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Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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DEVELOPMENT OF TECHNOLOGIES FOR RECYCLING AND BIOTECHNICAL RECOVERY OF ASH SLAGS WASTE

Abstract. There is a significant number of thermal power plants in Kazakhstan, as a result of which more than 500 million tons of ash and slag waste have been accumulated. Ware housing and storage of ash and slag causes a very significant impact on the environment in the area of their location. Therefore, it is highly relevant to address the issues of reducing the load on the environment by developing technologies for utilizing ash and slag, as well as biotechnical reclamation of the dusty surface of ash dumps.

The article presents the results of a study of the physical and technical characteristics of a binder based on bitumen and ash and slag. The study of samples using a bitumen ash and slag binder showed that they meet the requirements of regulatory documents (ST RK 1225-2013) and have the following characteristics: ultimate compressive strength (after 28 days at 20°C) - 2.1 MPa; compressive strength (after 30 minutes at 50°C) - 1.9 MPa; average density - 2.38 kg / m3 and water absorption - 2.1%. A technology for producing a bitumen-ash-slag binder for the construction of road bases has been developed and its main parameters have been determined (the type and content of bitumen in the binder, the mixing time in the mixer and the density of the bitumen-ash-slag dough).

A technology has been developed for biotechnical reclamation of ash and slag using new physiologically active drugs that stimulate plant growth from brown coals, which suppresses dust emanating from the surface of ash dumps. At a wind speed of 2-10 m / s, the amount of dust emitted decreased by 85%. The composition of an adaptogen preparation for processing seed material of wild plants has been determined. The selection of varieties of wild-growing plants was carried out directly in the locations of ash dumps. The time of laying and drying of seed material of wild-growing plants before sowing was determined. At the stage of ontogenesis of green mass, the optimal modes of spraying with a solution of the preparation for vigorous plant growth in the absence of moisture have been determined.

Key words: technology, ash and slag, physical and chemical properties, binder, ash dump, biotechnical reclamation.

Introduction. At present, more than 500 million tons of ash and slag waste from thermal power plants have been accumulated on the territory of Kazakhstan, the reserves of which are increasing every year. It is known that the storage of ash waste is a very costly undertaking. According to expert estimates, investments in the reconstruction of one ash dump can reach 5 billion tenge, and the construction of a new one costs 10-12 billion tenge. The storage of ash and slag waste leads not only to the withdrawal of significant land areas, but also causes a very significant pollution of almost all environmental components in the area of their location. Therefore, at mining enterprises that have their own thermal power plants (CHP), it is very important to address the issues of reducing the load on the environment by developing technologies for the disposal of ash and slag, as well as biological reclamation of the dusty surface of ash dumps.

A review of previous scientific works showed that [1-6] in the neighboring countries the level of use of ash and slag from thermal power plants does not exceed 7-10%, while in developed countries it is about 50%, in France and Germany - 70%, in Finland - about 90%. At domestic enterprises, ash and slag waste is practically not used.

Earlier, based on the analysis of the qualitative and quantitative parameters of the accumulated ash and slag of the Rudnenskaya thermal power plant of SSGPO JSC (Kazakhstan), possible directions of their use for obtaining building materials were identified: for the production of fired bricks; in the form of an additive in the production of reinforced concrete products and as a hydraulic additive for concrete mixtures [9]. Ash and slag can also be used in mixtures for the formation of layers of the base of highways, as cement-ash and slag binders. This article is devoted to the development of a technology for producing a bitumen ash and slag binder using ash aslag waste and their biotechnical reclamation.

Materials and methods. To determine the physical and mechanical properties of the bases using a bitumen-ash-slag binder, initially a crushed stone-gravel-sand mixture (SHGPS) is mixed with ash and slag at a ratio of 70:30, and then this mixture is heated to 90°. Bitumen is heated separately to 120°C. Then they are mixed in a ratio of 94: 6. Further, from the finished bitumen-mineral mixture, samples are prepared by pressing - cylinders 5x5 cm in size. For the preparation of bitumen ash and slag binder (BZShV), viscous bitumen BND - 90/130 was used. The ultimate strength was determined for two types of samples. The former are dry samples, tested immediately after obtaining samples by pressing, the latter are samples that are tested after water saturation.

To reduce the negative impact on the environment of temporarily unused ash and slag, which will be disposed of in the future, research has been carried out on biotechnical reclamation of the dusty surface of ash dumps.

At the stage of biotechnological reclamation of technogenic landscapes on the surface of ash dumps of the thermal power plant, it is possible to sow seeds of wild plants such as brunets (alabota), quinoa (atriplex), wormwood (artemisia), festucasulcata (fescue), stiparubens (feather grass), arculusiadracongracilis (gallery of subtaxa) [7,8].

The most favorable time for sowing the seeds of herbaceous plants is the autumn period or early spring. Perennial grasses are sown with grain or grain-grass seeders, followed by harrowing and rolling with smooth rollers. The seeding depth of small seeds is 1-2 cm, for large ones - 3-4 cm. The seeding rate of seeds in ash dumps should be increased by 2.0-2.5 times in comparison with the generally accepted ones. For quick turfing, a heavily thickened crop is allowed. It is known that scarification of seeds (boiling in water or destruction of the shell with sulfuric acid) sharply increases their germination. With soil sowing of scarified seeds, their germination rate reaches 88-95%.

Results and discussion. The results of the study of the physical and mechanical properties of the bitumen ash and slag binder are shown in Table 1.

Table 1 - Physical and mechanical characteristics of samples using BZShV

Thenameofindicators	Unit measurements Indicators of physical and mechanical properties	Unit measurements Indicators of physical and mechanical properties	
		testedsamples	ST RK 1225-2013
Compressive strength after 28 days. at 20°C	MPa	2.1	2.0…2.5
Compressive strength after 30 min. at 50°C	MPa	1.9	0.9…1.6
Mediumdensity	kg/m^3	2.38	-
Waterabsorption	%	2.1	1…3

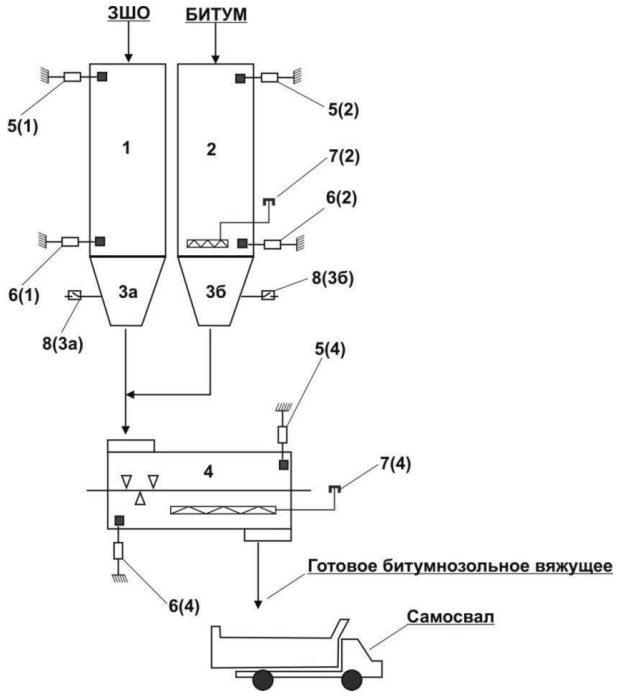
It can be seen from the table that the presented test results of samples on a bitumen-ash-slag binder fully meet the requirements of regulatory documents.

The production of bitumen-ash-slag binder and its use in the base of road pavements consists of the following main processes:

- preparation of bitumen ash and slag binder;
- delivery of the binder to the area of road construction;
- preparation of the subgrade;
- delivery of sand-gravel or crushed-stone-gravel-sand mixture to the place of use;
- displacement on the road of ASG or SHPGS with bitumen-ash-and-slag binder;
- formation of the foundation on the surface of the subgrade after or without the subbase;
- compaction of the base using rollers;
- checking the density and strength of the base for its reliability and stability.

Each of the above-mentioned technological processes is a series of separate operations performed in a known sequence, with a certain mode on the corresponding equipment.

The technology of obtaining a bitumen ash and slag binder includes the following operations: loading the ash and slag hopper; pumping bitumen into the bunker and heating it; dosing of the starting components; preparation of BZShV in a mixer; unloading of the finished binder. Figure 1 shows a process flow diagram for producing BZShV.



1 - hopper for ash and slag waste
2 - heated bitumen hopper
3 - batchers (3a-ash-and-slag waste; 3b-bitumen)
4 - heated mixer
5 - top level sensors (5 (1) -ZShO; 5 (2) -bitumen; 5 (4) -mixtures)
6 - sensors of the lower level (6 (1) -ZShO; 6 (2) -bitumen; 6 (4) -mixtures)
7 - temperature sensors (7 (2) - heating of bitumen; 7 (4) - heating of the mixture)
8 - open / close sensors. dispensers (3a - ash and slag waste: 3b - bitumen)

Figure 1 - Technological scheme for obtaining bitumen-ash and slag binder for the foundation of highways.

Homogeneous ash and slag delivered from the warehouse by a cement truck are fed into the hopper (1). Bitumen from the bitumen storage is pumped through a pipe into a bitumen-smelting installation-bunker (2), where the bitumen is heated to a temperature of 120-130°C. From the hopper (1), the ash and slag through the batcher (3a) enters the mixer (4), and heated bitumen enters the same place through the batcher (3b). In the mixer (4) from ash and slag and bitumen (in a ratio of 94: 6,%) a homogeneous mass is obtained at a temperature of 120 - 130°C. The finished BZShV is delivered to the object by a dump truck.

The type of bitumen, depending on the type of base, can be different, for example:

• for hot asphalt-concrete mixtures, viscous bitumen is used in BZShV (BND - 90/130, BND - 60/90, BND - 40/90), while the bases are laid at a temperature of 120-130°C;

• for warm asphalt concrete mixtures BZShV consists of liquid bitumen (SG - 130/120) or low-viscosity bitumen (BND - 130/120, BND - 200/300), while the base is laid at temperatures of 60-80°C;

• for cold asphalt concrete mixtures BZShV is prepared from liquid bitumen (MG - 70/130 or SG - 70/130) and the base is laid at a temperature corresponding to the ambient temperature (but not lower than + 10°C).

In the autumn, a laboratory experiment (on a phytotron) was carried out to test the effectiveness of the use of physiologically active humic preparations from brown coal on the ecological resistance of the Brunets plant to planting on ash and slag. The time of laying and drying of seed material of wild-growing plants before sowing was determined. At the stage of plant ontogenesis, the optimal modes of spraying plants with

a solution of the preparation were determined. A method for treating plants grown on a substrate of ash and slag in the growing season with a solution of an adaptogen preparation has been developed and the effective concentration of its aqueous solution has been determined.

The assessment of the results of the growth of wild plants was carried out in the following sequence:

1. Dry untreated seeds (control 1).

2. Surface treatment with ZnSO4 • 7H2O at the rate of 30 g / m2 - Background + dry untreated seeds (control 2).

3. ground + seed treatment with a 0.3% aqueous solution of a humic preparation.

4. ground + seed treatment with a 0.3% aqueous solution of a humic preparation with spring germination and subsequent spraying of vegetative plants with a 0.04% aqueous solution of a humic preparation mixed with urea.

During the period of branching of brunets and wormwood in April 2019 (variant 4 of the experiment), vegetative plants were sprayed with a physiologically active aqueous solution containing urea, a humic preparation, liquid soap and soft water. The consumption rate of the working solution was 40 ml / m^2 (16 mg of the humic preparation per 1 m^2). The results of the growth of wormwood, brunets are presented in table 2.

Table 2 - Results of the growth of wild plants

№№	Option	Germi-nation, %	Avera-geheight, cm	Productivityofland	
				Perplant, g	Increasetocontrol, %
1.	Dry untreated wormwood seeds - control 1	20	9	13	16
2.	ZnSCU • 7H2O - 30 g / m^2 - Background + dry untreated brunets seeds - control 2	31	39	20	100,0
3.	Background + seed treatment with 0.3% aqueous solution of humic preparation	65	74	37	185,0
4.	Background + seed treatment with a 0.3% aqueous solution of extraction of wild plants and a humic preparation, followed by spraying vegetative plants with a 0.04% mixture with urea at the rate of 40 ml of working solution per 1m^2 during germination and branching	89	81	53	265,0

The results of accounting for the germination of wormwood and brunets with the treatment with the extract of wild plants are presented in Table 3.

Table 3- Seed germination of brunets and wormwood

Plantname	Germination,%
Brunetsorpseudosophora - control	24
Brunetz - Processed with Wild Plant Extract	100
Wormwood - control	16
Wormwood - Processed with Wild Plant Extract	34

An experiment was also carried out to assess dust release from the surface of ash and slag with a cover of grown wild plants. The amount of dust from the surface of ash and slag waste was measured with an AFA-VP-10 device using an N-822 electric aspirator. Outgoing dust was removed and weighed on a VLA-200 analytical balance. At a wind speed of 2-10 m / s, the amount of dust emitted from the surface of the reclaimed ash and slag decreased by 85% [9].

Conclusion. Based on the study of the physical and mechanical properties of the binder with the use of ash and slag, a technology for obtaining a bitumen ash and slag binder has been developed, the main parameters of which are: the type and content of bitumen in the binder, the time of mixing in the mixer, the density of the bitumen ash and slag dough.

The use of ash and slag in road construction makes it possible to completely dispose of ash and slag waste

from thermal power plants, which makes it possible to solve the problems of environmental pollution. The use of ash and slag helps to reduce the cost of road pavements and makes it possible to obtain road bases with significant strength, density and durability.

For biotechnical reclamation of ash dumps at the TPP of SSGPO JSC, the most promising is the agromeliorative method of pre-sowing treatment of seeds of local wild plants with a humic preparation. Experimental studies have shown that the treatment of seeds of wild plants (wormwood and brunets) with a humic preparation ensures their high survival rate on highly saline ash and slag. At the same time, dense overgrowth of the ash and slag surface is achieved, which significantly reduces their dusting. At a wind speed of 2-10 m / s, the amount of dust emitted is reduced by 85%.

The proposed technical solutions make it possible to create low-waste technologies using ash and slag from thermal power plants, contribute to the rational use of mineral resources and solve environmental issues.

This study was carried out within the framework of the target scientific and technical program «Technological modernization of mining operations based on the transition to a digital economy» (BR05236712), section 6 «New technologies for the processing of solid waste».

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КҮЛ ҚОЖЫ ҚАЛДЫҚТАРЫН УТИЛИЗАЦИЯЛАУ ЖӘНЕ БИОТЕХНИКАЛЫҚ РЕКУЛТИВАЦИЯЛАУ ТЕХНОЛОГИЯСЫ

Аннотация. Қазақстанда жылу электр станцаларының едеуірлігінен 500 миллион тоннадан астам күл мен қож қалдықтары жинақталған және олар қоршаған ортаға айтарлықтай кері әсерін тигізеді. Сол себепті күл мен қож үйінділерінің шаңды бетінен қоршаған ортаға тарайтын зиянды заттарды тежеу әдістері қолданылып, тұрғындар мен жұмысшылардың денсаулығына конфортты жағдай туғызу көрсетілген.

Мақалада битум мен күл қожы негізінде байланыстырғыш заттар құрамының физикалық-техникалық сипаттамаларына зерттеу жүргізілген. Осы байланыстырғыш заттың үлгілерін түбегейлі зерттеу көрсеткендей, олар нормативтік құжаттардың талаптарына сәйкес келетіні дәлелденді (ҚР СТ 1225-2013): қысымдық шекті беріктік (t -20°С , 28 күннен кейінгі сынақ) - 2,1 МПа; қысымдық шекті беріктік (t- 50°С, 30 минуттан кейін) - 1,9 МПа; орташа тығыздығы - 2,38 кг / м^3 және ылғалды сіңіруі - 2,1%. Автожол құрамын қалыптастыруға арналған битум-күл-қож байланыстырғыш затын өндіру технологиясы беріліп және оның негізгі параметрлері анықталды (байланыстырғыштағы битумның қасиеті мен құрамы, араластырғыштағы уақыты және битумның тығыздығы). Бұл - автожол құрылысында күл қожын (золошлак) қолдануға болатындығына көз жеткізілді деген сөз.

Аталып отырған жұмыстың жаңалығы - қоңыр көмірден өндірілетін әртүрлі препараттарды қолдана отырып, күл қожы үйінділерінің бетінен шығатын зиянды шаңды басатын, биотехникалық рекультивациялау технологиясы берілген. Далалық-эксперименталдық тәжірибе көрсеткендей, желдің жылдамдығы 2-10 м / с соққанда бөлінетін шаң мөлшері 85%-ға төмендегенін көрсетті. Сол маңда өсетін жабайы өсімдіктердің тұқымы мен жоғарыда айтылған препарат-адаптогеннің құрамы зерттеліп, оның өсу үдерісі ойдағыдай болғаны анықталды. Субстрат бетіне жабайы өсімдіктердің тұқымын себу алдында оларды сұрыптау және кептіру уақыты анықталды. Онтогенез кезінде яғни ылғал болмаған жағдайда, өсімдіктердің қарқынды өсуіне препарат ерітіндісімен бүрке себу технологиясы ұсынылды.

Түйінді сөздер: технология, күл қожы, физикалық-химиялық қасиеттер, байланыстырғыш, күл үйіндісі, биотехникалық рекультивациялау.

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РАЗРАБОТКА ТЕХНОЛОГИЙ УТИЛИЗАЦИИ И БИОТЕХНИЧЕСКОЙ РЕКУЛЬТИВАЦИИ ЗОЛОШЛАКОВЫХ ОТХОДОВ

Аннотация. В Казахстане имеется значительное количество тепловых электрических станций, где накоплено более 500 млн. тонн золошлаковых отходов. Складирование и хранение золошлаков вызывает весьма существенное воздействие на окружающую среду в зоне их расположения. Поэтому весьма актуальным является решение вопросов снижения нагрузки на окружающую среду путем разработки технологий утилизации золошлаков, а также биотехнической рекультивации пылящей поверхности золоотвалов.

В статье представлены результаты исследования физико-технических характеристик вяжущего на основе битума и золошлаков. Исследование образцов сиспользованием битумозолошлакового вяжущего показали, что они отвечают требованиям нормативных документов (СТ РК 1225-2013) и имеют следующие характеристики: предел прочности при сжатии (через 28 суток при 20^{o}С) - 2.1 МПа; предел прочности при сжатии (через 30 минут при 50^{o}С) - 1.9 МПа; средняя плотность - 2.38кг/м3 и водопоглощение - 2.1%. Разработана технология получения битумозолошлакового вяжущего для устройства оснований автодорог и определены ее основные параметры(вид и содержание битума в вяжущем, время перемешивания в смесителе и плотность битумозолошлакового теста).

Разработана технология проведения биотехнической рекультивации золошлаков с использованием новых физиологически активных препаратов-стимуляторов роста растений из бурых углей, обеспечивающая подавление пыли, исходящей с поверхности золошлаковых отвалов. При скорости ветра– 2-10 м/сек количество выделяемой пыли уменьшилось на 85%. Определен состав препарата-адаптогена для обработки семенного материала дикорастущих растений. Осуществлён подбор сортов дикорастущих растений непосредственно в местах расположения отвалов золошлаков. Определено время залежки и сушки семенного материала дикорастущих растений перед посевом. На стадии онтогенеза зеленой массы определены оптимальные режимы опрыскивания раствором препарата для бурного роста растений при отсутствии влаги.

Ключевые слова: технология, золошлаки, физико-химические свойства, вяжущее, золоотвал, биотехническая рекультивация.

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