AMERICAN SCIENTIFIC JOURNAL

American Scientific Journal
№ 6 (6) / 2016

Layout man: Mark O'Donovan
Layout: Catherine Johnson

Address: 90 st. – Elmhurst AV, Queens, NY, United States
Web-site: http://american-science.com
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Copies: 1000 copies.
Printed in 90 st. – Elmhurst AV, Queens, NY, United States

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LIFE SCIENCES.

ENVIRONMENTAL SCIENCE.

УДК 504.05:62/69

СОСТОЯНИЕ ЗООПЛАНКТОНА В РАЙОНЕ ЗАЛИВА ТЮБ-КАРАГАН

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Аннотация. В работе приводятся результаты исследования за состоянием зоопланктона в районе залива Тюб - Караган по сезонам 2014 г. Путем исследования установлено, что средние значения численности зоопланктона за исследованный период возрастали от зимы к лету, и понизились к осени. Средние значения биомассы возрастали от зимы к осени.

Ключевые слова: Каспийское море, залив Тюб - Караган, зоопланктон

STATE OF ZOOPLANKTON IN THE GULF TUB - KARAGAN

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Abstract. Results of a research behind a condition of zooplankton near the gulf Tub-Karagan on seasons of 2014 are given in work. By a research it is established that average values of number of zooplankton for the studied period increased from winter by summer, and have gone down by fall. Average values of biomass increased from winter by fall.

Keywords: The Caspian Sea, the Gulf of Tub-Karagan, zooplankton

ВВЕДЕНИЕ

Залив Тюб-Караган расположен в Среднем Каспии, в 40 км от порта Баутино. Глубина моря в районе исследований около 8 метров. Сейсмические работы, проведенные в конце XX и начале XXI века, над солевом горизонте прогнозировали наличие углеводородного сырья, но результаты разведочных буровых работ опровергли прогноз.

Нами, в процессе проведения сейсмических работ в сентябре месяце, и после проведения их в октябре, было исследовано состояние гидробиологического сообщества в данном районе моря [1-4]. Были обнаружены основные три вида зоопланктона: коловратки, ветвистоусые и веслоногие рачки, причем в сентябре общая численность варьировала от 5567,7 – 7248,15 экз/м^3, в октябре от 5265,0 – 7862,4 экз/м^3, а биомасса в сентябре изменилась в пределах 0,537 – 0,980 мг/м^3, в октябре 0,601 – 0,899 мг/м^3. Основную массовую долю составляли веслоногие 38,1% и ветвистоусые рачки 38,3%.

В исследуемом районе Тюб-Караган, [5] по численности преобладали веслоногие рачки, их средняя численность составляла: в 2010 г. – 3866 мг/м^3, в 2011г. – 19541 мг/м^3, в 2012 г. – 8207 мг/м^3, по численности [6] в 2011 г. также имели преимущество веслоногие рачки, как в летний период, так и в осенних исследованиях 98 и 2026.3 мг/м^3 соответственно.

По нашему мнению нефтепоисковые работы на этом не завершатся, т.к. на шельфе Каспийского моря открыты перспективные нефтяные структуры, в связи с этим в данном районе необходимо проводить съемку фонового состояния гидробионтов.

ОБЪЕКТ И МЕТОДЫ ИССЛЕДОВАНИЯ

Объектом исследования выбран район Тюб-Караганского залива.

Пробы зоопланктона отбирались из поверхностного слоя воды сетью Апштейна и фиксировались 4% формалином. Затем они концентрировались осадочным методом.

В лабораторных условиях пробы обрабатывались по общепринятым методикам [7 -9]; определялись таксономический состав, численность (экз. на 1 м^3) и биомасса (мг. на 1 м^3) зоопланктонов.

РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ

Пробы воды для исследования отбирались с 9 наблюдательных станций, три с северной, три с восточной и три с северо-восточной стороны [10].

Видовой состав зоопланктонов приводится в таблице 1. Из таблицы видно, что в зимний и весенний период исследования, преобладали веслоногие рачки, а в летний и в осенний период прочие виды.

Таблица 1. Видовой состав зоопланктона по сезонам 2016 г.

№	Видовой состав	Количество видов			
		Зима	Весна	Лето	Осень
1	Коловратки	3	3	3	4
2	Ветвистоусые рачки	-	-	2	-
3	Веслоно́гие рачки	7	6	7	3
4	Прочие	3	4	9	5
5	Всего	10	13	21	13

На рисунках1 и 2 представлены численность и биомасса.

Из рисунка 1 видно, что по численности преобладают веслоногие – 48,87 %, на втором месте прочие виды – 26,43%, затем коловратки – 14,43 %, а ветвистоусые в наименьшем составе всего – 10,25 %.

На рисунке 2 по биомассе преобладают прочие виды – 78%, затем ветвистоусые – 14,01%, на третьем месте веслоногие – 6,91 %, а коловраток было в составе всего – 0,55 %.

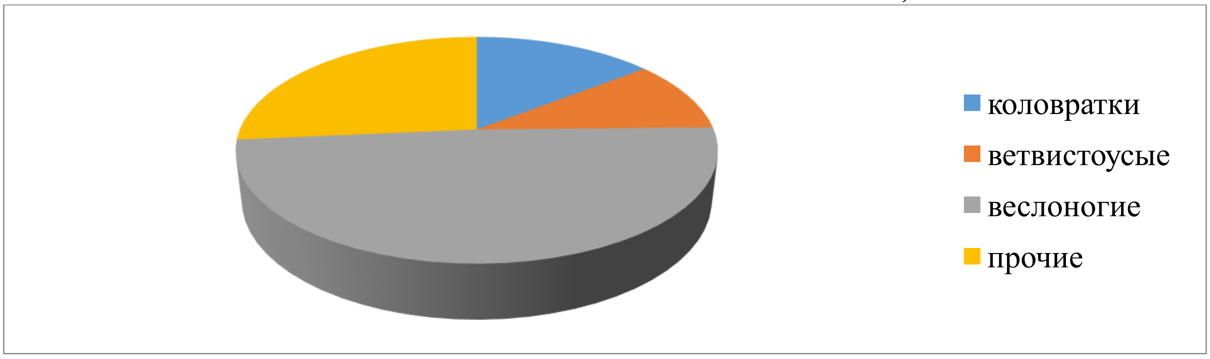

Рисунок 1. Численность основных групп зоопланктона по сезонам 2014 г.

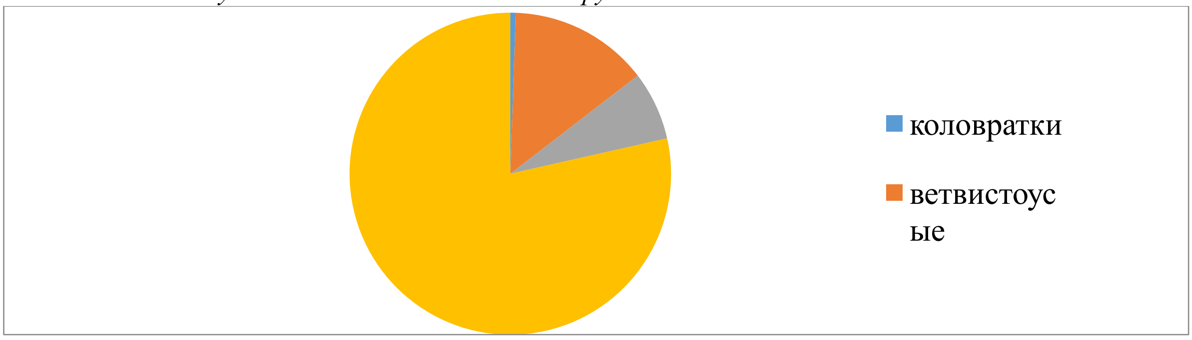

Рисунок 2. Биомасса основных групп зоопланктона по сезонам 2014 г.

Из вышеизложенного следуют следующие выводы:

Средние значения численности зоопланктона Тюб-Караганского залива в 2014 году возрастали от зимы к лету и понижались к осени. Средние значения биомассы возростали от зимы к осени. Зимой доминирующее положение занимали веслоногие, преобладающие как по видовому разнообразию, так и по количественному составу. Весной веслоногие сохраняли лидерство по количеству видов, тогда как по численности на первое место вышли коловратки, по биомассе – личинки моллюсков. Летом по количеству видов и

численности также лидировали веслоногие, по биомассе на первое место вышли ветвистоусые. Осенью более разнообразно были представлены коловратки, по численности преобладали веслоногие, по биомассе – медузы. В целом состав, структура, количественные показатели и сезонная динамика зоопланктона были обычными для данного района.

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MEDICAL SCIENCES.

PHARMACOLOGY, TOXICOLOGY AND PHARMACEUTICAL SCIENCE.

THE EFFECT OF THE LIGHT DESYNCHRONOSIS ON THE FORCED SWIMMING DURATION OF LABORATORY MICE

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ABSTRACT

In the current study, the effect of the model light desynchronosis on physical endurance of laboratory animals was studied. The light desynchronosis by using continuous strip lighting for 21 days was modeled. The level of mice's physical endurance by the duration of forced swimming with load was determined. The light desynchronosis caused a decrease in physical endurance. The return to normal lighting led to recovery of the swimming duration indicator in 14 days. The authors propose to make an assessment of desynchronosis-induced damage in terms of physical endurance.

Key words: light desynchronosis, laboratory animals, physical endurance, the duration of forced swimming

Introduction

General functional status and man's performance capability are directly dependent on the consistency of circadian rhythms, the resistance of their phase architectonics and coherence with the external cyclic phenomena, i.e. the optimal level of biorhythmic adaptation [2]. In case of the non-coincidence of the external regulators of biological rhythms with internal, acute desynchronosis occurs (de – + (greek *synchronismos* time coincidence, simultaneity + –is) – a painful condition caused by desynchronization of the biological rhythms and manifested by sleep, appetite disturbance, reduction of the performance capability. One of the most visible manifestations of this syndrome is the reduction of physical efficiency, rapid onset of fatigue, which were accompanied by a slow reaction and impaired psychomotor activity (decreased concentration, irritability and abrosia with mild depression) [6]. Endocrine, antioxidant, autonomic nervous, cardiovascular, immune and digestive systems also take part in the development of the syndrome [1, 3, 4, 9].

The study of the physical endurance is widely used in experimental practice to assess the severity of laboratory animals by a variety of pathological effects, as it is one of the most appropriate integrated indicators of the health [7, 8, 10, 11, 12].

The effect of light desynchronosis on the physical endurance of mice in terms of the duration of forced swimming with a load was studied. The aim of this research is to offer this indicator to evaluate the severity of the desynchrosis-induced damage.

Materials and methods

The experiments on 40 outbred male mice weighing 20±1.9 g were performed. After delivery to the laboratory and until the beginning of the experiment all mice had an adaptation to laboratory conditions within 14 days. Animals were maintained in cages with an area of 1450 cm^2 (5 mice in each) under natural light regime (8.00-20.00 − light, 20.00-8.00 − dark) at 22-25°C and humidity 50-55%, in conditions of free access to water and food.

Before the study, mice were randomly divided into 2 groups with 20 animals in each:

1. Control group – animals were kept in compliance with the standard light conditions;

2. Experimental group – animals, which in the course of the experiment were exposed to a modification of the light regime (modelling of light desynchronosis).

Modelling of light desynchronosis according to the scheme of continuous strip lighting (Beurer TL40, Germany) for 21 days was realized. The cages were lightened with the quantity of 1.51 Lux/cm^2.

The assessment of physical endurance was carried out according to the method of forced swimming with load [5]: on the 1st day of the experiment – before the change of light regime; the 21st day of the experiment – on the last day of the modification of the light regime; the 35th day of the experiment - in14 days after the cancel of the modification of the light regime. During the test, after weighing the animals, the load equal 7.5% of body weight were attached to their tails, after which each animal was immersed into a cylinder filled with degassed water with a diameter of 20 cm, height 40 cm, and water temperature of 24±2°C. The stopwatch timer was activated at the moment of immersion of the animal in the water. The criterion of swimming cessation was the immersion of the animal on the bottom of the cylinder and rejection surfacing. At this point, the animal was quickly removed from the water and were dried with a towel.

On the 1st day of the experiment (prior to the modeling of light desynchronosis) the duration of the swimming, for animals of both groups was 14,51±1.52 minutes. Later this indicator was called "the duration of preparatory swimming" and it contained 100% for each animal. All subsequent values of the swimming time of mice as a percentage of the duration of forced swimming were expressed.

Statistical processing of the results was carried out using the statistical software package MS Excel and Statistica V.10 with the help Student t-test.

Results and discussion

The study revealed that after 21-day continuous strip lighting of the animals the duration of swimming in the experimental group was significantly reduced to 57±9,2% in comparison with the duration of preparatory swimming ($p \leq 0.05$). The physical endurance in the control group kept approximately unchanged: the duration of the swimming compiled 103±9.7% of preliminary figures.

Through 14 days after discontinuation of continuous illumination, the swimming duration of the experimental group increased and amounted to 92±8.7 %, statistically illustrating the reactivation of the physical endurance of the animals. The resulting figure was not statistically different from that of the preparatory swimming ($p > 0.05$). The physical endurance of the animals in the control group kept approximately unchanged compared with the initial measure, that was obtained after 21 days of the experiment, and amounted to 109±10.9%.

Therefore, the obtained results indicate that continuous impact of the strip lightning for 21 days had a negative effect on the physical endurance. After returning to the normal light regime the physical endurance is restored almost completely after 14 days.

Implications

1. As a result of continuous lightning during 21 day, the experimental mice had signs of the desyncronosis, which is manifested by reducing the duration of forced swimming by 43% compared with the level prior to the modeling of desyncronosis.

2. The 14-day keeping under standard conditions after the cancel of the continuous lighting was restored the physical endurance of experimental mice almost to the primary level.

3. The obtained data allow to propose a measure of physical endurance (duration of the forced swimming) for the integral assessment of the severity of the desyncronosis-induces damage in the laboratory animals.

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PHYSICAL SCIENCES.

CHEMISTRY.

DIENOPHILIC ACTIVITY OF INTERNAL C_{17} OLEFINS IN [4+2]-CYCLOADDITION REACTION

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ABSTRACT
The diene type condensation of some C_{17} internal olefins (heptadecene-8, heptadecadiene-6,9) and oleic acid with cyclopentadiene has been carried out. It was found out that, the yield of an adduct of heptadecene-8 in this reaction is much lower than the yield of an adduct of oleic acid being 57 and 72 %, respectively. The physico-chemical properties of obtained adducts have been studied. The structure of the synthesized compounds have been proved by IR- and NMR-spectroscopy.

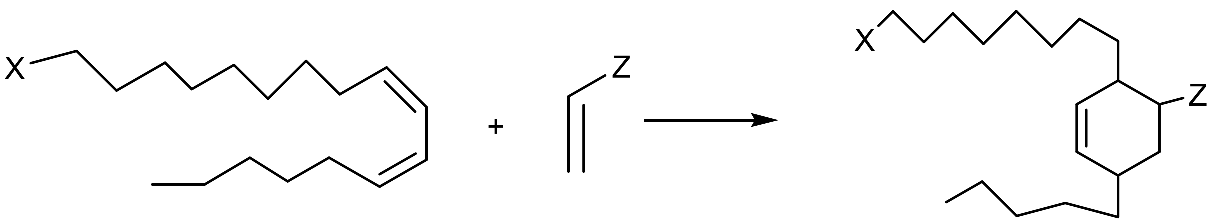
Keywords: [4+2]-cycloaddition, heptadecene-8, high internal olefins, adducts, heptadecadiene-6,9.

INTRODUCTION

It is well-known that, high internal conjugated diolefins and their derivatives

have application as dienes in Diels-Alder reactions [1]. In work [2], various novel fatty compounds have been synthesized by different catalytic addition reactions based on double bond (C=C) with of them being diene synthesis.

Diene condensation of methyl conjugate obtained from methyl linoleate by catalytic isomerization of the C=C double bond in the presence of DMSO has been carried out. Formed methylconjugate was used for diene synthesis with different dienophiles in the presence of BCl_3 or $SnCl_4$ according to Scheme 1. The authors reported that, the yield of adducts was in the range 70-90 %.

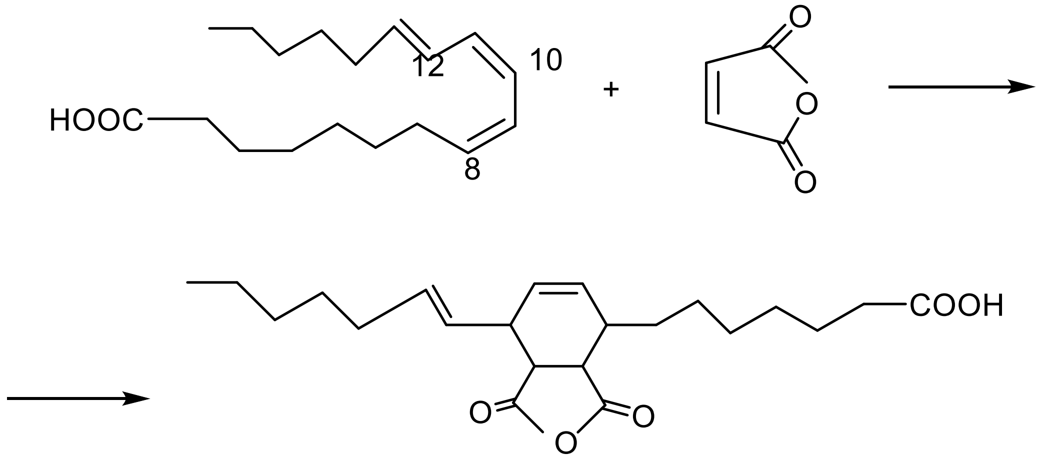


Scheme1. Diene synthesis reaction performed in [2] where: X = COOH, COOMe, CH_2OH; Z = CN, COOMe, COMe, COH

It was shown in [3] that, triflates (trifluoromethanesulphonates) of some metals, especially $Sc(OTf)_3$ and $Cu(OTf)_2$ are efficient catalysts for the Diels-Alder reaction of ethyl ester of a conjugated acid with methylvinylketone leaded to a regioselective mixture of four adducts in the molar ratio 1:1 with the yield of 81 %.

Diene synthesis of methyl-9,12-dioxo-octadeca-trans-10-enoate with isoprene and 2,3-dimethylbutadiene have been studied in [4] resulting in formation of substituted cyclohexenes.

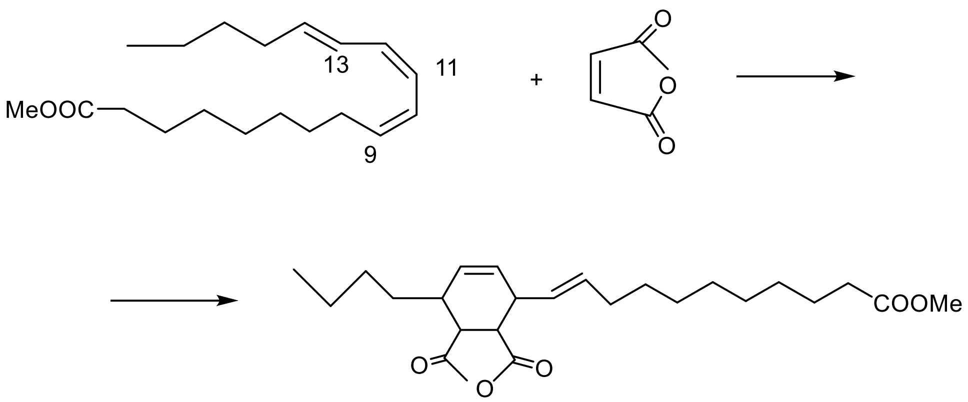
As demonstrated in [5] thermal, solvent- free addition of maleic anhydride to methylcalen-dulate (methyl-8,10-trans-12-cis-octadecatrienic acid) leads to formation of an with endo-Diels-Alder product with 78% yield and highly regio- and stereoselectivity on C-8 and C-11 carbon atoms of fatty compound according to Scheme 2



Scheme 2. Addition of maleic anhydride to methylcalendulate [5]

The adduct was separated from the reaction mixture by column chromatography and crystallized using petroleum ester/diethyl ester [5]. It is shown that, at the desired temperature the Diels-Alder reaction dominates over the -ene reaction.

In analogical conditions Diels-Alder addition of maleic anhydride to methyl-α-eleostearate (methyl-9-cis11,13-trans-octadecatrienic acid) has been carried out with formation of an endo-product with 62 % yield and regio- and stereoselectivity on C-11 and C-14 carbon atoms (Scheme 3)



Scheme 3. Addition of maleic anhydride to methyl-α-eleostearate

As it is seen from literature, conjugated high internal diolefins and their derivatives are widely used as dienes in [4+2]-cycloaddition reactions. At the same time application of non-conjugated high internal olefins as dienophiles in the same reaction has not been practically studied.

Therefore in the present work dienophiles activity of some high internal olefins and their derivatives in [4+2]-cycloaddition to cyclopentadiene has been investigated.

EXPERIMENTAL PART

Heptadecene-8 and heptadecadiene-6,9 obtained by catalytic decarboxylation of oleic [6,7] and linoleic acids, respectively were used as dienophiles. Freshly distillated from dicyclo-pentadiene cyclopentadiene (CPD) was used as diene.

It is well known that, olefins activated with electrophilic groups are taking part in Diels-Alder reactions more easily than olefins themselves. Therefore oleic acid, being an activated derivative of heptadecene-8, was also used as a substrate in diene synthesis.

The physico-chemical properties of the initial compounds are presented in Table 1.

Table 1 Physico-chemical properties of the initial compounds

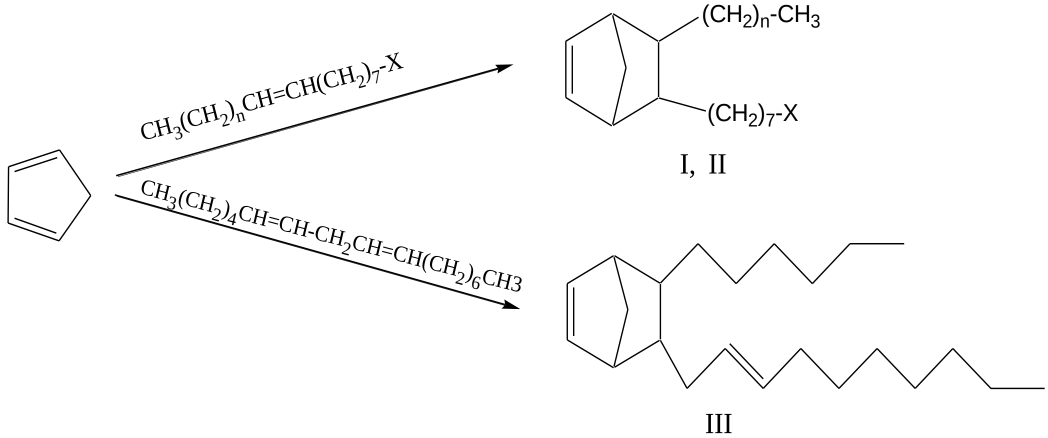
Initial compounds	B.p.,^{0}C (mmHg)	n_D^{20}	d_4^{20}	Acid number, mgKOH/g
CyclopentadieneCPD	42	1.4450	0.8050	-
Heptadecene-8	179 (20)	1.4427	0.8015	-
Heptadecadiene-6,9	324	1.4460	0.7935	-
Oleic acid	225 (10)	1.4560	0.8950	190

Experiments were carried out in a stainless steel batch reactor, which was loaded with 33 g of CPD and either 119 g of heptadecene-8 or 141 g of oleic acid. The reaction temperature varied between 180-200^{0}C and duration of experiments as 6-10 h. After the reaction, obtained product was distillated under vacuum (20-25 mm Hg) and its physico-chemical properties were determined.

IR-spectra of the initial and synthesized compounds were taken on UR-20 spectrophotometer in the range 700-4000 cm^{-1}. The NMR-spectra were registered on Bruker WP-400 (400 MHz). The chemical shifts were determined using tetramethylsilane (TMS) as a reference with C_6D_6 as a solvent.

RESULT AND DISCUSSION

The Diels-Alder reaction between CPD and used dienophiles is shown in Scheme 4.



Scheme 4. Diels-Alder reaction between studied substrates. In I: X = CH_3

and n = 6 (heptadecene-8); in II –X =COOH and n = 7 (oleic acid)

The results of experiments are illustrated in Table 2.

Table 2. Comparative yields of diene condensation adducts.

Initial amounts		Formed		Remained,g		Losses,g	
		g	% (theor.)	Dienophile	CPD	Dienophile	CPD
Heptadecene-8 119.0	CPD 33.0	87.0	57.0	50.5	13.5	0.7	0.3
OA 141.0		125.0	72.0	39.4	8.5	0.8	0.3

As can be seen from Table 2, the total yield for CPD and heptadecene-8 adduct was 57%, while a higher value (72%) as obtained when oleic acid was used as a dienophile. In our opinion, this higher yield of CPD - oleic acid adduct is related to the influence of an electrophylic group to the double bond in oleic acid.

The structure of the synthesized adducts was investigated by NMR with the corresponding spectra presented in Fig. 1 and 2.

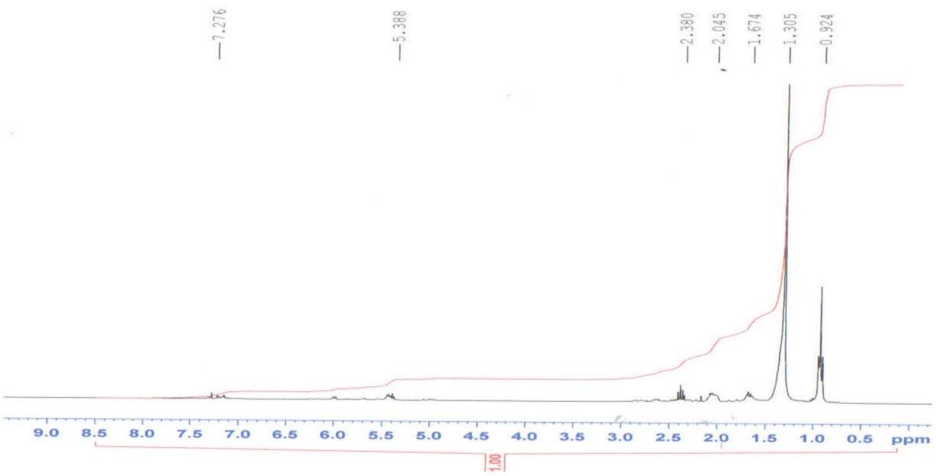


Fig. 1. NMR^{1}H spectrum of 5-heptyl-6-octylbicyclo[2.2.1]hept-2-ene

As it is seen from Fig.1, the signals of protons in CH_3 and CH_2 are observed at

0.92 and 1.31 ppm, the protons of cyclic CH_2 and CH groups give signals at 2.04-2.38 ppm., and the signals of protons near the double bond are visible at 5.40 ppm.

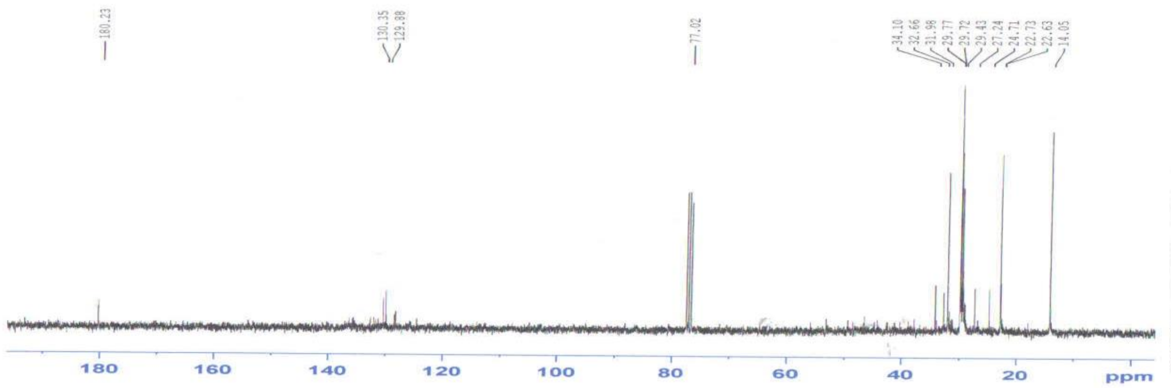


Fig. 2. NMR ^{13}C spectrum of 5-heptyl-6-octylbicyclo[2.2.1]hept-2-ene

As it seen from Fig. 2, ^{13}C signals changing in the range 0-200 ppm. The signals of carbon atoms from CH_3 are present at 14.1 ppm, while the signals of carbon atoms from CH_2 and CH groups were observed at 22.6-32.6 m.p. Carbon atoms near a double bond gave a signal at 130 ppm.

The IR- and NMR-spectra of the synthesized adduct of CPD and oleic acid - 8-(2-octylbicyclo[2.2.1]-hept-5-enyl)octanoic acid are shown in Figures 3-5.

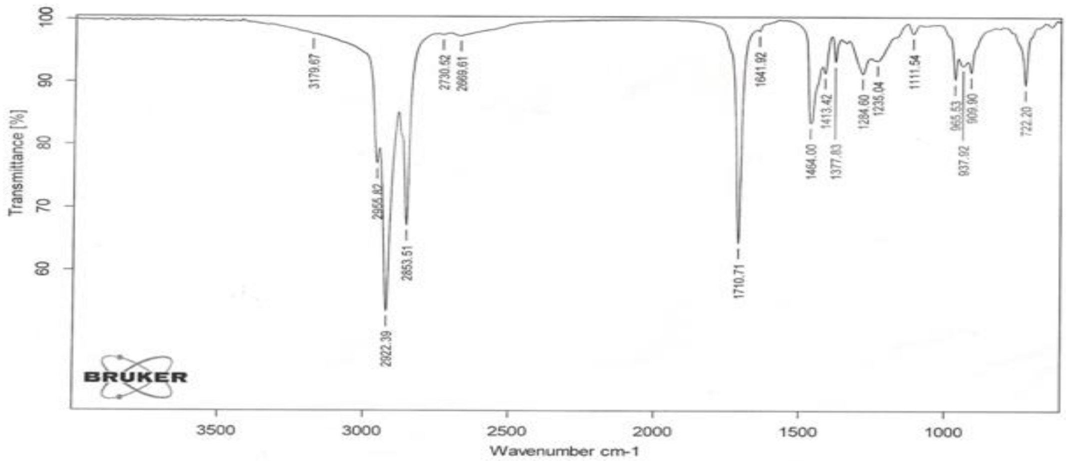


Fig. 3. IR-spectrum of 8-(2-octylbicylo[2.2.1]-hept-5-enyl)octanoic acid.

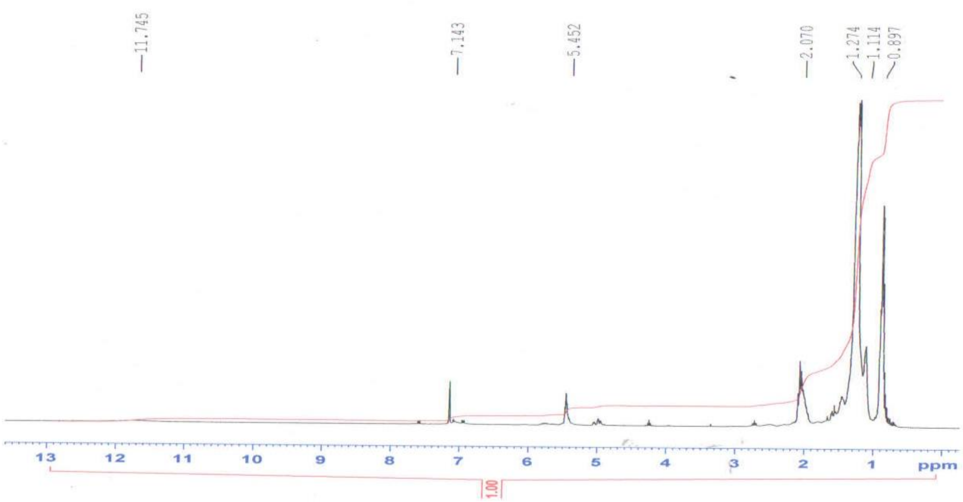


Fig. 4. H^1 NMP-spectrum of 8-(2-octylbicylo[2.2.1]-hept-5-enyl)octanoicacid

The peak assignment can be made in the following way. In H^1 NMR-spectrum of CPD and oleic acid adduct, the proton signals of methyl- and methylene groups were observed at 0.9-1.75 ppm, the signals of protons of cyclic methylene group were registered at 2.0-2.5 ppm hile protons of the double bond and carboxylic acid C=C are visible at 5.6 ppm and 11.8 ppm, respectively.

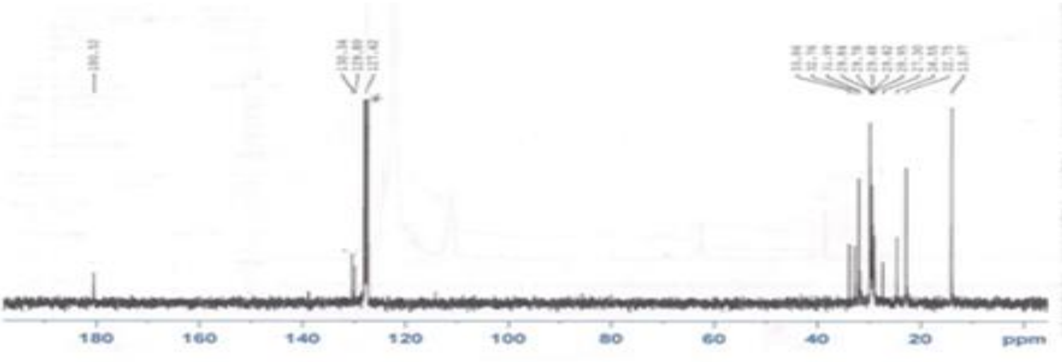


Fig 5. C^{13} NMP-spectrum of 8-(2-octylbicylo[2.2.1]-hept-5-enyl)octanoic acid.

It is seen from Fig.5, the following C^{13} signals were observed: 18 ppm (CH_3-group), 21-35 ppm (methylene groups), 127 ppm (carbon atoms near the double C=C bond) and 181 ppm (carbon atom from COOH-group).

The physico-chemical properties of the synthesized compounds were determined with the values given in Table 3.

Table 3. Physico-chemical properties of the synthesized compounds

Structure	Boil.p.,^{0}C (mmHg)	n_D^{20}	d_4^{20}	Acid number, mgKOH/g
(2-octyl,3-heptyl)bicyclo[2.2.1]-hept-5-ene (I)	86-89 (25)	1.4565	0.8395	-
8-(2-octylbicylo[2.2.1]-hept-5-en- yl)octanoic acid (II)	82-83 (25)	1.4510	0.8315	72.45
(2-hexyl-3-dec-8-enyl)bicyclo[2.2.1]hept-5-ene (III)	207 (25)	1.4507	0.8364	-

CONCLUSION

Summarising all, the investigation of dienophilic activity of heptadecene-8 and oleic acid in the reaction of [4+2]-cycloaddition with cyclopentadiene

showed that, the yield of obtained adduct of oleic acid is higher than the yield of adduct of heptadecene-8 with CPD and it is obviously related with activation of double bond by carboxylic group.

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POWER.

AN INTEGRATED STUDY OF FLOWS IN THE AERODYNAMIC TUNNEL OF IAM RAS BY virtual experiment TECHNOLOGY

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SUMMARY

The paper presents a virtual model of the real experimental setup implemented in the original software for a personal computer with a user friendly interface, based on the use of a powerful computing complex “Lomonosov” of Lomonosov Moscow State University (MSU). Integrated visualization enables interactive dynamic observance of the flow parametric fields during calculation and their changes over time, taking into account the configuration of the measuring system of the setup, requires no special training for flow modeling and allows optimal planning of the experiment by obtaining a priori information about the flow parameters and the overall picture of the process. Comparison of the results of experiments and calculations of flow in the tunnel, of flow around bodies of various shapes placed therein, of fuel combustion in the incoming flow and in the propulsion unit model, confirms adequacy of the virtual model of the aerodynamic tunnel.

1. INTRODUCTION

One of the results of cooperation between Russian Academy of Sciences (RAS) and MSU institutes has been the creation and testing of a virtual model of the real experimental setup implemented in the original software for a personal computer with a user friendly interface, enabling due to integrated visualization an interactive dynamic observance of the flow parametric fields during calculation and their changes over time at certain points, corresponding to sensors on the setup.

Thus, a new trend has been started, the creation of specialized computer software embodying virtual systems analogous to actual experimental devices, which can be used by researchers without special training. Such virtual systems allow carrying out a priori research, as well as adjusting the parameters of devices and the strategy of a real experiment almost charge-free, without the cost of production of expensive equipment and supplies. Given the experience of the undertaken studies, we can say that there has been implemented on a small scale the idea of Academician O.M. Belotserkovskiy concerning creation of domestic computer systems based on modern computing base, that are easy to control, have predictable properties, are reliable and simple in operation.

This paper first describes the mathematical model of flows of a multi-component gas mixture for the axisymmetric case in cylindrical coordinates, based on the Euler equations. As an example of chemical kinetics equations, one-stage kinetics of propane-air reaction mixture is given. Then, a computer software is presented having a friendly graphical interface for calculation in axisymmetric formulation of supersonic flows in the pulse supersonic aerodynamic tunnel of Institute of Applied Mechanics of Russian Academy of Science (IAM RAS). The program interface allows setting the gas-dynamic parameters of the initial state in the aerodynamic tunnel itself and in the high-pressure chamber, performing the visualization of flow gas-dynamic parametric fields during the calculation, and receiving dependencies of the flow characteristics on time at given points, as well as the forces acting on the body being flown around and on its individual elements. This software is essentially a virtual model of the real pulse supersonic aerodynamic tunnel and can be used by experimenters and employees of different branches of study who have no special training. In conclusion, the used equipment is presented, as well as the conditions and results of live experiments in comparison with the data of calculations of various flows, conducted using the virtual model of the IAM RAS aerodynamic tunnel.

Study of the processes of formation and propagation of shock waves, combustion and flow around bodies of different shapes, particularly in the hypersonic speed range, is a vital task for gas and fluid mechanics. Given the short duration of experiments and the absence of a priori information about the parameters of the observed processes, the optimal formulation of the experiment and the degree of detail of its understanding are hindered. Therefore, it seems appropriate to apply an integrated approach to the study of processes, combining the possibilities of mathematical and physical modeling.

1 HYPERSONIC PULSE AERODYNAMIC TUNNEL

IAM RAS has built the hypersonic pulse aerodynamic tunnel for experimental solution of the problems mentioned above.

Fig. 1 schematically shows the hypersonic pulse aerodynamic tunnel of IAM RAS specifying the main units.

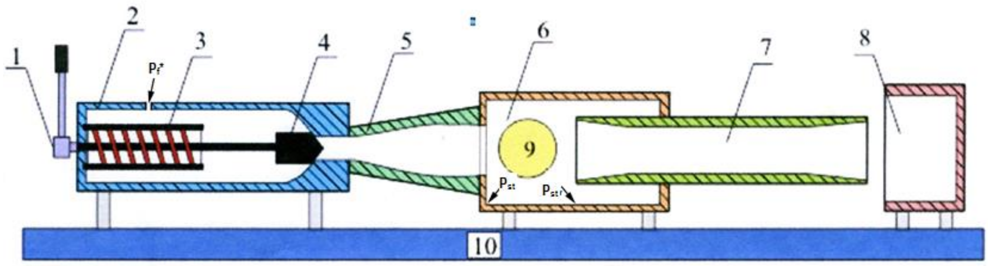


Fig. 1. The hypersonic pulse aerodynamic tunnel scheme. Main units:
1 – relief valve; 2 – stilling chamber; 3 – electric heater; 4 – rapid-action gate; 5 – nozzle; 6 – measuring chamber; 7 – diffuser; 8 – spreader; 9 – observation window; 10 – platform; P_f^*, P_{st} *– full and static pressure tapoff points, rewspectively*

To diagnose the flow parameters, full pressure P_f^* was measured in the stilling chamber of the pulse tunnel with the sensor DMP-150, and the static pressure was measured on the bottom wall of the Eiffel chamber at the nozzle output cross-section and the diffuser input cross-section with sensors Motorola MPX4115A.

It should be noted that because of devices fixing the model in space, the flow near the model bottom and in the wake of the model (Fig. 2b) when tested in aerodynamic tunnels is substantially different from the flow in these areas during the flight of the full-scale aircraft in the atmosphere (Fig. 2a) that leads to distortion of the model base pressure. The largest distortion of base pressure is caused by rigid suspension.

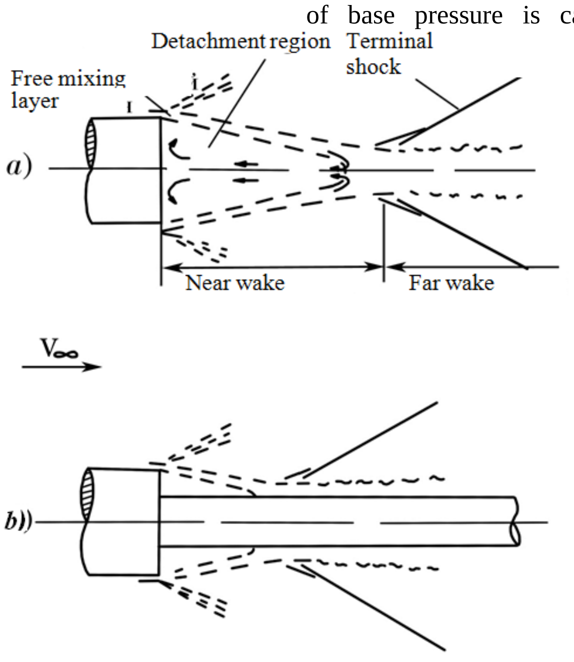


Fig. 2. The difference in flows past bodies in free flight (a) and in the aerodynamic tunnel experiment, because of the rigid suspension.

Distortion of base pressure leads to distortion of base drag of the model that is part of its overall drag, in some cases a quite substantial part. In particular, this applies to models of revolution bodies with a large area of the base section.

The base pressure behind the model depends on the shape of the tail holder (its relative diameter, cylindrical part length, taper angle behind the cylindrical portion), on the air blowing into the wake from under the holder fairing, on the condition of the boundary layer, on the angle of attack, on *M* number, on *Re* number, on presence of streams from flow channels of the model, and on other factors.

Typically, all models installed on the rigid suspension and for which the overall aerodynamic characteristics are defined, have a base chamber in the tail part. The intake drain openings are located on the tail holder in the section near the bottom of the base chamber. The pressure acting on the annular area of the bottom of the base chamber not occupied by the holder, is usually measured by stationary base pressure gauges.

The pressure acting on the crosscut end of the holder at its base under the rigid suspension fairing is also usually measured by stationary pressure gauges.

The advantage of small aerodynamic tunnels, such as the hypersonic pulse aerodynamic tunnel of IAM RAS, is that they have a fairly simple design, does not require a lot of energy and provide a turbulent flow state at hypersonic flow speeds (simulation by Reynolds numbers), which makes the conditions of aircraft models testing close to full-scale. This setup enables solution of problems of internal and external gas dynamics, such as study of flow in the elements of supersonic and hypersonic engines, flow around fore bodies of aircrafts, control of boundary layer, shock-wave drag, etc.

However, because of the short duration of the operating mode there are difficulties in measuring the flow parameters, as well as the forces acting on the tested objects. The measurement system must, on the one hand, respond to fast processes, and on the other hand, preparation and organization of the experiment should be based on a preliminary assessment of these fast processes, allowing selection of the sensor types, their measuring range, number and location in the tunnel, that is, should be based on the numerical simulation results.

For example, in situations where the model has a complex shape, it is very important to have a picture of its flow-around in real conditions of the aerodynamic tunnel, obtained as a result of numerical calculation. The calculation that precedes the experiment in the tunnel makes it possible to represent the flow, to choose and place correctly the pressure and temperature sensors, and to highlight areas with large gradients of flow parameters. In some cases, calculation is the only possible way to take into account the base pressure, or to adjust the measurements of the base pressure.

In case of testing of aerodynamic models in a pulse tunnel with flow characteristics changing over time, without a numerical calculation of such flows is extremely difficult to interpret the results of measurements of the characteristics of the tested objects. Thus, the reasonability of the integrated approach described above in solving the problems does not admit of doubt.

For these purposes, Institute of Mechanics of Lomonosov MSU has developed specialized computer software, a virtual setup analogous to the real experimental device that enables modeling of flows in the pulse supersonic aerodynamic tunnel of IAM RAS at experimental study of models of crafts and propulsion units, as well as adjustment of the parameters of devices and the actual experimental strategy.

2. THE MATHEMATICAL MODEL OF MULTICOMPONENT GAS MIXTURE FLOW

To describe flows of a multicomponent gas mixture without carry-over effects, a system of Euler differential equations [1-6] is used. At axial symmetry of the flow, it has the form

$$\frac{\partial(\rho r)}{\partial t} + \frac{\partial(\rho u r)}{\partial x} + \frac{\partial(\rho v r)}{\partial r} = 0, \quad \frac{\partial(\rho_i r)}{\partial t} + \frac{\partial(\rho_i u r)}{\partial x} + \frac{\partial(\rho_i v r)}{\partial r} = \omega_i r,$$

$$\frac{\partial(\rho u r)}{\partial t} + \frac{\partial[(p+\rho u^2) r]}{\partial x} + \frac{\partial(\rho u v r)}{\partial r} = 0,$$

$$\frac{\partial(\rho v r)}{\partial t} + \frac{\partial(\rho u v r)}{\partial x} + \frac{\partial[(p+\rho v^2) r]}{\partial r} = p,$$

$$\frac{\partial[(H-p) r]}{\partial t} + \frac{\partial(H u r)}{\partial x} + \frac{\partial(H v r)}{\partial r} = 0,$$

$$H = \sum_{i=1}^{N} \rho_i h_i + \rho \frac{u^2+v^2}{2}.$$

Here, *x* and *r* are longitudinal and radial coordinates; *u* and *v* – the corresponding velocity components; *t* – time; ρ, *p* and *H* – density, pressure, and the total enthalpy of the mixture, respectively; *N* – number of mixture components; h_i, ρ_i and ω_i – enthalpy, density of the i^{th} mixture component, and its rate of change in chemical reactions.

The caloric and thermal state equations have the form

$$h_i = c_{0i} + c_{pi} T, i = 1, \ldots, N, \quad p = R_0 T \sum_{i=1}^{N} n_i / \mu_i,$$

where T is mixture temperature, R_0 – the universal gas constant, μ_i – molecular mass of the i^{th} mixture component. The values of partial entropies $h_i(T)$ are derived by approximation of table values [7].

When considering flows of inert gas mixtures, it is assumed that ω_i=0 for all mixture components. In the study of detonation processes, single-stage combustion kinetics is used as described by a single stoichiometric equation [8-9] .. For example, in the case of combustion of propane-air mixture

$$C_3H_8 + 5O_2 + 20N_2 \rightarrow 4H_2O + 3CO_2 + 20N_2.$$

all ω_i are determined by one reaction rate according to the equations

$$\frac{\omega_{C_3H_8}}{\mu_{C_3H_8}} = \frac{\omega_{O_2}}{5\mu_{O_2}} = -\frac{\omega_{H_2O}}{4\mu_{H_2O}} = -\frac{\omega_{CO_2}}{3\mu_{CO_2}} = A T^{\beta} e^{-\frac{E}{R_0 T}} \left(\frac{\rho_{C_3H_8}}{\mu_{C_3H_8}}\right)^a \left(\frac{\rho_{O_2}}{\mu_{O_2}}\right)^b,$$
$$\omega_{N_2} = 0,$$

where the indices i are replaced with symbols of components, A, β, E, a, b are constants for C_3H_8.

3. COMPUTER SOFTWARE WITH A GRAPHIC INTERFACE

Numerical study of flows of multicomponent gas mixtures is performed using a modified method of S.K. Godunov [10] on multi-block computational grids. A program has been developed on its basis that enables calculation of axisymmetric flows of multicomponent inert and chemically reactive gas mixtures in a virtual model of the pulse supersonic aerodynamic tunnel with the samples of several complex-shaped structures placed therein. Currently, the program allows consideration of 6 different formulations of the problem:

1) flow in the empty aerodynamic tunnel;
2) flow around the body of a complex shape, located in the central chamber of the tunnel;
3) flow around the cylindric body;
4) flow around the body with a sharp needle;
5) flow around the solid fuel stick with a cylindrical shape;
6) flow around the complex-shaped body with a straight-flow combustion chamber on pasty fuel.

Each of the possible tasks is defined by a special text file.

Calculations are performed on the grid associated with boundaries of the computational domain and separating it into rectangular cells. Structured multi-block grids are used, the nodes of which in each block are ordered and numbered with two indices. Multi-block structure implies a breakdown of the computational domain into parts having the form of curvilinear quadrangles.

The program works in the Windows operating system starting with Windows 7.

On the control panel, the user can set a number of calculation parameters and result visualization parameters. The calculation parameters include: one of the six configurations of flow region as described above, the position of the installed body, defined in millimeters and available in configurations with an inner body, the initial air pressure in the setup, the initial temperature, the initial air pressure and temperature in the high-pressure tank, the number of calculation steps through which the gas-dynamic parametric fields will be recorded to files, and the coordinates of six sensors detecting in the points of gas-dynamic path the values of such components as velocity, velocity modulus, Mach number, density, pressure and temperature. In addition, there is a choice of four different values of spatial resolution, determined by the frequency of computational grid lines.

The visualization area displays the field of components of velocity, velocity modulus, Mach number, density, pressure or temperature at a particular time. The visualized parameter and the minimum and maximum range determining the conversion of values to color are indicated on the control panel. The visualization area also contains the symbol of axes *xy*, the axes *x, y* c signatures and coordinates in millimeters, the name of the parameter with the measurement unit, and the color scale that allows quick association of color with values of the gas-dynamic parameters. The control panel provides selection of number of divisions for axes, of a background color the entire imaging field, and display of the computational grid for computational blocks. There is also a possibility to select one of the nine color scales, including color and black-and-white ones. The visualization area can be saved as an image at any time by pressing the button on the control panel.

During calculation, the gas-dynamic parameters are recorded, which are captured by six sensors. Their position can be adjusted by the user. In addition, the value of the force acting on the installed body is also recorded. The files containing recorded time dependencies of the parameters can be imported into many programs including Excel.

4 VERIFICATION OF THE VIRTUAL MODEL

To verify the developed model, the experimental data were used obtained in the study of flow in the empty aerodynamic tunnel; flow around bodies of a complex shape; flow around the solid fuel stick with a cylindrical shape, and flow around the complex-shaped body with a straight-flow combustion chamber on pasty fuel.

Beforehand, a thorough methodical work had been performed for measurement of aerodynamic forces and parameters of the flow in the pulse tunnel of IAM RAS. To measure the pressure, fast-response sensors were used. To measure the aerodynamic forces, strain-gauge balance was used, and a high-speed ADC to record the experimental data.

The following equipment was used in this study:

- High-frequency absolute pressure sensors Motorola MPX4115A (1 kHz).
- Inertial sensor DMP-150.
- Three-component low-inertia strain-gauge balance made in Institute of Theoretical and Applied Mechanics of the Siberian Branch of the Russian Academy of Sciences (ITAM SB RAS) with measuring range up to *20 kg*.
- High-speed ADC National Instruments USB-6363 with 1 MHz digitizing frequency for all channels.
- Schlieren system and a high-speed video camera FASTCAM (10,000 frames per second).

The experiment begins with actuation of the rapid-action gate 4 (Fig. 1), after which the air stored in the stilling chamber flows out, and the pressure in the stilling chamber drops. Fig. 3 shows the process of variation of the full pressure in the stilling chamber over time, while Fig. 4 shows variation of static pressure on the wall of Eiffel chamber at points shown in Fig. 2 in the process of development flow in the tunnel. Fig. 3 and 4 show also the results of calculation using the virtual model of the tunnel for their comparison with the experimental data.

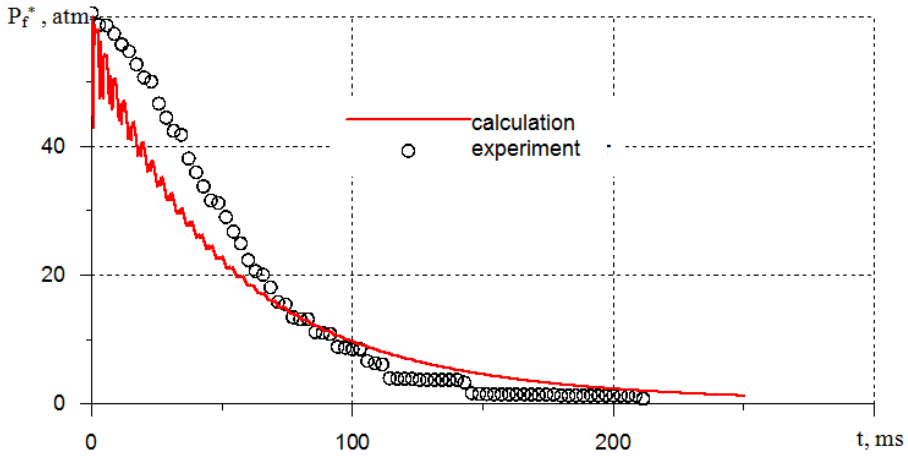


Fig. 3. Variation of full pressure in the stilling chamber over time.

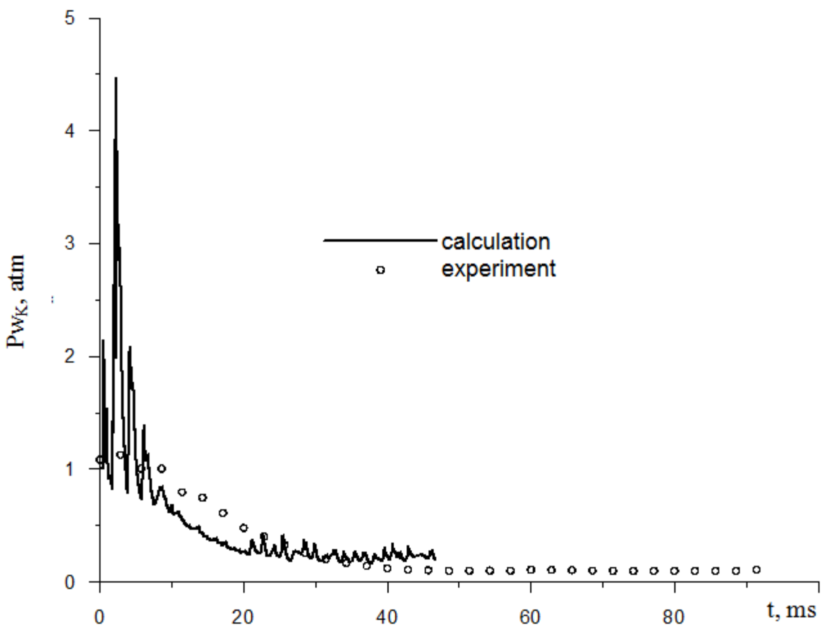


Fig. 4. Variation of static pressure in the Eiffel chamber over time.

The model “cone + cylinder” (Fig. 5) was used as the complex-shaped body in experimental studies. The scheme of experimental model installation on the balance is shown in Fig. 6.

The model tests were conducted at a Mach number at the nozzle exit *M = 4*, temperature in the stilling chamber of the aerodynamic tunnel *T* = 300 K*, and the full pressure in the stilling chamber of the aerodynamic tunnel $P^* = 60$ *atm*. The initial results of weight measurements in pulse mode are shown in Fig. 7.

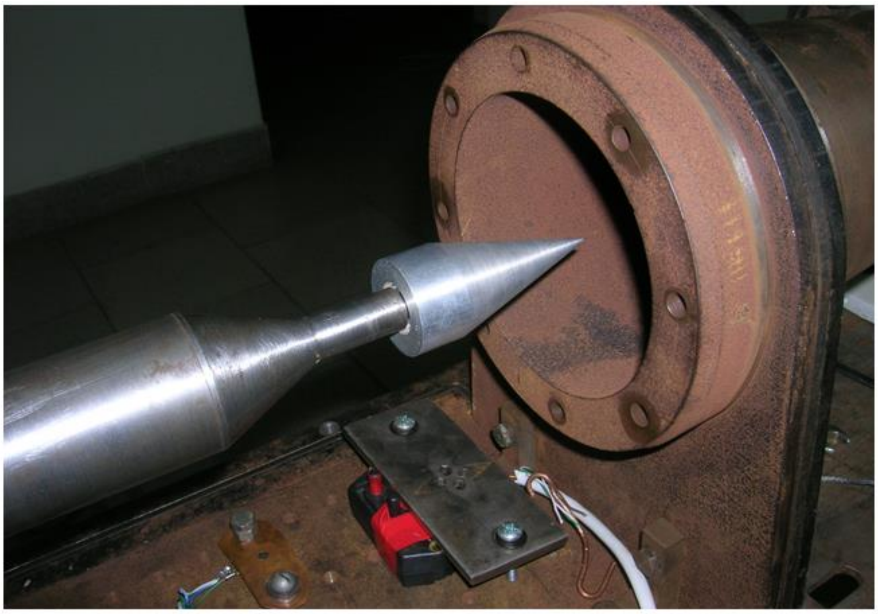


Fig. 5. Photo of the model "cone + cylinder", installed on the balance in the Eiffel chamber of the pulse tunnel.

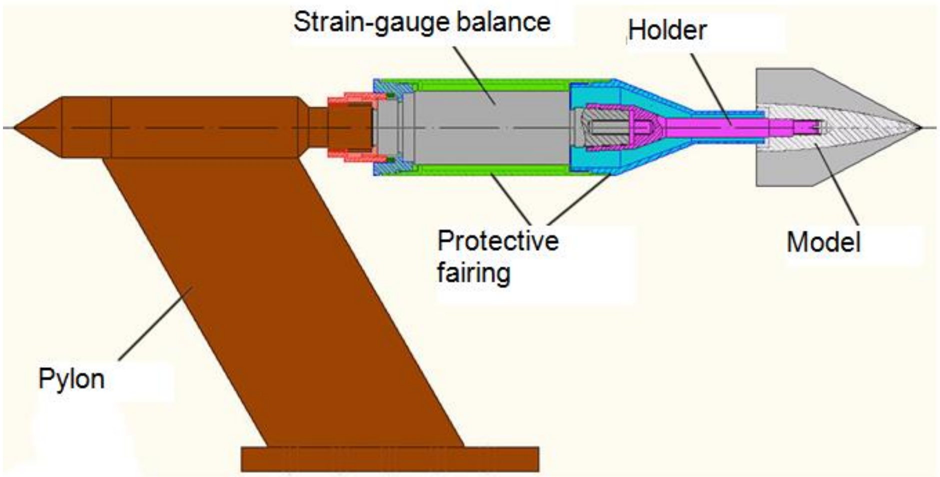


Fig. 6. Scheme of model fastening to the balance with a protective fairing.

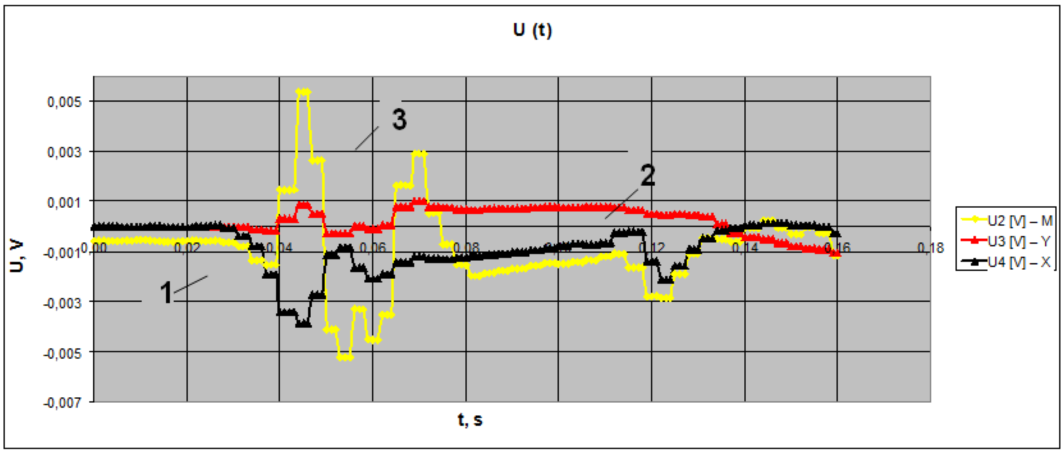


Fig. 7. Variation over time of values of output signals of strain-gauge balance components for determining forces along x, y axes and momentum of forces relative to z axis: 1 – voltage component Ux, 2 – voltage component Uy, 3 – voltage component Umz

Fig. 8 shows a shadowgraph of flow around the model "cone + cylinder" at $M = 4$, while Fig. 9 shows variation over time of the axial force acting on this model in the course of flow development in the pulse tunnel for identical M number conditions. For comparison, Fig. 10 demonstrates results of numerical calculation of the axial force on the virtual model of the tunnel.

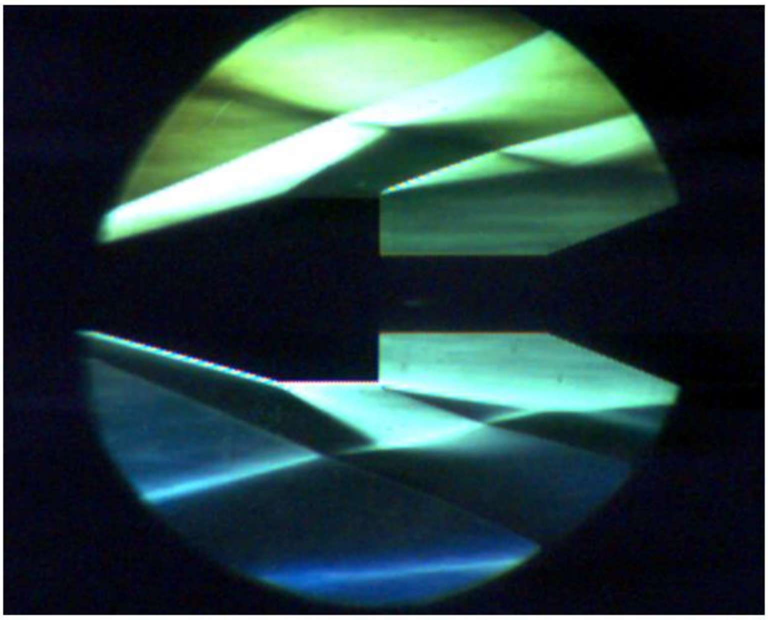


Fig. 8. Shadow picture of flow around the model "cone + cylinder" at M = 4

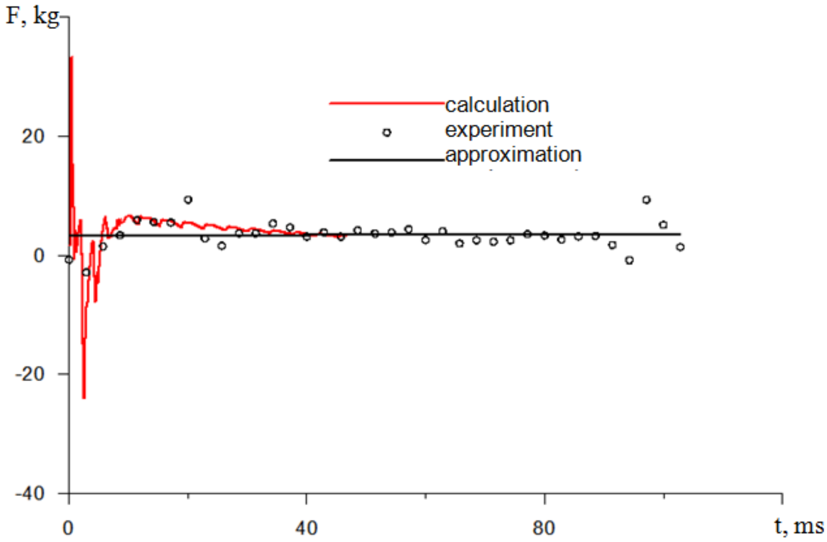


Fig. 9. Variation of force of shock wave drag of the model "cone + cylinder" at M = 4

The values of head drag coefficients Cx of the model "cone + cylinder", obtained in different experiments at $M=4$, are represented in Fig. 10. Comparison of the experimental data on Cx of the tested model with the theoretical data showed good correlation. Thus, measurement showed $Cx_e = 0.22 \pm 10\%$, and the calculation made on assumption that the relative base pressure $Pb/Pa = 0.5$ yielded at $M = 4$, $Cx_m = 0.217$. Here, Pa is static pressure in the approach flow.

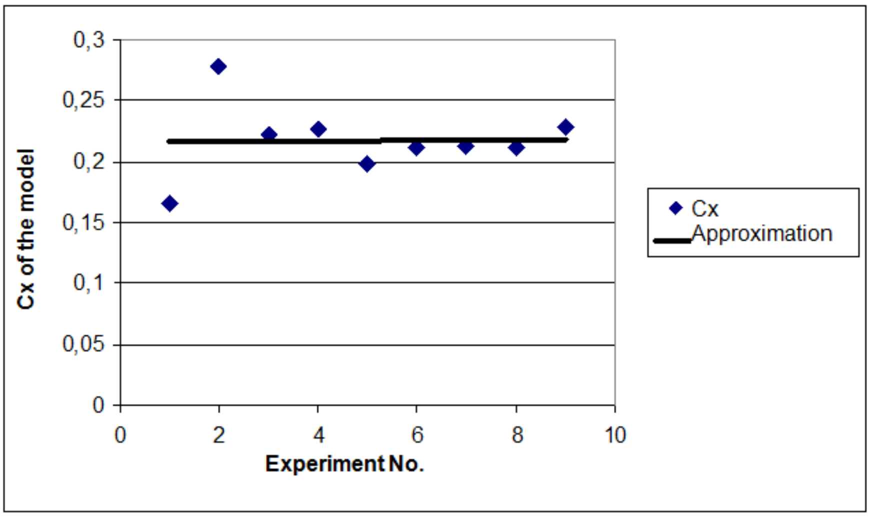


Fig. 10. Values Cx for the model "cone + cylinder" at M=4, P_f =60 atm*

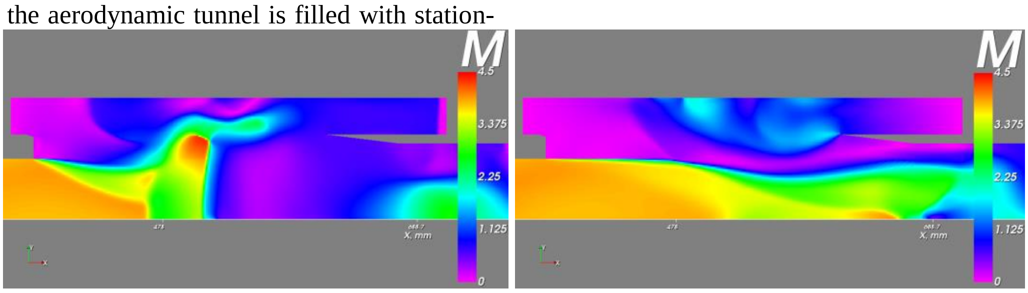
It should be noted that the comparison of the calculated and experimental data presented in Fig. 3, 4, 9 shows a satisfactory agreement between the real processes developing in the measuring section of the tunnel, and the prediction of the virtual model.

5 CALCULATION OF FLOW PARAMETERS ON THE VIRTUAL MODEL OF THE AERODYNAMIC TUNNEL

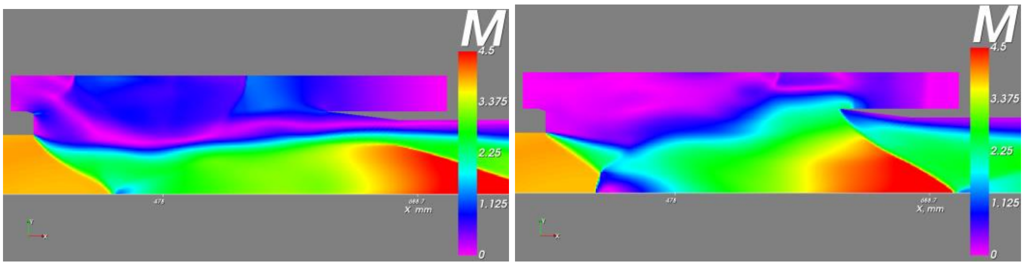
The capabilities of the developed software were fully used in the simulation of flows in the pulse hypersonic aerodynamic tunnel of IAM RAS. An ideal axisymmetric model was considered to identify the main features of flows. At the same time, the shape and size of most elements of the model fully corresponded to the actual setup. For performing the calculations, the computational domain was divided into a plurality of calculation blocks. In so doing, the computational grid had no clustering, and the spatial resolution was about the same throughout the whole computational domain. To simulate flows in the pulse tunnel, six different geometric configurations of the computational domain are used, corresponding to the six previously mentioned statements of the problem.

In the modeling, it was assumed that the entire space of the aerodynamic tunnel is filled with stationary air at a pressure P_0 in the range from *0.1* to *1 atm* and at a temperature T_0 = *300°K*, and in the high-pressure chamber there is still air at an elevated pressure P_f* from *10* to *200 atm* and at a temperature T_K from *300°* to *600°K*. It was assumed that at the initial moment the flow originates from rupture of the membrane separating the volume of the high-pressure chamber from the rest of the setup. In all examined cases, the calculations revealed a complex, highly unsteady flow structure with a lot of shock waves that interact with each other and with the walls of the chamber, with recurrent cumulative effects near the axis of symmetry. The following are the results of calculations showing the possibilities of the new computer software by the example of flows in an empty tunnel and flows around the body having a special shape in a wide range of determining parameters. All images represent the parametric fields in the computational domain limited from below by the axis of symmetry.

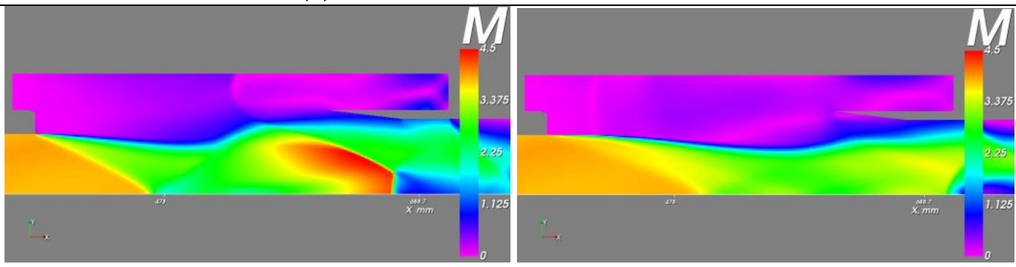
Fig. 11 demonstrates variation over time of the *M* number field in the empty tunnel, while Fig. 12 shows the flow around a sharp-pointed body with a special shape.



t =0.996 ms t =1.574 ms



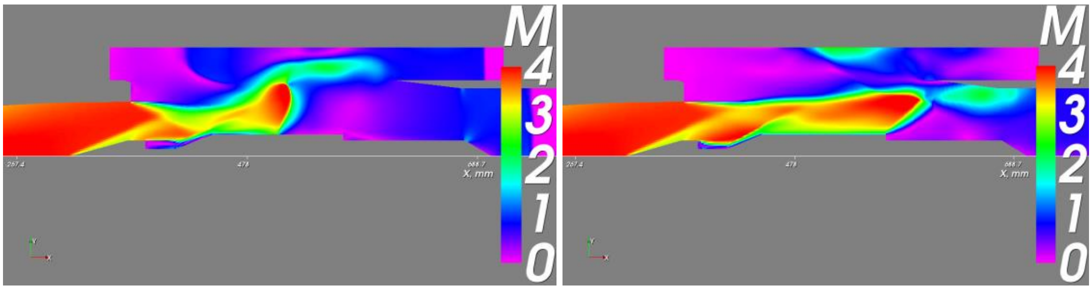
t =1.973 ms t =2.373 ms



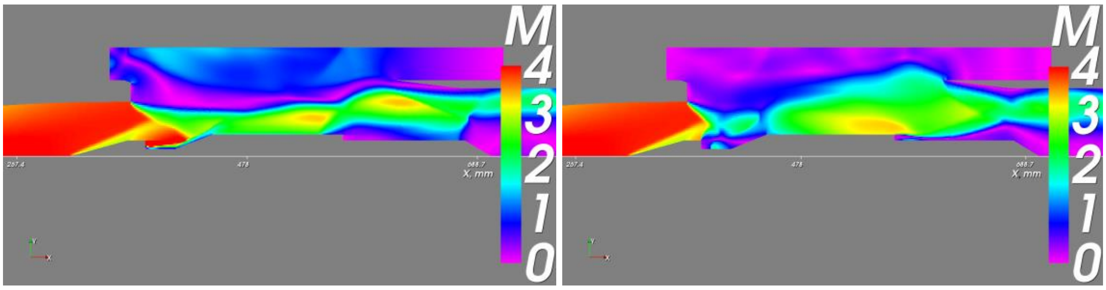
t =2.976 ms t =3.384 ms

Fig. 11. Mach number field for several moments of time.

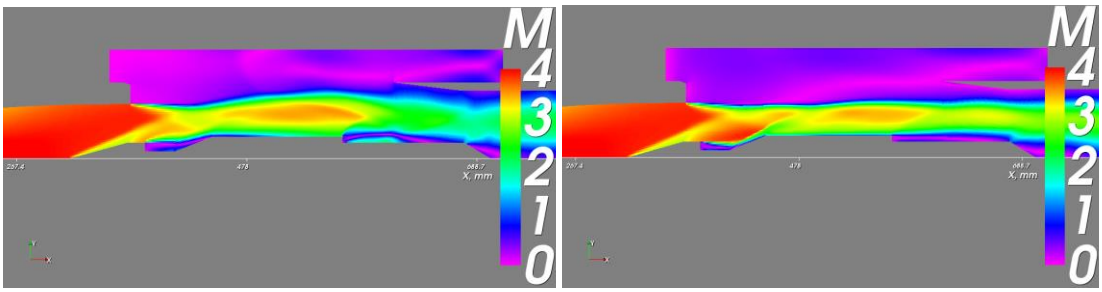
Fig. 13-14 shows results of modeling of combustion of a solid fuel stick in the form of a cylinder. The fuel stick combustion was modeled as follows. It was assumed that the fuel stick combustion occurs from the end exposed to the approaching flow, and that the combustion front remains flat. Its speed was calculated as $U=3.3\times10^{-3}\times(p/p_{atm})^{1/2}$, where $p_{atm}=1$ *atm* – atmospheric pressure, and p – variable average pressure behind the front. Stick density was taken equal to $\rho_s=1660$ kg/m^3, specific heat of combustion $Q=2.5\times10^7$ J/kg, adiabatic exponent of combustion products $\gamma_{pr}=1.22$, molecular weight of products – $\mu_{pr}=26.26$.



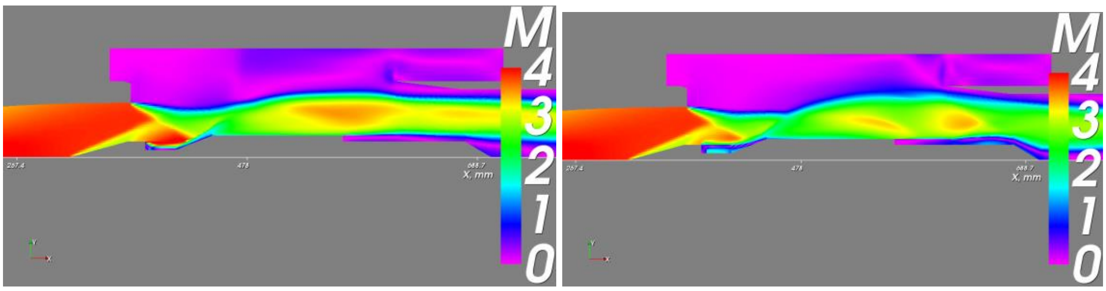
T =1.02 ms t =1.456 ms



T =1.899 ms t =2.322 ms



T =3.170 ms t =3.575 ms



T =3.960 ms t =4.354 ms

Fig. 12. Mach number field for several moments of time.

The calculation was performed on a partially moving grid, the boundaries of which were tied to the solid fuel stick boundary. In this case, across the border of the computational domain that corresponded to the combustion front came the products of combustion with a mass flow per area unit equal in magnitude to $\rho_s U$, and with an energy flow of area unit equal in magnitude to $\rho_s U^3/2+Q\rho_s U$. In the coordinate system associated with the combustion front, the momentum flux taken relative to the surface area unit, was equal to the local pressure behind the front *p*, since the solid fuel stick material was considered to be hard and impenetrable. According to calculations of air outflow from the reservoir with a pressure of P_f^* *=100 atm*, the pressure near the front end of the cylinder is *15.0 atm*. To validate the model correctness and to identify the characteristics of the products formation, calculations of the solid fuel stick combustion in still air were first carried out at a pressure of *15 atm* and a temperature of *300 K*.

Calculations have shown that the combustion model is adequate to the studied process, and in time periods during which the combustion products are propagated through a large space, the combustion front moves by a negligible distance. The combustion process is illustrated in Fig. 13, which shows dynamics of the field of mass fraction of the solid fuel combustion products.

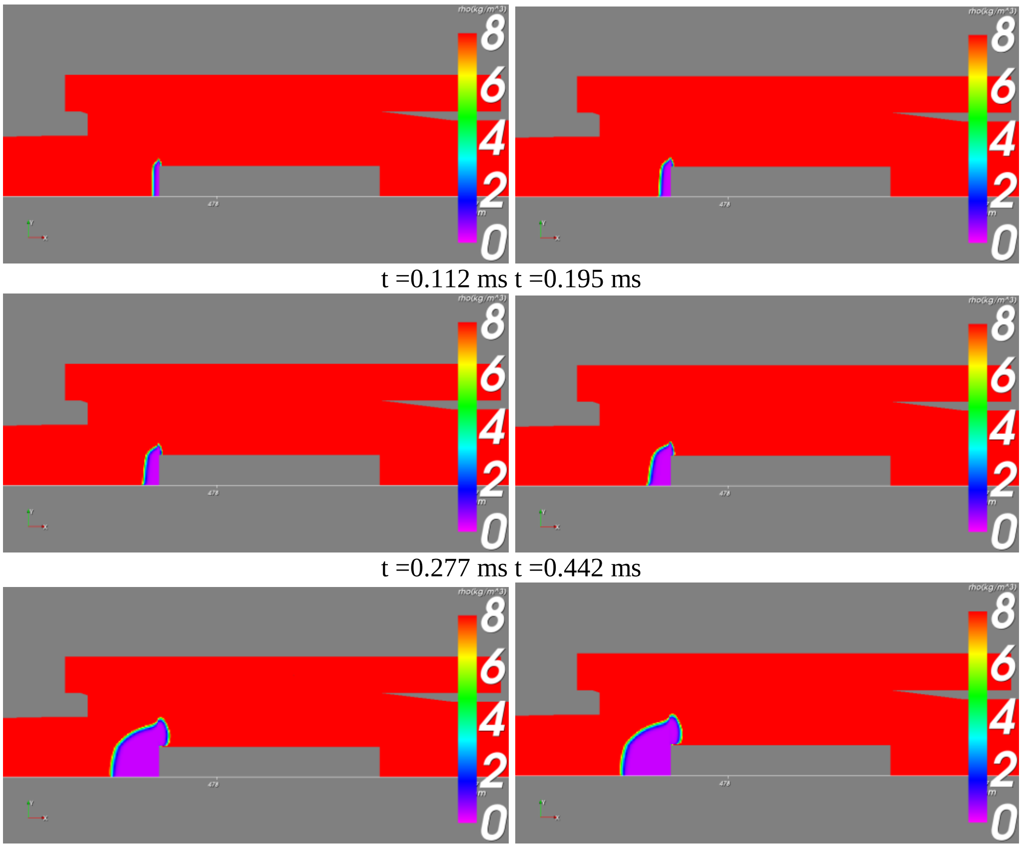


Fig.13. Mass fraction of products of solid fuel stick combustion in a still air.

The following are the results of calculations of flow around the burning solid fuel stick. It was assumed that at the initial moment, solid fuel stick combustion begins simultaneously with outflow of air from the stilling chamber to the tunnel filled with air at a pressure of *1 atm* and a temperature of *300 K*. According to the calculations, in the initial outflow phase the combustion products are propagated as in the case of combustion in air at a pressure of *15 atm*. The calculations with P_f^* *= 100 atm* have shown that the shock wave approaching the solid fuel stick from the stilling chamber heavily deforms the area of combustion products, and then they are swept by the supersonic flow. As a result, the flow of products takes place in a narrow layer near the surface of the solid fuel stick. Fig. 14, which shows fields of the mass fraction of combustion products, illustrates the process of their sweeping by the air flow. The calculations show that with decrease P_ϕ^* the thickness of the above layer of combustion products increases.

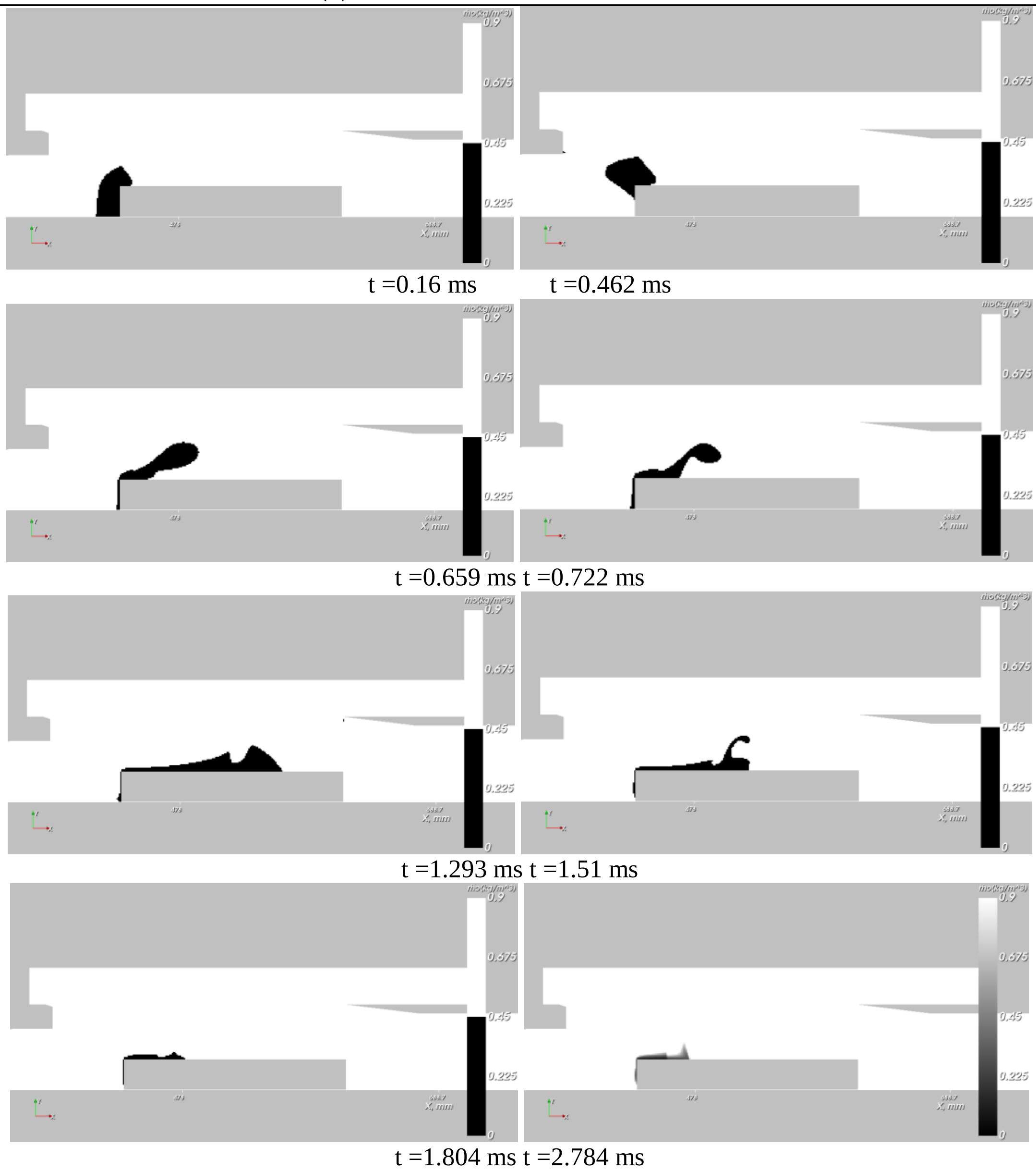
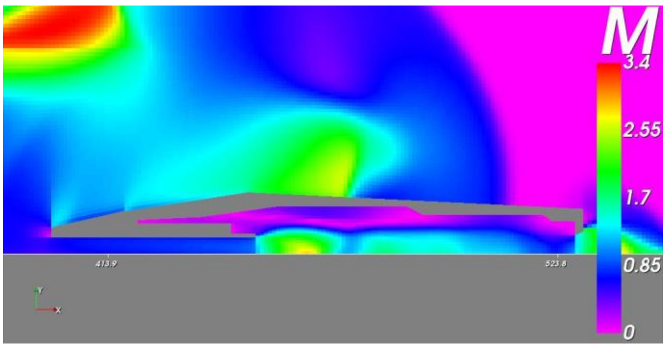


Fig.14. Field of mass fraction of solid fuel stick combustion products at outflow of compressed air at a pressure P_f = 100 atm.*

Fig. 15 shows results of modeling of the flow around a complex-shaped body with a straight-flow chamber at bottom combustion of pasty fuel in a supersonic air flow under conditions of the above-described experiment. Fig. 15 illustrates the fields of Mach number and temperature for the well-developed combustion process.



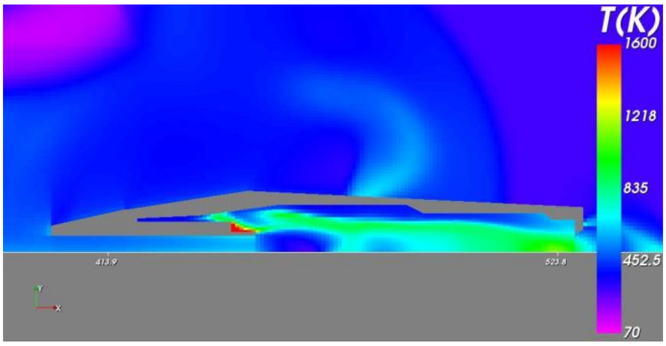


Fig. 15. Fields of Mach number and temperature for the well-developed process of bottom combustion of pasty fuel in a supersonic air flow.

6. CONCLUSION

A computer software with a user-friendly graphical interface has been created for simulation of flows in the pulse setup represented by a supersonic aerodynamic tunnel used in IAM RAS in the experimental study of models of crafts and propulsion systems with jet thrust generated by the combustion of solid rocket fuel.

The program interface offers the possibility to set the parameters of the initial state in the aerodynamic tunnel and in the high-pressure chamber, to perform visualization of flow gas-dynamic parametric fields during the calculation, and receive dependencies of the flow characteristics on time at given points, as well as the forces acting on the body being flown around and on its individual elements. The new software is essentially a virtual model of the real pulse supersonic aerodynamic tunnel and can be used by experimenters and employees of different branches of study who have no special training.

There was performed a methodical experimental study of flow about the model “cone + cylinder” model in the pulse aerodynamic tunnel at $M=4$, temperature in the stilling chamber $T_f*=300K$, and at a pressure in the stilling chamber at the initial moment $P_f*=60$ *atm*.

There were obtained time dependencies of the aerodynamic force acting on the test model, of the static pressure in the measuring chamber and of the full pressure in the stilling chamber of the tunnel, along with shadowgraphs of supersonic air flow around the model in the process of flux development. The discrepancy between the experimental value of the head drag coefficients Cx of the model at $M=4$ and the theoretical value does not exceed 20% (at $Pb/Pa = 0.5$ and $M =4$). There was examined the dynamics of development of pasty fuel combustion process in a jet propulsion engine model.

Using the obtained experimental data, there was performed a verification of the virtual model of the real pulse hypersonic aerodynamic tunnel for aerodynamic forces and pressures in the measuring chamber and the stilling chamber of the tunnel, which showed a satisfactory correlation between the processes developing in the measuring tunnel chamber, as predicted by the virtual model, and the actual results.

The developed software was used to perform a numerical modeling, and new data have been obtained on the characteristics of the flows in the pulse hypersonic aerodynamic setup of IAM RAS.

The work was performed with financial support of by project of Russian Science Foundation (grant № 14-19-01759).

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EXPERIMENTAL AND THEORETICAL STUDY OF PROCESSES OF COMBUSTION OF EMULSIONS AND SUSPENSIONS OF LIQUID AND SOLID HYDROCARBONS WITH WATER

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Summary

The water present in hydrocarbon fuels, as well as its vapor in air or other oxidants, have a significant impact on the behavior of various physical and chemical processes occurring in them, including the direct effects associated with combustion. Notably, this occurs both in the normal combustion reactions of organic and inorganic substances, and in case of mixing of solid and liquid hydrocarbon fuels with water. There has been accumulated a lot of experimental evidence concerning the influence of water on the occurring processes that still has not found an explanation. It turned out that in this case, the main influence is exerted by vibrational excitation of

H_2O molecules in the liquid and gaseous phases. This paper expounds the material describing physical and quantum-mechanical processes for the formation of emulsions and suspensions by mixing liquid and powdered solid hydrocarbon fuels with liquid water, and the phenomena of their combustion in the atmospheric air. A description is given of the experimental data on successful creation of such mixtures and significant improvement of the hydrocarbon fuels combustion efficiency. An explanation on a fundamental quantum-mechanical, vibrational-nonequilibrium chemical and spectral-physical level is given for the basic phenomena occurring during formation of emulsions and suspensions, as well as combustion processes.

Experimental data on combustion of water-hydrocarbon mixtures in the air

Let us mention, as an example of reactions of combustion of water-hydrocarbon fuels in the air, a number of experimental facts of their use in the devices, for which a fundamental explanation from the standpoint of equilibrium chemistry is absent in the scientific literature. It is known that when hard coal is soaked with water, it burns better and with greater heat dissipation, and therefore on thermal power plants hard coal is fed to furnaces of combustion chambers in the form of a suspension of fine powder with water, the mass of which amounts up to 20÷40%, and by so doing it turns out that the calorific value of hard coal increases by 10÷20%, while the content of *CO* and *NOx* in exhaust gases decreases [1].

A similar effect of water is observed when it is added as a finely dispersed emulsion to liquid hydrocarbon fuels (fuel oil, solar oil, kerosene, gasoline) at their burning in furnaces of boiler installations, gas turbine units and internal combustion engines [2÷8]. In this case, the mass content of liquid water ranges from 5 to 65%, with an increase of calorific value, reduction in fuel consumption, exhaust smoke opacity and content of harmful substances (*CO* and *NOx*), along with combustion process stabilization. As far as in the XVIII century an experiment was conducted, and repeated in the XIX century, for combustion of thoroughly dehumidified gasoline (kerosene) – it did not burn, and this fact has not yet been explained by science.

The experience of combustion of heavy hydrocarbons (fuel oil, petroleum), as well as gasoline, kerosene and solar oil, has shown that if water is added to them and a stabilized emulsion is created, that is stable enough for a long period of time and does not separate, such fuel burns better, its calorific value increases, viscosity decreases, and the economic effect grows. The principal difficulty of this problem lies in creating of a sufficiently stable suspension and emulsion, that would retain their properties at low temperatures for a long time.

The Scientific and Production Association "ARKON" showed at the exhibition "Archimedes 2008" in Moscow the results of testing the unit for the preparation of heavy and viscous oil fuels for combustion in order to reduce their viscosity, increase combustion efficiency, reduce content of toxic substances in exhaust gases. The unit includes a gear pump with a performance of 900÷1,100 *l/h* and a pressure of 60÷80 *atm*, and a disintegrator that provides intensive turbulence of flow and ultrasonic waves in the liquid. Testing of the unit for processing viscous petroleum fuels showed achievement of the following parameters at optimal conditions: fuel oil viscosity at a temperature of 100°C was reduced by 1.5 ÷ 1.7 times, fuel oil freezing point reduction took place from + 25ºC to – 2÷6°C, combustion temperature in an open crucible was increased from 110 to 160°C, calorific value was increased by 1.5÷3%. After processing of fuel oil at this unit, more light fractions are formed, and it was found that the resulting new physico-chemical properties of the processed fuel oil are stable and do not change for 3÷4 months.

The theory of processes of formation of stable emulsions and suspensions at mixing of liquid and powdered solid hydrocarbon fuels with liquid water

The experience of creation of stable emulsions and suspensions of liquid and powdered solid hydrocarbon fuels with liquid water in a variety of experimental devices has shown that collectively or separately, the following effects on the liquid mixture are applied: cavitation phenomena due to collapse of air bubbles, strong turbulent swirl of the flow, influence of ultrasonic and sonic vibrations, hydraulic hammers, interaction of vapor-air and liquid streams. Typical fluid medium parameters and properties generally were as follows: temperature range 20÷80°C, absolute pressure 5÷60 *atm*, liquid flow rate 20÷30 *m/s*, ultrasonic vibration frequency 20÷30 *kHz*.

It should also be noted that in case of conventional simple mixing, surface active substances (surfactants) have to be added to create stable water-hydrocarbon emulsions, and especially suspensions. In the absence of surfactants, the formation of stable emulsions and suspensions is unlikely, if they are not initially present in the hydrocarbon fuels themselves [9].

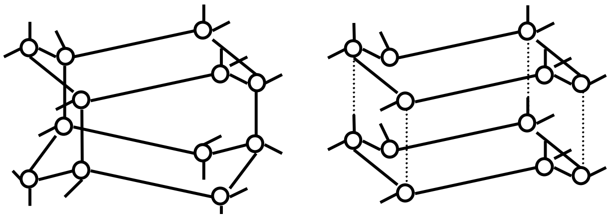
Nevertheless, the use of devices that provide strong swirl of liquid mixture of water and hydrocarbons, cavitation phenomena, ultrasound vibrations, hydraulic hammers, enables formation of sufficiently stable emulsions with small size of water droplets. In this environment and under exposure to such effects, two main processes occur: the formation of small stable water droplets and strong activation of liquid hydrocarbons with a change in their properties.

The total physical influence on a mixture of liquid hydrocarbons and water to create stable emulsions lies in splitting the whole mass of water into tiny droplets of 0.1÷4 μm, having a significant electrostatic surface charge of the double layer, created by the dipole moments of H_2O molecules. In this case, around the water droplets are created several layers of hydrocarbon molecules having a dipole moment of their own, or induced by polarization from the electrostatically charged water droplets. As shown by experiment [10], at mixing of liquid hydrocarbons with water,

water droplets are formed in diesel fuel, fuel oil, petroleum, gasoline, kerosene, and not vice versa, due to the fact that the surface tension of water in the temperature range of 20 ÷ 80°C is 3÷4 times greater than the surface tension of liquid hydrocarbons [11].

The process of formation of water droplets in mixture with liquid hydrocarbons occurs as follows: due to a strong turbulent swirling of fluid flow, collapse of air bubbles, the shock waves of ultrasonic and sonic vibrations, closed vortices (moles) are generated, and at the final stage their size is reduced to a minimum value of the *internal scale of flow turbulence*, determined by its speed and fluid viscosity. In such a case, since the viscosity of water is substantially less than the viscosity of hydrocarbon fuels such as kerosene, solar oil, petroleum, fuel oil, the size of water micro-vortices (moles) turns out to be significantly less than the size of hydrocarbons vortices. Thus, assessment of the *internal turbulence scale* by formula of K.N. Kolmogorov $\eta_K=(\nu^3/W)^{0.25}$, (where ν – kinematic viscosity, W – specific energy per unit mass dissipated per unit of time) gives for water flow speed 30 *m/sec* at the temperature of 40°C the value of $\eta_K \approx 3$ *μm,* that corresponds well to the size range of water droplets in the emulsions obtained experimentally.

Further, droplets begin to form from water micro-vortices in the presence of condensation nuclei therein, as their structure is determined only by water properties, and they must be similar to aqueous aerosols present in vapor or in the air. The condensation nuclei may emerge from primary clusters, the share of which in the water reaches 80%, having a tetrahedral crystal structure, an example of which is shown in Fig. 1 [12,13].



а) **б)**

Fig. 1 Tetragonal structure of the rings of O atomic bonds in a cluster of liquid water: a) open packed; b) tightly packed [13].

The dimensions of these clusters change in the range of 10÷400 Å, wherein the stored vibrational energy of asymmetric, symmetric and deformation modes of H_2O molecules in such crystalline structure is substantially greater than in free molecules [13]. In such clusters, the dipole moments of individual molecules are added vectorially, creating a great total dipole moment [13], thanks to which they become the nuclei of condensation of water droplets.

The nuclei of condensation of water droplets can be represented by clathrates, which contain in the center a molecule of gases O_2, N_2, CO_2, dissolved in water and hydrocarbons and surrounded by water molecules that create due to hydrogen bonds the ordered structures shown in Fig. 2 [14].

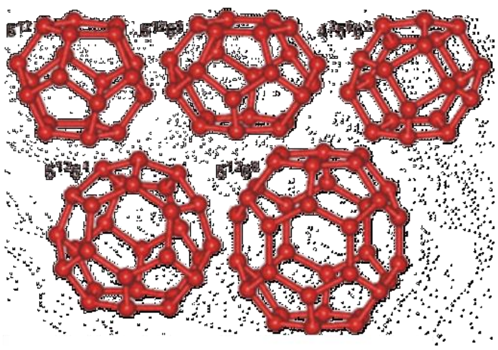


Fig. 2 Gas clathrates in liquid water [14].

Such formations have a significant integral dipole moment generated by the vector addition of dipole moments of H_2O molecules, that create an ordered structure around the gas molecule and can serve as nuclei of condensation of water droplets.

The nuclei of condensation of water droplets in a mixture with liquid hydrocarbons can also be H^+ and OH^- ions, which are always present in liquid water, as well as other ions present in hydrocarbons. In such formations, an excess static charge is created, due to which the surrounding water molecules are polarized that promotes the stabilization of water droplets.

In the presence of surfactants in a mixture of water and liquid hydrocarbons, nucleation of water droplets is significantly enhanced because their molecules generally have a great dipole moment, which leads to an increase of the total excess electrostatic charge of water droplets.

The structure and dimensions (0.1÷4 *μm*) of the formed water droplets in emulsions with hydrocarbon fuels are substantially similar to aqueous aerosols found in vapor and in the air, for example in clouds at about 10 *km* [13,15-17]. These aerosols do not freeze at – (50÷70) °C, the density of the water therein is 2÷2.2 g/cm^3, and in the course of its crystallization, freezing to ice VII with a cubic structure instead of the tetrahedral is observed. Calculations of critical droplets nuclei formation using the Gibbs equation [11,13] show that the total energy of bonds between H_2O molecules in them amounts to ≈270 *kJ/mol*, and taking into account the surface tension in droplets with a radius ≈4 μm it reaches ≈290 *kJ/mol* compared to the volumetric water figure 40 *kJ/mol*. This energy is located on the vibrational degrees of asymmetric, symmetric and deformation modes of H_2O molecules, up to level 5 or 6.

Thanks to an intensive combined effect exerted on liquid hydrocarbons by strong swirling of fluid, cavitation phenomena, ultrasonic vibrations, hydraulic hammers, the following physical, chemical and quantum-mechanical phenomena occur in them. Under the influence of shear stress in the fluid at the micro level, due to collapse of cavitation bubbles, shock waves, strong turbulent fluctuations of local velocity and pressure, a constant splitting of long chains of hydrocarbon molecules occurs. In such a case, a part of split molecules having open hydrogen and carbon bonds are looped, forming a molecule with a shorter chain length. Thus, only by physical influence on liquid hydrocarbons their lighter fractions are developed along with a certain concentration of radicals and molecules OH, H, H_2, O, O_2, CO, CO_2, C_mH_n. Moreover, as has been shown by extensive study of cavitation phenomena in liquids, through partial ionization of water molecules and triboelectricity effects of strong liquid friction on walls of devices, free electrons are formed which are hydrated by molecules of water and hydrocarbons. Cavitation in a liquid is always associated with a strong sonoluminescence that occurs due to the emission of light photons by hydrocarbons and water molecules that are present in films of cavitation bubbles [13]. These photons of light are absorbed in the surrounding molecules of hydrocarbons, water, radicals, molecules of dissolved gases, transferring them to the vibrational excited state. In addition, since H_2O molecules in water droplets are in the vibrational excited state of asymmetric, symmetric and deformation modes of up to the level 5÷6, they also emit photons of light that are absorbed by the surrounding molecules of hydrocarbons and radicals, transferring them to the vibrational excited state [13]. The presence vibrationally excited molecules of hydrocarbons, radicals and water leads to non-equilibrium vibrational chemical reactions, including chain reactions, the velocity of which is many orders higher *at lower temperatures* than for equilibrium reactions [13]. Under such conditions, amphiphilic lipid molecules start to form, which have a hydrophobic and a hydrophilic part. The hydrophilic part has groups formed by such radicals as $COOH$, NH_2, and the hydrophobic part consists of $S_mH_nO_p$ type hydrocarbon radicals. Such molecules are connected with their hydrophilic part (hydrogen bonds appear) to the water droplet, and with the hydrophobic part to the surrounding hydrocarbons (carbon, oxygen and hydrogen bonds appear). Water droplets, based on the principle of minimum potential energy of a particle system, become surrounded by such amphiphilic-lipid molecules which, on the one hand, prevent their coalescence, an on the other hand, provide sufficiently strong bonds with the surrounding hydrocarbon molecules, negating the difference in specific gravity between water and hydrocarbons. Similarly, stable colloidal emulsions of water droplets in liquid hydrocarbons are created, that are not stratified, do not freeze up to –40°C, their viscosity is significantly reduced, and they retain their properties for a long time.

Let us describe now the formation of stable suspensions from powdered hard coal and water. The existing theories of formation of colloidal particles in water are based on the main though experimentally unproven fact of adsorption by solid particles (nuclei) of ions in water, which have common chemical elements with the nucleus [9,18]. This concept requires at least partial dissolution of the solid nucleus particles in water, which is not observed in many cases of formation of colloidal solutions.

Let us present a theory of the formation of suspensions (colloidal solutions) of solid particles in water, as given in the monograph [13]. The substance of nuclei of colloid particles should be hydrophilic. When a hydrophilic mineral substance is wetted, a film of water is formed on its surface, as well as on the semipermeable membrane, having the following properties: dielectric permittivity decreases to ε_S=4.5 as compared to volumetric water ε_S≈80, viscosity increases by 35÷40%, the electric field strength reaches $10^5 \div 10^6$ *V/cm*, the coefficient of self-diffusion of molecules increases by ≈2.5 times, this water does not freeze up to –70ºC, it has less hydrogen bonds and does not dissolve salts [13]. Such properties of water are established due to quantum-mechanical and vibrational nonequilibrium chemical reactions that take place in the pores of atomic dimensions 20÷100 Å of hydrophilic substances (see 3.25÷ 3.27, Table 4.2 [13]).

Due to the high figures of binding energy of water molecules with atoms of solids (150÷300 *kJ/mol*), their partial dissociation and ionization occurs, which leads to the emission of free electrons. The virtually thermoneutral vibrational nonequilibrium chemical reaction contributes to this substantially (1) (Table 4.2. [13]):

$$H_2O(004) + \mathbf{e}^- \leftrightarrow H + OH^- - 4{,}84\ kJ/mol, \quad (1)$$

where the water molecule has the excited asymmetric vibrational mode up to level 4 with energy ΔE=14816 *1/cm* = 177 *kJ/mol*. The resulting free electrons, due to their high velocity (electron velocity in water is ≈100 times greater than the translational speed of H_2O molecules), depart from the nucleus material pores and are then hydrated in the proximate layer of water (3) (see Fig. 3).

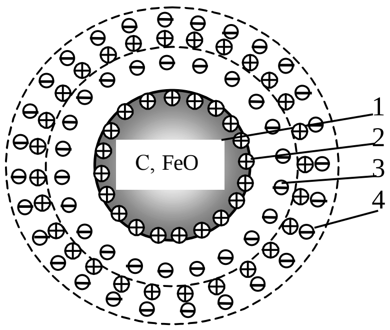


Fig. 3 The structure of carbon and iron oxide micelle: 1 – nucleus; 2 – charged nucleus layer; 3 – layer of hydrated electrons; 4 – layer of polarized water molecules.

In this process, outer nucleus surface is charged positively (2), while the next layer of water (3) is charged negatively. An electrostatic field is created between these charged layers with a strength of up to 10^6 *V/cm*. Due to this field, there is a polarization of water molecules surrounding the layer of hydrated electrons, from the outer side, and the second layer of polarized H_2O molecules is created (4). The stability of bonds between the nucleus, the electronic sphere and the sphere of polarized water molecules will depend on the energy of interaction between the active nucleus elements and water molecules, and specifically, for example, for carbon in the form of graphite and hard coal it is equal to 150 *kJ/mol* [13]. But hard coal is always has a lot of impurities (ash), the main components of which are silica (SiO_2), iron oxides (e.g., FeO), carbonates ($CaCO_3$), and the energy of their binding with the molecules of water is equal to 223, 236 and 210 *kJ/mol*, respectively [13]. In this scheme of colloidal particle, the presence of charged thick "coat", on the one hand, negates gravity force of the particle nucleus, and on the other hand, due to hydrogen bonds with the surrounding water molecules it ensures stability of the colloidal solution. In order to obtain a stable colloidal solution (suspension) of solid particles in water and, in particular, of hard coal powder, this mixture shall be passed through a device that produces an intense turbulation of the swirling flow with local speeds up to 30 *m/sec*, a strong cavitation, acoustic and ultrasonic influence.

This technology will allow to solve two main tasks of creating a stable suspension: breaking up of solid particles into smaller pieces and substantially activating the water, increasing the stored vibrational energy in H_2O molecules. If there is a need to enhance the hydrophilic properties of solid particles of suspension, appropriate surfactants can be added to the colloidal solution.

Features of processes of combustion of water-hydrocarbon emulsions and suspensions in atmospheric air

Numerous experimental data on combustion of finely dispersed water-hydrocarbon emulsions showed the following important features of the combustion process in the air: the flame jet expands and decreases in length, the average combustion temperature increases, the luminescence brightness increases, despite the fact that the proportion of water in the fuel reaches 20÷30% , its calorific value appears not less than for the original hydrocarbon, and even slightly increases, the completeness of combustion increases, the combustion products have substantially reduced concentration of such substances as *CO, NOx,* soot, benz(a)pyrene, the exhaust gas temperature decreases, carbon deposition on the structural elements of combustion chambers, water-heating devices, etc. substantially reduces. Improvement of hydrocarbon fuel combustion efficiency in such emulsions can be partially explained by the following effect: when, for example, diesel oil emulsion is sprayed using nozzles of the combustion chambers, 0.1÷1 *mm* drops are formed, containing 0.1÷7 μm droplets of water. Due to the fact that the boiling temperature of heavy hydrocarbons is 200÷300°C higher than that of water, by heating the water droplets in the flame jet they explode *generating vapor*, breaking and scattering hydrocarbon drops, which significantly improves the combustion process. But this phenomenon cannot explain a significant increase in the calorific value of the fuel, an increase in average temperature of the flame jet, or a substantial reduction of harmful substances content in exhaust gases. By all canons of equilibrium chemistry of burning of hydrocarbon fuels in the air, even if it is assumed that the H_2O molecule is a catalyst for the combustion process, the total calorific value of the fuel ought to be reduced, since energy is required for evaporation and heating of the water vapor, whereas we actually get the opposite result. A priori we may assume that the following process takes place under hydrocarbon fuel combustion conditions: for some reasons, H_2O molecule breaks into *OH* and *H* radicals, and the *OH* radical further reacts with $C_nH_mO_p$ hydrocarbon radicals, including *CO* at the last stage, and subsequently final combustion of hydrogen occurs. It is known that the reaction rate of hydrocarbons with the *OH* radical is by orders of magnitude greater than with the O_2 oxygen in the air, so the overall combustion processes can dramatically accelerate. However, in these conditions the main requirement must be satisfied: the energy required for dissociation of an H_2O molecule shall be significantly less than the energy released at combustion of hydrogen in the air oxygen. This situation may arise if conditions are created for vibrational excitation of the H_2O molecule as a reagent reacting with other elements, thereby increasing the rate of reactions by many orders of magnitude [13].

The described phenomena arising during combustion of water-hydrocarbon emulsions in the air are associated with a unique natural phenomenon, when at explosion of water droplets not only water vapor is formed, but also dissociation and ionization of H_2O molecules takes place with formation of elements OH, H, O, H_2O_2, HO_2, OH^-, H^+, $\mathbf{e}^-$, H_2O^*, OH^*,O_2^*(where * means vibrationally excited molecules), and generation of strong radiation, especially in the ultraviolet range [13,19].

Water aerosols present in vapor and atmospheric air in general have dimensions of 0.2÷8 μm, and the time of their stable state heavily depends on various types of low-power external influences (0.1÷0.001 W/cm^2) (acoustic, electromagnetic, microwave vibrations, heat, radiation) [9,13,19].

Under the influence of selective resonance effects, water aerosols explode, and an example of this phenomenon is shown in Fig. 7, which represents photographs and a diagram of the process of disintegration of water droplets (aerosols) present in the atmospheric air and a weak alternating electric field [19]. The characteristic size of the luminous sphere resulting from the explosion of aerosols (Fig. 4) amounts to a few millimeters, while the sphere has a negative charge, and the luminous core is charged positively, and there can be observed a high intensity radiation, mainly at a wavelength of 0.34 μm.

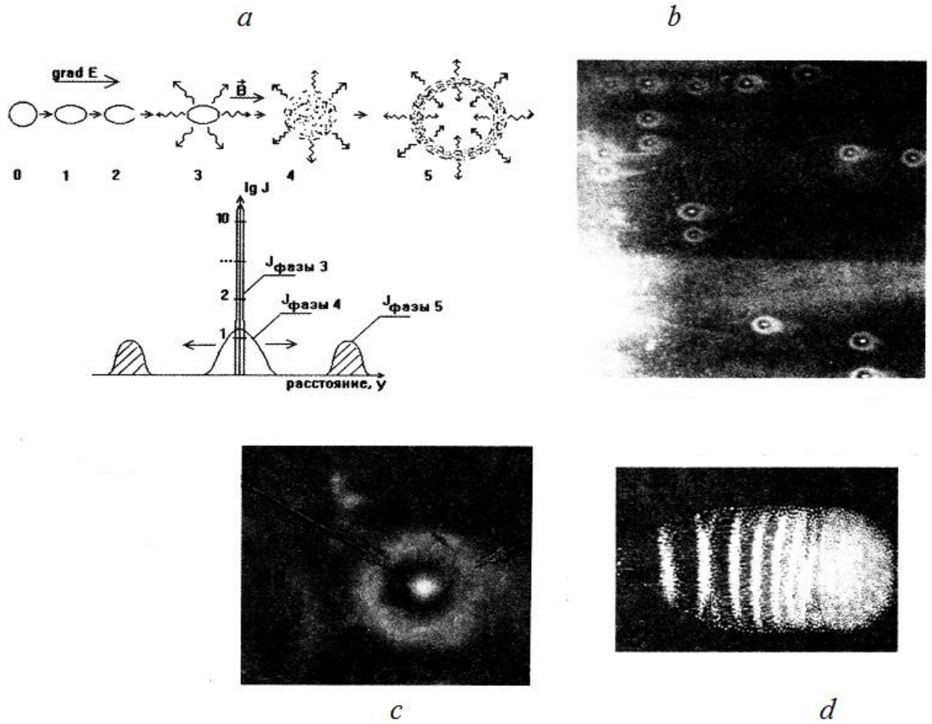


Fig. 4 Photos (b, c, d) and scheme of disintegration of water aerosol particles in atmosphere (a), exposed to electromagnetic field: c) scale 5:1; d) 35:1; disintegrating water aerosol in presence of the electric field, flying from the source to the atmosphere [16].

These experimental results can be explained by the processes of dissociation and ionization of H_2O molecules during the explosion of aerosols, wherein the OH^- ions and free electrons hydrated on water molecules ($H_3O_2^-$) form an outer luminous sphere, while the hydrogen ions create hydrate H_3O^+ ions, positively charging the nucleus of this formation.

Let us describe the processes occurring in the explosion of water aerosols. The total energy of H_2O molecules in the droplets is formed from its components distributed in all degrees of freedom: hydrogen bonds between the molecules in the cluster (4 degrees), vibrations of atoms in the molecule (3 degrees – symmetrical, asymmetrical, and deformation mode), angular oscillations of the molecules as a whole (3 degrees – rotational modes), translational motion of the molecules both as part of a cluster and individually (3 degrees). Let us note the important properties of water molecules in the liquid phase: at sufficiently high first energy levels of the symmetrical, asymmetrical and deformation modes – 3,744, 3,848, 1,757 *1/cm*, it has a relatively high their anharmonicity: 87, 96, 37 *1/cm*. In addition, the energy of hydrogen bonds between the molecules in the liquid phase according to numerous empirical data [13] amounts to $\Delta E_H \approx 21$ *kJ/mol* = 1,755.4 *1/cm*, which means that it is close to the first energy level of the deformation mode of the H_2O molecule.

When external selective influences are exerted on the water aerosol, structural transformations of crystals begin to occur in a droplet, the stability of clusters disappears, and the total energy of the connections between them decreases. There develop oscillatory processes of dynamic movement of parts of the liquid in the droplet with respect to each other, with tearing of numerous hydrogen bonds between molecules. Reduction of the total energy of hydrogen bonds takes place due to the quantum-mechanical reaction of light photons emission and their absorption by the H_2O

molecule to the first level of deformation mode, that runs with almost a full resonance (2):

$$h\nu(\Delta E_H) + H_2O(\nu_1,0,\nu_3) \leftrightarrows H_2O(\nu_1,1,\nu_3) \pm \Delta E_D = 2\ cm^{-1}. \quad (2)$$

Reaction (2) partially ensures pumping with the vibrational energy of the deformation mode of H_2O molecules, but basically it originates due to smaller energy quanta through rotational degrees of freedom, as detailed in [13]. The deformation mode in the H_2O molecule makes by energy capacity only ≈15%, so there begin the processes of its redistribution to symmetric and asymmetric modes by quantum-mechanical reactions (3,4) [13].

a) Quantum transitions between deformation and symmetric modes:

$$\begin{array}{ll}
1.\ H_2O(4,4,\nu_3)+H_2O(\nu_1,1,\nu_3)\leftrightarrows H_2O(5,3,\nu_3)+H_2O(\nu_1,0,\nu_3)\pm\Delta E_D=7\ cm^{-1}, & \\
2.\ H_2O(7,5,\nu_3)+H_2O(\nu_1,7,\nu_3)\leftrightarrows H_2O(8,4,\nu_3)+H_2O(\nu_1,6,\nu_3)\pm\Delta E_D=9\ cm^{-1}, & \\
3.\ H_2O(3,1,\nu_3)+H_2O(\nu_1,2,\nu_3)\leftrightarrows H_2O(4,0,\nu_3)+H_2O(\nu_1,1,\nu_3)\pm\Delta E_D=6\ cm^{-1}, & \\
4.\ H_2O(4,1,\nu_3)+H_2O(\nu_1,4,\nu_3)\leftrightarrows H_2O(5,0,\nu_3)+H_2O(\nu_1,3,\nu_3)\pm\Delta E_D=7\ cm^{-1}, & (3)\\
5.\ H_2O(6,4,\nu_3)+H_2O(\nu_1,6,\nu_3)\leftrightarrows H_2O(7,3,\nu_3)+H_2O(\nu_1,5,\nu_3)\pm\Delta E_D=4\ cm^{-1}, & \\
6.\ H_2O(4,3,\nu_3)+H_2O(\nu_1,2,\nu_3)\leftrightarrows H_2O(5,2,\nu_3)+H_2O(\nu_1,1,\nu_3)\pm\Delta E_D=7\ cm^{-1}, & \\
7.\ H_2O(6,7,\nu_3)+H_2O(\nu_1,3,\nu_3)\leftrightarrows H_2O(7,6,\nu_3)+H_2O(\nu_1,2,\nu_3)\pm\Delta E_D=4\ cm^{-1}, &
\end{array}$$

б) Quantum transitions between deformation and asymmetric modes:

$$\begin{array}{ll}
1.\ H_2O(\nu_1,5,5)+H_2O(\nu_1,1,\nu_3)\leftrightarrows H_2O(\nu_1,4,6)+H_2O(\nu_1,0,\nu_3)\pm\Delta E_D=2\ cm^{-1}, & \\
2.\ H_2O(\nu_1,4,5)+H_2O(\nu_1,2,\nu_3)\leftrightarrows H_2O(\nu_1,3,6)+H_2O(\nu_1,1,\nu_3)\pm\Delta E_D=2\ cm^{-1}, & \\
3.\ H_2O(\nu_1,4,7)+H_2O(\nu_1,7,\nu_3)\leftrightarrows H_2O(\nu_1,3,8)+H_2O(\nu_1,6,\nu_3)\pm\Delta E_D=5\ cm^{-1}, & (4)\\
4.\ H_2O(\nu_1,5,7)+H_2O(\nu_1,6,\nu_3)\leftrightarrows H_2O(\nu_1,4,8)+H_2O(\nu_1,5,\nu_3)\pm\Delta E_D=5\ cm^{-1}, & \\
5.\ H_2O(\nu_1,7,6)+H_2O(\nu_1,1,\nu_3)\leftrightarrows H_2O(\nu_1,6,7)+H_2O(\nu_1,0,\nu_3)\pm\Delta E_D=20\ cm^{-1}, & \\
6.\ H_2O(\nu_1,6,6)+H_2O(\nu_1,3,\nu_3)\leftrightarrows H_2O(\nu_1,5,7)+H_2O(\nu_1,2,\nu_3)\pm\Delta E_D=17\ cm^{-1}. &
\end{array}$$

H_2O molecules in this environment are in the vibrational excited state and, as a result of strong anharmonicity of its modes, processes of V-V energy quanta exchange always take place, resulting in a deviation from the equilibrium state of upper levels. At the same time, quanta of vibrational energy will be transferred from lower to upper levels, and the defect of energies (the difference of energy quanta) will be converted into kinetic energy of the molecules (heat).

At the extreme, when the H_2O molecules will have populated 10÷11 levels of its symmetrical, asymmetrical, and the 7th level of deformation mode, the total internal energy will be ≈500 *kJ/mol*, which is equivalent to its dissociation and ionization energy. Thus, the described process of selective external influences on the water in the droplets of aerosols in combination leads to dissociation and ionization of H_2O molecules due to *energy distribution between degrees of freedom* (from hydrogen bonds to the vibrational symmetric, asymmetric and deformation modes), with observance of particle system energy conservation law, absence of violation of the laws of thermodynamics, and formation of such elements as OH, H, O, OH^-, H^+, $\mathbf{e}^-$, H_2O^*, OH^*.

In such medium of liquid water containing radicals and vibrationally excited molecules, vibrational nonequilibrium exothermic chain chemical reactions start running, one example of which is shown in Fig. 5 [13]. As a result of such reactions, the following elements are formed: OH, HO_2, H_2O_2, H_2, O, O_2, O_3, H_2O^*, OH^*, and a lot of energy is released not only in the form of heat, but also as radiant emissions of broad spectral range. As a result of such complex processes, an explosion of water aerosols occurs with generation of large concentrations of radicals, electrons, ions and molecules OH, H, O, H_2O_2, H_2, O_2, O_3, HO_2, OH^-, H^+, $\mathbf{e}^-$, H_2O^*, OH^*,O_2^* and release of energy at "collapse" of the H_2O molecule up to ≈5000 *kJ/mol.*

$H_2O_{(aq)} \;{}^{K2}\!\rightleftarrows_{K1} OH_{(aq)}^- + H_{(aq)}^+ + 55{,}84$ *kJ/mol*
$OH_{(aq)}^- \rightleftarrows OH + e_{(aq)}^- + 538$ *kJ/mol*
$H_2O(\nu_1,0,\nu_3) + OH_{(aq)}^- \rightleftarrows H_2O(\nu_1,7,\nu_3) + OH(3) + e_{(aq)}^- + 0{,}01$ *kJ/mol*
$H^+_{(aq)} + e_{(aq)}^- \rightleftarrows H - 51$ *kJ/mol*
$H_2O(004)_{(aq)} + e_{(aq)}^- \Rightarrow H + OH_{(aq)}^- - 4{,}84$ *kJ/mol*
$H_2O_{(aq)}(004) + H \Rightarrow OH + H_2 + 107(-177)$ *kJ/mol*
$O_2(0) + e_{(aq)}^-(E) \Rightarrow O_2(\nu) + e_{(aq)}^-(E-\nu)$
$O_2(5) + O_2(5) \Rightarrow O_3 + O + 391{,}5\ (-130{,}1)$ *kJ/mol*
$O_3 + M \Rightarrow O_2 + O + M + 106{,}9$ *kJ/mol*
$OH(7) + O_2 \Rightarrow O + HO_2 + 220{,}7\ (-291{,}5)$ *kJ/mol*
Input: $3H_2O$, $3O_2$, e^-;
Output: $3O_2$, OH, $2HO_2$, H_2, OH^-; $\Delta Q = +1364$ *kJ/mol*

↓

$H_2(1) + O \Rightarrow OH + H + 7{,}8\ (-52{,}6)$ *kJ/mol*
Output: $2O$, $2OH$, HO_2, $2H$, OH^-; $\Delta Q = +7{,}8$ *kJ/mol*

↓

$OH + H + M \Rightarrow H_2O_{(aq)} + M - 542{,}84$ *kJ/mol*
Output: $2O$, OH, HO_2, H, H_2O, OH^-; $\Delta Q = -542{,}84$ *kJ/mol*

↓

$OH + H + M \Rightarrow H_2O_{(aq)} + M - 542{,}84$ *kJ/mol*
Output: $2O$, OH, HO_2, $2H_2O$, OH^-; $\Delta Q = -542{,}84$ *kJ/mol*

↓

$O + O + M \Rightarrow O_2 + M - 498{,}4$ *kJ/mol*
Output: O_2, $2H_2O$, HO_2, OH^-; $\Delta Q = -498{,}4$ *kJ/mol*

↓

$HO_2 + HO_2 + M \Rightarrow H_2O_2 + O_2 + M - 208$ *kJ/mol*
Output: $2O_2$, $2H_2O$, H_2O_2, OH^-; $\Delta Q = -104$ *kJ/mol*
$\Delta Q = -316{,}3$ *kJ/mol*

Fig. 5 Example of vibrational nonequilibrium exothermic chain chemical reactions running in liquid water with energy release for the cycle DQ = - 316,3 kJ/mol [9].

In the process of combustion of liquid hydrocarbons in the air, given the existence of exploding water drops, firstly, by means of oxidative radicals and molecules OH, O, H_2O_2, O_3, the processes of disintegration of hydrocarbon molecules and their oxidation are significantly enhanced, secondly, because of vibrational excitation of reagents the chemical reactions are significantly accelerated (by many orders of magnitude), and thirdly, hydrogenous elements (OH, H, H_2O_2, H_2, HO_2) are burned, greatly increasing heat output. It should also be noted that the presence of free electrons at high concentrations significantly accelerates many oxidation reactions, and recombination of OH^-, H^+ ions provides additional heat output. Moreover, presence in the mixture of gases of OH, H, O, H_2O_2, H_2, O_3, HO_2 elements at high concentrations provides high afterburning of CO, C (soot), disintegration of nitrogen oxides and complex hydrocarbons.

In the process of combustion of suspensions from powdered hard coal and water, aqueous aerosols are formed from filmy activated water during spraying through nozzles of combustion chambers, which also explode to form radicals, electrons, ions and molecules OH, H, O, H_2O_2, H_2, O_2, O_3, HO_2, OH^-, H^+, e^-, H_2O^*, OH^*, O_2^*. In the presence of such elements, superficial burning of solid particles of hard coal greatly accelerates, completeness of combustion of hydrocarbons increases, and due to combustion of hydrogenous elements (OH, H, H_2O_2, H_2, HO_2), heat output increases greatly.

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SOCIO HUMANITIES.

ECONOMICS, ECONOMETRICS AND FINANCE.

PROBLEMS AND DIRECTIONS OF REGIONAL INNOVATION ECOSYSTEMS FORMATION IN UKRAINE

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ABSTRACT

The purpose of this article is to define the problems of Ukraine regions development and to propose the directions and activities of regional innovation ecosystems creation in the context of European integration and decentralization policy.

As methods of research author used theories of regionalism and institutionalism especially the principles of the innovation concept systems and multi-level governance of regional development. The article based on the statistical analysis of the current state of the regions innovativeness and the characteristic tendencies. On the basis of the system approach developed proposals for the formation of state innovation policy in determining the directions of regional innovation ecosystems development.

Author has substantiated the conclusion that innovative changes in regional development, the formation of adequate to the challenges of the innovation environment should be based on innovation-driven development strategy, taking into account the specificity of each region in terms of its competitive advantages.

Keywords: neoregionalism, innovation ecosystems, technology, innovation, innovation policy.

In the conditions of globalization and the geopolitical challenges with regard to the world trends of economic development one of the key factors in the successful development of regions is their ability to move onto the platform of the new socio-technological paradigm and thus ensure competitiveness. In this case, as shown by the results of the latest research in the field of neoregionalism [1-3], the core competitiveness of the region can become an innovation ecosystem that integrates the scientific and technological, investment and human potential of the region on the principles of network organization for innovation activities. The reasons for the increased attention to regional development at the present stage is the region's ability to quickly and adequately respond to changing internal and external environment, and the flexibility to change the parameters of the economy to support an innovative environment.

The experience of leading countries shows that at the beginning of the XXI century. the innovation system has become a strategic factor for growth and can significantly affect the structure of social production and organization of economic activity, stabilize the social situation in the country. At the same time, in according to the increasing role of environmental factors and ecological innovations in the formation of economic systems at various levels in recent years, enhanced by the study of the phenomenon of innovation ecosystems.

For the entire period of existence of independent Ukraine, its regional development is the focus of scientists and practitioners. Thus, in most cases, the main problems of regional policy are the following: market reforms, especially in terms of creating modern institutions that are not brought to its logical conclusion, are kept distributional trends in the management of resources; the provision of social and managerial services to the population of the regions not provided with the necessary financial and material resources; organizational structure of management does not meet the requirements of democracy and the challenges of the external environment is not ensured "transparency" in performing management functions.

The main cluster regions by the combination of the two indices are in the range of gradation "medium-low", which indicates the relationship between knowledge resource and quality of regions population life. This situation is caused by a lack of effective as General economic and social policy of the state and discharge a long time of regional authorities from the coordination of innovation processes in the respective territories.

The resulting indicator of the above assertions should be considered a low level of research intensity of gross regional product (GRP) in all regions of the country, although some of them stand out mostly are the regions with developed industry that requires technological knowledge and innovation. In particular, statistics show that if the total gross regional product (GRP) and GRP per person, 2010-2013 had a somewhat positive trend, the General trend in all regions of Ukraine should be considered a lower level of research intensity of gross regional product on the background of differentiation reduction (tabl.1).

Table 1

Indicators of GRP and its knowledge intensity in the regions of Ukraine

Region	GRP, mln. the national currency		GRP per one person, the national currency		GRP Research intensity, %	
	2010	2013	2010	2013	2010	2013
Crimea	32426	46393	16,5	23,6	0,5	0,3
Vinnitsa	23589	33024	14,3	22,3	0,2	0,1
Volyn	14429	20622	13,9	19,8	0,1	0,1
Dnepropetrovsk	116136	152905	34,7	46,3	0,6	0,6
Donetsk	128986	164926	29,0	37,8	0,4	0,3
Zhytomyr	18743	25676	14,6	20,3	0,1	0,3
Trans Carpathian	15299	21400	12,3	17,0	0,2	0,2
Zaporozhe	23726	54352	23,7	30,5	1,9	0,9
Ivano-Frankovsk	20446	33196	14,8	24,0	0,3	0,1
Kiev	44953	68931	26,1	39,9	0,5	0,3
Kirovograd	15749	23513	15,5	25,5	0,2	0,1
Lugansk	45541	55108	19,8	24,5	0,3	0,3
Lviv	41655	63329	16,4	24,9	0,7	0,5
Nikolayev	24055	32030	20,3	27,4	0,9	1,9
Odessa	53878	69760	22,5	29,1	0,4	0,3
Poltava	44291	58464	29,7	39,9	0,1	0,1
Rivne	15882	22004	13,8	19,0	0,1	0,1
Sumy	18333	26765	15,7	23,5	0,6	0,5
Ternopol	12726	18085	11,7	16,8	0,1	0,1
Kharkiv	65293	85315	23,6	31,1	2,5	2,3
Kherson	15649	20767	14,3	19,3	0,3	0,2
Khmelnitsky	18096	26426	13,6	20,2	0,03	0,1
Cherkassy	22354	33087	17,3	26,2	0,2	0,2
Chernovtsy	9892	13757	10,9	15,1	0,3	0,3
Chernihiv	17008	24237	15,4	22,6	0,2	0,3
. Kiev city	196639	312552	70,4	109,4	1,8	1,5
. Sevastopol city	7785	11066	20,5	28,8	1,4	1,4

Source: calculated by the author according to [4].

The analysis of the innovative activity dynamics of industrial enterprises, representing the component's "business" in the regional innovation ecosystem (RIES), shows variability of indicators in the context of specific regions and the tendency for them to decline. So, in 2014 among the regions is above average in Ukraine the share of innovation active enterprises was in Kherson, Zaporozhe, Ivano-Frankovsk, Kharkiv, Mykolaiv, Sumy, Kirovograd, Odessa, Lviv regions and in Kyiv. The typical trend should be noticeable among other regions by the share of innovative products sales in total volume of industrial products sold in the Trans Carpathian and Sumy region. It should be noted that if high rates of Sumy region traditionally due to its significant industrial potential, especially the development of high-tech engineering, that Trans Carpathian in the last years is an example of formation of modern economy model through close technological cooperation with foreign companies in the framework of trans boundary cooperation and related international technology transfer.

The existence of opportunities to generate innovative ideas, traditionally the most active are companies and organizations located in the industrialized regions. So, during the analyzed period, the applicants Vinnitsa, Dnepropetrovsk, Zaporozhe, Lviv, Odessa, Kharkiv regions and Kyiv city received about 80% of the total number of applications for inventions and utility models. Thus, the distribution of graduate schools and doctoral programs across regions is uneven. Most of them are concentrated in Kiev – 222 and 108, respectively, and Kharkiv region – 63 and 39, Lviv – 34 and 20, Dnepropetrovsk – 28 and 14, Odessa – 27 and 19. In other regions their number in units, although there is no region where there was no graduate or doctorate [4].

Assessment of profitability from operating activities of processing industry in Ukraine gives grounds to conclude the unequal distribution between regions. In the inter-regional proportions of distribution of profit from operating activities is enhanced by the degree of differentiation and the level of concentration; analysis of the correlation of income and revenues indicates a relatively high profitability of technologically complex products production that are related to the category of high and medium-high-tech.

Technological sectors of most regions are not able to accumulate their own financial resources in volumes sufficient for expanded reproduction of production. However, the volumes of reinvested earnings are determined by the owners, so the real amounts of financing of technological reproduction are less than its own financial resources. Due to lack of own sources of funds for capital formation slowed the process of expanded reproduction of production based on new technology and increased demand for loan funds.

The existing imbalance of the distribution of owns sources of reproduction between technological sectors are holding back the improvement of the technological structure of Ukrainian production.

Interregional imbalances are sources for formation of own financial resources technological play cause inefficient division of labor, concentration of industrial production in several regions, posing a threat of de-industrialization of farms in most regions of the country, leading to loss of jobs, income, uncollected revenues in the budgets and other negative economic consequences for these regions.

At the regional level has emerged a growing imbalances trend of investments in fixed capital by sources of formation of investment resources. Thus, the external sources of economic growth up 21%, the overall share of foreign assets in the structure of investment capital in the regions of Ukraine is 64, 15%. In the future, the development this trend leads to negative processes of gradual loss of national resources of investment support for economic and technological development.

Among the factors that cause the problem in modern conditions is the uncertainty of the strategic priorities of regional development, the unwillingness of the regions to make full use of the opportunities of geopolitical location and distribution process of trans nationalization at the regional level. The specified leads to the emergence of strategic and tactical miscalculations of regional development of Ukraine, and the inhibition of the process of attracting industrial and intellectual potential, the formation of competitive advantages and competitiveness of the country and, accordingly, the formation of qualitative factors of economic growth.

Experience shows that the policy of equalization of socio-economic development of the regions, characteristic of the era of primary industrialization, and is designed for placing in regions of fixed assets used for the production model of mass production and concentration of the labour force was replaced by a policy of equalization of the effects of opening the domestic market. In Ukraine, budget alignment backward in adaptation to market conditions of the regions has not yet led to the expected results. For regional development directing in General and up to this time used a limited tool set that comes down mainly to budget transfers and state programs.

One of the main conclusions obtained in the course of investigations indicates the relationship of the national and regional economy, in particular, the fact that the current economic decline of the regions due to the backlog of Ukraine in the development of high-tech sector of industrial production as the main potential of the so-called problem regions were formed in this area. All regions of Ukraine felt the recession, but in varying degrees - depending on industry-specific characteristics of their industrial potential. Analysis of the crisis tendencies in the economy, employment and incomes of the regions shows that the averages for Ukraine hide rather heterogeneous trends at the regional level.

Almost all regions face the same difficulties, the most common of which is low income levels, peripheral geographical location compared to the economic center of the country and predominantly resource-based economy. The solution to these problems has seen in the development of regional production, which is hardly possible without innovation. Competitive today you can consider those regions where there is sufficient production capacity, advanced high-tech production, has cheap and skilled labor force and cheap resources. At the moment in most regions of the country there is a shortage of certain resources and businesses spend all their organizational and financial "strength" to fight for finding a very scarce resource within the region.

A comparison of the total economic potential of regions, their innovation potential and capacity to develop innovative networks revealed the following trends: practice of their implementation is substantially different from similar processes of OECD countries on the volume, structure and directions. In sectorial aspect of participants in networks are mainly scientific research institutions, educational institutions, industrial enterprises represented little; between the Ukrainian innovative enterprises, contrary to world experience, there is no large-scale technology partnership; in a country critically low innovative activity of small and medium enterprises, as manifested in their limited participation in technology transfer and joining networking organizations. In General, for the network activities in Ukraine involve spatial constraints on the course of technology transfer is significantly affected by the crisis of confidence between its members.

Activation of innovative activity implies the participation of the regions in innovation processes, which in turn necessitates the formation of an expanded system of innovative activity motivation at the regional level with the creation of modern organizational and economic mechanism of this activity.

Based on the analysis of foreign experience of formation of innovation systems, peculiarities of macroeconomic development of Ukraine, results of state and regional policy in the sphere of innovation and other factors, it should be stated that the most effective direction of development of national innovation system is its formation as a set of institutional regional innovation ecosystems. Regional innovation programmes should be aimed at establishing linkages and collaboration between research organizations and the private sector in the framework of partnership agreements, development of small and medium enterprises in mastering new technologies and know-how. Prerequisites for the implementation are the following: there are serious economic reasons for innovation support regional authorities; strong regional innovation ecosystems are characterized by high quality intensive links between firms, research institutes, universities, intermediaries, public institutions and other stakeholders; to achieve success the regions cannot strictly focus on support to specific sectors but should support learning and interaction between stakeholders in innovation participants.

Carried out researches have allowed to define the following constraints for the formation of a modern regional innovation ecosystems in Ukraine: the competence necessary for the development of the knowledge economy are limited and in decline; the decline of inventive activity in the regions due to the lack of state policy in the sphere of intellectual property management; low level of foreign direct investment (FDI) limit prospects for technology diffusion; enterprises with foreign participation is the main official channel of technology transfer; regions demonstrate the potential for entrepreneurship but its effective use requires further improvement of the business environment; although manufacturing plays an important role in the economic system of most of the regions it is dominated by traditional sectors in which opportunities for rapid new innovation (approximately half of value added in industry occurs in the mining sector, where innovations are possible but are not key competitive asset. These barriers not only hold back innovative development, but also significantly affect the quality of life of population of regions.

Among priorities that reflect a new stage of spatial development and strengthening the role of regions in development of their territories on the basis of innovative transformations must have the following: a substantial separation of functions between the centre and the regions, giving regions and municipalities the status of direct participants and organizers on qualitatively new innovation-based; development of the territorial network models of organization of production systems; bringing to the territorial network models of small productive and innovative businesses; the use of public-private partnerships as one of the basic mechanisms of interaction between government and the business community in innovation. The above requires active development of new projects and programs.

Whatever world events and their influence of globalization calls for the development of the national economy, problems of innovative development and creation of a developed industrial and social infrastructure in economic growth and improve the quality of life of the population are urgent. In the face of uncertainty and constant risks for the functioning of the business environment there is a need for a system of development institutions in the regions, aimed at strengthening mechanisms for the development and implementation of government economic policy in identifying the organizational, functional, and structural problems of spatial development. It is from the standpoint of technological modernization should be formed adequate methods of state involvement in regulation and governance, economic and legal norms, rules, and regulators. Mechanism, which contributes to the solution of the above tasks for the development and diversification of the economy and to improve the efficient use of government resources, are specialized organizations with state participation - development institutions that can become catalysts for private investment in priority sectors and sectors of the economy will promote innovation, improve the institutional environment.

Therefore, the first goal to turn of regional economies to innovative development should be the creation of regional innovation ecosystems - organizational and technological expert consulting, financial and information systems that ensures economic development of each region through sustainable and priority development of production and implementation of high-tech products, scientific and technical services; involvement of the intellectual potential of the region in productive activities and its expanded reproduction; involvement in innovative sphere of internal and external private investment; the formation from the high-tech industries task orders for higher educational institutions of the region, improving the quality of higher education; improving management and marketing in the high technology sector; positive impact on related sectors of the economy of the region (industrial high-tech industry that can use the created designs and products, telecommunications, banking, etc.).

Creating a favorable investment and business climate in the regions of Ukraine should be the basis of consolidating efforts to improve the level of relations and cooperation of entrepreneurs with local authorities, state authorities and be aimed at creating an attractive investment environment, improving the marketing strategy of the region, information consulting, educational and training support of innovative entrepreneurship and implementation of effective regulatory policies at the local level which is aimed at cooperation with organizations and participation in international projects.

In accordance with the trends that occur in modern socio-economic system of regions of Ukraine in the context of security, technological security of the region acts as a condition in which the innovation ecosystem is able to create scientific and technological resources are sufficient for the development of personality, social stability, and create conditions for economic growth. These requirements ensure not only the implementation of innovation policy of the government, especially in parts of the country on the path of sustainable economic development and the revival of domestic science-intensive production, but also ensure the growth of profitability and competitiveness of innovative products, increase employment and improve the quality of life that will ensure a high level of security of both the country and regions.

A strategic priority of the regional innovative policy should be the development of human resources necessary for a modern economy in the following areas: modernization of the training system at all levels, especially in academic, facilitating the process of integration of educational centers with public agencies and institutions in the regions on the principle of "triple helix"; the formation of regional systems of lifelong learning, adult education, distance learning, and vocational and special education; creation of modern material and organizational base for the development of ICT, network ICT systems in the public domain (administration, education, culture) and Economics.

An important component of regional innovation policy in the context of European integration and decentralization should be measures to permit foreign economic integration problems, primarily associated with a significant increase in global and regional competition. Under such conditions it is necessary to take a holistic integrated approach to providing progressive technological changes in the region when the control object is not a separate species or a result of innovative technology, regional innovation ecosystem, which covers all processes of the innovation cycle, while providing special values of the criterion of competitiveness of the region as a final result of regional innovation policy. The solution of these problems is largely due to strategic development and the interaction of the three basic components of the infrastructure of the innovation ecosystem are engaged in the promotion of the scientific researches, ensuring their commercialization and creation of partnership organizational culture combined with the necessary competencies for innovative entrepreneurship.

Therefore, innovative changes in the development of the regions of formation adequate to the challenges of the innovation environment should be based on innovation-driven development strategy, taking into account the specificity of each region in terms of its competitive advantages, the most promising industries, capable to provide economic growth to each regional entity, implementation mechanisms and expected results, science-based system for strategic and operational management of the implementation of planned activities. The success of government economic policy largely depends on how new knowledge is generated in the process of implementing plans of economic development of the region and how closely the local elites (especially scientists and entrepreneurs) to share knowledge. Therefore, the ability of the country to ensure that its regions with the necessary information, knowledge, networking, sharing knowledge and technologies, their diffusion and effective use become the main factors stimulating regional development.

In Ukraine is passed the "sustainable development Strategy of Ukraine for the period till 2020", which defines the goals, directions and priorities of country's development and involves consideration of economic, social and environmental factors as determinants of reform. To achieve the set goals is possible with the formation of the modern innovation ecosystem that includes not only the participants of the innovation process, but all businesses at the regional level.

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SOCIAL SCIENCES.

ГРАЖДАНСКО-ПРАВОВОЕ РЕГУЛИРОВАНИЕ ТРАСТОВЫХ ОПЕРАЦИЙ В БАНКАХ
CIVIL REGULATION OF TRUST OPERATIONS IN BANKS

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Аннотация

В данной статье рассматривается понятие и виды трастовых операций банков. Сделан четкий анализ всех видов операцией и их преимущества. Также охарактеризован зарубежный опыт в этой сфере. Особое внимание обращается на значение и особенности трастовых банковских операций. На основе проведенного исследования сделан вывод о преимуществе и недостатке трассовых банковских операций.

The summary

This article discusses the concept and types of trust banking operations. There are made an analysis of all types of operations and their advantages. It is also characterized by the international experience in this field. Particular attention is drawn to the meaning and features of trust banking operations. On the basis of the study concluded that the advantages and disadvantages of trace banking operations.

Ключевые слова: трастовые операции банков, трастовые услуги, агентские услуги, агент, трассовые средства, частные лица, операции банков, доверие, долговые обязательства, ценные бумаги.

Key words: the trust operations of banks, the trust services, the agency services, the agent, the trace tool, individuals, the operations of banks, the trust and debt securities, the securities.

Трастовые операции банков (англ. trust - доверие) - операции по управлению имуществом и выполнение иных банковских услуг в интересах и по заданию клиентов. Многие банки берут на себя функции доверенного лица и выполняют разнообразные операции для своих личных и корпоративных клиентов.

Суть понятия «трастовые операции» сводится к услугам, созданным на доверительных правоотношениях, когда одно лицо учредитель, отдает свое имущество в распоряжение другому лицу доверительному владельцу, для управления в интересах третьего лица бенефициара.

В указанных правоотношениях участвуют три стороны: [4]

- доверитель имущества (основатель) юридических или физических лиц, который создал траст и / или передал доверительному собственнику принадлежащего ему имущества в соответствии с условиями указанными в договоре;

- доверительный владелец (траст) - сторона, которая реализовывает управление имуществом. Им могут быть специализированные трастовые компании (доверительные общества) или трастовые отделы банков;

- бенефициар - лицо, в пользу и в интересах которого оказываются доверительные услуги. Им может быть сам доверитель имущества или третье лицо [5].

Проанализировав имеющуюся литературу по рассматриваемому вопросу, можно выделить следующие факторы и особенности появления и развития доверительных услуг:

- отсутствием или избыточным уровнем знаний и умений владельцев имущества, чтобы распоряжаться им, особенно значительных и разных видов;

- возможностью потери собственником своего имущества в случае независимого осуществления операций;

- возрастающей заинтересованностью клиентов в приобретении большого набора банковских услуг;

- повышающейся конкуренцией между банковскими и небанковскими финансовыми и кредитными учреждениями, между самими коммерческими банками на рынке денег и рынка капиталов;

- вопросы ликвидности банков и уменьшение уровня прибылей традиционных банковских операций и услуг;

- относительно малые затраты на реализацию обозначенных услуг;

- трастовые услуги дают возможность привлечь солидные средства, которые могут употребляться банком и доставлять ему доходы.

Итак, в формате трастовых услуг, предоставляемых субъектам хозяйственной деятельности, банки могут работать как доверенные агенты субъектов хозяйственной деятельности (предприятий) [3].

В их деятельность может входить выпуск долговых обязательств в интересах предприятий, выплата дивидендов или процентов по любым долговым обязательствам, реинвестирование дивидендов по требованию акционеров и погашение долговых обязательств по окончании срока их действия.

Также банки могут распоряжаться передачей прав собственности на акции компании, реализовывать их конверсию в долговые ценные бумаги.

Предоставляя трастовые услуги, банки обязаны иметь всю учетную деловую информацию применительно к той среде, в которой заинтересован клиент, и помогать своим клиентам оценивать существующие в ней риски.

Следует заметить, что предлагая квалифицированные услуги по управлению собственностью, банки дают предприятиям услуги типа «мастер траст», предусматривающий правление средствами пенсионных фондов или групп других компаний совместным счетом доверителей с целью максимизации прибыли последних.

В научной литературе выделяют следующие категории данных услуг:

- трастовые услуги физическим лицам;

- трастовые услуги предприятиям (коммерческим организациям);

- трастовые услуги некоммерческим организациям.

Каждая из этих категорий обуславливает деятельность банка как траст-агента клиентов.

Различают следующие виды трастовых услуг для физических лиц.

Распоряжение имуществом после смерти владельца - является наиболее распространенным.

Управление имуществом на основе доверия - осуществляется на равной правовой основе: по завещанию, специальным соглашением, распоряжением суда и др.

Разновидностями трастов, которыми распоряжаются банки, являются: заветный траст; прижизненный траст (лицо передает деньги или ценности в управление банка, получая доход в течение жизни, после его смерти выплачивается доход родным), страховой траст (лицо назначает банк доверенным лицом по страховому полису и поручает ему выплачивать доход родным после его смерти), корпоративный траст (основывается в форме имущества в качестве залога в банке для обеспечения выпуска облигаций) и др.

Выполнение агентских функций для частных лиц, деловых предприятий, учреждений, других доверенных лиц, государственных органов.

Агент - лицо, действующее от имени и по поручению другого лица (принципала). Отношения между ними называются «агентские функции». Их отличие от траста заключается в том, что в случае траста доверенному лицу предоставляется юридическое право на распоряжение собственностью, а при агентских отношениях право на собственность остается у принципала.

К агентским функциям относят:

- хранение ценностей в сейфе (банк получает, хранит и выдает ценности по поручению бенефициара без всякой инициативы или активных функций);

- хранение имущества с активными функциями (банк не только сохраняет ценности (например, ценные бумаги) в сейфе, но и покупает и продает их, получая доход, действует от имени принципала)

- управление имуществом (банк выполняет все функции хранения имущества и, кроме того, активно распоряжается им, например, анализирует состояние портфеля ценных бумаг, дает рекомендации и предлагает способы инвестирования капитала) [6].

Различают такие трастовые услуги юридическим лицам: передача доверенному лицу права распоряжения имуществом, находящимся обеспечением облигационного займа; агентские услуги и формирование фондов погашения задолженности по основному долгу, начисленным процентам, дивидендам.

Средства при доверительном управлении и других трастовых операциях передаются на основании специального документа-поручения или завещания. Суть этих операций вытекает из общественно-правовых отношений между доверителем и поверенным, оформляется договором-поручением.

Расходы, которые при этом появляются, относят, в соответствии с действующим законодательством о налогообложении, на себестоимость, на счет прибыли банка.

Учет результатов деятельности по операциям доверительного управление осуществляется обособленными структурными подразделениями банка отдельно от результатов деятельности банка по прочим операциям.

Активы, принадлежащие установщику на правах собственности и находятся у управляющего в доверительном управлении, должны учитываться и храниться отдельно от собственных активов банка.

Выделим следующие основные задачи коммерческих банков при выполнении трастовых операций:

1. Расширение круга операций и услуг.

2. Развитие клиентской базы, улучшения ее качества.

3. Проникновение на другие сегменты банковского рынка.

4. Получение дополнительного дохода.

5. Приобретение контроля над фирмами, различными фондами

6. Обход законодательно установленных для банков ограничений по возможностям инвестирования средств в экономику (долевое участие, фонд, приобретение контрольного пакета акций и т. д.).

7. Увеличение роли банка как участника фондового рынка.[6]

Условия, на которых базируется трастовое (доверительное) соглашение между клиентом и банком, действуют или в течение многих лет, или в бессрочном порядке. В этих случаях доверенное лицо должно работать непрерывно.

По физическим лицам трастовые отношения ограничиваются или жизнью доверителя плюс 21 год, или жизнью двух людей, указанных в завещании и живущих в момент смерти наследника, то есть лицо, оставило завещание. В основном поручения, вытекающие из завещания, продолжаются 20-25 лет, а с пожертвования - более 40 лет. Между тем благотворительные отношения могут быть бессрочными.

Эффективность функционирования указанной системы финансово-экономических отношений, результативность действий каждого из участников зависит от правового обеспечения трастовых операций.

Итак, рассмотрев сущность и полезность трастовых операций, можно сделать вывод, что в настоящее время эти операции считаются многообещающими и необходимыми, так как банк выступает полномочным арбитром между рынком и покупателем и приобретает целый ряд выгод от их совершения.

Благодаря трастовым операциям банк приобретает:

- наиболее широкий доступ к дополнительным денежным ресурсам, которые имеют все шансы существовать с выгодным вложением для банка;
- комиссионные по трастовому договору или долю прибыли от значимых бумаг, которыми заведует банк.

Существуют и другие преимущества для банка; маневрируя состоянием третьей стороны, банк несет обязанность лишь в рамках трастового контракта; учет трастовых операций никак не затрагивает балансовых счетов банка, а заработок от их воплощения приобщается к общему заработку банка.

Следует заметить, что для воплощения трастовых операций требуется персонал с высочайшей квалификацией во многих областях: законодательстве, навыков в инвестиционной работе, управлении собственностью.

В современных условиях в России еще не сотворена необходимая законодательная основа для совершения коммерческими банками трастовых операций, что считается негативным фактором, но отдельные их виды все же осуществляются. Однако, можно предположить, что в перспективе банки станут шире применять и использовать управление активами по доверенности и завещанию по образцу западных государств.

Перспективное понимания существа отношений, возникающих при производстве трастовых операций банков, обуславливает необходимость создание специфических правовых условий, регулирующих данные отношения.

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American Scientific Journal
№ 6 (6) / 2016

Address: 90 st. – Elmhurst AV, Queens, NY, United States
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Copies: 1000 copies.
Printed in 90 st. – Elmhurst AV, Queens, NY, United States