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NOTES ON SOME RECENT EXPERIMENTS

On the Magnetic Concentration of Iron Sands from the Lower St. Lawrence.

By John F. Robertson, M.Sc., S.Can.Soc.C.E.

(Read before the Mining Section, 30th November, 1905.)

In attempting to use the iron sands from the lower St. Lawrence in a blast furnace, three difficulties are met with:—

First, the low percentage of iron on account of the dilution of iron bearing minerals with ordinary sand.

Second, the presence of an amount of titanium much greater than that usually considered permissible in an iron ore.

Third, the fineness of the material.

The third difficulty can be overcome by briquetting and may be left to the metallurgist. This note deals only with attempts to cheaply overcome the first and second difficulties.

The apparatus used in the experiments described below is of special design based on the Heberli drum separator. It consists of a thin hollow brass cylinder about eight inches in diameter and six inches long, revolving loose on a hollow axle through which wires are passed to a set of eight electro magnets arranged radially around the axle, and together filling one-half of the drum. The pole pieces just clear the inside of the brass cylinder.

Each has a width of ¾ to 1¼ inches as desired, perpendicular to the axis, and a length of about six inches parallel to it. Each magnet is wound with fifty-five turns of insulated wire, and the wires are led out through the hollow axle to a connection board so arranged that the magnets can be connected in series, or

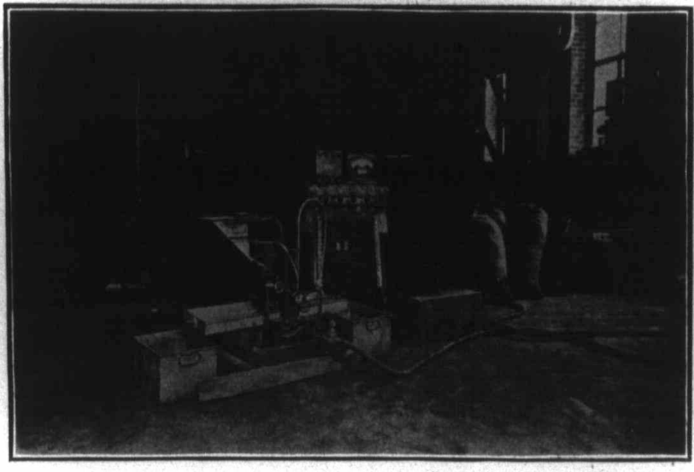

FIG. 1. View of Apparatus.

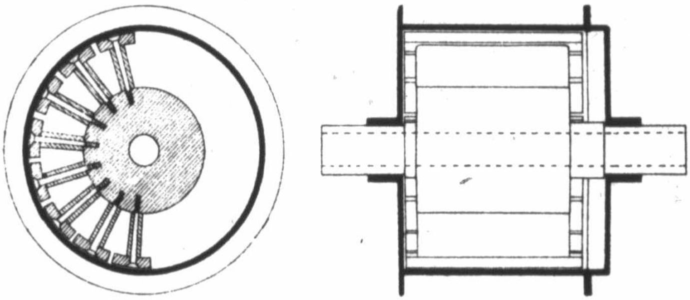

FIG. 2.

Sectional Elevations of Separator.

parallel, and each can be given either north or south polarity. In the experiments described below, the magnets were all in series, with alternate polarity thus: N-S-N-S-N-S. The magnets do not revolve with the cylinder, but may be set to cover any 180 degrees of its circumference desired. The sand is fed to the machine from an adjustable hopper which can be placed in different positions so that the feed can be run in at the top or at any part of the side of the revolving cylinder. Fig. 1 shows a photograph of the whole machine and Fig 2 two sectional elevations of the cylinder.

The advantage of having the magnets of alternate polarity is that the little grains of iron are turned end for end in passing each magnet. As there are eight magnets, the grains of iron are reversed six or seven times, and in trying to arrange themselves to suit the magnetism of the various poles they liberate the grains of sand which might otherwise be entangled in a bunch of grains of iron and thus be carried over into the finished product.

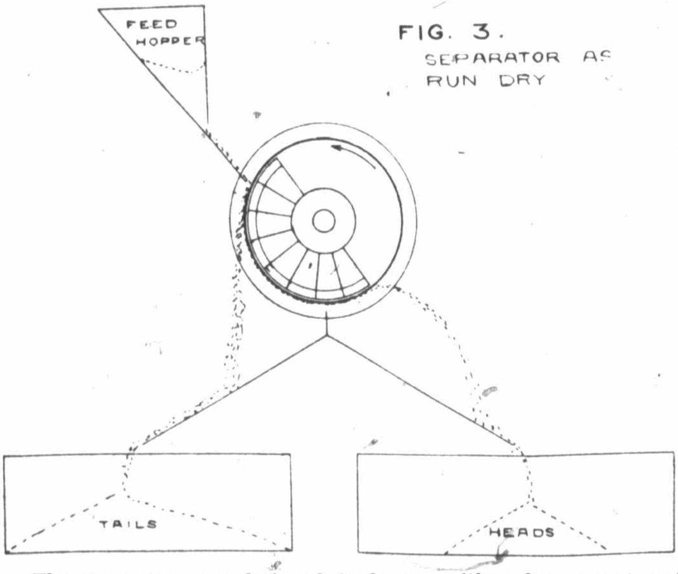

FIG. 3.
SEPARATOR AS
RUN DRY

The apparatus was designed to be run either dry or wet and the drum can be rotated in either direction and at a great variety of speeds.

In concentrating dry sands, the machine is run as in Fig. 3, the sand being fed near the top of the revolving cylinder. The non-magnetic material is collected directly under the edge of the cylinder, while the iron, pulled radially by the magnets and moved by the cylinder, passes under the latter and falls off on the other side.

When working with wet sand, the cylinder is rotated in the opposite direction, and the sand fed against the side about half way down. The sand, with some water from the jet A (Fig. 4), reaches the cylinder at B. That part of the cylinder is moving upwards, and the friction of the magnetic material as pulled by the magnets is great enough to carry it with the cylinder against the stream of water from the jet C. The non-magnetic minerals, not being attracted, are washed down and away. D and E are two water jets to clean the cylinder from any materials which tend to adhere beyond the proper points for discharge.

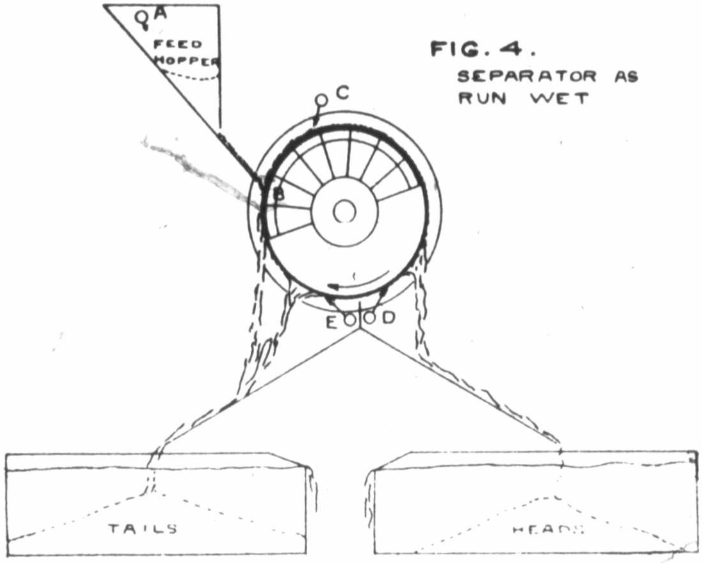

FIG. 4.
SEPARATOR AS RUN WET

It was found that the co-efficient of friction of magnetite on brass is so low that the grains tended to accumulate in rows in front of each pole piece. This difficulty was overcome by placing a few strips of electric tape across the drum parallel to the axis. Covering the drum with canvas was also tried, but while this gave good results in dry concentration, it carried too much non-magnetic stuff when run wet.

The magnetic field utilized in the separator is the stray field. As first designed, the gap between the pole pieces was made quite small, with the result that a large current was required to produce a sufficient strength of stray field outside the cylinder. The gap was then widened, giving better results. It is now proposed to further increase the air gap between the pole pieces, and enclose the whole working side of the apparatus in an external shield or armature. This will cause a stronger and more even field to pass through the drum, or will make it possible to secure the present strength of field with far less current.

The only dry run that has been completely assayed was on a sample of sand containing about 57% metallic iron and 16.2% TiO_2. It is probable that the major part of the titanium was in the form of ilmenite. Some may have occurred as rutile, and some no doubt was contained in minute grains of ilmenite enclosed in magnetite. Assuming that the titanium occurred as ilmenite (Fe Ti O_3) the 16.2% of TiO_2 had combined with it 16.2 x 56/80=11.3% of iron, so the amount of iron capable of being magnetically separated from the titanium would be only 57.0—11.3=45.7%. If rutile (TiO_2) was present the percentage of iron free from titanium may have been more. If much titanium was enclosed in magnetite the free iron may have been less.

As preliminary work, several field strengths were tried, the weakest used gave practically no concentrates, while the strongest took out nearly all the titaniferous material as well as the magnetite. As magnetite has a much higher magnetic permeability than ilmenite, there should be some strength of field at which the heads product obtained contains almost all the magnetite and still very little ilmenite. Unfortunately grains of ilmenite cannot be distinguished by the eye from grains of magnetite and assays for titanium in the heads and for iron in the tails should have been made to show what were the limiting amperages for successful concentration. In the test in question, this was impracticable and a current of seven amperes was used.

The result from 52 lbs. of sand was 22 lbs. of heads assaying 70.46% of metallic iron and 1.91% of TiO_2 and 30 lbs. of tails assaying 45.30% of metallic iron and 23.30% of TiO_2. This works out to a recovery in the heads of 65% of the total free iron, the heads carrying less than 1/16 of the titanium. A considerably better recovery than this could have been obtained with a slightly higher amperage and no harm done to the product as iron ore having 2.5% of TiO_2 or under is not objected to by blast furnace people.

A screen analysis of 43¼ lbs. of tails from a somewhat similar dry run showed:

(1) Remaining on an 80 mesh sieve.. .. . .. 9¾ lbs.
(2) Remaining on a 100 mesh sieve.. .. .. .. 27¾ lbs.
(3) Passing through a 100 mesh sieve.. .. .. 5¾ lbs.

Assays of these three sizes showed

	Fe%	SiO_2%	TiO_2 and Al_2O_3%
Over 80 mesh	35	15.0	35
80 to 100 mesh	42	4.5	35
Under 100 mesh	60	1.5	15

The capacity of the machine dry is about 300 lbs. per hour. Its resistance as used is 3 ohms, so the magnets with seven amperes passing required about 150 watts or 1/5 H.P. It takes less than 1/5 H.P. to drive the cylinder, so the total consumption of power is less than one-half H.P. A large machine designed for economy of power could easily do equally good work with one-half or one-third of the current and power per unit weight of sand, viz., from 100 to 150 watt hours per 300 lbs. At 10 cents per killowatt hour, this would amount to 7 to 10 cents per ton of sand. The capacity can probably be further increased by runnng any but very rich sands very fast so as to make a large amount of poor heads, and then cleaning these heads by re-running them.

Run wet, the machine will probably duplicate the work it does dry, but the adjustments need more careful watching and the capacity is lower. Six wet runs on sands from Seven Islands gave heads containing 1.10, 2.36, 2.30, 1.48, 1.48, and 1.67% of TiO_2 Preliminary runs on each ore and numerous assays are necessary for the determination of the adjustments required. A wet run for the exhibit of the Quebec Government at the Liege Exhibition, which had to be done without assays or sufficient preliminary work, gave concentrates carrying 7.13% of TiO_2. This sand was practically identical with that used in the six wet runs mentioned above, all of which gave very low titanium in the heads. The assays made after the test was completed, are as follows:—

Heads	Metallic Iron	64.31%
	TiO_2	7.13%
Tails	Metallic Iron	44.95%
	TiO_2	20.17%

The weights were

Heads	27 lbs. 12 oz.
Middles (not exhibited)	3 lbs. 10 oz.
Tails	27 lbs. 11 oz.

61% of the free iron was got into the heads with about 1/5 of the titanium. The sand was the same as that used in the dry run previously described, and is practically identical with that which gave such excellent results when preliminary assays were made.

The capacity of the separator wet is about 100 lbs. per hour. About 0.02 cu. ft. of water per minute is required to reduce the damp sand to a pulp, and about 0.10 cu. feet per minute to wash the tails from the heads. Sometimes water is used for cleaning the heads and tails from the bottom of the cylinder and sometimes not. The water could easily be pumped back and used over and over. The total power used in the present small machine when running wet costs on an average about 50 cents per ton of sand, but on a large machine this could certainly be cut down to one half or one quarter that amount. The separator either wet or dry is usually run at 87 revolutions per minute. The amperages used range from 3 to 11, 5 and 7 being the commonest.

The machine used in the above tests was designed by Dr. J. B. Porter, Professor of Mining Engineering, and built in the shop of the Mining Department of McGill University. The work detailed was all done under his advice and general direction, but great credit is due Mr. R. A. Chambers, a former student, for tests which he carried out on the Seven Islands sand. The author is responsible for the more recent work, and thanks are due Mr. J. Obalski, the Mining Engineer of the Province of Quebec, for material. The chemical analyses were nearly all made by Mr. M. L. Hersey, Provincial Analyist, by authority of Mr. Obalski. The main part of the sand was furnished by Mr. William Robertson, of Montreal, but the Seven Islands sand came from Mr. Ganong, of Quebec. The wet and dry tests last made were carried out at the suggestion of Mr. Obalski and samples of all products were included in the Canadian Exhibit at Liege this year.

On the conclusion of the paper the author exhibited a set of samples of the sand sent to Liege, as follows:—

1: Original sand.
2: Heads of dry concentration.
3: Tails dry concentration.
4: Heads of wet concentration.
5: Middles of wet concentration.
6: Tails of wet concentration.