

Petroleum coking additive - raw material component for metallurgical coke production.

Part 2. Experimental studies of obtaining a petroleum coking additive

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Petroleum coke is a potential partial replacement of coking coals (being in short supply) in manufacture of metallurgical coke; in Russia and other CIS countries it was entitled as petroleum coking additive (PCA), petroleum coke with output of volatile substances within the range 15–25 %. The second part of the work describes the results of conducted experimental researches in the field of manufacture of petroleum coke additive on the example of use of two kinds of sulfuric petroleum residues of "KINEF" JSC as raw materials: residue of atmospheric distillation and mixture of residues of vacuum distillation and visbreaking. The research was conducted for two temperature procedures within the ranges 455–465 and 475–485 °C. Eight samples of carbon material were obtained as a result of conversion, and influence of input parameters of the coking process on composition and physical-chemical properties of obtained carbon materials was established. Based on content of volatile substances in petroleum coke additive and its group chemical composition, which was determined via extraction method (content of α -, β - and γ -fractions) and via infrared Fourier spectroscopy, assessment and ranging of the eight obtained PCA samples were carried out by their sintering susceptibility. Interpretation of infrared spectra of obtained PCA samples was conducted via comparison with infrared spectra of coking coal, which have identical absorption stripes. Relation between PCA sintering ability and procedure parameters of the coking process was revealed. It was determined that technological process occurring at the less coking temperature 455–465 °C provides high quality PCA forming, otherwise the procedure with higher temperature (475–485 °C).

Key words: petroleum coke, coking coals, petroleum coke additive, delayed coking, metallurgical coke, petroleum residues.

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Introduction and setting the problem

Quality of metallurgical coke together with properties of iron ore agglomerates have substantial effect on blast furnace practice [1, 2] and determines efficiency of cast iron melting as well as blast furnace productivity [3]. The main coke quality parameters, such as CSR and CRI, in their turn, depend directly on charge composition of the coking process [4]. Addition of petroleum coke with output of volatile substances within the range 15–25 % in the charge was widely used at the coke chemical works in Russia and other CIS countries; it was entitled as petroleum coking additive (PCA). It is applied as a partial replacement of coking coals (being in short supply) and have active influence on thermal plastic properties of coking mass in the conditions of laminar coking [5].

The aim of this research is formulated as establishment of relation between the main technological parameters of the process of delayed coking [6–8] and the same important

PCA quality parameters, such as output of volatile substances and group chemical composition (α -, β - and γ -fractions), which characterize indirectly their sintering and binding ability during their addition in coal charge in the process of metallurgical coke manufacture [9].

Materials and methods of research

Two kinds of industrially produced as raw materials of "KINEF" JSC were taken at investigation objects: residue of atmospheric distillation from the unit ELOU-AVT-6 (raw material No. 1) as well as mixture of residues visbreaking from the visbreaking C-3000 unit and residues of vacuum distillation from the unit ELOU-AVT-6 (raw material No. 2); they were taken in mass relation 6.5:3.5 respectively.

The method of delayed coking

To obtain petroleum coke additive from two kinds of heavy petroleum raw materials of "KINEF" JSC, laborato-

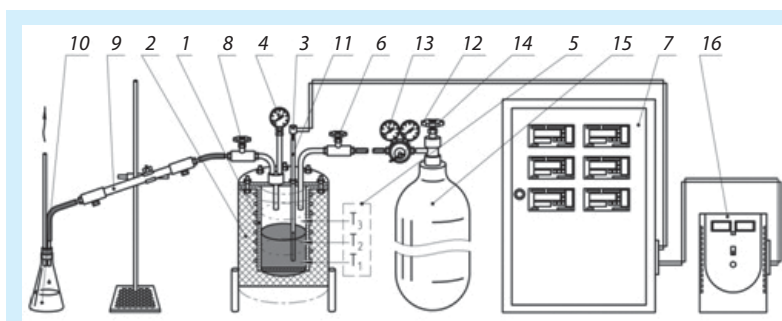


Fig. 1. Process flow chart of the laboratorial delayed coking unit “UZK -1”:

1 – coking reactor; 2 – heat insulator; 3 – thermocouples of the top and bottom layer of the reactor; 4 – reactor pressure gauge; 5 – three heating zones; 6 – pressure test needle valve; 7 – electric control unit; 8 – reactor needle valve; 9 – double-pipe water heat exchanger; 10 – distillate receiver; 11 – thermocouple pocket; 12 – nitrogen reducer; 13 – pressure test pressure gage; 14 – pressure test valve; 15 – nitrogen cylinder for purging and pressure testing; 16 – voltage stabilizer

Table 1. Parameters of technological coking process of raw materials No. 1 and No. 2 at the laboratorial delayed coking unit “UZK-1”

Parameter	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Ex. 8
Raw material	Raw material No. 1 – Atmospheric residue				Raw material No. 2 – Visbreaking and vacuum residues (6.5:3.5)			
Overpressure, MPa	0.15	0.45	0.15	0.45	0.15	0.45	0.15	0.45
Temperature, °C	455-465		475-485		455-465		475-485	
Holding time, min.	60							
Mass of raw materials, g	250							

rial unit for retarding coking “UZK-1” from St. Petersburg mining university was used (Fig. 1).

Both kinds of raw materials (No. 1 and No. 2) were subjected to thermal conversion process with obtaining of carbon material at different coking procedures in two series of experiments. During the first series, PCA was manufactured at the coking temperature 455–465 °C and at excessive pressure 0.15 and 0.45 MPa. During the second series, carbon material was manufactured at the coking temperature 475–485 °C, at excessive pressure also 0.15 and 0.45 MPa. Isothermal conditions at the preset experimental temperature were held during 60 min. The procedure parameters of coking process at the laboratorial unit “UZK-1” are presented in the Table 1.

The method for determination of PCA group chemical composition

Determination of group chemical composition was carried out via consequent extraction of γ -, β -, α_2 -, α_1 -fractions in Soxhlet extractor, using different solvents, and weighing of a mounting with mass

1 ± 0.1 g before the extraction process and after it, in correspondence with ASTM D6560-17 «Standard Test Method for Determination of Asphaltenes (Heptane Insolubles) in Crude Petroleum and Petroleum Products». Mass part of each extracted fraction was determined via the formula (1). Extraction was conducted until complete solvent lightening in the zone of fraction extraction. At the same time, light petroleum was used for segregation of γ -fraction, while toluene, quinoline and residue of extractive extraction were used for segregation of β -, α_2 -, and α_1 -fractions respectively.

$$C = \frac{m_3 - m_1}{m_2 - m_1} \cdot 100 \%, \quad (1)$$

where m_1 — mass of empty filters, g; m_2 — mass of filters with analyzing sample, g; m_3 — mass of filters with residue, g.

The method of infrared Fourier spectroscopy

Infrared Fourier spectra of the PCA samples were shot at infrared Fourier spectrometer Shimadzu IRAffinity-1 [10–12]. PCA samples were mixed with dried KBr and formed under pressure 10 MPa during 2 min in a pellet with mass 500 mg. All spectra were obtained within the range of wave numbers 400–4000 cm^{-1} .

Results and discussion

Influence of procedure parameters on PCA physical-chemical properties

Material balances of the process of delayed coking were obtained on the laboratory unit “UZK-1” for raw materials No. 1 and No. 2 (Table 2).

Influence of pressure and temperature on the output of distillates and carbon material saves the common tendency for use of both kinds of raw materials. However, use of atmospheric residue with large potential of distillate fractions leads to rise of the output of distillates in the case of pressure increase higher than in use of more heavy raw material No. 2, when larger rise of the coke output caused by pressure rise is observed.

The main physical and chemical properties of obtained petroleum carbon materials were determined and presented in the Table 3.

The following regularities were revealed based on the results of determination of physical and chemical properties of carbon materials, which was fabricated from the raw materials No. 1 and No. 2 for different technological parameters (overpressure, temperature):

Table 2. Material balances of delayed coking for raw materials No. 1 and No. 2 on the laboratory unit “UZK-1”

Material balance	Content, wt. %							
	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Ex. 8
Input:								
Raw material 1	100.0	100.0	100.0	100.0	-	-	-	-
Raw material 2	-	-	-	-	100.0	100.0	100.0	100.0
Output:								
Total distillate	66.40	66.40	59.20	66.00	58.00	59.20	66.00	58.00
Carbon material	25.20	25.20	26.80	22.80	25.60	26.80	22.80	25.60
Gas + losses	8.40	8.40	14.00	11.20	16.40	14.00	11.20	16.40
Total:	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 3. Physical and chemical properties of obtained petroleum carbon materials

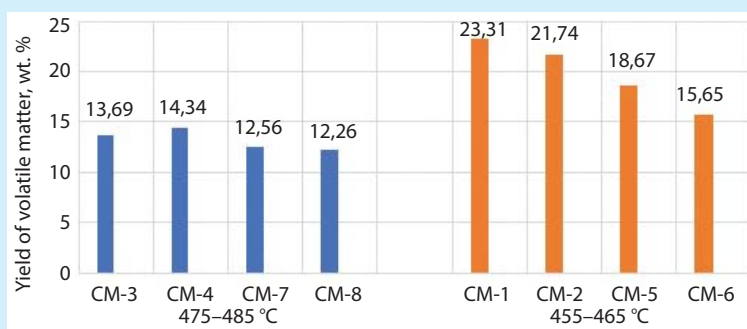
Parameter	Ex. 3	Ex. 4	Ex. 7	Ex. 8	Ex. 1	Ex. 2	Ex. 5	Ex. 6
	CM-3	CM-4	CM-7	CM-8	CM-1	CM-2	CM-5	CM-6
1. Coking parameters:								
Temperature, °C	475-485				455-465			
Overpressure, MPa	0.15	0.45	0.15	0.45	0.15	0.45	0.15	0.45
Raw material	1	1	2	2	1	1	2	2
2. PCA properties:								
Moisture, wt. %	0.35	0.40	0.45	0.30	0.35	0.40	0.40	0.40
Yield of volatile matter, wt. %	13.69	14.34	12.56	12.26	23.31	21.74	18.67	15.65
Ash content, wt. %	0.03	0.04	0.06	0.07	0.04	0.04	0.05	0.06
True density, g/sm ³	1.139	1.262	1.460	1.509	1.113	1.248	1.403	1.477
Microstructure, score	1.1	1.1	1.6	1.6	1.1	1.1	1.6	1.6
Sulfur, wt. %	2.9342	2.7855	3.4261	3.9652	2.9252	2.7657	3.4201	3.9598

- three factors (composition of investigated raw material, pressure and temperature) have the influence on the output of volatile substances in carbon material; PCA parameters, which were obtained from the raw material No. 1, are characterized by more high values of the output of volatile substances in comparison with additives, which were obtained from the raw material No. 2; it is explained by high content of low-boiling components in atmospheric residue – the difference of the outputs of volatile substances in PCA from the raw material No. 2 achieves 6.09 % (mass.);

- lowering of the temperature from 475-485 °C to 455-465 °C allows to increase the output of volatile substances of the samples of petroleum coke additives to 15-25 % (mass.) (see Fig. 2), these values are sufficient for PCA manufacture;

- sulfur content makes from 2.7 to 3.9 % (mass.) in all obtained samples, it can be considered as an increased parameter and required attention during preparing of charge composition, paying attention to preventing of total sulfur content excess comparing with the requirements of standard specifications.

The temperature procedure 475-485 °C with overpressure 0.15 and 0.45 MPa does not provide PCA manufac-

**Fig. 2. Temperature influence on the output of PCA volatile substances**

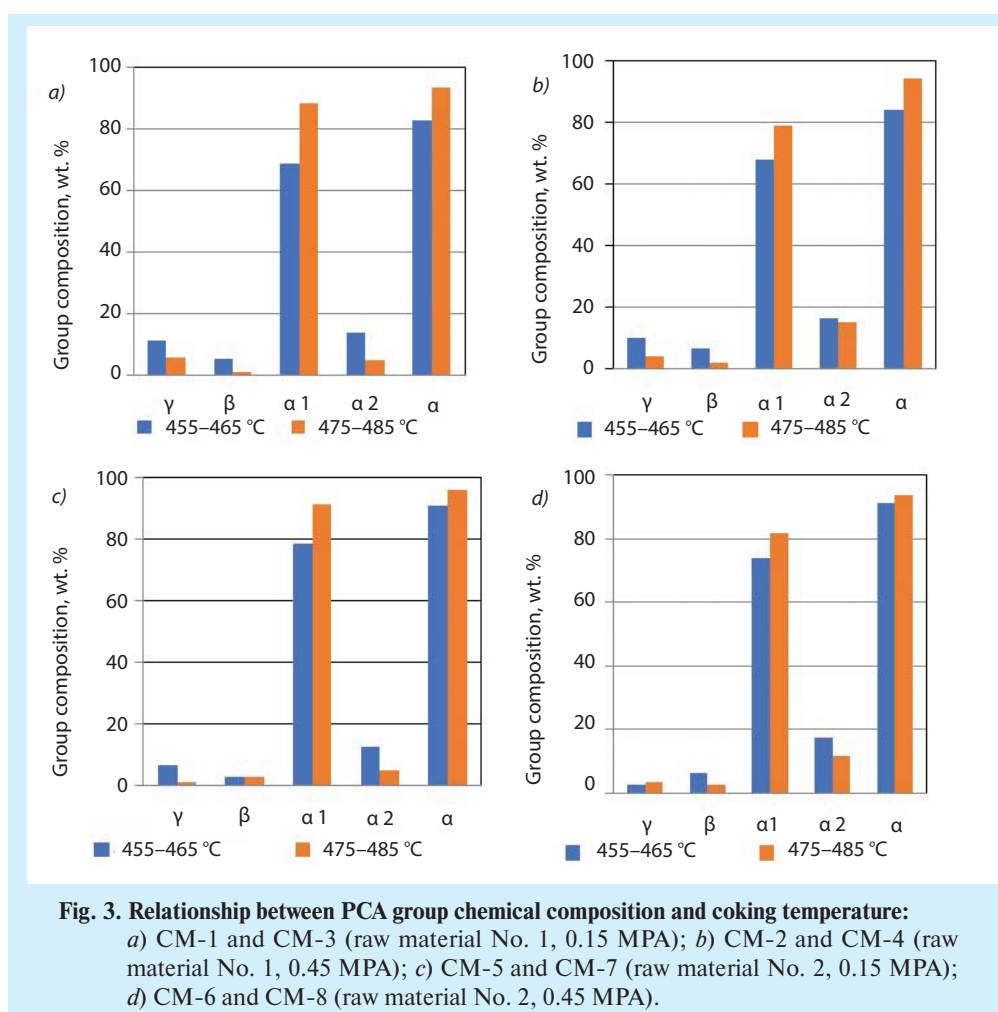
ture with the required quality, according to the technical requirements of TU 0258-229-0019437-2008 for production of petroleum coke additive which is using at coke-chemical plants. It is caused the lowered output of volatile substances in this additive (< 15.0 % (mass.)), what testifies indirectly in its turn on low sintering ability of this carbon material.

PCA group chemical composition

The results of determination of group chemical composition for obtained PCA are presented in the Table 4.

Table 4. PCA group chemical composition

Parameter	CM-1	CM-2	CM-5	CM-6	CM-3	CM-4	CM-7	CM-8
1. Raw material	Raw material 1		Raw material 2		Raw material 1		Raw material 2	
2. Temperature, °C	455-465				475-485			
3. Overpressure, MPa	0.15	0.45	0.15	0.45	0.15	0.45	0.15	0.45
4. Group chemical composition, wt. %								
γ	11.47	9.94	6.51	2.45	5.75	4.08	1.19	3.43
β	5.67	6.31	2.61	6.28	1.07	1.97	2.70	2.83
α_1	68.80	67.63	78.33	73.76	88.02	78.80	91.20	81.94
α_2	14.06	16.13	12.55	17.51	5.16	15.16	4.91	11.81
α	82.86	83.76	90.88	91.27	93.18	93.96	96.11	93.75
Total:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00



Let's consider the samples CM-1, CM-2, CM-5 and CM-6. They were obtained within the temperature range 455–465 °C with varying of raw material composition and pressure from 0.15 to 0.45 MPa. The data presented in the Table 4 testify that the maximal output of α_2 -fraction (17.51 % (mass.)), which is responsible for sintering ability, was observed for the sample CM-6, which was obtained from raw material No. 2 at the temperature 455–465 °C and pressure 0.45 MPa.

Let's also consider the samples CM-3, CM-4, CM-7 and CM-8. They were obtained at the increased temperatures 475–485 °C. It is concluded that the sample CM-4 is characterized by the maximal output of α_2 -fraction, which was obtained from raw material No. 1 at the pressure 0.45 MPa.

Based on the group chemical composition, we can establish that the following operations are most expedient for PCA manufacture with high sintering ability:

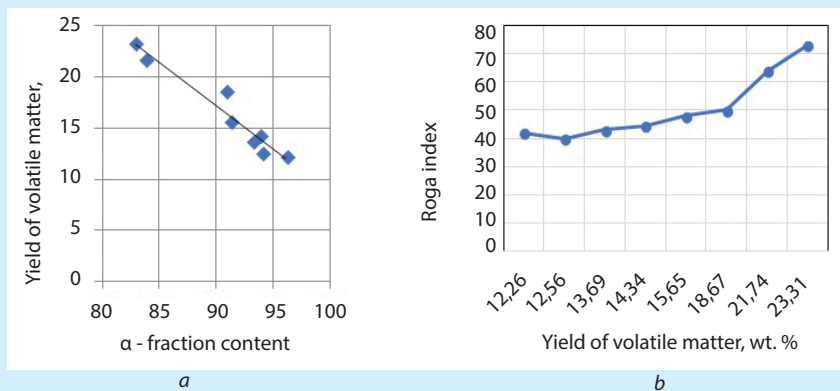


Fig. 4. Relationship between the output of PCA volatile substances and the parameter: a) α -fraction; b) Roga index

- use of heavy mixture of visbreaking and vacuum residue (raw material No. 2), which contains large part of aromatic substances and asphaltenes increasing coking ability of raw material;

- conducting the procedure with overpressure 0.45 MPa for intensification of the processes of stepwise polymerization and compacting with forming of carbenes, having positive effect on PCA sintering properties;

- conducting the operation at more soft temperature procedure 455–465 °C, which provides smaller cracking part with dominating liquid phase compacting of raw material.

Influence of coking temperature and pressure on PCA composition

When coking the raw material No. 1 with the coking temperature from 455–465 °C to 475–485 °C and overpressure 0.45 and 0.15 MPa, the output of α_2 -fraction decreases from 16.13 % to 15.16 % and from 14.06 % to 5.16 % respectively. However, the total output of α -fraction increases. Thereby, increase of the coking temperature leads to elevation of the output of α_1 -fraction (carboids) (see Fig. 3).

Also it can be concluded that all additives obtained at lower coking temperature (455–465 °C) have in all cases the higher output of carbenes (α_2 -fractions), other than for the samples obtained at increase temperature (475–485 °C). This appearance can be explained by the fact that the temperature as a parameter of process adjusting supports not only providing the required thermolysis speed, but also adjusts relationship between the speeds of decomposition and compacting, as well as between the speeds of stepwise polymerization (what is also very important).

Additives of CM-3, CM-4, CM-7 and CM-8 contain essentially less amount of α_2 -fraction because the speeds of destruction and stepwise polymerization reactions increase dramatically at the increased temperatures, consequently, forming of α_1 -fraction (carboids) enlarges, while this fraction has not the required sintering properties. Thereby, the output of α_1 -fraction increases proportionally with temperature rise; decrease of the temperature leads to inverse relationship

of content of α -fractions, i.e. the output of carbenes (α_2 -fraction) increases.

The following regularity was revealed during PCA investigation using extraction of each fraction: as soon as pressure rises from 0.15 to 0.45 MPa, the output of α_2 -fraction increases in all cases. Content of the α_2 -fraction increase slightly by up to 1.5 times with pressure rise from 0.15 to 0.45 MPa for additives obtained at the temperature 455–465 °C, but variation gradient of content of this fraction for additives obtained during coking with the temperature 475–485 °C and pressure 0.45 MPa, was rather

larger (by at least 3 times in several cases).

It was mentioned above that sufficient value of the Roga index (above 50) is reached during the output of the total α -fraction from 30 to 90 % (mass.). The data presented in the Table 4 testify that the additives with numbers CM-1, CM-2, CM-5 and CM-6, which were obtained at the lowered coking temperatures 455–465 °C, achieve up to 91 % (mass.) of α -fraction in their content and meet the technical requirements for additive obtaining with preset sintering properties. The additives CM-3, CM-4, CM-7 and CM-8, which were obtained at increased coking temperatures, exceed allowable limits of α -fraction content and achieve 93–96 % (mass.).

Relation between the output of volatile substances, α -fraction content and Roga index

It can be established based on the obtained experimental data, that increase of the output of the total α -fraction finalizes in practically direct proportional decrease of the output of volatile substances (Fig. 4, a). This fact is explained by forming the substances during coking in the following row: monocyclic aromatics → polycyclic aromatics → resins → asphaltenes → carbenes → carboids. In other words, high total content of carbenes and carboids in PCA testifies about the fact that the output of volatile substances in PCA does not correspond to the minimal allowable value according to the technical specifications (15 % (mass.)).

The values of Roga index were compared with the values of α -fractions in the obtained carbon materials according to the graph presented on the Fig. 4, b. The following direct relationship can be concluded on the base of analysis of the Roga index values and the output of volatile substances: increase of the Roga index (sintering index) leads to increase of the output of volatile substances. It can be seen from the Fig 4 that minimal threshold sintering index is equal to 50 points and it was achieved by CM-5 carbon material, while the value makes 18.67 % (mass.).

Raw material No. 1 (atmospheric residue): the output of α -fractions decreases from 93.96 to 82.86 % (mass.) with increase of the output of volatile substances from

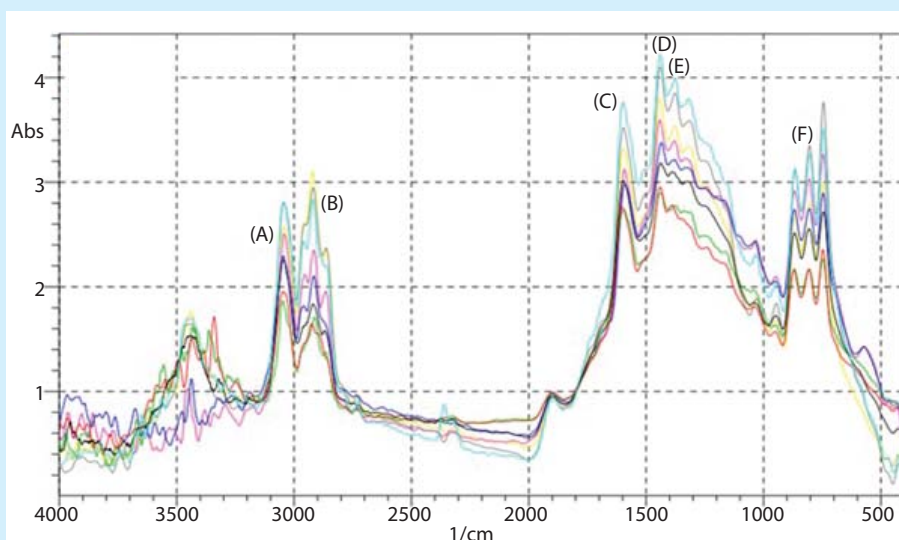


Fig. 5. IR spectra of obtained PCA samples:

— Experience 1, — Experience 2, — Experience 3, — Experience 4,
— Experience 5, — Experience 6, — Experience 7, — Experience 8

Table 5. Parameters of PCA aliphatic and aromatic properties

Index	CM-1	CM-2	CM-5	CM-6	CM-3	CM-4	CM-7	CM-8
A_{aroCH}	317.3465	262.2375	283.2771	311.9942	132.1146	225.0519	185.9032	271.1546
A_{aliCH}	458.0974	368.5022	463.586	383.0146	190.2497	285.1358	252.3137	242.8304
$A_{\text{aroCH}}/A_{\text{aliCH}}$	0.692749	0.711631	0.611056	0.814575	0.694427	0.789280	0.736794	1.116642

13.69 to 23.31 % (mass.), due to decrease of hardly sintering α 1-fraction from 88.02 to 67.63 % (mass.); the output of β -fraction (from 1.07 to 6.31 % (mass.)) and γ -fraction (from 4.08 to 11.47 % (mass.)) increases as well. Raw material No. 2 (mixture of visbreaking residue and vacuum residue with mutual mass relation 6.5:3.5 respectively): increase of the output of volatile substances is connected with observation of similar relationships of variation of PCA group chemical composition (in the same way as for raw material No. 1).

Study of composition of petroleum coke additive via IR spectroscopy

Fig. 5 presents IR spectra of eight obtained PCA samples, which have similar absorption bands. If we compare the obtained eight spectra with IR spectrum of coking coal [13], the following typical reflexes, corresponding to aliphatic and aromatic PCA components, can be underlined: (A) — aromatic CH, CH₃ (3,030-2,950 cm⁻¹), (B) — aliphatic CH, CH₂ и CH₃ (2,920-2,850 cm⁻¹), (C) — oscillations in the aromatic ring (1,600 cm⁻¹), (D) — CH₂ и CH₃ (1,450 cm⁻¹), (E) — groups of CH₃ (1,375 cm⁻¹), (F) — aromatic CH outside the plane (900-700 cm⁻¹) [13].

Petroleum coke additive is characterized by larger intensity in the wave length range 1,000-1,500 cm⁻¹ (the

area of CH₂ and CH₃ oscillations), in comparison with IR spectrum of coking coal. It is caused by the fact that coking additive presents a product of high-temperature conversion of petroleum raw material and contains substantial part of -CH₂, -CH₃ groups in its composition. To provide semi-quantitative assessment of aliphatic and aromatic properties of coking coals, two absorption bands (A) and (B) are used; according to them the relationship $A_{\text{aroCH}}/A_{\text{aliCH}}$ is determined. It characterizes indirectly aromatic properties, plasticity range and reflecting ability of coals [14]. The obtained PCA samples were assessed by identical absorption bands, using calculated $A_{\text{aroCH}}/A_{\text{aliCH}}$ parameter (in the same way as for coking coals). The results of IR spectroscopy are presented in the Table 5.

Based on the obtained values of $A_{\text{aroCH}}/A_{\text{aliCH}}$, we can testify that increase of aromatic properties of PCA samples is observed due to intensification of stepwise polymerization processes in the conditions of pressure rise from 0.15 to 0.45 MPa. The samples CM-3, CM-4, CM-7 and CM-8, which were obtained at more severe thermal conditions (475-485 °C), are characterized by larger $A_{\text{aroCH}}/A_{\text{aliCH}}$ parameters owing to rise of carbonization degree of raw materials at increased temperatures.

Plasticity range, depending on content of aliphatic compounds in carbon material, is an important parameter in assessment of sintering ability for coals or PCA.

Table 6. Ranking of 8 obtained PCA samples for their susceptibility to sintering ability

Parameter *	CM-1	CM-2	CM-5	CM-6	CM-3	CM-4	CM-7	CM-8
1. Raw material	1		2		1		2	
2. Temperature, °C	455-465		455-465		475-485		475-485	
3. Overpressure, MPa	0.15	0.45	0.15	0.45	0.15	0.45	0.15	0.45
4. α_2 -fraction content	14.06	16.13	12.55	17.51	5.16	15.16	4.91	11.81
Sintering tendency according to no 4	4	2	5	1	7	3	8	6
5. Yield of volatile matter, wt. %	23.31	21.74	18.67	15.65	13.69	14.34	12.56	12.26
Sintering tendency according to no 5	1	2	3	4	6	5	7	8
6. $A_{\text{aroCH}}/A_{\text{aliCH}}$	0.6927	0.7116	0.6110	0.8145	0.6944	0.7892	0.7367	1.1166
Sintering tendency according to no 6	2	4	1	7	3	6	5	8
Total sintering tendency	1	2	3	4	6	5	7	8

* Susceptibility for sintering ability is ranking from 1 to 8 (from the best to the worse)

The smaller s coal 9or PCA) aliphatic ability, the smaller is the thermal plasticity range and, consequently, sintering ability of carbon material [15]. Based on this we can assess indirectly that PCA will have larger sintering ability (more wide range of thermal plasticity); these PCA are obtained at lower temperatures (CV-1, CM-2, CM-5 and CM-6), what corresponds with assessment of the output of volatile substances and extractive method for researching the group PCA chemical composition. Additionally, PCA samples obtained at lowered temperatures are characterized not only by high aliphatic ability, but also increased aromatic ability in comparison with the samples obtained at the temperature 475–485 °C. Thereby, IR spectroscopy allows to conclude that the temperature range 455–465 °C for manufacture of petroleum coke additive is preferable.

Ranking of PCA samples for their susceptibility for sintering ability

Based on analysis of the output of volatile substances in petroleum coke additive, content of α_2 -fraction in PCA and interpretation of IR spectroscopy, assessment and ranking of 8 obtained PCA samples for their susceptibility to sintering ability were conducted. The ranking results are presented in the Table 6.

It can be concluded on the base of conducted ranking that susceptibility to PCA sintering ability will be determined by the sum of all parameters, and firstly by such parameter as coking temperature. PCA obtained from more light kind of raw material (raw material No. 1) has smaller susceptibility for sintering at higher coking temperatures (475–485 °C), than PCA obtained from more heavy kind of raw material (raw material No. 2) at lower coking temperatures (455–465 °C). The kind of raw material is considered as the second determining parameter, because more light raw material (raw material No. 1) always has larger susceptibility for sintering in comparison with more heavy kind of raw material (raw material No. 2) for equal temperatures and overpressure of coking. PCA susceptibility for sintering

ability increases with pressure rise from 0.15 to 0.45 MPa, practically in all examined cases with permanent raw materials and coking temperature.

Conclusions

Experimental researches were conducted at the laboratory unit for retarding coking “UZK-1” from St. Petersburg mining university, using petroleum products of “KINEF” JSC as two kinds of heavy petroleum raw materials – atmospheric residue and mixture of vacuum residue (35 % (mass.)) together with visbreaking residue (65 % (mass.)). The samples of petroleum coke additive were obtained during varying two technological coking parameters: temperature (455–465 °C and 475–485 °C) and overpressure (0.15 MPa and 0.45 MPa).

Relationships between varying physical and chemical properties and group chemical composition of petroleum coke additive (from one side) and the main technological parameters of coking of heavy petroleum residues (temperature, overpressure) (from other side) are established:

- the output of carbon material increases slightly with rise of coking pressure from 0.15 to 0.45 MPa, the same effect can be achieved for more “soft” coking conditions (455–465 °C);

- decrease of the temperature from 475–485 °C to 455–465 °C allows to increase the output of volatile substances in the samples of petroleum coke additives to 15–25 % (mass.), what is required for PCA manufacture with sufficient quality. The temperature procedure 475–485 °C with researched pressure from 0.15 to 0.45 MPa does not provide PCA manufacture with required quality, because the additive is characterized by decreased output of volatile substances (< 15.0 % (mass.)), what testifies indirectly about low sintering ability of the additive;

- to provide PCA with high sintering ability, it is mostly favourable to conduct coking process at low temperatures (455–465 °C), increased pressure 0.45 MPa (based on the output of α_2 -fraction), and to use raw material which contain

most part of aromatic substances and asphaltenes, increasing coking ability of raw materials, in its composition. In this work they are presented by visbreaking residue and vacuum residue;

- all additives obtained at lower coking temperature and high pressure, in all cases have more high output of carbenes (α_2 -fractions), unlike the samples obtained at increased temperatures (475–485 °C) and low pressure (0.15 MPa);

- based on ranking of sintering parameters of PCA samples, technological procedure of atmospheric residue thermolysis ($T = 455\text{--}465\text{ °C}$ and $P = 0.45\text{ MPa}$) with obtaining CM-2 sample is considered as the most optimal, because this sample occupies the 2nd position practically for all parameters of indirect assessment of PCA sintering ability. The samples CM-7 and CM-8 occupy the worse position for all parameters of indirect assessment of PCA sintering ability and characterize the most unfavourable procedure of PCA manufacture (475–485 °C);

- based on the technical specification TU 0258-229-0019437-2008 for petroleum coke additive, the sintering index (Roga index) should constitute not less than 50 points. This value is achieved during the output of total α -fraction from 30 to 90 % (mass.). PCA which were obtained from two kinds of raw materials at “soft” coking procedure, contain up to 91 % (mass.) in its composition. The additives obtained at increased coking temperatures exceed allowable limits of α -fraction and achieve 93–96 % (mass.);

- on the base of this research it can be concluded about relationship between the output of volatile substances and group chemical composition: the output of volatile substances for α -fraction content 91 % (mass.) corresponds to minimal allowable value according to the TU 0258-229-0019437-2008.

The method of IR spectra interpretation for petroleum coke additives was developed on the base of adaptation of the method of IR spectra identification of coking coal which has identical absorption bands with PCA. The method was tested on the example of eight PCA samples obtained during the research. Based on the established values of $A_{\text{aroCH}}/A_{\text{aliCH}}$ relationship, it was revealed that PCA have more wide range of thermal plasticity (sintering ability), when they were obtained at the lower coking temperatures (455–465 °C). It correlates with assessment of parameters of the output of volatile substances and the results of group chemical composition, obtained via extractive method.

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