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Magnetofluidic sensor for mineral quality control in preparation processes

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Abstract

A sensor consists of two independent components. The first is made of an electromagnet having pole shoes characterized by a shape which ensures an isodynamic magnetic field characterized by an horizontal gradient. The second component is a vertical parallelipipedic container, movable on horizontal direction of the symmetrically plane of air gap. Inside of the container there are magnetic fluid, launching device for samples to be analyzed and collector. The distance between collector device and launching point of samples is adjustable so that mineral quality control may be improved.

Keywords: Magnetic fluids; Sensors; Quality control

1. Introduction

It is well known that mineral quality control in separation processes is usually made in special laboratories which belong to preparation plants [1]. If we take into account the magnetofluidic methods for material separation [2,3] we shall realize that magnetofluidic spectrometry [4] may be extended for the quality control of the separated minerals. The magnetofluidic densitometer made by Kaiser and Miskolczy [5] is based on levitation phenomenon of a nonmagnetic body immersed in magnetic fluid positioned in a magnetic field gradient. The aim of this paper is to point out the conditions in which a magnetofluidic spectrometer can become a sensor for quality control in preparation factories, especially for analysis of complex ore samples.

2. Experimental apparatus and procedure

The apparatus for such a quality control consists of pole shoes characterized by a shape which ensures an isodynamic magnetic field characterized by an horizontal gradient and a parallelipipedic vertical container full with magnetic fluid. These two components of the magnetofluidic sensor are independent of each other. Thus, the horizontal magnetic field gradient produced by an electromagnet may be used for any other experiments and on the other hand the vertical container full with magnetic fluid may be used in any other configurations

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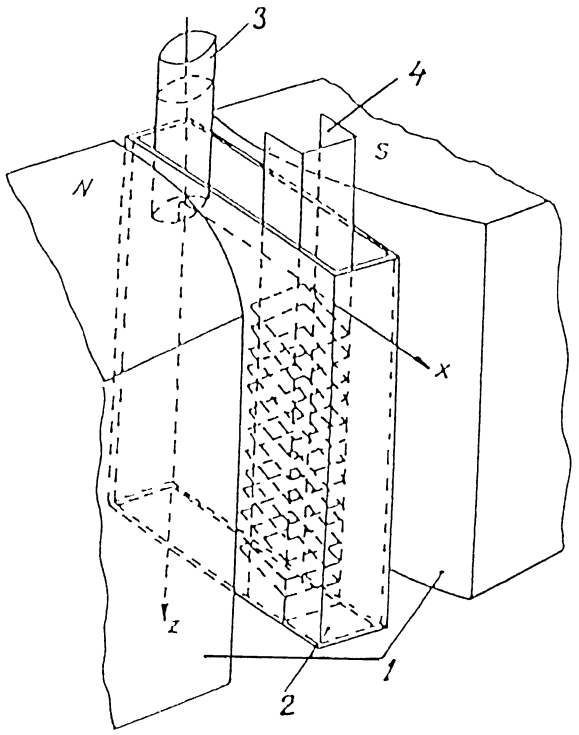

Fig. 1. The schematic diagram of the experimental apparatus for mineral quality control. 1 – pole shoes; 2 – nonmagnetic vertical container; 3 – device for launching the samples to be analyzed; 4 – collector device of the analyzed fractions.

of the magnetic field for a variety of experiments and applications.

Fig. 1 shows a schematic diagram of the experimental apparatus. The parallelipipedic shape of the nonmagnetic container allows the existence inside, in addition to the magnetic fluid of a vertical collector of fractions of the analyzed sample and a specially cylindrical device which allows the choosing of the launching position of the mineral sample to be analyzed. This container filled with magnetic fluid, together with device for launching the samples to be analyzed and collector device of the analyzed fractions immersed in it represents essential component of the magnetofluidic sensor. The other component consists of pole shoes of on electromagnet which ensures an isodynamic magnetic field characterized by an horizontal gradient. The apparatus shown in Fig. 1, as a schematically magnetofluidic sensor, is in fact a concrete version for a spectrometer of density like mass spectrometer.

Starting from the equation of the trajectory of a nonmagnetic particle inside the magnetofluidic spectrometer of density [4]

$$z = -\frac{(\rho_S - \rho_F)g}{\mu_0 \chi_F H \mathrm{d}H/\mathrm{d}x} x, \tag{1}$$

where ρ_S is the density of the particle, ρ_F the density and χ_F the magnetic susceptibility of the magnetic fluid, we can choose the value of $H\mathrm{d}H/\mathrm{d}x$ so that all particles of the sample which are moving on different trajectory through magnetic fluid to be gathered in the collector device of the magnetofluidic sensor.

The linear dispersion of the sensor is defined by the formula

$$D_l = \frac{\mathrm{d}z}{\mathrm{d}\rho_s} = -\frac{g}{\mu_0 \chi_F H \mathrm{d}H/\mathrm{d}x} x, \tag{2}$$

which allows the choosing of the number of the small boxes of the collector device so that the sample to be analyzed by sensor will be tested with sufficient accuracy. The dependence accuracy of the analysis defined by a range of densities collected in a small box as a function of horizontal distance from launching point of the sample inside the sensor to the collector device, $\mathrm{d}\rho_S = f(x)$ is shown in Fig. 2. This diagram is true for our experimental apparatus characterized by $H = 2 \times 10^5$ A/m; $\mathrm{d}H/\mathrm{d}x = -5 \times 10^6$ A/m^2; $\chi_F = 4 \times 10^{-2}$; $\rho_F = 900$ kg/m^3 and $\mathrm{d}z = 5 \times 10^{-3}$ m for high of a small box of the collector. The accuracy may be improved if we take a smaller value of the $\mathrm{d}z$.

3. Experimental results and discussion

The nature of the sample to be analyzed, especially the range of the densities of its components, will establish the value of $H\mathrm{d}H/\mathrm{d}x$ used and the position of the collector inside of the container filled with magnetic fluid. The complex ore from preparation plants were analyzed using the magnetofluidic sensor shown in Fig. 1.

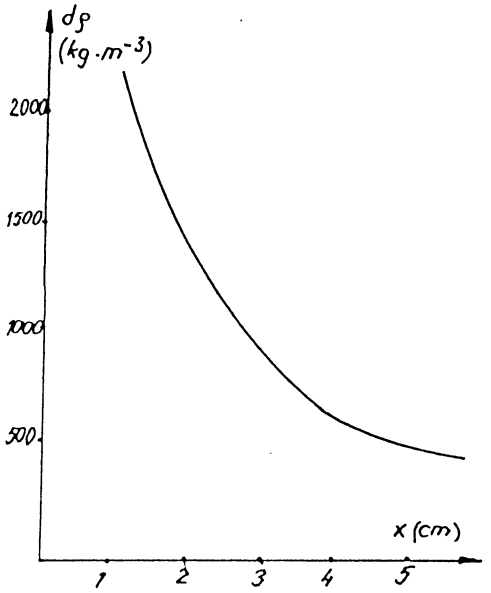

Fig. 2. The dependence of the analysis accuracy on the distance from the launching point of the samples to the collector device.

In order to obtain the best accuracy of the densimetric analysis the sample has to be a granular nonmagnetic material characterized by the same class of granulometry.

Fig. 3 shows the calibration curves of the magnetofluidic sensor characterized by the abovementioned data. This curves was verified for pure copper, aluminium, and pyrite for three positions of the collector ($x_1 = 2$ cm, $x_2 = 4$ cm, $x_3 = 6$ cm). The conditions in which a magnetofluidic spectrometer can become a sensor for quality control in preparation factories emphasized in this experimental research have shown that results may be improved though moving collector along the x-axis. For a better accuracy of the densimetric analysis may be taken the fractions gathered in a small box of collector and launched as a new sample for a more large value of the horizontal distance from launched position and collector.

4. Conclusions

The results obtained show the prospects of the magnetofluidic spectrometer as a sensor for quality control in preparation factories. It has been found experimentally that the densimetric analysis made by this magnetofluidic sensor may be improved if we will take into account the conditions mentioned in this paper.

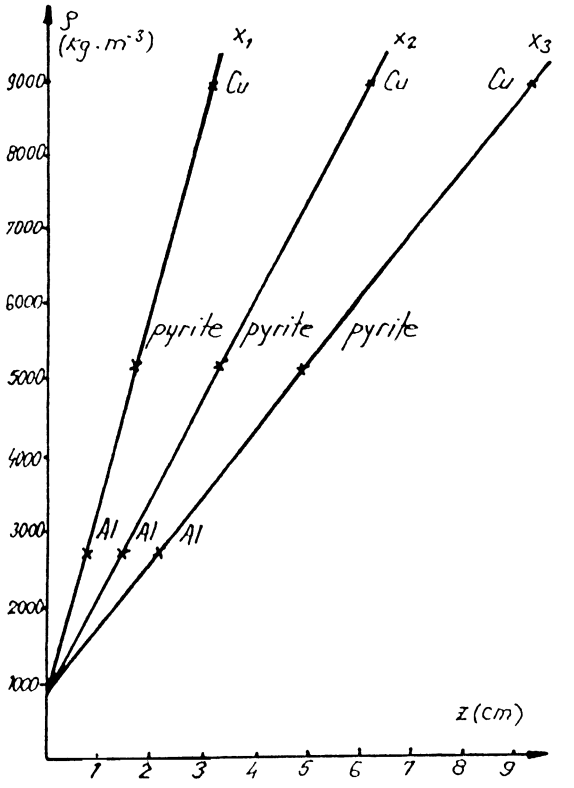

Fig. 3. The calibration curves of the experimental apparatus for three values of the x coordinate ($x_1 = 2$ cm; $x_2 = 4$ cm; $x_3 = 6$ cm).

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