Innovative Technologies for the Processing of Cleaning Plant Rejects in the Production of Construction Materials

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Abstract

Development of the resource saving technologies directed on the economy of raw material components with the simultaneous solution of ecological problems by involving production and industrial products wastes is the issue of the day. Experimental and technological researches showed, that mill tailings, after extraction of gold from them, can be used as basic raw material for silicate wall materials.

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1. Introduction

There are three main groups of cities:

- City centers (capitals, territory, region) with diversified industry, with different composition and power sources of air emissions;
- Cities, specialized types of production, usually with large metallurgical, machine-building, chemical, mining and processing, macrobiotic, often with the most powerful air emissions;

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Cities - bedrooms, often satellites or metropolitan areas, as well as small towns with local industry and usually minimal emissions associated with local energy and transport.

Typical structure of pollution of these cities is essentially different. Consider the second group of cities.

In the process of mining plants’ activity the huge amount of very small final tailings and ore slime are being accumulated. It occurs as during treatment of many types of ores all extracted mined rock is being grinded up till the size of grains less than 0.1 mm and only then the ore components are taken from it with the assay value from 1 to 50 % for different types of deposits. The remained 99-50 % of gangue are stored in as final tailings and slimes, occupying thus the big ground areas and demanding substantial expenses for the organization of the storage [3-5]. Omissions and lacks of functioning of such pond tailings lead to an intensive drift of the crushed rock by water and wind and to environmental contamination. The situation is aggravated with the display of general objective tendency to decrease of assay value of useful components in the resources taken from interior bowels, to complication of their material and a chemical composition, to translocating of mining operations to the bigger depths. All this leads, finally, to increase the volumes of production per unit of output and processing of minerals, and thus wastes [6-9]. In the context of deterioration of environmental ecology the question of industrial wastes recycling has become very actual.

The important nature - protection value, when developing the mineral deposits, belongs to the technologies directed first of all on the increase of useful components’ extraction from the ore minerals at reducing the volumes of dump products and decreasing therein the content of harmful admixtures that considerably reduces the level of contamination to the environment and the other negative ecological effects. Taking into account dramatically increasing requirements to the environmental protection, the low-waste technology was developed in order to extract gold and silver from gold-containing quartzites with the use of waste waters in circulation [12-14]. The final tailings after enrichment were neutralized and stored after treatment.

2. Experimental part

This article is devoted to the possibility of using refinement tailings of gold quartzites as raw materials for manufacture of silicate materials for walls[15].

Refinement tailings (hereinafter referred to as “tailings”) of gold quartzites of the Madneulsky deposit (Table 1) received at their treatment in semi-industrial conditions were the subject of this research.

Table 1. Characteristic of refinement tailings

| Composition [mass %] | Incineration losses | SiO₂ | Al₂O₃ | Fe₃O₄ | CaO | MgO | Na₂O | K₂O |
|----------------------|--------------------|------|-------|-------|-----|-----|------|------|
|                      | 84.2               | 1.96 | 0.83  | <0.15 | 0.16| 0.44 |

| Ridling No 01         | 3.1                |
| Specific surface area [cm²/g]| 2800               |
| Leak tightness [ g/cm³]   |                    |
| Titrimetric bulk weight  | In loose condition |
| [g/cm³]                 | In compact-grained condition |
| Organic impurities content| No presence       |

The chemical compound of tailings is characterized by high silica content. The level of unconsolidated SiO₂, alkalis, clay and organic impurity in refinement tailings allows to meet the requirements of standard "Sand for manufacture of a silicate brick and products from autoclaved concretes" (Industry specific standard 21-1-72)[16]. With their grain structure these tailings are finely dispersed and refer to nonconforming sands (module of fineness less than 1).

According to requirements of the standard mentioned above tailings are unusable as a sand– aggregate of heavy concrete, but can be used as an aggregate of cellular concrete and as a compound component of calcareous- siliceous
cementic concrete. At a later stage usability of tailings was ascertained by their testing in masses of silicate bricks, heavy and cellular concretes. In this testing lime received by roasting of limestone of the Tsitelskorojsky deposit (Georgia) at temperature 1100 °C during 2 hours was used as a calcareous component (Table 2).

Table 2. Characteristic of lime

| Incineration losses | Content [mass%] | Duration of slaking [min] | Temperature of slaking [°C] |
|--------------------|----------------|---------------------------|-----------------------------|
|                | SiO₂ | Al₂O₃ | Fe₂O₃ | CaO | MgO | CaO+MgO | non slaking grains |
| 7.0               | 0.50 | 0.15 | 0.70 | 90.0 | 1.10 | 85.0 | 3.0 | 7 | 75 |

2.1. Silicate brick

Raw mixes were made on the basis of tails and lump quicklime, which were beforehand comminuted up to specific surface area equal 5500 cm²/g. After careful intermixing in a centrifugal mill, a mixtures were moisturized and were in the process of ageing within 3 hours till full lime slacking. The moisturized mixtures were additionally intermixed and sifted by screen No1, and by way of pressing under the pressure of 150 kgs/cm² samples in the shape of small cylinders (D=50 mm, h = 50 mm) were formed.

Samples’ steam treatment was carried out in accordance with the mode: 1+8+1 (hours) at 8 atm. Samples were exposed to test for mechanical durability in 24 hours day after steam treatment (Table 3).

Table 3. Influence of activity of a raw mix on samples’ mechanical durability

| Raw mixture composition [mass %] | Mixture activity [mass %] | Molding moisture content [mass %] | Strength at compression [kgs/cm²] |
|---------------------------------|---------------------------|----------------------------------|----------------------------------|
| tailings                        | 93                        | 6                                | 6                                | 190                             |
| lime                            | 90.6                      | 94                               | 8                                | 230                             |
|                                 | 82.2                      | 11.8                             | 10                               | 320                             |
|                                 | 86.0                      | 14.0                             | 12                               | 330                             |

As it is shown in Table 3, with the increase in activity of a raw mix the tensile components of steamed samples increase as well. The durability gain at activation of a raw mix of 10 % makes approximately 120-140 kgs/cm².

For manufacturing of the aggregative test samples of semi-bricks (125x120x55 mm) the raw mixture of optimum structure with the activity of 10 % was used. Agitation of a dry mixture humidified in the laboratory mixer was made in the centrifugal mill. The whole cycle of raw components agitation was equal to 15 minutes. Homogeneous mixture was ageing during 3 hours and from a mixture with molding-moisture content of 10 % semi-bricks were manufactured by pressing under the pressure of 150 kgs/cm². Steam treatment was made the next day after molding in accordance with the mode 1+8+1 (hours), at 8 atm (Table 4).

Table 4. Physical and mechanical properties of a silicate brick.

| Bulk density [g/cm³] | Water saturation [mass %] | Strength at compression [g/cm²] |
|----------------------|---------------------------|---------------------------------|
| 1.8                  | 13.2                      | 280                             |

Physical and mechanical properties of a silicate brick (grade 250) meets the requirements of state standard – (all
3. Results

3.1. The use of innovative technologies

In order to expand the scope of the studied waste for use in the manufacture of wall materials the effect of activation of the prepared raw mixes on the shaking table before steaming in an autoclave was studied[18-22].

3.2. Heavy concrete

For the purpose of manufacturing of heavy silicate concrete raw mixtures with the activity of 8-12 % after intermixing in a dry condition were moisturized and again intermixed in the laboratory dram mixer during 3 hours. The moisturized mixtures were ageing within 3 hours, then raw mixtures again were intermixed and placed in metal forms (cubes 70 x 70 x 70 mm) for consolidation on laboratory vibrating stand at frequency of 3000 vibrations per minute and at amplitude of 0.45 mm within 3 minutes. The formed samples were placed in an autoclave under steam treatment the next day on a mode 1+8+1 (hours), 8 atm (table 5)[23-25].

Table 5. Influence of activity and forming humidity of a concrete mixture on mechanical durability of samples

| Concrete composition [mass%] | Mixture activity [mass %] | Strength at compression, [kgs/cm²] | Strength at molding moisture content [mass%] |
|-----------------------------|--------------------------|-----------------------------------|-----------------------------------------|
| 90.6                        | 9.4                      | 220                               | 280                                     |
| 82.2                        | 11.8                     | 250                               | 300                                     |
| 86.0                        | 14.0                     | 295                               | 315                                     |

The resulted data demonstrates that from a raw mixture with the activity of 10 % and with molding moisture content of 22-24 % and by use of activation on vibration stand the samples with mechanical durability of 300 kgs/cm² can be manufactured.)[26-30].

3.3. Cellular concrete

Cellular silicate concrete was produced from a raw mixture with the activity of 18-20 %. After intensive agitation of tailings with quick lime in a centrifugal mill, the mixture was loaded in mortar mill and water suspension of aluminium powder was pumped (quantity of aluminium powder of 0,1 % from the whole mass of mixture).)[31-34]. Molding moisture – 40-44%. Additional agitation was carried out within 3 minutes, and obtained creamy concrete mix was poured into metal molds to 2/3 volume and activation was carried out on the shake table till the process of distention was finished. In 2 hours after moulding "top crust" was cut off and forms with samples were located in an autoclave. Steam treatment samples (cubes 70x70x70 mm) was carried out in the mode -1+8+3(hours) at 8 atm. Samples were tested after drying to constant weight (Table 6). The minimum volume weight at sufficient mechanical durability characterizes the samples made from cellular concrete mixture by activity of 20 % and with forming humidity of 42 %, at dispensing of aluminium powder of 0,1 )[35,36].

Table 6. Physical and mechanical properties of cellular concrete samples

| Activity of cellular concrete mixture [mass %] | Molding moisture [mass %] | Strength at compression [kgs/cm²] | Volume weight [g/cm³] |
|----------------------------------------------|---------------------------|----------------------------------|----------------------|
| 18                                           | 40                        | 52                               | 0.76                 |
| 18                                           | 42                        | 50                               | 0.73                 |
| 18                                           | 44                        | 48                               | 0.72                 |
4. Conclusion

Laboratory and technological study on concentration tailings of gold bearing quartzite of Madneuli deposit, obtained by enriching the quartzite in semi-industrial conditions, have shown that they can be used as the main raw material for the production of silicate wall materials.

Sand-lime brick, heavy products and cellular concrete in its physical and mechanical characteristics meet the requirements of the relevant state standards.

Expansion of the use of final tailings of quartzite’s enrichment from Madneuli deposit for the manufacture of heavy and aerated concrete is possible by activating the prepared raw mass produced on a shake table before autoclaving.

For the final decision it is necessary to conduct big laboratory and industrial tests of concentration tailings followed by the study of construction and technical properties and durability of the received wall materials.

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