OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

19767

CLT 92/051
31 May 1992
ORIGINAL: ENGLISH

Advice on an appropriate strategy for the improvement of productivity in Chimbote Steel Works of SIDERPERU (Empresa Siderurgica del Peru)

Technical report: Fact-Finding Mission in SIDERPERU

Consultant:
Prepared by Kiyoshi Isomura
Expert on production and plant planning

for

Industrial Technology Promotion Division,
Department for Industrial Promotion,
Consultations and Technology
United Nations Industrial Development Organization
Vienna

CONTENTS

List of Tables

List of Figures

ABSTRACT

Technical report of fact-finding mission in Chimbote Steel Works of Siderperu

This mission was carried out under Project No. CLT 92/051 of IPCT/TP of UNIDO. The objective of the mission was to advise the company of Siderperu on an appropriate strategy for the improvement of productivity in Chimbote Steel Works and the technology options to be applied. The duration on site in Peru was about two weeks from 27 April to 8 May 1992.

Mr. Keiki Fujita, Direct of IPCT/TP of UNIDO, Mr. Juan Angulo Chueca, the residential consultant engineer in Lima, Peru and Kiyoshi Isomura, the international expert on production and plant planning, jointly carried on the fact-finding surveys at Chimbote Steel Works and Headquarters of Siderperu and at the Ministry of Industry of Peru.

In this report, the historical development of Siderperu since its commencement in 1958 was reviewed, the current condition, which was critical, in Chimbote Steel Works was survey, technical strategy for the improvement of its productivity and the reduction of production cost there was proposed, and the total reduction of product costs resulted was assessed. The technical strategy proposed was planned as to utilize the existing production lines at reasonably high rate with a minimum capital investment involved and by applying my proposed measures on technical basis for the improvement of productivity and the reduction of production cost. Technical options, which require considerable size of capital investment, were listed in separate.

In addition, environmental problems were briefly mentioned for the future consideration of Siperperu.

Current political as well as financial situation of Peru and financial situation of Siderperu were taken into account as the fundamental information for our work on the strategy, but these were not contained in this report except when necessary.

Introduction

The mission was implemented under UNIDO IPCT/TP/OD programme to undertake a fact-finding mission to Chimbote Steel Works and Headquarters of Siderperu for the period of two weeks from 27 April to 8 May 1992 and to advise the company on an appropriate strategy for the improvement of its productivity and technology options to be applied. The mission was composed of three persons, Mr. Keiki Fujita, Director of IPCT/TP of UNIDO, Mr. Juan Angulo Chueca, Consultant engineer in Peru and Kiyoshi Isomura.

As an expert on production and plant planning in iron and steel plant technology, my survey was focussed on productivity and production cost in the integrated steel production processes.

Through our initial meeting with key persons of Ministry of Industry and of Headquarters of Chimbote Steel Works of Siderperu, it was quickly found that the management and production of Siderperu were fatally destroyed during the last decade or so due to the misleading of Peruvian government to the national industrial economy, the unreasonable political involvement to the management of the company as to plunger the profits to be earned, the too-frequent changes of top management of the company, and so forth, and that, as the result, the commercial competitiveness of the company went down to the poorest level even among Latin American steel companies.

However, when the historical development of Siderperu since its commencement in 1958 was reviewed, it was found that additional investments for modernization of steel works were carried out successively in reasonable steps, and the production was achieved at near the design capacity in the 1970s.

At present, the production level is too low to survive due to various reasons such as decreased national market, decreased market share, shortage of electric power supply, shortage of necessary spare parts for plant maintenance, and so forth. In addition, many skilled operators left the company. Notwithstanding, it was rather surprising to find that engineers in plant supervising level were in a high morale and working hard to keep production and to improve it. These human resources can be, I believe, the power for Siderperu in its survival. Therefore, top management persons in headquarters and steel works must be highly responsible for leading the entire employees to effective contribution for survival before these useful engineers and operators become too tired to work in vain. The activities of top management should include a clear and timely indication of company's policy and measures to overcome the crisis, the promotion of sales activity completely different from the previous manner, the industry-based negotiation with Peruvian government for reasonable tax and duty systems, and the arrangement of funds for the minimum investments required for improved maintenance and production.

In consideration of current critical situation, I have chosen, in the first place, to analyze and propose various remedial measures with minimum investments required for the increase of liquid steel production, the increase of steel products obtained therefrom, and the improvement of heat economy in the processes, which should respectively contribute to the reduction of fixed cost and variable cost, and in the second place, to propose the measures to advance to a commercially competitive level, although they shall need a considerable size of investment, and shall belong to technical option. I have to keenly request you to understand that this technical report was prepared based upon the above-mentioned realistic consideration with emphasis on the survival of Siderperu, otherwise I am afraid you will misjudge the value of this report.

I. HISTORY OF SIDERPERU IN BRIEF

In 1958 Siderperu commenced its steel production in Chimbote, which was located at the Pacific coast about 420km north of Lima. Its initial equipment arrangement comprised two Elkem furnaces for ironmaking, two high power electric arc furnaces (EAF) of 30 tons a heat each, attached with two transformers of 15,000 kVA each, a casting arrangement for small ingots, and a merchant bar and rod mill. The Chimbote Works was provided with a pier for directly receiving an ocean boat up to 22,000 tons load, ample supply of water in good quality, ample and stable supply of electric power hydraulically generated, and coal and limestone available in relatively short distance.

The first expansion programme was carried out from 1966 to 1968, when installed were a blast furnace of 5.5m in hearth diameter, two LD converters of 30 tons a heat each, and No. 1 4-strand continuous casting machine for billets.

The second expansion programme was successively carried out from 1970 to 1971 for flat steel products by hot and cold rolling arrangements and a continuous galvanizing line. The hot rolling line comprised a 2-high/4-high roughing mill and a steckel mill with soaking pits and a slab reheating furnace. The cold rolling line comprised a continuous pickling line, a dual-purpose cold reduction and temper rolling mill and a set of batch annealing furnaces.

Additionally installed were a modern continuous electrolytic tinning line in 1976, a wire rod mill in 1976, two electric arc furnaces of 25 tons a heat each in 1977 and 1979, No. 2 3-strand continuous casting machine for blooms and billets in 1977, and three direct reduction kilns of SL/RN type for sponge iron in 1980.

Highest monthly production of liquid iron was marked in August 1974, and lowest fuel consumption in blast furnace was achieved in September 1973. Highest annual production of liquid steel was marked in 1974. Table 1 shows the historical annual production of liquid steel by respective steelmaking furnaces.

These results obviously indicate that operational techniques in production processes were established steadily and quickly and that high standard of engineers and operators in production plants and maintenance was possessed in Chimbote Works.

Table 1. Historical annual production of liquid steel in Chimbote Works

Year	EAF 1	EAF 2	LD converter	EAF 3	EAF 4	Total
1958	21,338	*				21,338
1959	52,549	*				52,549
1960	61,156	*				61,156
1961	75,545	*				75,545
1962	72,893	*				72,893
1963	73,410	*				73,410
1964	75,212	*				75,212
1965	81,406	*				81,406
1966	61,348	*				61,348
1967	59,248	*	2,681			61,929
1968	21,777	*	62,144			83,921
1969	31,503	*	137,498			169,001
1970	10,356	*	61,593			71,949
1971	47,557	*	108,325			155,882
1972	41,734	*	125,659			167,393
1973	105,329	*	227,570			332,899
1974	81,719	83,721	291,061			456,501
1975	65,124	76,637	265,406			407,167
1976	50,067	66,616	205,652			322,337
1977	49,085	68,459	223,056	6,367		346,977
1978	41,538	55,530	225,908	15,011		337,987
1979	44,809	61,687	238,625	31,062	2,625	378,808
1980	55,182	51,991	243,423	29,554	26,804	406,954
1981	56,953	58,019	170,621	28,430	17,591	331,614
1982	38,349	53,221	152,603	0	2,105	246,278
1983	46,238	43,502	100,965	10,047	2,898	203,650
1984	58,939	60,805	0	39,274	38,467	197,485
1985	44,172	47,807	149,513	23,981	20,843	286,316
1986	58,181	61,508	195,212	24,947	17,756	357,604
1987	50,121	53,871	162,675	31,331	31,618	329,616
1988	51,626	50,089	146,314	29,728	30,253	308,010
1989	28,677	33,425	188,241	6,561	8,409	265,313
1990	33,095	31,949	79,499	9,111	14,096	167,750
1991	12,737	21,187	192,624	5,735	2,674	234,957

*Production by EAF 2 is included in that by EAF 1.

II. CURRENT PLANT CONDITION IN CHIMBOTE WORKS

A. Production process flow

Figure 1 shows the flow diagramme of production processes in Chimbote Works.

B. Production capacity - designed or estimated

Table 2 lists the designed or estimated production capacity of respective production units.

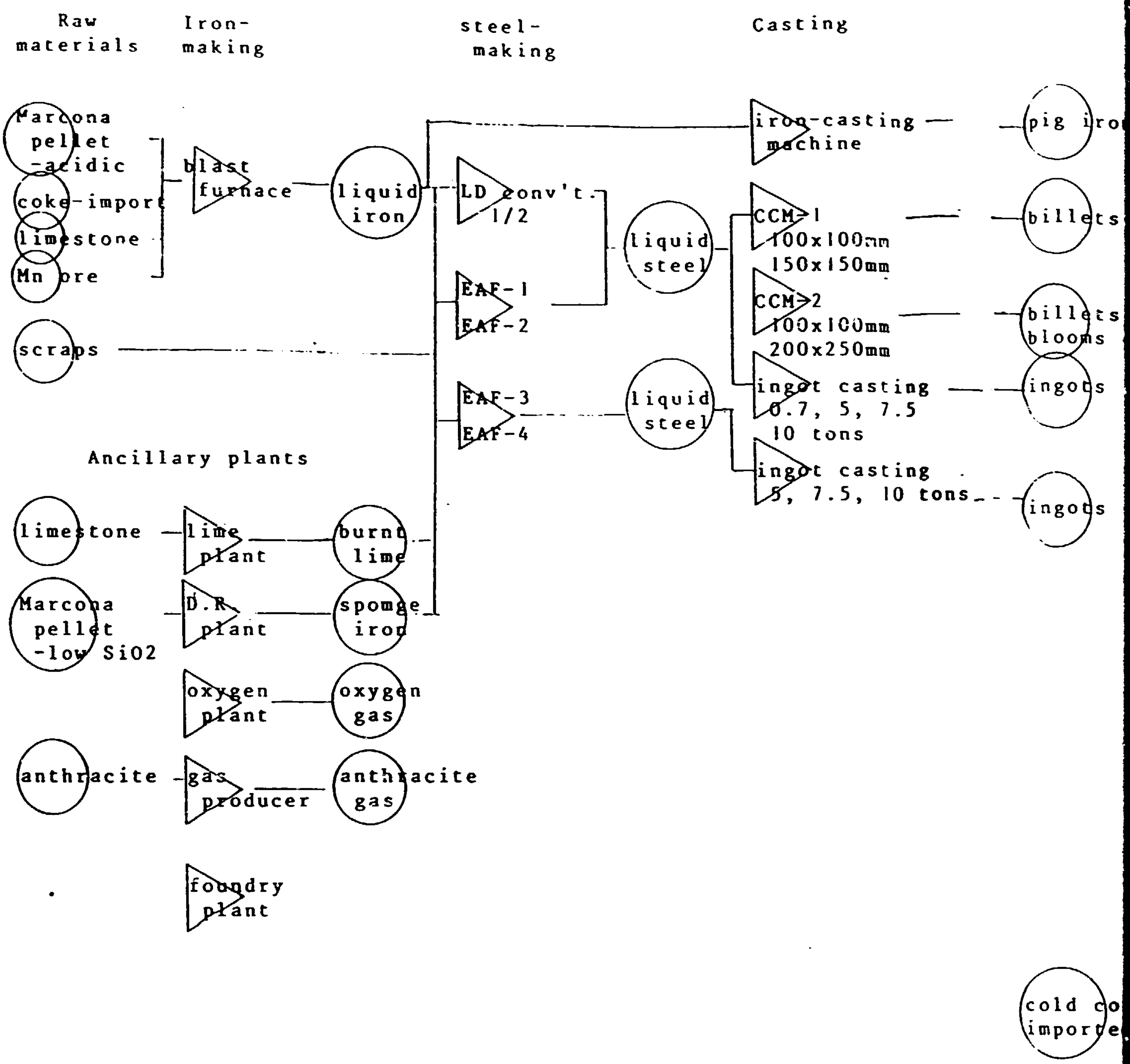
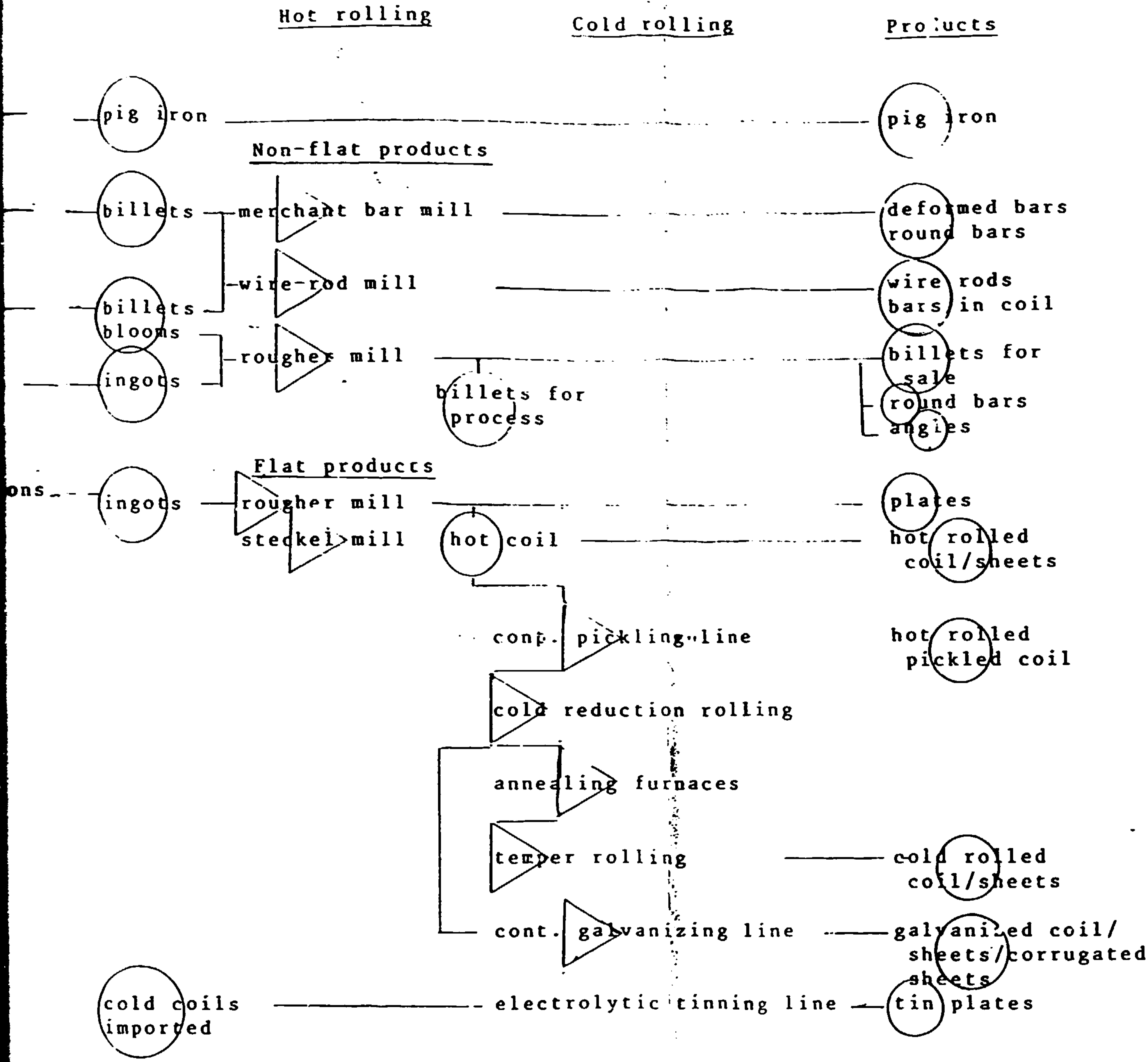


Fig.1. Flow diagramme of production process in Chimbote Works

SECTION 1


Hot rolling
Cold rolling
Products
pig iron
pig iron
Non-flat products
billets
merchant bar mill
deformed bars
round bars
wire-rod mill
wire rods
bars in coil
billets
blooms
ingots
rougher mill
billets for sale
round bars
angles
billets for process
Flat products
ons
ingots
rougher mill
steckel mill
hot coil
plates
hot rolled coil/sheets
cont. pickling line
hot rolled pickled coil
cold reduction rolling
annealing furnaces
temper rolling
cold rolled coil/sheets
cont. galvanizing line
galvanized coil/sheets/corrugated sheets
cold coils imported
electrolytic tinning line
tin plates

SECTION 2

Table 2. Production capacity of respective production units
- designed or estimated

production unit	description		production capacity
blast furnace	hearth diameter: 5.5 m inner volume: 533/556 m3	nominal maximum	550 ton/day 1,000
LD convertor	1/2 furnace operation, heat size: 29 to 32 tons		310,000 ton/y
EAF - 1 & 2	heat size: 30 to 32 tons transformer: 15,000 kVA x 2		82,500 ton/y
EAF - 3 & 4	heat size: 25 to 30 tons transformer: 7,500 kVA x 2		50,000 ton/y
CCM -1	4 strand, vertical and bending billet: 100 x 100, 150 x 150 mm		160,000 ton/y
CCM -2	3 strand, curved mold, bloom : 200 x 250 mm billet: 100 x 100 mm		180,000 ton/y
<u>NON FLAT PRODUCTS LINE</u>			
rougher	2 stand x 3-high roll reheating furnace: 15 ton/h for bloom and small ingot		120,000 ton/y (130 ton/shift)
merch.bar mill	rougher: 2 x 3-high roll cross country: 5 x 2-high mills 1 x finish with a pattern a cooling bed of 80 m long reheating furnace: 30 ton/h		180,000 ton/y -estimated
wire rod mill	rougher: 2 x 2-high roll, intermediate train: 8 stands finishing train: 6 stands, 4 coilers reheating furnace: 30 ton.h		80,000 ton/y (100 t/shift-3/8") (70 t/shift-1/2")
<u>FLAT PRODUCTS LINE</u>			
rougher	2 -high/4-high mill 6 soaking pits, a slab reheating furnace for plates and strips		225,000 ton/y (120 ton/h)
steckel mill	70 ton/h in direct rolling 100 ton/h in inindirect rolling reheating furnace: 100 ton/h		200,000 ton/y -estimated
continuous pickling line			30 ton/h
cold rolling mill		reduction rolling temper rolling	12 ton/h 25 ton/h
annealing furnaces			not available
continuous galvanizing line			2.5 to 4 ton/h
continuous electrolytic tinning line			100,000 ton/y
<u>ANCILLARIES</u>			
oxygen plant	No.1: 2,200 Nm3/h of oxygen gas in 99.5% purity, or, 2,025 Nm3 of oxygen gas and 175 Nm3/h equivalent of liquid oxygen, No.2: 3,200 Nm3/h of oxygen gas, 320 Nm3/h of liquid oxygen and 480 Nm3/h of nitrogen gas		
D.R.sponge iron	3 rotary kilns of SL/RN type		100,000 ton/y
burnt lime			
foundry plant	Capacity is great, casting iron, steel and non-ferrous metals, but not detailed.		

III. TECHNICAL STRATEGY FOR IMPROVEMENT OF PRODUCTIVITY AND REDUCTION OF PRODUCTION COSTS

A. Introduction

Possible survival of Siderperu is supposed to be obtained on one hand, by the increase of sales to domestic as well as export market, and, on the other hand, by the increase of products and the reduction of production costs. These two actions are required to be promoted in parallel as if they are the two wheels of a cart. In addition to the reduction of production costs, the reduction of overhead cost is necessary, which I will not be involved in, but leave to two other mission members to discuss.

B. Basic technical strategy

Based upon the assumed survival policy and programme, I would propose the technical strategy for the increase of products and the reduction of production costs in Chimbote Works in the following:

The existing production process flow was taken as the basis. My basic strategy is composed of:

1) Increase of iron production to start with,

2) Increase of liquid steel production in LD converter using the liquid iron in minimum ratio in charge materials and scraps and sponge irons in maximum ratio, and increase of liquid steel production in EAF plants using scraps and sponge irons and using available electric power in quantity and time,

3) Increase of steel products from the given amount of liquid steel by fully utilizing continuous casting process, and by improving metal ratio in various processes of hot rolling, cold rolling and treatment,

4) Selection of steel products which brings in higher profits and preferential production of those products from a limited amount of semi-steels,

5) Increased utilization ratio of processing lines by purchasing process materials by reasonable, not full, financial arrangement, or by fabrication contract (maquiladora method). These include import or contract-based supply of cold rolled or hot rolled coils for electrolytic tinning line (ETL), that of slabs for hot rolling and that of hot-rolled coils for cold rolling and that of hot-rolled coils for cold rolling and galvanizing,

6) Improvement of heat economy in reheating process,

7) Others,

8) Utilization of foundry plant is another important item for cost saving and profit-making.

9) Maintenance of production plants and auxiliaries is an essential support to the achievement of production programme here I proposed. Revamping of water treatment system is also essential.

10) Improvement of environmental problems throughout the Works belongs to a serious subject in future, which is not included in this production programme here, but I should call your attention on it by listing the items separately.

A strategic production programme I propose as one of the best examples is summarized in Table 3, including some alternatives.

In the following, I will discuss technical details in respective processes.

C. <u>Blast furnace ironmaking</u>

In view of given conditions such as ore burden of 100% Marcona pellets, decreased wind temperature obtainable from existing hot stoves, decreased wind pressure obtainable from existing blowers, etc. I would evaluate high capabilities of engineers and operaters in blast furnace plant to have established their own operational know-how for relatively stable and high production. Marcona pellets are adversely featured by high alkali content and swelling characteristics. Alkali charged into furnace is generally assumed to exit by around 50% into slag and by around 30% into top gas and dusts, and a considerable fraction of alkali is recirculated within the furnace and deposits on the furnace wall, which accidentally exfoliate to cool the furnace, causing a serious trouble. Therefore, a high slag volume as around 270kg/ton of iron is arranged in the operation practice in Chimbote Works by international charge of quartzite and ballast, and a surplus heat level in the furnace is cautiously arranged to avoid a dreadful trouble, resulting in a higher Si content in liquid iron of 0.7% +/- 0.1%. Slag basicity (CaO/SiO_2) is preferable to be lower for the increased washing ratio of alkali into slag, but is arranged as around 1.23 for desulfurization of liquid iron. It is a matter of balance between the decrease of slag basicity for increased alkali distribution into slag, though it results in the decreased slag volume and the decreased desulfurization capacity, and the increase of slag basicity for the reverse effects.

As for permeability in the furnace, Marcona pellets are not so much expected to contribute due to their swelling characteristics, so cokes are major materials to contribute to it, as far as the charging materials are concerned. So burden distribution at the top seems to have been trialed variously by dumping schedule and others as to reach several reasonable alternatives.

When the best monthly blast furnace performances in the past were reviewed, the highest iron production was achieved in August 1974, and the lowest fuel rate was achieved in September 1973, major data of which are respectively listed in Table 4.

Table 3. Strategic production programme in Chimbote Works

Products		production (ton/y)	description
liquid iron	BF	324,000	926 ton/24h required, coke rate: 580 kg/t, oxygen enrichment: 4.0 to 4.5% slag basicity: 1.12, volume: 250kg/t, large size coke breeze recovered, increased wind temperature not included, though recommended.
liquid steel	LD	374,500	34 ton/heat, cycle time of 40 min, with revamped Quantvac, working ratio of 85%.
		396,000*	*after a ladle furnace introduced.
	EAF-1&2	86,400	30 ton/heat, cycle time of 3 h, working ratio of 50%
	EAF-3&4	57,600	30 ton/heat, cycle time of 4.5 h, working ratio of 50%
total liquid steel		518,500	
billet	CCM-1	233,400	sequential cast--6 heats of 32 ton
	CCM-2	26,280	sequential cast- 3 heats of 32 ton
total billet		259,680	
bloom	CCM-2	120,310	spare capacity: 71,760 ton/y bloom
ingot		110,660	
<u>Non-flat products</u>			
rougher products		114,580	120,310 ton/y of bloom only used
bars for construction			
	bar mill	167,470	182,540 ton/y of billet,all produced by CCM
wire rod	rod mill	70,120	77,140 ton/y of billet,all produced by CCM
<u>Flat products</u>			
plate	rougher	41,800	as-rolled basis, 2-shift operation
hot coil	steckel	98,760	2-shift operation
		52,550	direct rolled with own ingots
		46,210	rolled with imported slabs
		(208,240)	spare capacity of rolling slabs imported and contracted

Table 3. - continued

Products	production (ton/y)	description
pickled coil		
pickling line	86,760	30,600 ton for cold coil for sale 23,280 ton for galvalizing 32,880 ton for imported hot coil for tin plateETL)
cold rolled coil		
cold rolling mill	85,080	same three categories as above
cold rolled coil-annealed and temper rolled	about 62,000	
galvalized coil/shets	24,000	
tin plates	100,000	imported cold coil: 66,840 ton cold coil produced from imported hot coil of tin plate quality: 32,280 ton

<u>import of materials required</u>

		(optional)
slabs	46,200 ton/y plus	222,820 ton/y
hot coil of tin plate quality	34,200	
cold coil of tin plate quality	66,840	

While, monthly blast furnace performances in 1991 are also shown in Table 4. data in February through April are excluded, because the furnace was stopped for the period from 22 January to 11 March due to labor strike.

Evaluating various operational data of the blast furnace shown in Table 4. and taking account of current conditions orally informed in the meetings, which included deteriorated capacity of blower in terms of wind pressure and volume, deteriorated capacity of blower in terms of wind pressure and volume, deteriorated capacity of hot stoves in term of wind temperature, non-available oil injection system, and the refreshed furnace lining after a recent partial relining, I would propose that the blast furnace in Chimbote is qualified to aim a stable iron production in amount of 900 ton/day in average (27,000 ton/month) with a net coke rate of 580 kg/ton of liquid iron.

In order to achieve this target, I would recommend several measures described below to be examined and applied by Chimbote people.

Table 4. Operation data of blast furnace, Chimbote in Aug. 1974, Sept. 1973 and 1991

		Aug. 1974	Sept. 1973
Production of liquid iron	(ton/24h)	986.1	816.6
Fuel rate	(kg/ton)		
coke		516.94	447.72
oil		25.33	44.95
total		542.3	492.7
Slag volume	(kg/ton)	274.3	274.9
Slag basicity (Cao/SiO2)		1.22	1.23
Wind temperature	(°C)	917	947
oxygen enrichment		0	0
Iron analysis	(%)		
Si		0.43	0.65
S		0.038	0.040
P		0.045	0.049
Mn		0.77	0.78

Month in 1991	production liq. iron (ton/d)	fuel rate coke * (kg/ton)	slag CaO/SiO2	wind O_2-enrich (%)	iron analysis Si (%)	S (%)
Jan.	(733)	608.7	1.012	7.0	0,98	0.036
May	788	597.9	1.048	0	1.13	0.035
June	687	609.7	1.089	0.6	1.10	0.045
July	763	614.8	1.065	1.1	1.21	0.044
Aug.	678	626.3	1.098	0.9	1.32	0.047
Sept.	518	662.2	1.057	0.2	1.35	0.063
Oct.	750	599.7	1.104	0	1.03	0.042
Nov.	753	581.8	1.117	0	0.86	0.091
Dec.	495	614.6	1.072	0	1.16	0.046

Note: * no oil injected

- slag volume (kg/ton) not available,
- wind temperature of 827°C in January, only available.

1) Oxygen enrichment in wind by 4.0 to 4.5 vol %

Assumption:

No. 1 oxygen plant produces:	2,500 Nm3/hr of oxygen gas
No. 2 oxygen plant does:	3,200 Nm3/hr of oxygen gas and
	320 Nm3/hr equiv. of liq. oxygen
	480 Nm3/hr of nitrogen gas
oxygen gas in total	5,700 Nm3/hr

oxygen gas required in LD convertor:

50 Nm3/ton-liq. steel x 33 ton/heat x 60 min/40 min
= 2,475 Nm3/hr = 2,500 Nm3/hr

oxygen gas required in various plants: 500 Nm3/hr in total,
oxygen gas available for enrichment of wind: 2,700 Nm3/hr
with volume in blast furnace: 48,200 Nm3/hr
oxygen concentration after enriched:
(48,200 x 0.21 + 2,700)/(48,200 + 2,700 = 0.252
increase of oxygen concentration: 0.252 - 0.21 = 0.042 (4.2%)

Note: Oxygen enrichment was practiced in BF, Chimbote in 1992.
Note: Oxygen gas production cab be increased by about 10% without increase of power consumption when gas separation level is modified as to obtain oxygen gas containing 95 to 95% of oxygen and 5 to 4% of argon.

2) Decrease of slag basicity and decrease of slag volume upon agreement

In view of low phosphorus content in liquid iron in Chimbote Works, LD convertor is relatively less loaded in refining of steel, thereby, I would propose what LD will accept some more load in desulfurization upon mutual agreement among BF, LD and QC.

I believe LD plant is rewarded for its contribution by the increased supply of liquid iron at the reduced cost.

Accordingly, I would propose to decrease slag basicity to 1.12 level by steps and to decrease quartzite charge into, say, a half also by steps. These two actions will result to decrease slag volume by 18.5 kg/ton-liquid iron and to decrease coke ratio by 3.7 kg/ton-liquid iron and iron production will naturally increase, as far as the same wind volume can be maintained.

3) Recovery of large size fraction of coke breeze

Cokes are screened before they are charged into a skip using a rubber screen having 19mm square opening. the ratio of under-screen against original coke is reported as 13%. I would propose to recover the large size fraction of coke breeze in the size range of, say, above 12mm and charge them to blast furnace in a separate layer from ordinary lump coke. During the meeting in blast furnace plant, I was pleased to know that they had ever tried this practice in the past, so they know how to do it.

Naturally, this measure shall result the reduction of variable cost as well as the saving of foreign currency for import of coke.

4) Increase of wind temperature

I suppose the surface of checker bricks in hot stoves has been vitrified due to insufficient cleaning of blast furnace gas (BGF) for many years. While lower BFG calory is the result of stable blast furnace operation, which shall not be complained. I would propose that anthracite gas produced in the Works is added to BFG for hot stoves in order to increase gas calory and to increase wind temperature. I would further propose to install additional anthracite gas producers in Chimbote Works for multi-purposes.

5) Production of sintered ore using various ferrous dusts and coke fines both accumulated in Chimbote Works

I know that they were preparing a semi-commercial equipment for this sintering. I hope this project shall progress successfully and quickly. Even though the amount of sintered ore is small, its effect to blast furnace performance must be positive and it will solve a great part of environmental problems simultaneously.

6) Supplemental consideration and notes

I have proposed several remedial measures for the increase of production and the reduction of cost in blast furnace iron-making. However, the most important thing is to keep furnace operation stable by all means, therefore, the measures proposed are necessary to be implemented by reasonable steps.

As obvious, the measures 1), 2) and 3) shall be scheduled to be implemented soon without any capital investment involved, the measure 5) has already been put on a rail, and the measure 4) shall be investigated on availability of anthracite gas, capital investment required, feasibility and safety.

My last proposal shall be a thoughtful challenge to decrease Si content in iron. This can be carried out only under a stable furnace condition and with a prepared manual on how to quickly retire to a safety zone when any irregularity is indicated.

D. Production of liquid steel by LD and EAF

1) Production quantity of liquid steel by LD

1.a) Quantity of liquid steel obtainable by LD convertor from available liquid iron.

27,000 ton/month x 100/80 x 1/1.09 = 30,960 ton liq. steel/month
27,000 ton/month x 100/75 x 1/1.09 = 33,030 ton liq. steel/month
Assumption for above calculation:
All liquid iron of 27,000 ton/month is supplied to LD converter without being cast to pig iron.

Hot metal ratio: 80% (and 75% when a ladle furnace is equipped).
Metal ratio: 1.09.

Therefore, my first proposal should be a lower hot metal ratio and an increased scrap in charge. Scrap inventory is too abundant and D.R. sponge supply is limited in Chimbote Works.

1.b) <u>Quantity of liquid steel obtainable by LD converter depending upon heat size and working ratio</u>.

It is calculated as below:

30 ton/heat x 60/40 x 24 x 30 x 85/100 = 27,750 ton liq. steel/month
x 90/100 = 29,160
34 ton/heat x 60/40 x 24 x 30 x 85/100 = 31,210
x 90/100 = 33,050

Assumption for above calculation:

Heat size: 30 and 34 tons

Cycle time (tap-to-tap): 40 min.

Working ratio: 85 and 90%

It is seen that heat size of 30 tons is not good enough to reach the quantity given in subsection 1.a) even at the working ratio of 90%. Thereby, my second proposal is the increase of heat size up to 33 to 35 tons.

1.c) <u>Decrease of cycle time in LD converter operation</u>.

Another calculation below given was based upon a cycle time of 36 min.

30 ton/heat x 60/36 x 24 x 30 x 85/100 = 30,600 ton liq. steel/month
x 90/100 = 32,400
34 ton/heat x 60/36 x 24 x 30 x 85/100 = 34,680
x 90/100 = 36,720

Therefore, my third proposal is rehabilitation of Quantvac (vacuum emission spectrometer) in order to decrease the analysis time of steel sample and to decrease cycle time to 36 min. which is normal internationally. It was surprising to know that they were forced to waste 8 to 10 min without doing anything before the sample analysis was reported. This analysis time should be less than 5 min. including the times for sampling, sample conveying, analysis and reporting.

My advice given to the steel plant chief during meeting shall be remembered that, although I recognize well the effective investment to a ladle furnace, he had better to propose to the top management people in Chimbote Works to give priority to the rehabilitation, that is, intensive maintenance or replacement, of Quantvac analyzer, if a fund is too short to invest in both.

The reduced cycle time in LC operation is also effective to match with the casting time in No. 1 continuous casting machine (CCM), so that sequential continuous casting operation in increased number of heats is supported on one hand, and increased scrap ratio is supported on the other hand.

2) **Production quantity of liquid steel by EAF**

Because of restricted and unreliable electric power supply, steel production by four EAFS is hard to assess theoretically. However, as scrap inventory in Chimbote Works is very high, which should be value-added, and as the demand for semi-steel in the down-stream processes in Chimbote is high, the higher steel production by EAF is requested to be managed in the given condition.

Based upon rough and rather conservative assumption, steel production by EAFs is calculated as:

EAF No. 1 and 2:
30 ton/heat x 24/3 x 30 x 50/100 x 2 = 7,200 ton. liq. steel/month

EAF No. 3 and 4:
30 ton/heat x 24/4.5 x 30 x 50/100 x 2 = 4,800

TOTAL 12,000

Assumption for above calculation:

- Cycle time: 3.0 hr in EAF No. 1 and 2, and 4.5 hr in EAF No. 3 and 4
- Working ration: 50% respectively (effect of metal ration is included in it)

E. Cost reduction in steelmaking

1) **Cost reduction in LD convertor plant**

Liquid steel temperature at blow-end was reported to be in the range of 1,680 deg.C to 1,700 deg.C in case of continuous casting, compared to around 1,620 deg.C in case of ingot casting, which causes a high refractory consumption in LD furnace and a restriction to the decrease of hot metal ratio.

Installation of a ladle furnace can one of the effective measure for the decrease of blow-en temperature. In addition, I would propose following measures to be applied immediately before a ladle furnace is installed.

1.a) **Rehabilitation of Quantvac analyzer**

As previously mentioned, decreased sample analysis time by about 5 minutes should allow a decrease of blow-end temperature by 10 deg.C.

1.b) **Turning-around rate of hot steel ladle**

Take one ladle out of a fleet of steel ladles presently turned around, and put it at a ladle preheating station as a stand-by. Then, liquid steel are tapped into ladles at higher temperature, so that the temperature drop of liquid steel can be reduced before being cast. Bold estimation will allow the decrease of blow-end temperature by 10 to 15 deg.C.

Above two measures together will allow decreased blow-end temperature by 20 deg.C, which must be a critical improvement for the present problems.

1.c) **Additional measures for decreased blow-end temperature**

In knowing that a lid has been applied on a steel ladle and some amount of heat insulating materials like rice chaffs is applied to cover the surface of liquid steel in a ladle, additional measures I would propose is application of insulating refractories as safety lining of ladle and application of an increased amount of heat insulating materials on liquid steel in ladle.

1.d) **Other cost reduction measures**

The steel plant management has set up a series of cost reduction targets to be worked at in the year of 1992, as shown in Table 5. All of the items are important for cost reduction, and I hope the targets are achieved steadily.

Among various items projected, I will discuss and propose some measures for cost reduction of refractories in LD furnace, EAF and steel ladle.

- **Refractories for LD furnace lining**:

90% MgO bricks are presently used. Campaign life of furnace lining is said to be about 400 heats in average and 570 heats at the best. Slag coating practice is applied for protection of refractory lining on the sides of steel tapping and slag dumping.

Decrease of steel temperature at blow-end, as previously proposed, should belong to fundamental measures for longer service life of furnace lining. Decrease of holding time of liquid steel at the highest temperature in the furnace by a quicker sample analysis must contribute greatly to the same purpose. Increase of MgO content in slag in furnace can be a protective measure to MgO bricks. I suppose this practice is going to be applied in EAF operation, but why not in LD operation. Intensive gunning repair on trunnion side lining using a suitable gunning equipment and suitable gunning mix is another useful measure to be worked for.

Unfired MgO-C bricks have been developed and popularly applied to the lining of LD furnace in Japan and the world, and have proven to achieve a campaign life over 4,000 heats. These bricks should be examined for a trial.

- **Refractories for EAF lining:**

Continuous feeding system of sponge iron was already installed on EAFs, and is useful not only for the increase of steel production, but also for the reduction of refractory cost.

In future consideration, remodelling of EAF No. 3 and 4 to the side wall structure of water panel type is recommended for refractory cost reduction, especially when the transformer capacity is levelled up.

Table 5. Cost reduction targets of steel plant in Chimbote Works in 1992

item		1991	Std	1992
EAF No.1 and 2				
metal ratio	(kg/t)	1,101	1,100	1,090
energy concumption	(kWh/t)	761.0	720.0	720.0
electrode consumption	(kg/t)	5.6	6.0	6.0
refractory consum.-wall	(kg/t)	3.5	3.5	2.9
gunning material consum.	(kg/t)	5.8	6.5	7.0
dolomite consumption	(kg/t)	N.D.	3.0	5.5
EAF No.3 and 4				
energy consumption	(kWh/t)	760.0	700.0	700.0
electrode consumption	(kg/t)	9.1	7.0	7.0
refractory consum.-wall	(kg/t)	13.0	13.5	10.5
gunning material consum.	(kg/t)	7.6	6.0	7.0
dolomite consumption	(kg/t)	N.D.	5.0	6.5
LD converter				
metal ratio	(kg/t)	1,090	1,085	1,083
furnace lining life	(tap)	375	375	380
refractory consumption	(kg/t)	8.5	8.5	8.2
fluospar consumption	(kg/t)	4.3	5.0	4.0
Mn or consumption	(kg/t)	9.7	10.2	9.0
CCM No.1				
metal ratio	(kg/t)	1,049	1,050	1,045
sequential casting	(heat)	3.0	5.0	5.0
tundish refractory consum. without PF	(kg/t)	7.3	7.0	6.8
life of mold-100x100mm	(t/mold)	814	735	814
CCM No.2				
metal ratio - bloom	(kg/t)	1,121	1,100	1,100
metal ratio - billet	(kg/t)	1,100	1,085	1,070
sequential casting via LD	(heat)	2.0	3.0	3.0
tundish refractory consum. without PF	(kg/t)	13.2	13.0	12.5
increase of use of tundish with PF	(%)	-	15.0	20.0
oil consumption	(gal/t)	3.29	-	3.00
life of mold-100x100mm	(t/mold)	761.0	735.0	760.0
life of mold-200x250mm	(t/mold)	2,071	1,650	2,071
Ingot casting				
metal ratio - flat ingot	(kg/t)	1,027	1,020	1,020
metal ratio - type E ingot	(kg/t)	1,112	1,080	1,080
ingot case consumption	(kg.t)	29.6	23.0	23.0
stool consumption - flat	(kg/t)	9.84	9.00	8.00
ladle refractory consum. with nozzle/stopper	(kg/t)	11.52	7.5	7.0
ladle refractory consum. with sliding gate valve	(kg/t)	12.5	7.0	6.5
reduction of waste liquid steel	(%)	10	10.0	8.0

- **Refractories for steel ladle lining:**

I understand that a series of comparison test is being arranged between conventional silica-alumina bricks and high-alumina ones on the side wall of steel ladle. I hope they will get a good result.

Slag cutting during steel tapping from LD convertor is another effective practice for prevention of refractory erosion in ladle. Slag ball technique is recommended to be tried, instead of sophisticated slag detection and cutting system.

F. Casting

1) Continuous casting

Continuous casting of steel belongs to one of the most effective processes for improvement of metal ratio and heat economy in steel production. Therefore, all liquid steels are desired to be cast by two continuous casting machines (CCM) in Chimbote Works, except a minimum amount required for ingots for flat products.

At present, cycle time of LD convertor tends to be longer than casting time. Thereby, I proposed emphatically to decrease the cycle time of LD convertor in preceding subsection D.1).

Production capacity of CCM is calculated by equation below.

$$Q = (To \times 60 \times WR/100)/[ton/heat/(A \times Nst \times Vc \times 7.8) \times n + Tp] \times ton/heat \times n \times Y$$

where,
- Q: production quantity of semi-steel (ton)
- To: total hour on calendar
- WR: working ration of CCM (%)
- A: cross sectional area of semi-steel (m2)
- Nst: number of strand
- Vc: casting velocity (m/min)
- n: number of heats sequentially cast
- Tp: preparation time (min)
- Y: metal yield (ratio of semi-steel/liquid steel)

As is well known, the increase of n is most effective to the increase of production capacity, as well as to the increase of metal yield. It was 3 heats in average in 1991, and it is aimed to be 5 heats in 1992 in No. 1 CCM. I would propose that 7 to 8 heats in average can be aimed for sequential casting using a tundish in this CCM, because operators have experienced up to 8 heat-sequential casting some time in the past, so they are qualified to do that. While 3 heats shall be the highest number expectable in No. 2 CCM due to a limited supply of liquid steel in time.

I previously proposed billet production of 19,400 ton/month by No. 1 CCM in a strategic production programme in Table 3, based upon heat size of 32 tons, WR of 75%, Vc of 2.5 m/min, n of 6 heats and TP of 60 min, and billet production of 2,190 ton/month and bloom production of 10,030 ton/month with a spare bloom production capacity of 5,980 ton/month by No. 2 CCM, based upon heat size of 32 tons, WR of 65%, VC of 2,5 m/min for billet and 1.6 m/min for bloom, n of 3 heats and Tp of 70 min.

The data below will be a useful information for SIDERPERU to refer to in future, which was stably achieved by a CCM in Japan.

billet production: 443,600 ton/year
heat size: 76 tons
WR: about 75%
A: 0,0169 m2 (130 x 130 mm)
Nst:4
Vc: 2.6 m/min
n: 18.83 heats in annual average (by change of tundish)
Tp: about 50 min
Y: 99.2% or metal ratio of 1.008
casting time and cycle time: both 65 min/heat

2) <u>Ingot casting</u>

At present, ingot casting arrangements have been made for slab ingots of 10 tons, medium size ingot of 3.75 tons, and small billet ingots of 0.7 tons. Liquid steel is cast into ingot cases on a baggy.

In my proposed production programme, casting of small ingots was excluded from operation, because all billets to be rolled in a merchant bar mill and a wire rod mill can be supplied by two CCMs. Thereby, following description is related only to slab ingots.

For the improvement of metal yield from liquid steel to ingot, it is essential, in the first place, to control the heat size as to fit 3 x 10 ton ingot or 8 x 3.75 ton ingot so that a minimum amount of liquid steel is wasted, and, in the second place, to increase ingot size as to match the increased heat size like 33 to 35 tons, as I proposed in preceding section D.1.b). Increased ingot size should result in an increased metal yield in roughing rolling process.

For the increase of metal yield in roughing rolling from ingot to slab, my first recommendation is intensive application of hot top, perhaps of exothermic type, to large killed steel ingot. In this connection, I would advise to study a possible application of electric heating at ingot top using a conventional welder and consumable metallic electrode obtained from the crops of bars and rods. My second recommendation is a slight modification of ingot botton shape in convex so as to reduce the shear loss due to fishtail in roughing rolling.

Anyway, the recommendations given above are effective before a continuous casting machine for slab/bloom is installed.

3) <u>Additional measures to be taken in CC plant for the improvement of metal yield in merchant bar mill</u>

A stopper was recently installed at the cold shear in bar mill. Adjusted shearing operation belongs to the job of bar mill, aiming at an increased product yield from the hot-rolled and cooled bars. In order to achieve a satisfactory result here, the first support should be provided by a scheduled and controlled operation of the flying shear on delivering line

Table 6. Guidance information on profits of various steel products (US$)

	Ps	Cv	Cf	Ct	profit
billet for sale	325.9	238.68	13.70	252.39	73.47
bars for construction	437.8	297.26	50.24	347.50	90.34
wire rod for wire/nails	439.3	358.96	70.51	429.48	9.82
wire rod for electrode	508.3	377.42	66.48	443.91	67.36
round bar for mine	483.4	286.91	64.60	351.51	131.90
round bar for balls	472.1	297.05	51.81	348.85	123.29
straight commercial bars	472.1	283.75	51.81	335.56	136.58
thick plate	566.0	393.26	42.57	435.83	130.17
hot rolled coil	492.5	338.03	41.40	379.43	113.11
hot rolled sheets	540.7	323.35	40.50	363.85	176.83
cold rolled coil	610.9	449.07	124.52	573.58	37.33
cold rolled sheets	645.3	439.60	117.44	557.05	88.20
galvanized sheets, corrugated	945.2	514.48	130.96	645.45	299.77
tin plates for lacteous products	954.1	884.22	34.93	919.16	34.90

Remarks: Ps: sales price
Cv: variable cost
Cf: fixed cost
Ct: total cost
Profit = Ps - Ct

after the finishing stand. In addition, the second support can be provided by CC plant by cutting billets exactly in various specified lengths. In this connection, quality control department should be responsible for the feed-back and feed-forward of actual operational information between merchant bar mill and CC plants, directly or via some production scheduling section, depending upon the job responsibility organization in Chimbote Works.

G. Rolling and coating processes

1. Strategic production programme

The improvement of metal ratio in down stream production processes is very important not only for the increase of products amount, but also for the reduction of cost. Otherwise, added values accumulated in the preceding processes are wasted in form of return scrap.

According to a guidance information on the profit of various steel products of SIDERPERU prepared in its headquarters, as listed in Table 6, the products of high profit included corrugated galvanized sheet and plain galvanized sheet/coil, those of medium profit included hot rolled sheet, straight commercial bar, thick plate, hot rolled coil, round bar for mine and round bar for ball, and those of very low profit included wire rod for wire and nails and cold rolled coil. Tin plate seems to bring in an acceptable profit in export market. The other products like deformed bar for construction, wire rod for electrode, cold rolled sheet, and billet bring in just acceptable profits.

Under the current condition in the Steel Works of insufficient production capacity of liquid steel to feed both non-flat and flat rolling mills, it should be the strategic principle in the first place to arrange a greater production of high profit products and a small or non production of low profit ones. The latter includes wire rod for wire and nails, which is supposed to occupy a large fraction of wire rod market. While production capacity of CC machines for 100 mm square billet was calculated to be good enough to satisfy both merchant bar mill and wire rod mill. I came to a dilemma, but decided, as one of the choices, to allow the wire rod mill run at reasonably high rate, in order to take advantage of low metal ratio between liquid steel and billet in CC process. Then, a positive solution to this dilemma is necessary to be thought as to make this mill profitable, which will be discussed later.

Round bar and other products from the non-flat rougher line are medium profitable, so this production was assigned at full rate. While No. 2 CCM reserves a spare production capacity of bloom of about 72,000 ton/y. Therefore, it shall be noted that additional blooms can be easily supplied, if the rougher line can increase its production without causing a bottle-neck in its down stream, like straighter, cooling bed, and stock yard.

I assumed that the capacity of flat-rougher and steckel mill line is too big to work fully, even a considerable amount of slabs is imported, so I assigned two-shift operation to this line. Production of thick plate on as-rolled and sheared basis was assigned as 41,000 ton/y. All of hot coils were assumed to be rolled directly from ingot, except from imported slab.

Production of cold rolled coil and sheet via annealing and temper rolling was assigned as 30,000 ton/y which was much lower than its capacity, but was not squeezed drastically, though they are low profit products, because they are important and basic material for advanced industry and are the own products of SIDERPERU.

In consideration of spare capacity of cold rolling, a part of cold rolled coil for tin plate was switched to hot rolled coil, both to be imported. I hope a risk of quality problem is overcome, except the case of thin tin plate.

Production of the other lines was calculated on full rate basis, and the distribution of billet and bloom from CCM and those of ingot, slab, hot rolled coil and cold rolled coil were arranged reasonably.

Finally, respective amounts of slab, hot coil and cold coil were determined as summarized in the proposed production programme.

2) **Calculation for production programme, for example**

2.1) **Non-flat products line**

- rougher: products: round bar and others
  130 t/sh x 3 sh/d x 26 d/m = 10,140 t/m
  10,140 t/m x 11.3 m/y = 114,580 t/y
  bloom required: (metal ratio: 1.05)
  114,580 x 1.05 = 120,310 t/y

- merchant bar mill: products: deformed bar for construction
  190 t/sh x 3 sh/d x 26 d/m = 14,820 t/m
  14,820 t/m x 11.3 m/y = 167,470 t/y
  billet required: (m.r. 1.09)
  167,470 x 1.09 = 182,540 t/y

- wire rod mill: products: wire rod
  1/4" 70 t/sh 50%
  3/8" 100 t/sh 50% average 85 t/sh
  85 t/sh x 3 sh/d x 25 d/m = 6,375 t/m
  6,375 t/m x 11 m/y = 70,125 t/m
  billet required: (m.r. 1,10) - (1.07 to be aimed at)
  70,125 x 1.10 = 77,140 t/y

- billet and bloom balance
  total billet required: 182,540 + 77,140 = 259,680 t/y
  billet supplied from No. 1 CCM: 233,400
  billet to be supplied from No. 2 CCM: 26,280
  billet production capacity of No. 2 CCM: 125,800 t/y
  utilization ratio of No. 2 CCM for billet required:
  26,280 / 125,800 = 0.2089
  bloom production capacity of No. 2 CCM: 242,880 t/y
  available bloom production capacity of No. 2 CCM:
  242,880 t/y x (1 - 0.2089) = 192,140 t/y
  bloom required: 120,310
  spare bloom production capacity of No. 2 CCM: 71,830 t/y

- liquid steel balance and ingot

liquid steel supply:			
LD convertor			374,520 t/y
EAF in total			144,000
TOTAL			518,520
liquid steel used:			
No. 1 CCM: for billet.	233,400 t/y	x 1.045 =	243,840 t/y
No. 2 CCM: for billet.	26,280	x 1.10 =	28,910
for bloom.	120,310	x 1.10 =	132,340
TOTAL			405,090
liquid steel available for ingot:			113,430 t/y
ingot obtained: (m.r. 1.025)			110,660 t/y

2.2) Flat products line

- shift schedule

	shift	working time
rougher and steckel	2	4,752 h/y = 8 x 2 x 30 x 11 x 0.90
pickling	3	7,128 h/y = 8 x 3 x 30 x 11 x 0.90
cold rolling	2	
galvanizing	3	
tinning	3	

- rougher for thick plate:
  production of thick plate (as rolled as sheared):
  3,450 t/m x 11 m/y = 41,800 t/y
  working time required: 41,800 t/y/ 100 t/y = 414 h/y
  working time of rougher available for direct rolling:
  4,752 - 414 = 4,338 h/y

- steckel mill for hot strip coil
  production capacity of hot coil (direct rolling from ingot)
  in available time: 70 t/h x 4,338 h/y = 303,660 t/y
  hot coil required for cold rolling and
  coating processings:

for cold rolled coil/sheet for sale:	33,530 t/y
for galvanizing:	25,680
for tinning:	36,210
TOTAL	95,420 t/y

hot coil produced from available ingot: 60,900 t/y/ 1.15 (metal ratio) =	52,960 t/y
hot coil required for above three processings to be produced from imported slabs:	42,460 t/y (95,420 - 52,960)
(imported slab required):	(45,430 t/y)
hot coil for optional sales to be produced from imported slab:	208,240 t/y (303,660 - 95,420)
(imported slab optionally required)	(222,820 t/y)

3) Problems and remedial measures in non-flat products line

3.1) Merchant bar mill

Metal ratio of 1,088 was explained to come from mill scale of 2.0% misroll of 2.7% and crop loss of 3.8%, which comes mostly from cold shear and some from flying shear.

Cold shear operation of bars is most responsible in this plant for production quantity and cost, because the crops sheared off is a waste of all added values in the preceding production processes. It must be a great step forward that a stopper was installed recently for bar end alignment.

In addition, I would propose that the operation of flying shear should be adjusted in relation to the specified length of final bar products by customers.

I would also propose that the length (more exactly speaking, weight) of billet cut in continuous casting machines should be adjusted under major responsibility of Q.C. department, as I previously discussed in subsection F.3).

A high misroll ratio is another big problem. I assume it is more often attributed to inadequate guide in terms of shape and set position as well as to, of course, inadequate roll caliber. It is a complicated technical matter, so I would recommend to be consulted with an expert.

A problem is reheating furnace is a high exhaust gas temperature which was as high as 800 deg. C., though about a half of this waste heat energy was recovered by a recuperator. (Exhaust gas temperature after a recuperator was 400 deg. C. and combustion air was preheated up to 300 deg. C.) Extension of furnace length, which was said to be projected, is the best solution by arranging a relaxed heating rate and a stable soaking of billets in the furnace. Before, and even after this tension, I would recommend to apply optimum plus-pressure control in furnace.

3.2) Wire rod mill

A high metal ratio of 1.147 was reported, comprising scale loss of 2.0% misroll of 3.1% and crop loss of 8.2%, an unbelievable figure. The main reason for this high crop loss explained was decreased bar temperature especially in the rear part before entering the intermediate roll train, and the obliged shearing-off in a considerable length.

The remedial measures I would propose are 1) installation of a heat-holding arrangement between roughing roll and intermediate roll train with a cover and a burner, and 2) revision of rolling schedule as to have a larger bar gauge from roughing roll.

A fundamental solution to this problem shall be included in the following proposal for improving the wire rod mill as profitable and commercially competitive. It contains,

coil weight of wire rod is doubled,
billet size is changed from 100mm square to 150mm square,
a stand is added to the intermediate roll train,
bar gauge from roughing roll is enlarged,
reheating furnace is revamped, and
a patenting arrangement, for instance, of Stelmore type, is incorporated.

4) <u>Problems and remedial measures in flat products line</u>

4.1) <u>AGC in steckel mill</u>

It was complained that automatic gauge control (AGC) system was not maintained healthy, resulting in a steel strip poorly controlled in thickness as well as in width, and the latter caused a high trimming loss in the picking line. This instrument is a necessity in steckel mill, like a Quantvac in LD converter. I would propose that AGC is completely overhauled or replaced at the highest priority.

4.2) <u>100% direct rolling</u>

The strategic production programme I proposed was based upon a complete direct rolling, because this practice has been well established. When some operational problems such as to disturb continuation of direct rolling happened, the remedial measure I would propose is to stop the rolling operation, because some time loss might be allowed. It is highly probable that this mill is not fed sufficiently with imported slabs even upon two-shift operation basis.

4.3) <u>Continuous pickling line</u>

A high crop loss was reported to occur at the entrance of pickling line by cutting both front and rear ends of strip in a large length and by trimming the side in relatively large margin. The former was explained to be due to oxidation-oriented surface defects on strip, which were assumed to be attributed to the remaining of strip end in air atmosphere without entering into furnace coiler. I partly agree with this assumption, but think it will not be the entire reason. I would propose to test a blowing of inactive gas, like exhaust gas from the furnace coiler, onto the surface of strip during rolling, so that they can quickly identify the contribution of air oxidation to these defects.

A tentative remedial measure I would propose before a fundamental solution is obtained is that the crop shearing of slab on its front side is roughing rolling of ingot is shortened intentionally within such an extent that no trouble is caused on the steckel mill line. The, the crop loss of useful strip on its front side sheared in the pickling line can be saved.

Regarding the trimming loss, the trimming margin should be adjusted sensitively, say, into a half. In my observation, they can do it manually before a sophisticated control system is introduced.

IV. OTHER PROBLEMS TO BE SOLVED

A. Water supply system

Original water is supplied to Chimbote Works from the wells in the valley of Rio Santa, located at about 7 km north of the Works and across a hill. At the top of the hill in elevation of about 100 m. two water reservoirs of 1,500 m3 capacity each are placed, thereby, a water line pressure of about 9.5 kg/cm2 is given. Quality of the water is mostly good containing about 500 ppm of cations. Softening treatment by ionic exchanger is applied to water for particular equipments, including blast furnace, hot stove, boiler, EAF and CCM. However, water recirculation system was not designed appropriately and has not been maintained well, though it belongs to one of essential infrastructures in an integrated steel works demanding a great amount of water in reasonable quality. In fact, many problems were claimed by various plants because of poor water quality supplied by recirculation. Under the rehabilitation project, especially in its Lot 3 group, a part of these problems is understood to be solved in near future as to satisfy various functions such as cooling, separation of dusts, separation of oil and grease, and softness control, depending upon the requirements. However, I am afraid many problems will remain unsolved for some time due to the limited financial allowance. I would propose that an additional attention shall be paid to the re-examination of very necessary facilities in water supply system with the minimum investment in order to remove the critical obstacles from the production processes which are struggling for a full achievement of the proposed product programme for the survival of Siderperu.

B. Environmental problems

They are briefed as follows:

- **Items in first priority:**

  Complete dust collection from exhaust gas of LD converter without releasing that dark brown smoke into the atmosphere.

- **Items in second priority:**

  Handling of dry and wet dusts collected in blast furnace gas cleaning system, the handling system of which preferably includes a washing-off treatment of alkali.

  Dust collection arrangement for burnt lime fines at lime kiln plant and at steel plant.

  Disposal of oil and grease separated from recirculated water.

  Disposal of sewage water.

  Arrangement of granulated blast furnace slag to cement plant and other useful application.

- **Items of third priority:**

Collection of fines of coke, pellet, sponge iron and limestone generated during various handlings such as screening, conveying, stacking, reclaiming and unloading.

Pavement of roads inside the Works and maintenance of them clean.

V. TECHNICAL OPTIONS

They are listed below with a brief description:

- **Items in first priority:**

A ladle furnace - to be installed in LD converter plant.

- **Items in second priority:**

A slab/bloom CCM - by remodelling of No. 2 CCM, but preferably by installation of a new equipment in connection with the installation of No. 3 LD converter and that of No. 2 blast furnace.

Gas producers - using anthracite, but not limited.

Import of sized iron ore - for dilution of adverse effects of Marcona pellets.

- **Items in third priority:**

Installation of No. 4 hot stove for No. 1 blast furnace.

Installation of No. 2 blast furnace - inner volume of 1,000 m3 of high top pressure type.

Installation of No. 3 LD converter

Recovery of LD gas - by non-combustion system.

Replacement of transformers for EAFs to ultra-high power level.

- For confirmation, following items are understood to belong to those implemented without question.

Extension of reheating furnace for merchant bar mill.

Refreshment of Quantvac analyzer.

Refreshment of AGC in steckel mill line.

Revamping of water recirculation system for critical necessity.

VI. ENTIRE COST REDUCTION ASSESSED

Entire cost reduction was assessed in the region from iron production in blast furnace to the production of both non-flat and flat products by hot rolling, excluding the production of hot coils from slabs optionally imported. In this region, EAF steelmaking and non-flat rougher products were excluded due to lack of cost data. The region of cold rolling and coating was also excluded from this assessment, because the results could be too variable, depending upon the amount of imported materials for those processes. This assessment was carried out based upon the conditions given in my proposed strategic production programme, and were compared to the cost data prepared by the financial department in Chimbote Steel Works.

The results are listed below:

	Monthly Production (ton)	Reduced cost ($/ton) Variable	Fixed	Total
Liquid iron - BF	27,000	6.34	1.36	7.70
Liquid steel - LD	30,960	22.27	2.09	24.36
Billet - No. 1 CCM	19,400	21.76	5.77	27.53
Billet/bloom - No. 2 CCM	12,220	19.84	19.48	39.32
Bar mill	14,820	30.83	9.97	40.80
Wire rod mill	6,370	97.72	23.76	121.48
Thick plate	3,450	25.14	10.60	35.74
Hot coil-direct	4.410	4.06	9.82 *	13.88
	3.450 *1			
Total hot coil	7,950			

*1 - Hot coil produced from imported slab.
* - This figure can be increased, depending upon the utilization of spare rolling capacity of 17,350 ton/month.

VII. CONCLUSION

Thanks to the full support of all persons concerned in Chimbote Steel Works, who shared their time for discussion with us and forwarded necessary information to us quickly, and to a number of persons in the Headquarters of Siderperu and of the Ministry of Industry of Peru, we could carry our fact-finding mission effectively and efficiently during the limited period of two weeks.

As the results, the actual conditions in the whole Works and respective plants were cleared, the problems were identified and the remedial measures were proposed for immediate action with a small or no capital investment involved and for near-future action, with some size of investment after a thorough examination by Siderperu.

The proposed strategic production programme will seem to be so great in terms of productivity, compared to the actual production they have performed in the past, especially to the current production level. But I do not think the proposed figures are too theoretical. In fact, the production capacity of iron and steel making is too small to feed the full operation of all hot rolling lines in parallel. Therefore, it must be true that they have not had the opportunity of real full operation without a great amount of imported materials for rolling. They may start from any production level to the proposed one, but should progress by 5% higher in every three to six months.

Participation of all operaters in the plant not only to the operation but also to fact-finding, reporting and group discussion for trouble shooting is effective and really necessary.

As I emphasized in the early part of this report, market development for Siderperu is the most important support to the survival of the company.

I hope this report will provide a valuable guidance for the improved productivity and the reduced cost immediately as well as in near future, eventually making Siderperu a competitive and attractive commercial enterprise.

ANNEX 1

TERMS OF REFERENCE

Post Title: Expert on production and plant planning

Duration: 2 weeks

Date Required: 27 April 1992

Duty Station: Peru (Lima, Chimbote)

Purpose of Project:

To undertake a fact-finding mission to Chimbote Steel Works and Headquarters and to advise the company on an appropriate strategy for the improvement of its productivity. For this purpose, the expert is to:

(i) investigate the current conditions at the plant in terms of

(a) production,
(b) operation, and
(c) maintenance;

(ii) pinpoint problem areas impairing production stability and increases;

(iii) suggest solutions; and

(iv) calculate rough costs of items (ii) and (iii)

Duties: The expert is to join the UNIDO mission to Chimbote and participate in the preparation of a joint advisory technical report, especially in the areas of production and plant planning.

Qualifications:

(i) university graduate or equivalent academic career

(ii) more than five years of experience in a steel company or steel company subsidiary

(iii) cooperative personality

Language: English, some knowledge of Spanish would be an asset.

TOKYU TOURIST CORPORATION

HASHIMOTO BLDG 2ND FLOOR
24-1 SAKURAGAOKA-CHO
SHIBUYA-KU TOKYO JAPAN
AREA CODE 150
PHONE (03)464-[illegible]
FAX [illegible] 2474

ANNEX 2

ITINERARY

Mr. K. Isomura

DATE: April 22, 1992

DATE	DAY	PLACE	LV/AR	TIME	FLIGHT NO.	CLASS	REMARKS
Apr 25	Sat	Tokyo, Narita	Lv	14:00	NW-006	C	OK 25J
		Minneapolis	Ar	11:15	(11:15) nonstop		smoking
Apr 25	Sat	Minneaplis	Lv	13:15	NW-576	F	OK 1D
		Miami	Ar	17:50	(03:35) nonstop		nonsmoking
Apr 26	Sun	Miami	Lv	16:50	AA-917	Y	OK 37B
		Lima	Ar	21:40	(05:50) nonstop		smoking
May 09	Sat	Lima	Lv	02:15	RG-846	C	OK 13J
		Los Angeles	Ar	08:30	(08:15) nonstop		smoking
May 09	Sat	Los Angeles	Lv	12:00	JL-065	C	OK 28K
10	Sun	Tokyo, Narita	Ar	15:20	(11:20) nonstop		smoking
April 29	Wed	Lima	Lv	07:00			
		Chimbote	Ar	08:00			
May 06		Chimbote	Lv	17:30			
		Lima	Ar	18:30			

Prepared by S. Adachi

ANNEX 3

SCHEDULE

Day/Month		
26/Apr.	Sun	Mr. Juan Angulo at Lima airport
27/Apr.	Mon	Meeting with Mr. K. Fujita and Mr. J. Angulo. Meeting with Ministry of Industry, Mr. Jorge A. Portocarrero, Vice Minister and his colleagues
28/Apr.	Tue	Meeting with Siderperu, Mr. Victor Yoshimoto Y. President, Mr. Ruben Wong G. and their colleagues.
29/Apr.	Wed	Plant tour in Chimbote Works in the morning, the first meeting with Mr. Claude Leclere P., our counter party.
30/Apr.	Thu	Meetings with blast furnace plant, non-flat rolling plant and tin plate plant
01/May	Fr	Meetings with steel plant and flat rolling plant
02/May	Sat	Meetings with rehabilitation project group and finance and cost analysis department. Lunch meeting with Mr. Yoshimoto and all plant supervisors.
03/May	Sun	A meeting with maintenance department.
04/May	Mon	Meetings with maintenance & service department, including foundry plant, quality control department, industrial relation department. - Mr. Fujita and Angulo flew to Lima at 5 pm
05/May	Tue	Meetings with blast furnace plant, water supply section in maintenance and services, cost analysis section, and steel plant.
06/May	Wed	Meeting with flat rolling plant and rehabilitation project group. K. Isomura flew to Lima at 5 pm.
07/May	Thu	Meeting with Italimpianti and others
08/May	Fr	Final meeting with Ministry of Industry.