Pelletising of Hematite Ores

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SINTERING of iron ore fines is assuming great importance in the field of the world's iron and steel industry.

This fact depends chiefly:

(a) upon necessity of treatment and concentration of lower grade ores, with consequent production of fine concentrates.

(b) upon development of beneficiation techniques, which allow to use ores that up to a few years ago were of no commercial importance.

(c) upon advantages shown by burden preparation for blast furnace requiring the separation of fines from the charge.

Most of such fines is sintered in Dwight-Lloyd type continuous grate machines, that hold the first place in sintering ferrous fines.

For some time there has been a growing offer of very fine ores, i.e. magnetite concentrates, fine pyrite cinders, flotation concentrates and flotation tailings whose treatment in usual sintering plants poses considerable difficulties.

The increasing production of these fines has resulted in the development and set up of other agglomerating methods, that were partially known long since, but had not found industrial application.

Among such processes, the pelletising method has been considerably developed recently: it consists of two separate phases: in the first phase the ore powder is pelletised; in the second phase the pellets are subjected to a subsequent firing treatment in a shaft furnace or on a travelling grate, in order to confer on the product such a strength that it can withstand stresses during transport to the blast furnace.

Ores, suitable for this process, must have a very fine grain size because cold forming process occurs only by rolling of ores on a continuously moving surface.

In this way pellets are obtained, which have a solidity comparable to that of briquettes mechanically produced at pressure of some hundreds of atmospheres. The pellets, in course of formation, during rolling meet ore particles of only a few microns in size and therefore the reciprocal pressure between pellets and ore particles is some hundreds of atmospheres.

By means of this compression, particles strongly stick to one another and among them thin channels are formed, that are full of water, whose capillary tension develops a considerable adhesive force.

It is therefore logical that only very fine ores are suitable for this forming process, and allow the production of green pellets with sufficient strength to withstand transport to furnace and stresses developed in the first stage of firing.

Ores, which are successfully pelletisable, have really a grain size clearly different from fines used for grate sintering.

Fig. 1 shows the grain size distribution of ores generally used for sintering and pelletising; from the diagram it is seen that the grain size limits are sharply marked.

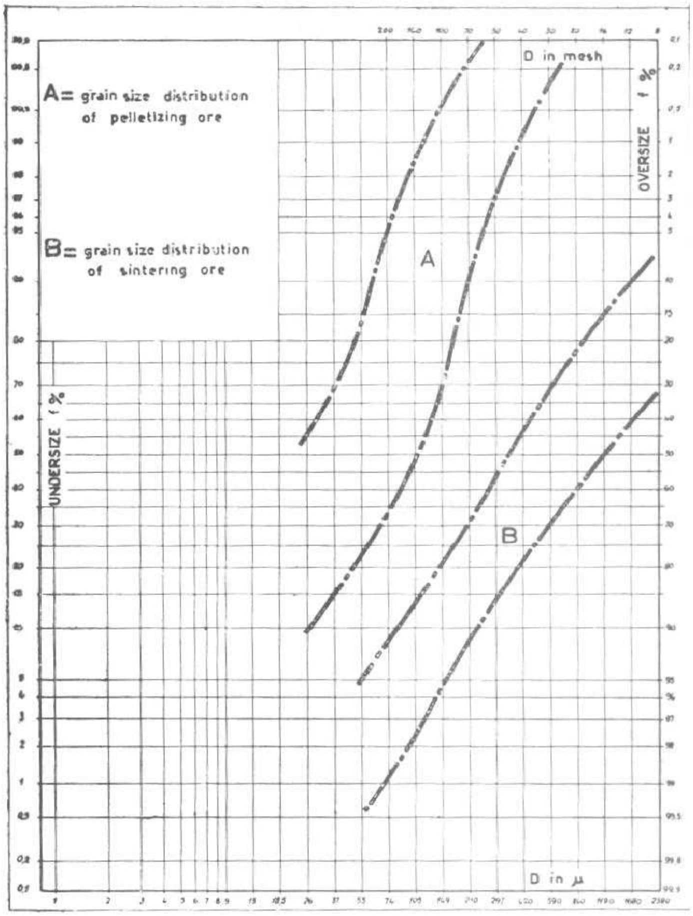

Fig. 1.

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Application of pelletising to Elba Isle hematite ore

Till few years ago, pelletising was used in industrial practice for the treatment of magnetite concentrates of high iron content. It was, however, not used in the case of hematite ore of Elba Isle.

The ore deposits of Elba Isle mined by open pit methods consists for the most part of hematite ores which are shipped to the blast furnace after screening.

The long exploitation of these deposits, which started in pre-romanic age, has considerably depleted the resources of directly usable ores. For this reason attention was directed towards exploitation of other deposits of lower grade which required subsequent beneficiation :

(*a*) "*Ferriferous earths*" *deposits*, consisting of decomposition residues of mineralised rocks and of old exploitations. Such ores, which are mixtures of hematites, limonites and clays with an iron content of 30 per cent, are subjected to mechanical gravity concentration, which separates impurities and the product is classified in various fractions according to grain size. The finest fraction obtained by decantation equipment has a low content of clay, a good iron percentage (45-50 per cent), but is difficult to use due to its fineness and water content, which are undesirable for handling and utilisation in sintering plants ;

(*b*) *Open pit pyritic deposits*, containing low quantities of lamellar oligiste. After desliming and flotation extraction of pyrite, tailings with high content of oligiste are obtained as by-product. The iron content of this material, after gravity concentration on shaking tables, is about 55–60 per cent ; considerable difficulties can arise for transport of this very fine ore from Elba Isle to the Continent, where iron and steel works are located ;

(*c*) *Sulphureous oligiste deposits* of substantial size, recently discovered ; the exploitation of these deposits will be made partly by open pit and partly by underground mining. After differential flotation of oligiste and pyrite, large quantity of oligistes with high iron content (experimental runs have produced concentrates containing 60-62 per cent Fe) is obtained ; this concentrate however is not easily transportable owing to its high grade of fineness (50–60 per cent minus 200 mesh) and its water content (15 per cent).

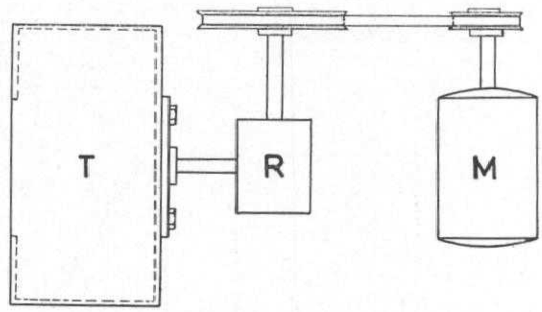
The problem of agglomerating these products most economically was posed to societies of FINSIDER Group since 1951.

A committee of engineers was constituted to study the question and to state if the pelletising process, already tried with success in Sweden and USA on magnetite ore, could also be applied to hematite and limonite fines, mined in Elba Isle.

Laboratory scale experiments

After a careful study of technical literature and some preliminary experiments it was found that it would be difficult but possible to pelletise these hematite ores and therefore the installation of laboratory scale equipment was taken up, to obtain essential data for the study of forming and firing processes.

Initially, a small laboratory rotation drum (Fig. 2) 40 cm in diameter and 20 cm long was employed for making pellets. Experimental pellet firing was performed : (*i*) in a laboratory electric muffle furnace with variable temperatures and times ; (*ii*) in a small oil fired tunnel furnace in which green pellets are charged on refractory scoops, dried, preheated, fired and cooled ; and the optimum conditions of firing to impart a satisfactory strength in pellets were determined.



T=pelletising drum (400 mm × 200 mm)
R=speed reducer M=electric motor

Fig. 2.
Laboratory pelletising drum

Experimental plant on semi-industrial scale

After gathering laboratory data, a small experimental pelletising plant was built with a production rate of 10–20 tons per day, depending on the type of ore.

This plant consists of two sections for the forming and firing of pellets. The pellet forming section consists of the following equipment as shown in Fig. 3 :

(*a*) a Karr type disintegrator for crushing the ore lumps,

(*b*) a feeder consisting of a hopper provided with weigher and variable speed chain elevator ; a second small hopper is used for adding and weighing binders and fuels,

(*c*) a paddle blade type mixing machine for mixture homogenising,

(*d*) a pelletising drum (2·00×0·90m) slightly inclined and rotating at variable speed ; at the drum end, wire screen allows to separate seed pellets that are recycled by two belt conveyors,

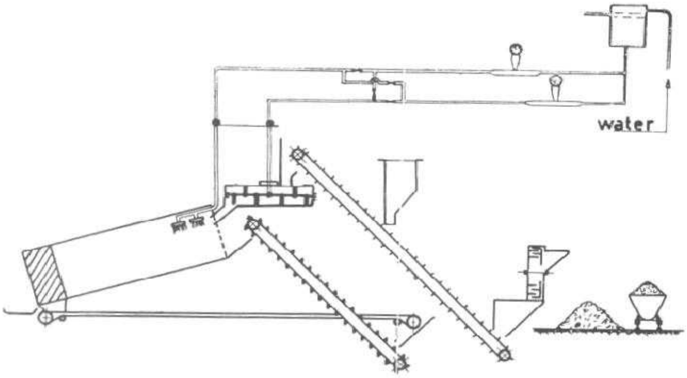


Fig. 3.
Layout of pilot plant for cold forming of pellets

(*e*) a regulating device for water, provided with flowmeter and constant level tank.

Sized pellets (20 cm dia.) are manually charged to the conical firing furnace. It is 2·10 m high with a diameter of 40 cm at the top and of 60 cm at the bottom (Fig. 4.).

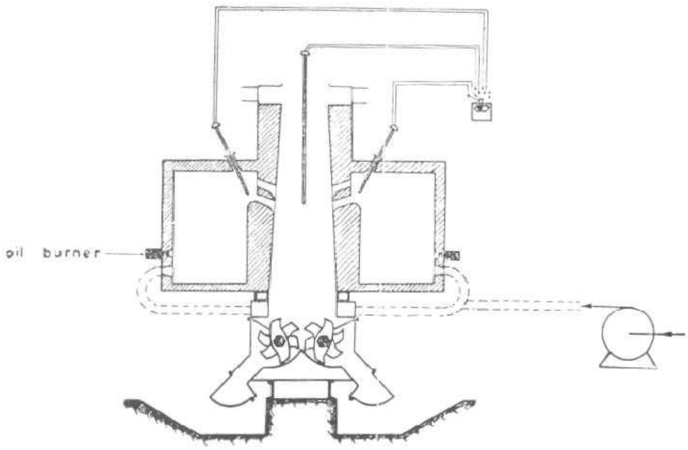


Fig. 4.
Layout of trial furnace for pellet firing

About 90 cm above stock level, walls are provided with holes for letting in hot gases, coming from three oil fired combustion chambers, in which compressed air is introduced.

Pellet discharging from furnace bottom is accomplished by two toothed-shafts rotating at very low speed, discharging the pellets to two small hoppers, that are opened from time to time.

Results of trials performed in semi-scale plant

The above mentioned plant was used to study the pelletising of various hematite ore fines of Elba Isle and their mixtures.

Grain size of the important ores is reported in Table I.

TABLE I

Screen analysis of Elban hematite fines

ASTM Mesh	Washing refuses	Flotation tailings	Concentrated oligistes	Ground oligistes concentrate
+8	3·87	0·10	—	—
8 +16	4·40	0·40	0·40	—
16 +30	8·90	4·80	2·00	—
30 +50	15·80	14·80	5·40	—
50 +100	25·90	24·30	12·40	0·35
100 +200	18·50	23·10	22·20	4·75
—200	22·60	32·50	57·60	94·90

During trials with such ores, forming plant and firing furnace have been modified so that plant could be suited to run at conditions required by each type of ore. In Table II running data of furnace and mechanical properties of produced pellets are reported.

Building and running of industrial pilot plant

In consequence of results supplied by numerous continuous runnings in the experimental plant, sufficient data were obtained for design and building of an industrial scale pilot plant at Elba Isle.

This plant has been built near a mine, where

TABLE II

Running data of semi-scale shaft furnace

	Washing refuses	Flotation tailings	Concentrated oligistes	Grounded and conc. oligistes
Green pellets moisture (%)	12	11	10	10
Firing temperature (°C)	1050–1100	1150	1200	1200
Production rate (kg/h)	600	300	300	300
Heat consumption (cal/t)	350·000	400·000	450·000	450·000
Charge descent speed (cm/mt)	3·6	1·8	1·8	1·8
Comb. chamber pressure (H_2O mm)	300	250	280	280
Crushing strength (kg/pellet)	130	120	110	167

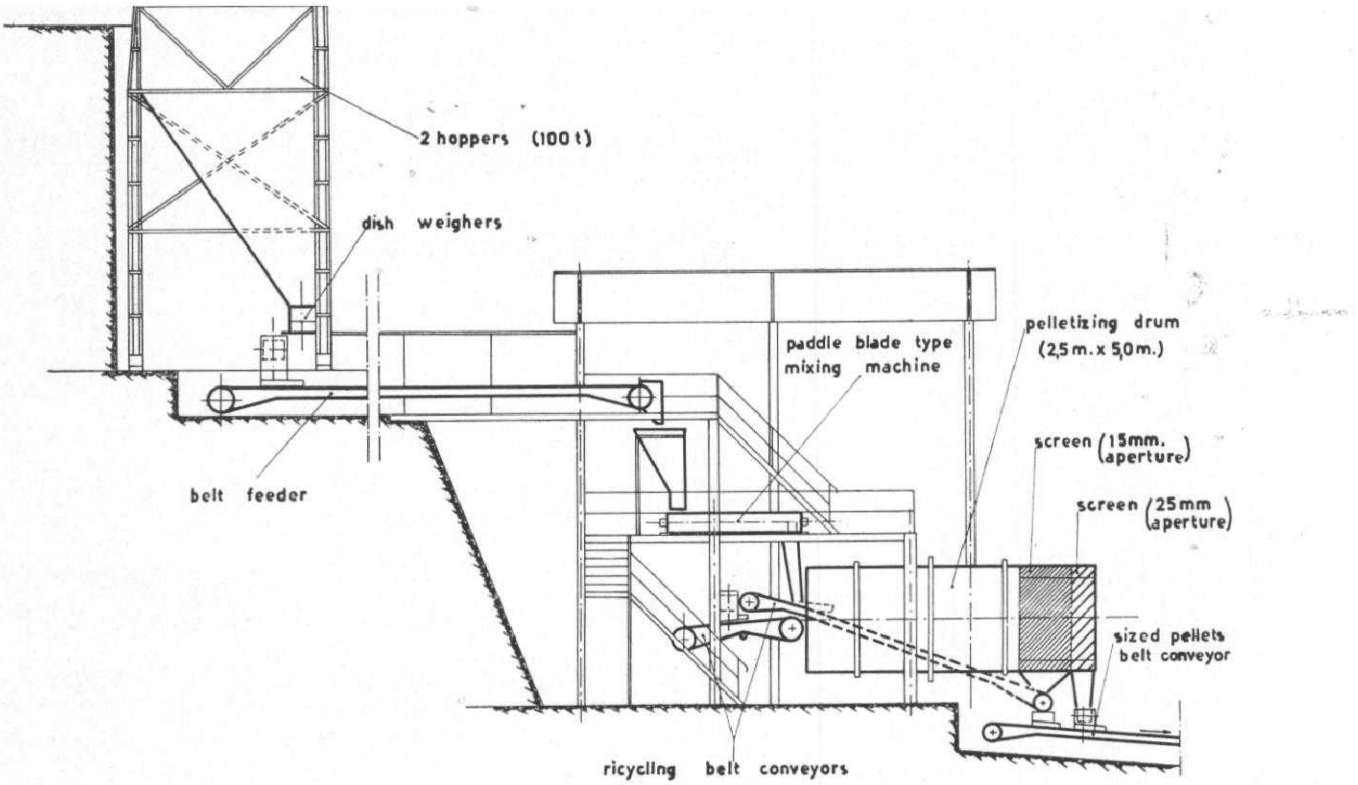


Fig. 5
Pelletising pilot plant of Elba Isle—Cold forming section

some types of fine ores are produced. Other types of concentrates, produced in plants located at distances of some kilometres, are transported by trucks. The other consideration for choosing the site for the plant was its nearness to one of the ore loading wharfs.

In the pellet forming plant the ore is conveyed by two belt conveyors from two 100t hoppers to one double shaft mixer, for mixing the fines (Fig. 5).

Pelletising is performed in a rotating drum of 2·5 m diameter and 5 m length. At the drum end, two wire screens are placed, which are coaxially joined to the drum. The first screen 1 m long, with 15 mm apertures, separates seed pellets which are then recycled in the drum by four belt conveyors.

The second screen 0·5 m long, with 25 mm apertures, separates too large pellets and ore lumps.

Sized pellets are then conveyed by belt conveyors 20 m long to the shaft type firing furnace (Fig. 6) 5 m high; diameters of various furnace zones are:

Stock column level	...	1·40 m
Combustion chambers	...	1·70 m
Furnace bottom	...	2·00 m

Hot gases for firing are supplied from annular combustion chamber provided only with one oil burner; hot gases pass through 18 holes at 1·40 m from charging top. Refractories used for furnace lining are alumino-silicate refractories (52% Al_2O_3). Their behaviour during various furnace runnings is satisfactory.

At the furnace bottom a horizontal holed grate is provided to break pellet lumps; an assembly of three air tight valves with hydraulic control performs discharging of pellets that are conveyed to shipping bunkers, by Decauville tilting wagons.

The above mentioned plant has run for about one year with various hematite ore types; interesting results have been actually obtained using lamellar oligistes concentrated on shaking tables (55% Fe) and ground to —200 mesh.

These pellets have sufficient strength to withstand high stresses to which they are subjected during shipping from pelletising plant to iron and steel works, located on the Continent. Examination of pellets during loading at Elb Isle and on arrival to blast furnaces has indicated that only 10% of pellets undergoes degradation during shipping.

Table III reports data relating to latest running period and total pelletising cost.

At Elba Isle mines, industrial scale trials of differential flotation of oligiste and pyrite are starting soon;

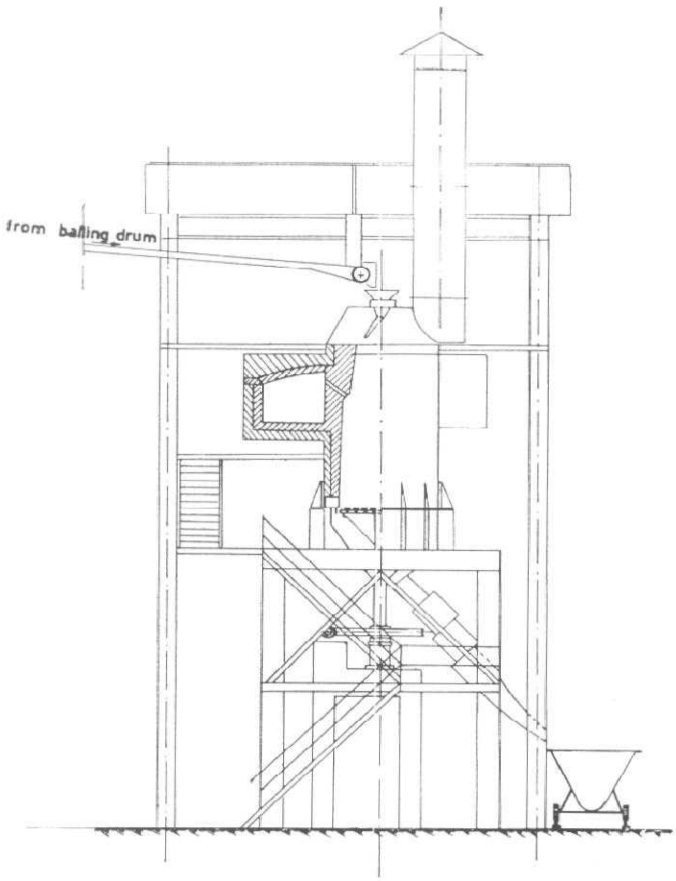


Fig. 6.
Elba Isle pelletizing pilot plant shaft furnace

such treatment, within one year, will produce large quantities of fine oligistes (−200 mesh), which can be successfully agglomerated in pelletising plant.

TABLE III
Running data of pilot furnace of Elba Isle

Green pellet moisture	...	10%
Firing temperature	...	12,50°C
Daily production	...	100t/24h
Fuel oil consumption	...	33 kg/t of fired pellets
Combustion air flow	...	65 $Nm^3/1'$
Cooling air flow	...	30 $Nm^3/1'$
Sulphur content in green pellets	...	2·3%
Sulphur content in fired pellets	...	0·15%
Labour	...	20 workers/24h
Electric power consumption	...	1920 kWh/24h
Total cost of pelletising	...	1580 liras/t of pellets

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DISCUSSIONS

Mr. G. Brandes, Lurgi Gesellschaft, Germany: Question very often arises which of the two processes, namely, pelletising and sintering is to be used in a particular case. Both of the processes serve the same purpose of agglomerating of fine ores. The pelletising process, however, serves mainly the purpose of converting very fine ores or concentrates into an easy transportable product and can be applied economically and successfully only if the raw materials supplied are always of more or less constant nature. The sintering process on the other hand can very easily cope with the varying nature and characteristics of ores and other raw materials from different origins. Because of this the pelletising plant should best be situated near the mines or the ore dressing plants and the sinter plant near the blast furnaces for supplying them with uniform burdens preferably of self-fluxing nature.