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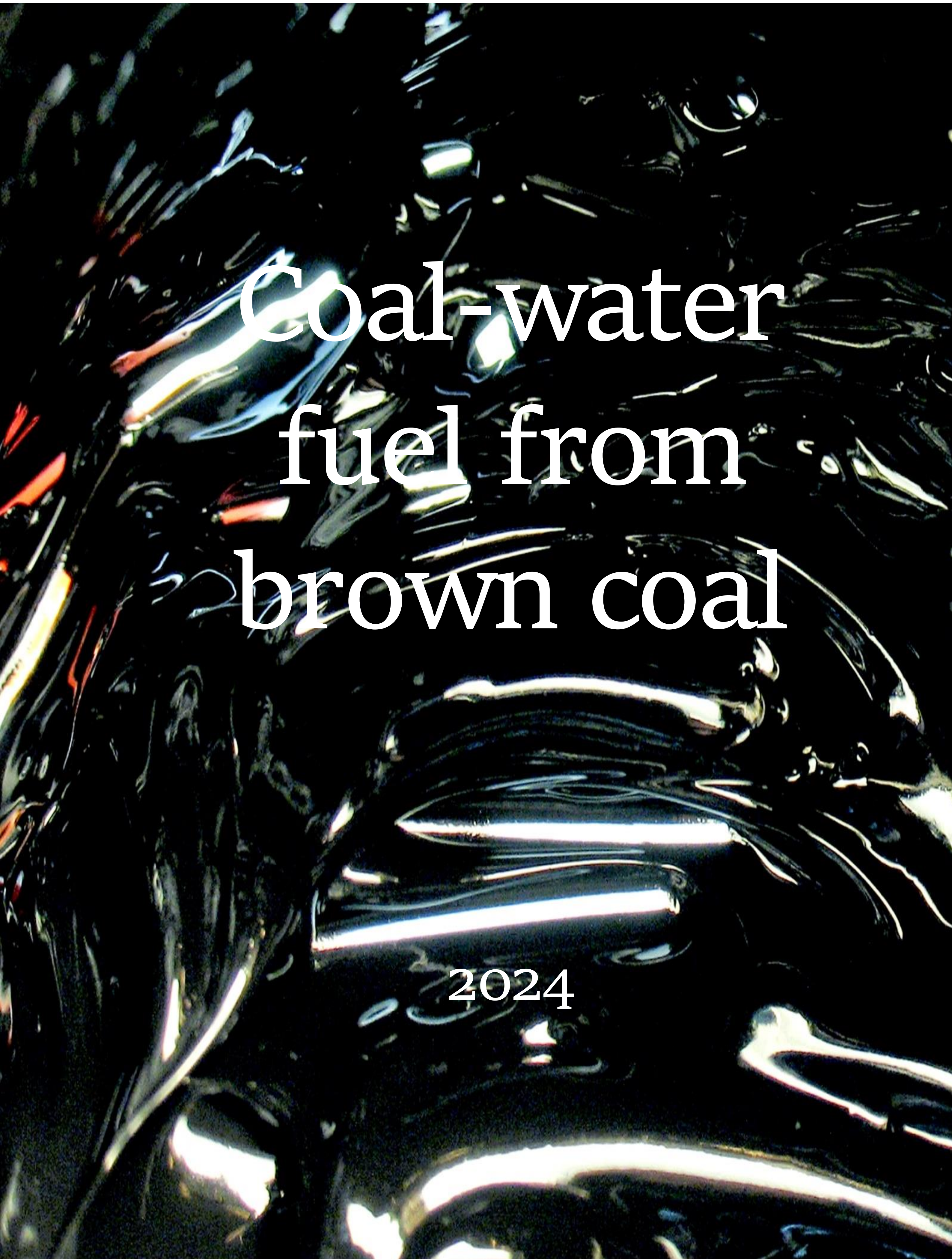


Coal-water fuel from brown coal

2024

Coal water fuel

Coal-water fuel (abbreviations: WCF, CWS, CWSM, CWM) is a new, efficient and clean coal-based suspension used as fuel for furnaces, boilers, gas turbines, diesel engines, as well as thermal and power plants or raw material for synthesis gas. It consists of 65-70% crushed coal with a size of 0 to 100-250 µm, 30-34% water and 1% chemical additives, prepared in accordance with certain requirements and has a low ash and sulfur content. Ash content of less than ten percent is desirable for boilers. There are no restrictions for diesel engines.

Depending on the type of coal, various types and series of additives are used to prepare coal-water suspension. They are able to change the viscosity, stability and other properties of the resulting product. Additives are introduced to increase the reactivity of the “liquid - solid phase” system.

Water in the suspension is an inert material that reduces the calorific value of the fuel. Therefore, in the process of preparation, the maximum value of the mass concentration of the hard phase is achieved, while ensuring the necessary fluidity of the suspension.

WCF is a slurry fuel that can be pumped, sprayed, stored and stably burned like oil. Its calorific value is equivalent to fuel oil and can replace half of the fuel oil in boilers, power plants, industrial furnaces and furnaces, or be used to replace coal. Water-coal fuel has the advantages of high combustion efficiency, convenient load adjustment, reduced environmental pollution, improved working conditions and coal savings.

A significant advantage of CWF compared to solid fuel and fuel oil is its complete explosion and fire safety, almost complete absence of losses during transportation in tanks and pipelines, and environmentally friendly combustion.

Practice has proven that the efficiency of combustion of coal-water suspension in boilers and furnaces can reach 95-98%, while the operating costs for burning coal-water suspension are only 1/3 of the cost.

Consumers of CWF can be small, medium, and large industrial enterprises, thermal power plants and coal mining complex enterprises: mines and processing plants.

Coal-water fuel can be transported by different types of transport: pipeline, rail or road. With a cargo flow of up to 1 million tons / year, transportation by pipeline is economically advantageous, with an increase in the transportation distance to 100 km or more, transportation by rail has an advantage.

Automobile transportation is appropriate for small volumes of deliveries and a delivery radius of 40-60 km, and with a decrease in freight traffic, the maximum transportation range increases.

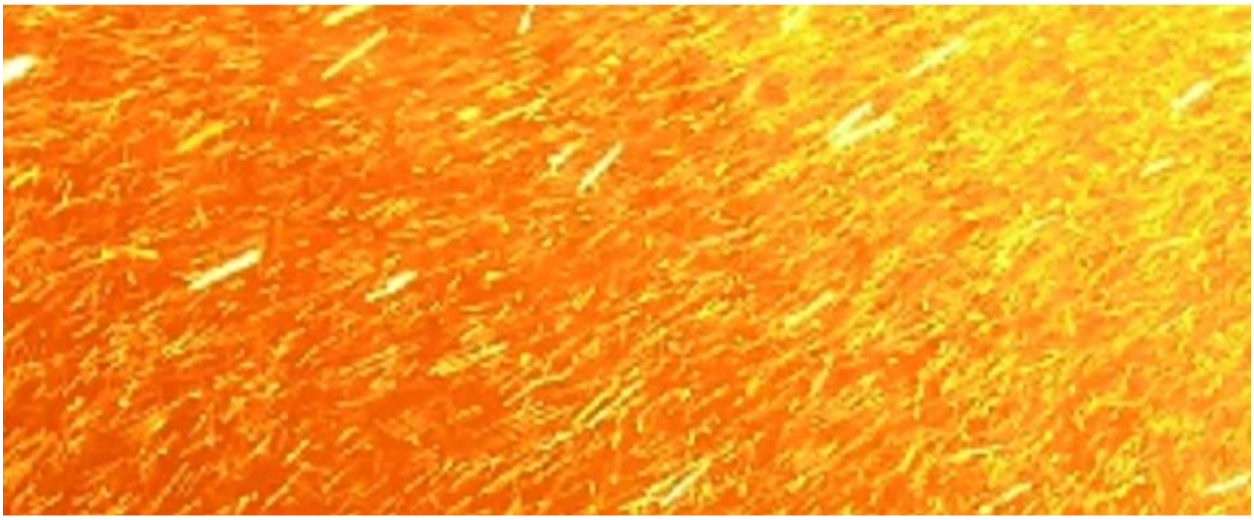
CWF pipeline transport is effective for transportation volumes of, as a rule, more than 0.5 million tons/year.

Technological requirements for coal quality

Water-coal fuel is obtained from coal of different grades: anthracite, hard and brown coal of different ash content, water of any quality, as well as high-ash enrichment waste.

It is clear that coal quality, coal particle size gradation and additives are the three main factors affecting the preparation of coal-water slurry. In order to increase the efficiency of coal combustion, coal particles must reach a certain size.

Also, to achieve the required combustion properties with stable combustion, coal must have at least 10% equilibrium moisture, less than 1.6 "bound carbon-volatile matter" ratio, more than 30% volatile yield and less than 3 degree of free swelling (tendency to agglomeration). At the same time, it must have as high an ash melting point as possible.



Historical background: *the use of CWF instead of petroleum products began in the early 70s of the 20th century during the global oil crisis in China, Japan, Sweden, the USA and the USSR. Currently, these works have reached their greatest development in Japan and China. Thus, in China in 2001, more than 2 million tons of CWF were produced and consumed, in 2006 - already about 15 million, and by 2020 it reached 100 million tons per year.*

Technological features and production of CWF

The peculiarity of CWF is the relatively low ignition temperature (800–850 °C [1,470–1,560 °F]), combustion temperature (950–1,150 °C [1,740–2,100 °F]), calorific value of 3,700–4,700 kcal/kg and high degree of fuel burnout – up to 99.5%. Such favorable conditions for combustion significantly reduce the content of nitrogen oxides (up to 1.5…2 times), carbon (2 times) and benzopyrene (5 times) in combustion products.

initial moisture content and production costs, the quality of CWF is characterized by its rheological properties, dynamic viscosity and stability.

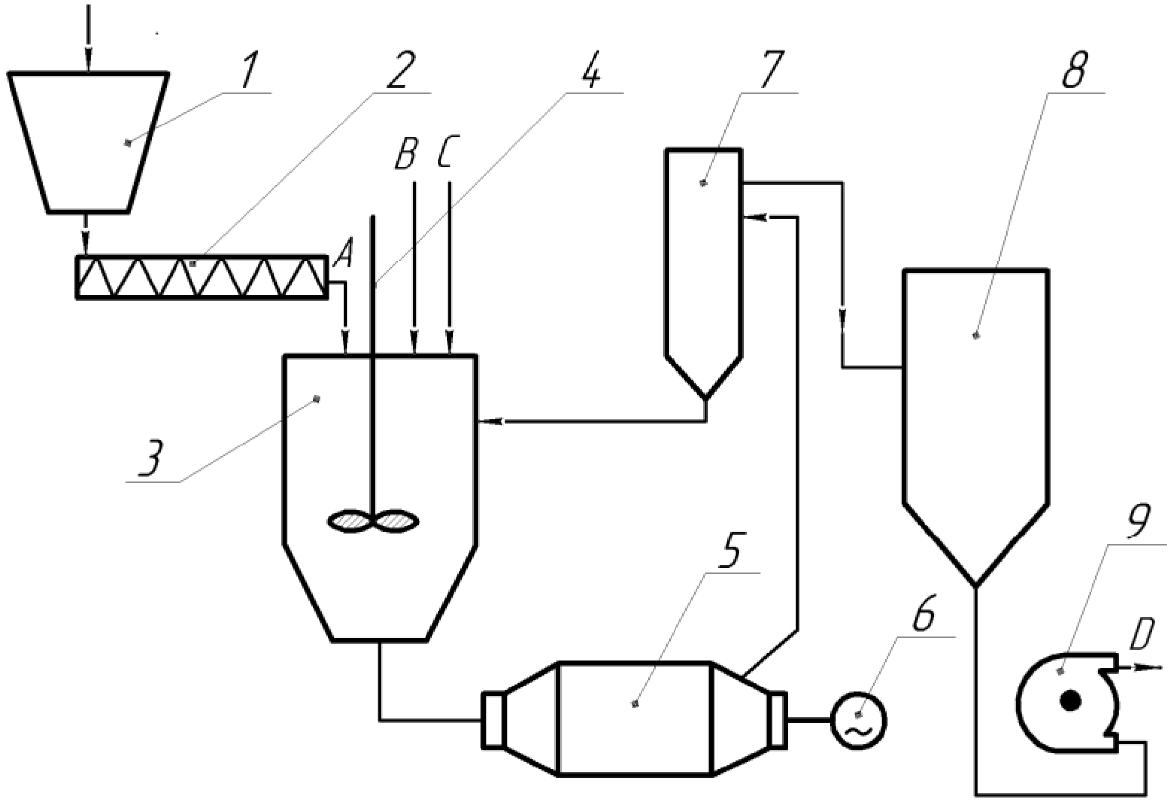
The main industrial devices for the production of CWF using traditional technology are ball and rod mills of "wet" grinding, which are characterized by energy consumption from 86 to 248 kW h / t. The main reason for the high energy costs of these mills is low (less than 1%) energy efficiency. The second

disadvantage is significant mechanical and corrosive wear of the surfaces of the mill bodies (400 ... 1,000 g per ton of product), which is 3 ... 5 times higher than similar characteristics in dry grinding of coal. Thus, in China, the production of CWF using traditional technology has a fairly high cost - about 25 US dollars per ton of coal-water fuel. Optimal parameters of CWF in terms of technological properties and energy consumption for preparation for boiler houses: coal content 62...65%, average heat of combustion - 21,000 kJ/kg, coal particle size - no more than 250 µm.

The process of preparing CWF is based on mechanochemical activation, during which the structure of coal is destroyed. When coal is crushed, its active surface increases, and impurities are removed.

The crushed coal and water, which plays an important role in this process, are mixed, plasticizer reagents are added, resulting in the formation of a specific dispersed system with technologically acceptable fluidity and stability.

Technological scheme of CWF production:



1 – coal bunker; 2 – screw feeder; 3 – mixer; 4 – stirrer;
5 – ball drum mill; 6 – electric drive; 7 – hydrocyclone;
8 – intermediate tank; 9 – feed pump; A – coal;
B – water; C – additives; D – finished CWF.

To obtain the required coal fraction, special grinders are used.
The best results are achieved when obtaining a bimodal distribution of particles of large (100–250 μm) and small (< 40 μm) fractions, a plasticizer reagent is added to it, the mass fraction of which is about 1–2%.
The viscosity of conditioned fuel suspensions, as a rule, is within 0.5–1.2 Pa s, sedimentation stability – up to 30 days.

Stages of CWF production

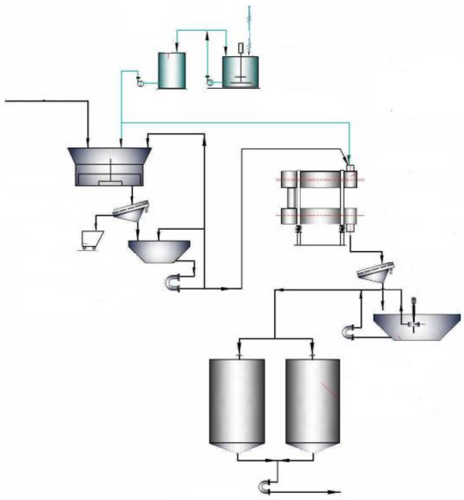
The preparation of CWF consists of three main stages.
The first stage (preliminary crushing) is necessary to obtain coal crumbs with a fraction of 10-12 mm. Crushing is carried out on standard crushers (hammer, jaw, etc.). If coal beneficiation waste (middlings, filter cakes, coal sludge) is used as raw material for the preparation of CWF, then this stage is excluded from the general line for the preparation of suspensions, since coal sludge consists of a very small (up to 500 µm) fraction of coal. The preparation of CWF from coal processing waste allows you to reduce the cost of grinding to an acceptable fraction.
At the second stage, wet grinding is carried out to a fraction of less than 100-150 µm. This stage is key in the preparation of CWF, since it determines its further characteristics: granulometric composition, viscosity, stability, etc. In some cases, at the stage of wet grinding, various additives may be included in the CWF composition, which are necessary to increase the static stability of CWF, reduce viscosity, etc. Also at this stage, various production wastes may be included: oil refining industry, municipal and household waste, woodworking and agricultural industries.
The third stage - homogenization - is necessary to obtain a homogeneous suspension, without lumps, with an acceptable granulometric composition. In the hydraulic shock unit of wet grinding, wet grinding and homogenization are combined and carried out simultaneously.
The use of CWF implies a quantitative reduction in the concentration of NOx and SOx formed during their combustion. Combustion of suspensions is not a method of gas purification. Concentrations of anthropogenic emissions are reduced exclusively due to the processes and chemical reactions that occur during ignition and combustion of fuel.

Technological schemes for the preparation of CWF based on finely dispersed waste from coal enrichment

Currently, two main variants of technological schemes for the preparation of CWF based on TDOU have been developed:

- variant No. 1 (using a twin-screw mixer as the main technological equipment);
- variant No. 2 (using a twin-screw mixer and a mill (vibratory or drum) for additional grinding and mixing as the main technological equipment)

Variant No. 1:



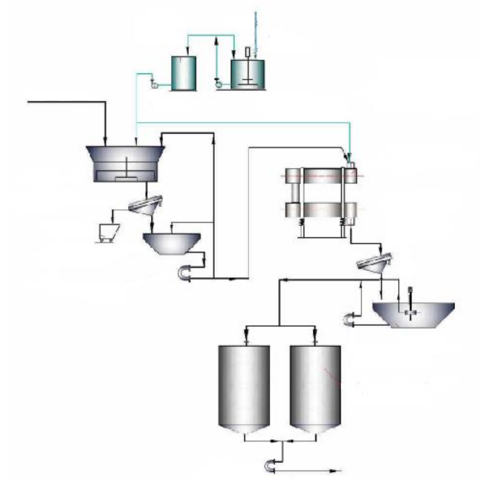
Finely dispersed waste is delivered by motor transport to a closed warehouse of the technological complex. The warehouse capacity must provide a 3-day supply of the initial material and be located in close proximity to the technological equipment of the CWF preparation section.

From the warehouse, finely dispersed waste is fed by a loader into the receiving hopper of the belt conveyor, which directs them to a twin-screw mixer. Simultaneously with the waste, an aqueous solution of the reagent is dosed into the mixer from a supply tank by a dosing pump.

The aqueous solution of the reagent is prepared in a preparation unit consisting of a metal container with a stirrer and a centrifugal pump.

After mixing the finely dispersed waste with the aqueous solution of the reagent in the mixer, the coal suspension flows by gravity to the coarse filter to remove foreign impurities and large particles. After filtration, the under-screen product flows by gravity into the sump storage tank and is then sent to the storage tank by an activator pump, during which the homogenization process is carried out, which allows reducing the viscosity of the fuel. The finished CWF is accumulated in vertical metal tanks with a lower outlet. The number and volume of tanks provides for the daily requirement of the boiler plant.

Variant No. 2:



According to the second option, the finely dispersed coal waste is loaded into a mixer, where an aqueous solution of a plasticizer reagent is dosed simultaneously with it. After mixing in the mixer, the resulting water-coal suspension is unloaded into a receiving tank, from where it is dosed by a pump into a vibratory mill for additional grinding and mixing.

Characteristics of filter cake and CWF prepared according to different schemes

№	Parameter name	Unit	Scheme No. 1 Finely dispersed coal waste	Scheme No. 1 CWF	Scheme No. 2 CWF	Scheme No. 2 CWF
1	Coal grade	mm	G	Г	Т	Т
2	Particle size	mm	0 - 0,5	0 - 0,5	0-0,6	0-0,250
3	Moisture	%	33	42	29,4	40
4	Ash content	%	25-28	25-28	21,3	21,3
5	Lower heating value	kcal/kg (MJ/kg)	3600-3800 (15,1-16,0)	3100 – 3300 (13–14)	4375 (18,3)	3631 (15,2)
6	Effective viscosity at a shear rate of 81 s -1	mPa×s	-	Not more 800	-	less 500
7	Consumption of plasticizer reagent	% of dry mass of Finely dispersed coal waste	-	0,5	-	0,5

Combustion of CWF

Despite the active use of coal-water fuel in a number of countries, some problems remain unresolved. Thus, the introduction of coal-water fuels with the addition of liquid combustible components into industrial heat power engineering, solving the problem of the low calorific value of typical CWF, is held back by the lack of experimentally obtained characteristics of the jet after spraying such fuels.

At the same time, most studies in the field of suspension fuels are currently aimed at studying the characteristics of ignition and combustion.
Combustion of a stream of droplets of sprayed coal-water suspension is a complex physical and chemical process that occurs, especially at the initial stage, under conditions of sharp non-isothermicity of the environment. To understand the combustion mechanism of the CWF, it is necessary to take into account that the combustion of coal-water suspensions in the furnace volume is carried out by spraying them in the air flow.

The combustion of a drop of water-coal suspension occurs simultaneously with the evaporation of moisture from its interior, and the evaporation of moisture does not slow down the process of carbon combustion. Jets of steam escaping from the interior of the drop activate combustion on the surface of the drop. As a result of the simultaneous flow of these two processes, the drop of suspension turns into a porous body, which ensures intensive contact with oxygen and rapid complete combustion of carbon. Water contained in the drop of suspension activates the carbon surface of the particles at the ignition stage and in the initial period of combustion, and then actively reacts with the fuel carbon, increasing the rate of carbon burnout.

In the process of CWF spraying, two qualitatively different systems are formed: the first system with “droplets” with a diameter of over 80-100 microns is represented mainly by coal particles; the second - by water-coal droplets.

The residence time of the largest sprayed fuel droplets in the combustion chamber is at least 5-6 s, which ensures their complete burnout.

The combustion of CWF in a vortex furnace with a thermal capacity of 0.3 Gcal/h is characterized by the following parameters:

- combustion temperature 800-1250°C; compressed and blast air pressure 0.2-0.5 MPa and 0.001-0.002 MPa, respectively;
- CWF consumption per 1 Gcal from 300 to 360 kg;
- excess air coefficient equal to 1.2-1.4.

Pilot and industrial tests of the CWF combustion technology in vortex furnaces have shown high efficiency of fuel combustion (mechanical underburning of captured ash particles does not exceed 3-5%) and a reduction in the level of harmful emissions by 3.3-4.3 times.
The economic effect of introducing CWF prepared from coal sludge and flotation waste in boiler houses is ensured by reducing the cost of the fuel component by 10-150 dollars per 1 Gcal compared to the layer combustion of raw coal.
In recent years, the low-temperature vortex combustion method (LTVC) of water-coal fuels has become widespread.

Application areas of CWF:

In addition to thermal power plants and thermal power plants, industrial enterprises are regular consumers of energy resources: construction plants, concrete plants, light industry enterprises, etc.
For such enterprises, in addition to the task of reducing cost, it is also important to have stable fuel supplies to their own facilities and independence from existing limits.
As a rule, the fuel component plays a significant role in the cost of the final product.
Coal-water fuel allows enterprises to reduce fuel costs for the generation of heat and electricity by replacing a significant share of the consumed fuel oil and (or) gas.
To store coal-water fuel, it is sufficient to maintain it at a positive temperature (+5 ... +10 degrees).
This means that when replacing fuel oil with coal-water fuel, in addition to direct savings on the fuel component, enterprises will also save on the maintenance of fuel oil facilities, which require up to 30% of the generated heat.
Coal-water fuel is used by energy-intensive enterprises (metal production, cement, concrete production, etc.); brick and other building materials firing plants; greenhouses and hothouses, especially in northern regions; bakery production.
Most industries require heat supply from standard boiler units. In this case, the introduction of CWF is accompanied by standard modernization of boiler equipment or installation of new (for new construction).

CWF in the world

The world experience of using coal-water fuel is quite broad and includes significant practical and scientific contribution of research institutions.

The state program of the Government of China during the 10th five-year plan (2001-2005) implemented a step-by-step transfer of enterprises from oil and gas fuel to coal-water fuel.

This allowed to reduce oil imports by more than 70 million tons, and fuel oil - by 20 million tons per year, which reduced the dependence of the country's fuel and energy complex on the external market.

For technical guidance on the introduction of coal-water fuel in the PRC, the State Center for Coal-Water Suspensions of the Coal Industry was created. In recent years, more than 20 million tons of such suspensions have been produced and consumed in China per year. Fuel preparation is carried out at several dozen plants with a capacity of up to 600 thousand tons per year.

Thermal power plants that previously operated on fuel oil have become consumers. Water-coal suspensions are also used by enterprises in the chemical, metallurgical, pulp and paper and other industries.

Today, there are 4 research centers in China that are working on the topic of coal-water suspensions: Beijing Coal Research Institute, Beijing Coal Design Institute, Guobang Scientific and Technological Company, Sheyang Thermal Power Institute, six plants are operating for the production of coal-water suspensions, and up to 2 million kW of energy is produced at boiler houses and power plants when burning coal-water fuel.

The largest projects implemented in China are: 1998 Shandong Thermal Power Plant (220 tons of steam per hour), 2003 Shenyang Oil Refinery (75 tons of steam per hour), 2004 Tingdao Thermal Power Plant (130 tons of steam per hour, 2 turbines of 12 and 25 MW), 2004 Guangdong Thermal Power Plant (670 tons of steam per hour), 2005 Coal Water Preparation Plant and Thermal Power Plant in Maoming (440 tons of steam per hour, 1.5 million tons of coal water). The technology for preparing coal water fuel in China is traditional and consists of two-stage wet grinding of coal in ball mills, mixing in plasticizing and stabilizing chemical additives, feeding the resulting product for storage and subsequent combustion in chamber furnaces of boilers.

There is an example of the preparation of coal-fuel oil slurry in China by the joint Japanese-Chinese enterprise Japan COM Co. Ltd and its further transportation by sea tankers to the Joban Joint Thermal Power plant in Nakaso, Japan (600 MW power unit, up to 500,000 tons per year).
Mitsubishi Corporation in Japan has developed an industrial technology for the production and combustion of coal-fuel oil slurries. Since 1985, such fuel has been used in two units with a capacity of 265 MW each at the Yukosaka power plant. In Nakaso, tests were conducted on a 7.5 MW unit consuming 3.2 tons of fuel per hour. Units with a capacity of 60 and 100 MW with a coal-fuel oil consumption of up to 21 tons per hour were also tested.
A number of coastal thermal power plants in Japan, where the necessary modernization of combustion and ash removal systems was carried out, use coal-fuel oil slurry on an industrial scale.
Combustion of coal-liquid fuel is carried out together with fuel oil mainly at night or during hours of significant load reduction.
Some of the works show that the best technical and environmental characteristics of boilers are achieved with the joint combustion of pulverized coal and coal-water suspension with a share of coal-water fuel from 30 to 80% (depending on the operating mode) in the heat balance of the boilers. In gas-oil boilers, the share of coal-water fuel can also be most effective from 25% to complete replacement of gas (fuel oil), while the maximum share of coal-water fuel is determined by the ash content of the original coal and the presence of appropriate ash collection systems.
In the USA, a program for the use of coal in industrial and domestic energy is being implemented for the next 6-10 years with a total funding volume of 6 billion dollars. About 20% of this amount is supposed to be spent on solving problems related to the creation, transportation and use of coal-water fuel.
According to American sources, its widespread implementation is held back by the relatively high cost of coal enrichment and opposition to the laying of main coal pipelines from railway companies and the US Congress.

The experience of converting power plants to combustion of coal-liquid fuel in Ukraine is not so large-scale and successful.

In Ukraine, an innovative technology for preparing coal-liquid fuel has been proposed, taking into account the experience of Reosarb technologies.

Coal is ground in one stage in a ball mill.

The required homeostatic state is achieved by changing the number and diameter of grinding bodies in the ball mill. Preliminary mixing of coal and water is proposed, after which the mixture is fed for grinding.

The proposed technology for preparing the mixture for grinding allows for almost 2 times less electricity savings in the process of preparing coal-liquid fuel, as well as significantly improving its transport and consumer properties, in particular by increasing sedimentation stability.

The technology is used in Ukraine to obtain experimental batches of coal-liquid fuel (NPO Uglemekhanizatsiya).

A project for converting mine boiler houses to use CWF (Ukrainian Heat Company) has been implemented.
CWF transportation technology is being implemented at the state level by the State Enterprise Ukteplocom as a component of the national project Energy of Nature.
The enterprise is implementing a project for hydrotransportation of CWF to municipal boiler houses. Before the technology is implemented at the industrial level in any country, issues of pricing, business schemes for interaction, investments and their protection, etc. must be resolved.

Coal Water Fuel Market

The coal-water slurry market was valued at US$3,107.1 million in 2024 and is expected to reach US$7,113.6 million by 2032, growing at a CAGR of 12.3% during the forecast period 2024–2032.

The major coal-water slurry manufacturers include Datong Huihai, Mao Ming Clean Energy, EET GmbH, MeiKe Clean New Energy, 81 LiaoYuan, Sanrang Jieneng, Tai An Xinhuanneng, Xinwen Milling, Pingxiang Shui Mei Jiang, and Cynergi Holding, with a market share of about 22%.

China is the largest consumption location with a consumption market share of nearly 38%. After China, Europe is the second largest consumption location with a consumption market share of 22%.

Brown coal water fuel

Brown coal is the lowest member of the general coalification series of fossil coals with a higher specific heat of combustion of wet ash-free mass of 25.5-35.5 MJ/kg, a lower 6.1-13.8 MJ/kg of soft coals, and 9-18.8 MJ/kg of dense coals, a density of 1.2-1.5 t/m³, a bulk density of 1.05-1.4 t/m³, and a bulk density of 0.7-0.97 t/m³.

Specific gravity is 0.5-1.5.

The average chemical composition, excluding ash: 50-77% (on average 63%) carbon, 26-37% (on average 32%) oxygen, 3-5% hydrogen, and 0-2% nitrogen. Large reserves of brown coal are found in Germany, Russia, Ukraine, Poland, Greece, the USA, Australia, and China.

The difference from hard coal is that it has a lower carbon content and a significantly higher content of bituminous volatile substances, so brown coal burns more easily and is still widely used as a fuel due to its availability and relative cheapness.

It is calculated that the cost of the fuel component of 1 Gcal from brown coal is 2.7 times less than the cost of the gas component and 4.8 times less than that from fuel oil.

In addition to its use in power engineering for generating electricity at thermal power plants, metallurgy, chemical and construction industries, brown coal, except for humidity, meets all the above-mentioned characteristics in this paper for obtaining water-coal fuel.

Developments by Ukrainian and world scientists make it possible to solve this problem by applying hydrothermal treatment using "hot" water drying technology. *

** The technology of hydrothermal treatment "hot water drying" was developed by the Energy and Environmental Research Center (EERC) of the University of North Dakota (USA).*

The technology is aimed at its refinement for further effective use in the preparation of high-concentration coal-water fuel in coal processing processes for industrial and domestic purposes.

Comparative characteristics show that the hydrothermal treatment method can eliminate the main negative features of Ukrainian brown coal: high humidity and hygroscopicity, high reactivity to atmospheric oxygen.

This allows it to be used for chemical-technological processing or direct combustion in the form of coal-water fuel. The technological scheme was used on the basis of brown coal from the Dnieper coal basin*

** In Ukraine, brown coal reserves are estimated at 2.24 billion tons. Coal seams of the Dnieper brown coal basin with a thickness of 3-4 m lie at a depth of 15-100 meters.*

As a result of scientific research on obtaining coal-water fuel from brown coal, it is known that for production, coal must have the following characteristics: equilibrium moisture - less than 10%, fuel coefficient (fixed carbon6 volatile substances) - 1.6%, yield of volatile substances - more than 30%, degree of free swelling (tendency to agglomeration) - less than 3%.

The essence of the hydrothermal treatment process "hot water drying" is the pressing of coal in an aqueous medium. It has been experimentally established that moisture in low-metarphized coal is released under conditions similar to those that occur during metamorphism. With a certain increase in temperature and pressure, brown coal loses internal and chemically bound water and acquires a state where water resorption does not occur.
As a result of changes in the structure of brown coal, the resins that are present in it in large quantities clog the pores and do not allow moisture to enter the coal. Thus, coal passes from a hydrophilic state to a hydrophobic one. At the same time, sodium is removed during the drying process, which reduces the risk of contamination and slag formation in boilers.
NPO "Khaymek" (Donetsk) in collaboration with Williams Technologies Inc. and Coal-Water Fuel Services (USA) carried out research on the "hot water drying" technology on brown coal from the Konstantinovsky open-pit mine of the Alexandriaugol Mining and Chemical Complex.
The coal had a primary state with a moisture content of about 55% (equilibrium moisture content of about 36%) and had undergone a full technological cycle of preparation of the hydraulic mixture, heat treatment and preparation of coal-water fuel.
Hydrothermal treatment was carried out in a special reactor at a temperature of 300 to 320 ºC and saturated steam pressure for 10 to 30 minutes.

As a result of hydrothermal treatment, a significant improvement in the chemical characteristics of brown coals was noted, including a decrease in the oxygen and sulfur content with an increase in the energy potential. Equilibrium moisture decreased from 36 to 10%. In the final stage, coal-water fuel (CWF) was obtained at a mass concentration of 60% without the use of chemical additives with a combustion heat of 3444 kcal/kg.
During the research, brown coal went through a full technological cycle of manufacturing coal-water fuel, which confirmed the technical feasibility and economic feasibility of using this type of fuel as the main and "back-up" fuel at thermal power plants.
The calculation of the efficiency of using various heat carriers by power plants in Ukraine is presented in the table below.

Efficiency of using various heat carriers by power plants in Ukraine

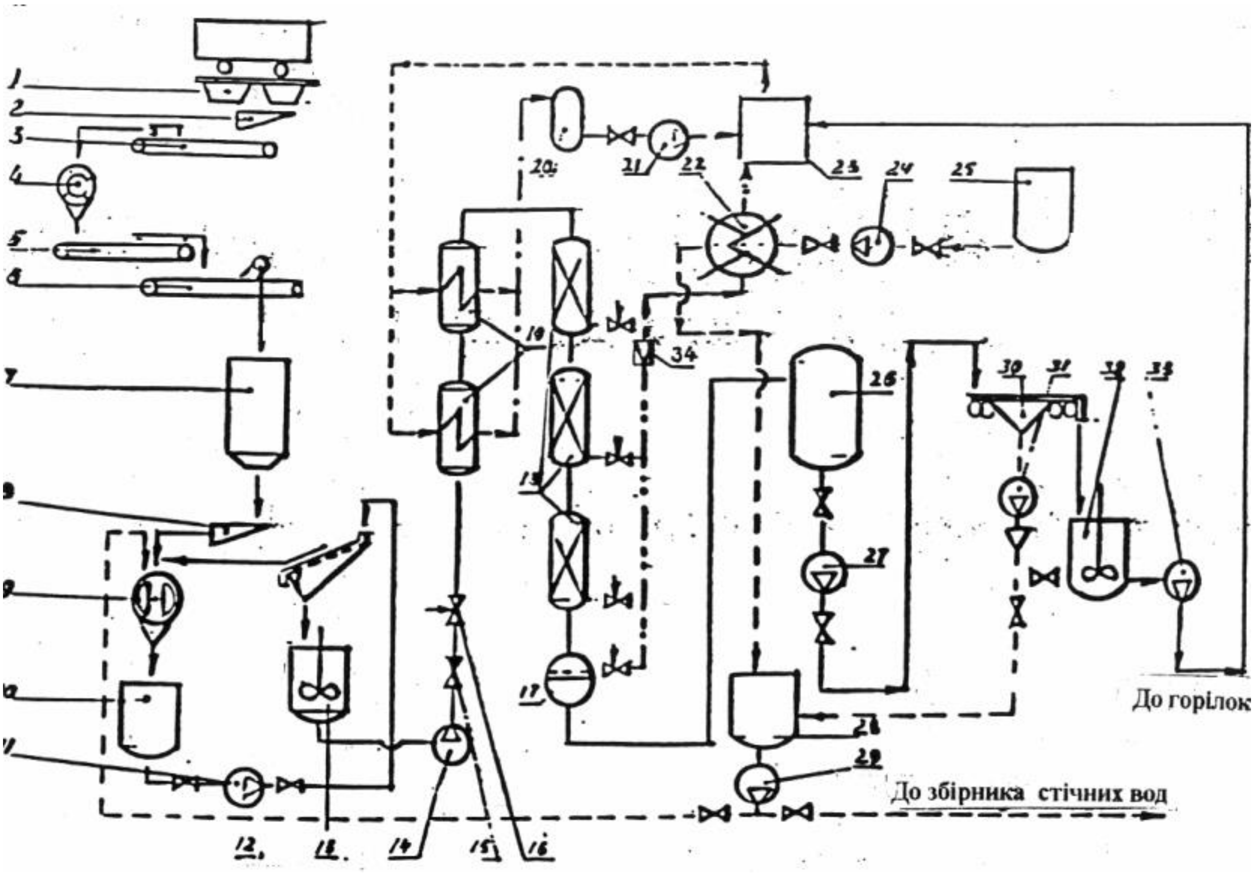
Indicators	**Coal grade G**	**Coal grade D**	**Coal grade T**	**Coal grade A**	**Coal grade B**	**Gas**	**Fuel oil**	**CWF backlight**	**CWF main**
Cost from supplier, $/Gcal	6,19	6,43	7,42	8,25	6,28	10,40	11,19	8,37	8,37
Cost price of 1 kWh at thermal power plant, US cents:									
Krivorozhskaya TPP	-	-	2,68	-	-	-	-	2,53	2,53
Slavyanskaya TPP	-	-	-	2,94	-	-	-	2,59	2,74
Pridneprovskaya TPP	-	-	-	2,69	-	-	-	2,53	2,50
Zaporizhzhya Thermal Power Plant:									
Coal	2,03	-	-	-	-	-	-	2,04	2,40
Gas-oil fuel	-	-	-	-	-	-	2,73	-	2,32
Tripolskaya TPP:									
Coal	-	-	-	2,67	-	-	-	-	5,50
Gas and fuel oil	-	-	-	-	-	-	2,63	-	2,37
Zmievskaya TPP	-	-	-	2,82	-	-	-	2,69	2,50

The above confirms the technical feasibility and economic feasibility of using coal-water fuel at thermal power plants in Ukraine.

The world reserves of brown coal are estimated at 1.3 trillion tons. The world annual production is 950 million tons. Brown coals are used mainly for combustion in thermal power plants, as household fuel, and on a smaller scale - for briquetting, gasification, production of coal-lusk reagents, and mountain wax. In Ukraine, brown coal deposits are concentrated in the Dnieper brown coal basin, Transcarpathia, Prykarpattia, and Transnistria. In the structure of the balance coal reserves of Ukraine, the share of brown coal is 6.6% (2.54 billion tons as of 01.01.95). Brown coal reserves concentrated in the deposits of the Dnieper basin are estimated at 2.2 billion tons. The most promising are also the Novodmitrovskoye deposit (about 400 million tons) and Sulay-Udayskoye (504 million tons.

Below is a flow chart of the VUT preparation terminal developed by NPO Khaimek by order of the Ministry of Fuel and Energy of Ukraine, the main technological elements of which are the enterprises of the holding company "Alexandriaugol" (an enterprise for the extraction of brown coal in the Kirovograd, Cherkasy and Zhitomir regions). To ensure stable operation of the pilot plant, 240 tons of brown coal with an ash content of 10-12% at a moisture content of 57% per working mass are required daily, which will ensure VUT productivity of 170 tons/day at a mass concentration of 60%.

Technological scheme of the VUT preparation terminal:



1 - pit for imported coal; 2 - feeder; 3 - conveyor with metal trap; 4 - crusher; 5 - belt conveyor; 6 - conveyor with unloading cart; 7 - crushed coal bin; 8 - feeder-doser; 9 - ball mill; 10 - tank for hydraulic mixture; 11 - pump; 12 - hydroscreen; 13 - mixer; 14 - vacuum pump; 15 - non-return valve; 16 - regulating valve; 17 - separator; 18 - reactors; 19 - heat exchangers; 20 - condensate collector; 21 - feed pump; 22 - condenser; 23 - boiler; 24 - pump; 25 - water tank; 26 - equalization tank; 27 - pump; 28 - water tank; 29 - pump; 30 – belt vacuum filter; 31 – vacuum pump; 32 – homogenizer; 33 – finished VUT pump; 34 – pressure relief valve

The cost of coal-water fuel, including the cost of brown coal as the initial product ($7.5/t), was $14.16/t or $6.5/Gcal (as of 2011).

The project envisaged the maximum possible use of existing primary and auxiliary equipment, utility networks and communications, and the construction period for this project was 11 months.

Alexandria brown coal complex

Conclusions

Coal is one of the main and cheapest energy sources used for combustion in heat-generating units of various industries and in housing and communal services.

In the last decade, the tendency to replace hydrocarbon liquid and gaseous fuels with coal has become increasingly clear, which is associated with the high shortage of hydrocarbon fuel and constantly rising prices for it.

The increase in the specific share is evidenced by the constantly growing volumes of coal production.

Modern industry has begun to develop equipment that allows for more efficient enrichment of fine-grained sludge (screw separators, hydrocyclones, pneumatic flotation machines, etc.), as well as mechanical dewatering equipment that reduces the moisture content of enriched sludge (centrifuges with a high separation factor, filter presses, pressure filters).

However, only large particles of sludge (20 ^ 30%) are captured and enriched, and the rest is sent back to the waste heaps.

The most effective way to utilize coal enrichment waste is to burn it in the form of water-coal suspensions. In this case, all the coal mined is used for its intended purpose, and the ash formed during combustion is a good building material.

As a result, it becomes possible to significantly reduce the volume of areas occupied by hydraulic dumps and settling ponds, and to reclaim disturbed lands.

In Europe, America and the Asian continent, the utilization of coal enrichment waste is carried out by preparing and burning coarse coal-water suspensions in fluidized bed boilers and pulverized coal boilers.

In this case, coal-water suspensions are used as additional fuel.

Widespread introduction of a new type of liquid fuel from coal - coal-water fuel can serve as the basis for an effective replacement of expensive, scarce, environmentally friendly natural energy sources (natural gas and oil) at many thermal power plants and state district power plants with minimal capital costs and maintaining the required level of harmful emissions into the atmosphere.

Currently, leading positions in the implementation of VUT technology are occupied by countries that, lacking their own natural resources of hydrocarbon energy sources, are forced to import large quantities of oil and natural gas for the needs of their developing economies, thus becoming economically dependent on their suppliers.

The economic attractiveness of water-coal fuel technology is as follows: it allows to reduce the use of natural gas for heating and heat generation in the power industry, industry, housing and utilities by 25-30%, to increase the efficiency of heat generation by 30-40% compared to traditional coal combustion technologies. It allows to reduce the cost of heat energy and eliminate the risk of coal dust explosion and spontaneous combustion of coal.

It is a safe fuel for transportation and unloading.

It improves the combustion process and reduces the temperature in the combustion zone, and also minimizes emissions of harmful substances into the atmosphere during combustion.

The benefits of using water-coal fuel in thermal power engineering are also evidenced by such advantages as the possibility of the most complete use of the infrastructure of power boiler units with minimal reconstruction of devices and fuel supply systems, high packing density during storage compared to stacking dry coal, complete explosion and fire safety, no losses during transportation, and the possibility of underground storage.

Water-coal fuel is stable and environmentally friendly at all stages of production and use, its operating experience has shown significant technological advantages and high efficiency of the combustion process, as well as reliable operation of the main process equipment.

Water-coal fuel has a number of environmental, technological and economic advantages at all stages of its production and use: it has a low percentage of waste during combustion, which simplifies the solution of the complex problem of catching fly ash; its cost is two to four times lower than the cost of fuel oil and does not exceed 15-20 percent of the price of the original coal at the place of its production with the possibility of using coal of any grade; it can be used like liquid fuel with full mechanization and automation of the process of receiving, feeding and burning, etc.

Recently, various countries and market participants from different regions have shown interest in CWS projects due to growing political instability.

The existing great potential of projects related to fuel substitutes can lead the world market for water-coal fuel to explosive growth.

The tasks of large-scale use of water-coal fuel do not include a complete replacement of traditional energy resources.

There is a clear understanding that energy consumption is growing at a rapid pace, with the International Energy Agency estimating that consumption will increase by 40% by 2040.

The growth of production capacity will not allow abandoning existing energy sources and using only Water-coal fuel, which would require huge volumes. It is assumed that the optimal share of energy generated by burning suspension fuel should be about 20-25%. The transition to water-coal fuel is especially relevant for regions with developed coal and oil industries and where there are problems with the environmental situation.

From an environmental point of view, the transition to water-coal fuel will significantly reduce the burden on the environment.

If we assume that 20% of the energy produced will be generated by coal-water fuel compositions, then this will ensure a significant reduction in sulfur oxides and nitrogen oxides.

The basis of the suspension fuel can be non-energy brown coals, waste from coal mining and coal processing, residual products of oil refining.

A feature of obtaining a coal-water suspension from brown coals is their low degree of metamorphism.

At the same time, high reactivity allows using brown coals as a solid phase of a coal-water suspension together with lower-reactivity coals or sludges.

The conducted scientific research allowed us to propose a technological mode for obtaining suspension coal fuel based on brown coal by carrying out its preliminary modification and showed the possibility and economic feasibility of its use as an energy carrier.

The obtained fuel can be recommended for use as an alternative boiler and furnace fuel in public utilities, as well as for a number of heat and power generating enterprises.

Currently, the technology for the production of water-coal fuel has been established in many countries on an industrial scale, it is cheap, low-capital-intensive, environmentally friendly, waste-free, explosion-proof and fireproof.

The main advantages of water-coal fuel are the possibility of its transportation through pipelines over almost any distance and direct combustion in furnaces without preliminary dehydration by spraying through nozzle devices.