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Environmentally Friendly Technologies Based on Combustion Processes

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Abstract

The paper reviews some technologies basing on Combustion chemistry processes being developed in the Combustion Problems Institute (ICP), there are:

- Obtaining of target products in cool flame hydrocarbon oxidation;
- Catalytic methane combustion;
- Sooting flames as chemical reactors;
- Oil wastes processing into road-building materials;
- Solid phase combustion of oxide systems.

Introduction

Nowadays is a time of high technologies, based on fundamental knowledge. This includes understanding and comprehending of such physical phenomena as combustion, showing improved characteristics of higher energy density, ecological safety and high efficiency. It is observed an ever-increasing tendency to elaborating of combustion process that is very important for power industry.

The applied aspects of hydrocarbon combustion chemistry, based upon the results, obtained by the author and his colleagues in al-Farabi Kazakh National University, are considered in the given paper. Some regularities of natural gas and oil waste (oil-contaminated soils) processing, aimed at the improvement of target product yielding, are considered, concerning particular characteristics of cool-flame oxidation [1] and catalytic combustion [2]. Besides, in the paper there are given the data on sooting flames in combustion processes [3,4] and solid phase combustion of oxide systems.

Obtaining of target products in cool flame hydrocarbon oxidation

The investigation of technological potentialities of low temperature processes, especially of cool flame technologies, is of particular interest, considering the possibilities to reduce power consumption for reactor heating and so to increase reactor service life.

A number of works [5,6] were completed, aimed at investigation of the possibilities to synthesize target products in cool hydrocarbon flames. As it was found in [7], at lower propane conversion degrees the propylene is mainly formed, while the most marked selectivity for propylene is observed in negative temperature coefficient field.

In [1] the comparative analysis of compositions of cool-flame propane and pentane-air mixture oxidation products and those of catalytic method of olefins obtaining [8] was carried out. It results from this, that in conditions of cool flames a more efficient and complete propane conversion is obtained without expensive catalyst application.

In propane oxidation at temperatures exceeding 447°C a higher quantity of ethylene is formed, while in [1] there was shown that further oxidation process results in selective formation of ethylene oxide. In certain conditions the ethylene is not practically consumed and the process of ethylene oxide formation is quite intensive. Thus, it may be assumed that the ethylene consumption is due to ethylene formation from propane. There was stated that with temperature increasing the yield of ethylene oxide is increasing too, while the yield of propylene oxide is decreasing.

Last time the increasing attention is devoted to the synthesis of unsaturated hydrocarbons with over two carbon atoms. The results of comparative analysis, performed from this point of view, with thermal py-

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rolysis of light gasoline fraction, consisting mainly of pentane, which is the most used in petrochemical synthesis that conforms to literature data, are given in the Table 1.

The comparison of reported data [1] shows that in cool flame oxidation the propylene amount is exceeding nearly by twice its yield in thermal pyrolysis, while the ethylene content is being reduced. A more dropping temperature conditions of cool flame make possible to decrease the formation of methane by more than half. Besides, in oxidation conditions the oxygen, containing compounds as methanol and acetaldehyde, are formed.

Thus, while the contact time being substantially more prolonged, compared with that of thermal pyrolysis, the possibility in principle of cool flame use in technology of several target products obtaining is showed. Based on the particular dependencies of compound yields on the varied factors, there is possible to optimize the process under consideration.

Table 1
Major characteristics of thermal pyrolysis and cool flame pentane oxidation.

Conditions	Thermal pyrolysis			Cool flame oxidation		
Inlet temperature or temperature of 1st section (°C)	580	596	598	490	140	165
Outlet temperature (°C)	780	807	830	-	-	-
Temperature of combustion chamber or 2 nd section (°C)	1000	-	1102	350	550	450
Contact time duration (s)	0.5	0.5	0.5	6.7	5.07	5.75
Pentane concentrations in mixture (% mass)	-100	-100	-100	41.6	51.1	18
Oxidation and pyrolysis products (kg/100 kg of reacted fuel):						
Methane	12.1	15.4	17.2	0.6	6.9	3.3
Ethylene	22.9	27.6	29.7	5.9	11.6	8.5
Propylene	18.3	19.1	16.8	34.7	24.7	35.9
Products $\sum C_4$	12.6	11.8	10.0	Traces	Traces	Traces
Butadiene	4.3	5.0	4.9	-	-	-
Pyrolysis gasoline	27.0	18.9	16.7	-	-	-
Boiler fuel	1.3	1.6	2.8	-	-	-
Methanol	-	-	-	24.8	7.6	9.0
Acetaldehyde	-	-	-	11.0	2.7	9.6
Pentene-1	-	-	-	8.8	4.3	9.1
Conversion	-98	-98	-98	41.5	61.3	68.6

Catalytic methane combustion

One of the most promising advanced technologies is the synthesis gas, obtaining in catalytic low-temperature methane combustion [2]. The catalytic activity of cobalt catalyst, prepared in SHS (self-propagating high temperature synthesis) conditions, was studied for methane oxidation process [9]. The initial composition of cobalt catalyst was as follows: 94% Co_3O_4, 6% Al. The temperature range was remained from 400 to 700°C (ratio $CH_4:O_2 = 2:1$, the reactant volume feed rate was equal to 9000 h^{-1}) with 100°C temperature increase stepping. The chromatographic analysis data processing revealed that the major products of methane oxidation conversion on the cobalt SHS catalyst are the following substances: H_2, CO, CO_2 and H_2O.

The reaction of catalytic methane oxidation is running all over the studied temperature range. The methane conversion is being increased from 70% at 400°C temperature up to 98% at 800°C. The hydrogen concentration, increasing with reactor temperature increases, achieves its maximum 55% at 700°C. The carbon oxide concentration also increases with temperature increasing. A more gently sloping section located within 600-700°C temperature intervals, is, evidently, indicating oxidation condition changes on the catalyst surface.

The maximum of water vapor concentrations in the reaction products fells on the 500°C temperature range, while in 500-600°C temperature interval they are sharply decreasing practically down to their constant values equal to 4-4.5% volume. The increase of water content in 400-500°C temperature interval indicates that the processes of more complete catalytic oxidation are proceeded in the above-mentioned temperature range, resulting in formation of substantial amounts of such compounds as CO_2 and H_2O.

As it is well known, H_2 and CO are initial raw materials for synthesis of many organic compounds, *e.g.*, in obtaining of aliphatic hydrocarbons, octosynthesis and hydroformylation of olefins with formation of aldehydes, synthesis of carbonic acids and their derivatives. The diagram of dependencies of $[H_2]/[CO]$ and $([H_2] + [CO])/([H_2O] + [CO_2])$ on the temperature is plotted (Fig. 1) by estimation method. On our opinion, the most preferable temperature is at 700°C range, where $[H_2]/[CO]$ ratio is close to two. From the energetic point of view, a lower temperature down to 600°C is the most suitable.

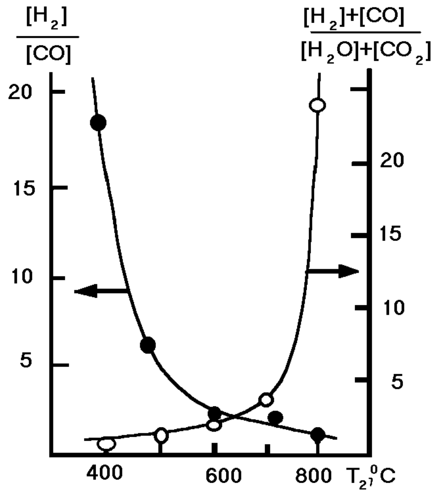


Fig. 1. Dependencies of $[H_2]/[CO]$ and $([H_2] + [CO])/([H_2O] + [CO_2])$ ratios on the temperature of second reactor section.

Sooting flames as chemical reactors

Taking into consideration that the problem of hydrocarbon recovery became today critical issue for gas and oil industry not only in Kazakhstan but also all over the world, the authors of this paper pay especial attention to some aspects of crude hydrocarbon processing, *e.g.*, sooting flames and industrial applications of combustion technologies.

As it is known, the high-temperature conditions of crude hydrocarbon processing result in carbon black formation, while these is a region of low-temperature soot-formation flames. It should be underlined that in this technological reaction zone both the soot particles and polycyclic aromatic hydrocarbons (PAH) are available as combustion products [10,11].

The gravimetric analysis of soot samples, obtained at low temperature, showed the carbon, hydrogen and oxygen contents as 90.06, 3.17 and 6.77% respectively. It was found that the carbon concentrations in the soot, obtained at high temperature, are usually 96-99%. Carbon balance was calculated, based on the results of chromatography and obtained soot masses. Total methane conversion is 93-95%, while its conversion into solid carbon product (soot) is up to 25%. From chromatography data it is following that the extract contains up to 70% of polyaromatic hydrocarbons, up to 17% of resin, 10-11% of asphaltenes and 1-2% of paraffin and naphthene hydrocarbons.

PAH formation in low-temperature soot flames

The data on extraction of soot, formed from a flame of methane and propane, are given in Table 2. From which it is visible, that if the greatest quantity PAH in methane soot is equal 22.31%, in propane soot it is equal 50.25%.

Besides, from the Table 2 it is visible that the reactor temperature, when the maximum content of PAH is observed, was lowered on 373°C at significant decreasing of T_1 at transition from a methane flame to a propane flame. The considered data allow to assume that in a regime of low temperature methane and propane combustion the precursors of soot are PAH.

During extraction of received soot it is revealed that from 20 to 50% of substance transmit in an extract.

The analysis of soot extracts is carried out by IR- and UV-spectroscopic methods. Such compounds are rather reliably identified, as anthracene, anthantrene,

Table 2
Data on extraction of soot, fond from a flame of methane and propane.

	Feed rate of O_2, cm^3/min	T_1, °C	T_2, °C	Dry residue mass, mg	Dry extract yield, %
Methane	1150	550	600	223.1	22.31
	1150	550	700	214.0	21.40
	1150	550	750	177.4	17.74
	1400	25	25	301.5	30.15
Propane	2450	150	500	502.5	50.25
	2450	150	600	410.2	41.02
	2450	150	700	220.0	22.00

1-12-benzpyrelene, pyrene, coronene, phluorantene, and also in spectra of absorption there is a number of bands, which identification is difficult (Table 3). *I.e.* in extracts of received soot there is mixture of various polyaromatic compounds, which ratio depends on conditions of obtaining of soot.

The fluorescence spectra of solution of soot extract in iso-octane (λ_{exc}=294 and 405 nm) are taken.

Table 3
PAH identified in soot extracts of low temperature propane combustion.

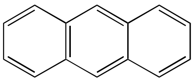
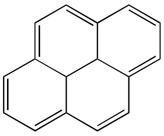
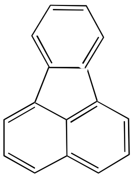
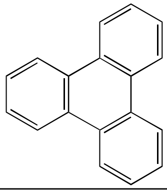
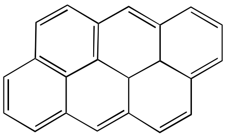
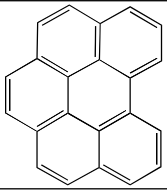
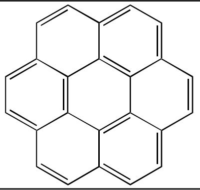
PAH	Structural formula	Molecular weight
Anthracene $C_{14}H_{10}$		178
Pyrene $C_{16}H_{10}$		202
Fluoranthene $C_{16}H_{10}$		202
Triphenylene $C_{18}H_{12}$		228
Anthanthrene $C_{22}H_{12}$		264

Table 3
Continued

PAH	Structural formula	Molecular weight
1.12-benzperylene $C_{22}H_{12}$		264
Coronene $C_{24}H_{12}$		288

In fluorescence spectra (Fig. 2) the intensive bands with a precise oscillatory structure and main maximums are observed at 429, 456, 487 and 510 nm. The quantum output of observable fluorescence is close to 0.3. The reference of fluorescence bands to individual compounds is difficult, as in a solution there is a mixture of polyaromatic products. Nevertheless, it is possible to assume that in soot formation process there is a synthesis of polyaromatic luminophors has high quantum fluorescence outputs in blue and green area of a spectrum.

Soot formation in electric field [4]

Dependence of soot yield on applied potential for the first series (curves 1 and 2) and the second (curve 3) series of experiments is shown in Fig. 3. A decrease in soot yield from 11.2% (without potential) to 3% (at 2.2 kV) occurs at application of positive potential to the upper electrode (relatively to the lower one) (Fig 3a, curve 2). There is a greater decrease in soot yield, when the upper electrode is charged positively relatively to the lower one (Fig. 3a, curve 1).

In the second series of experiments (Fig. 3a, curve 3) it was observed two times decrease in soot yield even at 0.1 kV under similar conditions, obtained without field application. Further increase in potential causes negligible decrease in soot yield. According to data of electronic microscopy, the radius of soot particles, obtained at methane combustion in electric field of different strength, depends also on the value of applied potential (Fig. 3b). It is worth noting that particle size value spread decreases with an increase in field strength; more homogeneous soot forms.

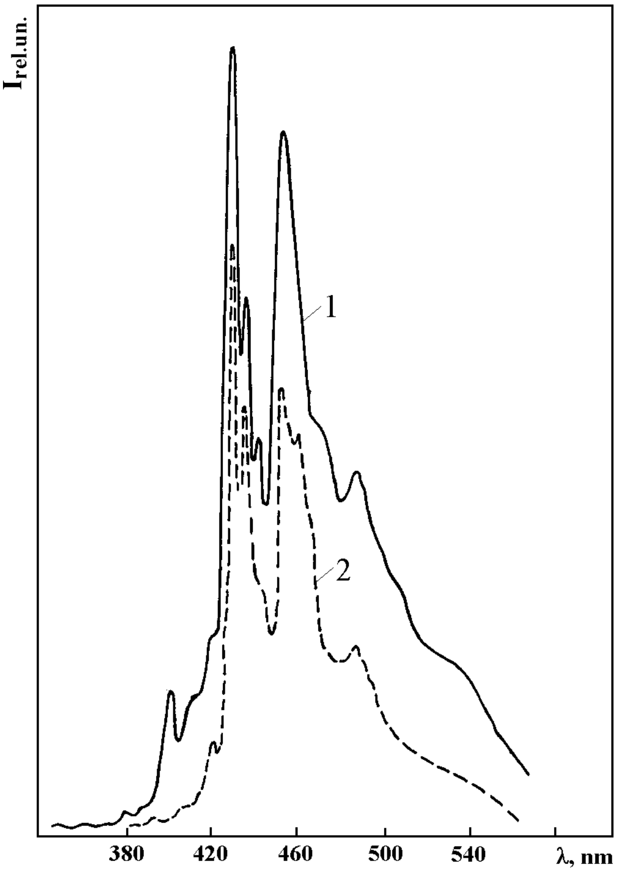


Fig. 2. Fluorescense spectra of a solution of soot extract (solvent - iso-octane): 1 - at $\lambda_{exc.}$= 340 nm, 2 - at $\lambda_{exc.}$= 405 nm.

When the electric field direction speeds up positively charged particles a decrease in interplanar d_{002} occurs in obtained soot (Table 4). For example, value of d_{002} is equal to 3.50 Å at 2.2 kV, but at application of field with inverse polarity the change in interplanar distance is negligible (d_{002} = 3.57 Å).

In the second series of experiments, as it can be

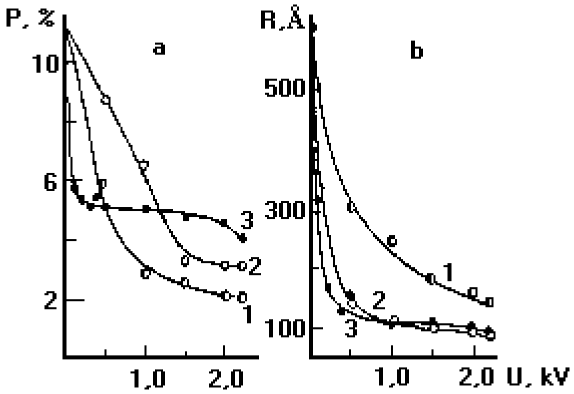


Fig. 3. Dependence of soot yield P (a) and soot particle size (b) on the applied potential value at polarity on the electrodes: 1 - ∓; 2 - ±; 3 - ∓ (distance between the electrodes of 90 mm for 1 and 2, 205 mm for 3).

Table 4

Roentgenostructural characteristics of soots under electrical field effect.

U, kV	Electrodes polarity	Quantity of formed soot, %	d_{002} , Å
The field series of experiments			
	-	11.21	3.58
0.5	∓	5.9	3.52
1.0	∓	4.01	3.52
1.5	∓	2.64	3.52
2.0	∓	2.02	3.52
2.2	∓	2.02	3.50
0.5	±	8.82	3.57
1.0	±	6.62	3.57
1.5	±	3.06	3.57
2.0	±	3.03	3.57
2.2	±	3.00	3.57
The seconds series of experiments			
		11.21	3.58
0.1	∓	5.7	3.575
0.2	∓	5.6	3.55
0.3	∓	5.2	3.54
0.4	∓	5.5	3.52
0.5	∓	5.3	3.52
1.0	∓	5.0	3.52
1.5	∓	4.6	3.52
2.0	∓	4.5	3.52
2.2	∓	3.8	3.52

seen from the table, a decrease in d_{002} from 3.58 to 3.52 Å was observed at an increase in U from 0 to 0.4 kV.

The qualitative explanation of observed phenomena may be made using conceptions on the electric influence on soot forming flame due to the presence of charged particles in it [4,12]. Thermoionization processes in large hydrocarbon molecules and processes of charge exchange between a soot particle and the surrounding it cloud of other charged particles determine such influence.

In case of electric field application in the way, when the positive electrode is situated below, formed soot particle are charged under thermal electron emission effect and, having got the positive charge, are speed up by the external field. Due to faster passing through the combustion zone, they don't have enough time to grow to the sizes, which are typical for the particles, formed at the absence of field; it results in decrease in soot weight. This direction of electric field has an influence on the earliest stages of soot particle formation; it is confirmed by the first discovered change in interplanar distance d_{002}.

In case of an opposite direction of electric field (positive electrode is above) soot particles are trapped by the field in the negative charge area. At the simultaneous effect of thermal electron emission and recharging the latter it is the prevailing mechanism of charge obtaining. And soot particles, formed in the positive charge area and charged positively, are recharged and speed up by external electric field after negative charge area passing.

Oil wastes processing into road-building materials

Oil-gas field takes a leading place in the economy of the Republic of Kazakhstan. Every year the volume of extracted and transported oil is increasing. The intensive development of oil-gas industry is resulting in very grave ecological consequences. At present all processes, involving oil processing are impending danger for the ecology. The oil industry encounters the paramount problem of oil waste utilization accumulated and stored by refineries. The considerable pollution of ground and water by drilling sludge, containing the hydrocarbons, heavy metals and polymers, is resulting of the drilling rigs. The oil spills during its mining cause numerous negative phenomena resulting in soil corrosion. The pipeline failures cause the enormous oil losses and oil contamination of areas [13,14].

The oil sludge resulted of oil waste processing, stable nondistruct emulsions production, reservoirs scarfing, agents discharges and other oil mining and processing operations should be unloaded into the special waste storage precipitators. Besides that, the oil recovered from the sewer systems, oil pumps (with soil) pipeline failures is discharged into these storage precipitators.

In this connection, the work is aimed to study compositions and properties of oil waste and to work out ways of processing and further utilization.

Extraction and thermal methods carried out the extraction of organic fraction from oil waste. Besides, the extraction of organic fractions from oil waste was carried out on the stationary laboratory unit of thermal processing [13]. The component group composition of extracted oil was determined by the adsorptive chromatography method. The performance parameters of obtained bitumen and asphalt concrete were determined by the standard methods.

The objects of study were oil sludges, constituted of oil reservoir scarfings, and oil contaminated soils from the oil storages with oil spills recovered on the failures of the main oil pipeline Zhetybai – Uzen – Atyrau. The physical and chemical characteristics and component compositions of these sludges are presented in Table 5.

Table 5

Physical and chemical characteristics and component compositions of oil waste.

Characteristics	Oil wastes	
	oil sludge	oil contaminated soil
Density (kg/m^3)	1260	1665
Component composition (mass %):		
Organic fraction	81.8	23.6
Water	10.2	1.2
Mineral fraction	8.0	75.2
Congelation temperature, °C	+ 40	+ 36

81.8 mass % of organic substance are extracted from oil sludge and 23.6 mass % - from the oil contaminated soil by extraction method as it is evident from the Table 5. The oil sludge content of water is 10.2 mass %, while the contaminated soil contains only 1.2 mass % of water. The main fraction of contaminated soil is constituted by mechanical impurities (75.2 mass %), while their content in oil sludge is negligible.

The oil, extracted from oil sludge, contains the paraffin-naphtene (40.84%), aromatic hydrocarbons (26.08%). The significant content prevailing of petroleum-benzene tars (11.46%) over benzene and spirit-benzene tars (4.33 and 4.53% respectively) is typical for the oils. The asphaltene content is 12.76%. Thus, the oil, extracted from oil sludge by extraction, differs from usual oils by high paraffin, asphaltic-tarry substance contents that makes processing of such raw materials quite difficult.

The negligible oil content of paraffin-naphtenes (6.49%) and higher aromatics (28.12%) represents organic fraction of the oil-contaminated soil. In comparison with oil from oil sludge, the quantity of tars is very high: petroleum-benzene – 35.80 %, spirit-benzene – 14.57%, benzene – 3.09%. The asphaltene content is 11.91%. So, the hydrocarbon phase of composition of contaminated soil may be classified as high tarry oil.

There was prepared asphalt mixture with following component ratio: 40-46% mass of solid residue with 15-20 mass % of oil product retained in the cold state were mixed with 30% of mass of natural sand and 20-26% of mass Cockle-shell dust. The Cockle-shell dust is used as mineral filler of the mixture. Then it was stirred within 15 minutes till obtaining of homogeneous viscous mass.

The physical and mechanical properties of asphalt mixtures are shown in Table 6. From comparative analysis of the data of Table 6 it is evident that physical and mechanical characteristics of asphalt mixtures meet the requirements of State standard 9128-84 [14]. In the beginning the oil residues have diluting effect on the used bitumen and with time in result of oxidation in the open air and bitumen viscosity increasing the strength of asphalt cover increases. The advantage of asphalt mixture is its low cost and homogeneity, achieved through natural sand, oil waste and other local materials use to produce cheapest asphalt concrete. Scarce rocky material is not necessary for asphalt concrete production and the quantity of bitumen additions is substantially reduced.

This investigation confirm that the production about the purposive of bitumen and asphalt concrete from oil waste and other harmful substances, contained in waste, is the most promising and economically efficient way to convert them into valuable

Table 6
Physics-mechanical characteristics asphalt concrete.

Physical and mechanical properties	Mixture		State standard
	1	2	9128-84
Specific weight, g/cm^3	2.18	2.20	-
Water saturation, vol.%	5.4	5.0	5.0 - 9.0
Swelling, vol.%	0.6	0.4	maximum 2.0
Ultimate strength at compression at 20°C, kgs/cm^2	12.2	12.4	minimum 12
Water resistance coefficient	0.62	0.63	minimum 0.60

and ecologically safe products.

Solid phase combustion of oxide systems

The physical and chemical bases and macro-kinetic regularities of alumothermal solid-phase combustion of oxide systems in conditions of self-propagating high-temperature synthesis (SHS) have been considered [15].

The obtained results enabled to elaborate new refractory materials as alumo-silicate and magnesium SHS mortars. There is shown that the SHS mortars are superior to ordinary refractory mortars and refractory powders in their physical, mechanical and heat characteristics. The technical characteristics of industrial SHS refractory materials of «Furnon» family and their applications have been specified. Some results of «Furnon» SHS-mortars applications as brickwork mortars in repairs of thermal units showing increase in lining strength by 1.5-2 times have been presented.

Now many divers combined processes on the SHS base are developed. One of the most promising scientific research trends, currently got its notable elaboration, is a combination of SHS and thermodynamics. High temperatures and thermal effects characterize the metallothermal oxidation-reduction reactions proceeding in combustion waves. The synthesis temperatures reach up to 1600-3000°C. At such temperatures refractory oxide compounds and salts, being of practical interest, as refractory materials are formed. For the first time the possibility of refractory materials and products, obtaining by SHS method, was proved in. The systematic investigations of solid-phase metallothermal combustion of oxide systems, aimed at elaborating of new technology of refractory materials production, were completed in the Combustion Problems Institute and were headed by G.I. Ksandopulo and M.B. Ismailov [16].

«FURNON» SHS-refractory materials

The simplest refractory materials are mortars, *i.e.* refractory masonry mortars. As a rule the mortars are composed of two components: finely milled refractory filler and binder. The mortars have lower refractory and strength characteristics, compared with bricks that results in accelerated joint wearing during refractory lining service, being associated with brick splitting-off and falling-out.

The “FURNON” refractory materials are elaborated and produced by the Combustion Problems Institute, using SHS technology [15,16]. The «FURNON» SHS refractory mortars are water soluble powder. The solid phase combustion of properly prepared exothermal mixtures results in reaction products being mixtures used in brick works as masonry mortars or protection coatings of thermal unit linings. Usually, aluminum is used in exothermal mixture as a reducer, while the ore concentrates, clays, natural and manufactured refractory materials, mining and processing production wastes, being used as fillers refractory materials: alumo-silicate, magnesial, chrome-magnesite and high-carbon products even if source materials weren’t such ones. Combustion temperatures up to 1600-2000°C and combustion rate up to 1 mm/s characterize the «FURNON» SHS mortars.

The experience in industrial applications of SHS refractory materials proves that 1 ton of SHS mortar used as a masonry mortar makes available savings up to 10 - 12 brick tons only through increase in unit service life. The results of «FURNON» mortar applications are given in the Table 7. The economical expediency of SHS refractory applications in specific enterprises is determined by numerous factors, *i.e.* output of basic production, financial positions of the enterprise, operation conditions of fuel unit, availability of similar material *etc*. The achieved results and available experience evidence that the SHS refractory applications are very wide and their potentialities are so far from being up.

The high temperatures and huge heat release in SHS process make achievable the effective synthesis, sintering and structure formation of refractory compounds, such as corundum, mullite-corundum, spinels, carbides *etc*. The lining heating up to 750-1100°C temperature on the working surface of thermal unit results in self-ignition of joints burning down to 45-50% lining depth in case of vertical joints. The combustion wave is extinguished from the back of the lining due to heating temperature decrease and heat loss increase in the brick works. The unique property of the «FURNON» mortars is manifested by effect of brick-works «welding» in single whole monolith. This effect due to the fact that SHS process results not only in the joint material synthesis, but also in chemical interactions between joint material and brick.

So, the «FURNON» mortars are gained in operating characteristics through heating process of thermal unit and reaching operation conditions. The abovementioned effects provide high technological adaptability of SHS mortars to be applied as masonry mortars. At the same time, the «FURNON» SHS mortars yielding to no one of the best traditional high-alumina and magnesial mortars in refractoriness rates, they prove their superiority over them in high temperature strength of brick binding. At 1000°C temperature the binding strength of usual mortars achieves 5-7 MPa, while the same feature of the «FURNON» mortars being up to 12 - 15 MPa.

Within the study of mineral feedstock over-carbonisation processes during thermocatalytical pyrolysis, a possibility of carbon-containing refractory materials production that can be applied in metallurgy has been investigated. Obtained materials may be used in the production refractories and others also, including the SHS technology. Produced SHS-refractory materials with the addition of carbonised chromite sludge contain metals carbides and elementary carbon and they have better operational characteristics than other similar refractory materials [17].

Earlier it has been determined that thermocatalytic pyrolysis of hydrocarbons on mineral feedstock leads to the formation of carbon fibres of various morphology and structure and with typical properties and physical-mechanical parameters. In this connection, application of carbon-and-mineral compositions as refractories was actual. The application of chromite sludge from Donskoi Miming Plant (GOK) was used as a mineral component of mining industry wastes.

In the course of carburisation the carbon is accumulated both in the pores of the material and on its surface in the form of fibrous carbon with graphitised structure. Also, the results of electronic microscopy, X-ray phase analysis, micro-diffraction and electron paramagnetic resonance spectroscopy have identified the presence of metal carbides such as Cr_3C_2, Cr_7C_3 *etc*. in the material. It is interesting that chromium oxide CrO_3 - a toxic compound – is absent in over-carbonised products.

Obtained over-carbonised sludge is important as one of SHS-refractory blend component. In accordance with research, conducted at the Russian Academy of Science, Institute of Structural Macrokinetics (ISMAS), when a combustion wave goes through

Table 7

Major results in "FURNON" mortar applications.

Brand	Applications	Results
FURNON-3ChP	Threshold, cooling and sintering zones of rotary kilns	Increase of threshold and cooling zone service life as much as by 2-3 times and sintering zone - by 1.2-2 times
FURNON-3	Walls of syphon-pour steel-teeming ladle Chamotte zone of refractory clay roasting rotary	Increase in service life of 3-tons ladles lining as much as by 3 limes and of 16 tons ladles by 1-4 times
FURNON-7	Hot zone of roasting rotary kilns	Increase of lining service life as much as by1.8-2 times
FURNON-7Ch	Cold zone of roasting rotary kilns	Increase of lining service life as much as 1.8-2

carbon-containing components and graphite and mineral components, due to favourable conditions, the metals carbides constituting mineral raw materials are being formed.

Due to very high dispersity of formed carbon it's sufficiently reactive to participate in carbide forming reactions. This results in a composite material, framed with mineral compounds such as spinels, carbides and oxides and space between them filled with carbon. Evidently, carbon-containing components of refractory materials are inert to slag and metal melts substantially slow down destruction. Besides, decrease in porosity leads to better strength characteristics. The SHS refractory mortars are new generation of refractory materials, differing in principles of the traditional ones, obtained by «furnace» technology. They are notable for practically complete synthesis of working ceramic body at heating stages of linings through internal energy of components.

Conclusions

The applied technological aspects of hydrocarbons combustion chemistry have been considered on the base of literature data and primary author's investigation results.

It was studied nonisothermal butane and pentane-air cool flames, aimed at obtaining olefins and oxicompounds, as well as catalytic methane combustion and low-temperature methane combustion in sooting regime, the combustion parameters being varied in wide limits. High efficient technology of oil-contaminated soils, processing into valuable products, *i.e.* cool asphalts, has been elaborated and implemented.

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