FERROCHROME PRODUCTION AT FERROCHROME PHILIPPINES, INC.

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ABSTRACT

HISTORY AND DEVELOPMENT OF FERROCHROME PHILIPPINES, INC.
ERECTION, DESIGN AND PLANT FACILITIES
PRODUCTION RESULTS SINCE START-UP, MODIFICATIONS
RAW MATERIALS, RESPECTIVELY, SIZE GRADE REQUIRED
FOR ORES TO BE PELLETIZED
OPERATION DATA AND CONSUMPTION FIGURES FOR THE
PELLETIZING AND SMELTING PLANT
PLANT ACTIVITIES AFTER START-UP
CONCLUSION

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H I S T O R Y

Ferrochrome Phils., Inc., a joint venture between the Austrian Voest-Alpine and the Philippines Herdis Group was founded in 1979 and decided to erect a plant for the production of ferrochrome based on the supply with local ores.

The location of the plant should be Mindanao Island near Cagayan de Oro City, mainly because of the availability of cheaper hydropower.

The foundation ceremony was held on December 1980 and within only two years, the plant was erected under the leadership of Voest-Alpine Industrieanlagenbau.

Ferrochrome production was started in January 1983 and the first year of production was already successful apart from the necessity of some modifications on the plant and a critical power shortage, caused by a drought in the whole area.

D E S I G N

Voest-Alpine AG decided to adapt the design concept of the preheating process which has been operated successfully by Outokumpu in Tornio, Finland. The nominal design capacity of the ferrochrome production plant has been fixed at 50.000 mtpy but has been increased now up to 60.000 mtpy.

The pelletising plant is designed for 112,000 tpy sintered pellets.

Preheating in a rotary kiln up to 1000 deg. cent.

Closed electric submerged arc furnace, transformer capacity 3 x 10 MVA

Most of the cleaned furnace off gas can be utilized in the sinter shaft furnace of the pellet plant and in the rotary kiln.

A pellet plant for agglomeration of concentrate was foreseen, because the Philippine partner is shareholder on the Acoje chromite mining, the biggest chromite mining in the Far East. This mine produces about 100,000 tpy of chrome concentrate and is the main supplier for the smelter.

The arc furnace design is based on the concept of burden pre-heating using by-product CO-gas and, therefore, low electric power consumption.

The size of the furnace power supply was calculated on the basis of data as per table 1:

	Cold charge (200 D. cent.)	Hot charge (800 D. cent.)
Production, tons p.a.	50000	50000
El. power consumption (arc furnace) (FeCr saleable) KWH/T	3600	3300 (3000 for molten metal)
Furnace power factor, %	0.90	0.90
Working time, hrs. (300 days/a)	7200	7200
Arc furnace capacity, MVA	27.8	25.5

$$\frac{50000 \times 3600}{7200 \times 0.9} = 27.8 \text{ MVA for cold charge}$$

$$\frac{50000 \times 3300}{7200 \times 0.9} = 25.5 \text{ MVA for hot charge}$$

Table 1

SPECIFICATION OF PLANT FACILITIES

Harbour:

Berthing capacity - 20,000 ton dead weight ship

Draft - 11 meters

Ship harbour crane - 12.5 tons capacity

Material handling system - 200 tons/hr capacity

Storage Area:

Open concrete stockyard for 40,000 MT chrome ore

Coke shed for 7,000 MT nut size and 1,000 MT fine size coke

Open concrete stockyard for 20,000 MT saleable FeCr

Electronic scale bridge, 40 T capacity

Pellet Plant:

1 unit wet-type ball mill for fine ore - 20 MT/hr capacity

2 units drum filter, 20 ton of filter cake capacity/hr

1 unit pelletising disc, 5.0 meters diameter, 25 ton/hr capacity

1 unit shaft furnace, CO-gas or oil fired, 20 tons/hr capacity

Preheating:

1 unit rotary kiln, 500 MT/day capacity, 3.4 m. diameter x 40 meters long; CO-gas or oil fired

CO-gas System:

2 units 3-stage venturi scrubbers

1 thickener, continuous type

1 CO-gas compressor, 1600 Nm3/hr capacity for the supply of the sintering plant

Water Supply System:

Industrial water supply system
Closed circuit cooling system

Automatic ion exchanger softener, 20 m3/hr capacity

Automatic chemical dosing system

Emergency fire - fighting water system

Air Supply:

3 unit screw compressor, capacity 18.5 m3/min, 7 bar

1 unit piston compressor, capacity 6 m3/min, 7 bar

Electric Power Supply:

4 single phase 10 MVA power transformer 138 KV/31.5 KV

1 emergency generator, 600 KW capacity, diesel operated

Submerged Arc Furnace:

30 MVA closed - type furnace, equipped with computerized dosing system, automatic charging system, and water jet slag granulating system.

6 furnace bins
capacity approx. 4 m3 each

1 pneumatic machine for taphole opening

1 pneumatic clay-gun for taphole closing

Casting Bay:

7 ladles, 28 ton tapped metal capacity

2 ladle preheating stations, CO-gas fired

1 ladle descaler, electrically driven, hydraulic type

1 teeming crane, 50/15 tons capacity

600 sq. m. FeCr fines casting bed

Product Handling:

1 ingot metal breaker

1 jaw crusher, 25 ton/hr capacity
550 mm x 800 mm jaw opening
50 - 150 mm discharge opening

1 vibrating screen with 10 mm and 60/80 mm screens, 25 tons/hr capacity

Transport:

4 Komatsu payloader

3 Toyota Forklift

Workshop:

Facilities for electrode casing fabrication and other minor fabrication works:

- Machine shop
- Motorpool shop
- Electrical and Instrumentation workshop
- Planning and project engineering

Laboratory:

Material sampling preparation facilities

Physical testing laboratory

Chemical laboratory, equipped with:

Photometer, atomic absorption spectrophotometer, C&S analyzer miscellaneous apparatus for wet type inorganic analysis

Administration:

- Locker and shower rooms
- Canteen
- Training facilities

Process Description:

All raw materials are unloaded by a stationary, slewable grab crane, dumped into an intermediate bunker, discharged by vibrating feeder to a conveyor system and transported to the stackers which pile them on the respective storage yards. In order to keep humidity of coke as low as possible it is stored under roof. All in- and outgoing materials are weighed and registered.

During day shift raw materials are reclaimed by a frontloader and transferred via a receiving hopper and belt conveyors to the pertaining day bins.

From there chromite concentrate, fine coke and dust, the latter recovered from the dedusting systems, are drawn-off at the correct mixing ratio and charged into a wet grinding ball mill and ground to a fineness suitable for pelletizing. The slurry is desiccated in two parallel drum filters to approximately 10 % humidity.

The filter cake subsequently is mixed with bentonite and charged on to a pelletizing disc for processing of green pellets. After separation of undersized pellets on a roller screen for recycling the feed is conveyed to the sintering shaft furnace where the material is dried, sintered and cooled. The green pellets are hardened and/or sintered at at temperature of + 1400° C by cleaned off-gases from the closed-type submerged arc furnace.

Having been cooled again in the lower part of the shaft furnace the pellets are fed to the day bins via a skip hoist.

Now the proper burden composition is carried out by extraction preset quantities of pellets, coke and fluxes from the day bins through weighing hoppers and charging the batches via a skip hoist to the rotary kiln where the charge is preheated up to a temperature of approx. 1000 $^{\circ}$. Again cleaned furnace off-gases from the submerged arc furnace are used for that purpose.

From the rotary kiln the preheated material is charged directly into a special distribution ring above the electric furnace bins.

For emergency cases another skip hoist is foreseen in order to by-pass the rotary kiln by feeding cold charge material from the day bins into the distribution rings thus allowing continuation of smelting at a reduced capacity rate.

The hot charge in the distribution ring is fed into six furnace bins controlled by min-max. probes.

The submerged arc furnace is of a closed stationary type, the off-gases being cleaned in two venturi scrubbers and reused for sintering the chromite pellets and preheating the electrical furnace charge thus giving substantial savings in electric power consumption for smelting.

The furnace has one taphole and will be opened approx. every two hours by means of an air drill. Slag is separated from the metal by overflow and granulated by a water jet. The liquid metal is cast into FeCr-fines moulds and cooled.

The metal slab subsequently are first crushed by a pneumatic hammer on a grid then by a jaw crusher and finally screened according to market requirements The product is stock piled depending on grain sizes and qualities and off-transported form the plants own pier by boat

The granulated slag will be dumped in a separate plant area by frontloader and shall be used for road building purposed or similar.

Waste gases from the rotary kiln and the sintering shaft furnace are cleaned in cyclones and the flue dust accumulated is recycled in the pelletizing process. In order to comply with environmental protection regulations, the dust accuring at the transfer points and bunker charging points is sucked off by a blower and drydedusting system with filters and the cleaned air is blown into the open.

COMPANY ORGANISATION

The headquarter in Manila is dealing with the Marketing, Purchasing and Financial Management, and is staffed with 15 personnel. The plant in Tagaloan is operated by 215 regular employees and about 40 contractual or occasional workers. The main shareholder Voest-Alpine AG is represented by the President and two Vice-Presidents.

Before start-up of the plant, the technical personnel of the smelting operation and maintenance were trained at the plant of Outokumpu OY in Tornio, Finland, at Ferrochrome plantsite, and at Voest-Alpine, Linz, Austria.

Training activities on special technical fields are on-going. Also, a quality circle program was introduced in the plant.

The influence on the income of the Philippine population is considerable. Not only the directly concerned families of about 300, but the employment on many small scale chromite mines in the Philippines and other suppliers give livelihood to about 2,000 families.

Table 2: Manpower breakdown

PLANT PERFORMANCE AFTER COMMISSIONING

The contracted capacity of 50,000 tpy ferrochrome saleable and 112000 tpy sintered pellets could be proved soon as realistic.

Graph 1: Annual production

However, the annual production figures in the year of start-up 1983 was less mainly because of electric power supply difficulties during the extreme dry season of this year. Slight power supply difficult was also experienced in 1984.

MODIFICATIONS

When it turned out that there were only a few bottlenecks in the plant to be removed to exceed the design capacity, then modifications were immediately started.

- Boosting of the arc furnace gas cleaning system by erection of a third stage venturi.

The original 2 stage scrubber system was just enough for max. 50,000 tons, but not sufficient for a production increase

- Installation of watercooled steel roof for the arc furnace, instead of the original refractory mass roof.

-Erection of sinter coke pre-screening system to stabilize the sintering process of the pellets. Oversize in fine coke for pelletising caused lumps in the furnace, therefore, screensize under 5 mm only is allowed to the ballmill.

Also, a number of small modifications on equipment and operation were done to improve the plant - operating time availability.

Many efforts were done to produce hard pellets and thus to minimize dust content in the charge.

RAW MATERIAL PROPERTIES

The plant was designed for the smelting of mainly Philippine chromite concentrate from Acoje Mining. A certain amount of fine ores of other sources and a percentage of lumpy chromite could be in the blend.

The ore properties are the basis for the typical ferrochrome specification of min. 60 % Cr, max. 4 % Si, max. 8.3 % C, max. 0.04 % S, max. 0.03 % P.

Smaller chromite deposits in the Philippines with definitely low Cr/Fe ratio would be proper for charge chrome production, therefore, trials were done to use these ores. However, the long term economic outlook for these deposits is not yet clear and mine prospecting are going on.

Attention has to be paid to the sizing of ores, if the pelletising process should run smoothly. Most favorable are concentrates in the range of 0.6 to 0.07 mm (28 to 200 mesh), complicate to handle are run-of-mine ores with oversize above 5 mm (above 1 mesh) and undersize below 0.04 mm (below 400 mesh).

Beside the problem connected with the rescreening of this ore before charging to the ballmill, the undersize shows troubles by clogging the drum filter cloth.

The present usage of different ores in FPI is mainly for the reason of research for different possibilities to run the plant not depending on only one ore or production of only one FeCr grade.

Table 3.4.5: Analysis of raw materials

Graph 2: Chrome ore size distribution

OPERATION DATA AND CONSUMPTION

The characteristic operation data and consumption figures of the pellet- and the smelter plant are shown in table number 6 and 7.

The specific power consumption for smelting of raw lump ore in comparison to pellets can be seen in the graph.

This explains the experience that the change from raw lumpy ore to pellets with high quality, increase the capacity of the furnace by 10 %. If these pellets are preheated to 800 deg. cent., another furnace capacity increase of 10 % was experienced.

The pre-heating process is especially advantageous for the smelting of low grade ores with high gangue material amounts.

The graph 4 shows the energy input of all production steps enables contemplation about the effort of pre-heating in the rotary kiln.

The input of energy to be purchased via electric power, coke and oil could be decreased by higher usage of off-CO-gas and the efficiency of heat usage improved, but can still be increased by modifications.

Graph 5: Energy consumption

NEW PLANT ACTIVITIES SINCE START-UP

1. Recovery of FeCr out of slag

The skimmed slag and the ladle skull contains FeCr which decrease the overall Cr-yield by 1 - 2 % unless it is not recovered from them.

A simple, but good enough and effective system is in operation and still under modification. It consists of a crusher (jaw crusher for - 20 mm) and a jig for separating the FeCr. The fine material in the second hutch is then further concentrated in another jig for only FeCr fines.

A hammer mill, which is more proper for this purpose of separating slag from FeCr, will be added soon. Another jig, special construction for the continuous discharge of FeCr 5 - 20 mm will be a next investment.

2. Usage of slag instead of dumping it as waste

Granulated slag is a proper material for sandblasting substitute of the dangerous quartz sand. Crushed lumpy slag is not only good for road construction because of its high abrasive strength, but also turned out as the most proper for concreting, substituting gravel. Therefore, a hollow block production was also taken in.

3. FeCr fines excess

The proper screening of the FeCr fractions 10 - 60 (65, 80, 150) mm creates about 15 % undersize under 10 mm.

It turned out as useful to rescreen this material at 5 mm. The FeCr fines under 5 mm is for building up the casting moulds. The consumption is higher since the resmelting of this fines is easier. The remaining 5 - 10 can be sold, however, at a lower price.

4. Slag in FeCr

The work of collecting pieces of slag from the FeCr piles for scale cannot be avoided but continuous efforts to minimize this work were done.

Our present solution is a casting mould

CONCLUSION

The results of 3 years operation after fullfilling the technical expectations of the plant, the decision for the plant design based on the ore specification and strategic location proved right.

However, improvements are still possible and the target for the next year is clear:

1. The Cr recovery figure must be further increased by 2 %. Since this is also dependent on the conscientiousness of our crew, this is one main topic in the ongoing quality circle program.

2. The plant availability will be further increased to 90 %, by eliminating the bottlenecks in equipment and operation.

3. The CO-rich off gas must be used with a higher efficiency. Thus the electric power consumption can be further decreased and the plant capacity increased.

4. Investigations for methods to further increase the Cr recovery must be conducted.

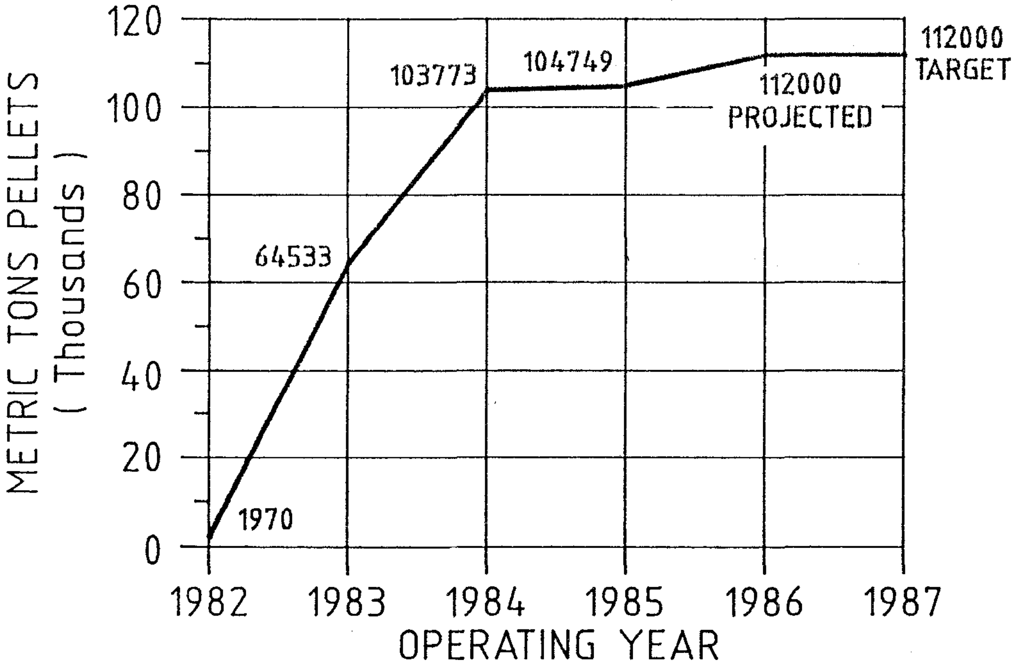
MANPOWER BREAKDOWN

	Supervisory	Skilled Semi-skilled	Unskilled	TOTAL
1. MANILA HEAD OFFICE				
DEPARTMENT :				
Administration	1	2		3
Logistics	2	3		5
Finance	2	4	1	7
Sub - total	5**	9	1	15
2. PLANTSITE Tagoloan , Misamis Oriental				
DEPARTMENT :				
Production	18	67		95
Planning and Metallurgy	2	2	10	4
Maintenance	15	54		72
Logistics	2	6	3	8
Laboratory	2	11		14
Personnel	2	5	1	13
Accounting	5	4	6	9
Sub - total	46*	149	20	215
GRAND TOTAL	51	158	21	230

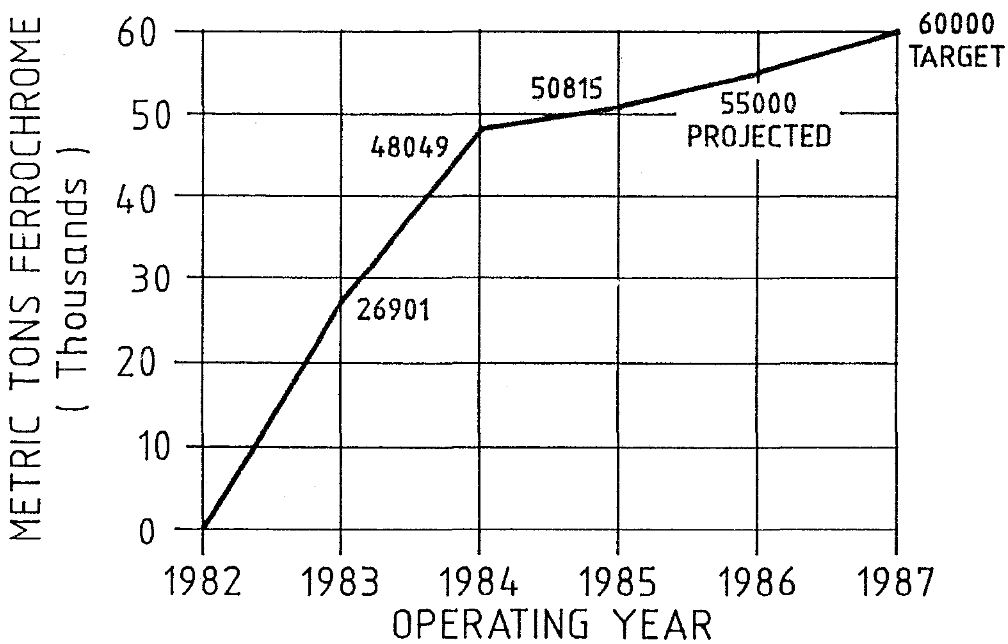
* Includes (1) SVP - Operations , (1) VP - Maintenance
** Includes (1) President , (1) SVP - Finance , (1) Mining engineer .

TABLE 2

PELLETS ANNUAL PRODUCTION



FeCr ANNUAL PRODUCTION



GRAPH 1

TYPICAL ANALYSES OF MAIN RAW MATERIALS

CHROMITE ORES :

Source	Mesh	ACOJE CONC.	CAS-ISA FINES	IMPORT. FINES	DAVAO LUMPS
Moisture %		5.32	7.6	7.9	4.4
Sieve Analysis :					
Concentrate/fines					
Above 26.6 mm				7.53	
26.5 -16				1.54	
16 - 5	Above 4		0.82	13.90	
5 -2	4- 10		3.85	6.19	
2 -1.18	10- 16	0.04	9.12	3.31	
1.18 - 0.6	16- 30	2.32	30.21	8.67	
0.6 -0.3	30- 50	18.77	20.00	16.20	
0.3 -0.15	50-100	42.04	9.80	16.21	
0.15 -0.075	100-200	25.98	6.65	5.36	
0.075-0.038	200-400	5.50	10.10	9.50	
Below 0.038	Below 400	5.35	9.45	11.59	
Lumpy ores					
Above 150 mm					33.38
150 - 100					9.29
100 - 50					13.98
50 - 25					11.26
25 - 5					9.98
5 - 1	4 - 18				11.17
Below 1	Below 18				10.94
Chemical Analysis :					
LOI		0.86	1.57	4.12	1.07
Cr_2O_3		48.39	50.3	48.1	51.5
FeO		17.97	18.9	17.37	18.49
SiO_2		3.79	2.35	7.14	4.12
MgO		15.84	12.19	11.03	13.35
Al_2O_3		12.77	14.42	11.91	10.86
CaO		0.11	0.014	0.1	0.39
P		0.005	0.005	0.006	0.003
C		0.003	0.053	0.055	0.036
S		0.012	0.007	0.007	0.004
TiO_2		0.22	0.2	0.16	0.18
Cr/Fe		2.37	2.34	2.44	2.45

TABLE 3

TYPICAL ANALYSES OF MAIN RAW MATERIALS

COKE LUMPS :

Source		Import.
Moisture		9.18
Sieve Analysis		
	Mesh	
Above 25 mm		9.47
25-20		31.14
20-15		30.12
15-10	2.0	21.07
10- 5	2-4	3.92
Below 5 mm	Below 4	4.28
Tumbler's test		
Passing thru 5 mm (before)		3.97
Passing thru 5 mm (after)		7.11
Chemical Analysis		
Ash		11.31
VCM		2.04
Fixed Carbon		86.45
Sulfur		0.66
Mineral Analysis		
Phosphorus		0.005
Al_2O_3		3.31
CaO		0.02
Fe_2O_3		0.80
MgO		0.20
SiO_2		6.47
TiO_2		0.21

COKE FINES :

Source		Import.
Moisture		11.0
Sieve Analysis		
	Mesh	
Above 4.75 mm	Above 4	1.10
4.75 -4.00	4- 5	3.32
4.00 -1.18	5- 16	57.11
1.18 -0.60	16- 30	15.83
0.60 -0.30	30- 50	9.58
0.30 -0.212	50- 70	2.50
0.212-0.106	70-140	3.20
Below 0.106 mm	Below 140	7.36
Chemical Analysis		
Ash		11.18
VCM		2.61
Fixed Carbon		86.21
Sulfur		1.41
Mineral Analysis		
Phosphorus		0.03
Al_2O_3		2.48
CaO		0.53
Fe_2O_3		0.41
MgO		0.25
SiO_2		5.78
TiO_2		0.11

TABLE 4

TYPICAL ANALYSES OF MAIN RAW MATERIALS

QUARTZ :

Source		MCCI
Moisture		4.04
Sieve Analysis		
	Mesh	
Above 45 mm		
45 -37.5		5.74
37.5 -26.5		57.51
26.5 - 9.5	2.0	36.16
9.5 - 4.75	2- 4	0.28
4.75- 1.00	4-16	0.11
Below 1.00 mm	Below 16	0.20

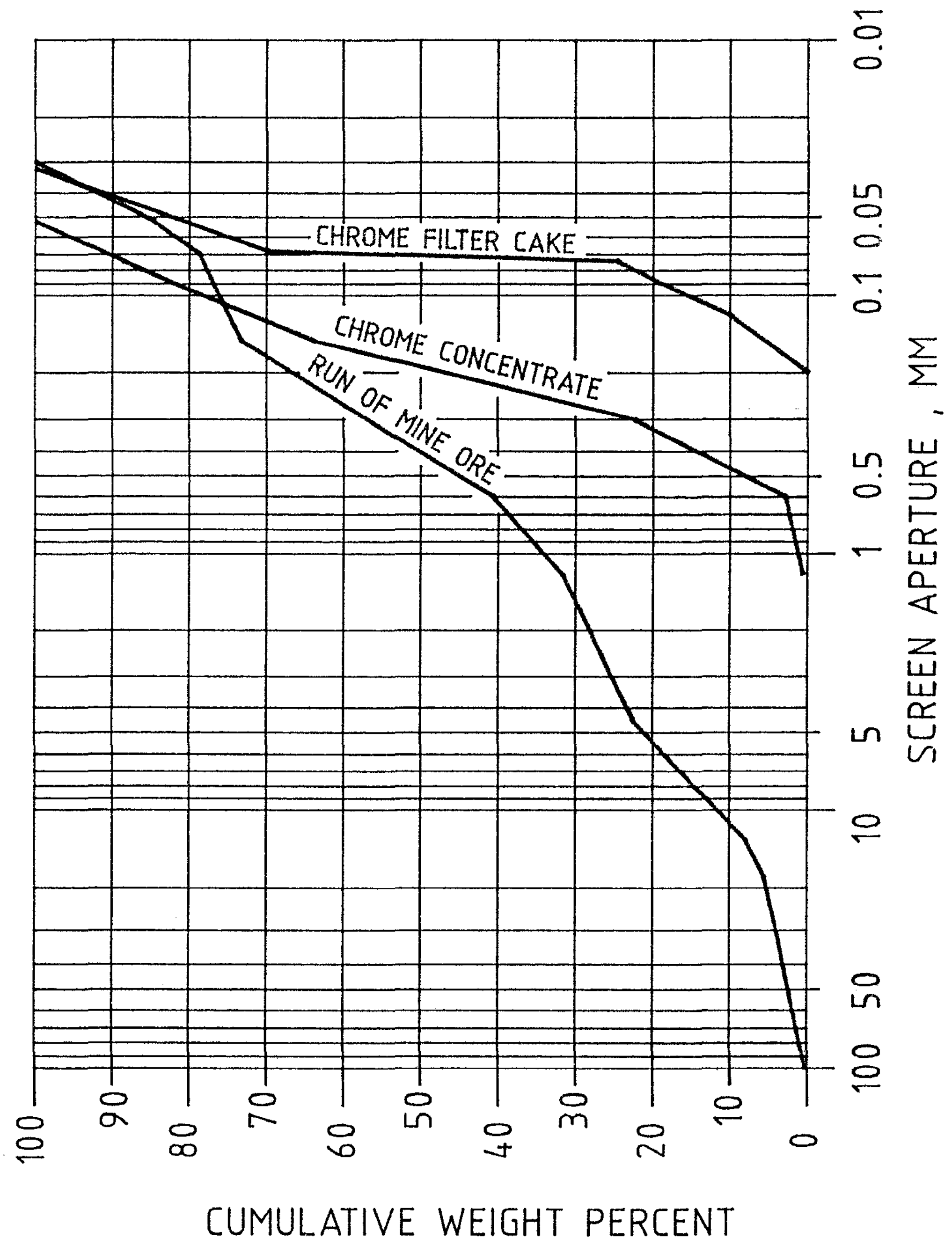
Chemical Analysis	
SiO_2	98.1
P	0.003
Al_2O_3	0.29
CaO	0.06
Fe_2O_3	0.59
MgO	0.05
C	0.032
S	0.007
TiO_2	0.85

BENTONITE :

Chemical Analysis	
SiO_2	62.48
Fe_2O_3	1.48
MgO	3.88
Al_2O_3	18.14
CaO	0.47
LOI	7.30
Others	6.26

TABLE 5

CHROME CONCENTRATE / FINE ORE SIZE DISTRIBUTION



GRAPH 2

FERROCHROME PRODUCTION

	1983	1984	1985
Production , tons	26 901	48 049	50 819
No. of days	339	344	365
Tons / calendar day	79.4	139.70	139.20
Tons / avail. operatg. day	102.4	163.9	165.70
Furnace availability , %	77.5	85.20	84.0
Average power , MW	15.30	22.50	23.10
KWH / ton (Arc Furnace)	3 578	3 298	3 357
Cr recovery smelter , %	79.70	83.60	82.80
Slag / ton FeCr	1.209	1.226	1.207
CHEMICAL ANALYSIS :			
FeCr Cr	60.52	60.86	60.93
C	7.81	7.93	7.95
Si	3.03	3.19	3.0
S	0.034	0.03	0.027
P	0.021	0.02	0.018
Slag Cr_2O_3	9.18	9.27	9.27
MgO	29.97	31.23	30.86
SiO_2	29.38	28.71	28.13
Al_2O_3	26.02	25.10	25.93
SPECIFIC RAW MATERIAL CONSUMPTION :			
Pellets	2.329	2.172	2.08
Coke (DB) MT	0.576	0.531	0.542
Quartz MT	0.261	0.232	0.210
Electrode paste kgs	10.57	8.30	8.60
Reverts (Rec.) MT	0.022	0.046	0.037
Local lump ore		0.097	0.124
Imported lump ore			0.073
Cr RECOVERY :			
Local fine ore	2.301	2.001	1.841
Imported fine ore		0.125	0.201
Total fine ore	2.301	2.126	2.042
Local lump ore		0.091	0.124
Imported lump ore			0.073
Total lump ore		0.091	0.197
Total Cr ore consumption	2.301	2.217	2.239
Overall Cr recovery to FeCr , %	79.60	83.90	83.40

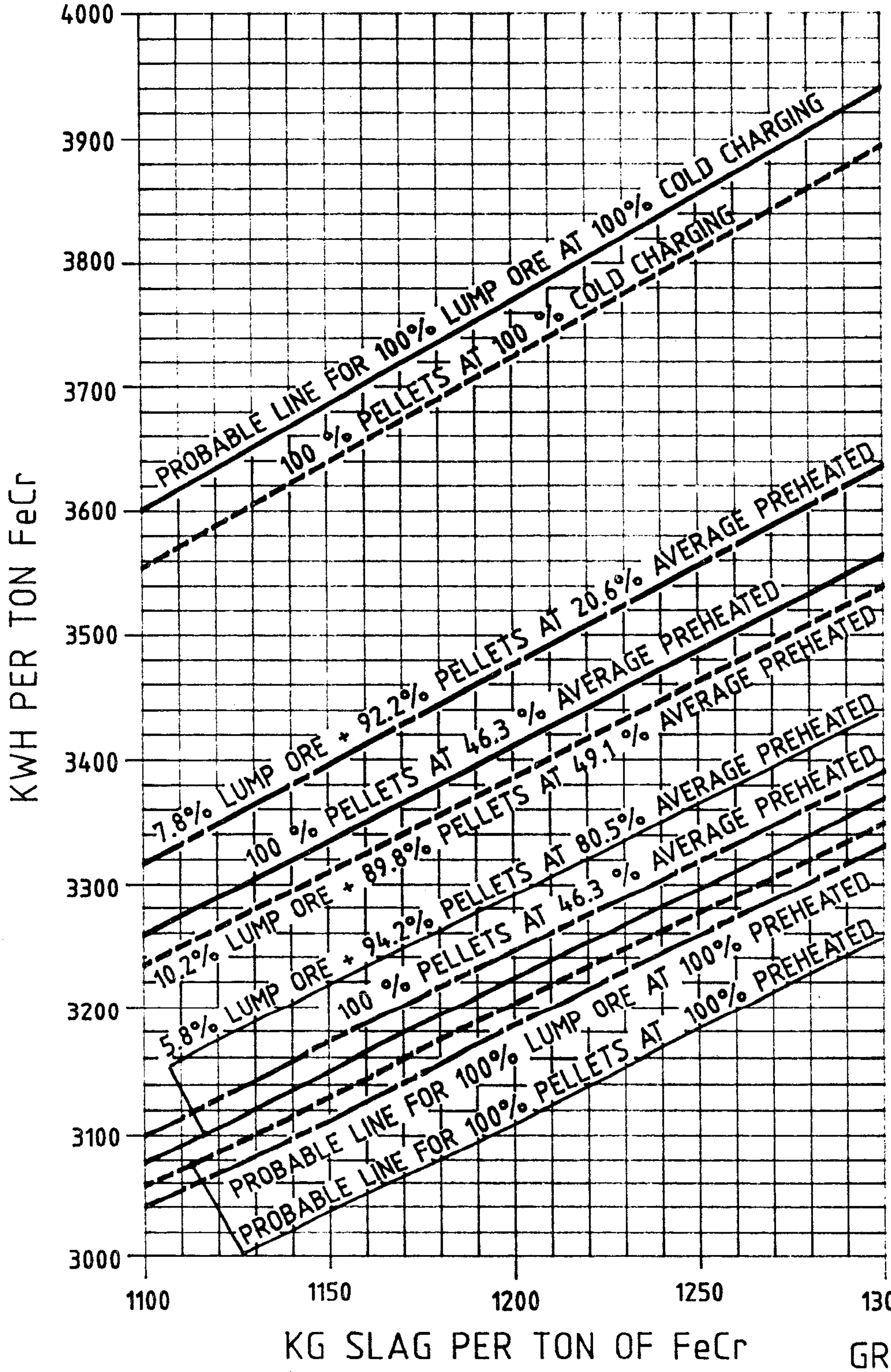
TABLE 6

SINTERED PELLETS PRODUCTION

	1983	1984	1985
Production , tons	64 533	103 773	104 749
No. of days	365	366	365
Tons / day	177	284	287
Availability , %	54.10	81.50	81.80
LABORATORY ANALYSIS :			
% Moisture	9.40	9.60	10.55
% C	1.97	2.20	2.22
Grain size % - 200 mm	78.20	75.70	71.84
GREEN PELLETS :			
% Moisture	11.0	10.70	11.8
Dry comp. str. kg	9.8	11.4	12.8
Ave. size mm	17.10	19.5	17.3
SINTERED PELLETS :			
Comp. str. kgs	249	199	175
Tumbler test % - 0.59 mm	25	25	26
Ave. size mm	17.50	19.3	16.9
SPECIFIC MATERIAL CONS. / TON SINTERED PELLETS :			
Total Cr ore fines (DB) MT	0.988	0.986	0.984
Fine coke (DB) kgs	21.10	27.6	26.8
Dust / Rec. pellets kgs	108.60	152.0	119.7
Grinding balls kg	2.18	2.30	1.9
Bentonite kgs	11.90	15.5	16.8
Diesel oil li	8.0	7.3	2.90
CO - gas Nm^3	38.30	50.4	79.8
PREHEATING KILN :			
Availability , %	30.51	49.1	52.5
Product discharge temp. , °C (max)	684	850	796
Co - gas cons. Nm^3 / ton FeCr	249	228	287.8
Oil consumption li / ton FeCr	9.2	2.9	1.90
Feed rate , TPH max	18.50	21.25	23.50

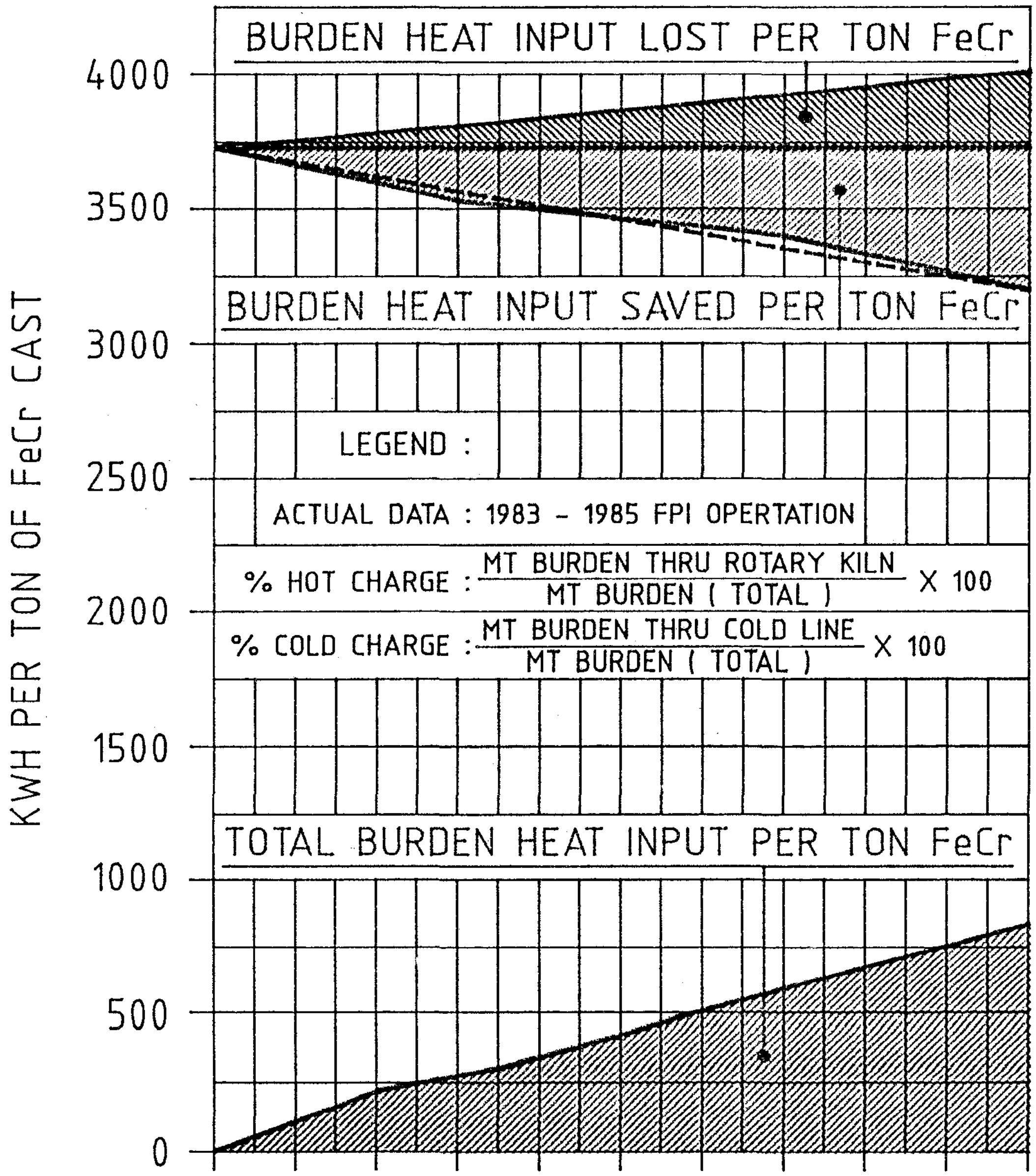
TABLE 7

KWH/TON FeCr VS. KG SLAG/TON FeCr



GRAPH 3

HEAT INPUT ON PREHEATED BURDEN

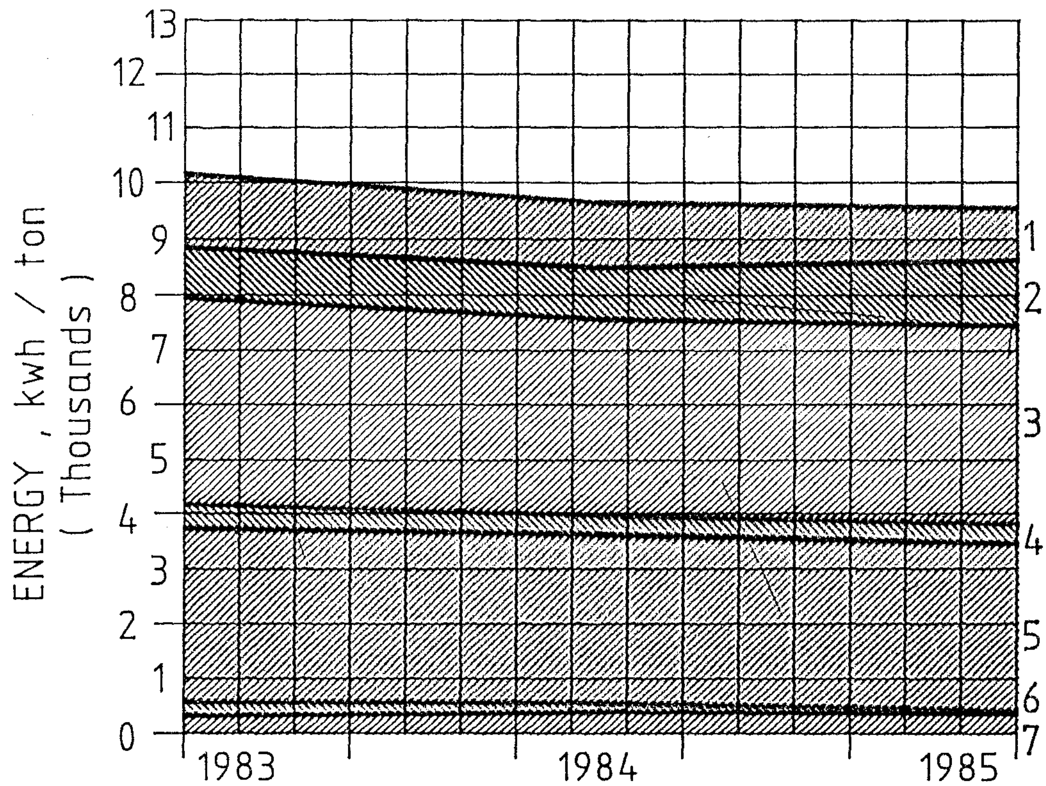


COLD CHARGE %	100%	90	80%	70%	60%	50%	40%	30%	20%	10%	0%
HOT CHARGE %	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
BURDEN TEMP.°C	0	80	160	240	320	400	480	560	640	720	800
BURDEN HEAT INPUT KWH PER TON FeCr	0	-	219	263	323	391	464	541	619	701	784

GRAPH 4

ENERGY CONSUMPTION

PER TON , CAST FeCr YEARLY



KWH/TON,CAST FeCr		1983	1984	1985
1	WASTE CO GAS STILL NOT YET USED	1322	1149	917
2	USED CO GAS	903	927	1183
3	COARSE COKE	3770	3605	3638
4	AUXILIARIES NPC POWER	434	339	343
5	FURNACE NPC POWER	3161 (3000)*	3050 (2900)*	3037 (2890)*
6	DIESEL OIL	259	164	60
7	FINE COKE	324	408	360
3-7	SUB-TOTAL HEAT INPUT	7948	7566	7438
1-7	TOTAL HEAT INPUT	10173	9642	9538

* FURNACE POWER CONSUMPTION FOR MOLTEN METAL IN THE LADLE.

GRAPH 5