IMPROVEMENT AND REHABILITATION
OF
DIMAG STOCK CORPORATION STEEL PLANT
MISKOLC, HUNGARY
(UNIDO CONTRACT NO. 90/187/CW)

OCTOBER 1991

KOBE STEEL, LTD.

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PREFACE

DIMAG Stock Corporation intends to execute improvement and rehabilitation of the steel mill and has requested assistance of UNIDO using the fund provided by the Japanese Government.

Kobe Steel, Ltd. agreed to respond to the requirement of UNIDO and conducted fact-finding at the steel mill and held discussions with the experts in DIMAG.

Through analyses of the data and information so obtained and based on our knowledge accumulated through extensive experience in the operation of our own steel mills, we have prepared this report.

The recommendations included in this report for improvement and rehabilitation in DIMAG reflect the opinions of DIMAG's experts dispatched to Kobe Steel's Kobe Works in May 1991 and are classified into short-, medium-, and long-term recommendations.

In addition to these recommendations, we emphasize the importance of DIMAG's own efforts in the improvement of interdepartmental communications and production planning to improve productivity, quality, and energy consumption.

We hope that our recommendations will contribute to the achievement and continuation of healthy operations of the steel mill to produce quality steels.

We sincerely thank the UNIDO officials for the valuable instructions and advice including the comments on the preliminary report (in the fax of 1 October 1991) and we also thank the DIMAG people for their whole-hearted support during the preparation of this report as well as during the site survey and discussions.

CONTENTS

ABBREVIATIONS

SB	:	Shot blasting
UST	:	Ultrasonic test
MF	:	Magnaflux test
RM	:	Rolling mill
BF	:	Blast furnace
BFG	:	Blast furnace gas
HS	:	Hot stove
DH	:	Dortmunt-Hörder Hutten-Union A.G. (a vacuum degassing method)
PCI	:	Pulverized coal injection
MJ/p-t	:	Mega joule/pig iron-ton
VD	:	Vacuum degasser

NOTES

1. In this report, data missing in the attached Tables shown by - or by blank are the data either unavailable and unnecessary for the analyses there or unrelated.

2. All references to tons(t) in this report are understood to be metric tons.

1. EXECUTIVE SUMMARY

1.1 Introduction

This report analyses the major plant areas of DIMAG Stock Corporation in Miskolc, Hungary, and gives corresponding recommendations for the improvement and rehabilitation with regard to production plan (product mix), product quality, production process, productivity and availability of the plant, energy consumption and pollution control, and budget and economic contribution.

The recommendations included in this report are classified as follows:

1) Short-term recommendations are those to be implemented as soon as possible, without significant investment.
2) Medium-term recommendations are those to be implemented in the very near future, with investment, to quickly improve DIMAG's profit.
3) Long-term recommendations are those to be implemented in the future, with investment, considering market trend, production quantity, quality requirement, raw material conditions, etc.

Fact-finding was conducted by engineers from Kobe Steel, Ltd. (KSL) from February 14 to March 1, 1991. During this period, analyses were made of the present operation and maintenance activities; confirmation was also provided by experts of DIMAG. Investigations of the major plant areas were also carried out with the full support and cooperation of DIMAG.

1.2 Outline of Present Situation

DIMAG is an integrated steel mill equipped with a blast furnace, a basic oxygen furnace, an electric arc furnace, secondary metallurgy equipment, a billet caster, rolling mills, and associated facilities for yearly production of about 1.0 million tons. The plant is located at Miskolc, Hungary and has contributed to supply of steel products to domestic and foreign markets and to employment of people from the region.

Due to recent political changes in Eastern European countries, DIMAG faces many obstacles that affect continuous activities as a steel mill. These obstacles are identified and briefly discussed below:

1) Background

- Decrease in production because of unstable markets
- Rapid changes in the administrative system because of DIMAG's transition from a state company to a private company
- Technological stagnation because production is not market-driven.
- Shortages of money to obtain raw materials, equipment and machine parts, and new production technology
- Lack of sales strategy, especially for Western countries

Faced with these obstacles, DIMAG has been making every effort to survive as a steel mill by means of improvements of its profitability through a shift to value-added steel products, increase in productivity, and restructuring of its sales organization.

2) Production of steel products

Rolled products in 1990 amounted to 532,000 tons, which shows a decrease in production compared with 688,000 tons in 1989 and 755,000 tons in 1988. The production of quality steel was approximately one third of that of rolled products.

3) Main production processes of iron-making, steelmaking, and rolling

One low-pressure 950 m^3 blast furnace is operated to produce hot metal using low Fe content sintered briquets made from iron ore imported from USSR, and Polish coke.

One 80 t/heat basic oxygen furnace and one 80 t/heat UHP electric arc furnace are used, and molten steel produced by them is further processed by ASEA-KSF type ladle metallurgy equipment and argon bubbling method; molten steel is then cast by the 5-strand billet caster and conventional ingot-casting. Continuous casting ratio at DIMAG is now approximately 50%.

The five rolling mills (blooming and billeting mill, beam mill, Schlöemann section mill, SKET section mill, and SKET bar and wire rod mill) are operated at a rather low running rate of approximately 60%.

4) Quality assurance

Various modern methods are applied to quality improvements, including ASEA-SKF ladle metallurgy for inner quality, electromagnetic stirrers in the moulds of the billet caster for inner quality, billet grinders for surface quality, billet inspection facilities for inner and surface quality, and surface conditioning of rolled bars for surface quality.

5) Productivity

Obsolete shops sucn as the small size blast furnaces, the open hearth furnaces, and the forging and casting shops have been shut down, and many employees have been dismissed.

1.3 Summary of Recommendations

Many recommendations have been made in this report to improve the present situation; improvements without investment are defined as "short-term" and those with investment as "medium-term" and "long-term."

1) In the iron-making process

More utilization of pellets that contain higher Fe, size control of feeding materials into the furnace, low silicon operation, etc. are recommended as short-term improvements to decrease operation costs.

Optimization of hot stove operation, installation of movable armor and blast furnace gas holder, introduction of pulverized coal injector, etc. are recommended as medium- and long-term improvements for further cost reduction through productivity increase and energy saving.

2) In the steelmaking process

Improvements of steel quality by more utilization of ASEA-SKF furnace, increase of continuous casting ratio, and application of billet hot charging are recommended as short-term improvements for production of value-added products, such as for the automobile industry in Western markets, and for cost saving.

Hot metal pretreatment, installation of a new bloom caster with a large cross-section, etc. are recommended as medium- and long-term improvements for further improvement of quality, and cost reduction.

3) In the rolling process

Mainly energy-saving methods at the reheating furnace in the rolling mill shops are recommended as short-term improvements, and market orientation of product mix for value-added products and modification of rolling mills for production of high quality wire rods are recommended as medium- and long-term improvements.

For these medium- and long-term improvements, some investment will be required. A study of budgets and economic contribution is given in this report.

4) Production capacity in the near future

Maximization of production using the present plant would be the best way to increase profit.

The simulations of production quantity made by DIMAG give the highest and lowest estimates. Annual rolled production of 825,000 tons is the highest estimate if consignment of wire rod rolling by a wire rod mill of other company is possible.

Rolled production of 410,000 tons is possible as the lowest estimate if quality steel products are produced only at DIMAG's own plant without any significant investment.

The actual production quantity would come between the highest and the lowest. However, we recommend to produce rolled products, preferably value-added products, as much as possible in order to increase profit through highest utilization of the plant's capacity.

For this purpose, production of wire rods by means of consignment production will be effective because a capacity increase of between 20% and 30% can be expected through addition of these wire rods to the present product mix.

Of course, quality improvements are also essential for sales in Western markets; these must be achieved by improvements in production technology for steelmaking, rolling, and quality assurance for production of nondefective products through introduction of latest operational technology from a leading steel mill in a Western industrialized country.

In the course of immediate improvements, DIMAG should frame and execute further improvement plans such as installation of a new bloom caster and a new bar and wire rod mill. This will stabilize profit by production of market-oriented steel products in line with the recommendations stated in this report.

5) Pollution control and energy saving

Investigation of pollution was conducted, and recommendations are given in this report.

No equipment generating significant quantities of pollutants was observed, mainly because equipment such as open hearth furnaces and obsolete blast furnaces have been stopped, and because sintering plants and coke plants which usually generate pollutants do not exist at DIMAG.

Further reduction of pollutants is recommended in this report by means of a decrease in energy consumption through technological improvements, especially full utilization of blast furnace gas and adoption of hot charging of billets into the reheating furnaces.

Installation of water treatment facilities for the blooming and billeting mill and Schlöemann section mill is also recommended to minimize effluent discharge into the river.

2. ANALYSES OF PRESENT PLANT OPERATION

2.1 Production Record

The annual production of rolled products since 1988 is as follows:

1988: 755,000 t
1989: 688,600 t
1990: 532,200 t

The decrease in production in these three years resulted from market problems such as reduced consumption of steel products in the domestic market, extreme decrease in exports to USSR, and cessation of exports to the Middle East because of the Gulf War.

For analyses of the product mix and steel grades produced in DIMAG, rolled products are listed in Table 1 on the next page.

The production quantity of 688,600 tons in 1989 consisted of commercial grade steels 68% and quality steels 32%. This level of production of quality steel seems to be rather high considering the historical situation of DIMAG.

SECTION 1

Table 1. Productions Classified by Pr

Classification	Products (Size Range)	Stee		
		A	B	C
1. Small	Wire rods (to 24ϕ)	18,900	28,200	3,700
	Round bars (to 48ϕ)	14,500	19,300	5,200
	Square bars (to 50 sq)	10,800	2,200	300
	Hexagonal bars (to 50 m)	2,100	900	400
	Angles (to ∡ 50)	83,400	-	-
	Flat bars (to 50 in width)	1,700	750	250
	Subtotal	131,400	51,350	9,850
2. Intermediate	Round bars (51ϕ to 100ϕ)	14,800	11,300	7,800
	Square bars (51 sq to 100 sq)	13,100	29,000	12,800
	Angles (∡ 51 to ∡100)	36,200	-	-
	Flat bars (51 to 100 in width)	6,900	1,500	400
	I beams (I 50 to I 100)	13,800	-	-
	Channels ([50 to [100)	43,100	-	-
	Subtotal	127,900	41,800	21,000
3. Large	Round bars (101ϕ to 200ϕ)	5,000	15,000	-
	Square bars (101 sq to 200 sq) (Including billets)	22,100	14,600	21,100
	I beams (I 101 to I 200)	13,600	-	-
	Channels ([101 to [200)	19,000	-	-
	Rails (110 to 180)	-	35,200	-
	Others	38,000	-	-
	Subtotal	97,700	64,800	21,100
4. Super-Large	Round bars (up to 320ϕ)	-	27,200	-
	Square bars (up to 400 sq) (Including billets)	9,100	-	-
	I beams (up to I 400)	21,600	-	-
	Channels (up to [260)	18,400	-	-
	Subtotal	49,100	27,200	0
Total		406,100	185,150	51,950

* A: Carbon steel for general use; B: Carbon steel for machine structural
D: High carbon steel for wire rod; E: Low carbon steel for wire rod; F:

SECTION 2

sified by Products and Sizes (1988-1990)

(Unit: tons)

Steel Grade Group*					Total		
C	D	E	F	G	1989	1988	1990
3,700	-	-	2,700	9,400	62,900	51,900	51,100
5,200	-	-	2,200	7,200	48,400	59,500	35,800
300	-	-	200	1,000	14,500	11,500	9,100
400	-	-	100	6,400	9,900	12,600	3,100
-	-	-	-	-	83,400	97,200	16,500
250	-	-	-	300	3,000	11,200	21,000
9,850	0	0	5,200	24,300	222,100	243,900	136,600
7,800	-	-	900	11,500	46,300	56,300	34,500
12,800	-	-	-	-	54,900	54,000	32,300
-	-	-	-	-	36,200	57,100	43,900
400	-	-	-	700	9,500	16,200	23,700
-	-	-	-	-	13,800	9,800	9,300
-	-	-	-	-	43,100	43,700	47,400
21,000	0	0	900	12,200	203,800	237,100	191,100
-	-	-	-	2,800	22,800	28,200	16,400
21,100	-	-	-	-	57,800	64,200	31,200
-	-	-	-	-	13,600	3,300	4,800
-	-	-	-	-	19,000	11,500	15,600
-	-	-	-	-	35,200	52,400	21,700
-	-	-	-	-	38,000	50,700	55,900
21,100	0	0	0	2,800	166,400	210,300	145,600
-	-	-	-	-	27,200	25,600	14,100
-	-	-	-	-	9,100	120	500
-	-	-	-	-	21,600	14,900	14,300
-	-	-	-	-	18,400	23,200	30,000
0	0	0	0	0	76,300	63,820	58,900
51,950	0	0	6,100	39,300	688,600	755,120	532,200

structural use; C: Low alloy steel;
ire rod; F: High alloy steel; G: Bearing steel

2.2 Product Quality

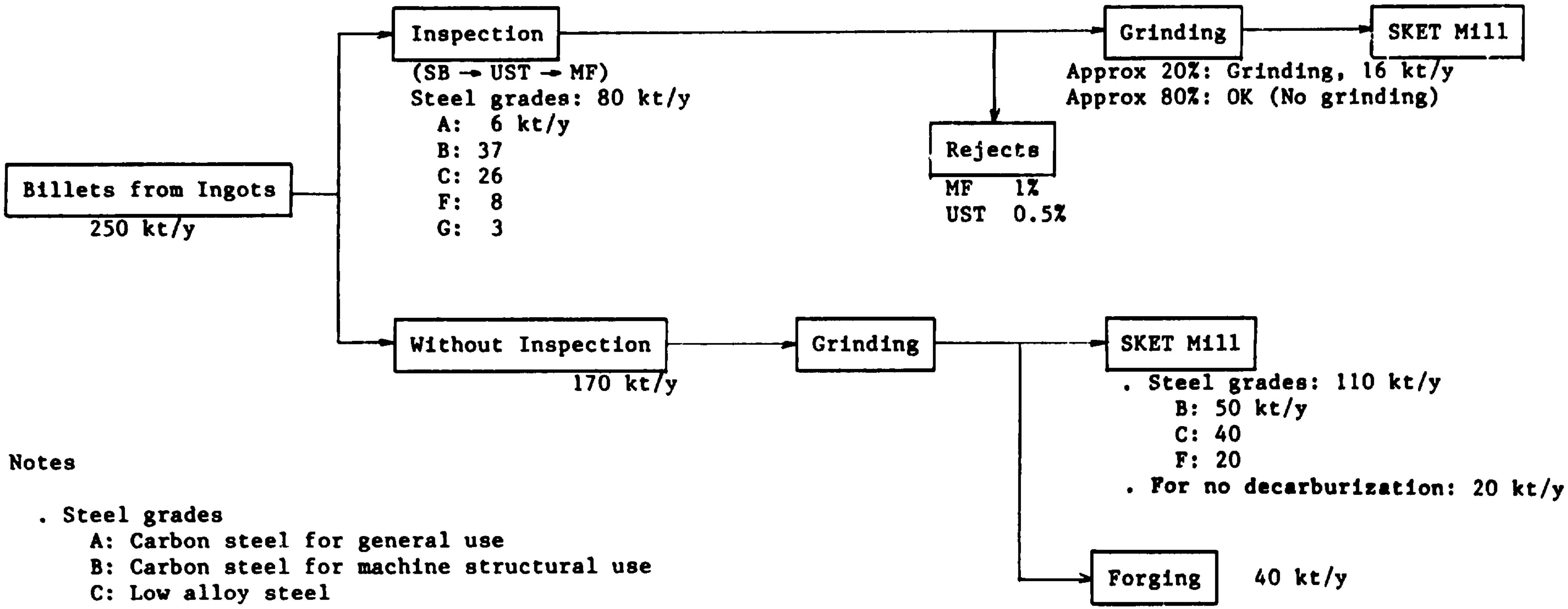
2.2.1 Product mix

In 1990, the ratio of quality steels was increased by some 10% over the ratio in 1989 according to the plan of DIMAG. However, half of the production is still commercial grade steels.

2.2.2 Quality control

For quality assurance of steel products, DIMAG performs surface conditioning of the billets to be rolled into quality steel products by means of grinding machines and automatic inspection machines. A flow chart of the billet surface conditioning and the record of rejected billets are shown in Fig. 1 and Table 2 on the following pages.

In the record of Table 2, the rejection ratio due to reasons in the steelmaking and casting process is approximately 1%, which is the same figure as for Japanese steel mills. The rejection ratio due to reasons in the rolling process is from 0.4% to 2.4%, which is 10 times as high as Japanese steel mills.



Notes

- Steel grades
  - A: Carbon steel for general use
  - B: Carbon steel for machine structural use
  - C: Low alloy steel
  - F: High alloy steel
  - G: Bearing steel
- Grinding: 4 faces, approx 0.5 mm/face
- Billets supplied to SKET Mill: Mainly for upset products, forged products, and ball bearings.

Fig. 1. Billet surface conditioning (1990)

Table 2. Rejects Classified by

Classification of Rejects \ Manufacturing		Steelmaking → Continuous Casting / Ingot-Making: BOF	UHP EAF	50 t EAF
1. Chemical Composition	. Out of allowable range . Mechanical properties . Hardenability	144 10 } 154	90 16 52 } 158	149 3 } 152
2. Pipe	. Shrinkage cavity . Mechanical pipe	3		2
3. Internal Quality	. Nonmetallic inclusions . Ultrasonic test rejects . Porosity	70 89 } 159	14 411 } 425	75 167 37 } 279
4. Pull/Heavy Cracks	. Heavy transverse cracks/ rupture . Lamination	2,280 10 } 2,290	1,472	651 6 } 657
5. Cooling	. White spots/flake . Over-cooled microstructure	176	9	
6. Surface Quality (External Appearance)	. Blowholes . Refractory inclusions . Scale/rolled-in scale . Scab/foreign matter	6 89 } 95	7 161 } 168	18 104 } 122
7. Burning	. Overheating/scale			
8. Shape/Size Accuracy	. Off gauge . Overfilled/fins			
9. Twist/Straightness	. Twist . Straightness			
10. Surface Cracks	. Cracks/seams . Dent . Overlap . Wrinkle/scratch			
11. Poor Production Control	. Lot mixing . Over-/underproduction . Wrong delivery & charging . Identification failure			
12. Others				
Total	. Total Rejects . Rejection Ratio (%)	2,877 0.44%	2,232 1.13%	1,212 1.18%

Classified by Reasons (1989)

(Unit: tons/y)

Casting ng	Blooming/Billeting			Rolling		
					SKET Mill	
50 t EAF	Blooming Mill	Billeting Mill	Beam Mill	Schlöemann Mill	Fine line	Medium line
149 3 } 152						
2	17*	199*	55*			5
75 167 37 } 279						
651 6 } 657	1,578	2,093	200			
		1	68			
18 104 } 122	6	10 226 } 236	2 1 } 3	9	34 63 } 97	22 14 } 36
	112	80	593			
	17 11 } 28	261 69 } 330	583 853 } 1,436	580 45 } 625	144 262 } 406	124 330 } 454
	10	51	70 1 } 71	28	6 16 } 12	98 146 } 244
		3	129 30 } 159	67 65 23 } 155	94 102 } 196	23 31 3 } 57
		9 93 29 } 131	7 7 8 } 22	17	109 24 87 2 } 222	180 9 298 3 } 490
			8	29	127	261
1,212 1.18%	1,751 0.37%	3,124 1.18%	2,615 2.40%	863 0.40%	1,060 0.86%	1,542 1.04%

*Caused in the ingot-making process.

SECTION 2

2.3 Production Process

Material balance and main process equipment from the blast furnace to the rolling mills are shown in Fig. 2 and Tables 3 and 4 attached.

The following have been observed:

1) Blast furnace

- Use of raw materials with low Fe content
- Low iron production ratio for the inner volume of the blast furnace
- High Si content in hot metal
- High shutdown ratio of the blast furnace

2) Steelmaking and continuous caster

- Low availability of process equipment due to decrease of sales amount
- Low continuous casting ratio
- Shortage of proper scrap for EAF
- Absence of hot charging of continuously cast billets
- Excess workers due to large proportion of ingot-making process

3) Rolling mills

- Absence of investment to produce suitable products required by the industry today
- Lack of energy-saving and lack of efficient use of manpower
- Lack of systematic production control, causing a lot of waiting time
- Maintaining considerably high skill and good workmanship in spite of obsolete equipment
- Insufficient communications between the rolling mills and the upstream shops for improvement of product quality and cost saving

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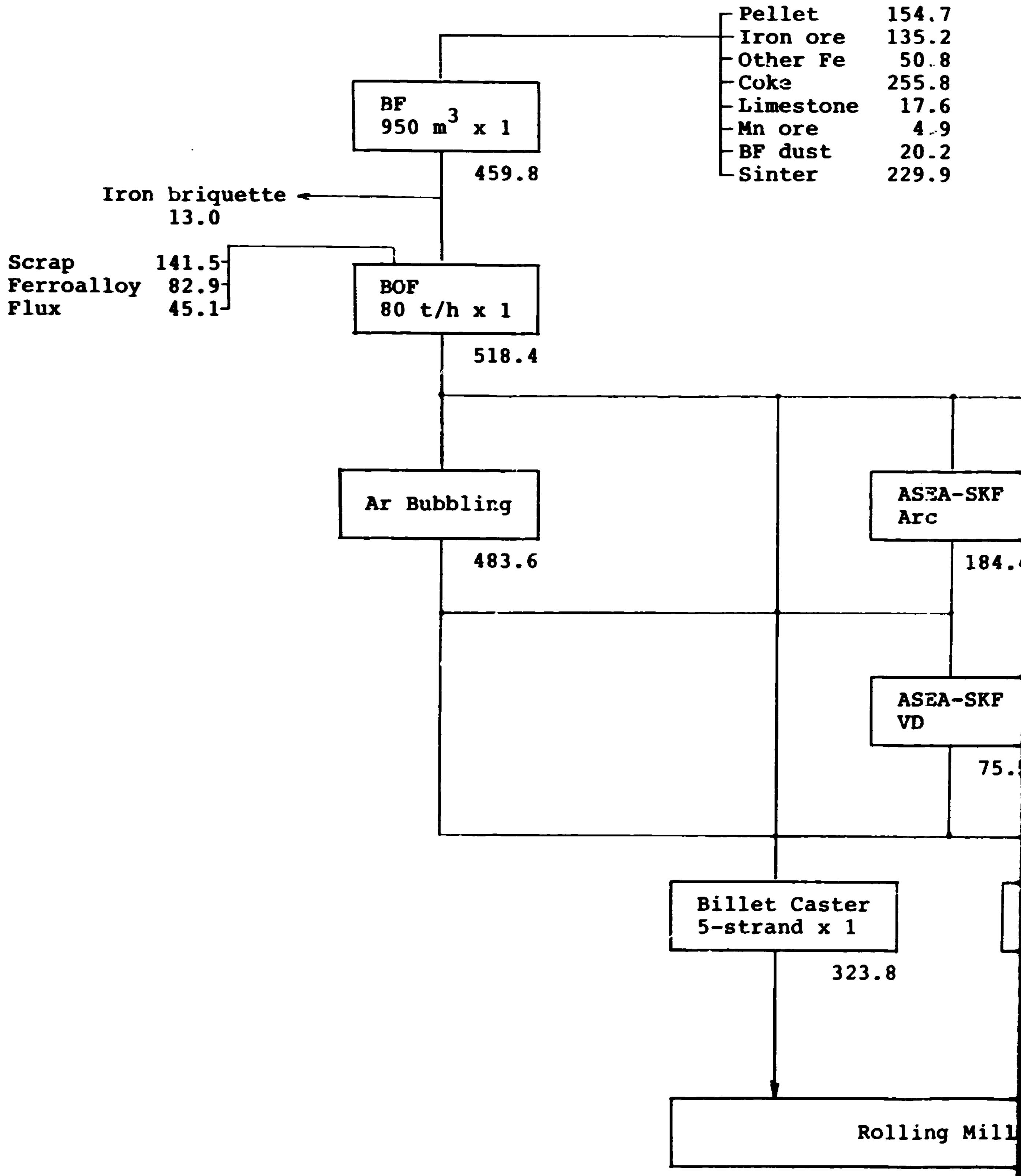
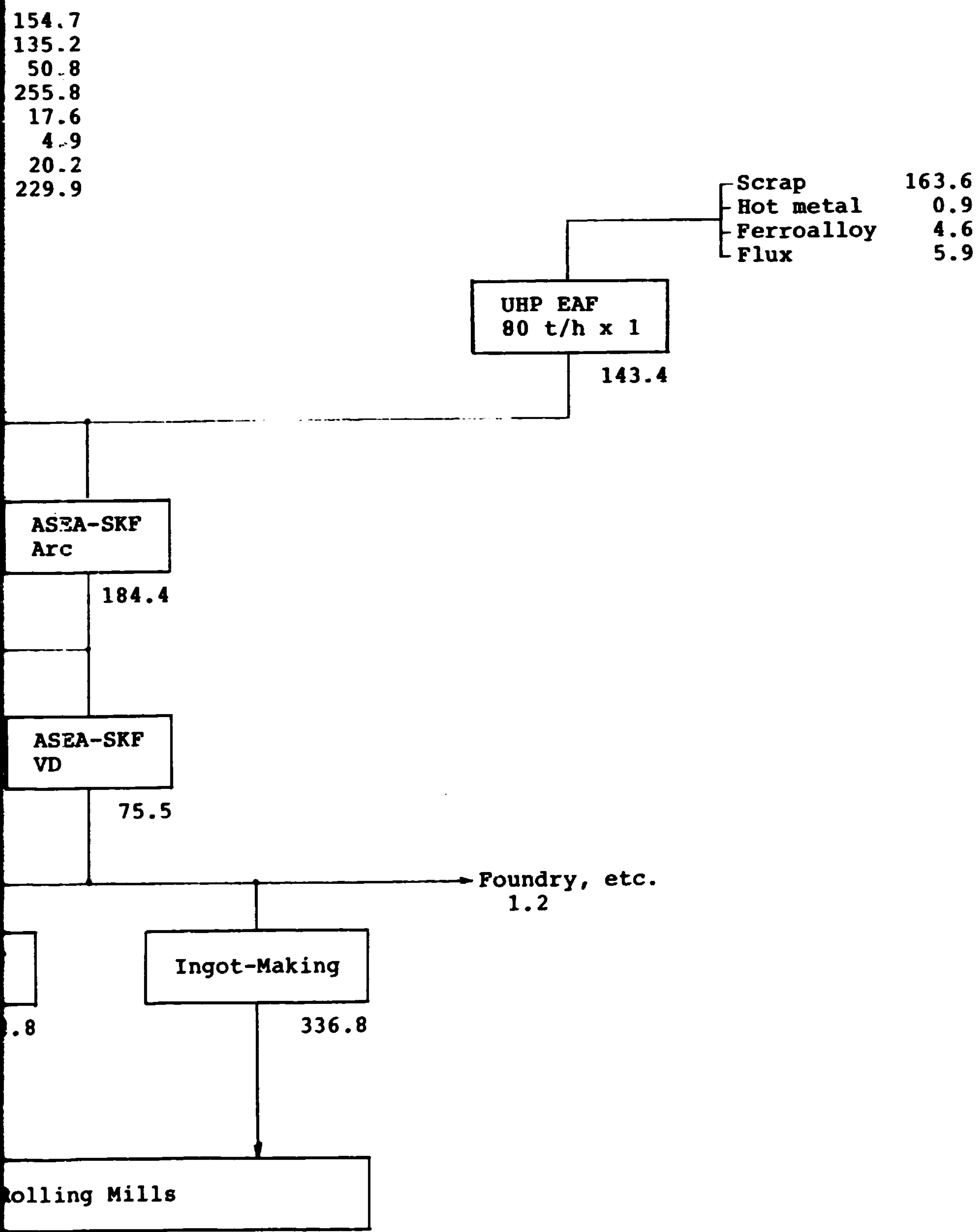


Fig. 2. Material bal

SECTION 1



(Unit: 10^3 t/y)

aterial balance (1990)

SECTION 2

Table 3. Main Equipment - B

Description	Blast Furnace	BOF
1. Start-up	1987	1980
2. Rated Capacity	360,000 t/y (1,015 t/d x 350 days)	700,000 t/y
3. Production Record in 1990	460,000 t/y	518,000 t/y
4. Main Specifications	. 950 m^3 . Low pressure operation . Raw materials Pellet : 18.5% Sinter : 72.5% Iron ore: 9%	. 80 t/heat x 1 . 1/1 operation . Top blowing type with gas cleaner
5. Work Shift	4/4	4/4
6. Availability	87%	44.2%
7. Yield	54.4% (ore ratio: 1.84 t/pig-t)	88.1%
8. Fuel Consumption	Coke ratio: 548 kg/pig-t	Oxygen consumption: 53.4 Nm^3/t

3quipment - BF, SM, and CC

Steelmaking and Continuous Casting			
OF	UHP EAF	ASEA-SKF	Billet Caster
30	1982	1980	1982
y	220,000 t/y	430,000 t/y	480,000 t/y
y	143,000 t/y	184,000 t/y	324,000 t/y
t x 1	. 80 t/heat x 1	. 80 t/heat x 1	. 5 strands, 10 m radius
ation	. 36/52 MVA transformer	. De-slag x 2	. 120 sq, 150 sq, 180 sq, and 180 x 240 mm
ing type cleaner	. UHP type with gas cleaner	. 8 MVA arc x 2	. With mould EMS
		. 0.5 Torr VD x 1	
		. With ORT 810 stirrer	
/4	4/4	-	4/4
.2%	43.0%	77%	50.2%
.1%	87.2%	-	98.0%
sumption: /t	Electricity: 460 kWh/t	-	-

SECTION 2

Table 4. Main Equipm

Description			
	Blooming	Billeting	Bea
1. Start-up	1964	1964	189
2. Rated Capacity	1,000,000 t/y	600,000 t/y	130,000
3. Production Record in 1990	299,000 t/y	161,000 t/y	112,000
4. Main Specifications			
. Reheating furnace	36 t/hole x 28 (soaking pit)	-	10 t/h x (batch t
. Rolling stand	2-high, rev. x 1	2-high, rev. x 1	2-high, rev. x 3
5. Raw Material	6 t ingot	210 x 300 mm	. 180 sq 2.5-4 . 215 x 285 x x 2.5-
6. Products (mm)	Sq : 180-580 Round: 210-320	Sq: 80-180	Sq : 1 I : 2 Rail: Max 60
7. Work Shift	2/2	2/2	3
8. Availability	49.5%	44.0%	57
9. Yield	83.1%	87.3%	89
10. Fuel Consumption (10^3 kcal/t)	375	-	5

SECTION 1

4. Main Equipment - RM

Rolling Mills				
ng	Beam	Section (Schlöemann)	Fine (SKET)	Section (SKET)
	1892	1955	1972	1972
y	130,000 t/y	300,000 t/y	180,000 t/y	220,000 t/y
y	112,000 t/y	150,000 t/y	139,000 t/y	106,000 t/y
	10 t/h x 3 (batch type)	65 t/h x 2 (pusher type)	50 t/h x 1 (walking hearth)	50 t/h x 1 (walking hearth)
	2-high, rev. x 3	R: 3-high x 1 I: V-H x 9 F: H x 1	R: 3-high x 1 I: V-H x 7 F: V-H x 10	R: 2-high, rev. x 1 I: 3-high x 1 F: H x 3, V x 1
mm	. 180 sq mm x 2.5-4.0 mm . 215 x 230 to 285 x 310 mm x 2.5-4.0 m	. 150 sq mm x 5 m . 180 sq mm x 5 m	. 120 sq mm x 5 m . 150 sq mm x 5 m	150 sq mm x 5 m
	Sq : 110-200 I : 200-400 Rail: Max 60 kg/m	U : 50-120 L : 45-90 Sq : 50-90 Round: 40-80	Round: 10-42 Sq : 10-35 Flat : 16-70	Round: 42-100 Sq : 35-100 Flat : 80-120 I : 80-140
	3/3	3/3	4/3	2/2
%	57.8%	67.5%	61.3%	61.0%
%	89.8%	91.5%	91.8%	86.0%
	552	523	545	523

SECTION 2

2.4 Plant Availability

Availabilities of the blast furnace, the main equipment of the steelmaking and continuous casting, and each rolling mill are shown in Table 5 attached.

The following have been observed:

1) Blast furnace

- The blast furnace is often shut down due to lack of raw materials and stoppage of the basic oxygen furnace (BOF).
- Frequent troubles with the blast tuyeres

2) Steelmaking and continuous caster

- Low availability caused by decrease of orders
- Frequent unscheduled shutdown of BOF
- Low availability of ASEA-SKF furnace due to product mix (half of the production is commercial grade steels without treatment by ASEA-SKF furnace)
- Low availability of the billet caster due to product mix in terms of product sizes

3) Rolling mills

- Low availability caused by decrease of orders
- Considerably long waiting time, causing high energy consumption as well
- Necessity of changing the rolls due to product mix

Table 5. Availability of

Description	Blast Furnace	Steelmaking and Continuous Casting			
		BOF	UHP EAF	ASEA-SKF	Cas
1. Working Hours	8,760	8,760	8,760		8,
2. Operation Hours	7,650	3,870	3,764		4,
3. Scheduled Maintenance	!28	1,205	3,495		1,
4. Unscheduled Downtime	342	2,755	1,122		
. Misoperation	166	2,287	406		
. Mechanical trouble	16	143	378		
. Electrical and instrumentation trouble	3	35	89		
. Others	156	290	249		
5. Waiting Time	240	930	379		2
Availability (Operation hours/ Working hours)	87.3%	44.2%	43.0%	(77%)	5(
Work Shift	4/4	4/4	4/4		4

SECTION 1

ability of Equipment (1990)

(Unit: hours)

us Casting		Rolling Mills					
SKF	Caster	Blooming	Billeting	Beam	Section (Schlöemann)	Fine	Section (SKET)
	8,760	6,805	5,670	8,001	4,332	7,319	5,911
	4,396	3,368	2,500	4,628	2,922	4,486	3,607
	1,862	54	23	976	680	1,361	1,354
	389	980	737	1,368	602	1,428	923
	17	279	85	864	290	1,003	638
	57	272	261	328	204	220	166
	35	41	28	64	52	124	95
	280	388	363	112	56	81	24
	2,113	2,403	2,410	1,029	128	44	27
7%)	50.2%	49.5%	44.0%	57.8%	67.5%	61.3%	61.0%
	4/4	2/2	2/2	3/3	3/3	4/3	2/2

SECTION 2

2.5 Energy Consumption and Pollution Control

2.5.1 Energy consumption

Energy consumption of the main equipment is shown in Tables 3 and 4 in Section 2.3.

The following have been observed:

1) Coke rate of the blast furnace is higher than that of Japanese steel mills by 40 to 50% due to low Fe content of raw materials, high Si content (two times as high as that of Japanese steel mills), and absence of a coal injection system.

2) Blast furnace gas is not used efficiently due to absence of a gas holder.

3) High electricity consumption of the electric arc furnace due to shortage of easy-melting scrap

4) Burning of the gas, generated during oxygen blowing process in BOF, on the stack due to absence of a gas holder

5) In the rolling mill shop, great consumption of energy in reheating the blooms and billets due to absence of hot charging method

6) Obsolete reheating furnace, and much waiting time for rolling

2.5.2 Pollution control

In DIMAG, no serious pollution has been observed maybe because DIMAG does not have very harmful facilities such as sintering, pelletizing, and coaking plants. In addition, the open hearth furnaces which were a source of pollution have been shut down. Use of natural gas as the fuel for the reheating furnace has also contributed to a decrease of dust and pollutant gas.

In terms of water pollution, effluent water from the rolling mills is not treated by the own facilities. Accordingly, water containing oil a little more than the standard (3 mg/lit) is drained to the river. Influence on nature is not so serious, but it should be improved in the future.

Efforts to decrease pollution will be needed. Recommendations concerned are shown in Section 3.5 of this report.

3. RECOMMENDATIONS FOR IMPROVEMENT AND REHABILITATION

3.1 Production Plan

The planned production of DIMAG after 1990 ranges in sales products from 410,000 to 825,000 t/y as shown in Table 6 attached. The quantity will fluctuate because of market conditions inside and outside Hungary.

Table 7, the record of the product mix and quantity of rolled steel produced as special steels in Japan in 1989, is a good reference for DIMAG to revise the present production plan because this table gives a fine example of product mix required by the industry today.

Through analysis of Tables 6 and 7, we can say the following:

1) The actual production level will come between the minimum and the maximum.

   If the production level is lowered to almost the minimum due to uncertain market conditions, DIMAG should consider further shutdown of the production lines such as the section mill (SKET) for specialization in quality steel and improvement of productivity. However, if the production level is raised to near the maximum, DIMAG can apply many methods for the improvement of product quality and productivity as suggested in 2) to 5) below.

2) The production capacity of the new bloom caster (see Section 3.3.2.7) should be increased as much as possible to obtain a high continuous casting ratio and to improve the quality level.

   On the other hand, the modified billet caster should specialize in the production of commercial grade steel using the hot charging method. This charging method will save energy and improve yield, thus cutting the production cost.

3) Considering the present share of wire rods (21.3%) in the total production of special steels in Japan (Table 7), installation of a wire rod mill, capable of rolling minimum 5.5 mm in diameter and equipped with block mills, is recommended in the near future.

4) When DIMAG installs a new wire rod mill, we recommend that a new bar in coil line should be installed in the new wire rod mill.

Then DIMAG will be able to produce coils of high unit weight (2 tons/coil) so that the existing fine (SKET) mill will be able to produce only straight bars.

After installation of the new wire rod mill, the quantity to be produced by two mills (the fine (SKET) mill and the new wire rod mill) will reach some 500,000 tons per year. In this case, DIMAG will have to consider shutdown of the section (SKET) mill due to shift in production efforts from commercial grade to value-added products.

5) As stated previously, the maintenance of sales quantity above a certain level is essential to making profits in the steel industry.

For this, sales promotion is very important, which can be attained by the efforts of DIMAG's own sales department as well as by close cooperation with the existing foreign trading companies. Of course, to support the sales department in sales promotion, continuous improvement is essential to the production department including punctual delivery of products, quality control, and reduction of cost.

Table 6. Production Plan

(Unit: 10^3 t/y)

Description	Record	Simulation	
	1990	Maximum	Minimum
1. Hot Metal	460.0	600	520
2. Molten Steel	661.8	970	720
. BOF	518.4	600	600
. UHP EAF	143.4	370	120
3. Crude Steel	640.5	950	705
. Ingot-making	323.3	150	255
. Billet caster	317.2	450	450
. New bloom caster	-	350	-
4. Products for Sale	534.0	825	410
. Ingot for forging	32.0 (Ingot for forging and Bloom/billet combined)	20	20
. Bloom/billet		70	40
. Section (Schlöemann)	145.0	-	-
. Beam	112.0	150	150
. Fine (SKET)	139.0	160	200 (Fine and Section (SKET) combined)
. Section (SKET)	106.0	200	
. Wire rod*	-	225	-
5. Surplus Blooms/Billets	-	-	192

*To be rolled either by DIMAG's own mill (if installed) or by other's mill.

Table 7. Hot Rolled Special Steel Production of Japan in 1989

(Unit: tons)

Steel Grade	Section	Bar	Flat	Pipe	Wire Rod	Plate/ Sheet	Strip	Total
1. Tool Steels								
. Carbon tool steel	-	25,419	10,946	-	5,273	6,985	94,302	142,925
. Alloy tool steel	-	72,076	27,457	636	7,092	7,787	16,642	131,690
. High speed steel	-	9,672	1,690	-	9,116	1,197	10	21,685
. Hollow drill steel, etc.	-	3,285	-	-	-	-	-	3,285
		74	-	-	-	-	-	74
Subtotal	-	110,526	40,093	636	21,481	15,969	110,954	299,659
2. Structural Steels								
. Carbon steel for machine structural use	49,071	1,820,286	193,786	69,919	1,165,692	177,915	566,199	4,042,868
. Alloy steel for structural use	118,470	1,402,469	40,392	561,667	424,553	40,883	103,761	2,692,195
Subtotal	167,541	3,222,755	234,178	631,586	1,590,245	218,798	669,960	6,735,063
3. Steels for Special Use								
. Spring steel	-	83,014	358,331	-	168,748	927	1,335	612,355
. Bearing steel	-	348,558	225	168,829	170,351	4,660	2,853	695,476
. Stainless steel	45,279	148,747	36,127	138,183	233,073	215,986	1,798,355	2,615,750
(Cr-based)	(1,134)	(36,297)	(14,898)	(31,066)	(42,327)	(25,314)	(605,014)	(756,050)
(Ni-based)	(44,145)	(112,450)	(21,229)	(107,117)	(190,746)	(190,672)	(1,193,341)	(1,859,700)
. Heat resisting steel	-	9,154	180	2,181	22,987	1,992	81,112	117,606
. Free cutting steel	-	884,405	74	1,263	368,099	-	141	1,253,982
. Piano wire	-	-	-	-	562,339	-	-	562,339
. High tensile strength steel	85,950	115,797	14,408	590,393	165,229	1,177,541	687,707	2,837,025
. High Mn steel	-	6,894	10	-	66,070	2,382	27	75,383
Subtotal	131,229	1,596,569	409,355	900,849	1,756,896	1,403,488	2,571,530	8,769,916
Total	298,770 (1.9%)	4,929,850 (31.2%)	683,626 (4.3%)	1,533,071 (9.7%)	3,368,622 (21.3%)	1,638,255 (10.4%)	3,352,444 (21.2%)	15,804,638 (100%)

3.2 Product Quality

Though the rejection ratios shown in Table 2 in Section 2.2 are not so bad, the rejection criteria in use should be reconsidered. If the criteria are based on the national standards, the strictness does not meet even stricter requirements of particular users such as parts producers of the automobile industry in Western countries. In this regard, Japanese steel mills apply very strict criteria in the production of steel products for the automobile industry.

In addition to the in-house inspection, DIMAG should collect claim reports from users and analyze them in detail including actual phenomena, ratio of defects among delivered steel products, process of defect generation, and compensation for them.

Also, DIMAG should prepare annual reports on claims to minimize losses to be caused by them and to improve the level of the overall quality assurance.

DIMAG has been producing a small quantity of steel products of cold forging quality, and intends to increase production of quality steel for the automobile industry with as much value added as possible in the future.

For this purpose, DIMAG tries to improve the chemical compositions of steel products by reduction of phosphorus, sulphur, and oxygen and nitrogen. Table 8 compares the harmful chemical contents between DIMAG and KSL.

Table 8. Comparison of Harmful Chemical Contents

	DIMAG	KSL
Example 1. 0.45% carbon steel		
. Phosphorus	0.025%	Max 0.010%
. Sulphur	0.022%	Max 0.005%
. Oxygen	40-45 ppm	15 ppm
. Nitrogen	70-105 ppm	30-60 ppm
Example 2. Bearing steel		
. Phosphorus	0.021%	Max 0.015%
. Sulphur	0.016%	Max 0.005%
. Oxygen	15-20 ppm	Max 10 ppm
. Nitrogen	60-70 ppm	30-60 ppm

As Table 8 indicates, DIMAG should reduce harmful chemical contents in the steel and improve the quality so that the steel will be accepted by Western users who mass-produce the first class parts such as by cold heading process.

We recommend the following to achieve the above:

1) To reduce phosphorus

   Hot metal pretreatment by oxygen and flux addition is an effective and economical method.

   To perform this pretreatment, however, low silicon operation of the blast furnace and high hot metal ratio for BOF operation are needed.

2) To reduce sulphur

   Utilizing the existing desulphurization equipment in the steelmaking shop, DIMAG can reduce sulphur content in steel products without any additional equipment.

3) To reduce oxygen and nitrogen

   DIMAG should improve the operation method of the ASEA-SKF furnace and the billet caster.

Considering the above totally, if DIMAG installs a new bloom caster and dephosphorization equipment, and tries to improve operational practices under the supervision of engineers rich in the experience of quality steel production in Japanese leading steel manufacturers, the level of steel quality will be greatly improved to compete with steel mills in Western countries.

As far as the rolling mills are concerned, the equipment needs improvement to be able to produce steel products that will meet the requirements of the industry today. That is, much rehabilitation will be needed under supervision of experts to improve accuracy and surface quality of rolled products.

3.3 Production Process

DIMAG, a steel mill integrated with the blast furnace, is capable of producing some 1.0 million tons of crude steel per year using BOF, UHP EAF, ASEA-SKF furnace, billet caster, and ingot-making, and processes crude steel to rolled products such as square and round bars, sections, and rods.

DIMAG intends to produce high quality and value-added steel products to be competitive in Western markets, and needs improvement and rehabilitation of the steel mill.

Accordingly, we make recommendations on the product mix of steel products, and improvement of the process equipment and the operation. When DIMAG implements these, further studies will be needed with suppliers of the equipment, process, and know-how considering the balance as the integrated steel mill.

In each recommendation, the following classification is applied:

. S: Short-term recommendation

. M: Medium-term recommendation

. L: Long-term recommendation

3.3.1 Ironmaking process

3.3.1.1 Installation of sinter screen and coke cutter (M)

1) The data for size distribution of sinter shows that the content of fine (-5 mm) of sinter is 17%. This value is rather high, and causes low gas utilization in the furnace ($CO_2/CO_2+CO = 0.43$), high fuel consumption (about 560 kg/p-t), and high dust content in BF gas (50-60 mg/Nm^3).

   To reduce the fine content to less than 10%, we recommend to install a sinter screen just before the skip car. In this case, the fine separated by the screen should be returned to the sinter plant as raw material.

   The sinter, transported by wagon from the Sajo sinter plant and directly fed to stock bin of BF from wagon, is transported by conveyor from the stock bin to the charging hopper of skip car. There is not enough space to install the screen between stock bin and skip car. To meet this problem, we present the following alternatives:

   (1) The most simple method is to install the screen at a position just before sinter is fed into the wagon in the Sajo plant. Detailed information concerning this is needed.

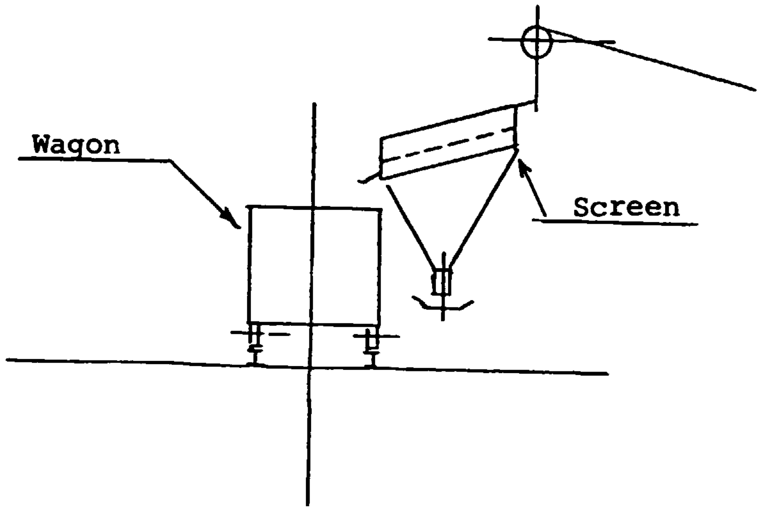


Fig. 3. Installing the screen in the Sajo plant

(2) If the screen is installed in the DIMAG plant, modification of the railway and installation of a new tripper will be needed.

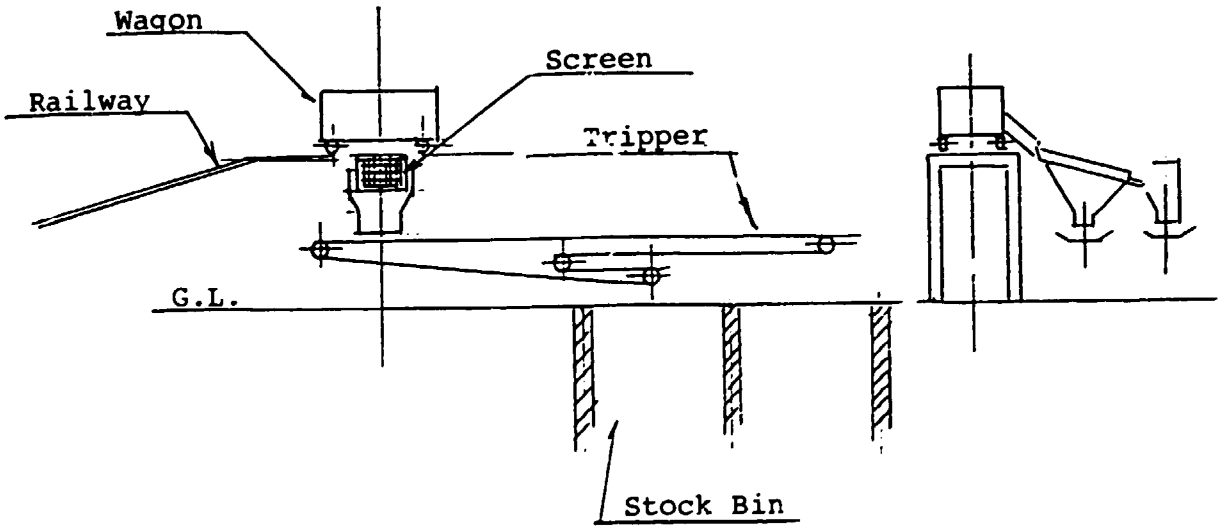


Fig. 4. Installing the screen in the DIMAG plant

2) The data for size distribution of coke shows that the content of 75 mm over is 45%. This value is extremely high. In Japan usually more than 75 mm block is screened out.

Coke is transported by wagon from the outside of the DIMAG plant and fed to stock bin and then transported by rally car from stock bin to charging hopper of skip car.

We recommend to install a coke cutter at the stock yard (outside the DIMAG plant) before coke is fed to the wagon in order to contribute to stable burden distribution at the furnace and improvement of coke strength. Some other method, like modification in the DIMAG plant, will be more complicated and expensive.

3.3.1.2 Optimized mixing of raw materials (S)

The charging ratio of sinter is 72.5%. Fe content of the sinter is 52.7%, which is rather low.

DIMAG also is studying optimum material source shown in Table 9. DIMAG charges mainly Sajokeresztur A sinter and Ural pellet. DIMAG tries to compensate low Fe content of sinter with pellet (Fe content 58-60%) and charges 3.5% flux pellet and 15% acid pellet.

It is profitable for DIMAG to establish the operation technique for high pellet charging, because in Hungary, pellet has higher Fe content and is less expensive than sinter. DIMAG can flexibly cope with change of material source situation if this technique is achieved.

As the first target, therefore, we recommend to increase the pellet ratio to about 30% and then try to further increase the ratio.

The present price level of raw material is not low enough, and utilization of the present raw material seems not to be economical even if the transportation cost is considered. Therefore, DIMAG should continuously study to use raw materials of various countries shown in Table 10 so as to cut cost and maintain stable operation even if unexpected social disturbances should happen in raw-material supply countries.

Table 9. Comparison of Pellet and Sinter Supply

($1 = 70 Ft)

	Composition (%)				Cost		Unit Cost/ %Fe	
	Fe	CaO	SiO_2	Added Lime-stone	Ft/t	$/t	Ft	$
1. Pellet								
. Kosztamuksa	60.02	4.53	5.66	3.3	3,245	46.4	54.07	0.772
. Ural (KLIMPEX)	58.7	4.59	3.63	0	2,930	41.9	49.91	0.714
. Krivoj-rog	54.57	3.98	7.77	9.4	2,658	38.0	48.71	0.696
2. Sinter								
. IDEX-TRADE	53.21	12.03	8.54	0	1,511	21.6	29.39	0.406
. Sajokeresztur								
A	52.0	13.10	10.60	0	3,084	44.1	59.31	0.848
B	56.0	13.10	10.60	0	4,059	58.0	72.48	1.036
C*	56.0	13.10	10.60	0	3,834	54.8	68.46	0.978
. KLIMPEX	54.5	11.8	8.8	0	2,809	40.1	51.54	0.736
. Jugoszlau	36.9	0.84	7.98	19.0	3,025	43.2	81.98	1.171

*Supplied at contract of large amount (485-500 x 10^3 t).

Table 10. Price of Pellets in the Europ

Brand Name	Fe Content %	1989			
		FOB $/%Fe	Freight $/t	CIF $/t	C
1. LKAB, Sweden	66.5	0.535	4	39.6	
2. Sydvaranger, Norway	-	0.504	4	-	
3. CVRD, Brazil	65.5	0.473	8	40.0	
4. Samarco, Brazil	67.5	0.465	8	39.4	
5. Carol Lake, Canada	65.0	0.486	8	39.4	
6. Mt. Wright, Canada	65.0	0.486	8	39.4	
7. Algarrobo, Chile	66.5	-	-	37.3	

SECTION 1

in the European Market (Rotterdam)

		1990			
CIF $/t	CIF $/%Fe	FOB $/%Fe	Freight $/t	CIF $/t	CIF $/%Fe
39.6	0.595	0.590	4	43.2	0.650
-	-	0.555	4	-	-
40.0	0.611	0.516	8	41.8	0.638
39.4	0.584	0.501	8	41.8	0.619
39.4	0.606	0.526	8	42.2	0.649
39.4	0.606	0.526	8	42.2	0.649
37.3	0.561	-	-	40.8	0.614

SECTION 2

3.3.1.3 Installation of movable armour (L)

We recommend to install movable armour at next relining period (scheduled in 1995) to control the burden distribution in the furnace.

DIMAG will be able to improve the furnace operation by this burden distribution control: to reduce fuel consumption by increasing the gas utilization ratio and to continue stable operation even when condition of burden material sources are fluctuated.

A cross probe and skin flow thermometers should be installed together with the armour for the verification of burden distribution control. Shaft zondes and infrared TV should also be installed, if possible, to help to control the armour.

3.3.1.4 Quality control of raw material and coke (S)

At present coke is supplied from Czechoslovakia and Poland, and sinter from the Sajo sinter plant, which was separated from DIMAG several years ago.

We recommend to form a committee of material sources with the suppliers. This way, DIMAG will be able to get the most suitable material in quality and cost through mutual understanding of the suppliers' requirements and DIMAG's requirements.

For example, DIMAG now uses sinter of low basicity, $CaO+MgO/SiO_2+Al_2O_3$. If sinter of higher basicity (average 1.6 in Japan) is used, the strength of sinter in hot condition will increase, then operation of furnace will be improved. And through introduction and maintaining of the quality index at standard levels, DIMAG will be able to control the quality and order suitable materials from the suppliers.

At present DIMAG controls the quality with following indexes:

. Sinter: Shatter index

. Coke : Drum index

. Pellet: Crushing index

The following indexes should also be introduced:

. Sinter: Reduction disintegration index and Drum index

. Pellet: Swelling index and Reduction test under load

3.3.1.5 Introduction of medium pressure operation of blast furnace (L)

At present DIMAG has two blowers for blasting to BF:

. Ordinary use: 2,700 m^3/min x 1.7 bar

. Spare : 2,000 m^3/min x 1.4 bar

Usually the blower is operated at 1.1 bar as the outlet pressure; 0.3 bar surplus even for operation of spare blower.

We recommend to apply medium-pressure operation of blast furnace. If the top pressure is increased by 0.3 bar, the production will be increased by about 20% (600 x 10^3 t/year).

When the top pressure is raised with the blast volume kept constant, actual velocity of the top gas will lower, improving the reduction rate. If the top gas velocity is lowered by 0.1 m/sec, coke consumption may be expected to lower by 2.5-3.0 kg/p-t. In DIMAG, increase of top pressure by 0.3 bar will decrease coke consumption by 3-5 kg/p-t.

It is better to modify the top charging equipment and gas cleaning equipment at the next relining period after investigating which part of the facilities should be modified to fit this higher pressure.

3.3.1.6 Low Si content operation (S)

At present Si content of molten iron is 0.81%, which is extremely high. According to DIMAG, this is because the steelmaking division requires high Si content of iron, for Si is used for heat source in the steelmaking stage. However, we recommend to operate with low Si, which is profitable when considered in total.

To produce quality steel in future, pig iron should have as low Si content as possible.

As generally said in Japan, if Si % is decreased by 1%, the coke ratio will be decreased by about 70 kg/p-t. That is, if DIMAG operates at 0.5 Si content (the same as Japanese mills), DIMAG can expect 20 kg/p-t reduction of coke consumption.

On the other hand, the hot metal ratio of BOF operation will need to be raised due to reduction of heat generated by Si during the steelmaking process in BOF. This higher hot metal ratio will also contribute to the production of clean quality steel.

3.3.1.7 Optimization of hot stove operation (M)

At present, the thermal efficiency of hot stove is 73%. Through investigation and application of optimized combustion condition, therefore, DIMAG can expect to improve thermal efficiency by more than 5%.

For example, single blasting mode, 120 min blasting, 360 min combustion, blasting with one stove, combustion with three stoves, and operation at 1,300°C dome temperature and at 1,000-1,050°C blast temperature.

We recommend to apply staggered parallel mode operation so that DIMAG can get a higher blast temperature with the dome temperature at the present level.

And DIMAG can expect to reduce mixing volume of cold blast to control the blast temperature.

To change the control mode, we recommend to modify or change the instruments and the system as soon as possible.

3.3.1.8 Improvement of casting floor (L)

DIMAG has the following modernization plan of the casting floor at next relining period:

. Two tap holes to be applied (present: one tap hole)

. Exchangeable main runner to be applied (present: fixed runner)

At present there are one tap hole and two cinder notches, and two tap holes and two cinder notches are difficult to apply within the present space of the casting floor.

If medium-pressure operation in Section 3.3.1.5 and material of high Fe content in Section 3.3.1.2 are applied, DIMAG can operate without removing slag from cinder notch; slag flows out of the tap hole so that slag and metal will be separated in the main runner.

It is better to keep one cinder notch for emergency. The existing space for another existing slag runner can be used for a new iron runner.

In addition to the above, runner covers, dust collection system, and flattening of the casting floor should be considered for improvement of the working environment.

Runner covers are good for better working environment and for decrease of heat loss of hot metal. First, a partial dust collection system of runner (tap hole part and flow-down part to ladle) should be installed. Also an emission control system for the whole cast house should be installed in future. Flatteness of the casting floor will improve safety and workability including mechanization of casting floor operation.

3.3.1.9 Replacement of BF gas cleaning system (L)

At present the dust content at the outlet of the electric precipitator is very high. High dust content has a bad effect on the downstream equipment (hot stove, boiler, reheating furnace).

Because the dust content at the outlet of cyclone is acceptable, we can judge that the electric precipitator is not working well due to its deterioration. The electric precipitator should be replaced at the next relining period.

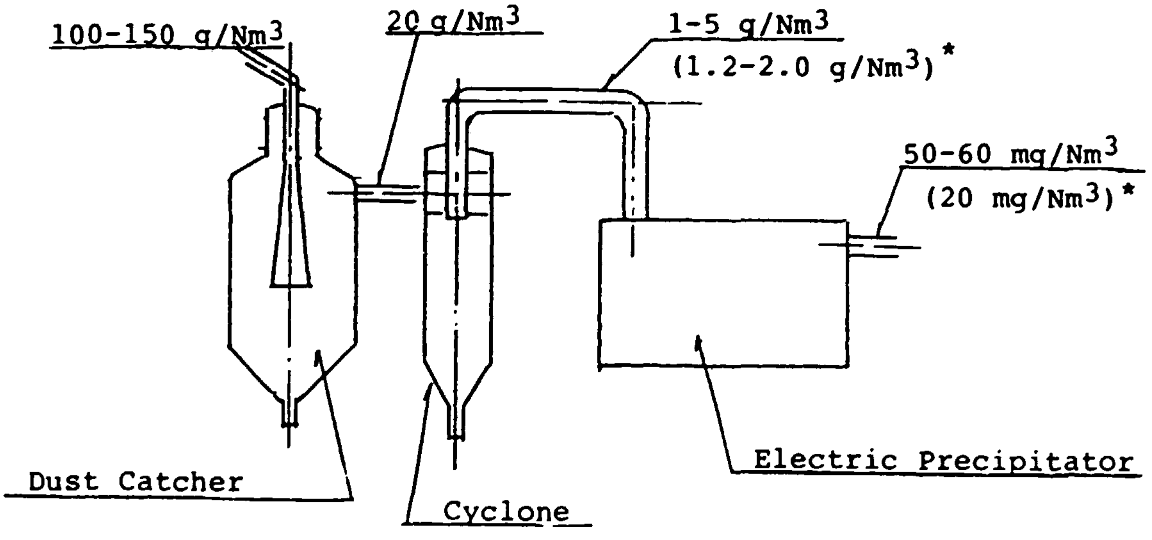


Fig. 5. Present operation of BF gas cleaning system

3.3.1.10 Installation of BF gas holder (L)

DIMAG has a plan to install a flare stack for absorbing the imbalance between supply and demand quantity. The momentary imbalance is 15,000-20,000 m^3/h. Refer to Fig. 6 for BF gas balance.

We recommend to install a gas holder for energy saving and pollution control. Its capacity should be decided based on the following:

- To absorb the imbalance between supply and demand
- To supply from the holder a proper quantity of BF gas needed for a period of time to change to another fuel safely

Normally in Japan, the capacity of BF gas holder = 0.1 x volume of generated gas (Nm^3/h).

For DIMAG, 90,208 m^3/h x 0.1 ≒ 10,000 m^3.

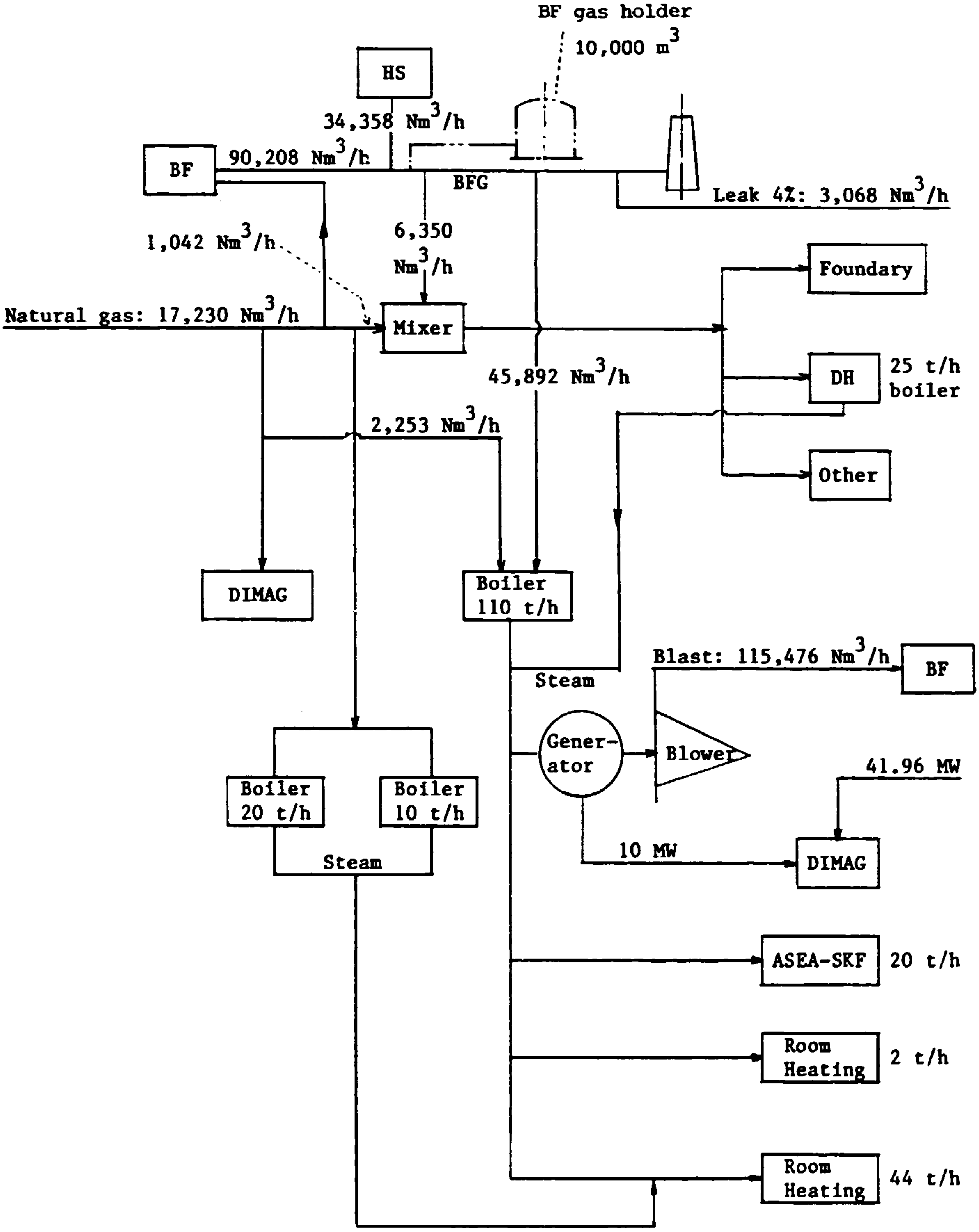


Fig. 6. Flow sheet of energy supply system

3.3.1.11 Decrease of shutdown time (S)

Plant availability in 1990 was about 87% (see Table 5 in Section 2.4).

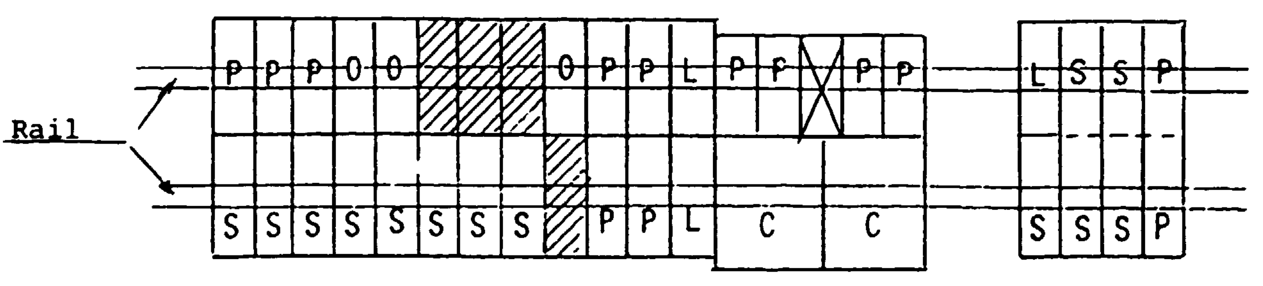
1) Change of the tuyere

At present DIMAG uses tuyeres of double chamber type. But water leakage often happens at the welded part. Therefore, quality control and inspection procedures for acceptance of the tuyeres delivered at shop should be established. In near future, water leakage detection system and tuyere exchange device are recommended to be installed.

The water leakage detection system will measure the difference between inlet and outlet flow rate of each tuyere. This way, DIMAG will be able to decrease unscheduled shutdown time, needed for changing the tuyere, from 36.51 hours to almost zero.

2) Nonarrival of materials (92.84 h)

The plant operation often has to be stopped because of shortage of material. The stock bins are arranged only at the BF side as shown below.



Present stock capacities

. Sinter: 2,853 m^3 (for about 4.5 days)

. Pellet: 2,530 m^3 (for about 16.5 days)

. Coke : 914 m^3 (for about 1.5 days)

Fig. 7. Present layout and capa[illegible] of stock bins

These capacities are not sufficient. When the upstream equipment has a trouble, DIMAG can not continue to operate BF plant. We recommend that DIMAG will prepare other stock area not to be disturbed by troubles at the upstream equipment. One idea is to use the stock bins of No.1 and No.2 BFs, now stopped, to increase the stock quantity.

3) Other

Cooperation and adjustment with upstream and downstream departments, as well as improvement of maintenance technique, will be able to reduce shutdown hours considerably.

3.3.1.12 Study for introduction of PCI (L)

In application of PCI, larger BF is more feasible than smaller BF. Introduction of the PCI system will prove profitable in the course of several years.

3.3.2 Steelmaking and continuous casting process

3.3.2.1 Improvement of hot metal pretreatment (M)

DIMAG intends to produce quality steel for sales to Western countries.

As stated in Section 3.2, the levels of phosphorus, sulphur, and oxygen and nitrogen in steel are very high for production of defectless and homogeneous steel products.

For reduction of phosphorus, the pretreatment of hot metal with low Si content is effective and economical. Therefore, the hot metal pretreatment is recommended by means of the newly installed equipment mainly consisting of large-capacity ladles, oxygen lancing device, flux additing device, and fume collecting device.

If this hot metal pretreatment method is employed, DIMAG can expect to decrease tap-to-tap time of BOF in addition to improved steel quality. Furthermore, DIMAG can expect to elongate the refractory life of BOF by five times. The life of 800 heats in DIMAG seems very short compared with the life over 4,000 heats in Japanese steel mills where the hot metal pretreatment method has been used. Of course DIMAG has to consider the difference in refractory qualities.

3.3.2.2 Optimization of process route according to steel grades (M)

After installation of new bloom caster for production of blooms, DIMAG will experience shortage of return scrap due to high yield in the steel mill and will have to purchase scrap outside the steel mill. Therefore DIMAG has to reconsider the process route of raw materials for BOF and UHP EAF.

We recommend that hot metal will be used as raw material to produce quality steel including low, medium, and high carbon steels and low alloy steel by BOF, and that scrap will be used as raw material to produce commercial grade steel and high alloy steel by UHP EAF.

In addition to this, in planning reconstruction of the blast furnace as the next campaign, DIMAG has to decide which is more feasible to adopt the blast furnace or UHP EAF, considering availability and price of raw materials in the market and their transportation costs.

3.3.2.3 Increase of quality steel production (S)

When we analyze Table 1 Productions Classified by Products and Sizes (1988-1990) on page 2-2 to examine production ratio of bar, flat, and wire rod, we obtain the following:

1) The production ratio of wire products in DIMAG is 20.0%.

2) The production ratio of wire products in Kobe Steel's Kobe Works and that of the average of nine European well-known quality steel mills is 55.5% and 40.8% respectively as summarized in Table 11.

   From this analysis, we can say that DIMAG has opportunity to increase the production of wire products by 20-30% if DIMAG intends to advance into the value added quality steel market in the West. A market study to be carried out by DIMAG will indicate that this will strengthen DIMAG's position in quality steel market by enabling DIMAG to supply quality wire rods in small size which are presently missing.

In terms of quality billet production, DIMAG has suitable equipment such as ASEA-SKF furnace, billet caster to be modified, blooming and billeting mill, and billet inspection and conditioning equipment.

In terms of rolling mill, DIMAG has the choice depending on the market size to modify the existing fine (SKET) mill by adding the wire rod finishing line consisting of a block mill train or to install a new wire rod mill.

At present, we have observed that bars in coil of quality steel and concrete bars in coil are rolled in the same rolling mill line at the fine (SKET) mill in DIMAG. In view of the difference of quality control concept between quality steel bar and concrete bar, the production lines should be separated as much as possible and the installation of a new wire rod mill separate from the existing mill is the most recommended case.

On the other hand, DIMAG has to improve inner and surface quality of products in order to be satisfied by Western users.

Table 11. Production of Quality Steels Classified by Shapes

(Unit: 1,000 tons)

	Bar	Flat	Wire rod
Small size	45.4	1.3	44.0
Intermediate size	73.3	2.6	
Large size	53.5		
Total	172.2 (78.2%)	3.9 (1.8%)	44.0 (20.0%)
Kobe Steel's Kobe Works	(43.7%)	(0.8%)	(55.5%)
Average of 9 European well-known quality steel mills	(59.2%)		(40.8%)

3.3.2.4 Improvement of availability of ASEA-SKF furnace (S)

DIMAG does not use ASEA-SKF furnace to produce the steel grade B shown in Table 1 in Section 2.1.

We usually adopt vacuum degassing method to improve the quality of these steel grades in order to meet the quality requirements of domestic and overseas customers.

The ASEA-SKF furnace in DIMAG has enough capacity to treat steel products into a category of quality steel.

3.3.2.5 Increased use of billet caster and decrease of ingot-making (S)

The availability of billet caster is now 50.2% with billet size of 120 sq mm to 180 sq mm.

Considering the product sizes of 120, 150, 180 sq mm cast by the existing billet caster, the availability is limited in relation with rolled products. Therefore, it is recommended that DIMAG will modify the billet caster to be able to cast 250 x 350 mm blooms within this autumn.

After the modification for production of blooms is completed, the availability of billet caster will be raised by 20 to 30% for production of blooms for big-section steel products.

The very long waiting time of billet caster in Table 5 should be shortened by increase of availability of BOF and improvement of production control.

3.3.2.6 More technological considerations needed for modification of the billet caster for casting 240 x 350 mm blooms (S)

According to the modification plan of billet caster for 240 x 350 mm blooms, a very small number of guide rollers are designed. This will result in sub-surface and inner defects due to bulging caused by the static pressure of molten steel in the bloom being solidified.

Accordingly, when quality steel is cast, low casting speed will have to be adopted. And this will result in low productivity.

We recommend to install more guide rollers below the mould. Details should be discussed with engineers responsible for the modification of billet caster.

If more guide rollers are installed to enable blooms to be cast at 1.0 m/min without bulging, DIMAG can cast about 600,000 tons of blooms by the billet caster per year. This figure corresponds to the quantity of blooms and billets required for rolled products in 1990.

This way, the continuous casting ratio would have reached almost 100%, apart from the steel grades which must be cast by ingot-making method due to metallurgical reasons including very high carbon steel and big cross section products.

3.3.2.7 Installation of one 1-strand new bloom caster with a large cross-section (M)

This item will quite contribute to the improvement of product quality, productivity, yield, and working conditions. DIMAG can attain approximately 95% of continuous casting ratio after installation of this bloom caster with a large cross-section.

The main specifications of the bloom caster will be as follows:

. No. of strands : One

. Bloom cross section: 320 x 480 mm

. Caster type : Radial

. Curvature : 12 m

. Casting speed
  . Commercial grades : 1.2 m/min
  . Low alloy grades : 0.8 m/min
  . High carbon grades: 0.6 m/min

. Production capacity: 350,000 t/y

The new bloom caster will have to be equipped with the following vital devices for production of quality steel:

. Shroud casting devices between ladle and tundish, and between tundish and mould

. Accurate level measuring and control system for the mould

. Mould incorporated with electromagnetic stirrer (M-EMS)

. High frequency mould oscillator

. Roller guide with small roller pitch to minimize burging of bloom

. Moderate mist cooling system in the secondary cooling zone

After start-up of the new bloom caster, quality steel and big round and square bars will be produced by this new bloom caster, and sections and commercial steel grade bars will be produced by the billet caster using a hot charging method. Of course, extremely high carbon steel and big cross section products will be produced by the present ingot-making method.

Then, the continuous casting ratio in DIMAG will reach approximately 95%. This is a top level among steel mills of long products in the world.

3.3.2.8 Hot charging of cast blooms into the reheating furnace (S)

For energy saving, a hot charging method is very contributory in the steel industry.

DIMAG has to employ hot charging of a maximum of cast blooms and billets using the production control system and the railway transportation system with wagons insulated and covered with refractories.

The reheating furnace in the beam mill should be modified a little in order to receive blooms to be produced by the new bloom caster.

3.3.3 Blooming/billeting process

3.3.3.1 Diversification of product mix (L)

As stated in Section 3.1, production of wire rods will contribute to diversification of the product mix.

If DIMAG produces wire rods by the newly installed block mill using billets produced by the new bloom caster and the existing blooming and billeting mills, with full use of the existing surface inspection and conditioning equipment, the quality of the products will be competitive in Western countries in terms of inner and surface quality.

The final use of wire rods will include essential parts for automobile industry, prestressed concrete wire (PC wire), wire rope, piano wire, and hopefully tire cord.

A new wire rod mill is capable of producing wire rods of more than 5.5 mmø at 80 m/sec from 120 sq mm billets.

This mill will consist of an 80 t/h walking hearth furnace, billet charging and extracting equipment, four horizontal and four vertical roughing mills, three horizontal and three vertical intermediate mills, three horizontal and three vertical finishing mills, a ten-stand block mill, guide devices, shears, a laying head, a conveyor, and coil handling devices. Lubricators and hydraulic devices and water treatment system will be included. When a bar in coil line is added, other equipment such as coilers and coil handling and bundling devices will have to be installed.

Since installation of this mill will require a huge investment, DIMAG will have to foresee the future market trend using enough marketing data to be collected.

Considering DIMAG's intention concerning production of quality steel and value-added products as well as the obsolete Schlöemann mill, we recommend a new wire rod mill to improve the competitiveness of DIMAG as the quality steel mill.

Big round and square bars will be competitive steel products as a part of product mix in DIMAG. Therefore big section blooms should be utilized as raw materials for production of these quality products.

3.3.3.2 Optimization of material supply from the steelmaking shop (L)

DIMAG should apply the hot charging method of continuously cast blooms and billets for energy saving, which will contribute to lower production cost.

Almost all cast blooms produced by the new bloom caster can be hot charged into the reheating furnace or the soaking pit. Also, billets produced by billet caster should be hot charged into the reheating furnace in the fine (SKET) mill and section (SKET) mill as much as possible.

Production control that will start with order entry in the commercial section and continue to the rolling mill shops is essential to cost saving through hot charging method.

Quality steel grade billets should not be hot charged because these billets have to be inspected and surface conditioned before further rolling.

3.3.3.3 Hot charging of cast billets into the reheating furnace (S)

As stated in Section 3.3.3.2, hot charging of billets produced by billet caster is possible through establishment of the production control system.

Blooms to be rolled by the blooming mill can also be hot charged through efforts not to lower the temperature of blooms by means of the production control system and good handling practice of blooms.

3.3.3.4 Decrease of ingot-making ratio (S) and introduction of hot scarfer in the blooming mill shop (L)

As stated in Section 3.3.2.7, the ingot-making ratio will be greatly decreased and the overall yield will be raised by approximately 12% after installation of the new bloom caster.

DIMAG does not adopt a hot scarfing method in the blooming mill and uses grinding machines for surface conditioning of billets for production of quality steel. If a hot scarfer is installed in the blooming mill shop, the billet surface area to be conditioned will be greatly reduced.

Almost all steel mills in Japan adopt a hot scarfing method and surface conditioning by grinding in order to meet the surface quality requirement of the automobile industry. DIMAG should consider installation of a hot scarfing machine to suit strictness of market requirements.

3.3.3.5 Improvement of soaking pit operation and combustion method (S)

According to our investigation, we recommend that unexpected waiting time of raw materials be reduced, and that the ratio of secondary combustion air be reduced by 10%. Both practices will contribute to energy saving and cost reduction.

DIMAG should keep more close communication between steelmaking and rolling mill departments in order to reduce unexpected waiting time of raw materials.

3.3.3.6 Optimized production plan of modified billet caster with 240 x 350 mm cross section (S)

After modification of billet caster to be able to cast 240 x 350 mm blooms is completed, we recommend to use this size only to increase production capacity as much as possible due to the following reasons:

1) To increase continuous casting ratio will quite contribute to an increase of yield by 12% compared with the present ingot-making method.

2) When only 240 x 350 mm blooms are cast, the annual production will reach approximately 600,000 tons, which is equivalent to the requirement of billets and blooms in 1990 as stated in Section 3.1.

   If production of rolled products is kept at the same level of 1990, DIMAG can use cast blooms for production of steel products except for very high carbon steel and big cross section products.

3) The above will lead to reduction of manpower required for ingot-making operation.

Considering the above, we show a simulation in which 500,000 tons of rolled products are produced by both the present ingot-making method and the modified billet caster.

	Record in 1990	Calculation
. Rolled products	502.0×10^3 t/y	502.0
. Required blooms/billets	557.0	557.0
Billets from caster	317.2	557.0
Billets/bloom from ingot	239.8	
. Required crude steel	604.0	560.0
Billets from caster	317.2	-
Blooms from caster	-	560.0
Ingot	286.8	-
. Required reheating energy for blooming/billeting	108×10^9 kcal	101×10^9 kcal

According to the above calculation, if DIMAG produces the same quantity of rolled products as in 1990 only by the modified billet caster, DIMAG can save 44,000 tons of crude steel without any increase of energy consumption.

This means that approximately 1,000 million yen (US$7.4 million) will be saved per year.

Therefore, we recommend DIMAG to use the modified billet caster as much as possible for cost saving and quality improvement.

3.3.3.7 Hot charging of cast blooms into the reheating furnace to be installed in the blooming mill shop (S)

As stated in Section 3.3.2.8, the hot charging method will quite contribute to cost reduction and energy saving.

For this, establishment of production control system, incorporating local conditions, is essential. Also, good communication in DIMAG is required to attain it.

3.4 Plant Availability

Availabilities of the main process equipment, as well as corresponding availabilities in Japanese steel mills, are shown in Table 12.

Of the recommendations for raising the availability stated in Section 3.3, those belonged to L are items to be executed soon after improvement of the market conditions. Those items can be attained with investment.

Table 12. Availability of t

Description		Blast Furnace	Steelmaking and Continuous Casting			
			BOF	UHP EAF	ASEA-SKF	Caste
Working Shift		4/4	4/4	4/4	(2/2)	4/
1. Working Hours	h	8,760	8,760	8,760	-	8,7
2. Operation*	%	87.3 (98.0)	44.2 (75.1)	43.0 (73.8)	77.0 (-)	50 (67
3. Scheduled Maintenance	%	6.0	13.8	40.0		21
					23.0	
4. Loss Time	%	6.6	42.1	17.1		28
Consisting of:						
. Misoperation	%	1.9	26.1	4.6		0
. Mechanical trouble	%	0.2	1.6	4.3		0
. Electrical and instrumentation trouble	%	0	0.4	1.0		0
. Other trouble	%	1.8	3.3	2.8		3
. Waiting	%	2.7	10.6	4.3		2

*Figur

SECTION 1

ability of the Main Equipment

ous Casting		Rolling Mills					
-SKF	Caster	Blooming	Billeting	Beam	Section (Schlöemann)	Fine	Section (SKET)
/2)	4/4	2/2	2/2	3/3	3/3	4/3	2/2
-	8,760	6,805	5,670	8,001	4,332	7,319	5,911
.0 -)	50.2 (67.2)	49.5 (67.0)	44.1 (63.0)	57.8 (81.0)	67.5 (81.0)	61.3 (88.0)	61.0 (85.0)
	21.3	0.8	0.4	12.2	15.7	18.6	22.9
3.0							
	28.6	49.7	55.5	30.0	16.9	20.1	16.1
	0.2	4.1	1.5	10.8	6.7	13.7	10.8
	0.7	4.0	4.6	4.1	4.7	3.0	2.8
	0.4	0.6	0.5	0.8	1.2	1.7	1.6
	3.2	5.7	6.4	1.4	1.3	1.1	0.4
	24.1	35.3	42.5	12.9	3.0	0.6	0.5

*Figures in parentheses are Japanese examples.

SECTION 2

3.5 Energy Consumption and Pollution Control

DIMAG's total energy consumption in 1990 is shown in Table 13.

For production of 640,500 tons of crude steel, DIMAG consumed 17.43×10^{15} J, or 27.2×10^{9} J/t.steel (6.5×10^{6} kcal/t.steel). Considering the energy supply to Miskolc for heating the houses, the net energy consumption for this production in DIMAG was 19.86×10^{9} J/t.steel (4.74×10^{6} kcal/t.steel). On the other hand, the average Japanese integrated steel mill consumes 18.42×10^{9} J/t.steel (4.4×10^{6} kcal/t.steel).

Table 13. DIMAG's Energy Consumption (1990)

Process	Energy Consumption 10^{12} J	%	Application
1. Ironmaking	8,723	50.0	Coke, natural gas, electric power, BF gas
2. Steelmaking	1,090	6.3	Natural gas, electric power
3. Rolling	2,325	13.3	Natural gas, electric power, BF gas
4. Forged products	389	2.2	Natural gas, electric power
5. Bolts and drawn products	205	1.2	Natural gas, electric power
6. Heating	4,698	27.0	Natural gas, electric power, BF gas
Total	17,430	100%	

We present recommencations for energy saving and pollution control on the following pages.

3.5.1 Energy consumption

3.5.1.1 Blast furnace

1) Decrease of coke ratio is recommended through low Si content operation and improvement of charging method of raw materials. When the Si content is decreased by 1%, the coke ratio will be decreased by 15 kg/p-t.

   Decrease of Si content should be performed with consent of the engineers in the steelmaking shop.

2) Increase of Fe content of raw material and decrease of slag quantity are recommended to reduce energy consumption.

   As stated in Section 3.3.1.2, higher Fe content of raw materials is contributory in every viewpoint if DIMAG can purchase better raw materials from supply sources other than USSR.

   If DIMAG tries to purchase raw materials from supply sources other than the present mines, cooperation with Duna Steel Mill may be preferable considering purchase quantity and overseas transportation.

3) As stated in Section 3.3.1.10, the installation of a BF gas holder is preferable to improve energy consumption.

4) As stated in Section 3.3.1.7, blasting method of hot air from the hot stoves to the blast furnace should be reconsidered.

   Temperature of hot air is now kept constant at approximately 1,000°C through dilution by cold air. However, we recommend to apply approximately 1,100°C without dilution by cold air as shown in Fig. 6. It will be possible to add control valves and to change control sequence.

This recommended method will contribute not only to a decrease of energy consumption but also to an increase of productivity of the blast furnace.

5) Recovery of exhaust gas from the hot stoves is recommended through installation of a recuperator if the required investment is compensated by energy saving.

6) Energy balance in the blast furnace is shown in Fig. 7. As stated so far, decrease of coke ratio, restraint of heating energy for the hot stoves, decrease of slag quantity, and recovery of exhaust heat from the hot stoves will contribute to overall energy saving in the BF process.

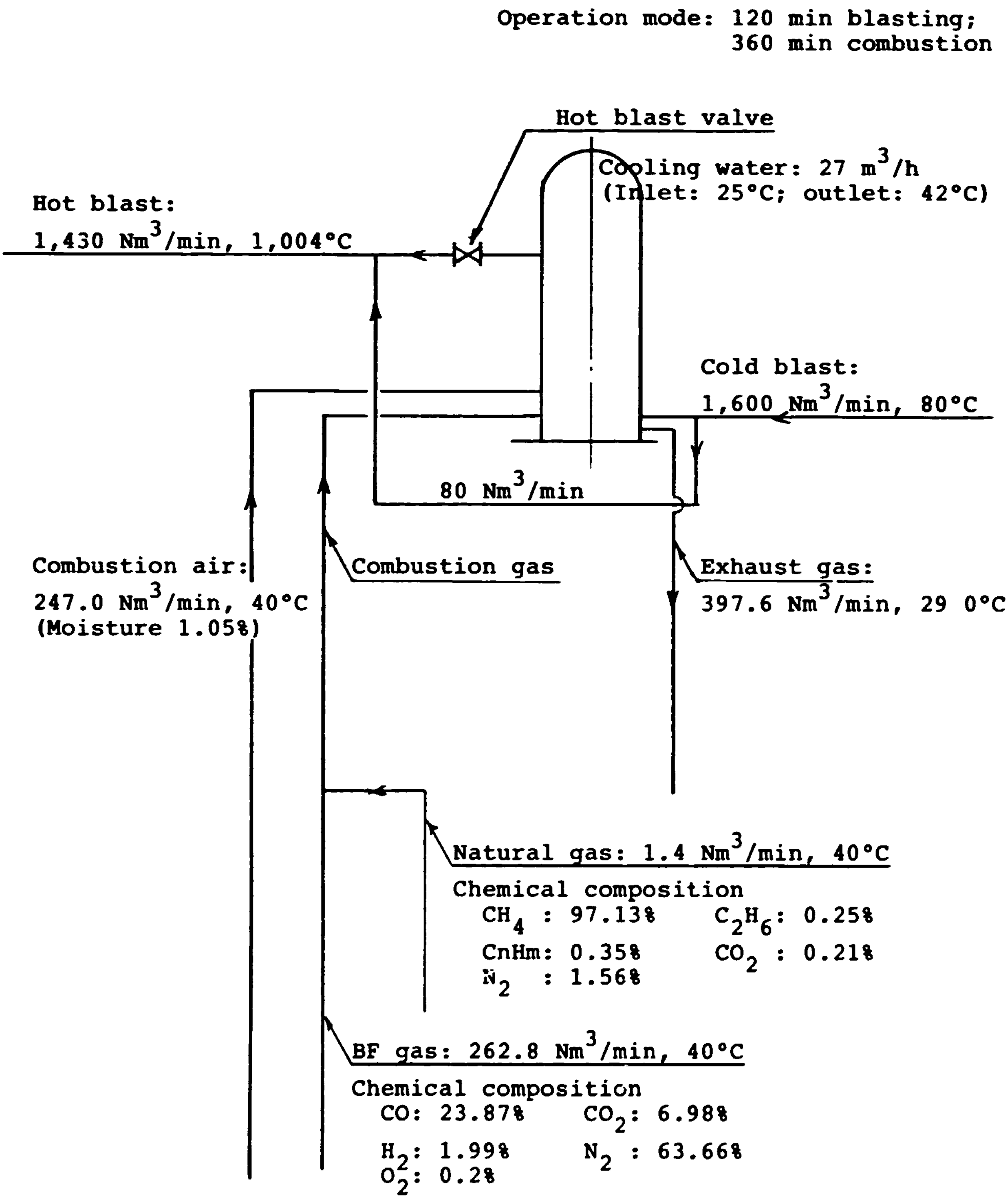


Fig. 6. Energy balance of hot stove

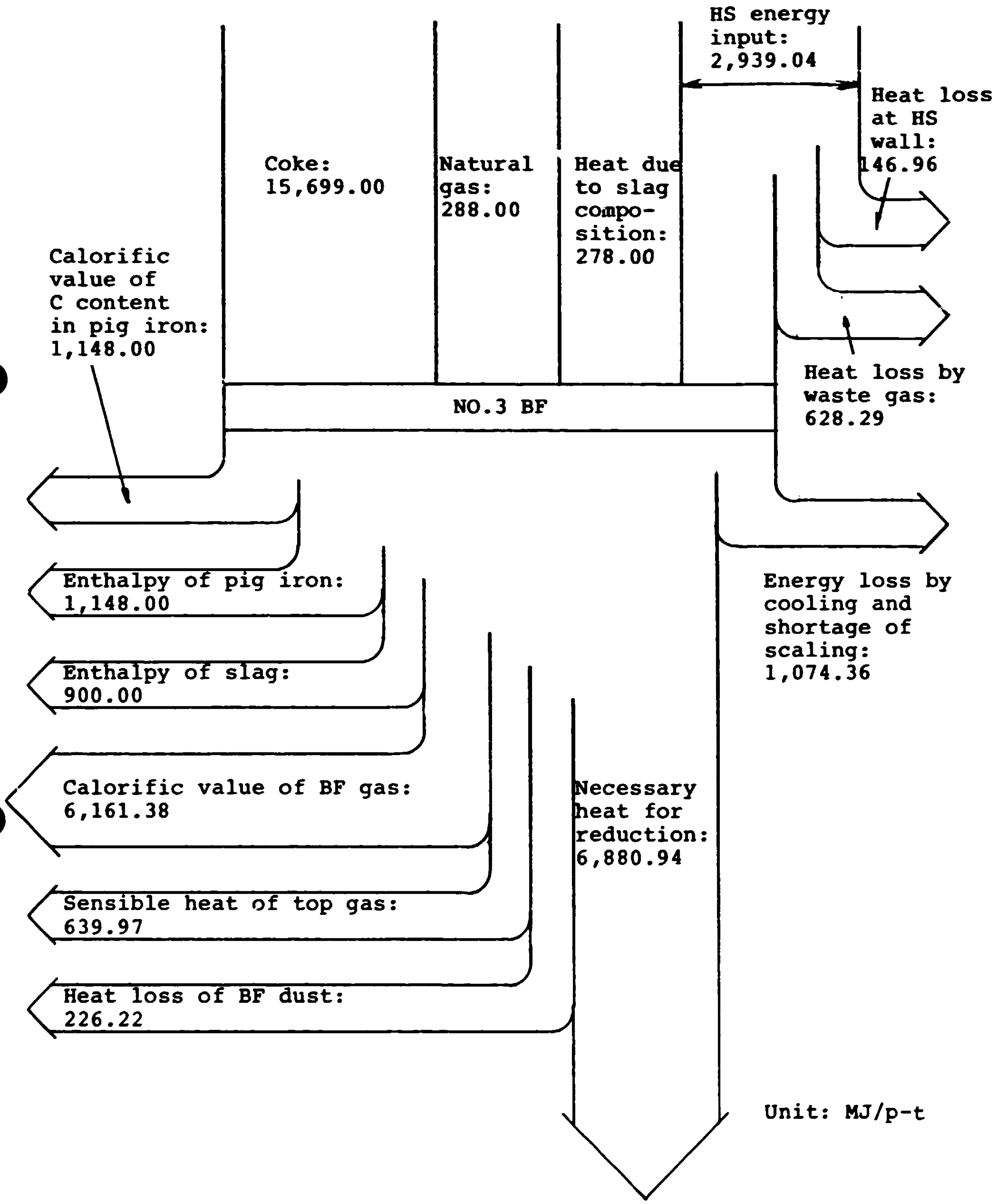


Fig. 7. Energy balance in No.3 BF

3.5.1.2 Steelmaking and continuous casting process

We do not recognize any particular items for reduction of energy consumption except reduction of electricity to melt scrap in the UHP EAF. For this, suitable selection and preparation of scrap for easy melting and installation of a scrap preheater are recommended.

As stated in Section 3.3.2.2, some changes of process route will also contribute to reduction of energy consumption in the steelmaking and continuous casting process together with more utilization of ASEA-SKF furnace to produce quality steel.

3.5.1.3 Rolling process

In the rolling process, more than 500 x 10^3 kcal/t of energy is consumed to reheat blooms and billets.

This figure is more than two times as high as in the Japanese practice; 240 x 10^3 kcal/t is consumed to reheat low alloy billets. On the other hand, 180 x 10^3 kcal/t is reported to be used for reheating billets for section and rebar steel by means of hot charging method in Japan.

Therefore we recommended the following:

1) Reduction of waiting time due to mismatch of production schedule between each rolling mill and upstream equipment.

2) Adoption of hot charging method for production of commercial grade steel.

3) Modification of the reheating furnace to keep high thermal coefficient by adoption of a long length of side extraction type and by employment of good heat-resisting refractories.

3.5.2 Pollution control

As stated in Section 2.5.2, noticeable pollution does not exist in DIMAG.

However, if DIMAG adopts several methods for reducing energy consumption, the level of pollution will be much lowered.

DIMAG uses ordinary burners for the reheating furnace. However, if DIMAG needs less exhaust of NOx from the reheating furnaces, low NOx generation type burners, available now, should be employed.

3.6 Budget and Economic Contribution

The budget and economic contribution for improvement and rehabilitation of the main equipment are summarized according to classification of our recommendations in Table 14 together with identification of contributions.

As stated in Section 3.3, our recommendations are classified in the following three groups:

1) Short-term recommendations (S) without significant investment

   Items in this group should be implemented immediately after enough investigations have been conducted and mutual consent has been obtained in DIMAG.

2) Medium-term recommendations (M) with investment

   Items in this group will quite contribute to profit improvement in DIMAG.

3) Long-term recommendations (L) with investment

   Items in this group form the subjects for DIMAG to restructure the steel mill in the near future in order to survive as a quality steel mill in the center of Europe.

When DIMAG implements recommended improvements, it is advised that DIMAG will organize a restructuring committee consisting of experts from the administration, finance, and sales departments, and engineers from the ironmaking, steelmaking, rolling, utility, and maintenance departments.

Also, we suggest that DIMAG will obtain both managerial and technical assistance from a Japanese steel mill for effective and vivid participation in the committee.

Our analyses and recommendations have been based on the premises that the existing process equipment, after partial improvement and rehabilitation, will be used for production of steels in principle.

Here, we have to consider that quality steel mills that produce steel from cold materials such as scrap and HBI seem to be more profitable than integrated steel mills in Western countries due to heavy investment, raw material conditions, and improvements of technology as represented by direct current EAF and secondary ladle metallurgy.

Considering all this, DIMAG has to start a study for a future direction, especially when DIMAG reconstructs the blast furnace or when DIMAG faces increased wage level as high as in industrialized Western countries.

Table 14. Budget and Econom

Recommendations	Classification			Contr	
	S	M	L	Quality	Yield
1. Ironmaking Process					
1.1 Installation of sinter screen and coke cutter		x			
1.2 Optimized mixing of raw materials	x				x
1.3 Installation of movable armour			x		
1.4 Quality control of raw material and coke	x				x
1.5 Medium pressure operation of BF			x		
1.6 Low Si content operation	x				
1.7 Optimization of hot stove operation		x			
1.8 Improvement of casting floor			x		
1.9 Replacement of BF gas cleaning system			x		
1.10 Installation of BF gas holder			x		
1.11 Decrease of shutdown time	x				
1.12 Introduction of PCI			x		

*To be calculated after furt

SECTION 1

udget and Economic Contribution (1/3)

x: Applicable

Contributory to the Improvement of:					Budget (million $)	Economic Contribution (million $/year)
uality	Yield	Productivity	Energy	Environment		
		x	x		0.4 (in case of Fig. 3)	0.5
	x	x	x		-	*
		x	x		0.8	*
	x	x	x		-	*
		x			2.5	1.6
			x		-	1.0
				x	1.5	0.4
				x	3.0	Improvement of working environment only
		x		x	1.5	Same as above
				x	1.5	*
		x			-	1.3
			x		15.0	2.5

ted after further engineering and establishment of optimized operational methods.

SECTION 2

Table 14. Budget and Economic

Recommendations	Classification			Contribu	
	S	M	L	Quality	Yield
2. Steelmaking and Continuous Casting Process					
2.1 Improvement of hot metal pretreatment		x		x	
2.2 Optimization of process route according to steel grades		x			
2.3 Increase of quality steel production	x			x	
2.4 Improvement of availability of ASEA-SKF furnace	x			x	
2.5 Increased use of billet caster and decrease of ingot-making	x				x
2.6 Technological considerations for casting 240 x 350 mm blooms	x			x	x
2.7 Installation of new bloom caster with a large cross-section		x		x	x
2.8 Hot charging of cast blooms into the reheating furnace	x				

*To be calculated after further

SECTION 1

dget and Economic Contribution (2/3)

x: Applicable

Contributory to the Improvement of:					Budget (million $)	Economic Contribution (million $/year)
Quality	Yield	Productivity	Energy	Environment		
x		x			6.3	*
					-	*
x		x	x		-	*
x		x			-	*
	x	x	x	x	-	7.4 (combined with row below)
x	x	x	x	x	1.0	
x	x	x	x	x	30.4	22.2
			x	x	-	1.8

ted after further engineering and establishment of optimized operational methods.

SECTION 2

Table 14. Budget and Econo

Recommendations	Classification			Cont	
	S	M	L	Quality	Yiel
3. Blooming/Billeting Process					
3.1 Diversification of product mix (Installation of a new wire rod mill)			x	x	
3.2 Optimization of material supply from the steelmaking shop			x		
3.3 Hot charging of cast billets into the reheating furnace	x				
3.4 Decrease of ingot-making ratio	x			x	x
3.4' Installation of hot scarfer in the blooming mill shop			x	x	
3.5 Improvement of soaking pit operation and combustion method	x				
3.6 Optimized production plan of modified billet caster with 240 x 350 mm	x			x	x
3.7 Hot charging of cast blooms into the reheating furnace	x				

*To be calculated after furt

SECTION 1

t and Economic Contribution (3/3)

x: Applicable

Contributory to the Improvement of:					Budget (million $)	Economic Contribution (million $/year)
ity	Yield	Productivity	Energy	Environment		
					122	43.9 (Details shown in APPENDIX)
		x	x		-	*
			x	x	-	0.4
x	x	x	x	x	-	*
x		x			4.2	Necessary when users require it
			x	x	-	Already as same as in Japan
x	x	x	x	x	-	Same as items 2.5 and 2.6
			x	x	-	Same as item 2.8

after further engineering and establishment of optimized operational methods.

SECTION 2

4. CONCLUSION

Through the investigation of the present operation in DIMAG and discussions with DIMAG's experts, we have collected data and information for preparation of recommendations concerning improvement and rehabilitation of DIMAG steel mill based on analyses of the present problems and related factors.

For survival of the steel mill, DIMAG will have to make best efforts to keep stable and feasible production level with reasonable profits. For achievement of this, reliability on product quality and punctual delivery must be obtained from the customers, production cost has to be cut, and marketing has to be performed based on effective production management and operation.

In Section 3.6, we have tabled our recommendations for the improvement and rehabilitation in three groups (Table 14).

Of these, the short-term (S) and medium-term (M) recommendations should be implemented as soon as possible because considerable profits can be expected with investment. Especially, maximum use of the billet caster and installation of the new bloom caster will prove quite profitable because of improvement in the yield and quality and reduction of the labor force.

Production of the steel products, mass-salable and easily value-added such as small-diameter wire rods, should be maintained at a properly high level to contribute to a larger amount of sales and profits.

To secure competitiveness of DIMAG in future, DIMAG should examine whether or not the present production process, mainly consisting of the blast furnace and basic oxygen furnace, will be suitable for production of some 600,000 tons/year of crude steel considering increased market share by steel mill based on cold materials like scraps and HBI in Western countries.

Considering all this, we recommend to start the study of improvement and rehabilitation as soon as possible with the assistance of a Western expert including a Japanese steel mill.

APPENDIX

FEASIBILITY STUDY OF NEW WIRE ROD MILL
(FS MODEL)

We made a brief feasibility study when a new wire rod mill is introduced for production of quality wire rods in DIMAG.

In the model attached, we apply the following premises:

1)	Production quantity	: 240,000 t/y
2)	Average sales price	: US$650/t
3)	Variable costs	
	. Billet cost (average)	: US$370/t
	. Electricity (32×10^6 kWh/y x US$0.055)	: US$1.76 million/y
	. Natural gas (9×10^6 Nm^3/y x US$0.163)	: US$1.46 million/y
	. Roll consumption (US$0.75/t)	: US$0.18 million/y
	. The other consumption (US$0.37/t)	: US$0.088 million/y
4)	Labour cost (260 persons x US$8,888/y)	: US$2.311 million/y
5)	The other fixed cost	: 10% of sales revenue

As shown in FS model, IRR figure of 26.06 seems to be very feasible.

The feasibility may vary mainly depending on sales price and quantity; therefore a reliable market research is required before investment. On the other hand, obtaining a loan at a reasonable interest is also essential.

A91008SA0134

FS MODEL

PROJECT NAME:

INPUT DATA / IRR

CURRENCY UNIT: (US$ 1,000/Year)

CONSTRUCTION COST	*122,200*
PRE-OPERATING COST	*0*
EQUITY RATIO(%)	*0*
LOAN(L) GRACE(YEAR)	*0*
LOAN(L) INSTAL. NO.	*10*
LOAN(L) INTEREST(%)	*14*
INVENTORY(MONTH)	*0.00*
AC RECEIVABLE(MONTH)	*0.00*
SALES REVENUE(FULL)	*156,400*
VARIABLE COST(FULL)	*94,500*
LABOUR COST	*2,311*
OTHER FIXED COST	*15,640*
DEPRECIATION(YEAR)	*10*
RESIDUAL VALUE(%)	*5*
AMORTIZATION(YEAR)	*10*
LOAN(S) INTEREST(%/Year)	*11*
OPERATION RATE(year-1)(%)	*75*
OPERATION RATE(year-2)(%)	*95*
OPERATION RATE(year-3-)(%	*100*
TAX RATE(%)	*0*
TAX HOLIDAY(YEAR)	*0*
INITIAL WORKING CAPITAL	*0*

CALUCULATION OF IRR(%)

(Post-Tax Basis)

IRR(%)= 26.06

(ON INVESTMENT) (Unit:1,000US$)

YEAR	*INVESTMENT*	*CASH INFLOW*	*NET FLOW*	*NET PV*
-3	24,440		-24,440	-24,440
-2	48,880		-48,880	-38,775
-1	48,880		-48,880	-30,759
1		28,474	28,474	14,214
2		40,854	40,854	16,177
3		43,949	43,949	13,805
4		43,949	43,949	10,951
5		43,949	43,949	8,687
6		43,949	43,949	6,891
7		43,949	43,949	5,467
8		43,949	43,949	4,336
9		43,949	43,949	3,440
10		43,949	43,949	2,729
11		43,949	43,949	2,165
12		43,949	43,949	1,717
13		43,949	43,949	1,362
14		43,949	43,949	1,081
15		43,949	43,949	857
RESIDUAL		6,110	6,110	95
(TOTAL)	122,200	646,775	524,575	0

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FS MODEL

IRR(%)=	5,706.03

(ON EQUITY) (Unit:1,000US$

YEAR	INVESTMENT	CASH INFLOW	NET FLOW	NET PV
-3	0		0	0
-2	0		0	0
-1	0		0	0
1		0	0	0
2		463	463	0
3		13,066	13,066	0
4		15,175	15,175	0
5		17,284	17,284	0
6		19,393	19,393	0
7		21,502	21,502	0
8		23,611	23,611	0
9		25,720	25,720	0
10		27,830	27,830	0
11		43,949	43,949	0
12		43,949	43,949	0
13		43,949	43,949	0
14		43,949	43,949	0
15		43,949	43,949	0
RESIDUAL		0	0	0
(TOTAL)	0	383,790	383,790	0

FS MODEL

SENSITIVITY ANALYSIS

INVESTMENT(US$1,000)

	Amount	IRR(%)
BASE CASE	***122,200***	***26.06***
PLUS 20%	146,640	22.15
PLUS 15%	140,530	23.03
PLUS 10%	134,420	23.97
PLUS 5%	128,310	24.98
MINUS 5%	116,090	27.23
MINUS 10%	109,980	28.49
MINUS 15%	103,870	29.87
MINUS 20%	97,760	31.38

SALES REVENUE/PRICE(US$/TON)

	SALES REV.	IRR(%)
BASE CASE	156,400	***26.06***
PLUS 20%	187,680	39.07
PLUS 15%	179,860	36.07
PLUS 10%	172,040	32.93
PLUS 5%	164,220	29.60
MINUS 5%	148,580	22.24
MINUS 10%	140,760	18.06
MINUS 15%	132,940	13.36
MINUS 20%	125,120	7.83

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FS MODEL

CASHFLOW DURING CONSTRUCTION

(Unit:1,000US$

YEAR	1	2	3	TOTAL
USES OF FUNDS				
CONSTRUCTION COST	24,440	48,880	48,880	122,200
PRE-OPERATING COST	0	0	0	0
WORKING CAPITAL	0	0	0	0
INTEREST	1,989	7,957	16,513	26,460
TOTAL USES	26,429	56,837	65,393	148,660
SOURCES OF FUNDS				
CASH & DEPOSIT(BEG)	0	0	0	0
EQUITY CAPITAL	0	0	0	0
LOAN(L)	28,419	56,837	65,393	150,649
TOTAL SOURCES	28,419	56,837	65,393	150,649
SURPLUS(DEFICIT)	0	0	0	0
CASH & DEPOSIT(END)	0	0	0	0

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FS MODEL

CASHFLOW

(Unit:1,000US$)

YEAR	1	2	3	4	5	6	7	8
USES OF FUNDS								
INCREASE IN WC	0	0	0	0	0	0	0	0
LOAN(L) REPAYMENT	15,065	15,065	15,065	15,065	15,065	15,065	15,065	15,065
LOAN(S) REPAYMENT	0	7,013	0	0	0	0	0	0
INTEREST(L)	20,036	17,927	15,818	13,709	11,600	9,491	7,382	5,273
INTEREST(S)	386	386	0	0	0	0	0	0
CORPORATE TAX	0	0	0	0	0	0	0	0
TOATAL	35,487	40,391	30,883	28,774	26,665	24,556	22,447	20,338
SOURCES OF FUNDS								
EQUITY CAPITAL								
LOAN(L)								
LOAN(S)	7,013	0	0	0	0	0	0	0
OPERATING PROFIT	14,219	26,599	29,694	29,694	29,694	29,694	29,694	29,694
DEPRECIATION	11,609	11,609	11,609	11,609	11,609	11,609	11,609	11,609
AMORTIZATION	2,646	2,646	2,646	2,646	2,646	2,646	2,646	2,646
TOTAL	35,487	40,854	43,949	43,949	43,949	43,949	43,949	43,949
SURPLUS/DEFICIT	0	463	13,066	15,175	17,284	19,393	21,502	23,611
CASH & DEPOSIT(CUM)	0	463	13,529	28,704	45,988	65,381	86,884	110,495

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FS MODEL

CASHFLOW

(Unit:1,000US$)

YEAR	9	10	11	12	13	14	15
USES OF FUNDS							
INCREASE IN WC	0	0	0	0	0	0	0
LOAN(L) REPAYMENT	15,065	15,065	0	0	0	0	0
LOAN(S) REPAYMENT	0	0	0	0	0	0	0
INTEREST(L)	3,164	1,055	0	0	0	0	0
INTEREST(S)	0	0	0	0	0	0	0
CORPORATE TAX	0	0	0	0	0	0	0
TOATAL	18,229	16,119	0	0	0	0	0
SOURCES OF FUNDS							
EQUITY CAPITAL							
LOAN(L)							
LOAN(S)	0	0	0	0	0	0	0
OPERATING PROFIT	29,694	29,694	43,949	43,949	43,949	43,949	43,949
DEPRECIATION	11,609	11,609	0	0	0	0	0
AMORTIZATION	2,646	2,646	0	0	0	0	0
TOTAL	43,949	43,949	43,949	43,949	43,949	43,949	43,949
SURPLUS/DEFICIT	25,720	27,830	43,949	43,949	43,949	43,949	43,949
CASH & DEPOSIT(CUM)	136,215	164,045	207,994	251,943	295,892	339,841	383,790

FS MODEL

PROFIT & LOSS STATEMENT

(Unit:1,000US$)

YEAR	1	2	3	4	5	6	7	8
SALES REVENUE	117,300	148,580	156,400	156,400	156,400	156,400	156,400	156,400
VARIABLE COST	70,875	89,775	94,500	94,500	94,500	94,500	94,500	94,500
MARGINAL PROFIT	46,425	58,805	61,900	61,900	61,900	61,900	61,900	61,900
LABOUR COST	2,311	2,311	2,311	2,311	2,311	2,311	2,311	2,311
DEPRECIATION	11,609	11,609	11,609	11,609	11,609	11,609	11,609	11,609
AMORTIZATION	2,646	2,646	2,646	2,646	2,646	2,646	2,646	2,646
OTHER FIXED COST	15,640	15,640	15,640	15,640	15,640	15,640	15,640	15,640
FIXED COST TOTAL	32,206	32,206	32,206	32,206	32,206	32,206	32,206	32,206
OPERATING PROFIT	14,219	26,599	29,694	29,694	29,694	29,694	29,694	29,694
INTEREST	20,422	18,313	15,818	13,709	11,600	9,491	7,382	5,273
PROFIT BEFORE TAX	-6,203	8,286	13,876	15,985	18,094	20,203	22,312	24,421
TAX	0	0	0	0	0	0	0	0
NET PROFIT	-6,203	8,286	13,876	15,985	18,094	20,203	22,312	24,421
CUMULATIVE PROFIT	-6,203	2,083	15,959	31,944	50,038	70,241	92,553	116,974

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FS MODEL

PROFIT & LOSS STATEMENT

(Unit:1,000US$)

YEAR	9	10	11	12	13	14	15
SALES REVENUE	156,400	156,400	156,400	156,400	156,400	156,400	156,400
VARIABLE COST	94,500	94,500	94,500	94,500	94,500	94,500	94,500
MARGINAL PROFIT	61,900	61,900	61,900	61,900	61,900	61,900	61,900
LABOUR COST	2,311	2,311	2,311	2,311	2,311	2,311	2,311
DEPRECIATION	11,609	11,609	0	0	0	0	0
AMORTIZATION	2,646	2,646	0	0	0	0	0
OTHER FIXED COST	15,640	15,640	15,640	15,640	15,640	15,640	15,640
FIXED COST TOTAL	32,206	32,206	17,951	17,951	17,951	17,951	17,951
OPERATING PROFIT	29,694	29,694	43,949	43,949	43,949	43,949	43,949
INTEREST	3,164	1,055	0	0	0	0	0
PROFIT BEFORE TAX	26,530	28,639	43,949	43,949	43,949	43,949	43,949
TAX	0	0	0	0	0	0	0
NET PROFIT	26,530	28,639	43,949	43,949	43,949	43,949	43,949
CUMULATIVE PROFIT	143,505	172,144	216,093	260,042	303,991	347,940	391,889

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FS MODEL

BALANCE SHEET

(Unit:1,000US$)

YEAR	1	2	3	4	5	6	7	8
ASSETS								
CASH & DEPOSIT	0	463	13,529	28,704	45,988	65,381	86,884	110,495
ACCOUNT RECEIVABLE	0	0	0	0	0	0	0	0
INVENTORIES	0	0	0	0	0	0	0	0
FIXED ASSETS	110,591	98,982	87,373	75,764	64,155	52,546	40,937	29,328
DEFERRED CHARGES	23,814	21,168	18,522	15,876	13,230	10,584	7,938	5,292
TOTAL	134,405	120,613	119,424	120,344	123,373	128,511	135,759	145,115
LIABILITIES & CAPITAL								
ACCOUNT PAYABLE	0	0	0	0	0	0	0	0
TAX PAYABLE	0	0	0	0	0	0	0	0
SHORT-TERM LOANS	7,013	0	0	0	0	0	0	0
LONG-TERM LOANS	135,584	120,519	105,454	90,389	75,325	60,260	45,195	30,130
CAPITAL	0	0	0	0	0	0	0	0
CUMULATIVE PROFIT	-6,203	2,083	15,959	31,944	50,038	70,241	92,553	116,974
TOTAL	136,394	122,602	121,413	122,333	125,362	130,501	137,748	147,104

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FS MODEL

BALANCE SHEET

(Unit:1,000US$)

YEAR	9	10	11	12	13	14	15
ASSETS							
CASH & DEPOSIT	136,215	164,045	207,994	251,943	295,892	339,841	383,790
ACCOUNT RECEIVABLE	0	0	0	0	0	0	0
INVENTORIES	0	0	0	0	0	0	0
FIXED ASSETS	17,719	6,110	6,110	6,110	6,110	6,110	6,110
DEFERRED CHARGES	2,646	0	0	0	0	0	0
TOTAL	156,580	170,155	214,104	258,053	302,002	345,951	389,900
LIABILITIES & CAPITAL							
ACCOUNT PAYABLE	0	0	0	0	0	0	0
TAX PAYABLE	0	0	0	0	0	0	0
SHORT-TERM LOANS	0	0	0	0	0	0	0
LONG-TERM LOANS	15,065	0	0	0	0	0	0
CAPITAL	0	0	0	0	0	0	0
CUMULATIVE PROFIT	143,505	172,144	216,093	260,042	303,991	347,940	391,889
TOTAL	158,570	172,144	216,093	260,042	303,991	347,940	391,889