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MAGNETIC SEPARATION IN ROMANIA

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Abstract The utilization of the magnetic separators of foreign and Romanian source is presented and the most important achievements in research, engineering design and manufacturing activity concerning the magnetic separation in Romania are reviewed.

INTRODUCTION

Magnetic separation in Romania, as a technological process and as a research and designing activity, must be considered in close connection with the economic and industrial development of the country. Before World War II, Romania was a poorly developed country. In the post-War period industrial development of the country was the main concern of the Romanian government and people.

Initially, this development was based on a massive import of technology from more industrially advanced countries. Nowadays industrial development is much less dependent upon external influences, so much so that there is world-wide recognition of many proprietary products of Romanian industry.

In this connection, magnetic separation in Romania may be considered as existing only since 1945. Until 1970, there existed only magnetic separation systems imported as part of a technological package. Thus, we find magnetic separators included in flow sheets from the extractive industry and ore processing, in metallurgy, food or chemical industries, cellulose and building material industries.

After 1970, with the setting up of large research and engineering design centres, a wide range of subjects was investigated with connections in magnetic separation, including optimization of already existing processes, studies on the feasibility of magnetic separation methods in processing low grade ores and other materials, researches concerning the theoretical bases of the separation methods and the designing and manufacturing of modern separators.

In this connection, an important part is played by the Centre of Technical Physics of Jassy (C.T.F.), the Research Institute for Electrotechnical Industry of Bucharest, the Research and Engineering Institute for Non-metallic Substances and Minerals of Cluj-Napoca, the Mining Research and Engineering Institutes of Deva and Baia Mare, Polytechnical Institutes of Jassy and Timisoara, and the Mining Institute of Petrosani.

In the following, we shall present in brief the applications of magnetic separation in Romanian industry, emphasizing the main areas benefitting from this technology, as well as the main types of magnetic separators in use and some of the more significant results obtained in research and engineering activity of the Romanian institutes.

MAGNETIC SEPARATION IN INDUSTRY

Almost all industries processing raw materials have flow sheets which include magnetic separation. This is necessary for the purification of various materials by removing the ferro- and paramagnetic bodies or thin particles or for the beneficiation of other materials, the magnetic product being used in this case.

Most of the magnetic separators are of foreign source, being imported from the Soviet Union, Czechoslovakia, East Germany, West Germany, Italy, Sweden, the United States. There is a large variety of such devices, including:

- Magnetic plates with permanent magnets or electromagnets, used in the food industry (for cereals processing), cellulose industry, chemical or coke industry. These are designed to pick-up tramp metals which are then removed manually.
- Belt magnetic separators used for picking-up tramp ferromagnetic bodies, for the purification of useful materials by removing the magnetic particles (as tailings) or for obtaining magnetic concentrates (in iron ore processing, iron extraction from the blast furnace slags and so on).
- Dry drum magnetic separators, used as above.
- Wet drum magnetic separators, in the three principal versions: counter-current, counter-rotating and noncurrent. These are mainly used for iron ore concentration or in the chemical industry.

Iron ore upgrading by means of wet drum magnetic separators is preceded at Teliuc-Hunedoara by the magnetizing roasting, extractions of more than 85 percent being obtained. These separators are also used for magnetite extraction from the copper ore flotation tailings (at the preparation stations in Maramures and Dobregea), from blackstone ashes (at the power plants), as well as from red bauxite slime. In coal processing with heavy liquids, the recovery and regeneration of magnetite or ferrosilicon is also done by means of wet drum magnetic separators.

The wet and dry drum magnetic separators include both imported devices and those designed and manufactured in Romania.

Magnetic induced-roll separators are mostly used in ore processing and in the chemical industry. In dry processing they are found in quartz sand purification by iron oxide removal (in the glass industry) and in rare mineral concentration. Along with imported installations of this kind, whole lines of Romanian induced roll magnetic separators have been introduced, modernized and optimized. Wet magnetic induced roll separators are largely utilized, especially for iron and manganese ore upgrading.

- High gradient magnetic separators were recently introduced into Romanian industry. They have already become the favourite tools of the kaolin and clay industries being utilized for deferrization and for increasing brightness. A SALA-type HGMS device has been installed at Rebrisoara mine, successfully processing the local kaolin. Romanian HGMS separators are also working in Romanian industry.

RESEARCHES CONCERNING THE PHYSICS AND TECHNOLOGY OF MAGNETIC SEPARATION

An important part in tackling research problems in Romania concerning magnetic separation is played, first of all, by two research institutes: the Centre of Technical Physics of Jassy, which is mainly concerned with the physics and technology of magnetic materials and phenomena, and the Research Institute for Electrotechnical Industry, which deals with the study and design of electromagnetic machines and devices. At the same time, an important role is played by the Mining Research and Engineering Institutes of Deva, Cluj-Napoca and Baia Mare, sponsored by the Ministry of Mines.

The problem of magnetic separation of materials is also dealt with by some Romanian institutes of higher technical education, as the Polytechnical Institutes of Jassy and Timisoara, the Mining Institute of Petrosani and some others. Their efforts are directed toward the optimization of already-existing magnetic separation processes, with a view to reducing their energy consumption and increasing their efficiency, studying the feasibility of magnetic separation methods for a large range of useful materials and minerals, and the possibility of introducing modern methods and designing new devices.

There is at the Centre of Technical Physics of Jassy, a group of physicists, engineers and technicians led by Dr. Nicolae Rezlescu which has been working on magnetic separation for more than 10 years. The preoccupations of this group include a large range of studies concerning almost all the various magnetic separation techniques. These studies have materialized, up to now, in the realization of lab devices and pilot-scale and industrial-size units [1, 2, 3].

As for conventional separation, a system for picking-up tramp metal from conveyor belt-carried materials has been designed and built. This system is equipped with a magnetic plate with permanent magnets, suspended above the conveyor belt and driven by a previously mounted metal detector.

At the same time, a 0.8 m long, 0.4 m diameter dry drum magnetic separator for the food industry has been designed and built, with an effective magnetic field range of 100 mm.

In order to obtain higher performances, larger active space and increased magnetic action within this space, a model magnetic separator has been built with a toroidal air-gap [4]. The separator (Fig. 1) is equipped with a toroidal magnetic circuit with two parallel branches driven by two coaxial coils. The feed is dispersed in the toroidal air-gap by means of a conic distributor mounted at the top. Ferromagnetic particles from the feed are retained on the central active element and the non-magnetic product keeps falling, leaving the magnetically active region through the lower holes made in the magnetic circuit. A scraper which goes round the torus periodically sweeps the ferrous bodies and discharges them through a region of zero magnetic field.

In matters of high intensity magnetic separation, attention has been focused on the application of induced roll magnetic separators. At the request of various users, our group made a series of studies to optimize the separation process as well as

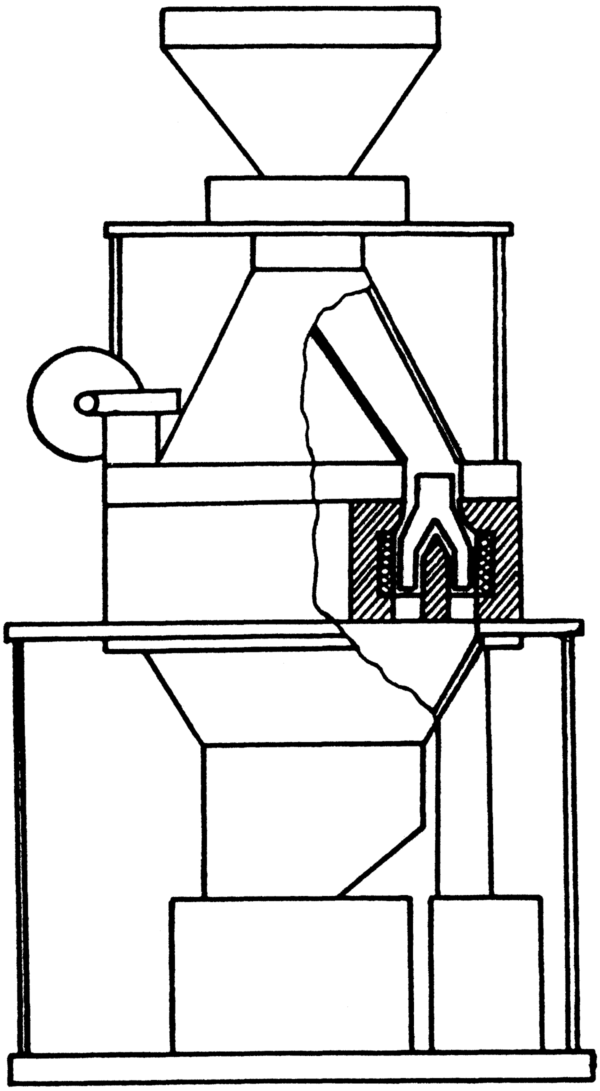

FIGURE 1 Model of magnetic separator with toroidal air gap.

the design and working parameters of the installations when processing specific materials. The researches in this field have materialized in the designing and manufacturing two types of induced-roll separators, one for lab analyses and the other for industrial purposes [5]. The lab separator has a 120 mm long, 110 mm diameter roll; the magnetic induction in the separation space can be continuously changed from 0.2T to 1.8T. It is designed for use in geology and chemistry laboratories of geology and chemistry. The industrial separator has four 1.0 m long, 0.11 m rolls, working in parallel, with the magnetic induction changing step by step between 0.2T and 1.0T. It is used in alumina plant using deferrized ash from thermal plants as raw material.

The group from the C.T.F. of Jassy have given increasing attention in recent times to the study of HGMS. The objective has been to get process data for the purpose of establishing the optimum conditions for processing specified materials as well as establishing the optimum working and design conditions for the manufacture of in-house HGMS devices. The resulting devices work in the longitudinal configuration. The ferromagnetic matrices are made of 65-165 μm thin wires drawed from magnetic stainless steel. For our own lab activity and for mineralogy and chemistry labs, two types of HGMS separators have been conceived and produced at C.T.F. of Jassy, with 150 mm long canisters 1.0 ℓ and 4.0 ℓ capacity respectively (Fig. 2).

The electromagnets of the two separators generate magnetic fields which can be ramped continuously between 0.5T and 1.8T. The coils of the electromagnets are wound after Allen's method/6/ for the first separator, the power requirement being of 70 KVA for the maximum field, and after Chikasumi's method /7/ for the second, the maximum required power being 45 KVA. At the request of the clay industry, a prototype pilot-scale separator was designed and constructed, with canisters of 80 ℓ capacity and

300 mm length. The maximum field was 1.8T for a power consumption of 75 KVA /8/.

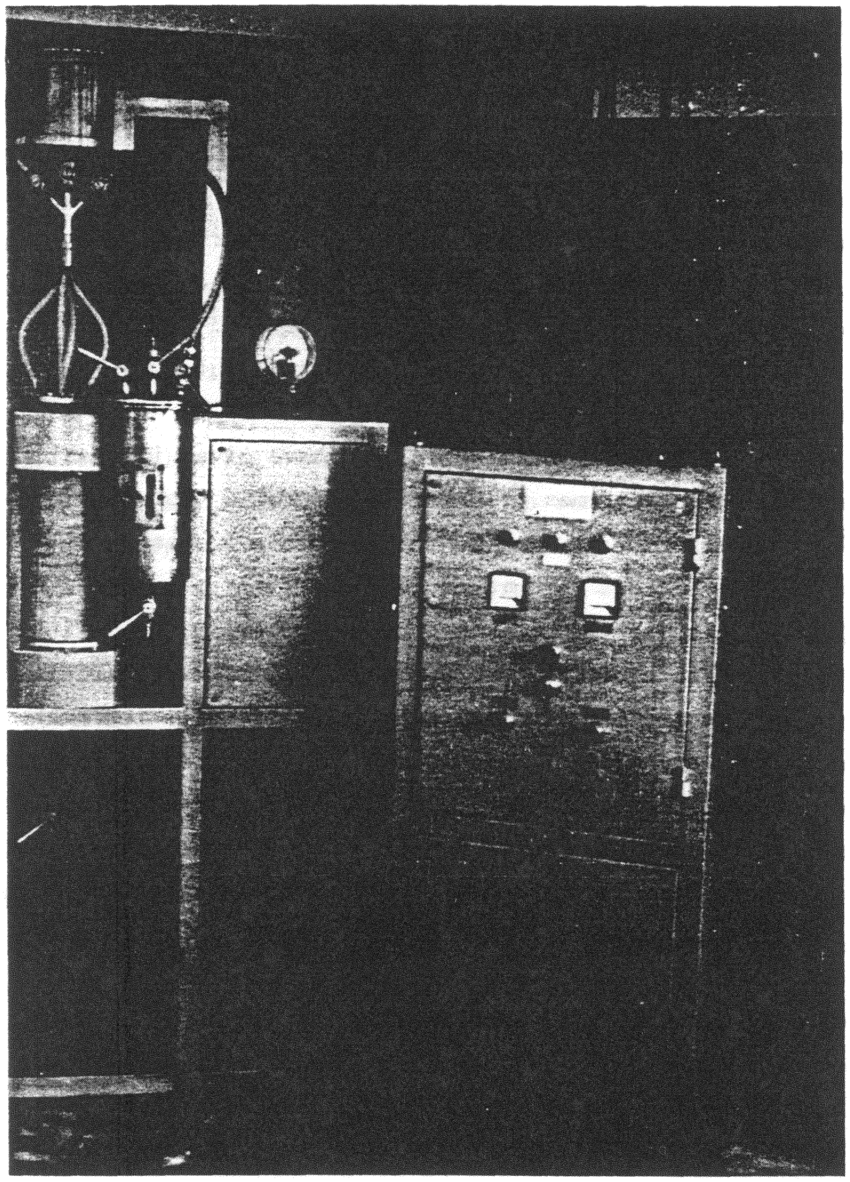

FIGURE 2 Laboratory HGMS separator.

Research work concerning magnetodensimetric separation (MDS) has involved both MHS separation with magnetic fluids and MHD separation with electroconductive fluids. In the period 1976-1978 two model MHS separators were made at the C.T.F. of Jassy (Khalafalla and Rosenweigh type respectively), with a view to testing practicability of the MHS method for non-ferrous ores. In 1979 an MHS model was conceived and made with petroleum-based ferrofluids and saturated solutions of paramagnetic salts being used as magnetic fluids /9/. The separator was of a dynamic type, with the working liquid flowing through the separation space, the resolution increasing with increasing channel length. Since the acquirement of linear air gaps longer than 1000 mm in C- or H-shaped electromagnets needs very large constructions and excessive power consumption, a magnetic circuit with a toroidal air gap was realized (Fig. 3).

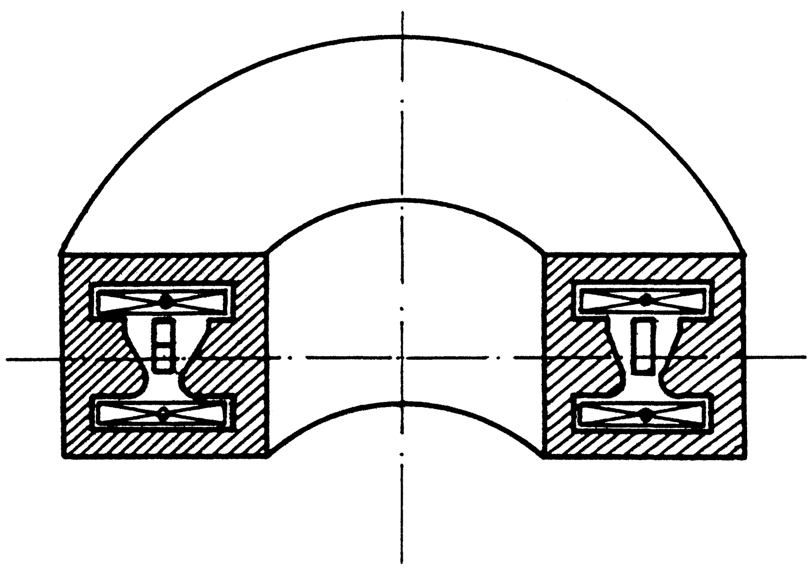

FIGURE 3 Magnetic circuit of the model of MHS separator.

With this set-up one can easily obtain air gaps longer than 3,000 mm. The exit of the separation channel is divided in two compartments, permitting the collection of two fractions from the mixture to be separated. By separating grained mixtures of Al- Cu, Al- glass and Cu- glass, concentrates were obtained at first with grades exceeding 75%. The tests were continued, a dependence being established between the efficiency and a series of parameters such as the flow rate of the working fluid through the separation channel, the channel height, and the characteristic size of the particles to be separated.

MHD separation was initially investigated at the Centre of Technical Physics of Jassy early in 1982. Three types of MHD separations have been studied, starting from the principles of the three classical processes of gravity concentration: jigging separation, ascending flow classification and horizontal flow classification [10]. In the MHD jigging (Fig. 4) the separation was rendered apparent by using PVC, rubber, glass, graphite and quartz grains. A 15% NaOH solution was used as electrolyte. The tests that were undertaken allowed for the determination of the optimum values of the parameters influencing the MHD jigging.

The ascending flow system was chosen for the sequential separation (Fig. 5). The mixture to be separated, consisting of more densimetric fractions, is introduced at the bottom of the separation cell, forming a fluidized bed downside the electrodes. By increasing step-by-step the magnetic or the electric fields- or both simultaneously- the apparent density of the electroconductive liquid increases, so that the liquid is able to carry over sequentially particles of corresponding densities from the mixture to be separated.

The closed horizontal channel system has as its main element the separation channel (Fig. 6), consisting of three sections:

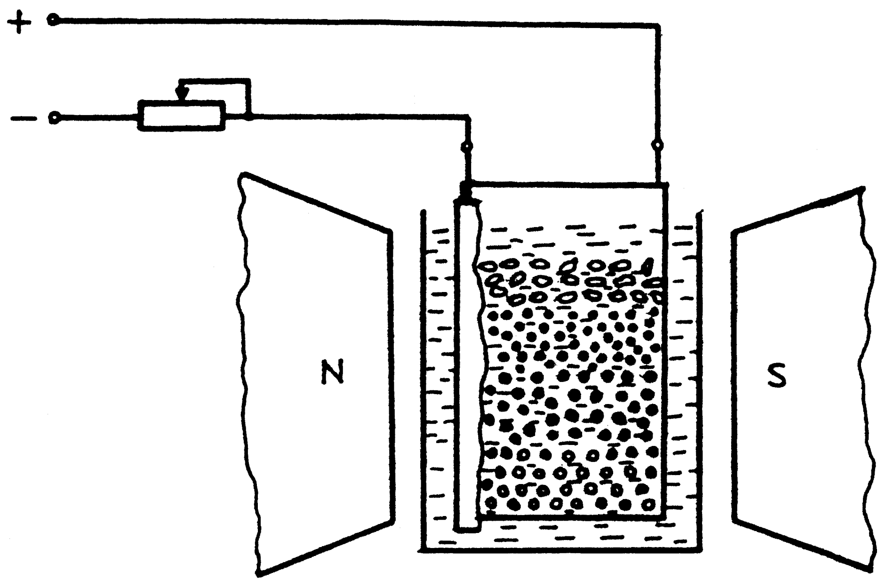

FIGURE 4 Schematic of MHD jigging.

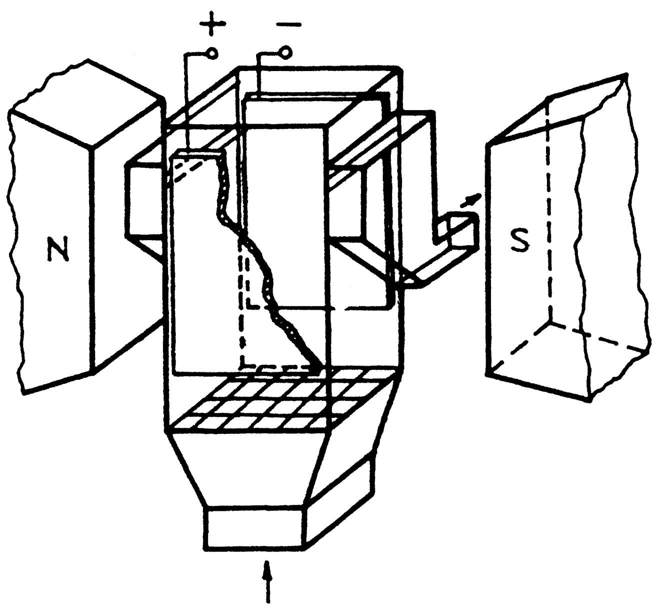

FIGURE 5 Sequential MHD separation system.

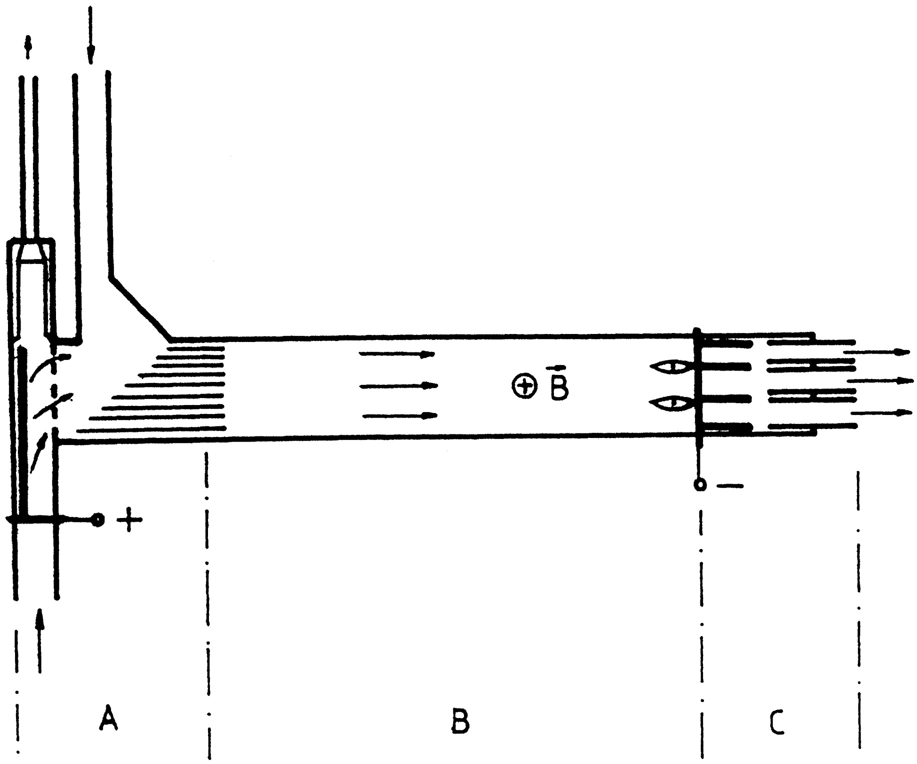

FIGURE 6 Horizontal closed channel MHD system.

section A for introducing the electrolyte and the mixture to be separated, section B of magnetohydrodynamic action, and section C for the removal of the separated phases. By working with current densities of 0.3- 1 A/cm^2, fields of 0.75- 2.0T and electrolyte flow rates of 0.5- 1 m/s within a 450 mm long separation channel, the stratification of certain mixtures was succeeded with densities ranging between 2.5 and 7 g/cm^3, in light and heavy fractions, thus obtaining concentrates with grades exceeding 75% in a single step separation.

On the basis of the results obtained with the first two systems, work was continued to produce lab analysers to facilitate the mineralogic analyses in geological survey laboraties.

The closed channel MHD separation system with horizontal flow will be rebuilt as a pilot scale prototype meant to concentrate coking coals as well as 0.3- 3 mm granulary non-metallic and non-ferrous ores. Its output will exceed 1 t h^{-1}, depending on the processed material.

A notable contribution to the assimilation of magnetic separation in Romania has been brought by the Research Institute for Electrotechnical Industry of Bucharest. The main activity of this Institute has been the design and fabrication of a series of modular dry induced-roll separators with one or two overband magnetic separators and dry drum magnetic separators with permanent magnets [11].

The Mining Research and Engineering Institutes of Cluj-Napoca, Deva and Baia Mare are particularly concerned with the introduction of magnetic separation methods in ore processing flow sheets. The Institute of Cluj-Napoca has as its main objective the utilization of HGMS method in clay, kaolin and feldspar processing, a HGMS separator with a 300 mm long canister having a 1.2 m diameter and a maximum field of 2.0T being designed and manufactured here.

The Institute of Deva is mainly concerned with iron ore processing [12]. It optimizes and projects flow sheets, many of these including magnetic separation. At the same time, a continuous (carousel) HGMS separator has been designed and built for use in iron ore recovery from the slimes deposited in settling tanks.

The main concern of the Institute of Baia Mare is in non-ferrous ore (Cu, Mn, Pb, Sn, Au, Ag) processing. Recent work there includes MDS separation with ferrofluids, a Khalafalla lab separator being produced for concentration tests on non-ferrous ores.

Finally, we should mention that there are at the higher education institutes of Jassy, Timisoara and Petrosami, research teams working on ferrofluid based MDS separation /13, 14/; they are mainly concerned with the theoretical aspects of MDS separation.

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