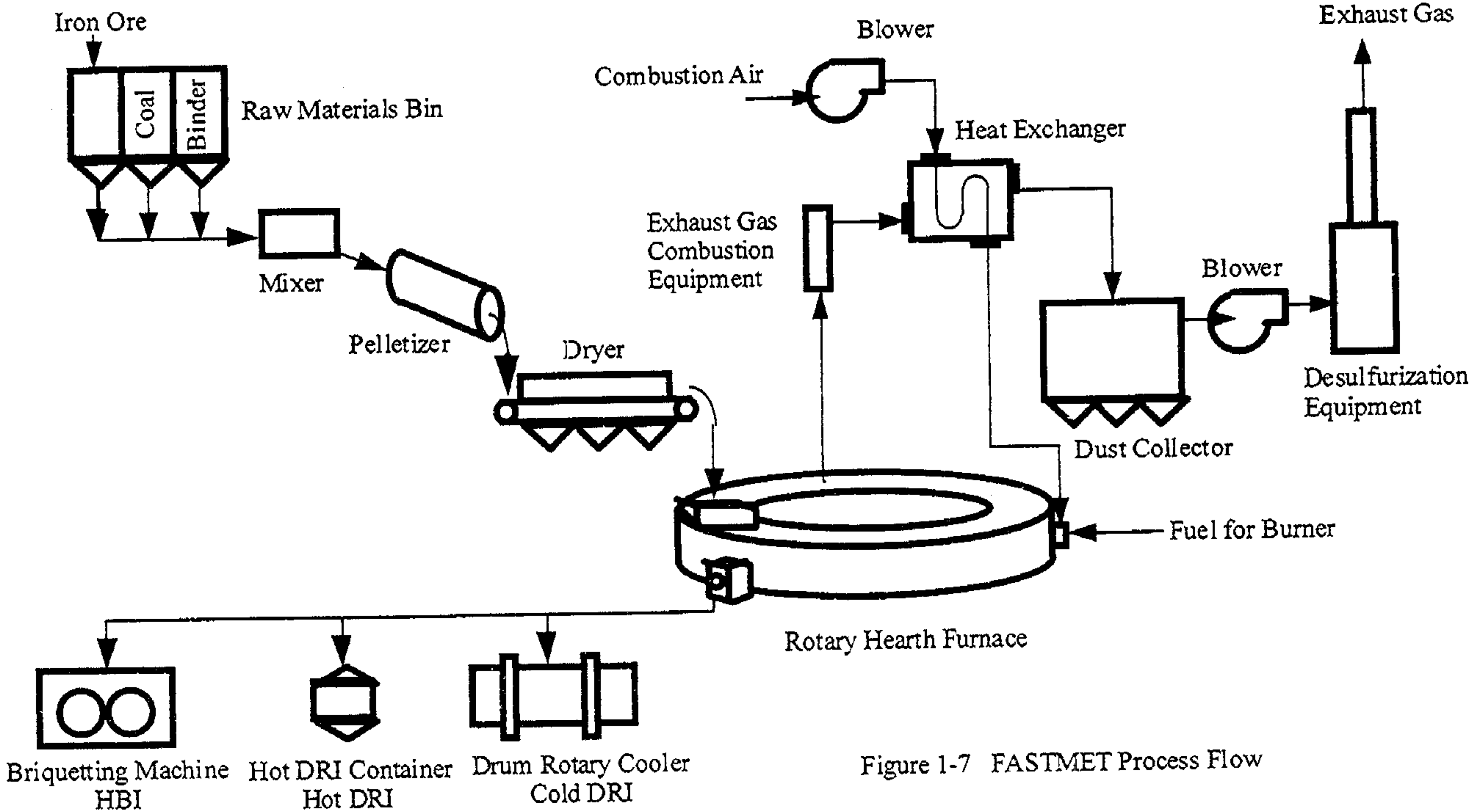


Figure 1-7 FASTMET Process Flow

3. Smelting reduction - Converter process

Smelting reduction - Converter has been developed recently. These processes have the characteristic which does not use the coking coal for making pig iron. In this part, three processes are introduced.

- DIOS - Converter
- COREX - Converter
- ROMELT - Converter

3.1 DIOS process

The DIOS process flow is shown in Figure 1-8.

The DIOS process is the direct iron ore smelting reduction method. This process produces molten iron using fine ore and granular non-coking coal and iron ore directly without coking process and ore agglomerating process.

The DIOS process development was started in 1988 and was finished in 1996 by JAPAN Iron and Steel Federation. Every elements were studied in the first three yeas. The pilot plant was constructed as an integration of results from element study. The pilot plant which has the pig iron production capacity of 500 tons/day was operated from 1993 to 1996. At last, the total system and feasibility were studied from the results of the pilot plant operations.

The fuel of DIOS process can use ordinary coals. The ferrous rawmaterials can use fine ore.

The ores are fed to the prereduction furnace by way of preheating furnace. The coals are fed directly to the smelting reduction furnace after drying. The pressure in smelting reduction furnace is maintained at 1.9 kg/cm^2. The oxygen is blown in the smelting reduction furnace filled the hot metal and slag through the top lance and burns the coal and the generated reducing gas. The nitrogen gas is blown in from the bottom stirs the hot metal and slag bath. The Fe-oxide in ores is reduced by char and carbon in the hot metal. Produced hot metal and slag are drained from a tap hole at intervals of several hours.

The exhausted gas reduces the iron ore before charging to smelting reduction furnace, heats up the ore before charging to prereduction furnace and exchanges the remained heat in the waste heat boiler. The gas which is passed the waste heat boiler is converted to the electric power.

3.2 COREX process

The COREX process flow is shown in Figure 1-9.

The COREX process is two-step smelting method and produces molten iron using agglomerated or lump ores. The COREX is based on reduction and melting processes which are called the reduction shaft and the melter gasifier. In this process, coal is used directly without coking process.

The COREX process had been developed to commercialize for a number of years. The industrial plant of COREX process which had the production capacity of 1000 ton/day was constructed in South Africa for the first time and was started up in 1989. The second industrial plant which had the production capacity of 2000 ton /day was constructed in South Korea and was started up in 1995.

The fuels of the COREX process can use ordinary coal. The ferrous raw materials need lumpy ores and/or agglomerated ores such as pellets, sinter.

The metallurgical work is carried out in two separate processes. The two processes are composed of the reduction shaft and the melter gasifier. The iron ore is charged into the reduction shaft and is reduced to about 90 % by the reducing gas coming up from the melter gasifier.
The reduced iron is extracted from the reduction shaft and is fed to the melter gasifier.The coal is fed to the melter gasifier dome and is resolved into gas and char. The oxygen is blown into the lower part of the melter gasifier, generating the reducing gas. The coal is fed to the melter gasifier dome and is resolved into gas and char. The oxygen is blown into the lower part of the melter gasifier, to the melter gasifier.The coal is fed to the melter gasifier dome and is resolved into gas and char.
The oxygen is blown into the lower part of the melter gasifier, generating the reducing gas. The coal is fed to the melter gasifier dome and is

resolved into gas and char. The oxygen is blown into the lower part of the melter gasifier, generating the reducing gas.

The ore which has the remained oxygen is reduced in molten state to produce the hot metal while the material is passing through a fluidized coal layer and a fixed coal layer in melter gasifier. The tapping procedure and further treatment of hot metal are exactly the same as with blast furnace pig iron.

The gas exhausted from the reduction shaft has a net caloric value of approximately 7500 kJ/Nm^3 . The gas can be used for metallurgical, heating and drying as well as power plant.

3.3 ROMELT process

The ROMELT process flow is shown in Figure1-10.

The ROMELT process is one-step smelting method and produces molten iron using fine or lump ore. The smelting principal is based on the use of a large volume, highly agitated slag bath as both the reaction containment medium and the heat transfer.

The ROMELT process pilot plant had been operated by the Moscow Institute of Steel and Alloys(MISA) at Novolipeski Metallurgical Kombinat since 1985. The prototype of the ROMELT process was the Vanyukov process in which copper nickel sulfide ores were oxidized-smelted in a gas stirred, liquid slag filled reactor. The pilot plant furnace had 20 m^2 hearth area.

Raw materials such as fine ores, fluxes and coals which are stored in material bins are discharged on the conveyer at proper ratio.
These materials are charged to the ROMELT furnace through chutes.
Being able to use not only iron ores but also ferrous dusts, mill scales and many ferrous materials, the ROMELT is superior to other process for materials recycle. The coals are used from low to high volatile matter.

Deoxidization reaction occurs in a vigorously agitated slag bath at temperature of 1400 to 1500℃. The coals play roles of fuel and reducing agents. Air enriched oxygen is blown in through lower

tuyeres, agitates the slag layer, burns a part of coals, and supplys heat to the slag.
Oxygen blown in through upper tuyeres burns the gas generated from the slag layer and supplys the heat to the slag layer. The pig iron is separated from slag through a calm slag layer under the lower tuyeres. The hot metal and melting slag are discharged through the siphon hole.

The exhausted gas at temperature of 1500 to 1800℃ leads to gas cleaning facilities through a boiler. The heat energy of gas is converted to the electric power at the boiler and power generator. The ROMELT furnace is operated at ambient pressure (at several mm Aq), so does not need complex mechanical seals.

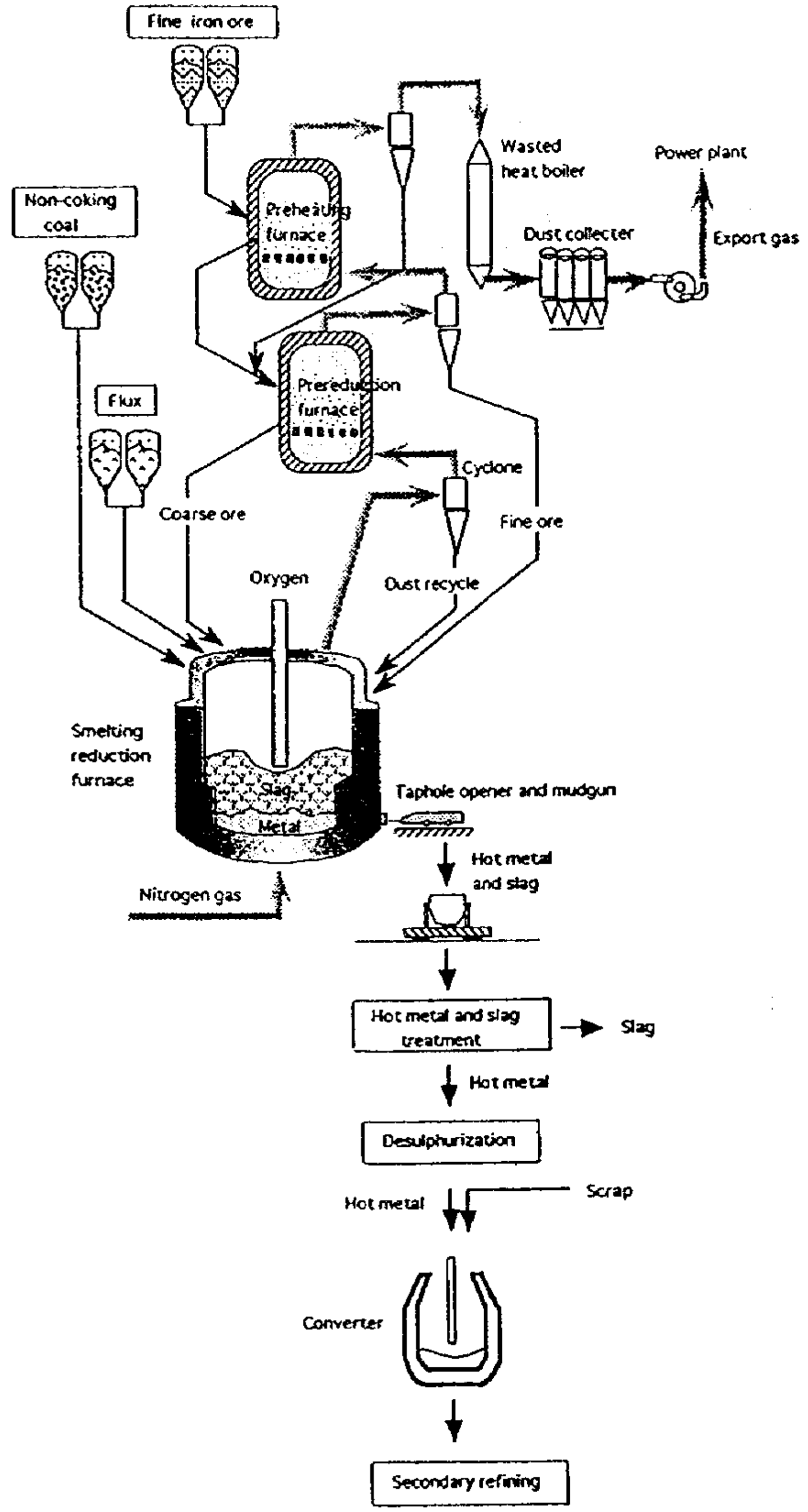


Figure 1-8 DIOS process flow

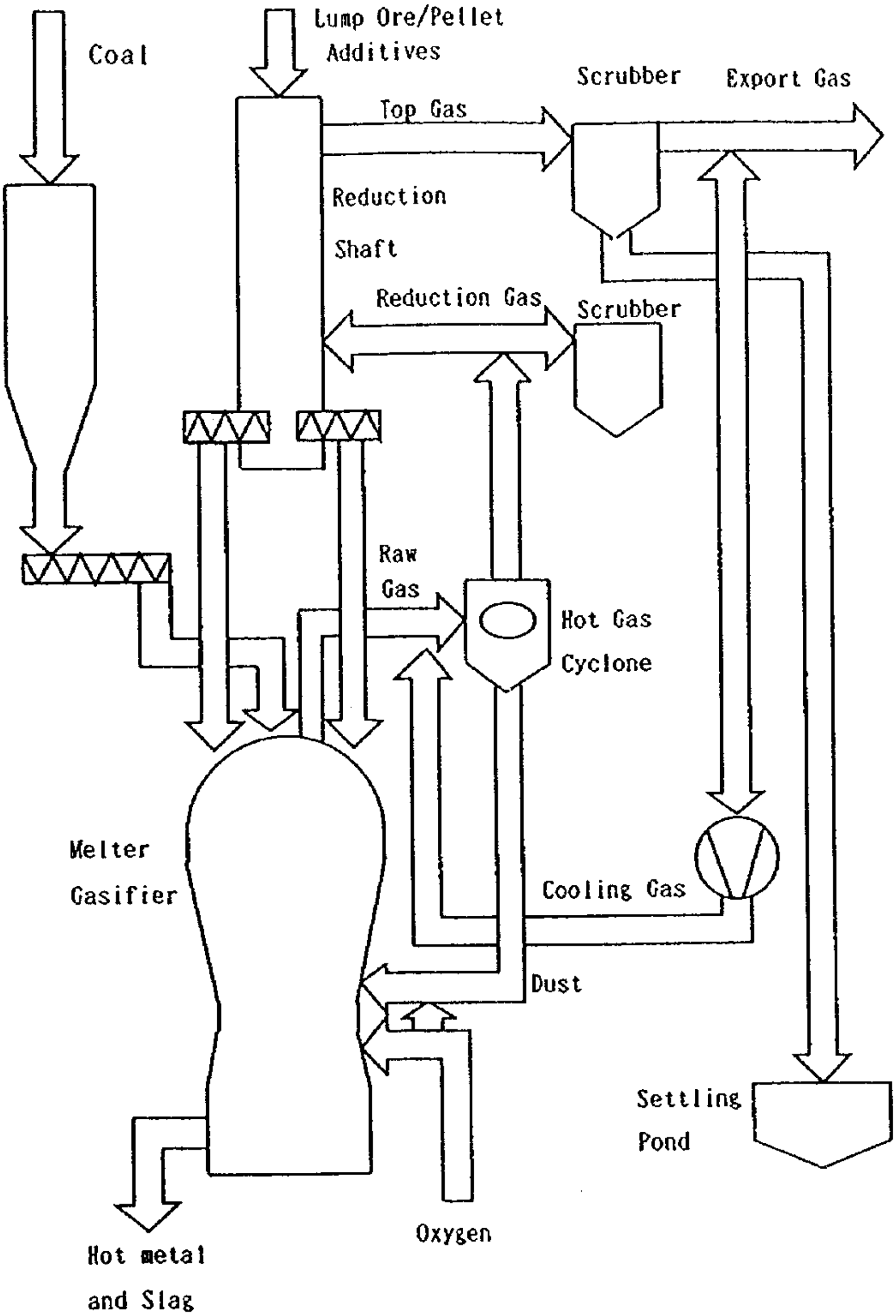


Figure 1-9 COREX process flow

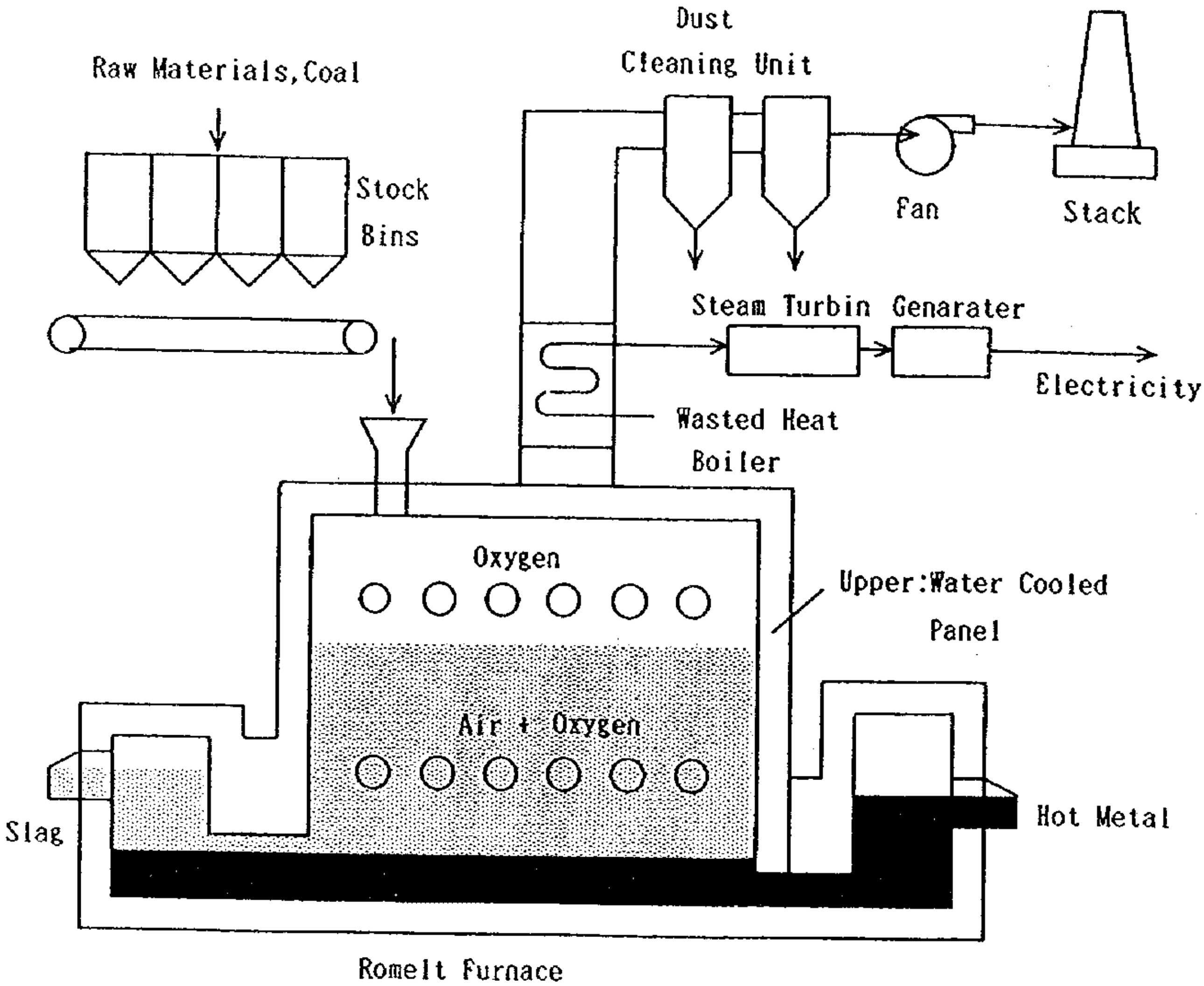


Figure 1-10 ROMELT process flow

4. SCRAP/EAF process

(1) Characteristic of process

(a) This process melts scrap in the electric arc furnace (EAF), performs composition adjustment and produces steel. The scrap/EAF process is often constrained by the quality variations of scrap.

(b) The tramp element(as Cu, Sn, Cr, Ni, etc.) which enter from scrap, and [N] picked up during refining in EAF makes impossible to produce the high grade flat steel..

(c) This process is equipped with EAF proper, ladle furnace, and degassing equipment ordinarily.

Table1-1 shows outline of Scrap/EAF process, and Figure 1-11 shows the schematic diagram of scrap/EAF process.

Table 1-1 Outlines of scrap/EAF process

Item	Sub items	Figure & Remarks	Remarks
Main Equipment	EAF Annual capacity Capacity t/ht Trans. Capacity Ladle Furnace	Approx. 0.8 × 10^6t/y/Furnace EAF 120～150 t/ht 80～ 90 MVA	 T-T;60～70min η ; 70～80%
Raw materials unit consumption	Scrap Pig iron etc.	1,080 kg/t-s	η ; approx. 93%
Energy unit consumption	Electric Power (EAF+LF) Electric power of others Electrode (EAF+LF) Oxygen Aux. fuel	Approx. 420 kWh/t-s " 80 " 2.0 + 0.4 kg/t-s " 30 Nm3/t-s " 1.5 L/t-s (Oil)	
Additive material	CaO Carbon Other Ferro alloy	Approx. 30 kg/t-s " 12 " 3 " 12	
Refractory	Refractory	Approx. 2.0 kg/t-s	
By-product	Slag	Approx. 60 kg/t-s	
Construction cost		Low	
Cost of molten steel		(See other data)	
Industrial status	Commercial	Many plant operated	

Note ; The values of unit consumption are the examples of usual EAF process.

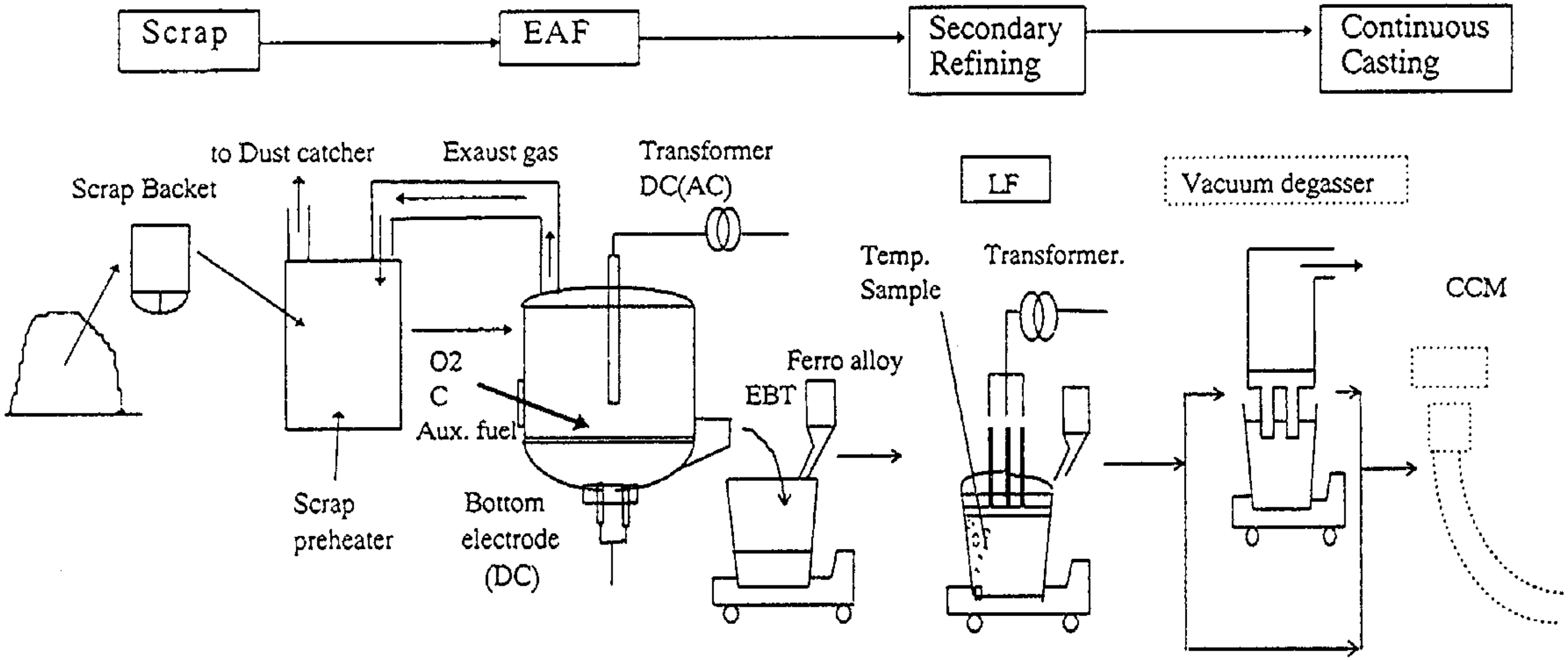


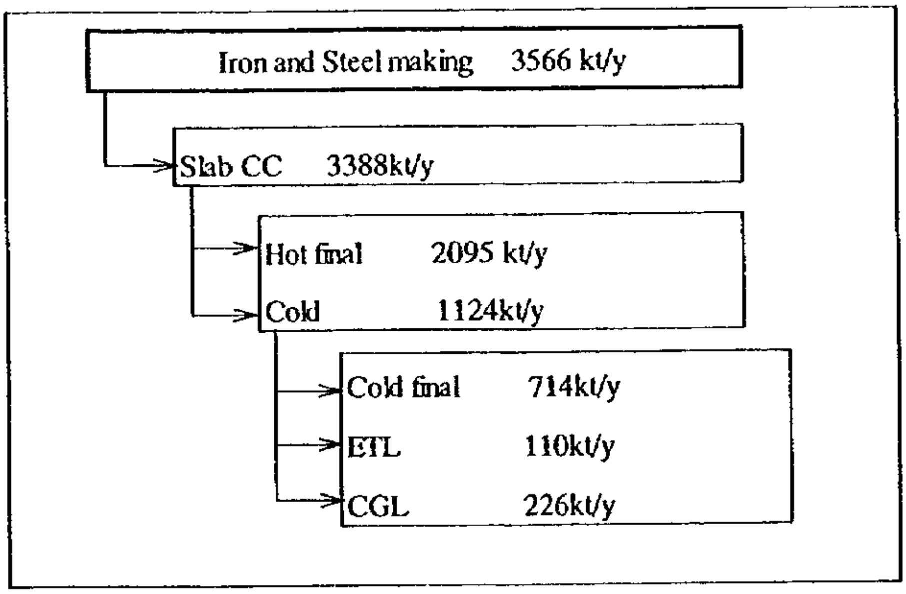
Figure 1-11 Schematic Diagram of Scrap／EAF Process

5. Study of the energy balance for applicable iron and steel making processes

5.1 Preconditions for the energy balance

The energy balance of electric power and fuel, and unit energy consumption per ton of crude steel for comparison with applicable iron and steel making processes are estimated for a production volume of a 3 million ton / year in Table1-2.

Table 1-2 Production plan to estimate the energy balance



5.2 Estimated power balance

Table 1-3 shows the power balance for a 3 million ton of crude steel/year plan.

Table 1-3 Power balance for a 3 million ton of crude steel / year plan

(Unit : Mwh/h)

		Plant	BF+BOF	DR+ EAF	SR+BOF	EAF
Consumption	Average Power	Iron /Steel making Plant	104	281	78	199
		Rolling mill	61	61	61	61
		Air separation Plant	25	6	207	10
		Utilities & others	29	29	29	29
		Total	219	376	374	298
	Peak demand		273	551	440	453
Production	Average power	Power plant in the steelworks	226	447	393	352
		(Output (MW) x No. of units)	(125 x 2)	(165x3)	(145 x 3)	(130 x 3)
Purchase	Average power		-7	-71	-19	-54
	Peak demand	(1 unit stop in power plant)	154	237	165	206

Note: Negative average power in purchase means that average power generated in the steelworks will be supplied to power company.

(1) The DR+EAF and SR+BOF processes, both of which will have same consumption level, consume a large amount of electric power because of the following factors:
  - High unit consumption of electric power by EAF in the DR + EAF process
  - High unit consumption of oxygen by SR , BOF in the SR+ BOF process
(2) The lowest power consumption will be in the BF+ BOF process.
(3) The DR+EAF process will generate the highest peak demand of the processes.
(4) In Average power of purchase, surplus power will be supplied to power company because capacity of the power plant will have larger capacity

than average power consumption of the steelworks to reduce peak demand required to power company.

5.3 Estimated fuel balance

Table 1-4 shows the fuel balance for a 3 million ton of crude steel / year plan .

Table 1.4 Fuel balance for a 3 million ton of crude steel / year plan

Unit: 10^6 kcal/h

	Plant	BF+BOF	DR+EAF	SR+BOF	EAF
Consumption	Iron /Steel making Plant	386	13	13	13
	Rolling mill	141	141	141	141
	Utility,Other	77	77	77	77
	Sub total	604	231	231	231
	Power plant	538	1064	935	839
	Total	1142	1295	1166	1069
Production	Iron and steel making plant	1045	0	1719	0
Purchase		97	1295	(Surplus) -553	1069

(1) The BF+ BOF process will consume the greatest amount of fuel in the production plant, apart from the power plant, while, iron and steel making by the DR+EAF, SR+BOF and EAF processes will not consume fuel in their operation in principle.

(2) The DR+EAF process will consume the largest amount of fuel in the whole steel- works because the bigger capacity of power plant consumes a large quantity of fuel.

(3) The BF+ BOF and SR+BOF processes will produce a large amount of by-product gas. A large quantity of surplus by-product gas will be produced by the SR + BOF process, so that effective use of surplus gas should be considered.

(4) The purchase of fuel for the BF+ BOF process will be very small, and none will be needed for the SR + BOF process.

5.4 Unit energy consumption

The unit energy consumption per ton of crude steel for a 3 million ton of crude steel / year as calculated by the following formula, is shown in Table 1-5.

Unit energy consumption per ton of crude steel = (Purchased energy including coal and NG for reduction - sold energy)/ (Crude steel production)

Table 1-5 Unit energy consumption for a 3 million ton of crude steel / year plan

Unit: Mcal/t

	BF+BOF	DR+EAF	SR+BOF	EAF
Purchased Energy				
Coal	6118	0	7920	0
Natural gas	0	2797	0	0
Fuel	237	3181	0	2626
Electric power	0	0	0	0
Sold energy				
By-product gas	0	0	-1357	0
Electric power	-46	-425	-113	-323
Energy Unit consumption	6309	5553	6450	2303

(1) The unit energy consumption of the EAF process will be the lowest because of using scrap.

(2) The BF+BOF, DR+EAF, SR+BOF and EAF processes will release part of electric power produced by the power plant on average to the power company because these processes will require to install the large-capacity power plant to reduce the peak power demand.

Section 2 Steelmaking process

Contents

1. Study of applicable steelmaking

1.1 Iron and steelmaking process

1.1.1 Scrap／EAF process

(1) Characteristic of process

- This process melts scrap in the electric arc furnace (EAF), performs composition adjustment and produces steel.
- The steel products that can be manufactured by the scrap/EAF process are often restricted by the quality variations of scrap.
- The tramp elements (as Cu, Sn, Cr, Ni, etc.) which enter from scrap, and [N] picked up during refining in EAF make impossible to produce high grade flat steel.
- This process is equipped with EAF proper, ladle furnace, and degassing equipment ordinarily.

Table 1-1 shows the outline of scrap/EAF process, and Table 1-2 shows the modernized EAF plant adopting the new technologies. Figure 1-1 shows the material flow, Figure 1-2 shows schematic process flow, and Figure 1-3 shows the improvement of EAF technologies.

Table 1-1 Outline of scrap/EAF process

Item	Sub items	Figure & Remarks	Remarks
Main equipment	EAF furnace ・Annual capacity ・Capacity t/ht ・Trans. capacity Ladle furnace	(For example) Approx. 1.0 x10^6t/y EAF 130 ～150 t/ht 80～ 90 MVA	T-T; 65 min η ; 80%
Raw materials unit consumption	Scrap Pig iron etc.	1,090 kg/t-s α	η = 92%
Energy unit consumption	Electric power(EAF+LF) Electric power of other Electrode (EAF+LF) Oxygen Aux. fuel	Approx. 420 kWh/t-s " 80 " 2.0 + 0.4 kg/t-s " 30 Nm^3/t-s " 1.5 l/t-s (oil)	
Additive material	CaO Carbon Other Ferro alloy	" 30 kg/t-s " 12 " 3 " 12	
Refractory	Refractory	EAF 5.0 kg/t-s, Other 3.0 kg/t-s	
Industrialized status	Commercial	Many plant operated	

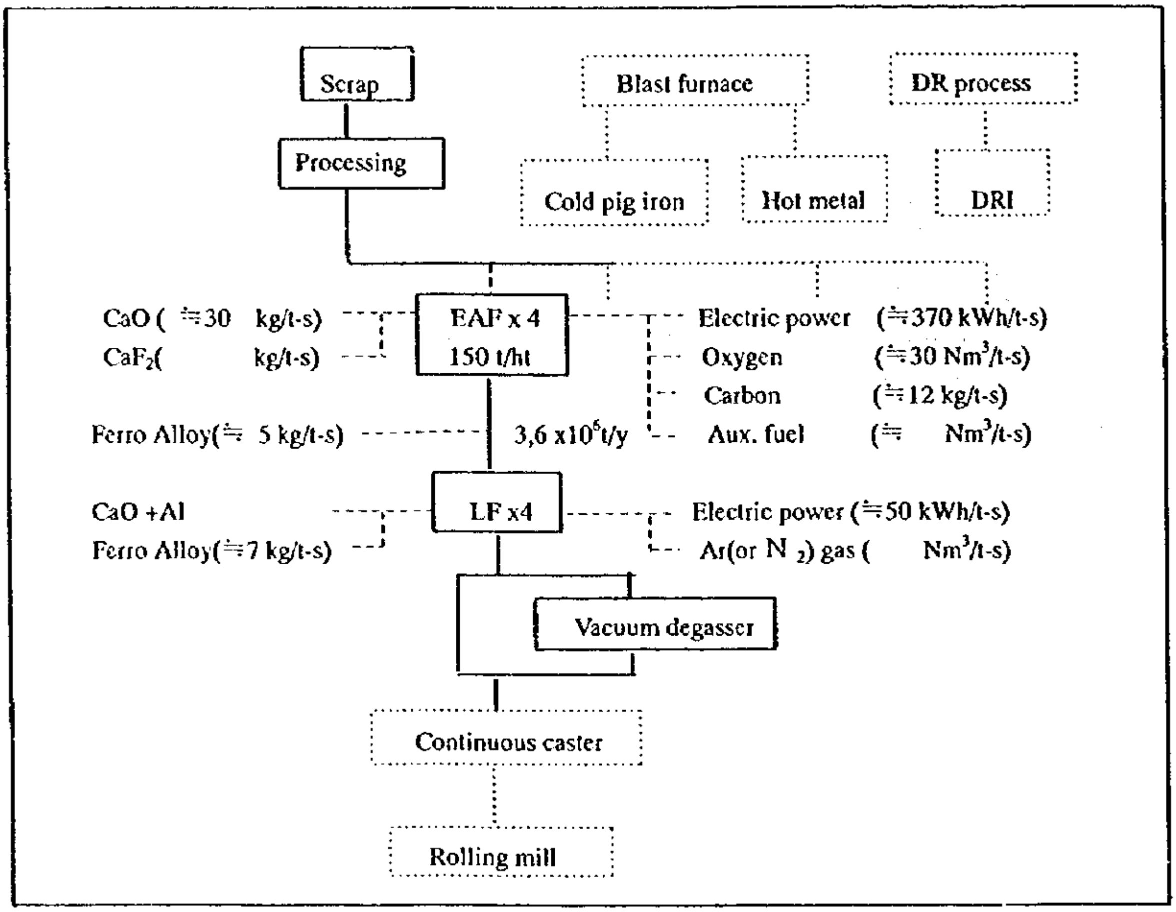


Figure 1-1 Typical material flow of EAF process

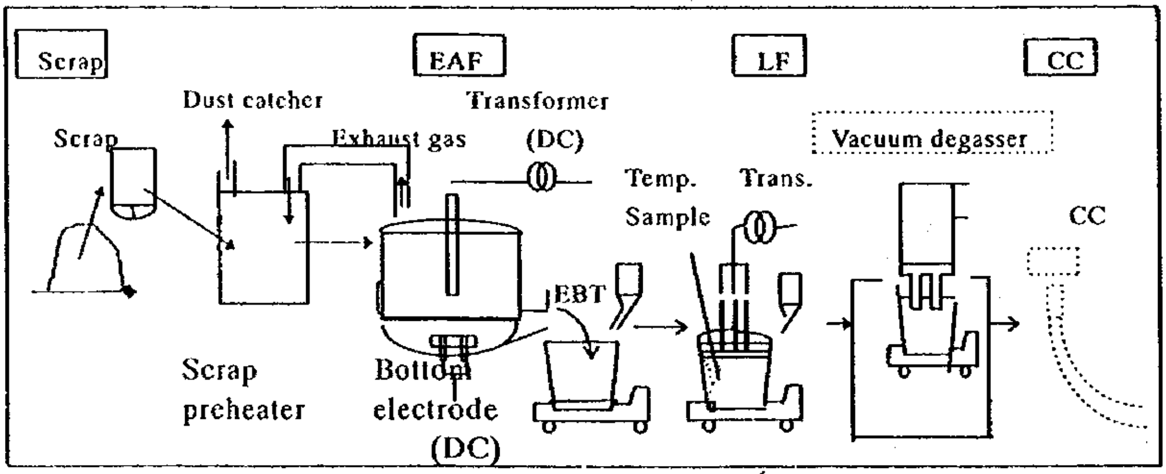


Figure 1-2 Schematic flow of scrap/EAF process

Table 1-2 Modernized scrap/EAF process technology

Item	Technology	Aim and effects
Scrap	Processing	Cutting, pressing, gas cutting, shredding
	Scrap preheating (SPH)	Energy saving
Productivity	Oxygen blowing	Electric unit consumption saving
	Ladle refining(LF, Vacuum)	Tap-Tap decreasing, Refining improving
	Water cooled wall, roof	Refractory saving, High power operation
	HP,UHP operation	Unit consumption improving, Short T-T time
	Big capacity EAF	~200 t/ht, operation index improving
	Carbon injection	Slag forming, Electric unit consumption saving
	Fuel burner	Electric unit consumption saving
	Twin shell type EAF	Energy saving by SPH. Reduction of T-T-time
	D C furnace	High power long arc operation, Flicker improving
	Bottom gas blowing (Stirring)	Yield, electric power saving, Prevention of boiling
	Sequence Casting ratio	Yield improving
Quality	EBT(Eccentric Bottom Tapping)	Slag free tapping
	LF & Degassing	RH, VOD, etc.
Automation	Automatic operation	Labor saving
Environment	Dust catcher	Furnace, Sky house, Building

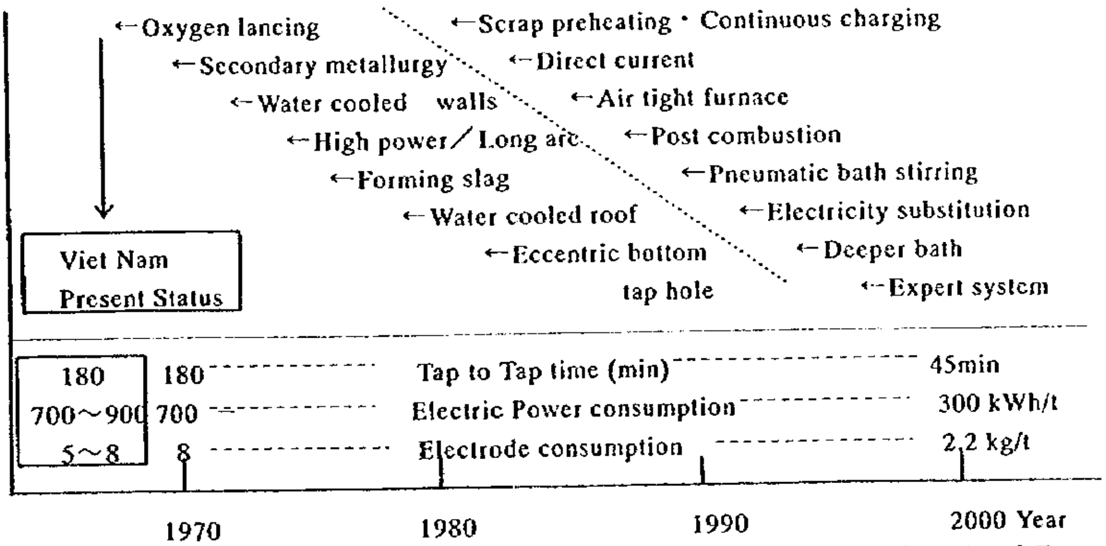


Figure 1-3 Improvements in the EAF technologies (By IISI 27 '93. Henri Faure)

1.1.2 Basic oxygen furnace process (BOF)

The BOF process is ① High productivity, ② High grade molten steel is easy to obtain, and ③ The Production cost is comparatively higher than EAF process. Table 1-3, Table 1-4, and Table 1-5 show outline of the BOF process. Figure 1-4 shows the typical schematic flow of BOF process.

Table 1-3 Outline of BOF typical process divided into three(3) stages

Stage	Item	Description	Remarks
1)Hot metal pretreatment	Vessel (transportation)	Torpedo car	
	De-[S]	Top lance injection	CaO+Al, CaC2, Powder
	De-[Si], De-[P]	Top lance injection	For extremely low[S], [P] steel grade. *1)
2)LD converter (BOF)	Raw material	Hot metal ratio> approx. 80% Scrap ratio < approx. 20%	
	Combined Blowing	Oxygen about 50 Nm^3/t-s	Top lance blowing
		Bottom blowing	O2(+LPG), Ar, N2, CO2, depending on process
	Suppressed gas(LDG) recovery process	Dust collector LDG recovery (CO gas)	About 80～100Nm^3/t-s
	Sub lance system	Measuring ; ・Temperature ・Carbon composition ・Free [O] ・Sampling End point dynamic control	Measuring during blowing & at blow end
	Flux & alloy charging	CaO, Iron ore, Sintered ore, Fluorspar, Coolant etc.	Batch or continuously charge to converter
	Slag stopper	Tap hole closing after tapping	Minimizing slag in molten steel ladle
3)Secondary refining	CAS-OB system	Air tight alloy charging Temperature control	A typical method
	Degassing system	Degassing & de[C]	RH, DH, VAD, etc.
	Bottom gas injection	Stirring of molten steel Floating of inclusion	

Note ; *1) This process is possible to add in the future when such steel grade is required.

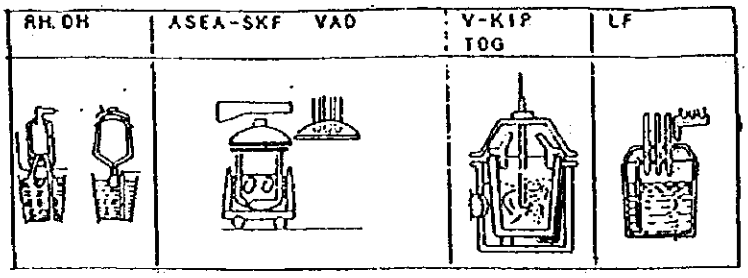
Table 1-4 Outline of typical BOF process(BOF)

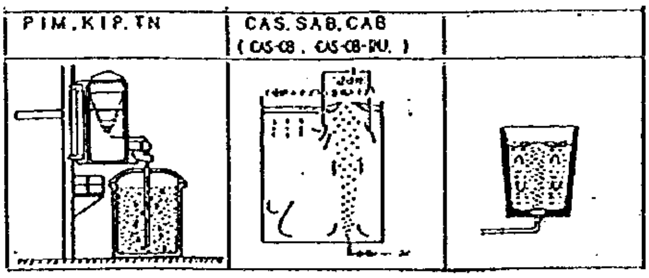
Item	Sub items	Description	Remarks
Main Equipment	LD converter		
	Annual capacity	1.5～3.0 x10^6 t/y Furnace	T-T; 35～40min
	Capacity t/ht	LD 150～330 t/ht	WTR; 70～85%
	Oxygen blow	30000～70000 Nm^3 ／hr	
	Ladle Furnace		
	CAS & RH		(Example)
Raw materials unit consumption	Total	1,090 kg/t-s	η; 92 %
	Hot metal	960	HMR 88 %
	Scrap	130	
	Pig iron	α	
Energy unit consumption	Oxygen	Approx. 50 Nm^3/t-s	
	Electric Power	30 kWh/t-s	
	Ar, N_2, CO_2,	Nm^3/t-s	
Additive material	CaO	Approx. 50～60 kg/t-s	
	Other	Approx. 9	
	Ferro Alloy	10～12	
Refractory	Refractory	Approx. 6～8 kg/t-s	
By-product	Slag	80～100 kg/t-s	
	LD-gas	80～100 Nm^3/t-s	2000 kcal/Nm^3
Construction cost		Generally high	
Industrialized status	Commercial	Many plants are operated	

Note ; The values of unit consumption are the examples of usual BOF process.

Table 1-5 The characteristics of secondary refining process

Typical Process	RH(OB) DH VOD	ASEA − SKF VAD	V-KIP	LF	PIM TN	CAS(-OB) SAB	Bottom blowing
① Vacuum	○	○	○	−	−	−	−
② O2 blowing	(○)	−	−	−	−	(○)	−
③ Powder injection	−	−	○	−	○	−	−
④ Arc heating	−	○	−	○	−	−	−
⑤ Bottom gas blowing	−	○	(○)	○	(○)	○	○
⑥ Air tight shield	○	○	○	−	○	○	−
⑦ E.M. stirring	−	○	−	−	−	−	−
⑧ Flux refining	−	○	−	○	−	(○)	−
Heating(Temp. control)	(○)	○	−	○	△	△(○)	△
De[O], Clean Steel	△	○	○	○	○	○	○
Composition adjustment	○	○		○	○	○	−
De-[S]	−	○	○	○	○	○	−
De-[P]	−	△	−	△	−	−	−
De-[H]	○	○	○	−	−	−	−
De-[C]	○	○	○	−	−	−	−
De-[N]	○	○	○	△	−	−	−
Typical BOF Process	○					○	





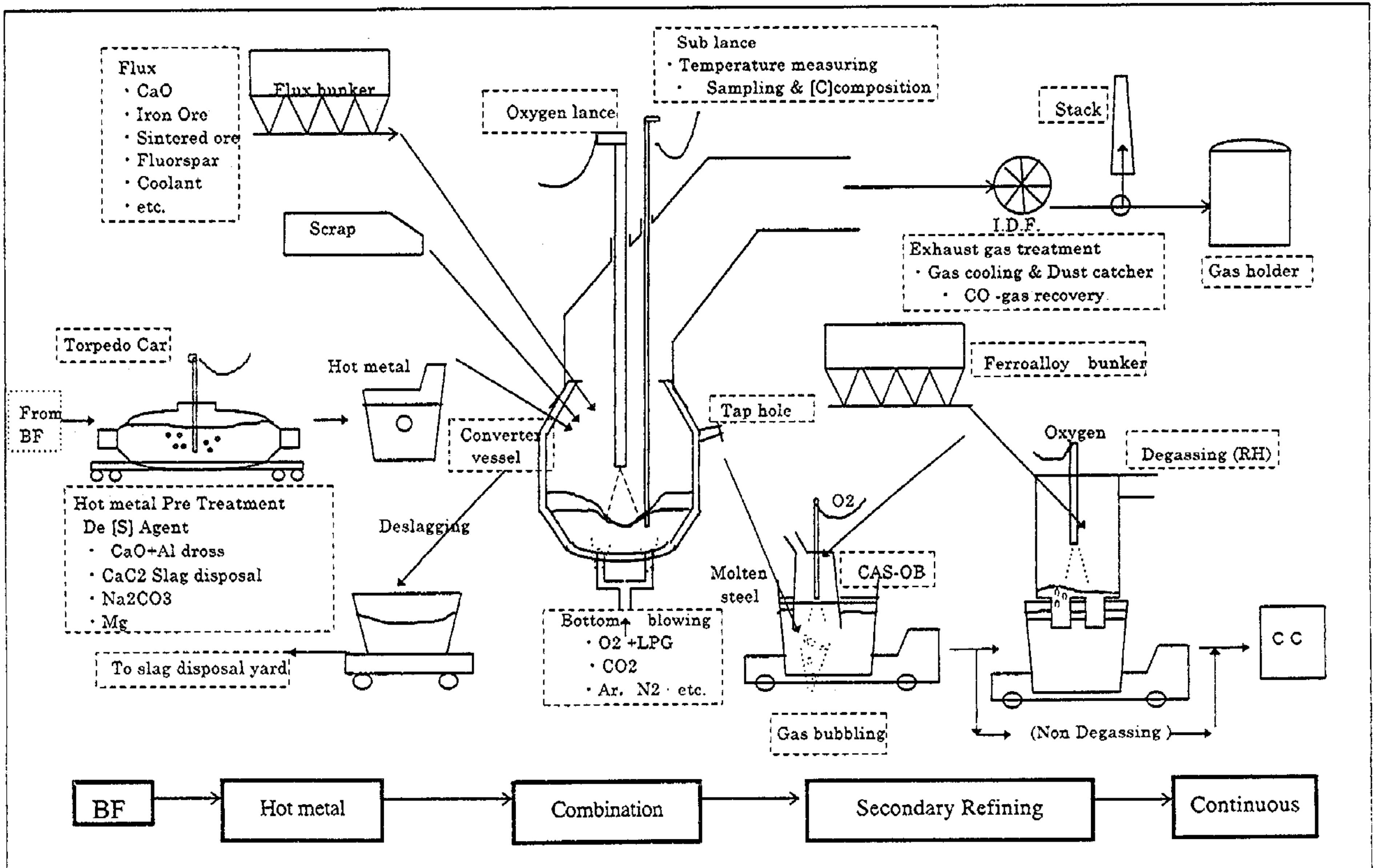


Figure 1-4 Schematic diagram of basic oxygen furnace (BOF) process

1.2 Continuous casting/hot rolling process

1.2.1 Thin Slab Process (TSP)

- The TSP is combined with EAF in mini mills usually.
- It is a dominant process for the commercial grade steel, because of low construction and operation cost.
- Because of high tramp element in scrap, and high casting speed, it is impossible to produce high grade steel such as extra deep drawing, automotive outer sheet use at present..
- Mini mills are trying to expand the steel grade by using the virgin iron such as the DRI, and new casting technologies as EMB(Electric Magnetic Break).

(1) ISP(In Line Strip Production) method

- Casting thickness is decreased by soft reduction and in-line reduction.
- The aim is to obtain fine crystallized and segregation improved slabs.
- For compact CC-Hot process of required length approx. 190 m, a coil box method is adopted.

Table 1-6 outlines, and the Figure 1-5 shows the schematic drawing of ISP.

Table 1-6 The outlines of ISP

Item	Sub Items	Description	
General	Works	Arvedi (Italy)	Kwangyang POSCO
	Plant supplier	Mannesmann Demag	Mannesmann Demag
	Started	Jun.,1992	Oct., 1996
	Steel grade	Structural steel, Deep drawing, API piping, Plate, etc.	
CCM	Product capacity	0.5 $\times 10^6$t/y/unit	1.0 $\times 10^6$t/y/str x2str.
	Casting speed	Max. 6 mpm Ave. 4.5 mpm	Max. 5 mpm
	Mold thickness	80/60 mm concave, V-B	75 mm flat-parallel-vertical
	Immersion nozzle	Flat nozzle	Flat nozzle
	Soft reduction	60 →40 mm	75 → 60 mm(100 →80 mm)
	In line reduction	4Hi x 3 std, →15~25 mm	4Hi x 2 std, →20~25 mm
Hot	Induction heater	Max. 350℃ heat up	Less than Cremona
	Coil box	Cremona Furnace 2 coils	Holding furnace 5 coils
	Finishing mill	4 Hi x 4 std	4 Hi x 5 std
Plant	Length	approx. 190 m	CC→Coiler
Industrialized status		Commercial	Commercial(just started '96)

(2) CSP(Compact Strip Production) method

- The Funnel shaped mold(about 180 mm thick) is used for easy casting into thin mold.
- Solidification is completed within vertical support zone.
- The long slab is heated in the tunnel furnace, and fed into the finishing mill.
- It is one of the most compact processes.
- The producible steel grade is restricted, commercial steel grade steel is possible to produce.

Table 1-7 outlines, and the Figure 1-6 shows the schematic drawing of CSP.

Table 1-7 The outlines of CSP

Item	Sub items	Description	Remarks
General	Works	Nucor ; Crawfoldsville Hickman	
	Plant supplier	SMS (Germany)	
	Started	19989 & 1992	
	Steel grade CGC; commercial grade steel	C-steel(L-C, M-C, H-C) Deep drawing Construction etc.	
CCM	Product capacity	1.0～1.1 x10^6t/y/unit x2 units	
	Casting Speed	Max. 6 mpm	
	Mold thickness	180/50 mm Funnel mold	～ /60 mm
	Immersion Nozzle	Flat nozzle	
	Soft reduction	No	
	In line reduction	No	
Hot	Furnace	Tunnel furnace (buffer)	150～ 200m length
	Coil box	No	
	Finishing Mill	4 Hi x 6 std (no rougher)	Hi-pressure descaling
Plant	Length	approx. 350 m	CC－Coiler
Industrialized status		Many commercial plants	12 plants 15 CCM in operation
Cost	Construction Cost	Low for low production	

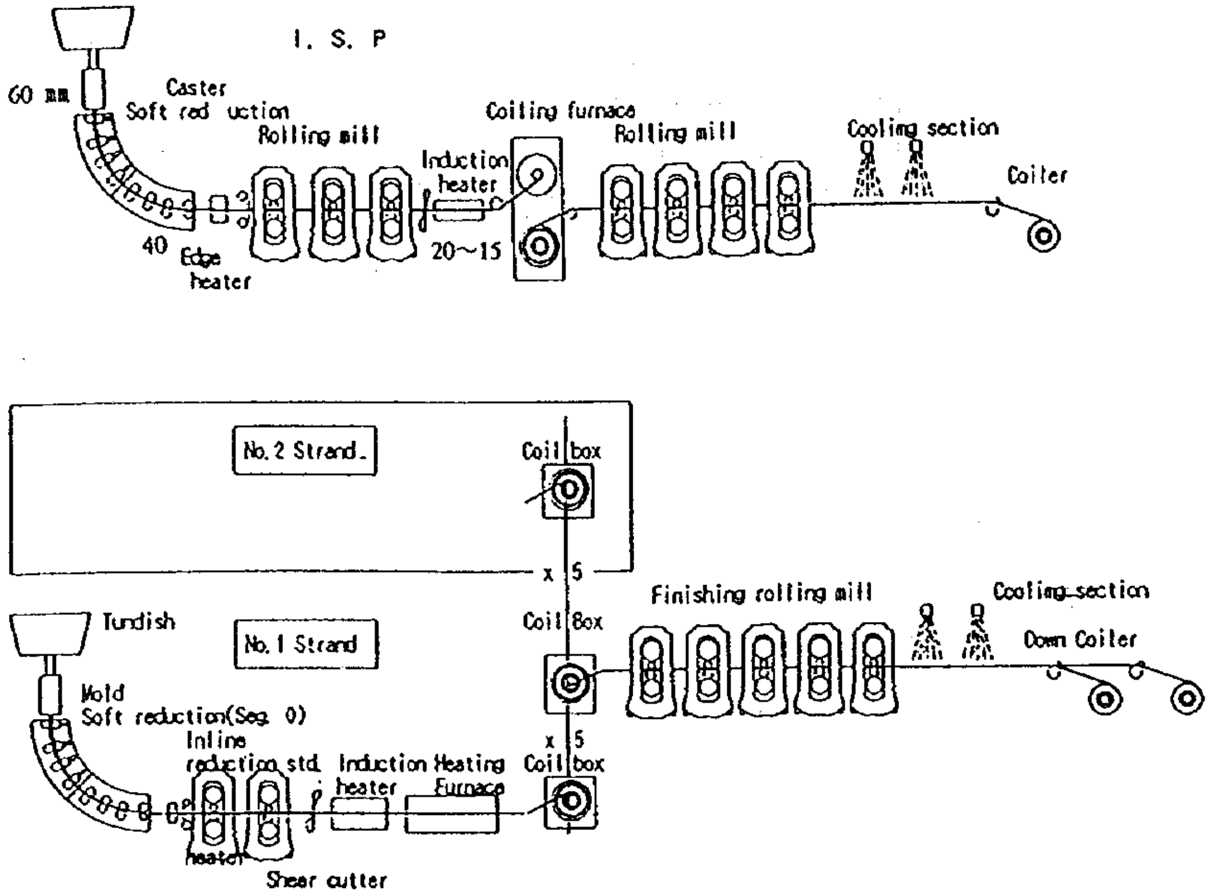


Figure 1-5 Schematic drawing of ISP

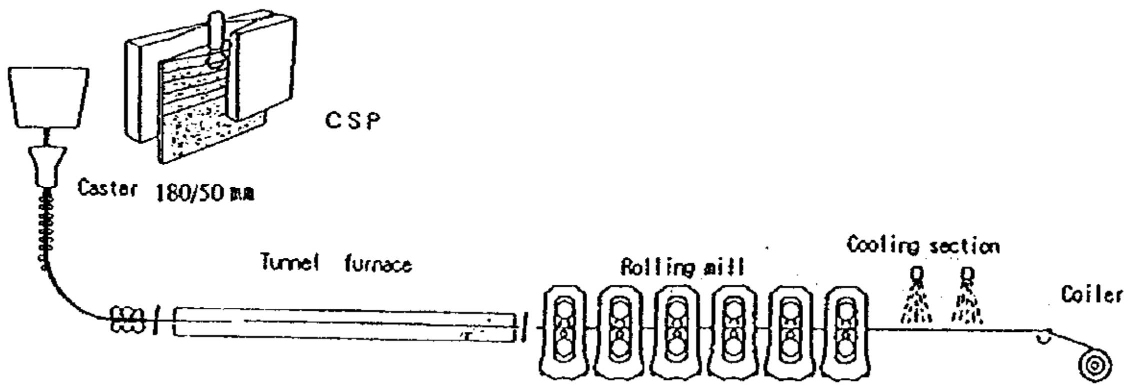


Figure 1-6 Schematic drawing of CSP

1.2.2 Medium thick slab process (MSP)

- The MSP is usually combined with EAF as a mini mill.
- This is ranked between TSP and conventional CC-Hot Process.
- Because of high tramp element in scrap, and high casting speed, it is impossible to produce high grade steel such as extra deep drawing, automotive outer sheet.
- The aim is to improve the surface quality better than TSP, though direct rolling is adopted.
- The other aim is to get the nearly same production capacity as that of conventional process.

Typical process

1) Conroll (VAI) process (See Figure 1-7)
2) SMI (Sumitomo Metal Industry) process (See Figure 1-8)

Table 1-8 outlines, and the Figure 1-7 and Figure 1-8 show the schematic drawing of MSP.

Table 1-8 The outlines of MSP

Item	Sub items	Description	
General	Works	ARMCO Mansfield (U.S.A.)	B-works
	Plant supplier	V A I	S M I / S H I
	Started	Apr. 1995.	Nov. 1996
	Steel grade	Structural steel. Deep Drawing API piping Peritectic steel etc.	Structural steel. Deep Drawing API piping Peritectic steel etc.
CCM	Product capacity	0.5 x10^{6}t/y/unit	1.0 x10^{6}t/y/str
	Casting Speed	Max. mpm	Max. LC 5 mpm MC 3 mpm
	Mold thickness	75～125 mm Flat parallel	90 mm Flat-parallel
	Immersion Nozzle	Flat nozzle	Flat nozzle
	Soft reduction	No	No
	In line reduction	No	No
Hot	Reheating furnace	Working beam type	Tunnel furnace
	Coil box	No	No
	Mill	Rougher + Finishing 6 stds	Rougher 2std+ Finishing 6std
Plant	Length	approx. 450 m CC－Coiler	
Industrialized status		Commercial (2 plants)	Commercial (Just started)
Cost	Construction cost	Medium for medium production	

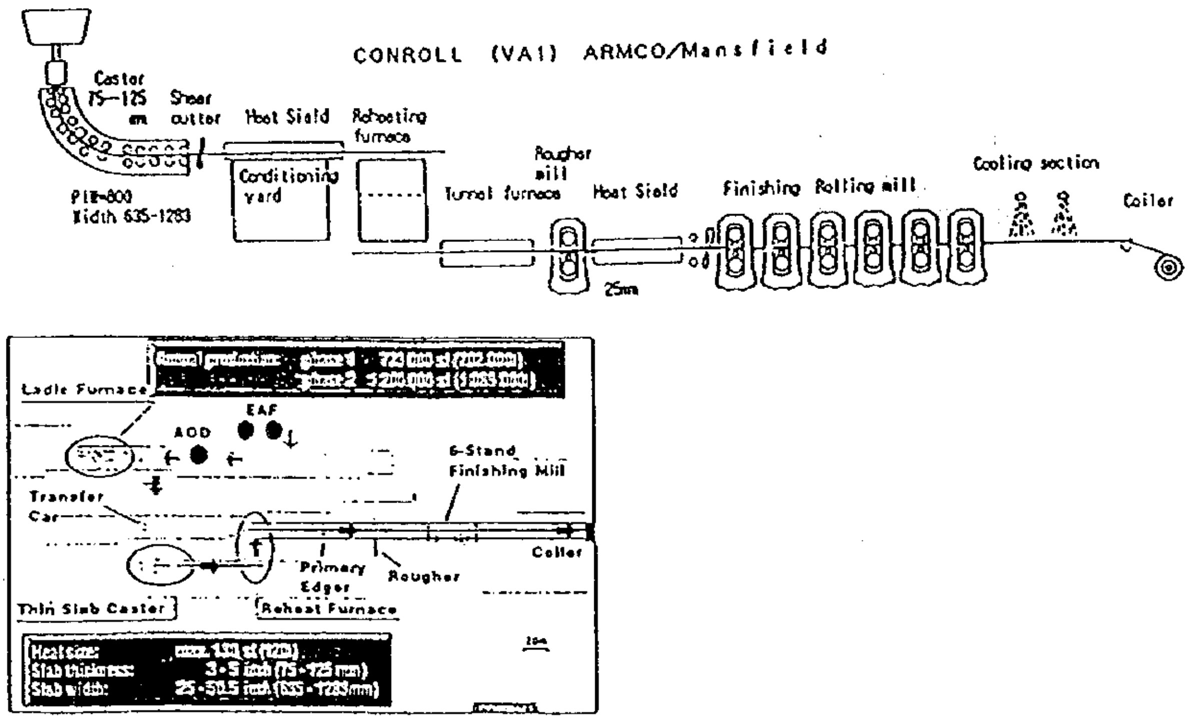


Figure 1-7 Schematic drawing of MSP
(CONROLL by VAI ARMCO/Mansfield)

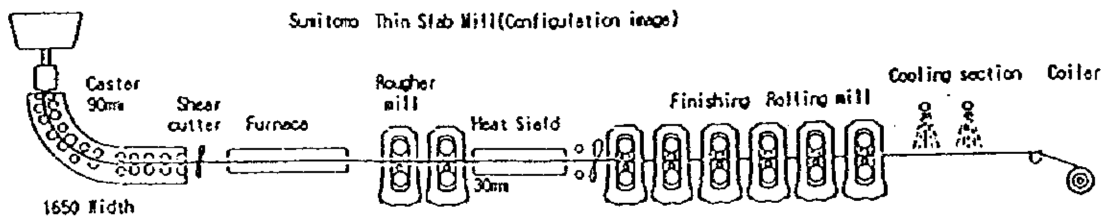


Figure 1-8 Schematic drawing of MSP
(Sumitomo Thin Slab Mill)

1.2.3 Conventional CC-Hot process (CVP process)

- The CVP is usually combined with BF/BOF process in a integrated steelworks.(Partially with EAF process)
- Standard thickness (200 to 300 mm) slab casters are most popular method, and the industrialization status is completed.
- This process is indispensable for producing the high grade steel such as extra deep drawing, automotive outer sheet use.

Table 1-9 outlines the CVP, and Table 1-10 shows the morernized main technologies to high grade steel.

Figure 1-9 shows the schematic drawing of CVP process.

Table 1-9 The outlines of CVP process

Item	Sub items	Description	Remarks
General	Works	Many works	
	Main Plant supplier	M-.Demag (Hitachi zosen), Concast(SHI), Danieli, VAI,	
	Steel grade	CGC DQ, DDQ, EDDQ SULC, Structural steel. API piping Peritectic steel Plate All steel grade is attainable	CGC; Commercial Grade CC steel SULC; Super Ultra Low Carbon steel
CCM	Product capacity	1.0～2.0 x10^6t/y/str	
	Casting Speed	Max. 2.0～3.0 mpm	
	Mold thickness	150～300 mm Flat parallel	
	Immersion Nozzle	Cylindrical nozzle	
	Soft reduction	Yes (at crater end)	Segregation free,
	In line reduction	No	
	Conditioning	Hot(cold) machine scarfing, Manual scarfing	Slab surface conditioning
Hot	Reheating Furnace	Working beam type	
	Coil box	No(Yes)	temperature uniformity
	Mill	Rougher + Finishing	
Plant	length	approx. 600 m	C C – Coiler(Not includes transportation)
Industrialized status		Commercial (many plants)	
Cost	Construction Cost	High for large production	

Table 1-10 The modernized main technologies

	Technology	Aim and effects
Productivity	Hot Direct Rolling Direct Hot Charge rolling	Energy saving, High slab temperature technique
	Width changeable mold	Productivity improve
	Thickness changeable mold	Productivity improve
	Continuous recycle operation of tundish under hot condition	Refractory, Labor, Energy saving
	C C ratio & sequence casting	Yield improving
Quality	Vertical bending type machine	Inclusion & gas floating
	Large scale tundish	Clean steel
	Temperature control in tundish	
	Revel control in mold	
	Coating of mold copper plate	Mold life up, Surface quality improving
	EMS, EMB in mold Mold powder optimizing	Surface quality improving
	Automatic casting control	Stable casing
	EMS at guide roll Soft reduction at crater end	Improving inner quality (Segregation)
	Compression casting	Outer, inner crack prevention
	Secondary cooling control	
Conditioning	Hot slab defect detector	
	Machine scarfing	

Note: TSP, MSP tends to apply some of these technologies.

1.2.4 Conventional coil box mill process (CVP-Coil box)

- The direct hot charge rolling process is popular technology recently.
- The CCM and HRM are located near, and designed as compact as possible.
- Especially it is effective in a case of commercial grade steel production.

Figure 1-10 shows the schematic drawing of conventional CCM/Coil box type process for example.

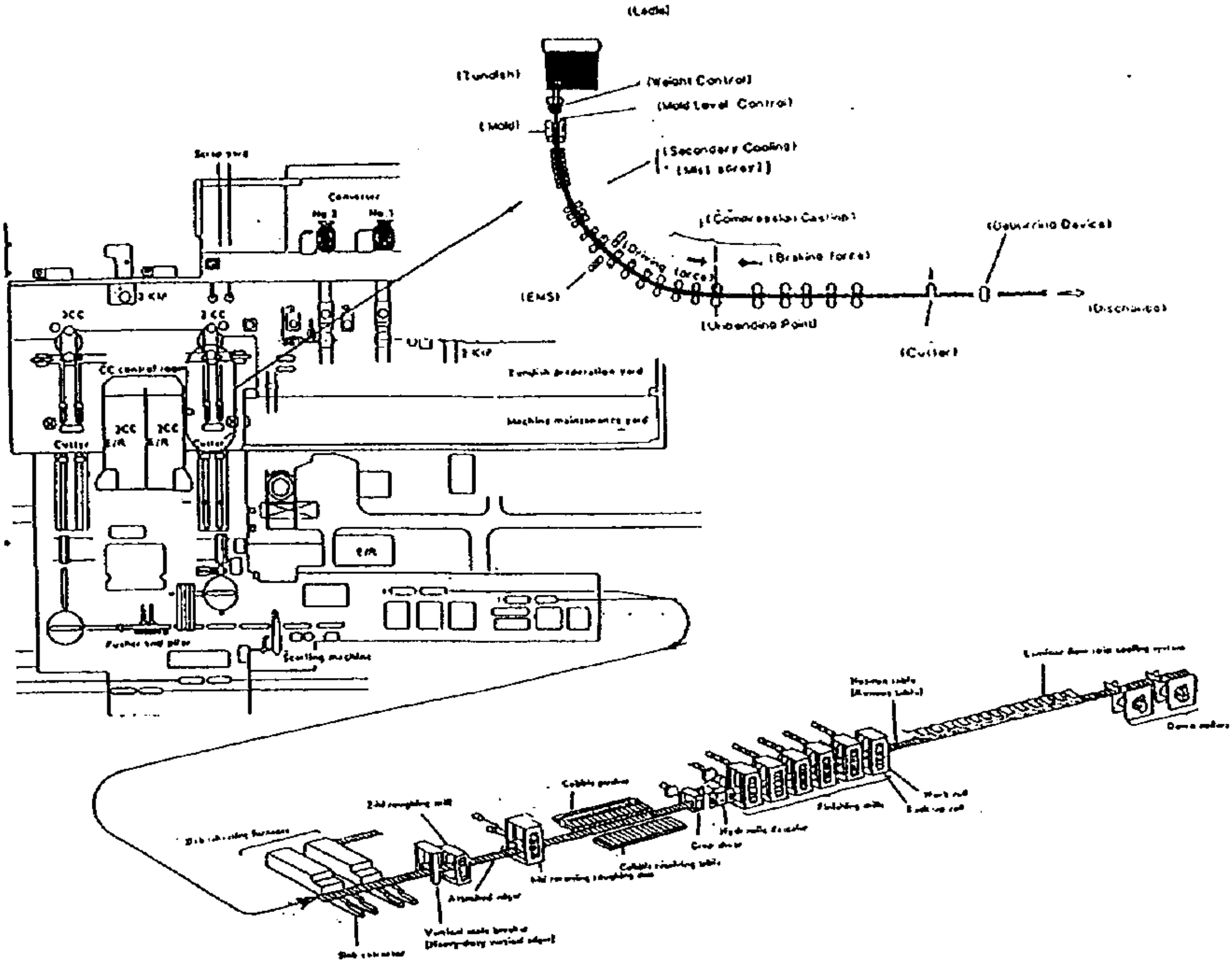


Fig 1-9 Conventional CC-Hot process (CVP)

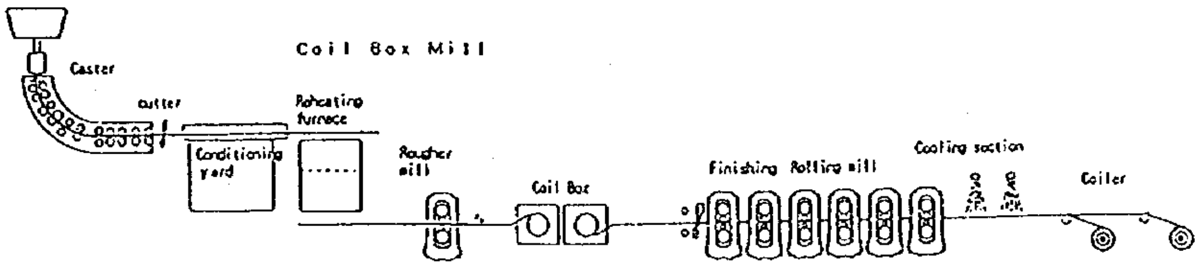


Fig 1-10 Schematic drawing of conventional coil box mill process