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TECHNIQUE OF COMPLEX SLIME WATER TREATMENT OF COAL-MINING BRANCH

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The possibility of complex slime water treatment at coal-mining and coal-treating plants producing marketable products: power-generating concentrate, coal-water fuel, magnetic fraction, industrial water is shown. A basic process flowsheet of slime water treatment presenting a united technological complex is suggested.

Developed coal-mining and coal-treating industry is of great importance to Russian economics. Large coal reserves in Russia allows orienting to a long-terms perspective of electrical power engineering development using widely coal as a basic strategic fuel, meeting country requirements in fuel for hundred years. Energy safety and social stability of Russia is connected, to certain extent, with coal power engineering development. Huge scales of coal mining and conversion make it necessary to develop measures and create new processes of wasteless technology using which all constituents of a mineral are divided into end marketable products, used in national economy.

Coal mining has a negative influence on depth, air and water basins, earth and soil. The important negative factor of mining is a significant damage to water basin, in this connection there appears the problem of conservation of Kemerovo region districts water sources. It is stipulated by discharging of large volumes of sewage water, containing, as a rule, suspended and soluted admixtures, into surface basins and channels.

At the present time, for example, only 40 % of Kuzbas coals go through concentrating mills. Within the long period of time, considerable quantity of slime waters and coal slacks, which contains 40...80 % of organic mass, was accumulated, and in future, the problem will be more urgent because coal enterprises (and there are 50 mines, 34 strip mines and 18 coal-cleaning plant in Kuzbas [1]) it is necessary to perform cleaning of nearly all mined coal.

Conversion of coal slacks into technologically acceptable fuel allows not only improving environmental situation in the region, but also obtaining significant saving rate.

Slime waters are fine-dispersed systems, which are very difficult to be influenced by means of using of traditional technologies (flotation, gravity concentration etc.) for their utilization, and sometimes it is not technologically feasible.

The alternative solution of this problem may be untraditional technology of complex slime waters treatment at coal branch enterprises. We suggest the following fundamental flowsheet of a complex slime waters treatment (fig. 1).

Realization of such flowsheet, or similar to it, allows carrying out complex slime waters utilization obtaining a number of marketable product and providing coal-cleaning plants with heat energy.

Coal branch enterprises must have, as a rule, fully closed water cycle of water-slime sector with reverse technical water-supply. Slime waters dumping into sewage system is possible only in cases of emergency, equipment maintenance, or at increasing of weighted substances concentration in water of reverse cycle higher than acceptable according to technological requirements [2].

Realization of a given flowsheet in laboratory environment was carried out by example of slime waters of OAO ЦОФ «Berezovskaya». The data of the quality of slime water (given by OAO ЦОФ «Berezovskaya»), directed into sludge pond are presented in table 1.

Table 1. *The results of water quality analysis*

Determinating component	Concentration, mg/dm^3							
	June 2002	November 2002	May 2003	July 2003	June 2004	July 2004	May 2005	August 2005
pH, unite pH	8,5	8,3	8,0	8,1	–	8,5	8,1	8,0
Solid residual	630,0	642,0	426,3	405,40	400,50	417,50	443,00	435,00
Hardness, mmole/dm^3	3,70	3,00	1,60	4,00	2,12	2,22	3,48	3,44
CPC, mgO$_2$/dm^3	7,8	19,38	50,76	116,62	60,06	56,64	63,21	61,74
Hydrocarbonates	–	–	1,5	1,40	1,70	1,85	189,62	3,20

The initial stage in utilization of such quality slime waters according to suggested flowsheet is coal constituent separation from liquid phase by means of concentration in centrifugal force field. As a result, two semi products are obtained – coal sludge, representing suspension with 60...75 wt. % of solid phase content and industrial water.

Separated coal slack is converted depending on further application (water carbon fuel [3], material for carbonization, semicarbonization, solid power-plant fuels etc.). If necessary, it can be enriched using the method of oil agglomeration, as particle size of coal slack (less than 500 micrometer) does not allow performing this by means of other methods.

Agglomeration process is widely spread at enterprises, connected with fine-dispersed materials conversion. It is usually a technological production cycle, providing a number of products (semi products) manufacturing, due to granules form of which the improving of their physical-mechanical properties is provided.

High selectivity at separation of particle less than 100 mkm, wide range of enriched coal ash content, possibility of carrying out the process at pulp density to 600 g/l, additional concentrate dehydration by displacement of water by oil forming coal oil granules are the main advantages of oil agglomeration process. All this allows us to consider oil agglomeration rather perspective when enriching coals and coal slacks of fine class [4].

As a result of the process coal-oil concentrate, being a low-ash and low-sulphur semi- product is formed (fig. 2).

The important matter at oil agglomeration is the choice of binding reagent, determining to a large extent cost of the process. Furnace fuel oil, gas oil, chemicals of trapping in by-product-coking production (straw and anthracene oils, polymers of benzene separation, acid pitch), diesel fuel, used crankcase oils etc. may be used as a binding reagent.

To determine the most efficient reagent preliminary experiments in enriching of CC m. Tyrganskaya brand coal slack (A^d=18,5 wt. %; W^a=3,6 wt. %; V^{daf}=30 wt. %; $Q_б^t$=30378 kJ/kg) were carried out. Used crankcase oil, furnace fuel oil, straw oil were used as a binding reagent (table 2).

It is seen from table 2 that the most acceptable reagent form used ones (by data of ash content and combustion heat) is used crankcase oil. Increase of heat combustion is explained by the fact that the crankcase oil itself (or other reagents) being in coal concentrate promote the rise of its heat combustion values.

Table 2. *Enriching of coal slacks of CC, Г, Д types by various reagents*

Reagents	A^d, wt. %	W^a, wt. %	V^{daf}, wt. %	$Q_б^t$, kJ/kg
Used crankcase oil	4,8...6,0	14,0...16,5	39,0...42,5	34350...35600
TM-100 furnace fuel oil	7,0...9,0	16,5...17,5	36,0...39,0	31000...32500
Straw oil	8,0...9,5	16,5...18,0	34,5...38,5	30500...31550

Yield into concentrate was 80...84 wt. %. Consumption of binding reagent was determined by the requirement for formation of agglomerated concentrate with minimal ash content A^d=4,8...5,6 wt. % and depended on ash content of initial coal slack.

The perspective area of coal-oil concentrate application is production of water-coal fuels on its basis. Therefore, the obtained coal-oil concentrate was further given into a ball mill for breakage and plastification. A component on basis of humic preparations was used as a base of placticizing agent.

As a result water-coal fuel with a content of solid phase mass fraction from 62, 4 to 63, 6 % and effective

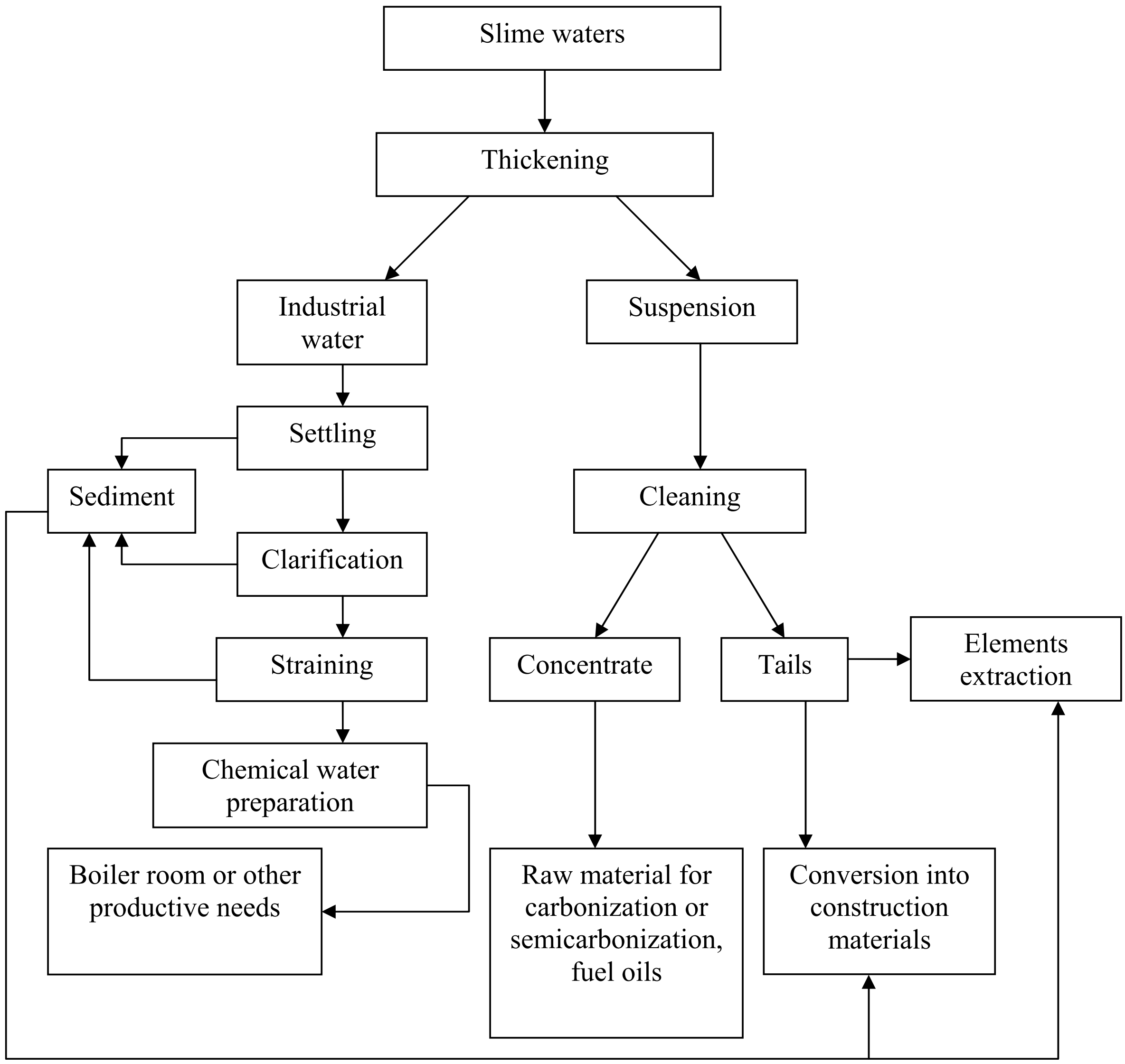

Fig. 1. *Fundamental flowsheet of complex slime waters treatment*

viscosity 1000 mP·sec. was obtained. Statistic stability investigations showed that breaking of water-coal fuel samples was not observed during more than 30 days. It is explained by its structure. While coal slack enriching reagent-collector is adsorbed on coal particles surface, in the process of water-coal fuel preparation at wet grinding coal-oil granules braking with a formation of surfaces without reagent occurred. In this connection sodium humate could interact only with free centres of coal particles surface and water. In this case, the interaction of sodium humate molecules with coal surface is hampered to some extent by preliminary adsorption of binding reagent. Hereupon, the interaction of sodium humates with coal particles surface in its presence decreases. From this it follows that when obtaining water-coal suspension an incomplete stabilization of dispersed system by sodium humate occurs.

At incomplete stabilization of dispersed system double electric layer and solvate shell of larger particles are only partially disturbed, particles adhesion at certain places on surface patches having no resistance factor after stabilization takes place, i. e. it occurs at the places where reagent-collector has been adsorbed. Spatial grid is formed, in loops of which the dispersion medium remains. Liquid interlayer formed between the particles though decreases structure strength but makes it slightly plastic and elastic.

At long storage (more than 30 days) water-coal suspensions have being shrunk step-by -step forming loose deposits, isolating liquid phase contained in their structure. It is supposed to be the result of coagulation rearrangement of particles, which contacts number significantly increases, that results in water-coal suspensions shrinking and «squeezing» dispersion medium from them. The reduction of suspensions initial structure occurred when applying mechanical effect (stirring). This phenomenon is explained by the fact that the given water-coal suspension retains to some extent the inner structure possessed at its formation [5].

It is known from scientific sources that structures reduction after their destruction under mechanical effect is characteristic for thixotropic systems. Thixotropy phenomenon is connected with reduction of disturbed bindings between particles at mechanical effect. Such phenomenon is named «jelly memory» and is observed in sols, gels, jellies.

Therefore, we may suppose that water-coal suspensions, prepared with the addition of fuel oil and sodium humate, possess structured spatial grid from coal particles.

These properties, stipulated by structure composition peculiarities, provide the obtaining of water-coal suspension with stable properties.

After water-coal fuel combustion ash remains practically without underburning – the unique material, often containing industrial conditions of rare and valued metals.

Ash of obtained water-coal fuel was sent to magnetic separation device where magnetic fraction was isolated. In this way, for example, 7 % of magnetic fraction was isolated.

«Reject» forming at the process of oil agglomeration of coal slacks may be also applied in the technology of rare dispersed elements extraction, production of construction materials, various filling materials such as ballast admixtures.

Industrial water was settled, separated from solid phase residuals by flotation and purified by chemical methods. After that, certain concentration of substances of organic origin – flotation reagents and flocculants – is determined in water.

Multiple circulation of industrial water and its contacting with coal results in excesses of flocculants and flotoreagents absorption by solid phase. Thus, industrial water purification from flocculants and flotoreagents occurs. Deep purification of reverse water from flocculants and flotoreagents may be performed by means of sorption method with the help of activated coal.

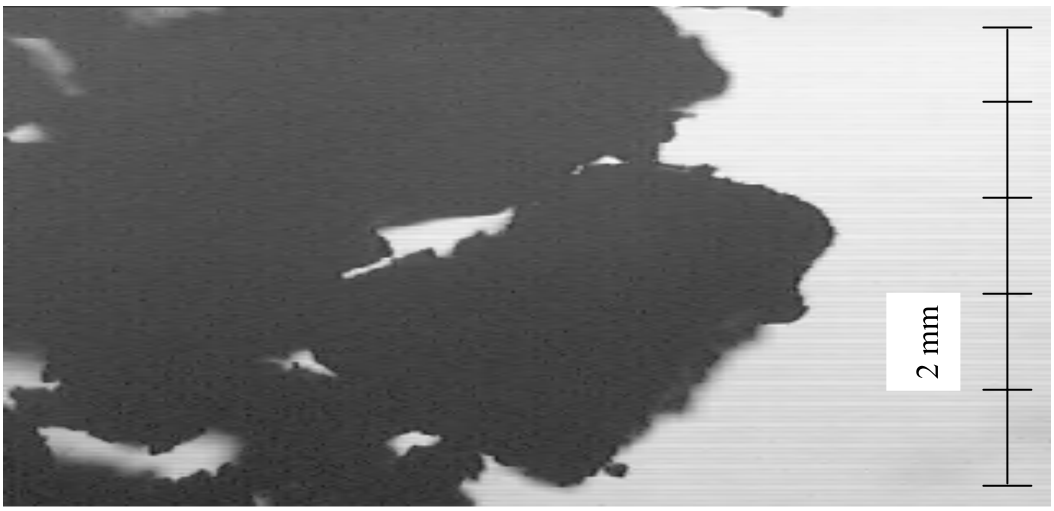

Fig. 2. *Granules of coal-oil concentrate*

Besides suspended insoluble matters there is a large content of soluble salts in reverse waters of coal enterprises. It is possible to decrease the content of soluble substances by the methods of chemical and physicochemical water preparation, it is necessary to do this for further water application in heat exchanging systems, as the probability of scale formation is large.

In heat-exchangers of reverse water supply and hot water-heating systems scale formation may be significantly decreased by water electrotreatment with continuous current [6, 7]. The essence of the method consists in extraction of scale-forming substances microchips from circulation water at water transmission between electrodes, on which continuous electric current is supplied. The electrotreatment method is based on the idea of electrochemical mechanism of scale deposition on heat-exchange surfaces [8]. Hot surface of heat-exchanger and water cooling it obtain the electric potential difference: thermo-e.m.f. under the influence of temperature difference. Deposition of scale-forming substances charged particles occurs under its influence.

Decrease of scale-formation at water electrotreatment is explained by the fact that scale-forming particles enlargement decreases abruptly their capacity to adherence on heat-exchangers walls. The process of coagulation occurs under the influence of water electrolysis products, which quantity is proportional to current density. The main cathode reaction is water decomposition with gaseous hydrogen and hydroxyl ions isolation

$$2H_2O+2e^- \rightarrow H_2\uparrow+2OH^-.$$

The main insoluble anode reaction is

$$2H_2O-4e^- \rightarrow O_2+4H^+.$$

OH^- ions flow causes coagulation of fine-dispersed particles of calcium carbonate in cathodic area of inter-electrode space but in anodic area H^+ ions flow promotes decay of scale-forming particles passing through it. The latter have positive charge in water because of primary adsorption of calcium ions, which concentration is usually higher than carbonate-ions concentration. Increase of hydroxyl ions concentration, representing counterions, results in decrease of particles electric potential and their coagulation.

At electrotreatment circulating water is passed through the scale-control electric device with insoluble electrodes on which the potential difference larger than thermo-e.m.f. is supplied from continuous current source. Owing to this, practically all scale, which could settle in heat-exchanger, is settled on electrodes [9]. As thermo-e.m.f. value is very small, insignificant voltage is enough to achieve high effect of scale-formation preventing in heat-exchanging devices.

Water treatment by electric field allows refusing application of chemicals for water preparation [10]. Application of this method of water preparation excludes environmental contamination with damaging drains of water preparation installations. Water electrotreatment does not require any bulky constructions, special checking laboratories and does not limit quantity of treated water. This method of water preparation allows efficient protection of heating equipment from scale.

Deposit, isolated at different stages of water preparation may be also used in technologies of valued metals and construction materials extraction.

Water, purified from insoluble, soluble salts and flotoreagents may be further applied in boiler installations or for other productive needs.

The obtained data show the efficiency of complex slime waters conversion technology with a number of valued products obtained from wastes of coal branch enterprises: low-ash concentrate, materials for ore-processing enterprises, construction materials and industrial water.

And, consequently, competitive ability of coal enterprises increases in product market. Coal production, containing rare and valued metals, with deep treatment provides a benefit in more than 2...4 times, than raw coals selling.

Thus, the introduction of the given technology of complex slime water conversion to coal branch enterprises allows increasing environmental safety of these enterprises and their economic efficiency.

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