

COMPOSITE MATERIALS USING INDUSTRIAL WASTE

Vinnitsia National Technical University

Анотація

Проведені дослідження підтверджують можливість комплексної переробки відходів фосфогіпсу, золи-винесення та металошламу. Метою таких досліджень є розробка технології виробництва жаростійкого бетону з використанням промислових відходів.

Ключові слова: зола-винесення; фосфогіпс; будівельні матеріали.

Abstract

The conducted studies confirm the possibility of comprehensive processing of phosphogypsum waste, fly ash and metal sludge. The purpose of such research is the development of heat-resistant concrete production technology using industrial waste.

Keywords: fly ash; phosphogypsum; construction materials.

Introduction

The largest amount of industrial waste is accumulated by enterprises of mining, metallurgical and heat industries. The colossal accumulation of such waste disrupts the ecological balance in nature, is a source of environmental pollution. The use of waste in the construction industry will solve a number of problems: - environmental (reduce the impact of harmful substances on the environment), economic (the cost of mortars, concrete and recycled products is much cheaper), and social (increase housing and other facilities, cheaper materials) [1-2].

Research results

In the Vinnitsia region on the territory of the former production association "Khimprom" accumulated about 800 thousand tons of harmful chemical waste - phosphogypsum [3]. The second harmful product of the region's production activities is the accumulation of ash and slag waste at the Ladyzhyn thermal power plant, the current number of which is about 20661 thousand tons [4]. About 300 thousand tons of dispersed metal waste - SHH-15 steel sludge - have been accumulated at the enterprises of metalworking productions of the region [5].

An obstacle to the full-scale use of man-made industrial waste in the field of building materials is the presence of natural radionuclides in their composition. According to the results of analytical studies, it was found that the total specific activity of phosphogypsum is 56.9 Bk/kg, fly ash - 284 Bk/kg, red sludge - 450 Bk/kg [5-6]. Therefore, it can be argued that the use of such waste in the manufacture of construction products is possible without any restrictions.

The search for new binders is mainly due to two reasons: on the one hand, high energy consumption and, as a consequence, the high cost of production of Portland cement; on the other hand, the need for materials with special properties (resistant to high temperatures, aggressive substances, radiation, biological organisms, with high or low density, etc.) [7-8]. The development of technological processes in the sectors of the national economy, the change in consumer demand for construction products require the development of new building materials and, above all, binders.

Obtaining a complex binder based on waste from the chemical industry will solve the problem of energy and resource conservation relevant to Ukraine by creating new building materials for multifunctional purposes.

Among the large number of known technologies for the production of building materials using man-made waste, there are none that would be widely used in the industry of building materials and products. Because these technologies are usually associated with deep cleaning, heat treatment of industrial by-products, which significantly complicates the technological process and leads to the re-accumulation of hazardous waste [9-10].

In [11-13] the authors proposed a complex metal-ash-phosphate binder, which can be used for the manufacture of heat-resistant concrete. Fine metal sludge is used as the oxide component of the binder. This sludge is practically not processed due to the high dispersion and content of lubricants and coolants. It is

formed during the manufacture of bearings from steel SHH-15. The percentage of iron is 86.3 - 87.96 %. The average particle size of the sludge is 2×10^{-5} m. The specific surface area of this powder reaches $0.5 - 2 \times 10^3$ m² / kg [14]. During storage of sludge in open dumps there is a deep oxidation of iron and drying of water components of lubricants and cooling substances. The oxide layer consists of hematite (Fe₂O₃), magnetite (Fe₃O₄), justice (solution of Fe₂O₃ in FeO), lapidocrit (FeO (OH)) [14-15].

The second component of the complex binder is phosphogypsum. Phosphogypsum waste is a by-product of phosphoric acid production by extraction. Depending on the temperature-concentration conditions of decomposition of phosphate raw materials, the solid phase of calcium sulfate can be represented by one of three forms: dihydrate, hemihydrate or anhydrite. Phosphogypsum waste can be attributed to gypsum raw materials, because they consist of 80-95% of calcium sulfate (table 1).

Table 1- Chemical composition of waste of Vinnytsia production association "Khimprom"

The main components	Content,% by weight	
	Phosphogypsum – dihydrate	Phosphogypsum – anhydrite
P ₂ O ₃ (general)	0,5 - 1,5	1,2-2,15
P ₂ O ₃ (water soluble)	0,1-0,7	0,5 -1,6
CaO	22-23	31-33
S ₀₄	38-39	52-56
R ₂ O ₃ .(R=Fe+Al)	0,1-0,3	0,2-0,5
F	0,1-0,2	0,9-1,2
Water is hygroscopic	21-29	18-22
Water is crystal hydrate	19-21	0,7 -1,2

Large-scale use of phosphogypsum in the technology of production of construction products is hindered by its specific features: the presence of phosphoric and sulfuric acid and water-soluble harmful compounds of phosphorus and fluorine. Residues of phosphoric and sulfuric acid, soluble salts - monocalcium phosphate, dicalcium phosphate, slow down hardening and reduce the strength of cement binders [16].

The authors in [17-18] suggest washing phosphogypsum with water using the additive "C-3" or "Relaxol". These additives provide better leaching of acids with less water. As a result, you can get a small amount of acidic effluents with a high concentration of phosphoric and sulfuric acids, which are then used for chemical activation of fly ash.

To destroy the vitreous ash-removal, the authors in [19-20] propose to activate ash-removal by acidic residues from phosphogypsum washing. The destruction of the vitreous ash-removal opens access to reactive components of its components. Its most important property is its ability to react with calcium hydroxide Ca (OH)₂, which is released during hydration of cement.

Conclusions

Analytical studies confirm the possibility of complex processing of phosphogypsum waste, fly ash and metal sludge. The purpose of further research is to develop a technology for the manufacture of heat-resistant concrete using industrial waste.

References

1. Hnes, L., S. Kunytskyi, and S. Medvid. "Theoretical aspects of modern engineering." International Science Group: 356 p. (2020).
2. Лемешев, М. С., et al. "Перспективи використання техногенної сировини при виробництві композиційних в'язучих." Сучасні технології, матеріали і конструкції в будівництві. № 2: 36-45. (2022).
3. Sokolovskaya, O. "Scientific foundations of modern engineering/Sokolovskaya O., Ovsiannykova L. Stetsiuk V., etc–International Science Group." Boston: Primedia eLaunch 528 (2020).
4. Kornyl, I., O. Gny, and M. Lemeshev. "Scientific foundations in research in Engineering." (2022).
5. Demchyna, B., L. Vozniuk, and M. Surmai. "Scientific foundations of solving engineering tasks and problems." (2021).
6. Boiko, T., et al. Theoretical foundations of engineering. Tasks and problems. Vol. 3. International Science Group, 2021.
7. Bereziuk, O. V., et al. "Increasing the Efficiency of Municipal Solid Waste Pre-processing

Technology to Reduce Its Water Permeability." Biomass as Raw Material for the Production of Biofuels and Chemicals. Routledge, 2021. 33-41.

8. Hladyshev, D., et al. Technical and agricultural sciences in modern realities: problems, prospects and solutions. International Science Group, 2023.

9. Ковальський, В. П., et al. "Использование минеральных заполнителей, наполнителей и микронаполнителей в сухих строительных смесях для поризованных растворов." Technical research and development: collective monograph. 8.9: 360–366. (2021).

10. Beresjuk, O., et al. Theoretical and scientific foundations in research in Engineering. Vol. 1. International Science Group, 2022.

11. Khrystych, O. "Technological parameters of the radiation-resistant concrete production." Scientific Works of Vinnytsia National Technical University 1 (2020).

12. Медведь, Я. О. Промислові відходи–альтернатива традиційним природним ресурсам. Черкаський інститут пожежної безпеки імені Героїв Чорнобиля НУЦЗ України, 2021.

13. Лемешев, М. С., Сівак, К. К., Стаднійчук, М. Ю. (2021). Сучасні підходи комплексної переробки промислових техногенних відходів. Сучасні технології, матеріали і конструкції в будівництві, 31(2), 37-44.

14. Сердюк, В. Р., et al. "Пути использования дисперсных металлических шламов." (2004).

15. Sivak, K. Use of industrial waste for increased experimental properties in construction. Львів: Національний університет "Львівська політехніка", 2023.

16. Лемешев, М. С., О. В. Христинч, and О. В. Березюк. "Дрібнозернистий бетон з модифікованим заповнювачем техногенного походження." Materiały XI Międzynarodowej naukowo-praktycznej konferencji «Naukowa przestrzeń Europy–2015». Sp. z oo «Nauka i studia», 2015.

17. Березюк, О. В. Фосфогіпсозолоцементні та металофосфатні в'язучі з використанням відходів виробництва. Київський національний університет будівництва і архітектури, 2011

18. Лемешев, М. С. "В'язуче на основі промислових відходів." Научные исследования и их практическое применение: материалы международной научно-практической Интернетконференции, 10-17 октября 2017 г.. Сборник научных трудов SWorld, 2017

19. Іванов, О. А. Перспективи утилізації техногенних відходів у будівельній галузі. Черкаський інститут пожежної безпеки імені Героїв Чорнобиля НУЦЗ України, 2021

20. Stadniychuk, M., Obtaining active mineral additives from industrial waste. Національний університет "Львівська політехніка", 2023.

Sivak Roman, graduate student of the Department of Construction, Municipal Economy and Architecture, Vinnytsia National Technical University, e-mail: lemishko.katya@gmail.com

Сівак Роман Васильович, аспірант кафедри будівництва, міського господарства та архітектури, Вінницький національний технічний університет, м. Вінниця, e-mail: lemishko.katya@gmail.com

Stadniychuk Maksym, graduate student of the Department of Construction, Municipal Economy and Architecture, Vinnytsia National Technical University, e-mail: b15.stadniychuk@gmail.com

Стаднійчук Максим Юрійович, аспірант кафедри будівництва, міського господарства та архітектури, Вінницький національний технічний університет, м. Вінниця, e-mail: b15.stadniychuk@gmail.com