CHROME ORE FINES SINTERING IN FERBASA

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S U M M A R Y

Ferbasa sinters the chrome ore fines (concentrate) < 2mm, originated from its own mines, using a charge to be sintered with the following composition: 55,06% of ore concentrate, 28,75% of sinter fines and 7,19% of charcoal fines. The mixture has a moisture content of 9%. It was reached a production rate of 17,81t/(m^2 . 24h) and the sinter presented a Tumbler Test JIS% > 9,52 = 59,47. The Greenawalt process is used with a pan of 13,9m^2. This paper presents the various steps of the process implementation which were as follows:

- Installation of a pilot plant which defined the sinterability of the chrome ore and the composition of the charge to be sintered.
- Installation of a semi-industrial plant which produced 2000 metric tons of sinter for the sinter test in the electric furnaces.

Brief comments are made covering the sintering process using charcoal.
Operational indeces, sinter physical and chemical characteristics in a Greenawalt sintering plant and the improvements to be introduced in the present plant are also shown.

INTRODUCTION

The Ferbasa production expansion of high carbon ferrochrome brought, as a consequence, a higher demand of chrome ore. In order to adequate this higher demand with the ore production possibilities offered by the Ferbasa own mines, it was necessary to think in a new operational process which could allow the use of a higher participation of chromite concentrate < 2mm in the electric furnace charge.

The development of an agglomerating process of the chrome ore fines, which could give us simultaneously, an improved productivity of the electric furnaces turned into a goal for the Company. The briquetting system had already been tested industrially with bad results. The binder high cost, the low mechanical resistance of the cold briquettes and the high wear of the briquetting machine rolls, obliged the Company to discontinue the process. Otherwise, the large availability of charcoal fines was a clear indication for the use of the sintering process in Ferbasa. The other process to be considered was pelletizing.

Table 01[01] shows that a definite preference was given to the use of the pelletizing process to agglomerate the chrome ore fines. Nippon Denko was the only firm using, at that time, the sintering process.

As Ferbasa is located in Pojuca (Bahia-Brazil) far away from the large Brazilian Steel Mills, the usual users of the sintering process, it was decided that the firm would directly and locally make all the experiments to develop the process with chrome ore. The sinterability of chrome fines was the first step of the project to be taken. A pilot sintering plant was installed and was ready for operation in February 1980. The sinterability of the chrome ore fines, as well as the charge composition, was defined in this plant.

As a consequence to the good results of the pilot plant operation a semi-industrial installation was designed and built. In this installation 2000 m.t. of chrome ore sinter were produced. The good results of the use of this sinter in the electric furnaces were conclusive for the installations of a sintering plant in Ferbasa in industrial scale.

Coincidentally, the Belgo Mineira, a Brazilian Steel Mill, had discontinued the operation of a Greenawalt sintering plant in its plant located in Monlevade, Minas Gerais State.

This sintering plant with two $13,9 m^2$ pans was purchased, dismouted, transported and installed close to the Ferbasa ferrochrome plant.

The installed sintering plant used only one of the pans. The rated capacity of one pan when operating with iron ore was 300 m.t./24h. Operational indeces, physical and chemical properties, as well as charcoal particularities when used in the sintering process are discussed here.

We hope that the experience Ferbasa gathered with the sintering implantation, may be useful for the colleagues working within the same field of activity.

CHROME ORE FINES SINTERING PILOT PLANT

Normally, the economical possibilities of a sintering plant are closely related to the availability of a low cost fuel. As far as Ferbasa is concerned, the use of charcoal fines was imperative considering that 100% of the coal used by the firm is charcoal. The low thermic efficiency of the charcoal (see aspects of the sintering process using charcoal) indicates its use in the sintering process when the ore has a low softening point temperature. Considering this point, the charcoal would not be recommended for the chrome ore sintering process. Preliminary tests, made by others, have shown that the addition of certain amount of iron ore was necessary to sinter the chrome ore. This addition would decrease the Cr/Fe ratio in the sinter to a level which turns its use economically unfeasible.

In spite of this first result, the Company decided to go ahead with the tests of sinterability.

A pilot plant was built (Fig nº 1) with materials and experiments available at Ferbasa plant. A flanged cast iron pipe 8" diameter was used as sintering pan. The exhaust fan was an old blower for 1050 mm H_2O, $43 m^3/min$. The mixture was prepared in an concret mixer. For the ignition, LPG burners were used. Dispite the precarious quality of the installation, the plant worked very well. Only the exhaust fan runner worn-out in few months.

From the beginning the sinter presented good mechanical characteristics.

The composition of the original mixture was: 87% chrome ore concentrate, 3% line (hidrate) and 10% fines of charcoal < 6 mm.

Other compositions were tested until we were able to obtain a sinter with good mechanical characteristics, using only chrome ore concentrate and fines of charcoal.

The good sinter mechanical strength, porosity, and chemical composition led to the conclusion that the same would present good results in the electric furnaces. The operation with, exclusively, fines of chrome ore and fines of charcoal could de reached at a very low cost.

CHROME ORE FINES SINTERING SEMI-INDUSTRIAL PLANT

The installation of this plant (Fig 2) was made with two goal:

- To produce an amount of sinter which would allow its use in an industrial scale in the existing electric furnaces.
- To fix the parameters for an industrial sintering plant as far as it would be demonstrated that the use of the sinter in the electric furnaces would give good results.

The installation was designed for a production of 01 m.t./h. The exhaust fan was for $150 m^3/min$, 1000 mm H_2O. Two sintering pans, each one with $1,7 m^2$ and a depth of 300 mm were installed. The fan would operate with one of the pans alternativily. Butterfly valves connected the fan with the pan to be operated. With this arrangment the process became practically continous; one pan was unloaded and reloaded while the sintering process was in course in the other pan. For the ignition, LPG was used. As the burner available was not good it was necessary to dispose of a fine layer of charcoal fines over the mixture layer to facilitate the burning.

Two thousand metric tons of sinter were produced and tested in two electric furnaces: first in a 8MW unit and then in a 14MW one. The sinter was used during 07 days in the same proportion as the concentrate used in the 10 previous days.

Operational conditions were maintained. The good results of the experiments are shown in Table 02. Additionally, the following advantages with the use sinter could be observed:

- The small quantity of ore fines in the charge and the porosity of the sinter improved the permeability of the furnace charge and the blowings practically disapeared.
- Furnace maintenance was reduced as a result of the lack of blowings.
- Loss of ore fines in the chimney emission was drastically reduced.

CHROME ORE FINES SINTERING INDUSTRIAL PLANT

The result reached with the use of sinter in the electric furnaces recommended the installation of an industrial sintering plant. Semi-industrial installation enlargement was possible to meet our industrial needs. It was decided to purchase the Greenawalt sintering plant, which was disativated by the Siderurgica Belgo Mineira, due to the low cost of the installation and the reduced handlabor required.

The installation was dismounted, transported and erected. Operation started in August 1982. Fig 3 shows a flow-sheet of the installation. Only one pan was used. Besides, the original installation designed to operate with iron ore was simplified.

The following modifications and simplifications were introduced.

- Metallic conveyors for the hot sinter were replaced by conveyor belts for high temperature.
- Rotating feeder tables were replaced by slide-box feeders.
- Mixers were installed in parallel instead of being in series.
- In order to reduce the extension of the pan deck, the ignition car was replaced by a suspended hood designed to use the same existing burners.
- Sinter cooling in the hopper was discontinued.

The installation operated quite well and the only problems were found in the ignition hood where small explosions occurred during the initial tests. Proper burning setting eliminated the problems.

Characteristics of the installation:

- Greenawalt pan with suction area of 13,9m^2.
- Nominal capacity - 300 m.t./day.
- Nominal rate - 21,44 m.t./m^2 - 24h.
- Maximum suction - 2000 mm H_2O.
- Height of walls - 360 mm.
- Ignition fuel: diesel or alcool.
- Mixer - (2 pug mill)
- Bins - 05
- Pan feeder. (car cylindrical feeder)
- Sinter crusher with toothed cylinder.
- Screening in grid with 6 mm.

Aspects of the sintering process using charcoal

The charcoal fines have very definite physical and chemical characteristics and it is necessary some considerations to understand the results reached with their use in the sintering process. Fig nº 4 shows the granulometric composition of the charcoal fines used in Ferbasa. Table IV shows the differences between the characteristics of the coke breeze and the charcoal fines.

The high reactivity of the charcoal modifies the heat transference and combustión process during the sintering. Voice and Wild (2) have shown that heat produced in the charge upper layer (combustion front) is transfered to the lower layer (heat transfer front), in such a way that the best results in thermic efficiency of the process and sinter quality are obtained when a coincidence between the heat transfer speed (heat transfer front) and the fuel burning speed (combustion front) is reached.

When charcoal is used, in the sintering process, a higher speed of the combustion compared with the heat transfer speed is reached. As a result a lower thermic efficiency and a process lower maximum temperature are reached as well. Wscieklica (3) verified this occurence in the Cia. Siderurgica Belgo Mineira Sintering Plant. This is a

disadvantage in the use of the charcoal in the sintering process as more fuel is required.
The low inflamability temperature of the charcoal is also a disadvantage, as the combustion initiates before the arrival of burning front. The volatil is released mostly during the process with low thermical efficiency. Wscieklica (3) has shown that 30% of the CO, 17,6% of the H_2 and 100% of CH_4 are not burned in the sintering process (the volatil composition in weight is: 37,2% CO_2, 40,7% CO,11,9% H_2, 10,2% CH_4).
With these considerations it is easy conclude that charcoal fines are not the ideal fuel for the sintering process of ore of high softening point, as the case for the chrome ore. chiefly if its contents in Cr_2O_3, Al_2O_3 are high.
The low density of charcoal fines causes a large contribution to the charge as far as volumetric composition is concerned.
When the charcoal is burned, the volume of generated voids is large and the sinter porosity increases. Beyond a definite limit the sinter becomes very weak.

Ore granulometric and chemical composition

Mechanical screening with squared mesh sieves is used to find the ore granulometric composition. Fig 5 shows the granulometric composition of the chrome ore as the best granulometric composition recommended by Astier (4) and the sinter feed as is used for the iron ore. If it is assumed: that the iron ore patterns are worth for the chrome ore, the permeability problem practically disapears, considering that the use of the sinter < 6 mm will correct the mixture granulometric composition curve towards the recommended one. The good permeability of the mixture will practically be a function of the moisture content.
Typical chemical analysis of the ore is:

Cr_2O_3	-	35	to	37%
SiO_2	-	10	to	14%
FeO	-	14	to	18%
CaO	-	1	to	3%
MgO	-	12	to	14%
Al_2O_3	-	12	to	14%

Charge composition

The charge mixture composition is made using the weight, including moisture of each component. The moisture determination of each component, made in samples taken before the mixture, has allowed us to find the real compositions of the sintering charge. The average results of 2 month operations are shown below:

- Chrome ore concentrate	-	55,06%
- Sinter fines < 6mm	-	28,75%
- Charcoal fines < 6mm	-	7,19%
- Moisture	-	9,00%

Operational results

Sinter charge density	-	1,623 Kg/m^3.
Bed depth	-	400 mm
Production	-	17,81 t./(m^2 . 24h)
Suction	-	1,480 mm H_2O
Chrome ore concentrate (dry)	-	895 Kg/t. sinter
Chrome ore bedding (dry)	-	159 Kg/t. sinter
Charcoal fines (dry)	-	117 Kg/t. sinter
Tumbler Test JIS% > 9,52mm	=	59,47
Ignition: Diesel Oil.	-	1,56 l/t. sinter.

The physical characteristics of the sinter, as evidenced by the Tumbler Test, are beyond our furnace quality requirements.
The sinter composition is practically the same as the chrome ore used, only charcoal ashes are incorporated in the sinter. When compared with the chrome ore the chemical composition of the sinter is, therefore, considered good. Installation

productivity is not yet considered satisfactory for Ferbasa. We are looking forward to reaching more productivity of the installation with the following improvements:

- The mixers will be installed for series operation with the installation of a drum mixer. It is expected a better micropelletizing of the charge as well as a permeability improvement.
- Improvement in the operation of the charging car will be made.
- All lump ore will be carefully screened to eliminate the fines completely. The oversize will be used in the furnace charge and the undersize will be used in the sintering.
- A recording thermemeter will be installed to follow the sinter burning process and to define better the end of the process.
- Improvement of the bedding ore granulometric will be introduced.
- Dosing feeders with moisture equipments of compensation will be installed.

Production cost

As there is no expense with either the preparation or the transportation of the charcoal fines we did not attribute any cost for them, considering both their lack of advantage and market as well. The sinter production costs US$ 3,430/t, whose expense is considered reasonable by the Company.

Conclusion

Ferbasa produces in its own or controled mines all the chrome ore required by its electric furnaces operations, for the production of chrome alloys. The sinter process has definetly contributed to improve the conditions for the use of the low grade chrome ore produced. Today the amount of fines in the chrome ore is no longer a problems. Improvements in the chemical composition of the ore is presently the main goal.

Low content chrome ore, can be concentrated and used in the electric furnaces with the help of the sintering plant, at present.

Besides these aspects we should also consider the stractegic side; in an experimental phase, we have already operated our furnaces with 100% of ore as sinter with no problems except those presented by the chemical composition (Cr/Fe ratio). Without the sinter the chrome ore fines (concentrate) use is at most limited to 35% of the charge and part of the same is lost in the chimneys draft.

The use of sinter has also improved the operational characteristics of the electric furnaces, reducing the consumption of electric energy, charcoal and ore and increasing the productivity.

The chimneys dust emission was drastically reduced. The blowing elimination reduced maintenance and accidents.

References

1) ICHIKAWA, K. - Progressos in Afinos de Aceros Inoxidables Y Tendencias en la Industrial del Ferro Cromo, paper presented to the ILAFA Ferralloy Congress, Pg 75-81. Acapulco, México, May 14-18, 1978.

2) E. W. VOICE, R. WILD - L'importance des Fhénomines de Transfert de Chaleur et de Combustion dans L'agglomeration Sur Grille Symposium International des Minerais de Ferro. Paris, Mai 1957.

3) J. WSCIEKLICA - Aspectos Térmicos da Sinterização com Carvão Vegetal. XVIII Congresso Anual da A.B.M. - Rio de Janeiro, Julho 1962.

4) ASTIER, J. E. - Aglomeração e Redução dos Minérios de Ferro. Metalurgía - A.B.M. V.21 nº 89 - Abril 1965. Pg 275/294.

PROCESS	COUNTRY	COMPANY	YEAR	CAPACITY	MAIN EQUIPAMENT
1· PRE REDUCED PELLETS	JAPAN	SHUNAN DENKO	1969	20 t/h	MOVABLE SCREEN ROTATING FURNACE
2·	JAPAN	JAPAN METALS	1970		ROTATING FURNACE
3·	JAPAN	SHOWA DENKO	1971	20 t/h	STACK FURNACE ROTATING FURNACE
4·	SOUTH AFRICA	CONSOLIDATED	1977	22 t/h x 2	MOVABLE SCREEN ROTATING FURNACE
5· SINTERED PELLETS	FINLAND	OUTOKUMPU			STACK FURNACE ROTATING FURNACE
6·	GERMAN FEDERAL REPUBLIC	GESELLSCHAFT FÜR ELEKTRO-METALLURGIE	1972	250 t/d	MOVEBLE SCREEN ROTATING FURNACE
7·	JAPAN	NIPPON KOKAN	1974	20 t/h	VERTICAL SING FURNACE
8· COLD AGLOMERATED PELLETS	SWEDEN	FERROLEGERINGER	1975	20 t/h	AUTOCLORE
9· SINTERING	JAPAN	NIPPON DENKO	1970	10 t/h	DWIGHT LLOYD
10· SINTERING	*BRAZIL*	*FERBASA*	*1982*	*12,5 t/h*	*GREENAWALT*

TABLE 01 – CHROME ORE AGLOMERATING PROCESS (1)

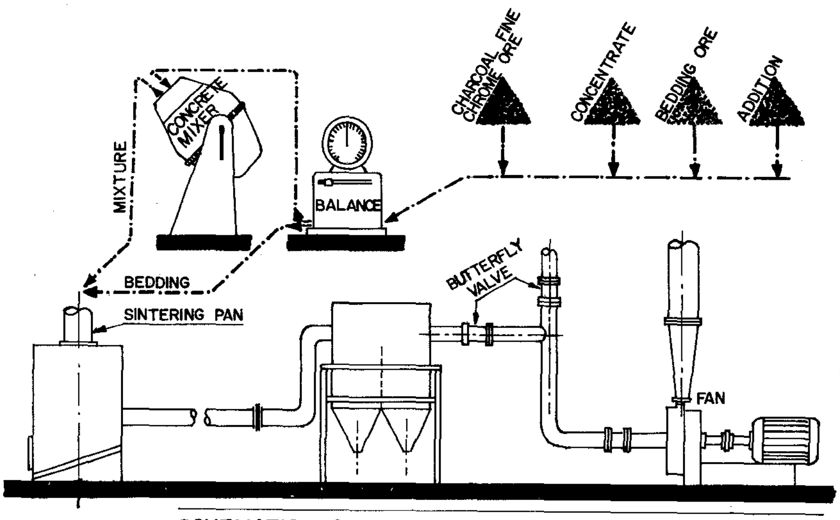


FIG. 01 – SCHEMATIC LAYOUT OF THE PILOT SINTERING PLANT

		CHARGE 35% ORE AS CONCENTRATE	CHARGE 35 % ORE AS SINTER	CHANGES %
FURNACE VI · 14 MW	PRODUCTION Kg/d	72.780	79.111	+ 8,7
	ORE /t Fe Cr	2.474	2.260	– 9,5
	Kwh /t Fe Cr	4.129	3.770	– 9,5
	CHARCOAL m^3 /Fe Cr	2.28	2.10	– 8,5
	COKE Kg/t FeCr	86	69	–24
FURNACE II · 8 MW	PRODUCTION Kg/d	32.394	36.960	+14
	ORE /t Fe Cr	2.688	2.502	– 7
	Kwh /t Fe Cr	4.436	3.970	–12
	CHARCOAL m^3 /Fe Cr	2.66	2.31	–15
	COKE Kg/t Fe Cr	73	68	– 7

TABLE 02 – PRODUCTION IMPROVEMENT DUE SINTER USE INTO THE FURNACE VI AND II

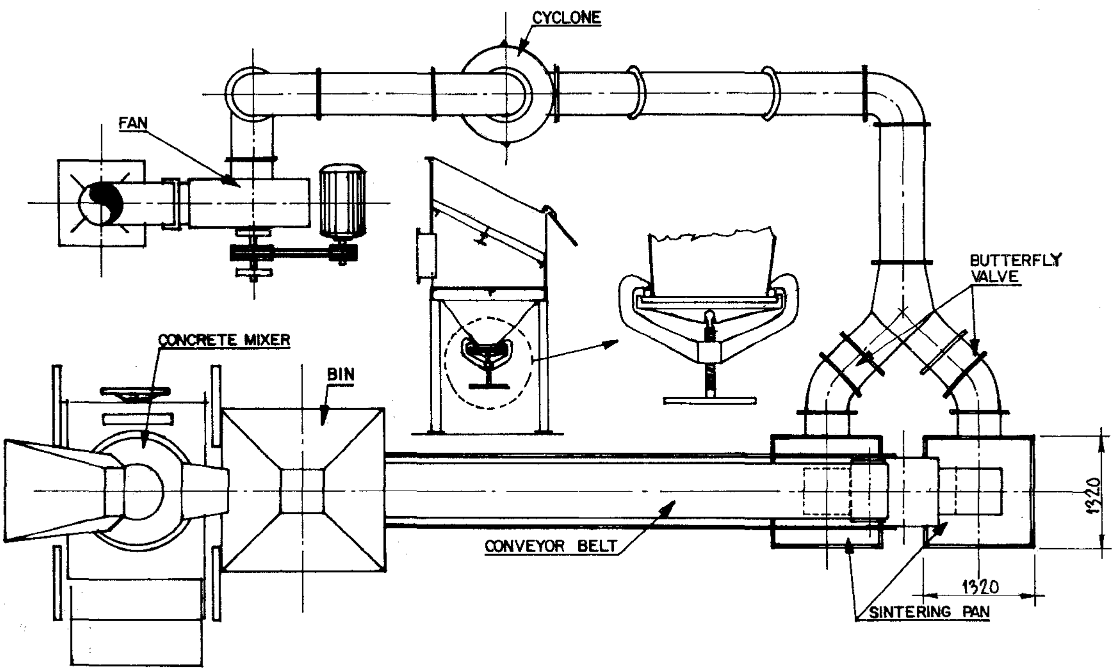
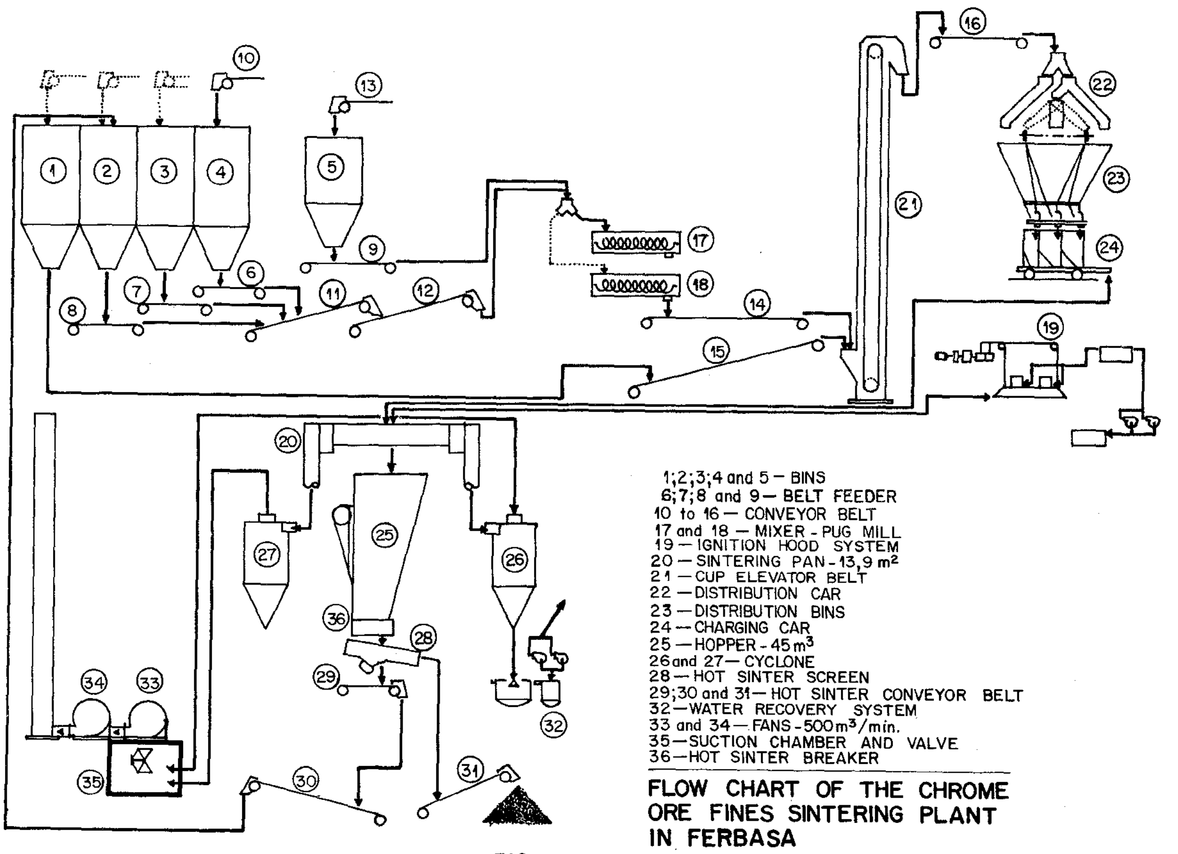


FIG. 02 – LAYOUT FOR SEMI-INDUSTRIAL SINTERING PLANT

		CHARCOAL FINES	COKE BREEZE
REACTIVITY		HIGH	MEDIUM
IGNITION TEMPERATURE °C		130 - 210	500 - 600
FIXED CARBON (%)		42 - 58	84 - 86
DENSITY (kg/m³)		350 - 370	750 - 850
MOISTURE (HUMIDITY)		10 - 15	8
ASH %		18 - 32	13
VOLATILE MATTER %		24 - 26	2 - 3
ASH ANALYSE	SiO_2	50 - 54	50
	CaO	16 - 20	3
	Fe_2O_3	5 - 6	11
	Al_2O_3	6 - 7	27

TABLE 03 — CHARACTERISTICS DIFERENCES BETWEEN THE CHARCOAL FINES AND COKE BREEZE



FLOW CHART OF THE CHROME ORE FINES SINTERING PLANT IN FERBASA

FIG. 03

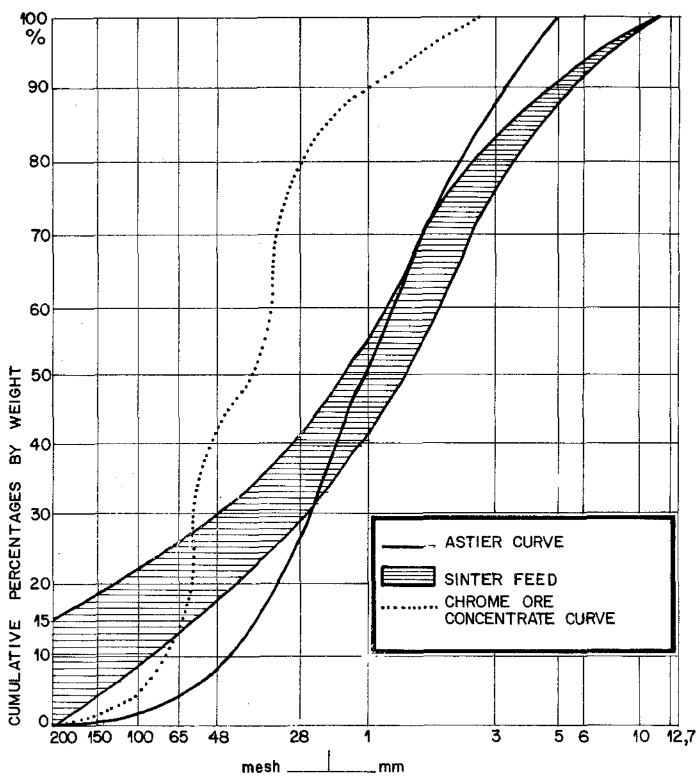


FIG. 05 – SINTER FEED, ASTIER AND CHROME ORE CONCENTRATE GRANULOMETRIC CURVE

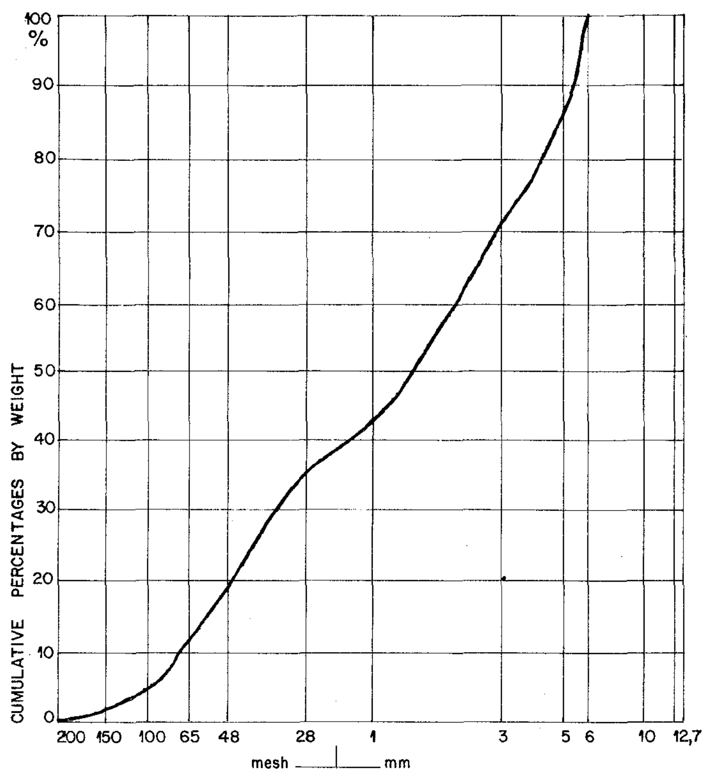


FIG. 04 – CHARCOAL FINES GRANULOMETRIC CURVE