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Study of Dehydration of Coal-Oil Concentrate

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Abstract

The article concerns the enrichment and dehydration of coal, namely the development of technology for selective oil agglomeration of fine and fine coal. The work is devoted to the study of technological properties of coal-oil concentrate as an object of dewatering. In particular, the dewater ability of coal-oil aggregates of individual structural types was studied on sedimentation and filter centrifuges, drainage, on sieves - an arc sieve, a vibrating screen, a mesh conveyor, in vacuum filters, special methods: the method of mechanical disruption and water. auxiliary method of reinforcing coal-oil aggregates with finely dispersed coal. Based on the research results, recommendations were developed for the use of the studied equipment and technologies for dewatering coal-oil aggregates depending on their structural type.

Keywords: *Coal enrichment and dehydration; Selective oil agglomeration; Coal-oil concentrate; Structure of coal-oil aggregates; Centrifugation; Drainage, screen; Vacuum filtration; Special dehydration methods.*

1. Introduction

A large number of works are devoted to the study of a special process of enrichment and dehydration of finely dispersed coal in a water-hydrocarbon-coal mixture - selective oil agglomeration - mainly by authors from the USA, Germany, Canada, India, Japan, Ukraine and other countries - developers of this technology [1-19]. Some of these publications are thorough reviews [5,16-18], some are devoted to the description of individual versions of the process of selective oil agglomeration of coal [2-4, 6-9], others - to the determination of optimal process parameters [1,10-14]. At the same time, most of the studies are empirical in nature, and only a few are devoted to the development of theoretical models of oil agglomeration of coal [1,16,18]. Studies of the influence of individual factors on the technological characteristics of coal-oil concentrate as an object of hydro transport and coking were studied, in particular, in works [20-22]. Studies of the physical properties of coal-oil concentrate, which significantly determine its technological characteristics, are presented in work [24]. In this case, the classification of coal-oil concentrate is based on the structural features of coal-oil aggregates [1,16,24]. binding between coal grains on the surface of the aggregate; III - drops of binder filled with coal grains; IV - a loose formation (accumulation) of coal grains connected by bridges of a binder [1,24].

A comprehensive study of the technological properties of the identified main types of coal-oil aggregate structures as an object of dehydration, combustion in furnaces, coking, pyrolysis, storage is relevant

The goal of this study is to study the technological properties of individual types of coal-oil concentrate structures as an object of dehydration. The study tasks: study of dehydration of coal-oil concentrate on settling and filter centrifuges; study of dehydration of coal-oil concentrate by drainage; study of dehydration of coal-oil concentrate on sieves; study of dehydration of coal-oil concentrate in vacuum filters, study of dehydration of coal-oil concentrate by special methods: 1 method of mechanical tearing off of water film 2 method of dehydration in organic liquid 3 method of reinforcing coal-oil aggregates

2. Experimental

To obtain coal-oil aggregates of various structural types, coal of the Donetsk coal basin grades G (gas), C (coking), F (fat), RB (ripening-burning) was taken; coal oils and oil products were used as a binder - fuel oil M100 coal charge oiling (CCO) for coking, polymer of benzene production (PBP) of Avdiivka coke and chemical plant. The initial water-coal-oil mixtures (pulps) for selective oil agglomeration of coal were prepared from dry coal or pulps of enrichment apparatuses were used - centrifuge sedimentation underflows, flotation waste. The size of the hard phase of the pulps is from -0.06 mm (centrates), 0.5-0 mm (flotation waste) to 1-0; 2-0 mm (dry coal). The process of pelletizing coal-oil aggregates was carried out on a continuous-action stand unit with turbulent mixing of the water-coal-oil mixture. The process parameters were taken according to the recommendations [1] for each individual structural type of coal-oil concentrate.

The study of the technological properties of individual types of coal-oil concentrate structures as an object of dehydration was carried out on sedimentation and filter centrifuges, drainage, on sieves, on vacuum filters and special methods - ejection (breaking off the surface water film), in organic liquids, reinforcement

In this case, the following centrifuges were used for dehydration:

- Sedimentation industrial centrifuge NORSH-325 operating in the Fr = 2200 mode with a nominal productivity of 6 m^3 h according to the control panel. According to the Fr number, the centrifuge NOGSH-325 is an analogue of Penvolt Super-decanter-centrifuge - IV structural type.
- filter laboratory centrifuge TsLS-3 The thickness of the compacted layer of coal-oil aggregates on the filter mesh with a cell of 0.2 mm was 20 mm. the duration of centrifugation at a given factor Fr - 8 s structural type.

To study the dehydration of coal-oil concentrate by drainage, aggregates of II, III and IV structural types were primarily taken, aggregates (granules) of type II. The pilot plant simulated a layer of material 1.2 m thick and was structurally made of a pipe 1.2 m high with a diameter of 100 m, which rested on a sieve with cells of 0.5 mm. The size of the studied coal-oil units do was 0.75; 1.25; 1.5; 2.0; 3.0 mm, duration of drainage τ_d – 0.15; 0.25; 0.5; 1.5; 10 and 24 hours.

Trial experiments of dehydration coal-oil concentrate on sieves showed a rapid decrease in the live section of the sieve due to sticking of aggregates of type III. Losses of aggregates of type I and IV in the undersize product reach 30 - 60% depending on the granule metric composition and the size of the sieve openings. The experiments were carried out on an arc sieve - an analogue of the one used in the Oliflok process, a 0.5 mm gap, a bending radius of 3 m, a GV-06 vibrating screen and a mesh stand conveyor with a 0.5 mm cell, the length of the working area is 0.5 m.

The study of dehydration of coal-oil concentrate in vacuum filters was carried out on the stand of the Donetsk National Technical University, which simulated the vacuum filtration process with a sieve cell size of 0.1 mm. The vacuum pressure was taken to be 0.6 kg/cm^2 during filtration and clog the sieve of vacuum filters. Therefore, only aggregates of I, II and IV structural types were taken for research, obtained in accordance with coals of size 0 - 1 mm and 0 - 0.1 mm.

The coefficient of specific resistance of the sediment (i.e. resistance per 1 m of sediment thickness, $1/m^2$) [25] and the specific productivity of the vacuum filter for the output coal and agglomerates of the adopted structure were determined.

In the thesis [1] three new original methods of dehydration of coal-oil concentrate are proposed 1 method of mechanical tearing off of water film by ejection 2 method of dehydration in organic liquid 3 method of reinforcing coal-oil units The first two have independent significance third additional technical solution

Dehydration of coal-oil concentrate by mechanical stripping of the water film was implemented and studied on a bench ejector unit (Fig. 1). The object of our research were coal-fuel oil units of I and II types since units of III and IV types are unacceptable due to their plasticity and mechanical fragility, which leads to sticking of the bunker of working chambers and destruction of units. Test conditions air temperature +1°C, +20°C pressure in the receiver - 8 atm air velocity at the section of the ejector nozzle - 102 m/s

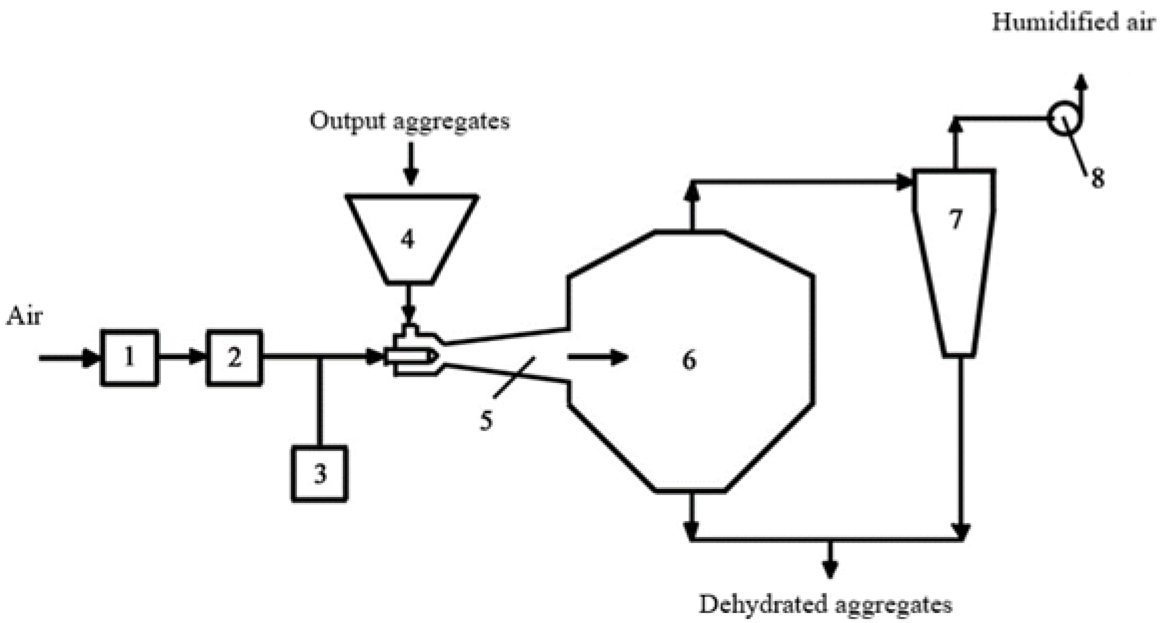

Figure 1 – Stand-alone plant for dehydration coal aggregates by the method of mechanical water film disruption: 1 – compressor; 2 – receiver; 3 – differential manometer; 4 – bunker; 5 – ejector; 6 – hopper for dehydrated product; 7 – cyclone; 8 – fan.

A tank with M100 fuel oil equipped with an electric heater was used to implement the method of dehydrating coal-oil concentrate in organic liquid,. The method of dehydration in organic liquid was developed specifically for type III units, since all other methods are unacceptable for them. liquid by known methods (vacuuming, filtration, etc.) or use it in a mixture with an organic liquid (for example, fuel) To implement the method of reinforcing coal-oil units, type II coal-oil granules in a hydraulic mixture and coal concentrate with a size of 0-100 μm were used. The "reinforcement" process was carried out on a stand-mounted coal-oil concentrate pelletizing unit under pelletizing regime parameters.

3. Results and Discussion

3.1. Study of dehydration of coal-oil concentrate on centrifuges

Deposition centrifuge. The research results (Table 1) show that sedimentation centrifugation effectively dehydrates aggregates of I and IV structural types with a mass fraction of binder Qm = 1-6 wt.%. The moisture content of the cake (centrifuge sediment) depends on the size of the aggregate-forming coal and is within 14-23% The finely dispersed rock fraction with an ash content of 79-86% will be separated into underflow. During the dehydration of type III aggregates, sludge is observed in the centrifuge. Type sedimentation centrifuge work unstable.

Thus, the content of the oil reagent in the initial product, which determines the structure of the aggregates, is decisive for the normal operation of the settling centrifuge. This is obviously due to the oiling of the working surfaces of the centrifuge, which equalizes the frictional forces of the sediment along the spiral of the screw and on the inner surface of the rotor. The settling centrifuge can be recommended for dewatering coal-oil aggregates only I and IV of a structural type with a binder oil content of no more than 5 6%. The obtained research results are confirmed by the practice of selective oil agglomeration of coal - a sedimentation centrifuge is successfully used for dehydration coal-oil concentrate at oil consumption Qm = 1-2 wt% [26], 4-6 wt% [27].

Table 1.The results of dewatering coal-oil concentrate on a sedimentation centrifuge of the NOGSH-325 type.

Raw material in the process of selective oil agglomeration				The obtained carbon oil concentrate				Dehydration products	
Product	Size of the aggregates, mm	Ash, A^d_c, %	Concentration of the aqueous mixture, g/l	A binding substance		Aggregate size	Structural type of aggregates	Cake	Underflow
				Product	Q_m wt%			W, %	A^d, %
Underflow NOGSH-325 Highly volatile coking coal after hydrotransportation for 250 km	- 0,06 98,5%	59,3	100	Fuel oil M100	6	0,2 - 0,3	IV	22,5	85,8
Underflow NOGSH-325 Highly volatile coking coal (Coal "G") Kotlyarevska Ukraine	- 0,06 87,4 %	49,6	100	Coal charge oiling (CCO) for coking	1	0,1 - 0,2	IV	22,0	79,3
Mid volatile coking coal (coal "K") Kuznetsk basin	2 - 0	26,0	600	Polymer from benzene production (PBP)	4	2,2 - 0,2	I	14,8	83,7
Coal „K", Donetsk basin	2 - 0	19,0	450	M100	10	2,5 - 0,7	II	13,9	84,1
Coal "F" Donetsk basin	1 - 0	18,2	350	M100	25	3,0 - 1,8	III	sludge	
Coal „G", Kuznetsk basin	2 - 0	14,1	587	M100	3	2,1 - 0,2	I	17,3	84,4
Bland coal „G" and type II coal-oil aggregates (80:20)	2 - 0	12,5	583	M100	15	1,5	II	20,1	53,8
Coal „ RB ", Donetsk basin	1 - 0	16,8	400	M100	25	3,0 - 1,6	III	sludge	
Flotation waste Avdiivka coke and chemical plant	0,5 - 0	57,0	70	CCO	2	0,2 - 03	IV	21,2	82,4

Filter centrifuge. Trial experiments showed that type III aggregates, even at a relatively small value of Fr = 100, are destroyed and block the sieve openings of the centrifuge, and type IV aggregates are destroyed and to a large extent (up to 40%) turn into underflow. Therefore, only the coal-oil concentrate represented by aggregates I (Qm = 1-6 mass %) and II (Qm = 8, 12, 15 mass%) of structural types Initial coal - grades G 2-0 mm A =1.41%. As for aggregates of type I, their behaviour in the filtering centrifuge is similar to the behaviour of non-agglomerated coal. Thin, non-agglomerated fractions can pass through the sieve cells into underflow. But in general, as shown by studies [28], dehydration of type I aggregates in filter centrifuges is effective. The results of studies of dehydration on a filter centrifuge of type II aggregates are illustrated in Figure 2.

Experimental data show the presence of a well-defined extremum-minimum curve $W^r_t(d_o)$ at d_o = 1.5 mm. The increased moisture content of small aggregates can be explained by a significant amount of surface moisture, and large aggregates by the presence of mechanically trapped (clamped between aggregates) moisture. The degree of destruction of type II granules in a filter centrifuge according to the method of expert assessments for Fr =210, 500, 700, 1500, 2000 warehouse, respectively 0; 5 – 10; 25 – 30; 70 - 80 and 90 - 100% coal-oil units.

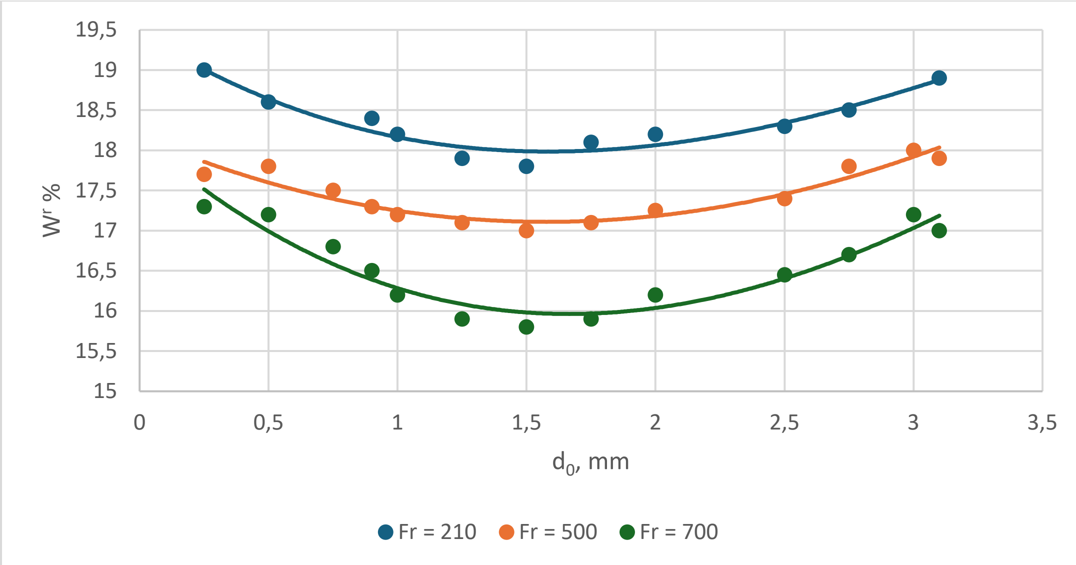

Figure 2. Results of dehydration of type II coal-oil aggregates on the TLS-3 centrifuge: W^r_t - total moisture, %; d_o – diameter of coal-oil aggregates, mm; Fr is the Froude number.

3.2. Study of dehydration of coal-oil concentrate by draining

The results of studies of dehydration of coal-oil concentrate by drainage are illustrated in Figure 3.

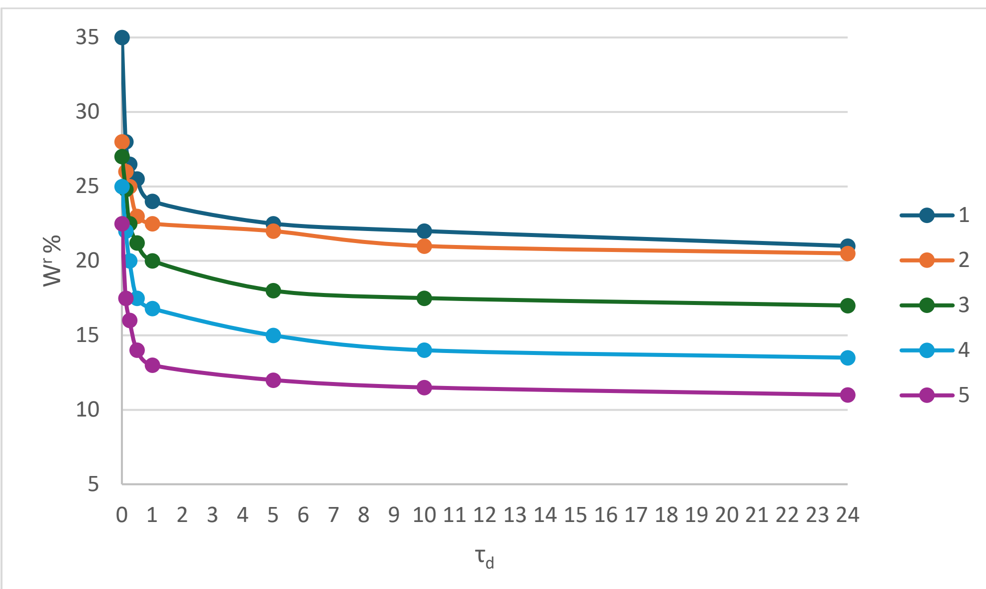

Figure 3. Results of the study of dehydration of type II coal-oil aggregates by drainage. The average size of the aggregates is: 1 – 0.75; 2 – 1.25; 3 – 1.5; 4 – 2.0; 5 – 3.0 mm.

The analysis of the obtained data shows that coal-oil aggregates of 0.75 – 3.0 mm size drain to a moisture content of 22 – 12%. Moreover, drainage is most intensive at the beginning of the process – during the first 30 minutes, 70 – 85% of the moisture is drained from the total amount removed in 24 hours. No moisture accumulation is observed in individual zones of the 1.2 m layer, only for aggregates of d_o=0.75 mm the moisture content of the lower layers is 1-2% higher than the upper ones. Thus, drainage as a method of dehydrating type II granules is quite acceptable.

3.3. Study of dehydration of coal-oil concentrate on sieves

The results of the research (Table 2) show that the moisture content of type II coal-oil aggregates dehydrated on sieves is 1.2-1.7 times higher than when dehydrated in a filter centrifuge (Table 1). In addition, there is oiling of the surface of the sieves, clogging the holes with micro aggregates.

Table 2.Results of dehydration of type II coal-oil units on sieves.

Granule-forming material	Share of M100 fuel oil in aggregates wt%	Moisture % of aggregates during dehydration at		
		arc sieve	vibrating screen	mesh conveyor
Coal	12	21 - 22	19 - 20	21 - 23
0 - 2 mm	15	19 - 20	17 - 18	19 – 20
Underflow	20	23 - 25	21 - 22	23 - 25
NOGSH-325	25	22 - 24	19 - 21	22 - 24

3.4. Research on the removal of carbon-oil concentrate from vacuum filters

The results of the study (Table 3) indicate the high efficiency of watering the carbon-oil concentrate of structural types I and IV on a vacuum filter, which results in the productivity of the filter when watering coal-oil units of type I and IV, when levelled with non-aggregated coal, they will increase by 3 - 6 times at one-hour change in the siege by 3 - 7%.

Table 3. Results of monitoring water-bearing coal and coal-oil aggregates using the vacuum filtration method.

Product	Waste of fuel oil M100, Q_m, wt%	Feeding ratio for support of the sieger r_s, m^{-2}	Pit productivity t/hour m^2	The humidity of the siege, %	Solid content in the underflow ρ_{ws}, g/l
Coal 0 - 01 mm	0	390	0529	303	32
IV type Aggregates with coal 0 - 01 mm	3	056	395	238	1 - 3
Coal 0 - 1 mm	0	697	0676	285	20
I type Aggregates with coal 0 - 1 mm	3	50	232	253	1 - 3
II type Aggregates with coal 0 - 1 mm	10	008	102	307	1 - 3

The filter performance during dehydration of type II units is 30% higher than for coal. But the humidity remains high due to the fact that gravitational moisture is not removed. In this case, the filling of the filter sieve with sediment is not continuous, i.e. dewatering of type II granules. A sharp increase in the vacuum filter performance is obviously due to a sharp drop in the hydraulic resistance of the sediment being assessed by the r_{oc} coefficient. For IV type units, this coefficient, compared to the output coal, decreases by two orders of magnitude (0.56 versus 39.0), and for type I units - by 14 times (5.0 versus 69.7). This is due to an increase in the permeability of the sediment for the aggregated material due to an increase in its porosity. The low hydraulic resistance of the sediment for type II granules is also explained by the lack of formation of the solid sedimentary layer itself. 0 - 1 mm compared to coal 0 - 01 mm is explained by the obviously higher density of grain packing in the sediment layer due to its polydispersity [1].

Thus, for the effective dehydration of coal-oil aggregates of types I and IV, the use of the vacuum filtration method can be recommended.

3.5. Study of dehydration of coal-oil concentrate by the method of mechanical stripping of water film (MSWF)

The results of bench studies of coal-oil concentrate dehydration on the unit in Figure 1 are as follows. The humidity of the units before mechanical moisture stripping was type I – 17.5-20.9%; type II – 18.5%; after breakdown at a working air flow temperature in the ejector of +1°C: type I – 10.7-12.8%; type II – 12.0%. Increasing the air temperature from +1°C to +20°C makes it possible to reduce the humidity of type I units to 9-11%, type II to 10%. At the same time, type II units periodically stick in the mixing chamber of the ejector and the bins for the dehydrated product cake.

Since the humidity of air-dry coal-oil units is within 3-7%, the method of mechanical stripping of the water film is the most effective non-thermal method of dehydrating coal units, which is also confirmed in thesis [29].

3.6. Study of dehydration of coal-oil concentrate in organic liquid (DOL)

To dehydrate type III coal-oil concentrate with a moisture content of 10-12% in a trial experiment, it was placed in a tank with M100 fuel oil equipped with an electric heater. The mixture was heated to 100 °C and stirred with an impeller stirrer for 10-15 minutes. (which is enough to evaporate the moisture present in the mixture), then the mixture was vacuumed on a grid with a mesh of 0.1 mm. The "fuel oil-coal" mixture and vacuum-degreased coal were examined for moisture. It was established that due to the application of heat treatment (in essence, the process is similar to thermal drying), the total moisture content of the M100 aggregates-fuel oil mixture is 1 and 0.5%, respectively, for 10 and 15 minutes. Aging at 100°C Coal sludge - coal degreased by vacuuming has slightly higher moisture content - 2-3%, respectively - obviously due to the internal moisture of the coal. It should be noted that there are no fundamental restrictions on the application of this method to aggregates of all structural types. In terms of the development of research on selective oil agglomeration of coal, an extended study of the dehydration of coal-oil concentrate in different organic liquids, at different heating temperatures, for aggregate-forming coal of different degrees of coalification, size, and structural types of coal-oil units.

3.7. Study of reinforcement of structural type II aggregates

The conducted complex of studies of dehydration of coal-oil aggregates showed that it is significantly hampered by the increased stickiness of the aggregates to the working surfaces of the process equipment - centrifuge sieves, vacuum filters, bunkers.

In a trial experiment, we inserted that with 2-3 minutes of agitation of type II aggregates in a hydraulic mixture with the addition of 5÷10 wt% coal concentrate with a size of 0-100 mm, coal grains stick to the surface of the aggregates. This allows us to significantly improve the technological properties of type II aggregates during dehydration in filter centrifuges on sieves and by the method of mechanical tearing off the water film.

4. Conclusions

Based on the results of the studies, it is recommended to dehydrate type I aggregate structure using a settling or filter centrifuge, a vacuum filter, and the MSWF or DOL methods.
For dehydration of type II coal-oil aggregate structure, it is advisable to use almost all research methods, except for a sedimentation centrifuge and a vacuum filter. Type III coal-oil aggregate structure can be dehydrated only using a DOL. Dehydration of type IV coal-oil aggregates is appropriate to be carried out in a settling centrifuge, a vacuum filter, and using a DOL.

Symbols

G	*grades coal gas,*
C	*grades coal coking,*
F	*grades coal fat,*
RB	*grades coal ripening-burning*
M100	*fuel oil*
CCO	*coal charge oiling,*
PBP	*polymer of benzene production,*
MSWF	*mechanical stripping of water film,*
DOL	*dehydration organic liquid.*

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