THE RESEARCH AND USE IN CONSTRUCTION OF THE BY-PRODUCTS FROM THE THERMAL POWER PLANT HYDRAULICALLY REMOVED ASH CLASSIFICATION

ABSTRACT

Today the environment protection is one of the most important issues in the world. The utilization of accumulating industrial waste is an up-to-date area of construction research. The paper suggests a method for processing an electricity production waste, namely an ash from the hydraulic removal in the thermal power plant (TPP). The special classification by fractions of ashes from the hydraulic removal allows to receive such products as iron-containing product, fine sand (coarse filler), aluminosilicate hollow microsphere, and product with pozzolanic activity (fine filler).

The experts of the State Enterprise "The State Research Institute of Building Constructions" and "Engineering Company "Perspective" have conducted a series of studies on the obtained products properties and chemical composition, as well as on determining the fractional composition of each product. The density and specific surface area were evaluated, and each product binding properties control was performed. It was found that the aluminosilicate hollow microsphere and the product with pozzolanic activity had binding properties, and hardened mortars based on these materials were insoluble in water. Chemical analysis showed that in each of the products, except for iron-containing one, oxides of silicon and aluminum predominated. The iron containing product had a high content of iron oxides and by its composition was close to magnetite.

The carried-out studies show that the products obtained during the hydraulic ash removal at TPP have a wide range of applications, both in the construction industry and in the chemical, mining, and metallurgical industries. In construction, these materials can be widely used as active mineral additives in the grinding of cements, or as additives improving the concrete mixtures and concretes properties. The iron-containing product is applicable in the special ultraheavy concretes manufacture.

KEYWORDS: aluminosilicate, ash, filler, magnetite, pozzolana, classification, flotation, slag

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SHEINICH L.  
Dr, Prof., Head of Dept., the State Enterprise "The State Research Institute of Building Constructions", Kyiv, Ukraine, e-mail: schein@ndibk.gov.ua  
tel. +38 (044) 248-88-73  
ORCID: 0000-0002-7684-9495

MYKOLAIETS M.  
PhD, Head of Laboratory, the State Enterprise "The State Research Institute of Building Constructions", Kyiv, Ukraine,  
e-mail: mmikolaets@gmail.com  
tel. +38 (044) 224-78-79  
ORCID: 0000-0002-8823-3401
The use of by-products is a pressing challenge worldwide, as it allows, inter alia, to solve the environmental protection issue of the accumulation of thermal power plants (TPP) fuel combustion products in the dumps. One of such large quantity by-products that pollute the environment is the waste, including fly ash or ash and slag, from the electricity production at TPP.

Addressing the problem of such wastes utilization, the TOV “Engineering Company "Perspective"” suggested the solution based on their recycling.

In compliance with the proposed technology, some types of mixtures are received during the classification by fractions of the ash from the TPP hydraulic removal. The products dispersion is a multistage process carried out by the method of flotation envisaging the buoying of ultralight particles and their collection by a defoamer, the particles classification in hydrocyclones, and magnetic separation. This process results in the following products:

- The iron-containing product;
- Fine sand (coarse filler);
- Aluminosilicate hollow microsphere;
- Product with pozzolanic activity (fine filler).

**INTRODUCTION**

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- The iron-containing product;
- Fine sand (coarse filler);
- Aluminosilicate hollow microsphere;
- Product with pozzolanic activity (fine filler).
The hardening time and water resistance were determined for the fine filler and aluminosilicate hollow microsphere. The study was performed according to the DSTU B B.2.7-100 method [10].

The normal dough consistency determination for a product with pozzolanic activity (fine filler) is based on the following:

- 400 g of fine aggregate + 200 g of lime putty (50% moisture) + 14.25 g of ground gypsum stone. Water consumption is 185 g. Dough is of normal consistency of 46.25%.

The normal dough consistency determination for an aluminosilicate hollow microsphere is based on the following:

- 200 g of aluminosilicate hollow microsphere + 100 g of lime putty (50% moisture) + 7.13 g of ground gypsum stone. Water consumption is 185 g. Dough is of normal consistency of 46.25%.

If the water consumption is 464 g per 400 g of aluminosilicate hollow microsphere, the dough is of normal consistency of 116.0%.

The further tests were performed using a Vick’s device with a pestle. In both cases, the end of hardening was observed after 24 hours.

The water resistance tests of the hardened sample on the basis of the fine filler showed that the mixture withstood the test, and no sample erosions were detected.

The water resistance tests of the hardened sample on the basis of the aluminosilicate hollow microsphere showed that there was a slight erosion of the sample, and the edges were blurred.

### Table 1 – Sieve analysis

| No | Material name                  | Sieve No residue percentage |
|----|--------------------------------|----------------------------|
|    |                                | 0.315 | 0.250 | 0.160 | 0.08 | sieve 0.08 |
| 1  | Iron-containing product       | -     | 1.5   | 1.6   | 6.9  | 89.9  |
| 2  | Fine sand (coarse filler)     | 0.9   | 5.0   | 3.8   | 47.8 | 44.4  |
| 3  | Aluminosilicate hollow microsphere | 1.5 | 25.2  | 13.3  | 26.9 | 33.0  |
| 4  | Product with pozzolanic activity (fine filler) | - | 0     | 0     | 3.25 | 96.70 |

### Table 2 – Physical and technical indicators

| Number | Mixture type                  | Selling humidity, not more than, % | Bulk consistency, g/cm³ | True consistency, g/cm³ | Specific surface, cm²/g |
|--------|-------------------------------|-----------------------------------|-------------------------|-------------------------|-------------------------|
| 1      | Iron-containing product       | 1                                 | 1.79                    | 3.50                    | 920                     |
| 2      | Fine sand                     | 12                                | 1.25                    | 2.10                    | 1520                    |
| 3      | Aluminosilicate hollow microsphere | 1                              | 0.29                    | 0.57                    | 3380                    |
| 4      | Product with pozzolanic activity | 1                               | 0.84                    | 2.13                    | 5270                    |

### Table 3 – Chemical compositions

| Mixture type                         | Chemical compositions % |
|--------------------------------------|-------------------------|
|                                      | LOI* SiO₂ Al₂O₃ Fe₂O₃ FeO TiO₂ CaO MgO SO₃ K₂O Na₂O P₂O₅ MnO |
| Iron-containing product              | 0.8-1.1 20.0-24.0 9.0-15.0 43.0-46.0 9.0-13.0 0.31-0.4 2.00-2.90 3.9-3.5 0.02-0.05 0.4-0.57 0.19-0.6 0.9-1.1 |
| Fine sand                            | 1.9-2.2 55.0-60.0 20.0-26.0 4.20-4.60 2.1-2.5 0.70-0.95 3.15-3.3 1.55-1.72 0.03-0.06 2.2-2.45 0.61-0.85 0.35-0.55 0.1 |
| Aluminosilicate hollow microsphere   | 0.26-0.35 60.5-64.1 25.3-28.1 1.00-1.20 1.56-2.1 0.65-0.8 1.00-1.21 1.11-1.3 0.05-0.15 3.35-3.71 0.41-0.81 0.1-0.19 0.03-0.2 |
| Product with pozzolanic activity     | 3.0-14.0 43.2-47.0 18.0-19.0 4.30-4.90 1.4-1.8 0.76-1.0 2.55-3.1 1.15-1.4 0.06-0.08 1.6-2.0 0.54-0.95 0.56-0.89 0.09-0.11 |

*Loss on ignition*
Fine sand can be used:
- as an aggregate in the mortars and concretes production, including the light and cellular concretes;
- as a filler in the polymeric materials, paints and varnishes production.

Product with pozzolanic activity can be used:
- as an active mineral admixture for cements;
- as an active mineral admixture in the manufacture of mortars, concretes, including light and cellular concretes;
- as a filler in the polymeric materials, paints and varnishes production.

CONCLUSIONS
1. The use and processing of the hydro-removal ash allows to solve the problem of recycling the electricity production wastes at the TPPs of Ukraine.
2. Based on a special technology of screening and classification of hydraulic removal ash the following products are received:
   - iron-containing product;
   - fine sand (coarse filler);
   - aluminosilicate hollow microsphere;
   - product with pozzolanic activity (fine filler).
3. The products of hydraulic removal ash classification that are proposed by the company TOV "EC "Perspective" have a wide range of applications both in the construction industry and in the chemical, mining and metallurgical industries.
4. Physical and chemical studies have shown that the obtained products can be used in construction as fillers and aggregates for concretes, special concretes, as well as active mineral additives in the cement production. The aluminosilicate hollow microsphere and product with pozzolanic activity have the binding properties that can be practical for reducing the cement consumption and improving the technological properties of concrete and mortar mixtures and of concretes.
5. To determine the mixtures (obtained sieving products) optimal content in heavy, light or cellular concrete and mortars the further research on the components selection should be carried out using the specific materials under the conditions of ensuring the concrete and mortar required quality in products and structures and necessary reinforcement corrosion resistance.

The results of some physical properties determination are shown in Table 2.
The mixtures chemical compositions and losses during firing are given in Table 3.
The material samples chemical analysis shows the following:
1) in the iron-containing product composition the iron oxides (trivalent and divalent) mixture and magnetite itself dominate – 55 %; there is a small fraction (32 %) of the aluminosilicates mixture. Alkali content (Na2O equivalent) is 0.82 %;
2) the coarse filler mixture composition is dominated by the silicon oxides (58 %) and aluminum oxides (23 %). Alkali content (Na2O equivalent) is 2.3 %;
3) in the aluminosilicate hollow microsphere the silicon oxides and aluminum oxides shares increase up to 63 % and 26 %, respectively. Alkali content (Na2O equivalent) is 2.96 %;
4) in the fine filler mixture (product with pozzolanic activity) composition the silicon oxides (47 %) and aluminum oxides (21 %) dominate as well. Alkali content (Na2O equivalent) is 1.97 %.

Given the above alkalis content in the obtained products, it is necessary to use these materials with caution in concrete and reinforced concrete structures operated in conditions favorable for alkaline corrosion. As a result of research, it was found that the products of the hydraulically removed ash classification can be used in various sectors of the economy.

Aluminosilicate hollow microsphere can be used in:
1) the construction – as an active mineral admixture for cements; active mineral admixture in the manufacture of solutions improving the lime mortars properties, liquid mortars, plaster mixtures, concretes, including light and cellular concretes; active mineral admixture for the coatings of insulating, roofing and soundproof materials;
2) the ceramic and refractory industry - as an active mineral admixture in the manufacture of refractory materials, light refractories, fireclay products, refractory bricks, abrasive highly porous materials;
3) the chemical industry - as an active mineral admixture in the manufacture of thermoplastic composition for marking roads and airfields with asphaltic and bituminous concrete pavements; filler for the polymeric materials, paints and varnishes production.

The iron-containing product can be used:
- in the manufacture of special concretes;
- for the production of ferrosilicon, cast iron, steel, raw material for powder metallurgy;
- in the manufacture of special heavy concrete with high average consistency;
- in the minerals processing as a weighting material.
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