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UNITED NATIONS

INTERREGIONAL SYMPOSIUM ON
THE APPLICATION OF MODERN TECHNICAL
PRACTICES IN THE IRON AND STEEL
INDUSTRY TO DEVELOPING COUNTRIES

11-26 NOVEMBER 1963

D03115

STEEL SYMP.1963/
Technical Paper/A.11
18 September 1963
ENGLISH
Original: FRENCH

OPERATION OF A LARGE BLENDING PLANT

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When calculating the value of ore-blending plant one should not overlook the fact that the function of furnaces is to produce pig-iron and that agglomeration is only a means to this end.

A decision to operate all the furnaces of an iron works on 100 per cent agglomerate may stem from confusion over means and ends, as the cost price per ton of pig-iron produced may be adversely affected by adoption of this process.

There is much sound literature on operating with 100 per cent agglomerates in various countries of the world and the consumption of coke per ton of pig-iron can be forecast with sufficient accuracy. This documentation also has helped to demonstrate the increased production made possible by blending, provided the agglomerate is well prepared.

The fact that even the best-equipped works operate on 100 per cent agglomerate under certain circumstances only shows that economic as well as technical considerations must determine the advisability of agglomeration. The furnace manager of a fully-equipped works may charge more agglomerate in some furnaces and less in others in order to avoid operating at about 50 per cent blend which is more heterogeneous and more difficult than operating with either under 30 per cent or over 70 per cent of blend.

The physical and chemical properties of the ore, its suitability for enrichment and whether it lends itself easily to screening must decide the advisability of the agglomerate to be used in a works.

100 per cent crushing and blending are rarely an economic proposition in the case of an ore that is easily screened.

The desirability of screening the crushed ore to 0/8mm and then blending must be studied when some furnaces in a plant are operating on 70-100 per cent blend and others on crushed ore.

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This depends on local conditions which must be known.

(1) Is the crushed mineral clean or, in other words, is there too much powder present?

(2) Can this ore be broken down to best possible granulometric proportions?

(3) Does the mineral not swell over-much in the furnace prior to reduction?

If the above conditions are not met, the cost of screening the crushed ore must be calculated accurately and weighed against increased production resulting from total blending.

A later diagram will show the consumption of furnace coke per ton of pig-iron under different conditions of fusion bed. But the economic considerations involved may be seen from the example below. Assuming that production of one ton of pig-iron requires 2.4 tons of mineral plus additions:-

Thorough crushing of the ore will cost	24 c./t x 2.4	=	58 c.
Preparation will cost	12 c./t x 2.4	=	29 c.
or, per ton of pig-iron		=	87 c.

Blending the ore on a 1,500 ton per day grid will cost:-

80 c./ton of fuel (gas or solid)

60 c./ton for labour, maintenance and electrical energy

80 c./ton for depreciation

2.20 dollars/t x 2.4 per ton of pig-iron = 5.28 dollars.

The overall costs of preparing the ore therefore will be more or less six dollars per ton of pig-iron.

There is, however, a saving of coke in the furnace. The consumption of coke per ton of pig-iron falls from 850 kg. to approximately 600 kg., representing a gain of approximately 250 kgs. of coke per ton of pig-iron.

The economy realizable through blending in any situation can be calculated according to the price of coke and the cost of gas for the furnace, being less in the second case.

Economic considerations generally do not favour blending which can be justified only where it makes increased production possible. The crushed ore must be studied before deciding to blend it in cases where the blending of powder cannot be avoided.

The above considerations show that considerable effort is required to achieve top-quality blending of perfect physical and chemical properties at as low a cost as possible, without nevertheless wishing to blend everything. The importance of blending, suitable for each plant, must be calculated with this in mind.

I - THE CONCEPT OF BLENDING

(a) Raw Materials

The granulometry of the materials on entering the blending plant is an important factor, and while mineral exceeding 8mm does not blend there cannot be more than 30 per cent of material of less than 1mm without risk of seeing the productivity of the plant decline.

Some low-grade ores with fusible matrix blend well even if they contain some powder, but this is not the case with high-grade ores.

On the other hand, experiments in blending high-grade haematites show it is desirable to have ores of low magnetite content available to obtain a coherent blend. The structure of the blend varies considerably, in fact, according to the iron content while the slag serving to bind low-grade blends is replaced by an interlocking of crystals of haematite and magnetite in very high-grade blends. The even admixture of very fine limestone assists formation of ferrous carbonates, a very desirable constituent in blends of high iron content.

To achieve good blending it is essential that the raw mixture be homogeneous before firing and the best way to ensure this homogeneity is preparation with a weigher belt. Correctly adjusted, this is accurate to 2 per cent, which suffices in most cases. But greater regularity can be achieved by using homogeneous beddings, especially where different ores are utilised. The proximity of built-up areas and local rainfall level will decide whether the machine and its recovery apparatus should be covered or not. This bedding makes a cone superfluous and ensures a very homogeneous blend. But the costs of operating and maintaining the machine have to be weighed against this.

(b) Preparation of materials

Material charged must be weighed as the combustible material and limestone added must be in very strict proportions. The same applies to the humidity of the mixture which must be kept below approximately 0.5 per cent.

These factors must be exactly controlled, for a slight lack of water reduces porosity of the mixture and cuts production. An excess of water clogs the maintenance apparatus and causes condensation in the mixture, thus impeding the blending process.

Similarly, too little coke in the furnace results in a crumbly blend while too much reduces the quality of the product - quite apart from being costly in itself. Errors in the order of .5 per cent in the relative weights of water, combustible and primary materials can be permitted - which shows that considerable care must be devoted to the weighing and homogenity of the mixture.

The materials are fed into one, two or three mixers in series. After weighing, water is introduced into the machine at the same time as "powder waste", that is, the fraction from the plant that is considered too fine for use in the furnace and fed back. These powder wastes can be used to good effect when warm, although they are often unusable cold.

Some complexes are equipped with a graining drum or pelleting discs. Use of this equipment is debatable because it is difficult to adjust according to variation in the quality of the raw materials, as the granulometry ranges from 0-10mm, and also because grains from 6-8mm destroy micropellets in process of formation. Results are seen in certain special circumstances only. This "micropelletisation" is very different from the granulation of fine ores to create pellets.

The loading of material on to the bed also must be carried out with great care as over packing will put up electricity consumption for the ventilator by 10 to 20 per cent.

No ideal loading device exists and a compromise, but practical solution, must be adopted.

(c) Firing

We shall not go into the technology of this process because the problem can be of interest to a small number of specialists only.

(d) Operation of the machine

The normal criterion of productivity for a blending machine is its daily production per square metre of belt and should be from 20-30 tons. A 100-square metre machine therefore will produce approximately 2,500 tons per day. Slow operation is very uneconomical because of the constant cost of labour and electrical energy.

Conversely, high-speed operation is only possible with raw material of medium granulometry (not more than 30 per cent of the material being smaller than 1mm). Any speedup will be at the cost of higher consumption of coke and a lessening of the reducibility of the blend.

(e) Cooling the blend

In principle the cooling apparatus should be of the same surface area as the band and be charged without separation. Circular coolers are also to be recommended. The end aggregate must be eliminated before the cooler, and it is advisable to recuperate the warm air - heated to 300 degrees at the beginning of the cooler - and lead it back to the band.

Some have suggested dispensing with this apparatus and loading the so-called "hot" blend into the furnace. This method presents difficulties in handling by belts, inscreening and in charging the furnace.

Introduction of hot matter into the charging bell already at a higher temperature harms the mechanical properties of the material. The most common remedy is to sprinkle the charging bell with water, but this technique is not to be recommended.

It is desirable to screen the blend as close as possible to the spot where it is charged into the furnace; homogenous granulometry being an imperative for perfect furnace operation.

If, as often happens, furnace tests using pellets are more successful than results obtained with blends, it is because the pellets are granulometrically nearly identical (10-12mm).

Apart from eliminating dust it is advantageous to charge medium and coarse blend separately, which leads us to a study of the blended state (see figure 1).

It is inadvisable to load agglomerate on waggons or to use mechanical shovels as its granulometry deteriorates with handling. Aggregates are best made right next to the furnaces, making it possible to charge the cones without prior handling, whatever the granulometry required.

This arrangement also simplifies the problem of returning the not-inconsiderable crushed coke and aggregate as well as gas powder to the blending plant.

(f) Automated blending

Numerous factors affecting productivity, and the quality and cost of the product, have been indicated several times in the course of this paper. Preparation of the materials and their proportions are of importance in operating the plant.

The problem is not that of introducing computers into the machinery, but rather of keeping a constant check on the water content, the degree of oxidation etc., with sufficient accuracy to provide usable data.

Agglomeration on a large capacity drum makes first steps towards full automation possible as well as installation of a control apparatus. This is quite apart from economic considerations discussed below.

Considerable funds have been made available in various parts of the world to secure means of permanent control over the humidity of the mixture, coke requirements, the drum operating speed in relation to the advance of flame in the bed during agglomeration, the coke-content and powder waste.

Metronomy remains the basic problem and progress is still slow.

This automation aims at securing a constant quality, the highest possible production and considerable saving of fuel rather than economy of skilled labour.

Furthermore, a powerful agglomerating plant can be fitted with devices to draw off dust wherever necessary.

Plant of this type is very expensive and can only pay off if production is high. In passing, it should be noted that cleaning of such apparatus may involve from 200 to 300 hours work every month - and this cleaning is illusory so long as flying dust is not drawn off.

II - PRODUCTION COSTS OF BLEND

Production costs are made up of the following three principal factors:-

Consumption: gas, electricity and combustible fuels;

operating costs: labour for cleaning, operation and maintenance, replacement of parts, etc;

depreciation: in this respect large complexes may be compared with others.

(a) Consumption

The solid combustible to be introduced into a blend depends on the ore to be agglomerated and the process used. From 45 to 110 kgs. of combustible are needed per ton of agglomerate.

The firing can be done with the cheapest locally-available combustible and the combustible solid in the mixture can be reduced by increasing the burner or the system for pre-heating the air.

The larger the capacity of the plant, the fewer kWh per ton of agglomerate required. The documentation refers to electricity consumption as from 16-25 kW per ton in agglomerates produced on drums of over 100 square metres in area. The ventilator alone uses between 50 and 70 per cent of this energy.

(b) Operating costs

The operation of a modern complex is very centralised and plant of this type can work with two or three specialists per shift-gang. Personnel for electrical control and maintenance will be very similar whatever the importance of the machine and the same applies for the cleaning staff. This means that almost all these costs remain practically constant and operating costs fall as the production unit grows.

Figure 2 plots operating costs per ton in relation to the importance of the machine - with 24 tons/100 square metres/day as a base.

(c) Depreciation

The fact that the price of the machinery is far from being proportionate to its production is the most tangible advantage of the modern complex. The graph in Figure 2 illustrates the advantages of large capacity units. With a 7 per cent interest rate on capital invested, the depreciation costs per ton - assuming the machinery is worn out in ten years - are seen from the table below:-

Area of drum	Production over 10 years	Depreciation per ton of agglomerate
11 m^2	720,000 T.	2 $ 50 cts.
90 m^2	6,900,000 T.	1 $ 25 cts.
140 m^2	10,750,000 T.	96 cts.
180 m^2	13,800,000 T.	80 cts.
210 m^2	16,100,000 T.	75 cts.

Figure 2 totals up the three curves to show that the cost of producing aggregate can double in passing from a blend of 210 square metres to one of 60 square metres. The figures above provide an indication only and depend on local conditions such as labour and power costs.

III - USE OF BLEND IN FURNACES

Having seen the costs entailed in production of aggregates, it is important to see what is gained from this process as is shown in Figure 3.

The vertical axis represents coke consumption per ton of pig-iron while the horizontal axis shows the operating speed of the furnace expressed in kgs. of coke consumed per cubic metre of available volume.

This figure immediately shows the specific production of each furnace by dividing the x-axis value of the appropriate point by its reading on the y-axis.

The figure shows that:-

(1) Increasing the speed pushes up coke consumption per ton of pig-iron in a constantly less-economical manner.

(2) Back-pressure makes it economically possible to reach higher speeds.

(3) The higher the iron content of the charge the lower the consumption of coke.

(4) The fastest operational speed and lowest consumption of coke are achieved together with aggregate fusion beds, although aggregates of fusible haematites have also given good results (in Japan).

The figure shows the gain that may be counted upon from agglomeration of the ore. It can be completed by the addition of other operating results interpolated in the graphs shown.

The agglomeration of an ore generally renders a gain of 200 kgs. in normal furnaces and a 10-20 per cent increase in the coke consumed. It results in 30-40 per cent higher production but the point of departure and target must be charted on the graph in each particular case to be sure of achieving major economies.

Much more attractive results are obtained by using pellets rather than aggregates as is indicated in the figure.

This observation merits four comments:-

(1) These two processes of ore-processing complement one another rather than compete, the first being suitable for very fine ores, while the second is for ores from 0-10mm. The vein itself therefore decides which should be used.

(2) The gain from pellets results, generally speaking, from their very fine granulometry. It is likely that comparable results would be achieved if the same care were taken with the aggregate: but this cannot be done.

(3) Granulation can be carried out most easily at the mine while it is generally desirable for blending to be done close to the furnace.

Quality of pig-iron

Figure 4 shows the properties of the pig-iron obtained from the ratio of CaO/SiO2 in the basic slag and demonstrates the possibility of lowering this index when the charge of ore is well prepared.

The quality of the pig-iron is shown by the product of sulphur by the square root of silicon.

This corresponds to use of a slight amount of carbonate in furnaces and brings about ensuing enrichment.

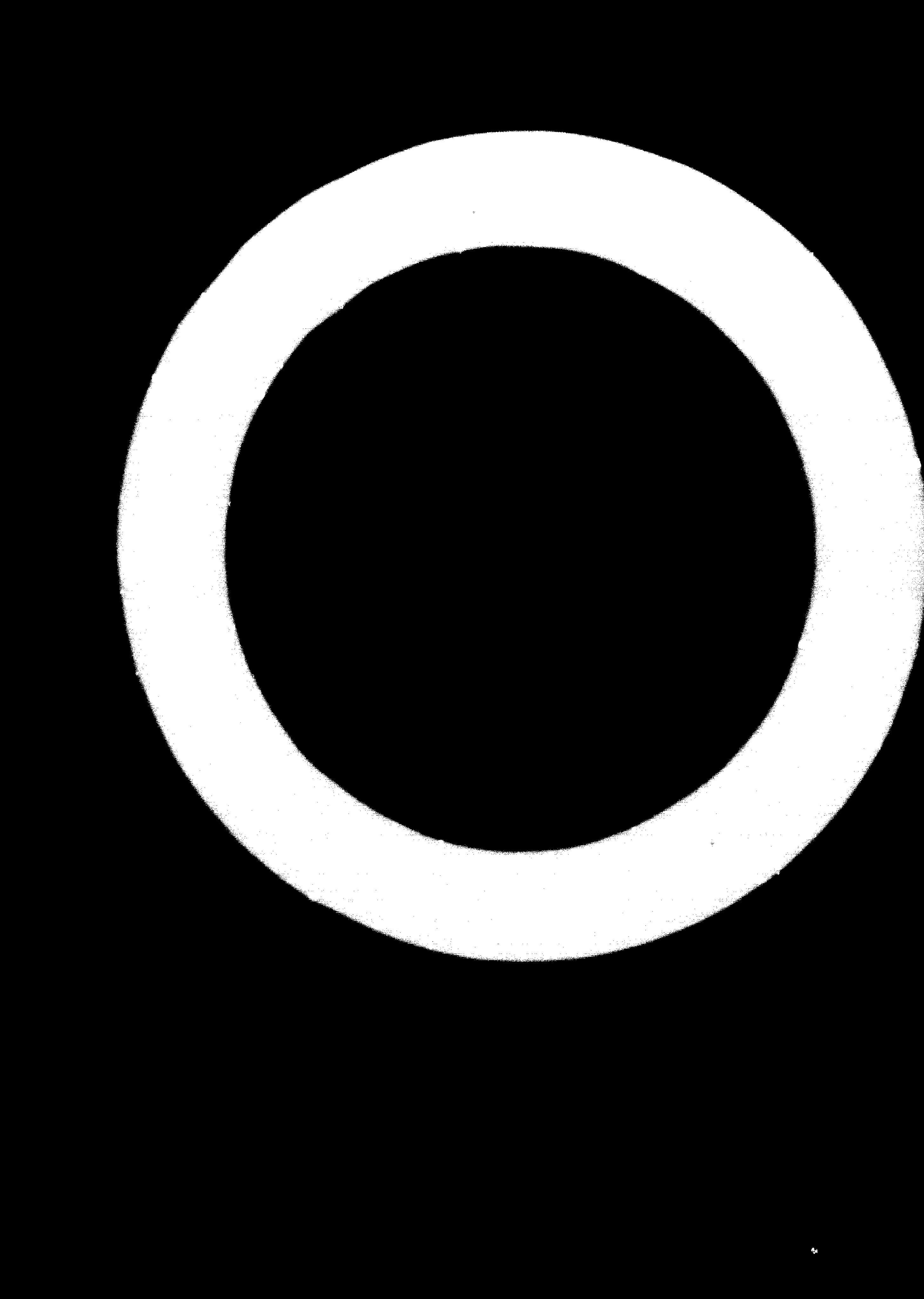
IV - CONCLUSIONS

The agglomeration and granulation of ores are complementary processes. Study of the vein and the possibilities of handling it suggest the correct decision with respect to its treatment.

Agglomeration should take place close to the furnace, wherever possible, to avoid transportation damaging the merchandise and facilitate incorporation into the aggregate of powder wastes from the furnaces.

The capacity of the plant must be calculated in the knowledge that it is generally uneconomical to crush a reducible ore simply in order to blend it.

It must also be understood that the more powerful the machinery the lower the cost of the aggregate produced.



FIGURES

Fine ore beddings in preparation

Chimney

Kramer unit

Mixing plant

cast iron pit

Balance

Granulometric grid

Sub-station

Blending belt

Electrostatic filter

Theysen filter

Discharge pits

1500-ton Chertal mixing plant

Discharge to belts

Grader

Feed from crusher

Discharge to crushing plant

Furnace charger

Coke Loader belt

Fig.I

1. Grid
2. Coke silos
3. Blend silos 6/20 or 20/50
4. Graded ore feed
5. Blended ore 20/50 feed
6. Crushed ore feed
7. Various discharge points to rail
8. Ore feed lines to furnaces 1 to 4
9. Skip for discharge from rail

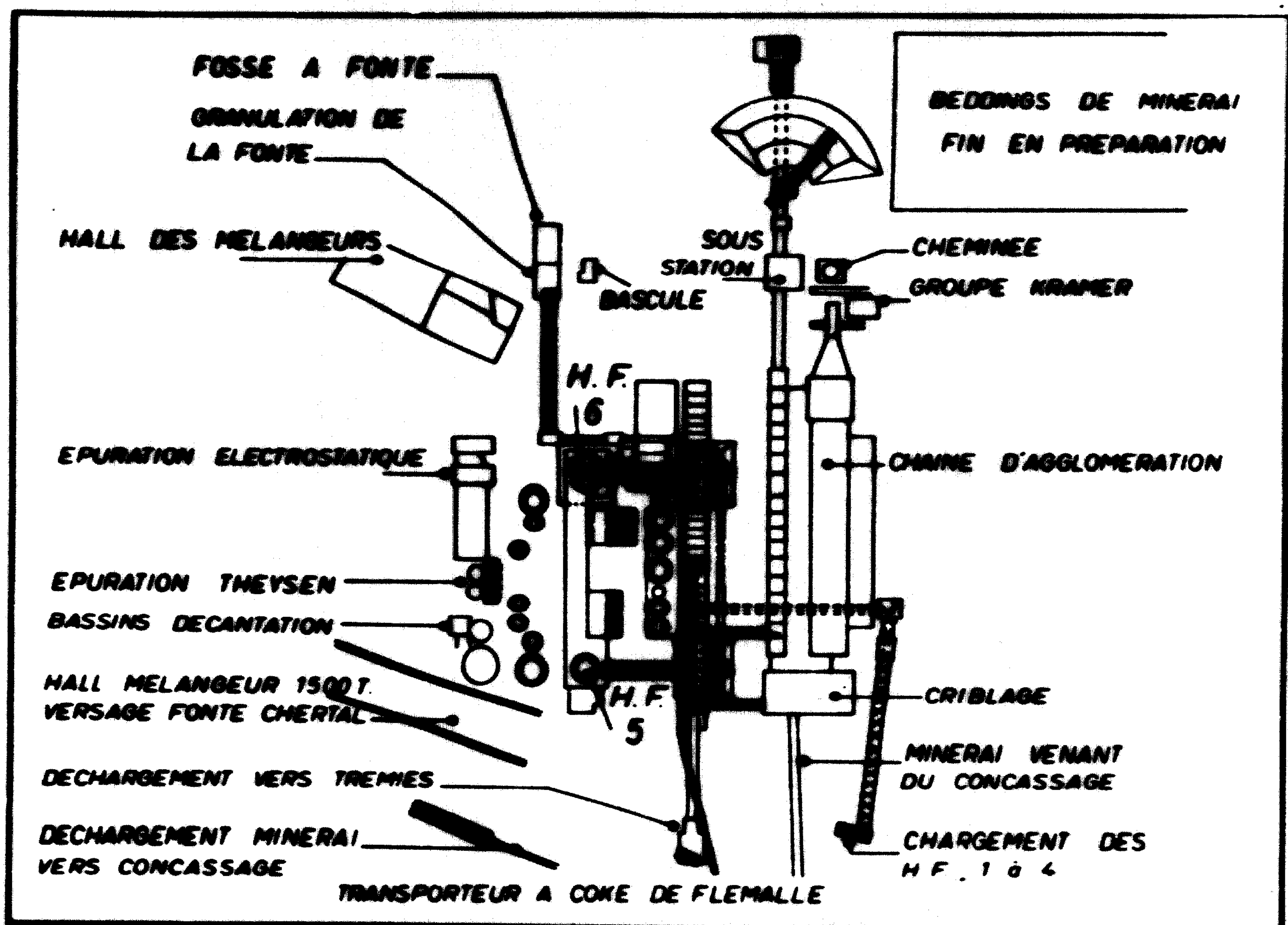


Fig. 1 Implantation des installations de criblage et d'agglomération

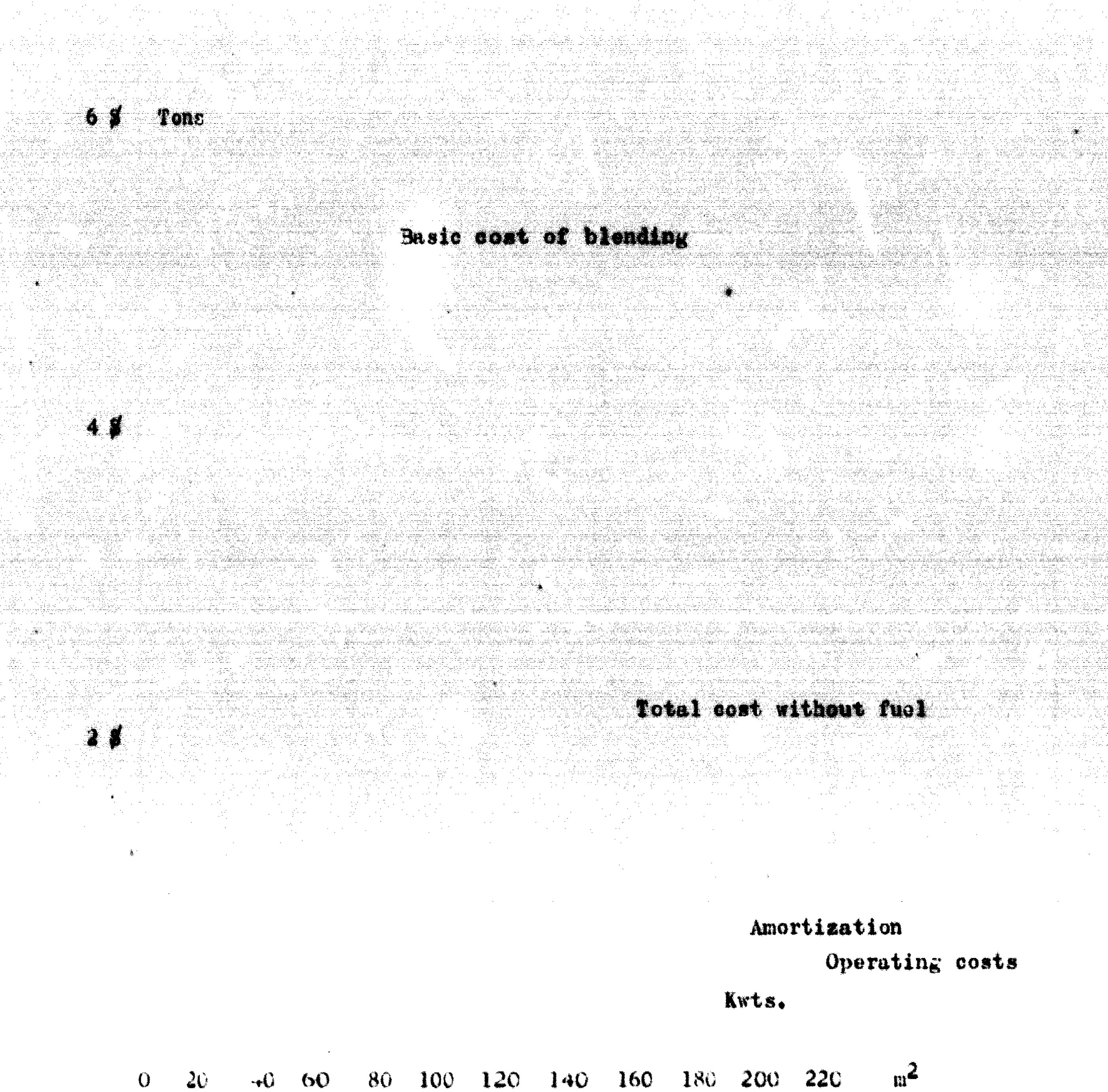
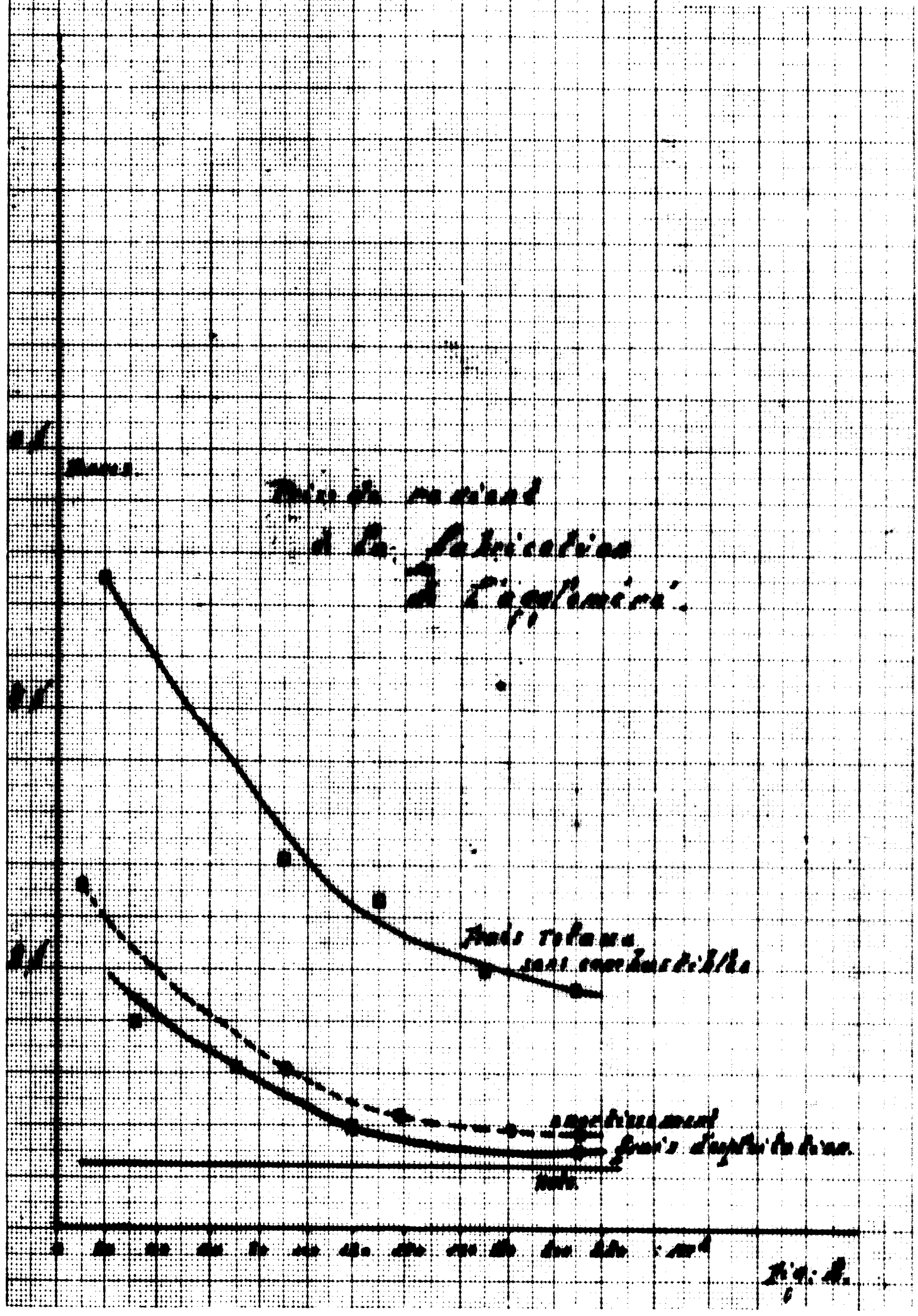
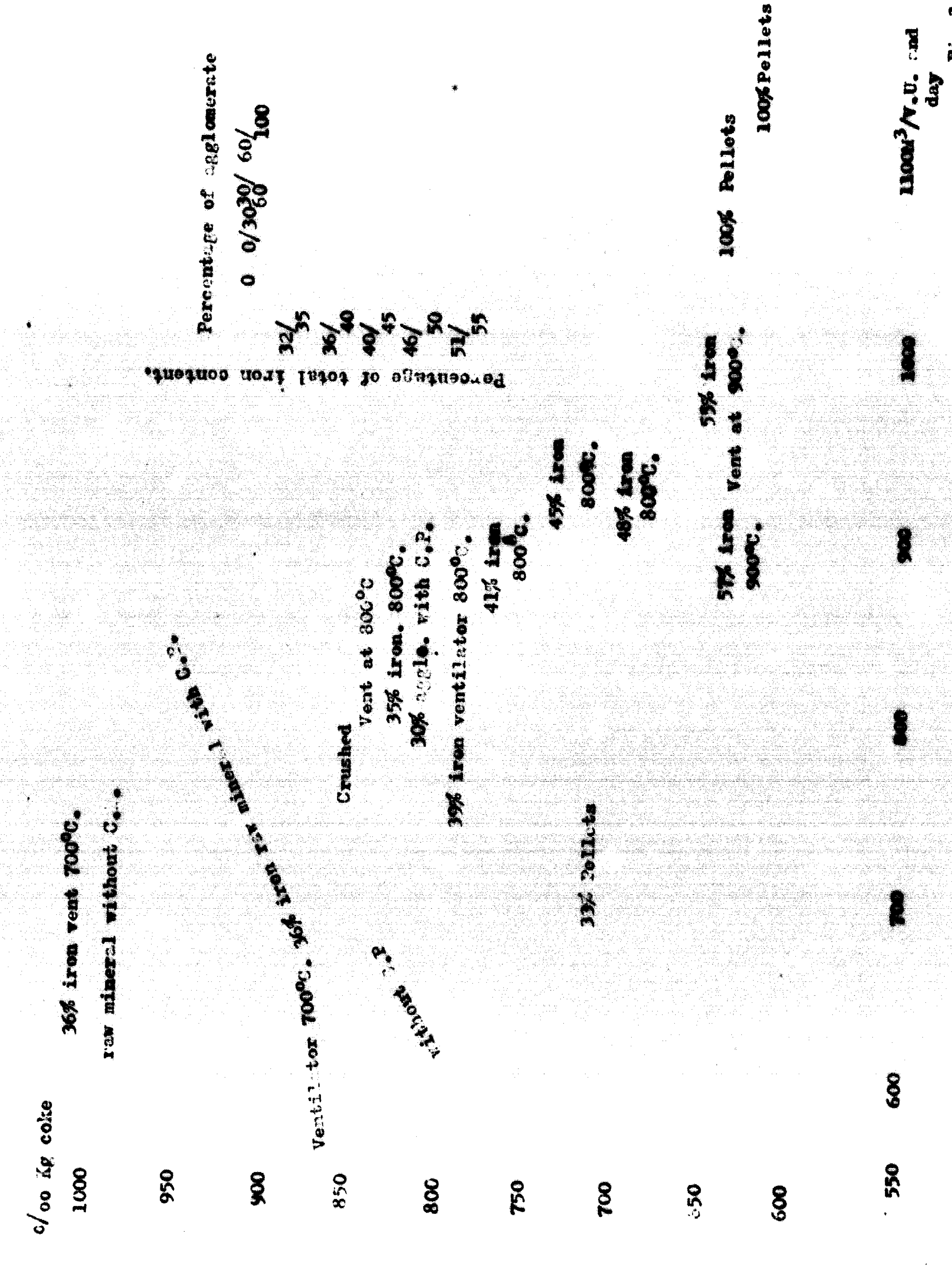

6 $ Tons
Basic cost of blending
4 $
Total cost without fuel
2 $
Amortization
Operating costs
Kwts.
0 20 40 60 80 100 120 140 160 180 200 220 m2

Fig:2




c/oo Kg coke
1000
950
900
850
800
750
700
650
600
550
600
700
800
900
1000
1100m³/V.U. and day
Percentage of agglomerate
0 0/30 30/60 60/100
Percentage of total iron content.
32/35
36/40
40/45
46/50
51/55
36% iron vent 700°C.
raw mineral without C.P.
Ventilator 700°C. 36% iron raw mineral with C.P.
without C.P.
Crushed
Vent at 800°C
35% iron. 800°C.
30% agglo. with C.P.
39% iron ventilator 800°C.
41% iron 800°C.
33% Pellets
45% iron 800°C.
48% iron 800°C.
57% iron 900°C.
55% iron Vent at 900°C.
100% Pellets
100% Pellets

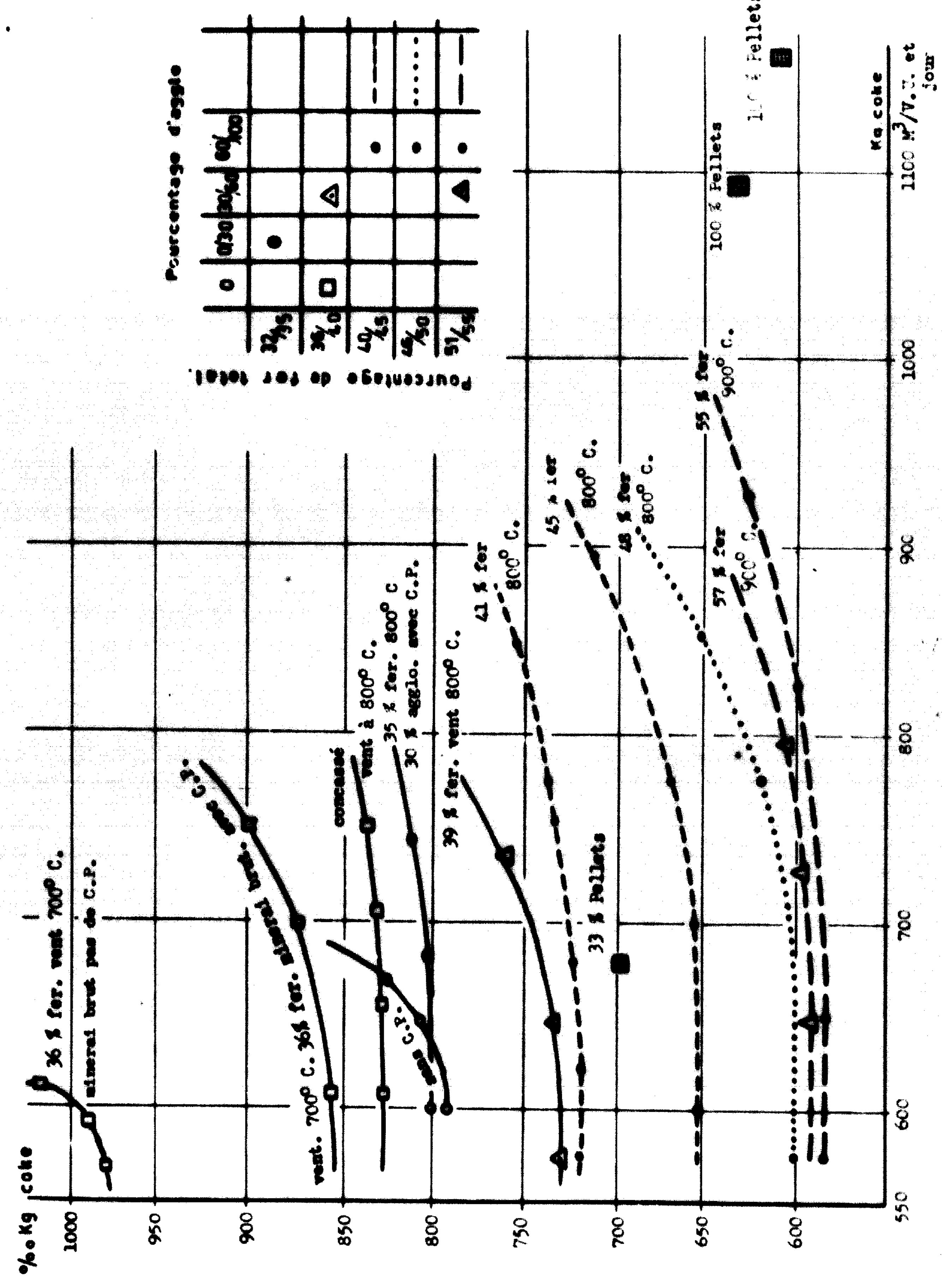

‰ Kg coke
Kg coke
1100 M³/M.U. et jour
Pourcentage d'agglo
Pourcentage de fer total
36 % fer. vent 700° C.
mineral brut pas de C.P.
vent. 700° C. 36% fer. mineral brut avec C.P.
concassé
vent à 800° C.
35 % fer. 800° C
30 % agglo. avec C.P.
39 % fer. vent 800° C.
41 % fer 800° C.
45 % fer 800° C.
48 % fer 800° C.
55 % fer 900° C.
57 % fer 900° C.
33 % Pellets
100 % Pellets

Fig. 3

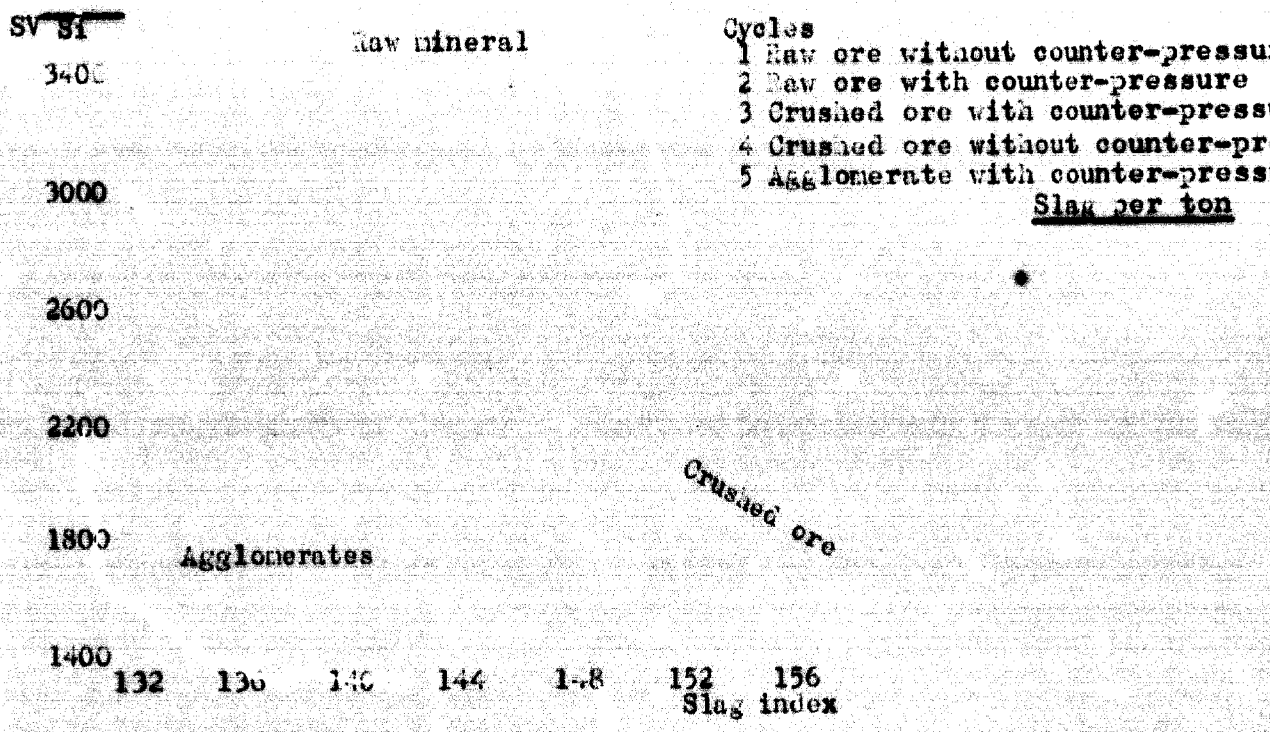


Fig.4 - S V in relation to the slag index during tests.

300

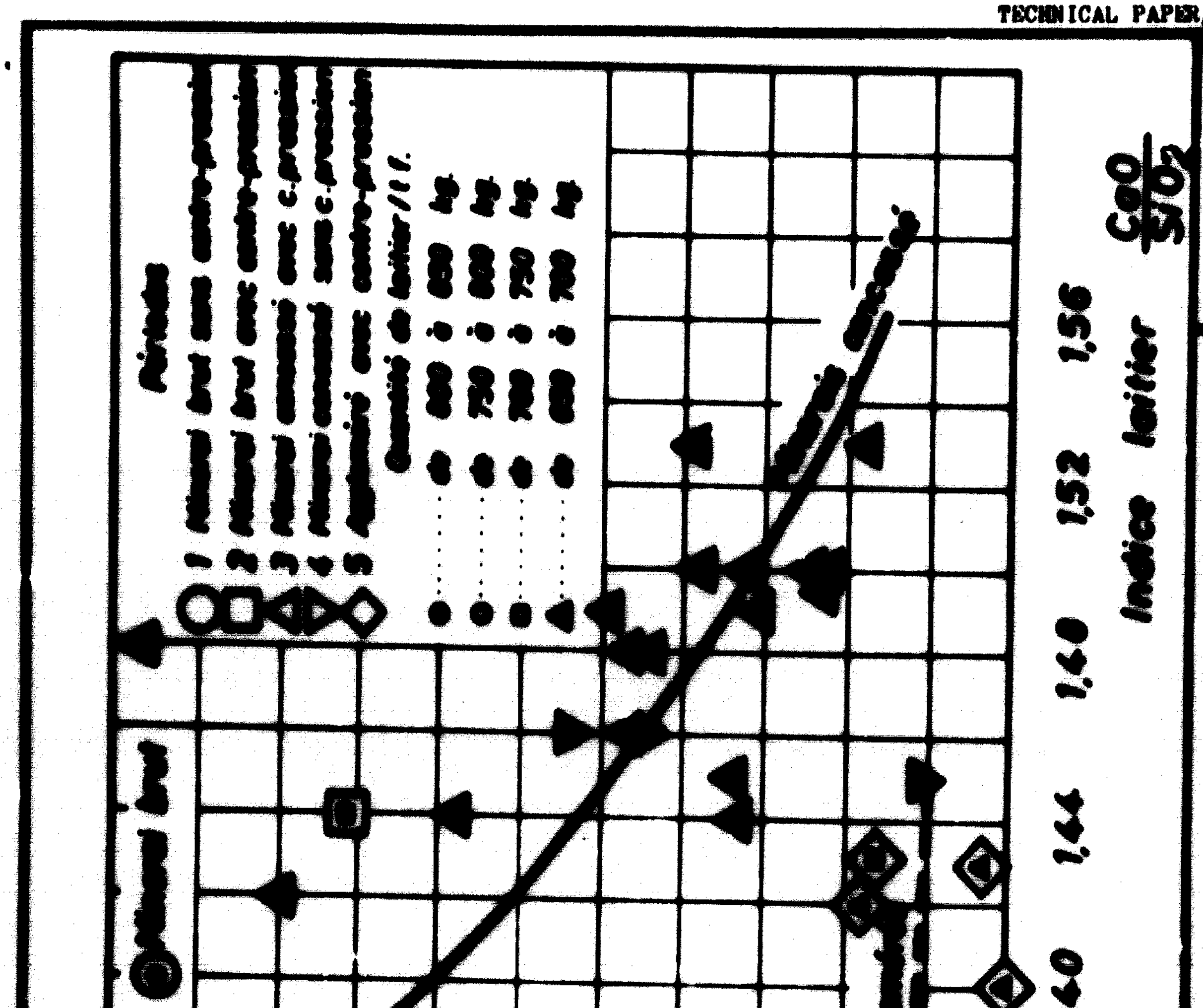


Fig 4 S √Si en fonction de l'indice de laitier au cours des différents essais.

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