Magnetic Separation News, 1985, Vol. 1, pp. 185–194
0731-3632/85/0104–0185 $25.00/0

MAGNETIC SEPARATOR FOR VOLATILE DUST

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Abstract

The construction and principle of operation of a new magnetic separator for volatile dust is described. The results, obtained on a model separator in laboratory conditions are discussed.

INTRODUCTION

A high percentage of magnetic powder, as iron trioxide, γ-Fe_2O_3, is in the chimney dust of coal-fire power stations (amounting in some cases to 15%), and the high industrial demand for such a product were incentives to separate it on a large scale in Poland |1|. The Enterprise for Utilization of Waste from Electric Power Stations in Katowice, Poland, commisioned the design and construction of a high capacity magnetic separator with dust flow to 20 t/h. Such a separator should give a good quality magnetic concentrate (MC) that contains over 50% of γ-Fe_2O_3 and less than 15% of silica powder (SiO_2). Work on this type of separator was begun at the Institute of Electrical Engineering, the Technical University of Kielce, Poland. As a result of three years of research, a prototype of a high capacity magnetic separator was developed; its construction and test results are presented in |3|. This separator, with 20 t/h of the dust flow capacity, tested in the 'RYBNIK' coal-fire power station, has satisfied the user. However, its construction was complicated, and a belt which moves in the dust atmosphere decreased its reliability. Further work which concentrated on eliminating these negative features led to

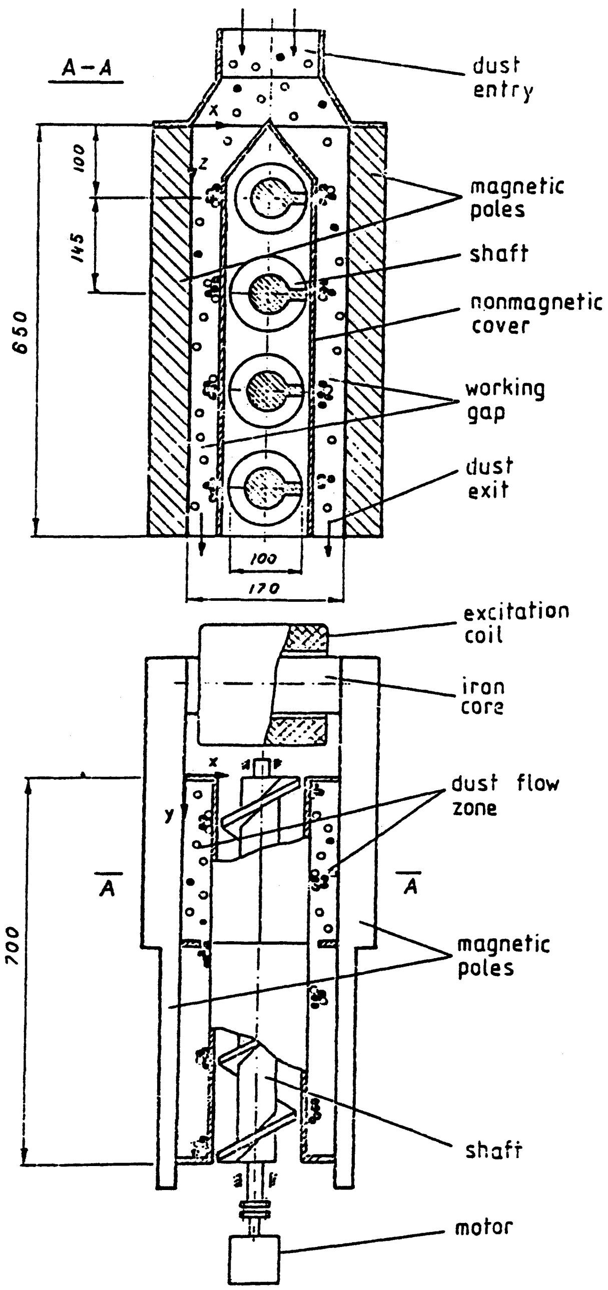

FIGURE 1. Scheme of separator structure

(a) - cross section

(b) - top view

a new construction of magnetic separator |2,4|. Its construction, the principle of operation and test results are the subject of this paper.

CONSTRUCTION AND THE PRINCIPLE OF OPERATION

The separator structure is shown schematically in Fig.1. The magnetic circuit contains an iron core and two iron plates giving magnetic poles. A coil, supplied from a d.c. source, is wound on the iron core. Four iron shafts are placed horizontally between the iron plates. They have teeth running helically on their cylindrical surfaces. A cover made of nonmagnetic material is placed on the shafts. This cover, together with the iron plates, creates two working gaps.

Dust is supplied to the part of the gap through an entry placed on the top. Nonmagnetic dust flows down to the exit but magnetic particles affected by the magnetic force tend towards the shafts where they become attached to the cover at points adjacent to the shaft teeth. When the shafts turn round, magnetic particles following the teeth move under the cover along the shafts to the end placed opposite to the dust entry, where they fall down to the exit of MC.

As can be seen there are no moving parts of the separator in contact with dust. This is due to a more dust-proof separator with higher reliability in relation to the one described earlier in |3|.

SEPARATOR TEST

A test has been carried out in laboratory conditions on the separator with four shafts. Its main dimensions are shown in Fig.1. The aim of the test was to find the optimum conditions for the separation process.

At first the distribution of a magnetic field and force acting on magnetic particles have been measured in the working gap

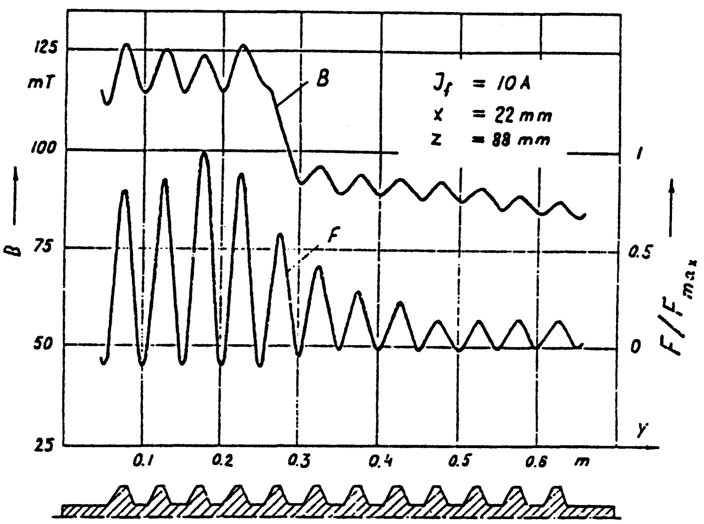

FIGURE 2. Magnetic field and force density distributions in working gap along iron shafts.

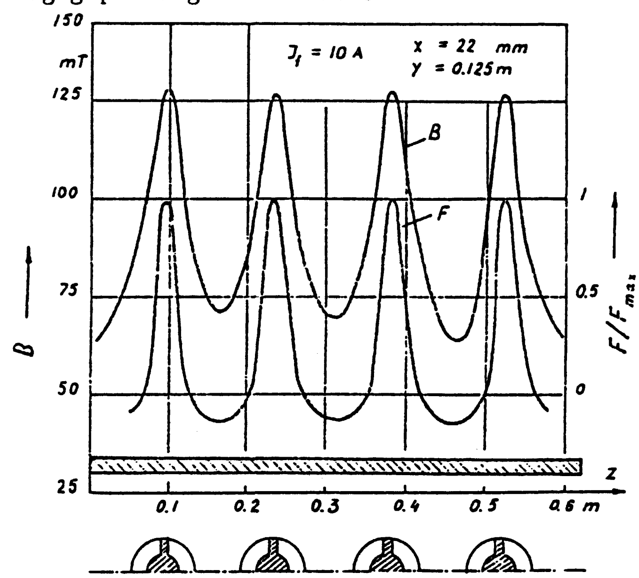

FIGURE 3. Magnetic field and force density distribution in working gap across iron shafts.

along, and transversely to, the shafts. The results are shown in Figs.2 and 3. The magnetic flux density and force are related to their components normal to the shaft cover surface. The results were obtained for excitation current I_f equal to 10A. The magnetic field and force distributions do not change during current variation. It is only their amplitudes that change, which is shown in Fig.4. In Fig.2 a significant change can be seen in the

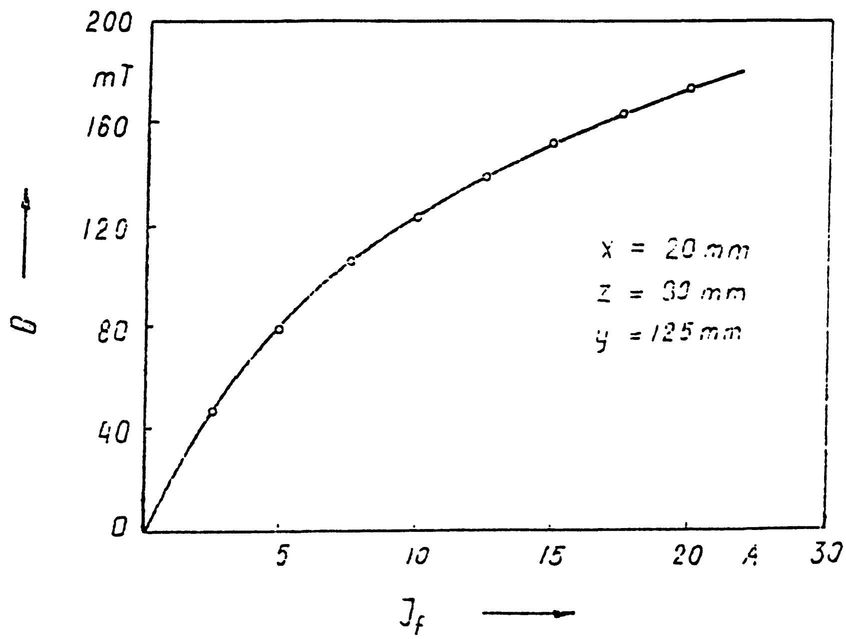

FIGURE 4. Characteristic of magnetic flux density against excitation current.

amplitudes of force and magnetic flux density at a crossing point from the zone of flowing dust to the zone where the MC is transported. This change is obtained by decreasing the iron plate thickness. A higher value of the magnetic flux density in the flowing dust zone ensures a more efficient separation of magnetic particles.

This additional research work is aimed to create such conditions in the working gap which would enable a maximum quality of magnetic concentrate to be obtained with minimum of impurities.

Dust taken for testing was not rich in MC. It contained 2.8% of γ-Fe_2O_3 and 16% by weight of SiO_2. Its particle diameter did not exceed 0.3 mm |3|.

The first separation tests indicated a low grade of the MC. There was a need to clean it during its transportation on the way along the shaft to the exit. It was achieved by making slots along the shafts /Fig.5/.

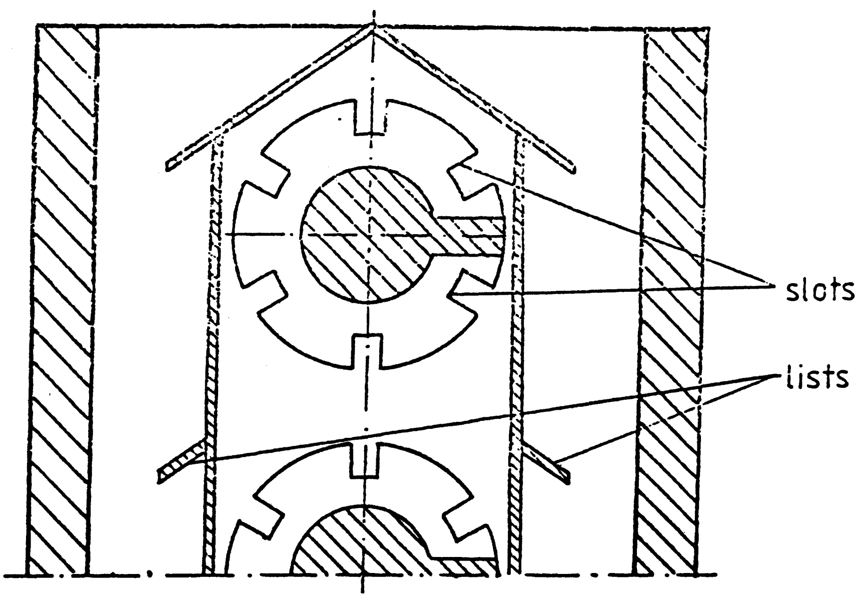

FIGURE 5. Longitudinal shaft slots and protecting lists on the shaft cover.

The transported MC was shaken during the shaft rotation and most of the impurities fell off. The grade of the MC was then much better than previously. The test was made for these working conditions at various excitation currents while preserving the same dust flow ($Q = 6.5$ t/h). To make a smooth dust flow in the working gap, a below-atmospheric pressure in the nonmagnetic dust exit was created. It contributes to the flow of dust particles with uniform velocity, whose value was estimated in the range 4-5 m/s. The test results are as follows:

	% MC	% γ-Fe_2O_3	% F_e	% SiO_2
$I_f = 10$ A	0.86	82.4	46.6	14.9
$I_f = 15$ A	1.12	81.8	46.3	15.1
$I_f = 20$ A	1.31	80.7	43.6	17.7

The percentage by weight of MC, iron /Fe/, magnetic fraction /γ-Fe_2O_3/ and silica /SiO_2/ were calculated as follows:

$$\% \text{ MC} = \frac{\text{MC}}{\text{Dust}} 100\%$$

$$\% \ \gamma \ Fe_2O_3 = \frac{\gamma\text{-}Fe_2O_3}{\text{MC}} 100\%$$

$$\% \text{ Fe} = \frac{\text{Fe}}{\text{MC}} 100\%$$

$$\% \ SiO_2 = \frac{SiO_2}{\text{MC}} 100\%$$

The above results indicate a slight increase in the MC with a current increase. Its percentage is, however, small.

The next test was carried out at dust flow $Q = 1.5$ t/h. The results are as follows:

	% MC	% γ-Fe_2O_3	% Fe	% SiO_2
$I_f = 15$ A	3.62	83.5	50.1	4.6

As can be seen, decreases in dust flow intensity much improved both the quality and quantity of MC. We found out that, at a high value of dust flow, the MC attached to the shaft cover was being dropped down by the flowing dust. In order to prevent it, leaves were fixed to the cover in place between the shafts /Fig.5/. Another test was carried out at Q = 6.5 t/h. It gave the following results:

	% MC	% γ-Fe_2O_3	% Fe	% SiO_2
I_f = 15 A	1.9	83.4	49.9	4.7

These indicate a significant increase in the MC.

The tests were also carried out for another shaft cover made in the shape of cylinders /Fig.6/. It was noticed that, during the shaft rotation, the magnetic particles were going to the middle of the cover, after which they were being torn off and were falling onto the iron plates. Part of this was captured again by the magnetic field but another part, (particularly that on the lowest shaft), fell down into the dust exit. The MC in this case was obtained in small quantities but its quality was much better. This behaviour of magnetic particles was caused by local magnetic forces. Their distribution calculated in the gap space between two shafts is shown in Fig.7.

CONCLUSIONS

The new construction of a magnetic separator tested in laboratory conditions proved its applicability to the separation of magnetic particles from volatile dust. In relation to the earlier one |3| tested by the present authors, it has some advantages that improve its reliability and make its production technology easier. Its performance needs, however, to be improved to make users more satisfied. It is necessary to improve the efficiency of the separation process and the quality of separated MC. Further

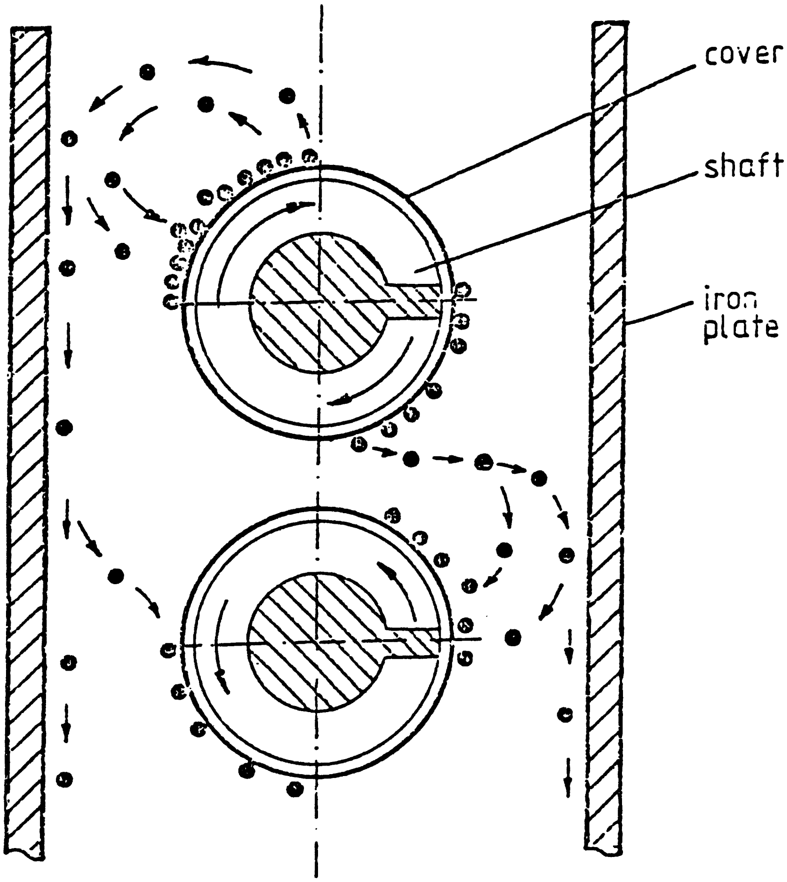

FIGURE 6. Behaviour of magnetic particles at cylindrical covers.

efforts to improve this type of magnetic separator will concentrate on this goal.

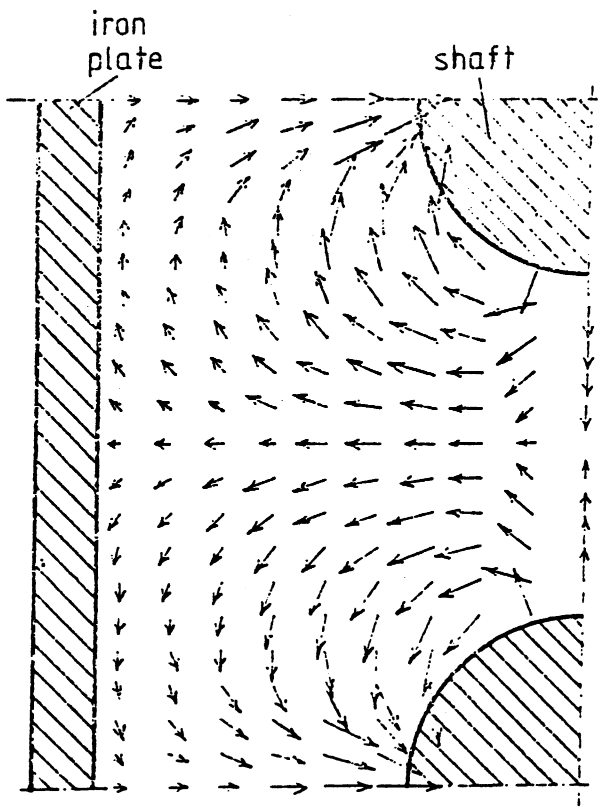

FIGURE 7. Magnetic force distribution in working gap

REFERENCES

|1| Enterprise for Utilization of Waste from Electric Power Station, Katowice, Poland, Rep.No.154-01, 1971-1975 /in polish/.

|2| K. Adamiak, E.A. Mendrela, E.M. Mendrela, Inst. of Electr.Eng. Techn.Univ. of Kielce, Poland, Rep.No. 1070-31, 1982.

|3| E.A. Mendrela, E.M. Mendrela, Z. Osadnik, K Staszak, High capacity magnetic separator for volatile dust, IEEE Trans. on Magnetics, MAG-19, 1476-1479 /1983/.

|4| E.A. Mendrela, W. Muszczak, J. Lisowski; Magnetic separator, Polish Patent No. P-237776.