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The Use of Environmental Technologies to Clean Up Contaminated Waste from Thermal Power Plant Ash Disposed for The Needs of Construction Industry.

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ABSTRACT

This work is dedicated to the development of economically feasible methods of advanced purification technologies for utilization ash-disposal TPP (Thermal Power Plants) areas from harmful and heavy dirt. Clean ash can is used in various industries including the production of ecologically clean construction materials. To solve this problem research on creation of drugs based on humic acids, which can clean up the environment from toxic technogenic pollution, was conducted. The production line, with separation of the toxic part, which is based on gravitational methods of purification, is developed. It is shown that using the technology of ecological (biological) protection on the basis of humic acids, derived from coal, it is possible to carry out the cleaning of ash turning it into raw material for construction industry appropriate international standards and current market requirements. Preparations based on humic acids have the properties to bind metal ions, herbicides, pesticides and many other substances harmful to humans with the formation of insoluble complexes that cannot be absorbed by plants. In this regard, the proposed project could make a tangible contribution to the solution of environmental problems: neutralization and removal from the biosphere harmful chemicals by adsorbent properties of humic acids.

Keywords: cost-effective energy, humic acids, construction materials, environmental tasks.

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INTRODUCTION

Nowadays, every big city faces the fact that it has utilized or active ash dump. The area of urban development cannot be reclaimed near existing harmful sources. It is established that waste products, contained in the ash, such as chromium, nickel, beryllium, asbestos, and others are turned out to be carcinogenic and can cause cancer diseases [1]. Maximum danger, for the health of humans and animals, represents the accumulation of toxic mercury metals, lead, cadmium, antimony, arsenic, chromium, cobalt, nickel, tin and others in food substances [2].

Many authors discuss information about the presence of rare earth elements in ash and slag wastes (ASW) of thermal power stations [3, 4]. The main harmful components are As, Sd, Sc, Se, Mn, Nb, Ga, Ge, Bi, Mo, V, Y, La, Cd, Ag, Li, Co, Ni, Zr, Cr, Cs and others.

Having regard to the above, the technologies of neutralization and disposal of harmful chemical substances are important and popular in the market for the environment improvement. One of the options of ash and slag recycling technology is the direction to create construction materials out of the recyclables. Studies ongoing in different countries indicate the possibility of manufacturing a wide range of construction products from raw materials of this kind [5-7].

METHODS

Methods that were used to develop advanced purification technologies for utilization of ash-disposal TPP areas from harmful and heavy dirt were founded on works of the department of Mining and Comprehensive Exploitation of FEFU [8, 9]. On this basis the advanced production line for the processing of ash waste was developed. This line is based on gravitational methods of purification and allowed releasing toxic part of waste ash. The production line of ash purification has a number of advantages: low power consumption, all equipment consumes amount of energy no more than 100 kW; simplicity of the design; reliable for operational characteristics.

The advanced production line (Fig. 1) operates on the following scheme:

1. The slag in the perspective developed production line is fed into a vibrating feeder (1) and falls into the crusher (2) with the use of feeder. When the hammers rotate under centrifugal force they extend in radial direction and hit with a force the pieces of the crusher feed slag onto the grate. The fine grains' size is smaller than holes in the grid; they fall through it, while the larger ones undergo an additional grinding by the hammers. Attrition occurs through a small clearance between the ends of the hammers and the grid. The hammers material, the alloy structural steel, is made according to the new technology, with the characteristics of durability and impact resistance. Regulation of the size and shape of the openings in the discharge grates is carried out on the characteristics of ash and slag mixture. The equipment's closed design solves the problem of contamination by harmful dust and leakage of raw materials.

2. Input of the ash to vibrating screen (4) for separating into fractions and then feed into the hopper is performed by conveyor belts (3, 6, and 8). The main grinding of ash occurs in a ball mill (9). The ball mill is used for dry and wet grinding, for pre-ground slag material and also for constructional material of low and medium hardness. Drum of the mill is a hollow steel cylinder. The process of loading of a raw material and selection of ground material is continued. The source material is loaded into one end of the drum, and the ground product is discharged in another end through the hollow studs that are in the front covers of the drum. Grinding of the material is achieved by impacts, abrasion and crushing of the ash and slug particles in the rotating drum. Grinding bodies are iron and steel balls with 150 mm diameter and round steel rods up to 130 mm diameter with a length equal to the length of the drum. The output product is a stable grain-size composition. There is great wear resistance of the lining. Low operating costs and 2 times low energy consumption is the distinction of this product.

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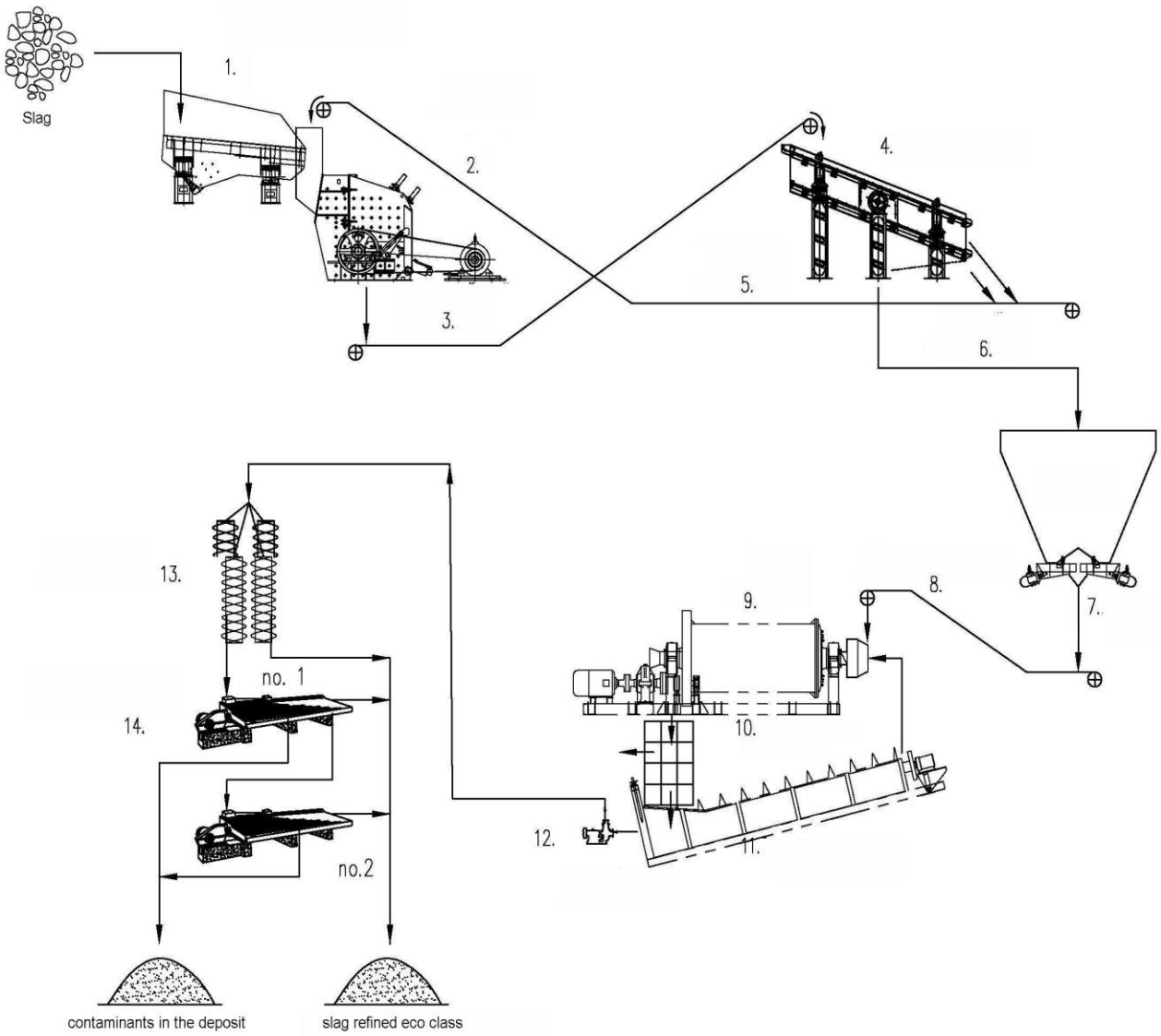


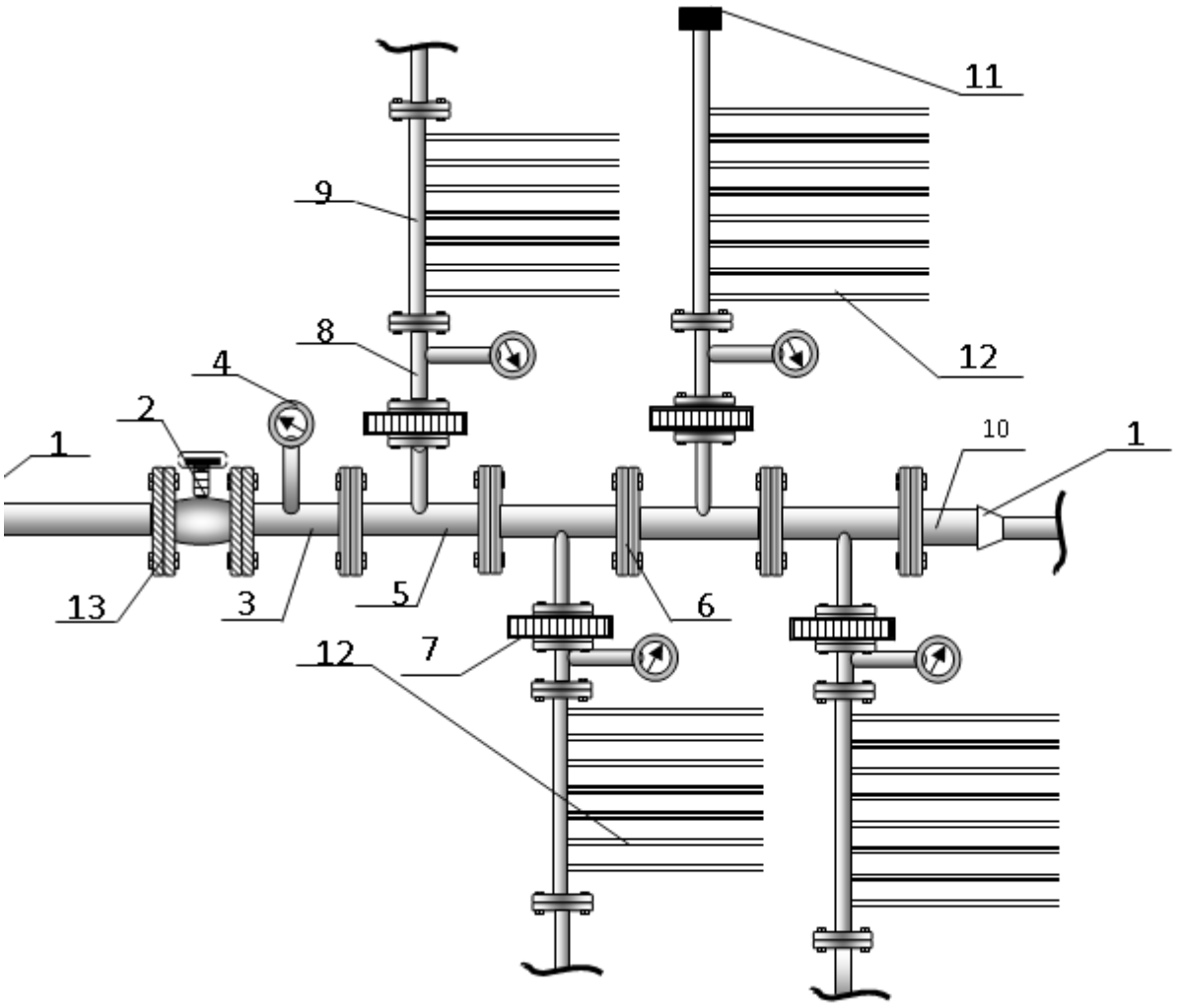
1 – vibrating feeder; 2 – crusher; 3,5,6,8 – belt conveyors; 4 – vibrating screen; 7 – electromagnetic feeder; 9 – ball mill; 10 – mixing plate; 11 – separator; 12 – slurry pump; 13 – spiral chutes; 14 – concentration table

Fig. 1 – Schematic diagram of the TPP ash dump slag purifying from contaminants to ecologically pure state

3. Stirring of the slag with water and cleaner humates for separating the toxic parts occurs in the separator (11). During the enrichment process, the spiral separator operates in a complex device for hydraulic classification, desliming and purifying of metals and compounds. The classification process is carried out in a moving stream of water. Helical classifier is a semicylindrical body in which the spiral rotates on a longitudinal shaft.
4. Pulp is fed into the sedimentation chamber of the classifier located at its bottom part. Smaller product particles are discharged as drain through the lower end of the classifier body. Larger material (slag sand) settles to the bottom of the body. It is picked up by the spiral and discharged at the top of the classifier. At the bottom of the classifier there is skimming weir, the height of which is varied depending on the desired particle size in the sink. By adjusting the height of the overflow threshold, grain size to be drained is set.
5. Mud slurry pump (12) feeds the spiral chutes (13). The expanded mass reaches the concentration tables (14) for the separation of heavy fine particles of slag by gravity enrichment of mineral according to the density (sometimes according to the form) in a flow of a thin layer of water on an inclined plane (deck). Concentration table is used for the enrichment of ores of rare, precious and ferrous metals (particle size 3-0.1 mm).

6. Concentration table (deck) makes almost horizontal asymmetric reciprocating motion, providing loosening of the layer of the particles and their transportation. As a result of the upper layer particle drift by a flow of liquid across the deck and transportation of the lower layer (where heavy particles are concentrated) along the deck, a different density (size) fan of particles is formed, which allows to collect particles of the same density in different receivers.
7. The output of the production line is clean eco-class slag for further production of construction materials and heavy contaminants for disposal by specialized plants.

The cleaned-up slag is placed in stock heaps. Irrigation system is installed immediately after dumping of slag stock heap; irrigation system, consisting of wobbler type of sprinkling system or pressure emitters (drip emitters of labyrinth type Fig. 2), is offered. In summer time, the system of wobblers is used for irrigation of slag stock heap.



1 – Inlet metal pipe Ø 160; 2 - Flap Ø160; 3 – T-socket for manometer installation on the main pipe-line; 4 - Manometer; 5 – Handling pipe connection T-socket; 6 – Plastic flange; 7 – Handling pipe flap; 8 - T-socket for manometer installation on the flooding pipe-line; 9 - Pipe Ø76mm; 10 – Head plastic pipe Ø160mm; 11 - Cover Ø 63mm; 12 – Polyethylene pipes -20mm with emitters; 13 – Metal flange; 14 – Reducing pipe 160/110

Fig.2 – The irrigation system of cleaned-up slag stock heap

The main pipelines (polyethylene pipe with the diameter of 76 mm) embed after 20÷25 mm, perpendicularly from the main pipe (polyethylene pipe with the diameter of 150÷220 mm), underlaid along the long axis of heap. Emitter lines are placed parallel to the main pipeline, forming a network 2×2 m in size with the emitter in the center of the square.

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The number of emitters is 5 pieces per 4 m^2 – in the process of irrigation of slag stock heap with the intensity of 200÷240 l/m^2 per day. The load on one emitter is 200÷240 l/m^2 per day. At the present time, the reclamation system of drip irrigation with watering step 1 meter is mainly used. When the pressure in the irrigation system is under 3.5 ATM, the productivity of one drip emitter makes up to 2.5 l/h (60 l/day), when the pressure is above 3.5 ATM, — 4 l/h (100 l/day). When nominal pressure is 2.5÷3.7 ATM, the number of drip emitters per one m^2 should be 4÷5 pieces.

The main advantage of using emitters and drip emitters is that the irrigation system provides continuous water runoff by drops. As a result of drip irrigation, the whole stock heap of cleaned-up ash is wetted both vertically and horizontally due to the capillary effect. Additional advantages of using pressure emitters is that it enables operation at low temperatures and reducing evaporative losses.

RESULTS AND DISCUSSION

The described production line, with separation of the toxic parts, which is based on gravitational methods of purification, is the most perspective (Fig. 1). Purification of contaminated territory is carried out until complete cleaning-up of the ash disposal area at the whole depth of bedding and distribution.

Reclamation starts after purification from harmful and heavy chemical impurities, utilized by ash disposal TPP areas. Trees and shrubs are planted out, grass is seeded. Chemicals, based on humic acids, are used for growth acceleration of plants [10].

The potential of the humic-containing chemicals use for the production of ecologically clean construction materials, corresponding to the current sanitary standards, is studied.

Based on the conducted researches, the perspective project of the automated line for the production of ecologically clean construction materials, produced from polymer concrete or foam concrete, is developed (Fig. 3).

There is a perspective direction for increasing the use of the emitted ecologically clean alumosilicate, to be used in construction in different areas, from the production of gypsum wallboard to cement production.

Prospects of using cindery mixture in road construction, both as a land bed, and in road pavement, are planned.

Further work in this direction will increase the implementation of advanced cleaning technology from harmful and heavy impurities, utilized by ash disposal TPP areas in the ecological program for clearing of areas in settlements for residential development.

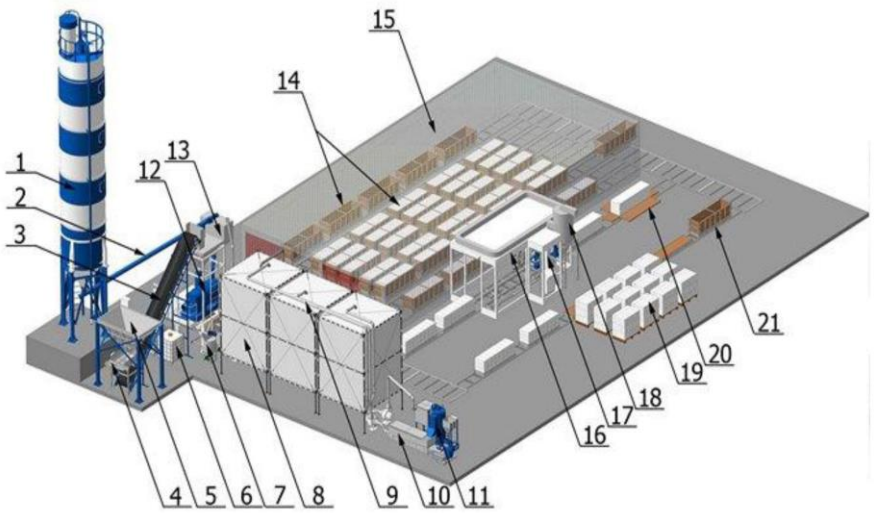

Fig.3 – The schematic diagram of automated line of super-light polystyrene concrete.

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Equipment of automated line for the production of polystyrene concrete:

1. Cement silo
2. Screw conveyor
3. Belt conveyor
4. Vibrating screen
5. Slag hopper
6. Complex of water treatment
7. Chemical additives' dispenser
8. Ageing Hoppers
9. Pneumatic conveying system
10. Drier device ПВГ
11. Polysterol frothing device HDP-500
12. Hermetical mixer РСГ-900
13. Volume batcher ПВГ
14. Formats FM-0.85
15. Heat treatment chamber
16. Chamber with air ventilation system
17. Cutting complete
18. Cyclone collector
19. Units package
20. Form removal area
21. Mould assembly area

The cleaned-up cinder mixture is applicable as filler for the production of ecologically clean construction materials, produced from polymer concrete or foam concrete. Polystyrene concrete, used in precast products, meets the requirements of GOST R 51263. There are 3 types according to the degree of heat-protective and structural qualities: heat insulting – 150-225 kg/m^3 density, heat insulting and structural – 250-350 kg/m^3 density and structural and heat insulating – 400-600 kg/m^3 density.

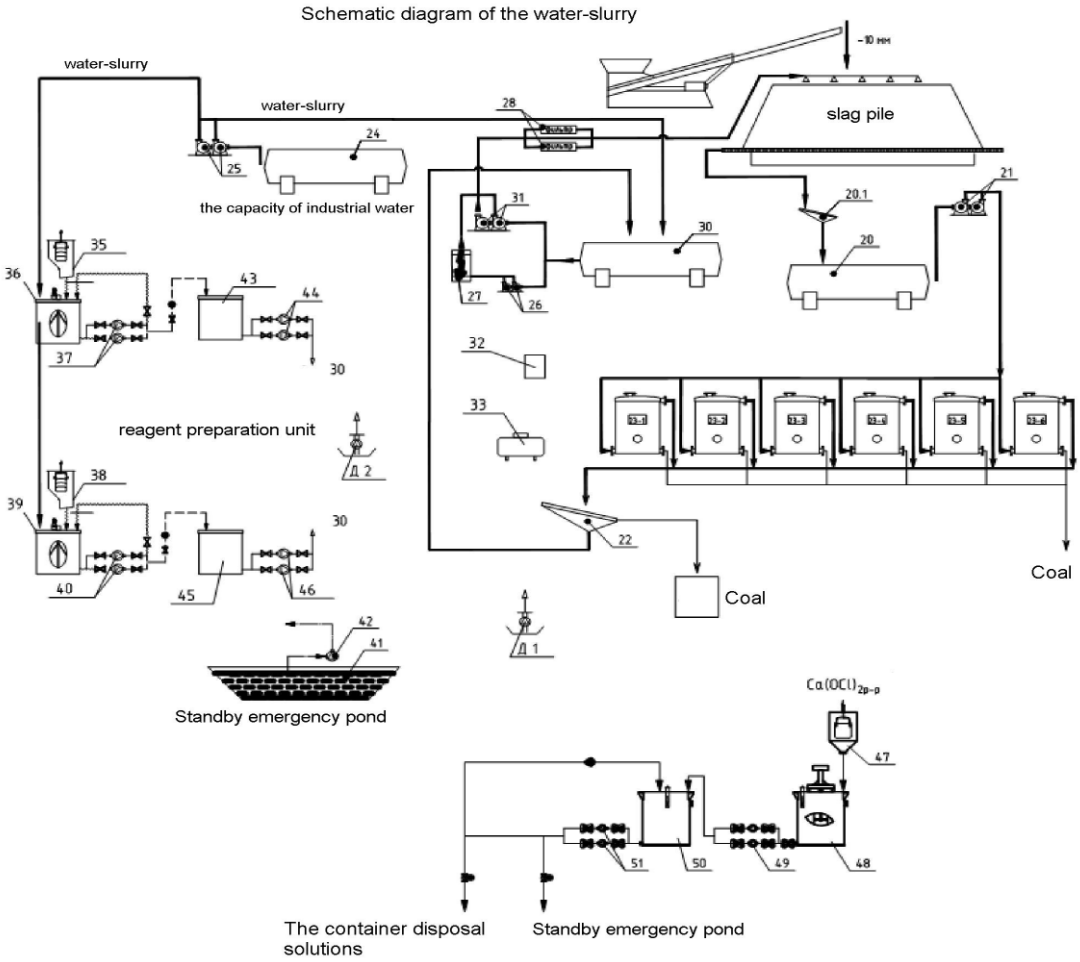

Fig. 4 – Principal scheme of the water-slurry for TPP ash dump slag purifying from contaminants to ecologically pure state

Thermo-technical and fire-technical characteristics in the process of manufacturing super-light polystyrene concrete with improved stress and strain properties will improve the energy efficiency of newly constructed buildings; further energy savings in the course of buildings maintenance with rising level of

thermal protection of external walls up to 40%; providing comfort, fire and environmental safety in the buildings maintenance. All the advantages and characteristics on constructions installation by the use of super-light polystyrene concrete are represented in “Rules, control of implementation and the requirements for operating results” [11]. The main advantages of using cleaned-up cinder mixture in the production line of construction materials are revealed.

Technological line calculation and description of the technology of polystyrene concrete production and foam concrete products in Fig. 3 are developed by LLC "The Construction Technologies of Siberia". All commercially available compounds are developed specifically for given raw material with the aluminosilicate component. The production company has the payback period within two years. The construction cost of ecologically clean construction materials from polystyrene concrete or foam concrete production is 92 million rubles.

Based on the advanced production line for the processing of ash waste, the scheme of the water-slurry for TPP ash dump slag purifying was offered (Fig.4). The equipment for this scheme was produced by an enterprise of heavy industry - LLC “Zhongding” and tested in one of Zhengzhou enterprises in China.

CONCLUSION

New systemic approach on environmental improvement, with application of neutralization technology and removal of harmful chemical substances from the biosphere, was offered.

Production of preparations, based on humic acids, derived from brown coals, turfs and soprapels using extracts of sea weeds (*Ahnfeltia, Gracilaria*) for ecological clean-up of contaminated areas (industrial sites, populated areas and other urbanized and contaminated sites) is arranged.

The technical solution is patented: Energy saving technology of humates’ production, allowing reducing prime cost of products by 25-30%. The patent for useful model No. 109756 of May 04, 2011 “The line for receiving humates of alkali metals”. Documentation for patenting preparation of ecological cleaning on the basis of humic acids is prepared.

Preparations of environmental protection provide neutralization and removal of harmful chemical substances from circulation in the biosphere (radioactive substances, heavy metals and organic compounds).

Implementation of ecological clean-up of populated areas and industrial facilities, production of organic agricultural products, production of ecologically clean construction materials is become possible.

Biological preparations are of interest in the context of organic plant production. Worldwide, including in Russia, separate components of biological preparations are used as a means for productivity increase and ecological purity of crops.

The low cost of the proved high efficiency preparations is the crucial aspect.

The range of knowledge-intensive products, based on humic acids is presented:

1. Preparation for ecological clean-up and protection of territories.

The preparations have the property of forming a water-insoluble complex with radioactive substances, salts of heavy metals and organic compounds, while achieving a sharp decline in the concentration of harmful substances in the territory. The preparation is effective for municipal facilities for processing the carriageway and adjacent areas, trees and shrubs. It’s suitable for treatment of recreation centers, rest houses, camps, and building surrounding land in ecologically harmful areas.

2. Biological preparations for environmental protection of agricultural products.

Biological preparations increase crop productivity, protect plants from pathogenic microorganisms. The content of harmful substances (salts of heavy metal, herbicides, pesticides, nitrates and other toxic

substances) are eliminated or significantly reduced. The preparations are effective as fertilizers for agriculture and indoor flowers. Removal waste that can be used as an additive for pets will reduce the harmful effects of biostimulants and hormonal preparations.

The biological preparation using allows:

- reduce herbicides, pesticides, nitrates, salts of heavy metals in crop products (vegetables, including potatoes) by 3-4 times;
- increase crop productivity by 30-40%;
- reduce risk of fungal infection of crop by 50%;
- increase productivity of livestock farming and aviculture by 20%.

3. Preparation for providing ecological safety of construction materials components.

The preparation allows producing ecologically clean construction materials, due to their physical and chemical properties. However, raw materials, which previously did not comply with the sanitary standards, may be involved in the process after appropriate processing of construction materials. The preparation is effective in the production of panels, cinder blocks, cement mixtures, gypsum fibre boards.

Potential customers of products

1) Preparation for ecological cleanup and protection of territories:

- Municipalities;
- Owners of houses and cottages in ecologically dangerous areas;
- Sanatoriums, rest houses, children's holiday camps;
- Industrial enterprises.

2) Biological preparations for environmental protection of agricultural products:

- Agricultural enterprises;
- Farming enterprises;
- Summer visitors, housekeepers.

3) Preparation for providing ecological safety of construction materials components:

- Manufacturing enterprisers of construction materials;
- Building organizations.

The industrial technology of ecological (biological) protection for preparations' production, on the basis of humic acids derived from coal, meeting the international standards and the present requirements of the market, can be a product of commercialization of the above-mentioned development. Preparations possess properties to bind ions of metals, herbicides, pesticides and many other substances, harmful to people. Upon that, insoluble complexes which are not absorbed by plants are formed.

The results of these developments can be used in consulting services in agricultural humates, medicine and in urbanized territories' environmental protection.

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REFERENCES

[1] Gusakova, N.In., A.I. Zabalueva, and V.V. Rumyantsev, 2006. Ecology: lecture. Taganrog: TRTU Press, pp.: 176.

[2] Rovinsky F.Y., S.B., Yochelson and E. I. Uschan, 1978. Methods of analysis of environmental pollution : Toxic metals and radionuclides. M.: Atomizdat Press, pp: 264.
[3] Shifeng Dai, Lei Zhao, James C. Hower, Michelle N. Johnston, Weijiao Song, Peipei Wang, and Songfeng Zhang, 2014. Petrology, Mineralogy, and Chemistry of Size-Fractioned Fly Ash from the Jungar Power Plant, Inner Mongolia, China, with Emphasis on the Distribution of Rare Earth Elements. Energy Fuels, 28 (2), pp: 1502–1514.
[4] Fiket, Ž., Medunić, G., and Kniewald, G, 2016. Rare earth elements distribution in soil nearby thermal power plant. Environmental Earth Sciences, 75(7), pp.: 1-9.
[5] Smol, M., Kulczycka, J., Henclik, A., Gorazda, K., and Wzorek, Z., 2015. The possible use of sewage sludge ash (SSA) in the construction industry as a way towards a circular economy. Journal of Cleaner Production, 95, pp.: 45-54.
[6] Franus, W., Wdowin, M., & Franus, M., 2014. Synthesis and characterization of zeolites prepared from industrial fly ash. Environmental monitoring and assessment, 186(9), pp.: 5721-5729.
[7] Yao, Z.T., Ji, X.S., Sarker, P.K., Tang, J.H., Ge, L.Q., Xia, M.S., & Xi, Y.Q., 2015. A comprehensive review on the applications of coal fly ash. Earth-Science Reviews, 141, pp.: 105-121.
[8] Korneev A.V., 2004. Operational economy analysis of the non-waste production's organization through the example of innovative technologies for the utilization of ash wastes. Institution of Far Eastern branch of Russian Academy of Sciences. Vladivostok.
[9] Taskin A.V., 2014. Analysis of chemical composition of ash and slag wastes of TPP plants of the far Eastern region as technogenic deposits of precious metals. Mining Information-analytical Bulletin, S4. pp. 259-271.
[10] Andreev A.V., 2014. Biologic drugs for environmental protection, Far Eastern Federal University, Vladivostok.
[11] Device structures using super-light polystyrene concrete. Rules, the monitoring of implementation and requirements to results of works, 2013. M.: STO NOSTROY, pp.: 77.