IMPLEMENTATION OF THE TECHNOLOGY OF SLAG SEPARATION AT NIKOPOL FERROALLOY PLANT

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ABSTRACT

In the report we analyzed the current state of the problem of generation the waste products of a large-scale ferroalloys production and the ways of its utilization in the Nikopol Ferroalloy Plant conditions. It was considered used on the plant technologies of the selection and returning into the production of the secondary manganese raw materials.

It is shown that deep structural changes in the economy associated with the implementation of the policy of production intensification, which are inseparable from the utmost economy of raw materials, fuel and energy, the using of resource-saving low-waste technologies, reduction of materials consumption, engaging into the reparation of secondary resources and previously unused waste materials. At the present scales of the steel production, including ferroalloys it is also directly linked to the question of environmental protection.

It is shown that an important source of secondary manganese raw materials is a dump slag, which inevitably contains in its structure a certain amount of metal phase in the form of individual inclusions of ferroalloys and metal slag.

In the report it was analyzed the ways of slowing the problem of extracting the metal phase from the dump slag and factors which led to the implementation on the factory the next generation technologies that are implemented in the Modules of lump sorting of mineral raw materials and industrial waste materials.

In the report it is shown the description of the Modules installation and its technical specifications.

KEYWORDS: *Waste product, slag, metal slag, modules of lump sorting of mineral raw materials and industrial waste materials.*

The one way of reducing the cost of ferroalloys is the maximal involvement into the production of secondary manganese raw materials. An important source of it is the dump slag, which is inevitable, because of its physical and chemical properties has in its composition the metallic phase in the form of individual pieces of ferroalloys and prometal slag, that are pieces of slag with small spherical inclusions, or as they called the metal "prills". The presence of such metal in the slag leads to unproductive losses and reduced production efficiency. For more than 40 years of work, these losses have already been significantly reduced, but because of objective reasons, its complete exclusion under the current technology is impossible. Moreover, during the production of crushed stone from the dump slag the presence of metal because of the strong differences between the various kinds of characteristics reduce the quality of the slag products, which in some cases even hold back its sale.

The question regarding the selection of metal component from the slag in the form of slag-metal mix (SMM) in order to be return it to the production at the plant started to study in 1999. First it was the organization of manual selection, by its own, and then with the assistance of contractors.

The biggest quantity of selection the secondary manganese raw materials, up to 6-7 thousand tons per month were during the period 2003-2006, due to the development at that time the most saturated with metal phase of the dump slag mass, which were formed during the development of ferroalloys production technology on the plant. This was followed by a natural decrease in the volumes of selection which were associated with the elaboration of slag mass, poor in content of the metal phase, formed in the later periods. Moreover, in this situation, the human factor comes into play when it is starts to be impossible by hands from the poor slag to choose more suitable for use in SMM because of very small or invisible metallic impurities inside the slag pieces.

Further promotion of this issue can be only with the use of special automatic devices - separators. For this purpose it was hold the studies regarding the distribution of the metallic phase in the crushed stones with the different fractions which was produced as from slag which is in dump as well as from the current which is generated in the process of production the ferrosilicon manganese. Analyzes were performed by Plant with the help of Electrometallurgy Department of National Metallurgical Academy of Ukraine. Currently the crushed stone is produced from raw materials, formed by mixing the dump and the current slag in the ratio of 4:1. The results of distribution of the metallic phase in the crushed stone of the different fractions from such raw materials are presented in a histogram (figure 1), with this, conventionally were adopted four quality gradations of secondary raw materials: SMM consisting of pure metal (Mn ~ 65%), rich SMM (Mn 50-65%), average SMM (Mn 35-50%), poor SMM (Mn 20-35%).

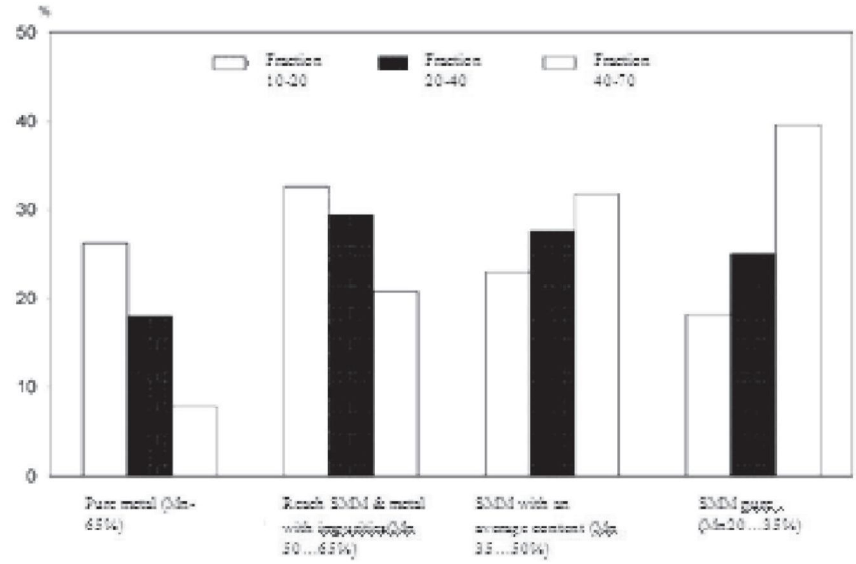


Figure 1: The above histogram of distribution the metallic phase in the charge, which was formed by mixing of the dump and the current slag in the proportion of 4:1

Based on the analysis of tested melts showed that economically feasible is SMM with the quality 32% Mn and up, according to the standard of PJV "NFP" STP 146-123-2005. Taking into the account the nonstability metaphase of dumping slag the lower boundary of SMM was agreed the level of 35% Mn.

To solve the task of extraction metal from slag-metal mix of ferrosilicon manganese and slag is hard cleanability of material, which is due to the relatively low content and physical properties of the useful component - metal phase and the nature of its distribution in the host environment. So, for ferrosilicon manganese it is natural the absence of obviously expressed magnetic properties, which limits, especially in the lump materials, the application of magnetic methods of enrichment, and commensurability of specific gravity of metal content bits and pieces of hollow slag, lead to the low efficiency of gravitational methods (for example, hydratransplantation). In addition, during the implementation of hydratransplantation it is requires capital structure and water resources with appropriate treatment systems, which significantly increases the cost of the process and requires the free space on the industrial site. Previously developed for other productions X-ray radiometric and photometric methods of enrichment in this case also showed itself as ineffective.

All of the above factors lead to the search for alternative and more effective special separation techniques, including the use of electronic methods of processing raw materials for receiving qualitatively new technical and economic indicators of production, the achievement of which is not possible with the application of the traditional approach.

Search for the suitable devices for this purposes, plant started in the 1990. At the time, were analyzed and tested several types of laboratory and experimental separators of different manufacturers, it was even the attempts to manufacture devices of their own design. However, the launch haven't been started because of their imperfections at the time, the low efficiency and lack of industrial production.

Specialists of the plant have been formulated technological requirements for the slag separation equipment, the main ones are:

1. The technology must be energy efficient, dry.
2. Removing of the metal phase should come from all the working fractions 10-20 mm, 20-40 mm, 40-70 mm at a level not less than 90%.
3. Integration of separation technologies into the current production shall not impair the performance of production lines, which for Crushing-Sorting Complex - CSC-1 is up to 90tons/hour, and for CSC-2 is about 120 tons / hour.

The question of choice the optimal technology repeatedly discussed at technical meetings. But each time the decision was postponed due to the fact that the known separation techniques do not meet the indicated requirements.

In condition of such uncertainty in the choice of optimal separation technologies we reviewed the proposal from "Gamayun" Research & Production Ltd., Ukraine, Krivoy Rog city, regarding the use of lump selected Modules (LSM) of the mineral raw materials and industrial wastes for the solution of our problem. We conducted a series of joint tests of the modules in the processing of materials from the manufacturer, and in 2007 with the company head managers it was agreed on technological tests of LSM in the plant at the existing Crushing – Selecting Complex-1 (CSC-1) in the industrial production of crushed stone with its inclusion into the technological process according to the time scheme.

Technological tests results have exceeded our expectations. After 19 days of continuous 3-shift operation, it was processed 3719 tons of crushed stone with the fractions 20-40 mm. At the same time, it was removed 135.85 tons of SMM with the quality of Mn_{total} 36.8%, which is counting as 3.8% of the output from the original volume. Subsequently, the results were confirmed by repeated tests with SGS inspection of independent experts according to the procedure of national standardization system DSTU B.V.2.7-71-98 (GOST 8268.0-97).

As a result of the long-time hard work of the creative team of "NFP" it was decided to arrange the technical retooling of the area of the slag processing on the plant. With the help of plant specialists the renovation project was completed in 2010, acquired the first three LSM on a production line of CSC-1. Currently, reconstruction has been finished and the CSC-1 there are three SMM in operation, respectively for the slag crushed stone fractions 10-20 mm, 20-40 mm, 40-70 mm. The daily selection of SMM is up to 20 tons with the average quality ~ 40% Mn_{total}. The example of the integration of LSM in the gallery of CSC-1is shown in figure 2.

The essence of LSM technology is sorting of lump material using electronic sensors and advanced software for processing data. Efficiency is due to the accuracy of measurement of weight of the metal phase Q in every piece of slag. The task is performed by a special measuring system using the standard calibrated mass developed by “Gamayun” Research & Production Ltd., team and protected by patents of Ukraine UA № 88 220 and 88 221. Technical characteristics of the Lump Selected Module LSM / T-I are given in table 1.

Figure 2: The location of the LSM in the CSC-1 gallery

Constructively the facility has a modular structure - a metal container inside of which there is a technological equipment complex, and manufactured according to the specifications of the TC U 29.5-13449523-001:2007 (Ukrainian Technical Conditions). The layout is shown in figure 3.

Table 1: Technical characteristics of the Lump Selected Module LSM / T-I

№	**Name of the Parameter**	**Unit of measure**	**Slag fraction, mm**		
			10-20	**20-40**	**40-70**
1	Productivity on initial raw material	MT/hr	12	30	40
2	Mn content in SMM, not less than	%	35*	35*	35*
3	Settled capacity	kW	30	25	25
4	Aspirating emissions	m^3/hr	600	500	500

* A possibility of set for the specified manganese content is foreseen

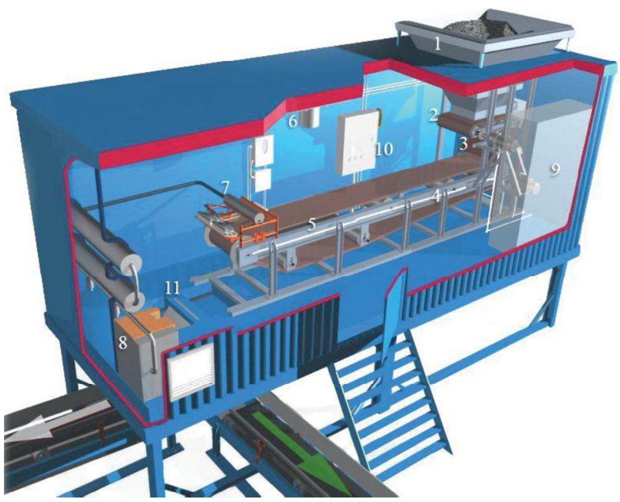


Figure 3: The layout of lump selected module

Initial lump raw material is loaded into the bunker (position 1). Raw material is accumulating in the bunker and supplied to the feeder (position 2), which supplies raw materials to the vibration table (position 3). Vibrating table forms monolayer of the material and delivers it to the tape of the transport conveyor (position 4). When the raw material is moving at the transport conveyor the process is controlling, fixing and performing the analysis of each piece of slag, which is carried out by blocks (position 5, 6). Special software (position 9, 10) processes the data and generates a control signal to the Sorting equipment (position 7). Sorting equipment by air separation (position 8) beats selected by analyzing the pieces of SMM. Thus, a two slag flow forming: "empty" and SMM. At figure 4, figure 5 showed fragments of the process.

Figure 4: Sorting equipment

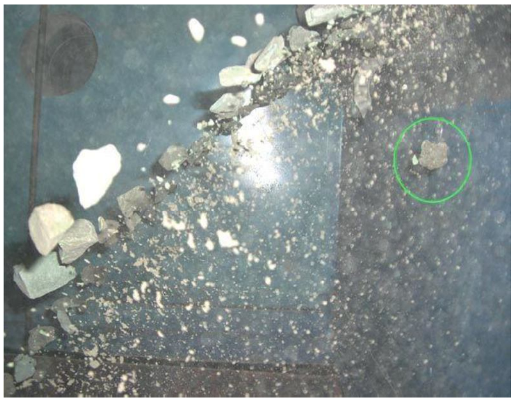


Figure 5: Separation process

An important issue of the quality material separation is installation of a output gate. The gate is installed in the output flow (figure 3, pos.11) perpendicularly to the moving material stream and divided flows of "empty" slag and SMM.

The information presented above, characterize the external parameters of equipment LSM. See the data which, although fragmentary, but give an idea of the internal "electronic-filling" technology. We will do it with the following example.

In the LSM in order to improve the productivity it was applied the high-speed pilling of raw materials into monolayer across the all width of the flat transport conveyor. Thus, for the continuous shooting by the air valves pieces of SMM, LSM technology should solved number of tasks: measurement of metal phase in the each lump, identifying useful/blank lumps, the identifying an exact coordinates of SMM lump, determining its trajectory, etc. .... As an example on the figure 6 (a), (b) shows the projection of the tracking system in order to track the coordinates of lump material movement.

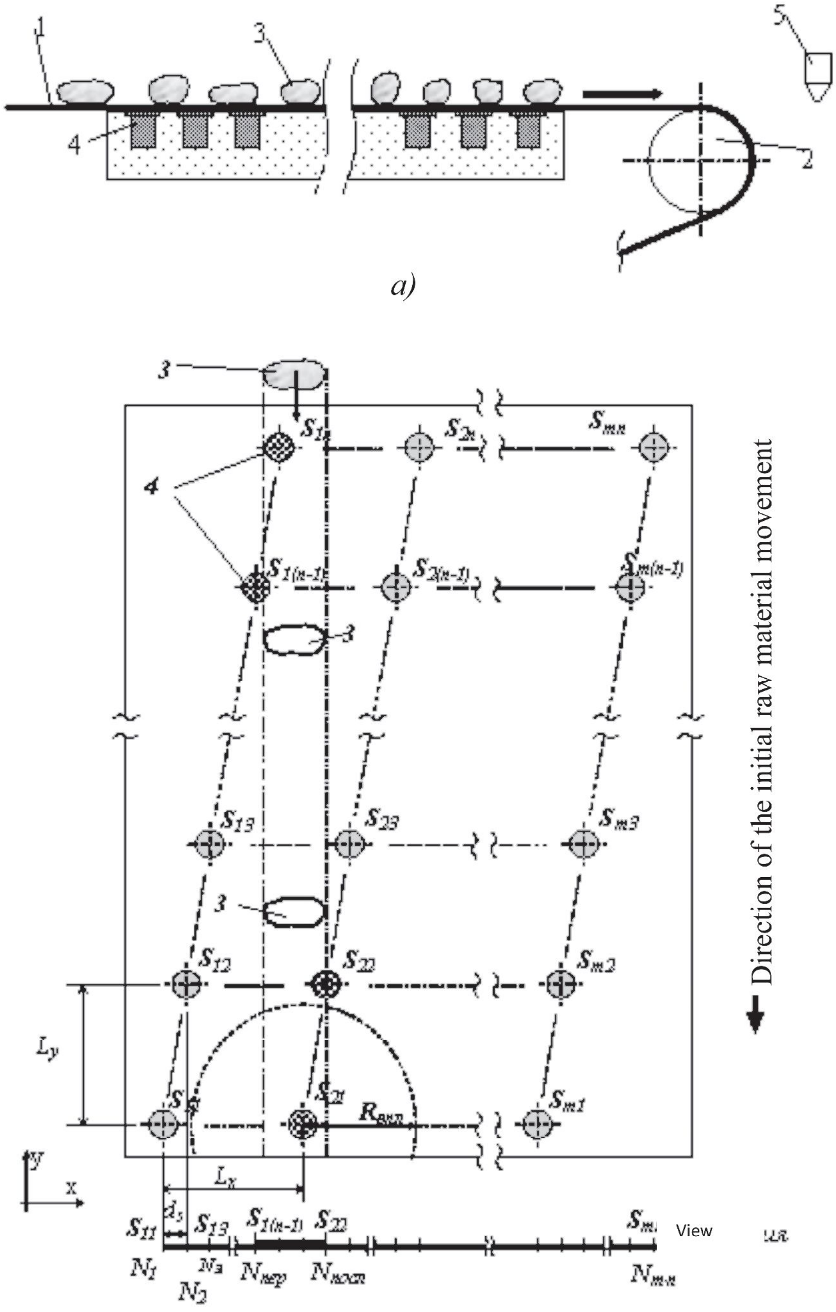
Performing the calculations used in the coordinate system where the axis x'' is perpendicular to the vector of transport conveyor 1 tape movement and the axis y'' is parallel to the vector of the transport conveyor tape movement.

System of induction sensor is designed as *n* rows, the distance between which is determined by the minimum distance between the central near the adjacent sensors, during which the interference of the sensors for a given sensitivity is excluded:

$$L_y > R_{вл} ,$$

where, L_y – the distance between sensor rows;

$R_{вл}$ – zone radius of the interference of the induction sensors.



b)

1 - transpor tape, 2 - conveyor drum, 3 - lump of crush stone, 4 - inductive sensor, 5 - pneumatic valve

Figure 6: Tracking system of lump raw materials coordinates

The number of sensor rows determined by the minimal possible distance between them inside the row.

The number of sensors *m* in the row determined by the width of conveyor tape 1, and is set up so, that the tape completely overlapped by the sensors in the cross section.

In the process of transporting material lump 6 on the conveyor tape, it has been recorded by a group of induction sensors, which are located at the line of lump movement, by which it is determined the location of the lump on the tape and speed of its movement, the coordinates of the geometric center of the lump for determining the number of involved for shooting nozzle and the time of its operation.

More detail information regarding the operation principles of this system can be found in the description of the patent of Ukraine UA № 88 220 and 88 221.

This example illustrates the complexity of the problem while transition from a one-dimensional linear to a two-dimensional (a stream of crush stone on the tape in the LSM technology). But the complexity of the task adequate to the complexity of technological requirements for the separation system, which were formulated by the plant itself.

The team of "NFP" Ltd., passed a difficult way from manual selection of SMM to electronic selection methods. Today, with full confidence, we can say that the LSM took place at the plant.

Currently plant develops the project of reconstruction the CSC-2. We believe that in the future other ferroalloy plants will be equipped with this technology.

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