SENSOR-BASED TECHNOLOGY FOR ORE AND SLAG SORTING

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ABSTRACT

"Scientific & Production Enterprise "Gamayun" was founded in 1992 to provide a full range of engineering services and integrated solutions adapted to the needs of specific consumers. Our specialization is the development of sensor technologies for enrichment of raw materials. Improving our product, we have come a long way from ideas and research to commercial implementation. With our own research and manufacturing capabilities, we are able to offer our clients the unique technology solutions for sorting raw materials which do not have analogues.

This article is devoted to the technology of lump electronic sorting. The technology is based on application of sensors together with software and provides differential analysis of raw materials in the stream. The sensors can measure electrical and physical characteristics of each individual lump of raw materials. The following characteristics are to be analyzed: conductivity; magnetic susceptibility; permittivity; thermal conductivity, surface property, etc. The software allows processing the data coming from sensors and analyzing the threshold principle. This enables to adjust the quality of concentrate.

In this article we will present the technology features and options for its use in certain types of raw material: ferromanganese ore, slags of ferroalloy production (SiMn).

1 INTRODUCTION

Integrated and rational use of raw materials at all stages of processing is one of the biggest challenges in modern production.

In mining industry such factors as rapid rise in price of raw materials, depletion of rich mineral resource, as well as the absence of effective solutions in traditional benefication technologies force to seek new approaches for beneficiation. The technologies of pre-benefication of materials are becoming important. They are the principles which allow entering new efficiency levels of benefication.

For metallurgical production it is important to improve the quality of incoming raw materials (concentrate). And the quality of concentrate affects the efficiency of the entire production chain. Another priority task is the recycling of metallurgical slags, which allows engaging in the production of additional low-cost resource. Other important aspects are improvement of energy and environmental components at all stages of production.

2 FEATURES OF SENSOR-BASED TECHNOLOGY

As a rule, technologies based on gravitational and magnetic methods are used to beneficate raw materials. Such methods are not always effective and able to provide the required quality of concentrate due to physical characteristics and material composition of the raw materials.

The technology of electronic lump sorting [1; 2] - sensor-based technology of ore sorting, has the following schematic diagram (Figure 1):

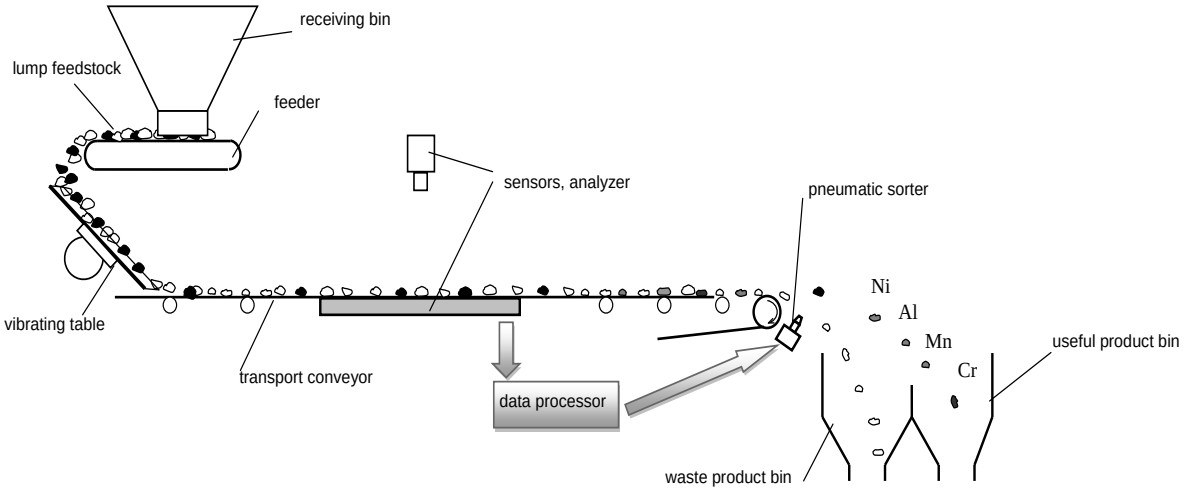

Figure 1: Scheme of electronic sorting technology.

The feed lump material is fed into the receiving bin. There it is accumulated and fed by the feeder onto the vibrating table. The vibrating table forms a monolayer of the material and feeds it onto the belt of transport conveyer. The moving material on the conveyor is controlled, the parameters of separate lumps are fixed and analyzed. By means of special software, the processor processes the data and generates a control signal for pneumatic sorting device. The sorting device with its air jets beats away the lumps selected. Thus, two streams of material are formed: the "gangue" and the "useful" ones.

The use of different sensors, including those of own production, as well as the unique software allows solving complex tasks in sorting of raw materials. This type of sorting can be designed for the criteria which are specific and unique in raw materials of a particular deposit.

To make the raw materials more contrasting various methods of their activation can be applied additionally, such as heating of raw materials in the microwave before analysis.

2.1 The Benefits Of Sensor-Based Technology

The technology has several advantages:

- it allows sorting by indirect characteristics of material composition of materials;
- dust and contamination of the surface of material does not affect the quality of sorting, because the volume rather than the surface is subject to analysis;
- physical characteristics such as weight, magnetic properties, colour do not have a decisive impact on the quality of sorting;
- the technology does not require water resource;
- there are no mechanical processes that consume large amounts of energy (for example, grinding).

2.2 The Facility For Sensor-Based Sorting – The MLS Sorter

The technology of sensor-based sorting is implemented in the facility of Module of lump separation (further referred to as MLS sorter). It is shown in Figure 2. The facility is created on the basis of energy-saving technologies. Energy consumption per 1 ton of raw materials is up to 0.5 kW. The MLS sorter is mobile and made as a container. Such sorters operate on lump material ranging in size from 10 to 100 mm. Performance of 1 sorter is up to 80 tons/hour.

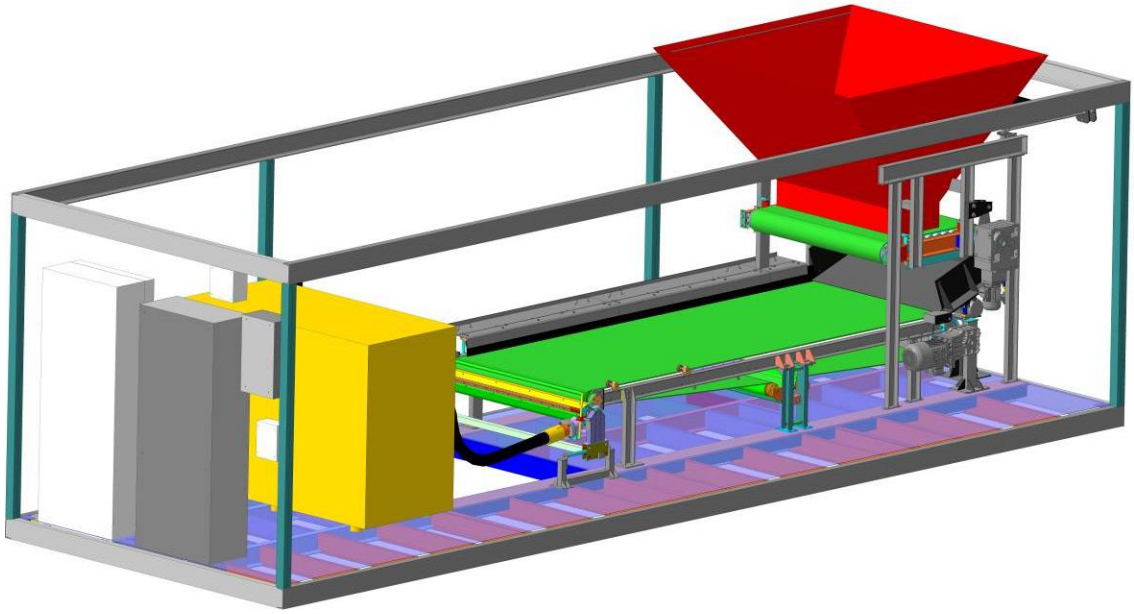

Figure 2: Layout drawing of the facility of MLS sorter

3 APPLICATION OF SENSOR-BASED SORTING FOR FERROMANGANESE ORE

In the process of processing the low quality masses are produced inevitably. They may be formed as a result of existing benefication process such as tailings, or as a result of selection of the so-called near-contact zones of ore bodies. Their benefication in existing production process is not effective. Sale of such resource is not economically feasible.

For example, JSC "Zhairem GOK" has significant amounts of extracted and stored ferromanganese ores with high iron content, which are not involved in production of commercial manganese concentrate. Their Mn content is 8-30% and Fe content is 10-34%. Total volumes of iron-manganese ores with high content of iron which will be produced before the end of the mining quarries, will be about 15 million tons [3].

Manganese in ores of this field is contained in such minerals as pyrolusite, manganite, braunite and iron is mainly represented by hematite. The iron and manganese are of similar weight, which makes it difficult to separate them by gravitational methods. And the main mineral representing iron is hematite, which is weak-magnetic. This makes magnetic methods inefficient.

In 2004-2010 JSC "Zhairem GOK" held studies of ferromanganese ores preparation characteristics.
The participants companies were: "Rados", "Metso Minerals", "Prodecology", "Geolanalit", "The Eastern Mining and Metallurgical Research Institute of Non-ferrous Metals", "Erga", "KazNTU named after K.Satbaev". Various beneficiation methods were applied: jigging, magnetic and X-ray methods. But the target of the studies was not achieved. Using the methods mentioned it appeared to be impossible to produce commercial manganese concentrate with high Mn:Fe ratio.

LLC "Scientific Production Enterprise "Gamayun" has developed the sensor system and the software which allows solving the task. Now it is possible to produce commercial manganese concentrate from low-quality ferromanganese material.

Figure 3: Site for ferromanganese ore sorting based on two MLS sorters. Kazakhstan, JSC "Zhairem GOK".

Site for sorting of low quality ferromanganese ores (Figure 3) consists of crushing and screening complex and two MLS sorters working with the grades of 20-40 mm, 40-70 mm. The peculiarity of the hardware design has allowed the complex installation on the open site, in direct proximity to the dump. This greatly reduced logistics costs of raw materials. Up to 30 000 tons of ore per month are processed on the site. The ore with a high content of ballast rocks and iron is allocated into tailings. The concentrate can contain up to 40% of Mn, with the original content of Mn being 12% (Table 1). Such concentrate is claimed by metallurgical enterprises.

Table 1: Options of benefication of ferromanganese ores.

Grade, mm	Grade output, %	Content in feed ore,%		Output of concentrate,%		Content in concentrate,%		Mn:Fe
		Fe	Mn	from grade	from ore	Fe	Mn	
Ferromanganese ore of Zhomart mine								
20-40	23.5	11.62	30.86	68.55	16.11	2.59	38.54	14.88
40-70	16.7	13.18	28.79	62.30	10.40	3.17	36.41	11.49
Ferromanganese ore Ushkatyn-(III) mine								
20-40	17.2	30.99	9.15	6.1	1.05	6.05	40.13	6.63
40-70	32.3	34.06	9.25	9.5	3.07	6.47	45.18	6.98

4 APPLICATION OF SENSOR-BASED SORTING FOR FERROALLOY PRODUCTION SLAGS

For any manufacturer of ferroalloy products it is important to reduce metal losses in the production cycle, and to increase its throughout recovery. One way to do this is to engage secondary raw materials in the production. The source of secondary raw material is current and dumped slag. With the existing technology of ferroalloy production, some metallic phase is left in slags. The residual content of metal phase reduces the market attractiveness of slag as construction material.

Such tasks are especially important for the world leading enterprises in ferroalloy production, such as JSC "Nikopol Ferroalloy Plant". With their annual production of hundreds of thousands of tons of ferroalloys, the loss of metal in slags grows correspondingly.

In the process of implementation of sensor technology at OJSC "Nikopol Ferroalloy Plant" all known silicomanganese slag sorting methods have been analyzed [4; 5]. They include pneumatic sorting, hydraulic jigging, magnetic separation, X-ray separation, hand selection, etc. Most solutions have suggested expensive capital construction. A water resource has been required for hydraulic jigging. The considered options have been energy intensive and inefficient.

As a result of comparative analysis of the technologies, it was decided to install the sensor-based equipment produced by "Gamayun" at OJSC "Nikopol Ferroalloy Plant" (Figure 4). The form of equipment allowed easy integration in the existing production chain of the enterprise.

Figure 4: MLS sorter in testing period. MLS is set under the gallery of crushing and screening complex. OJSC "Nikopol Ferroalloy Plant", Ukraine.

Today, the equipment operates on three different fractions of raw materials: 10-20 mm, 20-40 mm, 40-70 mm. The total recovery of slag and metal mixture is up to 4%. The quality of the concentrate provided is at the level of 32-35% Mn. The company uses the concentrate as a part of charge components while producing ferrosilicon manganese, which increases throughout recovery of manganese, silicon and reduces specific energy consumption. Slag crushed stone cleansed from the metal is successfully used in construction.

5 CONCLUSIONS

Today, sensor-based technology of sorting is the only technology of dry processing of lump materials that is able to provide the required quality of output product (concentrate). It does not demand major capital construction and water resource, which is a significant advantage in the conditions of dry or cold climate.

This technology is applicable for a wide range of ores and slags. The greatest economic feasibility is the use of the technology on the off-balance ores, slag dumps, distant deposits as ore pre-concentration.

Technological lines of sensor-based sorting solve a number of tasks, including:

- sorting of low quality FeMn ores with the purpose of discharge iron-bearing and ballast rock with simultaneous increase of Mn in the concentrate;
- sorting of Cr, Ni ores prior to benefication;
- sorting of FeHematite ores with the purpose of discharge of SiO_2 and ballast rocks with simultaneous increase of Fe in concentrate;
- sorting of slags of ferroalloy production with the purpose of extraction of non-magnetic metal and slag-metal inclusions.

On the basis of operating experience and calculations, it has been concluded that the investments made in sensor-based sorting pay off by mining and metallurgical enterprises over a period of 1.5 -2 years. Moreover, the technology improves the environmental aspects of operation of a company.

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