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B.R. Nusupbekov, G.K. Alpysova, N.K. Tanasheva,
A.Zh. Tleubergenova, N.N. Omarov, Zh.T. Omarova

Ye.A. Buketov Karaganda State University, Kazakhstan
(E-mail: gulnur-0909@mail.ru)

Technology of the dosed addition of reagents-plastificators in the mass of coal-water fuel

The article discusses the scheme of preparation of highly concentrated water-coal suspensions for the combustion of water-coal fuel. While, experimental studies were carried out on grinding coal and selecting organic compounds. Nowadays, many variants of technological schemes for the preparation of highly concentrated water-coal suspensions are known and tested in our country and as abroad. The choice of a rational technological scheme of preparation depends on many factors as the properties and quality of the feedstock, the required quality of the suspension, and the type of additives used in the process, economic opportunities, etc. In order to select the most effective plasticizers for water-coal suspensions prepared from coal slimes, the effect of plasticizers has been studied. These reagents meet the requirements for plasticizer reagents and are readily available. The effectiveness of these additives is due to their physicochemical properties, a feature of their structure, consisting of hydrocarbon, aromatic, carboxyl, hydroxyl and other groups. We obtained the dependence of the height of the dispersed phase layer on the time of the presence of the suspension with the addition of gelatin, fuel oil, lignosulfonate (LST), sodium humate. Suspensions with the addition of sodium humate have the best stability. As a result of the analysis of experimental studies, it has been established that the humic additive with content of the order of 1 % is the optimal binder reagent from the used (fuel oil, humic acid, gelatin).

Keywords: water-coal suspension, water-coal fuel, reagent-plasticizer, technological scheme, humic additive.

The development of energy, as well as the improvement of Kazakhstan's energy security, depends on a large extent on the widespread and effective use of coal as an energy fuel. To do this, first of all, it is necessary to improve the consumer properties of coal as an energy fuel, and also to master the production of alternative fuels based on coal when replacing scarce natural resources: gaseous and liquid petroleum fuel. To solve the above problem, it is very promising to carry out both in Kazakhstan and abroad work on the technology of obtaining and using coal suspensions, which are a composite dispersed system consisting of a solid phase in the form of fine coal and a liquid medium (water, alcohols, hydrocarbons, products processing of oil). Such a fuel system is considered as a suspension coal fuel (SCF). The most studied and promising in energy coal suspension is a water-coal suspension (WCS), in which the bulk of the liquid medium is water. At a high concentration of solid phase, the WCS is called a highly concentrated water-coal suspension (WCS) or also a water-coal fuel (WCF) [1].

Water-coal suspensions are mixtures of coal and water, which first arose as a waste of wet enrichment processes and by-products of coal dehydration. However, currently, water-coal suspensions, including those using plasticizer reagents, are one of the optimal forms of a new type of fuel - water-coal fuel, successfully developed in many countries of the world (Russia, China, Japan, Italy, USA, Sweden and etc.).

Over the past decades, in many countries around the world, a large number of works have been carried out to obtain WCF and its use in power engineering [2]. In Russia and abroad, a number of technologies have been developed for the preparation of WCF, for its transportation and storage for a long period, for burning WCF. In addition, research has been carried out on the combustion (gasification) of WCF at existing power plants of various types. The analysis of literature sources shows the promise of using a coal-water suspension as an energy fuel using coal mining waste, coal processing and other industries [3, 4].

WCF belongs to the class of artificial composite systems, the properties and characteristics of which depend both on the technologies for obtaining the system and on the technologies for using the system by a specific consumer at an energy facility.

Water-coal suspensions are characterized by the following main parameters and technological features: granulometric composition, including the maximum particle size of the coal particles in the slurry, the mass fraction of the solid phase, the ash content of the coal in the slurry, the rheological characteristics, the presence or absence of plasticizer reagents, the ability to maintain its properties during storage and transportation.

These parameters determine the rheological properties and stability of the WCF as a liquid fuel during transportation, storage and spraying in the combustion chamber. To obtain the WCF with optimal characteristics, a feasibility study is needed, taking into account energy and environmental factors [5, 6].

Based on the analysis of trial experiments to determine the binding agent, plasticizer reagents were used, which are used in various technologies for preparing water-coal fuel.

The main requirements that a reagent-plasticizer must satisfy are as follows:

1) the ability to act as a diluent and stabilizer;

2) the ability to maintain its properties during long-term storage;

3) do not change the organic mass of coal;

4) be affordable;

5) have high efficiency of action;

6) to have a favorable effect on the rheological characteristics of water-coal suspensions.

Studies have established that the effectiveness of the diluting and stabilizing action of plasticizer reagents on highly concentrated water-coal suspensions is related to the adsorption of the reagent on the surface of solid-phase particles. The magnitude of adsorption, as well as the nature of the adsorbent-adsorbate interaction, depends primarily on the nature of the surface of the particles in the dispersed phase. The carbon-adsorbent-aqueous solution interface is essentially a model hydrophobic surface in the study of the adsorption of reagents.

Our researched water-coal fuel (WCF) is a dispersed mixture consisting of finely ground coal, water and plasticizer reagent. The resulting coal was pretreated in the crushing unit of the electrohydraulic installation.

Before carrying out the experimental work, various reagents-plasticizers were added to the treated WCF material: fuel oil, gelatin, lignosulfonate, sodium humate.

Figure 1 shows photographs of water-coal fuel with the addition of sodium humate.

Figure 1. Photo of water-coal fuel

Throughout the history of the use of coal in the form of water-coal mixtures, the possibility of their transportation over long distances has always been considered. Various substances were used as the liquid phase, but the most suitable was water. To date, two technologies for hydrotransportation of coal have developed most: in turbulent and laminar regimes. According to the first technology, a water-coal suspension is prepared with a mass fraction of the solid phase, usually up to 50 %, consisting of an unstabilized mixture of large (max size of 1.5 and more mm) and fine coal particles. The second technology is characterized by the use of a stabilized highly concentrated water-coal suspension with a mass fraction of a solid phase of more than 55 % and a maximum particle size not exceeding, as a rule, 200 μm (Fig. 2).

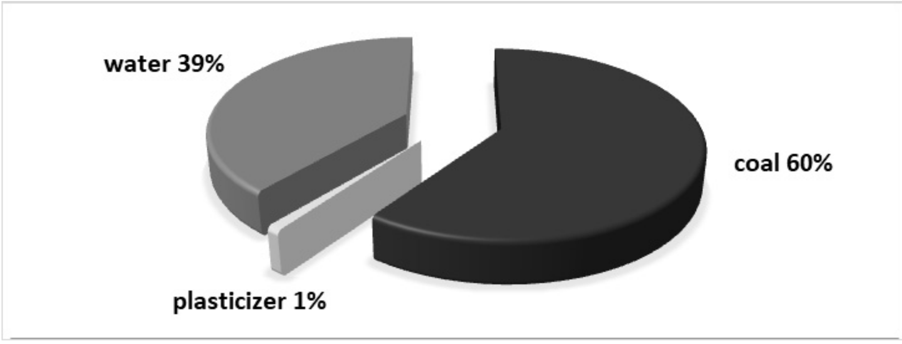


Figure 2. Percentage in a coal-water suspension with a mass fraction of the solid and liquid phase

For a more vivid idea of the effectiveness of the stabilizing effect of these plasticizers, the obtained data are presented in Figures 3-6 in the form of graphical dependences of the height of the precipitate of the dispersed phase on the time of the immobile state of the water-coal suspension. For this purpose, in the water-coal mixture, the plasticizer reagents were added in an amount of not more than 1 %. The process of obtaining the suspension was carried out mechanically.

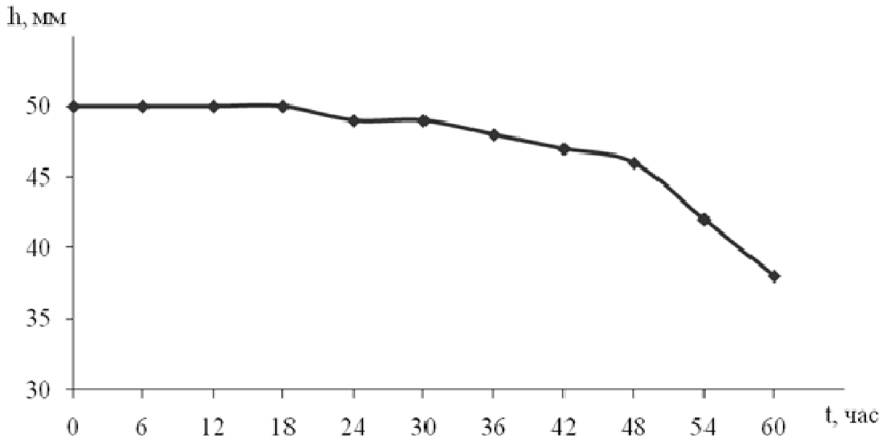


Figure 3. Dependence of the height of the dispersed phase layer
on the time of the suspension with the addition of gelatin

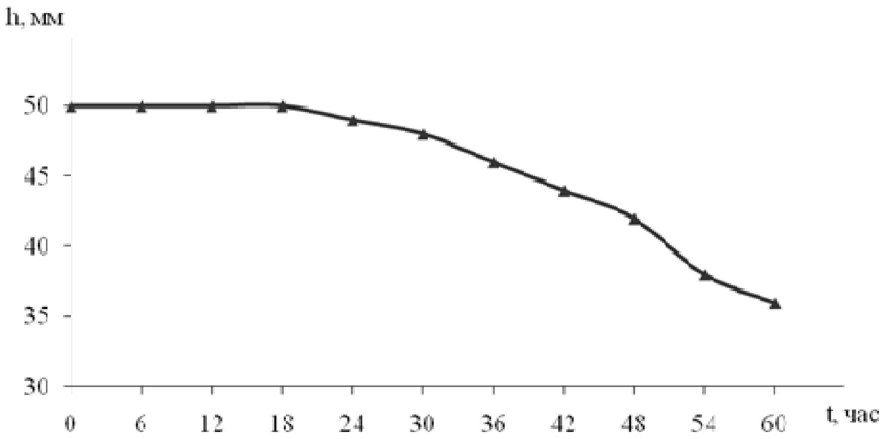


Figure 4. Dependence of the height of the dispersed phase layer
on the time of the suspension with the addition of fuel oil M-100

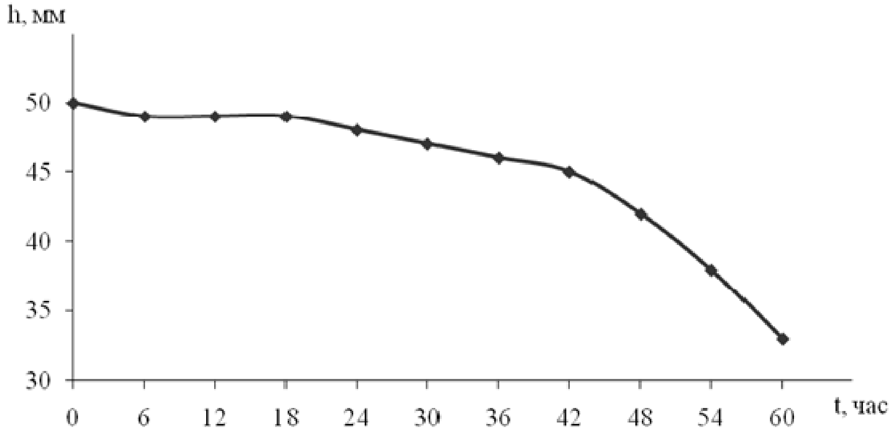


Figure 5. Dependence of the height of the dispersed phase layer
on the time of the suspension with the addition of lignosulfonate

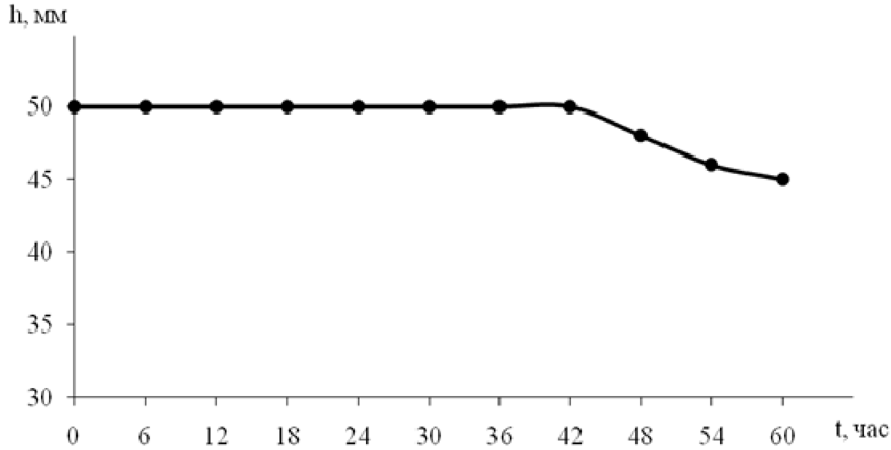


Figure 6. Dependence of the height of the dispersed phase layer
on the time of the suspension with the addition of sodium humate

It can be seen from the graphs that the slurry with the addition of gelatin is stable for 48 hours, and the sediment percentage is about 8 %, the suspension with the addition of fuel oil is stable for 36 hours. When the plasticizer-lignosulfonate is added to the water-coal mixture, the height of the dispersed phase layer remains up to 36 hours, but the sediment percentage is 12 hours. The most optimal binder is sodium humate, with the addition of this plasticizer, the mixture has been stable for 50-60 hours, but the stability without changes is about 42 hours, and at 52 hours it drops to 8 %.

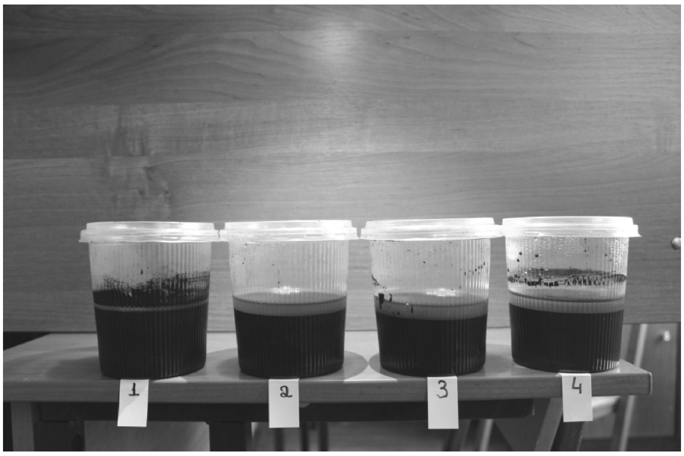
Consequently, further it was of interest to investigate the nature of the adsorption process of the sodium humate reagent on the surface of coal slime.

As a result of the analysis of graphical dependencies and experimental results, it has been established that sodium humate with a content of the order of 1 % is used as the optimal binder reagent used in this work (fuel oil, sodium humate, gelatin).

After a very long storage (more than 30 days), the water-coal suspensions were gradually compressed to form loose sediments, releasing the liquid phase contained in their structure. Presumably, this is the result of a coagulation rearrangement of particles, the number of contacts of which obviously increases, which leads to the squeezing of water-coal suspensions and the «squeezing» out of them of the dispersion medium. With the application of mechanical action (stirring), the original structure of the suspensions was restored. Repeated experiments analyzing the stability of these suspensions showed that the stability in suspensions with LST additives decreased. Whereas, in water-coal suspensions with the addition of sodium humate, its values remained unchanged.

To some extent, water-coal suspensions prepared with the addition of sodium humate retain the internal structure that existed during their formation. Thus, the mechanism of structure formation of these water-coal suspensions is different from the suspensions prepared with other additives. This is probably due to the presence of denser adsorption layers of humates on smaller particles of coal, which causes their repulsion and prevents aggregation; the particles slip one by one and occupy the most advantageous position, characterized by a minimum potential energy.

For comparison with previous experiments to determine the settling process, experiments were conducted to study the process of stability of the height of a homogeneous phase (Fig. 7).



1 — sodium humate; 2 — lignosulfonate; 3 — fuel oil; 4 — gelatin

Figure 7. Photo of water-coal suspensions with the addition of various plasticizers

From the data obtained, it can be seen that suspensions with the addition of sodium humate have the best stability. In connection with the above-mentioned requirements for water-coal slurries intended for direct combustion in boilers it was very important to determine the viscosity of the resulting water-coal slurries, by the values of which it was possible to draw conclusions about their fluidity.

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Б.Р. Нусупбеков, Г.К. Алпысова, Н.К. Танашева,
А.Ж.Тлеубергенова, Н.Н. Омаров, Ж.Т. Омарова

Сулы-көмірлі отын массасына реагент-пластификаторларды мөлшерлеп қосу технологиясы

Мақалада сулы-көмірлі отынды жағу үшін жоғарыконцентрациялы сулы-көмірлі суспензияны дайындау сүлбесі қарастырылған. Осыған орай көмірді ұсақтау және органикалық қосылыстарды таңдау бойынша тәжірибелік зерттеулер жүргізілді. Қазіргі уақытта біздің еліміздегі сияқты шетелдерде де жоғарыконцентрациялы сулы-көмірлі суспензияны дайындаудың технологиялық сүлбесінің көптеген нұсқалары белгілі және олар сыналып байқалған. Бұл үшін дайындаудың тиімді технологиялық сүлбесін таңдау көптеген факторларға тәуелді: бастапқы шикізаттың сапасына және қасиетіне, суспензияның талап етілетін сапасына, үдерісте қолданылатын, қоспалар түріне, экономикалық мүмкіндігіне және т.б. Көмір қалдықтарынан дайындалған, сулы-көмірлі суспензия үшін ең тиімді пластификаторларды іріктеу мақсатында мақалада пластификатордың әсер етуі зерттелді. Берілген реагенттер реагент-пластификаторларға қойылған талаптарды қанағаттандырады және ол қолжетімді. Осы қоспалардың әсер ету тиімділігі олардың физика-химиялық қасиеттеріне, көмірсутектерден, ароматты, карбоксильді, гидроксильді және басқа топтардан тұратын олардың құрылымының ерекшелігіне негізделген. Желатин, мазут, лигносульфонат, гумат натрий қоспалары қосылған суспензияның дисперсті фаза қабатының биіктігі уақыттан тәуелділігі алынды. Гумат натрий қосылған суспензия ең жақсы тұрақтылыққа ие. Тәжірибелік зерттеуді талдау нәтижесінде қолданылған реагенттерден (отындық мазут, гуминді қышқыл, желатин) оңтайлы байланыстырушы 1 % құрамымен гуминді қоспа болып табылады.

Кілт сөздер: сулы-көмірлі суспензия, сулы-көмірлі отын, реагент-пластификатор, гуминді технологиялық сызба, қоспа.

Б.Р. Нусупбеков, Г.К. Алпысова, Н.К. Танашева,
А.Ж.Тлеубергенова, Н.Н. Омаров, Ж.Т. Омарова

Технология дозированного добавления реагентов-пластификаторов в массу водоугольного топлива

В статье рассматривается схема приготовления высококонцентрированных водоугольных суспензий для сжигания водоугольного топлива. При этом проводились экспериментальные исследования по измельчению угля и подбору органических соединений. К настоящему времени известно и опробовано много вариантов технологических схем приготовления высококонцентрированных водоугольных суспензий как у нас в стране, так и за рубежом. При этом выбор рациональной технологической схемы приготовления зависит от многих факторов: свойств и качества исходного сырья, требуемого качества суспензии, типа добавок, используемых в процессе, экономических возможностей и т.д. С целью подбора наиболее эффективных пластификаторов для водоугольных суспензий, приготовленных из угольных шламов, в статье изучено влияние пластификаторов. Данные реагенты удовлетворяют требованиям, предъявляемым к реагентам-пластификаторам, и легкодоступны. Эффективность действия данных добавок обусловлена их физико-химическими свойствами, особенностью их строения, состоящего из углеводородных, ароматических, карбоксильных, гидроксильных и других групп. Нами получены зависимости высоты слоя дисперсной фазы от времени присутствия суспензии с добавкой желатина, мазута, лигносульфоната (ЛСТ), гумата натрия. Суспензии с добавкой гумата натрия обладают наилучшей стабильностью. В результате анализа экспериментальных исследований установлено, что оптимальным связующим реагентом из использованных (топочный мазут, гуминовая кислота, желатин) является гуминовая добавка с содержанием порядка 1 %.

Ключевые слова: водоугольная суспензия, водоугольное топливо, реагент-пластификатор, технологическая схема, гуминовая добавка.

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