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The Using of Technogenic Waste from Ferroalloy Production

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Abstract
When ferroalloys are produced, a large number of coproducts are also formed: slag, riddlings of small fractions of ore raw materials and finished products (ferroalloys), sludge, dust and a number of other materials. Their use and processing allows for reduced consumption of the original minerals, thereby increasing the efficiency of the main production and reducing environmental pollution. As a result, both enterprise costs in the form of environmental payments for emissions and waste disposal, as well as government costs associated with environmental measures are reduced. However, the scale of use of ferroalloy production wastes is relatively small. The replacement of the main and auxiliary equipment with new, environmentally friendly equipment, can promote to significantly reduce or completely eliminate hazardous emissions and the generation of unclaimed production waste. It is necessary to organize the use of blast furnace gas from ore reduction furnaces for preheating and partial recovery of elements of charge materials.

Keywords: waste, ferroalloy production, utilization.

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The waste of any metallurgical production is associated with the under-exploitation of raw materials in the process. Moreover, the deterioration in the quality of natural mineral raw materials, lowering the leading elements in it leads to an increase in the loss of materials and waste. This applies to ferroalloy production [1], where the low degree of use of valuable elements of alloys is associated with their losses at all production stages of raw materials.

On average the losses of chromium or manganese are 5–10% at the mining, 27–30% at the ore dressing, 12–40% at ferroalloy production, and 5–30% at steel smelting [2, 3]. As a result, through extraction of manganese and chromium into finished products does not exceed 30–40% of extracted from the mineral resources.

At the stage of production of ferroalloys, a large number of coproducts are formed: slag, riddlings of small fractions of ore raw materials and finished products (ferroalloys), sludge, dust and a number of other materials. Their use and processing allows reduce the consumption of the original minerals, and to increase the efficiency of the main production and reduce environmental pollution. As a result, both enterprise costs in the form of environmental payments for emissions and waste disposal, as well as government costs associated with environmental measures are reduced. However, the scale of use of ferroalloy production wastes is relatively small [4].

Significant attention to the issues of generation and use of industrial ferroalloy waste was given at the conference “Prospects for the development of metallurgy and mechanical engineering using completed basic research and R&D: FERROALLOYS ”[5]. The article ”Technogenic wastes of ferroalloy production” considers the main measures to reduce the negative effects of ferroalloy production on the environment. The replacement of the main and auxiliary equipment with new, environmentally friendly equipment, can promote to significantly reduce or completely eliminate hazardous emissions and the generation of unclaimed production waste. It is necessary to organize the use of blast furnace gas from ore reduction furnaces for preheating and partial recovery of elements of charge materials. Sealing and sheltering of the main smelting equipment, bulk transshipment sites, prevention of dusting of ore storage facilities can significantly reduce emissions.

The utilization of accumulated and current waste (slag, sludge, etc.) of the ferroalloys production, with the reduction or complete elimination of dumps, significantly improves both technical and economic indicators, and environmental friendliness of production. In the work of V.N. Makarova substantiated the economic efficiency of processing slag from ferroalloy production. The existence of a relationship between solving environmental and economic problems is noted. The environmental pollution with industrial waste entails an increase in the costs of their storage and disposal, elimination of pollution. The main economic damage caused by the storage of waste is the rejection of arable land. It is further leads to an aggravation of the problem of food supply for the population, an increase in the cost of production and land restoration.

The utilization of accumulated waste will also allow resource-saving in the building materials industry. To justify economic efficiency, the cost of the raw mix is calculated using and without industrial waste.

The economic effect (E) from the utilization of 1 ton of solid waste, taking into account the cost of maintaining the dumps, is determined by the formula:

$$E = (n_1/a)(C_1 + n_2 \cdot C_2 - C_3)$$

C1 and C3 are the cost of the raw mixture from traditional and utilizating materials. C2 is the annual cost of maintaining the dumps; n1 is coefficient taking into account the share of the costs of this type of material in the total costs of raw materials; n2 is coefficient taking into account the partial or complete elimination of dumps, ranges from 0.3–1; a is specific consumption of utilized raw materials per unit of production.

The calculation was made to obtain aerated concrete using waste slag produced by ferrosilicon manganese. The economic effect of the utilization of 1 ton of solid waste, taking into account the cost of maintaining the dumps at the time the technology was introduced (2013), amounted to 2535.8 rubles or 81.8 $ USA. Taking into account the consumption of 15.41 kg of ferroalloy slag per 1 m^3, it turns out that the production is 65 m^3 aerated concrete allows you to dispose of 1 ton of slag.

Demin and co-authors believe that the main tasks of processing ferroalloy slag include the extraction of metal inclusions. They properties vary widely not only depending on the type of ferroalloy, but also on the grade composition. As a rule, metallic inclusions in ferroalloy slags are weakly magnetic or non-magnetic materials. The modern enrichment methods and devices is used for their extraction. To extract metal inclusions from high-carbon ferrochrome, hand sorting, magnetic separation in a strong magnetic field, hydraulic jigging, pneumatic classification, etc. are used. The most common method is hydraulic jigging, which consists in dividing slag in density in an aqueous medium pulsating in the vertical direction. Dense particles of metal are deposited to the base of the bearing layer of slag surface and are removed from the stream by special corrugations, less dense particles float and are removed from the stream.

The advantage of this technology is the high efficiency of the separation of metal concentrate, reducing metal loss with slag to a minimum. The disadvantages are the need to prepare monofractions of the source material, the presence of water management, which requires maintenance and the difficulty of separating small fractions of slag less than 20 mm.

It is more difficult to organize the extraction of metal inclusions from the slags of refined ferrochrome. The slags is subject to silicate decomposition. The metal inclusions in them have lower magnetic susceptibility in comparison with high-carbon ferrochrome. In the process of magnetic separation, finely dispersed decomposition products, getting into the magnetic field of the separators, are electrified, acquire a charge and pass into the concentrate with ferromagnetic particles. Therefore, before magnetic separation, the slag of refined ferrochrome is kept for cooling and decay. The Ural Institute of Metals has developed a technology for accelerated cooling and decomposition of refined ferrochrome slags in a special cooler drum to eliminate this disadvantage.

For the processing of slag, metal inclusions in which relate to non-magnetic materials, gravitational, X-ray, and sensor methods of material enrichment are used. Due to vibration and impulse purging of the material layer the particles of uniform particle size are separated by density characteristics: heavier alloy particles settle in the lower layers of the foundation and are removed from the stream to the concentrate.

To extract valuable components from slag, sensor technology is used. Due to the response to the pulsed (high-frequency electrical, electromagnetic, radiation) effects on the flow of the enriched material, valuable components extracte from it. The operation of the lump sorting module is based on a method based on the use of highly sensitive electronics. It is capable of recognizing and sorting raw materials with high speed according to properties that are not manifested when applying traditional methods of material enrichment. Different components of the raw materials react differently to the effects of short-term high-frequency radiation. By registering this difference, electronic systems give an impulse to actuators unit - pneumatic baffle. In accordance with the setting, it changes the flight path of pieces of material, taking into account the sorting scheme, sort them according to conditional signs to suitable or unsuitable.

Methods of X-ray radiometric separation are able to separate the flow of dump slag by type, and then remove metal inclusions from this slag isolated from crushed and sorted into fractions of the dump mass. After extraction of the metal component, the slags of the ferroalloy production are used in various industries and in agriculture.

In the artricles of N.V. Kuzmina and V.A. Perepelitsin presents data on the processing of high-alumina slag of aluminothermic production of Klyuchevsky Ferroalloy Plant. These slags contain,%: 42–57 Al_2O_3; 15-24 CaO; 4-12 SiO2; 5–25 MgO; 2–7 Cr_2O_3; 0.4-0.7 TiO_2. Kluchevsky Concentrating Plant LLC sorts and processes slags from current production and dumps. The production of fused alumina product of various grades used for synthetic slags, clinkers, fluxes, etc. was mastered.

Agglomeration, pelletization and briquetting are used to agglomerate the small fractions of charge materials and ferroalloy formed during melting, crushing, and transportation. The articles of L.I. Polyansky and Yu.N. Loginova focused on improving the method of briquetting waste. The authors developed mobile briquetting devices having low metal consumption and low cost. The main recommendation for such devices is the use of preliminary pressing of the charges in units of various designs.

The experience of operating presses with a small diameter of work rolls showed the possibility of obtaining high-quality briquettes from various charges with and without a binder, including screenings of coke and lime, mill scale, ferroalloys, mineral fertilizers, etc.

The technology for briquetting screenings of ferrosilicon manganese with a grain size of 0–55 mm in devices of both roll and plunger type while reducing the cost of the process is developed.

The achievement of high strength of the finished briquettes is facilitated by liquid glass (~ 2%). It's performs the physical role of a binder in the claimed method without chemical interaction with the briquetted material, which allows to reduce the consumption of the liquid phase, i.e. liquid glass. The pressing pressure above 150 MPa for the briquetting process with liquid glass is impractical to use, since this is due to the destruction of small particles of material, which reduces briquette strength. As a result of the agglomeration, solid dense briquettes are formed, suitable for use in steelmaking.

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