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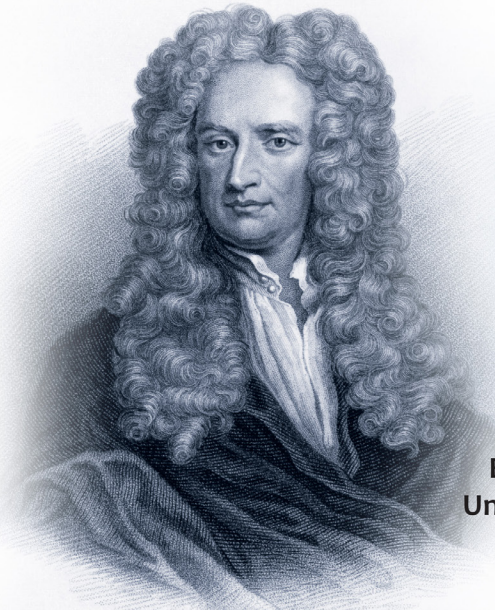

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OPERATIONAL EXPENCES EFFECT ON PERFORMANCE PARAMETERS OF MARINE SHIPMANAGEMENT

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Abstract. *The article presents the results of correlation analysis of budget and actual cost data reflecting fleet operational expenses groups and fleet performance quality data. All data is converted to uniform arrays where each element indicates the yearly value of vessel's performance. The initial data comes from corporate accounting and management software of world's leading tanker company having a fleet of more than 100 vessels for the period of 5 years. The correlation analysis concludes with unpredicted expenses impact to the quality of management processes and further necessity to allocate such expenses in OPEX to improve on cost analysis logic, provide justified methods of cost optimization and form rational approach toward asset insurance policy.*

Keywords: *Operational Expense (OPEX), fleet performance, corporate software, unpredicted expenses, cost analysis, insurance.*

Cost optimization issue is the key element of shipping company success. Provision of minimum cost to get desired management performance is the shipmanager's essential task providing competitive efficiency.

Nowadays most of shipping companies used to have the internal accounting and management systems that contain data on planned and actual cost values, as well as main fleet performance parameters. In most of the cases, such systems provide information in form of management and accounting reports lacking on performance improvement analysis. Digitalization expand in shipping industry and stable performance data flow nowadays can make management optimization solutions systematic, universal and realistic.

For the variety of data on vessel cost and performance, the work /1/ describes common procession approach that allows getting uniform arrays of OPEX data and data reflecting the quality of fleet management for further

correlation analysis.

Such approach was implemented to transform and process the data of the world leading tanker company containing more than a hundred of product and crude tankers, chemical carries and gas carriers of the most common industry types and tonnage. The immediate source of data is corporate systems consisting of marine accounting block SAP and relevant subsystem SAP BO providing reports and analytics for management, purchasing and maintenance registration block AMOS BS, HSE block AMOS EMS, operations block IMOS. Initial data based on following standards:

- IFRS standards with corporate unified chart of accounts.
- Internal SMS which covers budget codes matrix reflected in corporate software and supported with interblock mapping chart;
- Shipping KPI industry standard, as proposed by industry members /2/;
- Trump shipping commercial management indicators /3/;
- Management reporting policy.

Data description to form arrays for correlation analysis is presented below.

a) Annual data reflecting OPEX cost groups as identified by DREWRY /4/:

- Manning Cost:

$$Mann = \frac{Ann.\ Manning\ Actual\ cost - Ann.\ Mann.Drewry}{Ann.\ Manning\ Drewry} * 100\%;$$

- Spares Cost:

$$Sps = \frac{Ann.Spares\ Actual\ cost - Ann.Spares\ \ Drewry}{Ann.Spares\ Drewry} * 100\%;$$

- Stores Cost:

- $$Stor = \frac{Ann.Stores\ Actual\ cost - Ann.Stores.Drewry}{Ann.Stores\ Drewry} * 100\%;$$

- Management and Administration Cost:

- $$M\&A = \frac{Ann.M\&A\ Actual\ cost - Ann.M\&A.Drewry}{Ann.M\&A\ Drewry} * 100\%;$$

- Repair and Maintenance Cost:

$$R\&M = \frac{Ann.R\&M\ Actual\ cost - Ann.R\&M.Drewry}{Ann.Stores\ Drewry} * 100\%;$$

- Insurance Cost: $Ins = \frac{Ann.Ins\ Actual\ cost - Ann.Ins.Drewry}{Ann.Ins\ Drewry} * 100\%;$

- Lubricating Oil Cost:

$$Lub = \frac{Ann.Lub\ Actual\ cost - Ann.Lub.Drewry}{Ann.Lub\ Drewry} * 100\%$$

- Intermediate Survey and Special Survey Costs:

$$IS/SS = \frac{Ann.\frac{IS}{SS}Actual\ cost - Ann.IS/SS\ \ Drewry}{Ann.\ IS/SS\ \ Drewry} * 100\%;$$

- Total Operational Cost (OPEX), being the sum of all expenses above:

$$OPEX = \frac{Ann.OPEX\ Actual\ cost - Ann.\ \ OPEX\ .Drewry}{Ann.\ \ OPEX\ Drewry} * 100\%.$$

«*» sign used to identify budget values for OPEX and its DREWRY groups.

b) Annual data reflecting commercial performance of every individual vessel /1/:

- Average Time Charter Equivalent (TCE) value measures by average Baltic International Tanker Routes index (BITR) value of applicable vessel type (TCE/B):

$$TCE/B = \frac{Av.Ann.TCE - Av.Ann.BITR}{Av.Ann.BITR} * 100\%$$

- Idle Days (Idle) – Annual number of days in absolute value when the vessel is waiting for employment on trump trade for commercial reasons.

c) Annual data reflecting health, safety and environmental performance of each vessel:

- Vessel Availability (VA) /2/ ;
- Vessel Eligibility (VE) – total number of cases when the vessel was rejected for employment by Client's Quality and Assurance system;
- SIRE rate (SIRE) – annual average number of observations per inspection received during SIRE inspections;
- PSC rate (PSC) – average number of deficiencies per inspection received during Port State Control inspections;
- Incident Rate Assets (IRA) – average number of incidents per vessel, when total loss is above Hull and Machinery insurance coverage deductible value;
- Incident Rate Environmental (IRE) – average number of incidents per vessel that deal with sea or air pollution or risk of same, e.g. contained spill;
- Incident Rate People (IRP) – average number of significant incidents dealing with people, including Lost Time Injury /2/, Alcohol abuse;
- Incident Rate Reputation (IRR) – average number of incidents per vessel dealing with reputational impact to the manager or affecting vessel or manager's vetting status, include collision, allusion, fire, significant deviations in performance of voyage orders, etc., by default this classification is primary, e.g. if the incident categorized as reputational it

cannot be categorized as asset related;

- Incident Rate (IR) – total incident rate, consisting of the sum of incident rates above.

The above listed values form the arrays on each vessel annual values, for years 2012 – 2017. Results of correlation analysis of such arrays presented in tables below (for easy reference the arrays identified similar to values they represent).

Table 1. Actual cost correlation to Commercial Indicators.

	Mann	Sps	Stor	M&A	R&M	Ins	Lub	IS/SS	OPEX
TCE/B	0.15	-0.02	0.13	0.11	0.04	0.01	0.01	-0.07	0.16
Idle	0.05	-0.03	-0.01	-0.18	-0.05	-0.11	0.09	0.00	0.03

Table 2. Actual cost correlation to HSE Indicators.

	Mann	Sps	Stor	M&A	R&M	Ins	Lub	IS/SS	OPEX
VA	-0.02	-0.01	-0.06	0.00	0.04	0,03	0,06	-0,01	0,01
VE	0.09	-0.06	0.00	-0.02	-0.01	-0,06	-0,01	0,05	0,09
SIRE	-0.09	0.01	-0.1	0.03	-0.22	0,01	-0,15	-0,19	-0,25
PSC	-0.06	-0.26	-0.24	-0.33	-0.05	0,01	-0,26	-0,05	-0,12
IR	0.13	-0.09	0.01	-0.04	-0.12	-0,10	-0,02	-0,11	-0,03
IRA	0.08	0.06	0.10	0.11	-0.09	-0,05	0,00	-0,04	-0,05
IRE	0.03	-0.08	-0.04	-0.04	-0.11	-0,04	0,00	-0,11	-0,14
IRP	-0.05	0.11	-0.02	0.03	-0.06	-0,01	-0,15	-0,05	-0,09
IRR	-0.01	-0.05	-0.06	-0.11	-0.06	0,00	-0,02	-0,07	-0,03

Table 3. Budget values correlation to Commercial Indicators.

	Mann*	Sps*	Stor*	M&A*	R&M*	Ins*	Lub*	IS/SS*	OPEX*
TCE/B	0.09	0.01	0.13	0.20	0.16	-0.16	0.15	-0.06	0.27
Idle	0.11	0.01	0.01	0.02	0.08	0.01	0.06	-0.03	0.15

Table 4. Budget values correlation to HSE Indicators.

	Mann*	Sps*	Stor*	M&A*	R&M*	Ins*	Lub*	IS/SS*	OPEX*
VA	-0,05	-0,07	-0,05	0,00	-0,05	-0,07	0,00	0,00	-0,01
VE	0,06	-0,02	-0,06	0,07	0,11	-0,11	0,12	0,03	0,10
SIRE	-0,11	0,09	0,00	0,00	-0,12	0,04	-0,13	-0,09	-0,18
PSC	-0,09	-0,21	-0,29	-0,25	0,14	0,07	-0,32	0,03	-0,10
IR	0,03	-0,11	-0,01	-0,03	-0,01	-0,01	-0,04	-0,07	0,03
IRA	0,17	0,10	0,16	0,11	-0,06	0,20	0,01	-0,12	0,01
IRE	0,01	-0,06	-0,04	-0,01	-0,04	0,01	0,02	-0,05	-0,01

	Mann*	Sps*	Stor*	M&A*	R&M*	Ins*	Lub*	IS/SS*	OPEX*
IRP	-0,01	0,19	0,07	0,09	0,06	0,09	-0,10	0,01	-0,01
IRR	-0,04	-0,09	-0,05	-0,03	-0,01	0,01	-0,04	-0,03	-0,05

Table 5. Budget and actual cost correlation.

	Mann	Sps	Stor	M&A	R&M	Ins	Lub	IS/SS	OPEX
Mann*	**0.59**								
Sps*		**0.84**							
Stor*			**0.75**						
M&A*				**0.55**					
R&M*					**0.19**				
Ins*						**0.24**			
Lub*							**0.46**		
IS/SS*								**0.32**	
OPEX*									**0.45**

Table 6. Actual OPEX correlation in groups.

	Mann	Sps	Stor	M&A	R&M	Ins	Lub	IS/SS	OPEX
Sps	0.13								
Stor	0.33	**0.71**							
M&A	0.24	0.54	**0.54**						
R&M	0.07	0.16	0.15	0.17					
Ins	0.09	-0.05	-0.03	-0.02	0.04				
Lub	0.12	0.15	0.21	0.20	0.24	-0.06			
IS/SS	0.02	0.15	0.13	-0.01	0.09	0.08	0.02		
OPEX	0.47	0.29	0.42	0.29	0.41	0.18	0.28	0.43	

The following common table used to identify the association strength from the value of Pearson correlation coefficients above:

Table 7. Pearson correlation coefficient range and association strength.

Range	Strength of association
0	No association
0 to +/- 0.25	Negligible
+/- 0.25 - +/-0.50	Weak
+/- 0.50 - +/-0.75	Moderate
+/- 0.75 - +/-1	Very Strong
1	Perfect

Summary of above correlation data review:

- There's no substantial operational cost effect to results of commercial management or HSE fleet performance, e.g. the cost to enforce management standards is not associated to the effect of standards itself;
- Existing Budgeting process is not generally efficient in terms of cost control, R&M, Insurance and IS/SS OPEX groups have lowest control ability;
- The OPEX category change generally is not linked to change of other OPEX categories, except for Spares and Stores costs.

Thus budgeting process nowadays is unable to factor the actual OPEX, further actual OPEX is unable to factor fleet performance. At the same time cost control ability comes to be the first step towards effective fleet management.

The operational experience of shipmanagement gives following explanation of table 5 correlations values:

- Manning cost can be fairly controlled and predicted as based on approved ships' manning and wage scales, known contract terms providing crew change frequency, predicted crew training requirements and easy training cost estimation.
- Insurance cost based on accounting data thus reflecting the final balance of premiums paid and recovery received on insured incidents. Relevant receivables and payables are driven by unpredicted events thus affecting budget execution.
- Stores supply requirements can be hardly predicted, usually the demand of it from crew (issuing requisitions) is high and actual supply values are reduced by responsible officers unless shortage of same will effect fleet commercial or HSE performance. Such situations hardly predicted at budgeting stage and budget figures are used to be based on historical values e.g. cost taken from previous years' experience, relevant to the vessel type and adjusted to current reality (specific supply need, inflation rate, etc).
- Spares supply can be predicted based on Planned Maintenance Program (PMP) requirement. But the set of PMP software to the stage enabling the responsible officers to prepare justified budget figures is hardly realistic. Cost predication requires the detailed inventory and dataset of all machinery, equipment, relevant spares, inventory of approved PMP job lists, their relevance to spares stock and availability of average pricing. That amount can be hardly managed on board and in office due to the lack of management resource. The quality of such prediction is sensible to human errors that reduces the efficiency of HR allocation. That is why

spares supply budget is also used to be composed of average historical values, relevant to the vessel type and adjusted to expected operational needs (mainly to expected overhauls).

- None-withstanding with historical ground for Spares and Stores budgeting the actual cost values sufficiently correlate to budget values. Main reason for that is budget cost overestimation. This results in unjustified consumption to reach the budgeted values in the end of the budget period, build up of the onboard stock of spares and costly consumables. Also in such situations next year budget values are now changed by responsible officers driven by overconsumption risk in case of expensive machinery failures and breakdowns that still fall below H&M deductible values thus locating to Tech budgets.
- M&A cost structure based on fixed contracts fees, predicted schedule and cost of inspections and periodic certification and thus can be fairly controlled through budgeting process.
- R&M cost hardly predicted and mostly deal with recovery of failures, substandard performance or deterioration of the vessel structures or machinery. Relevant budgeting requires strong reasons and evidence, actual cost is often not meeting budget values as driven by unpredicted events that fall below H&M deductible values.
- Same situation is with IS/SS cost – a substantial work list for the shipyard is produced while production of repair specifications. Such process is preceding yard tender but most of the time follow budgeting – e.g. IS/SS yearly budget is often composed when detailed work scope is unknown. Together with unpredicted repair place on trump trade, it affects the quality of budgeting process when actual cost do not meet budget values.
- Mentioned above difficulties of prediction R&M, IS/SS cost, specifics of Insurance cost accounting process deducting the receivables off Insurance expenses make the efficiency of OPEX budgeting low.

Summarizing the above practical cost management experience the main drivers for low budget budgeting efficiency are availability of uncontrolled unpredicted cost, unclear efficiency of insurance policy. In addition, the cost management efficiency affected by historically based budgets that result in unjustified expenses and restrict the quality of cost prediction.

The unpredicted cost identification through cost procession gains on:

- Budgeting efficiency, generally the cost margins deemed to cover the unpredicted events costing below deductibles should be clearly identified, separated from the planned cost;
- Reduction of actual expenses on historically based budgets by eliminating of unpredicted cost margins.

- Efficiency of insurance policy, improving the returns ratio of insurance coverage, generally efficient insurance policy cannot be set without proper prediction of value subject to coverage.

- Cost management efficiency – as unpredicted cost have specific management strategy. Its reduction linked to efficiency of investigation, further identification and implementation of incident preventive activity.

Linkage of unpredicted costs to relevant event-based registry, known as incidents database, gives new management options allowing mapping of incidents related data such as object, reason, immediate cause, root cause, system cause, corrective action, preventive action to relevant expenses further managing the efficiency of incident preventing activity. Such cost-based approach to incident management not fully realized in the industry, incident preventive activity is now mainly limited to single incident details with restricted controls over efficiency of preventive activity. At the same time it worth mentioning that cost control process involves engagement of variety of competence within shipmanager's and shipowner's custody. Often corporate structures give manning, tech, VOYEX and insurance cost management to different departments or even organizations. Such distribution affects the cumulative quality of cost management due to coordination neglects thus aggravating the issue of unpredicted cost identification and management.

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ANALYSIS OF THE INFLUENCE OF A MONETARY POLICY ON ECONOMIC GROWTH AND STOCK MARKETS OF THE BRICS COUNTRIES IN A LONG-TERM PERIOD

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Abstract*. The study is devoted to analysis of the influence of a monetary policy on the economic growth and the behavior of stock markets in the BRICS countries. As methods of study, the Hodrick-Prescott filter (HP-filter) and development of a vector error correction model (VECM) were used. Empirical estimates were obtained for the BRICS countries from the monthly statistical data for the period from January 2009 to October 2019. Based on the revealed cointegration vectors, for each of the BRICS countries the presence of long-term interconnection was found between individual parameters of the country's monetary policy and the investigated characteristics of the behavior of the GDP and of the stock markets.*

Keywords: *BRICS, monetary policy, economic growth, stock market, VECM.*

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Introduction

The BRICS countries investigated in this study are the leading emerging market economies, which are characterized by certain specific features. This union is largely political; however, the member countries strive to find common interests in different areas, including the economic and financial sectors.

The activities of the governments in conducting monetary policies in the BRICS countries have both common features and differences. Over the recent twenty years, most central banks of the emerging market econo-

mies of the world have introduced inflation targeting as the monetary policy framework. Among the BRICS countries, four countries except China are now adhering to this framework. This factor accounts for the set of tools implied by the countries in their monetary policies and the interim targets, which are primarily related to achievement of price stability.

Fast developing stock markets have become another feature of the condition of the BRICS economies. This is related to the policies of financial development employed, including the activities of the central banks of the countries, which perform the role of mega-regulators of the financial market in some of the countries.

The objective of the study was to reveal interconnections among the indicators of the current monetary policies of the central banks, the condition of the stock markets and the macroeconomic parameters of economic growth in the BRICS countries, and to evaluate the character of the influence of the monetary policies employed by the central banks of the BRICS countries on the given financial and economic parameters in the long-term perspective.

Literature review

Among the BRICS countries, two countries, Brazil and the Republic of South Africa, have been acting in the framework of inflation targeting for already twenty years. However, the targets of a monetary policy and the goals faced by the central banks of these countries consist not only in maintaining price stability in the economy. Highly important are such parameters as volatility of currency rates, capital flows among the countries, the dynamics of the export and import of commodities, foreign currency interventions, the volume of the country's foreign debt, the internal condition of the economy and the factors of the global economic development (BIS, 2019).

Although the indicator of the prime rates of the central banks is of key importance in exercising the monetary policies in the BRICS countries, the tools enabling the governments to influence the exchange rates of the national currencies remain to be actively used (Ghosh et al., 2016; Bekareva et al, 2019). At the same time, implementation of the monetary policy in the emerging market economies is more exposed, compared to the financially developed countries, to the impact of external factors (Mihaljek, 2011).

In the scientific literature, there are studies investigating the impact of the monetary policies on the national stock markets (Rifat, 2015); it is noted that this influence may be weak in emerging market economies. The factors influencing the stock market of a country also include external

factors, such as prices of strategic commodities in the world, like oil and gold, and parameters describing the condition of the financial sector in the United States of America (Ji et al., 2018).

Different monetary policy frameworks may positively influence the economic growth, and adherence to the inflation targeting framework has been demonstrated to be most effective (Kartaev, 2018). In some studies, the impact of a country's financial development on its economic growth is assessed (Guru, Yadav, 2019; Fanta, Makina, 2017). The authors demonstrate connection of these parameters, using different characteristics to evaluate the condition of stock markets, international capital flows, the amount of the foreign debt, the structure of financial intermediaries, etc.

Methodology and data

Based on the studies available in the given area, we chose three groups of indicators for the purpose of this study: (1) monetary policy indicators, (2) external indicators, (3) studied variables. The parameters characterizing the tools of a monetary policy and certain interim results of its influence on the emerging market economies include the following. These are the interest rate for short-term (one-day) loans, the national currency exchange rate, the money supply (the monetary aggregate M2), and the consumer price index. The parameters demonstrating the external impact include gold prices, the Brent oil price, the S&P500 index, and the money supply in the USA (the monetary aggregate M2). The variable employed in the study included the stock prices and the GDP. All the variables are identical for all the BRICS countries. The Federal Reserve Bank of St. Louis statistics and the official documents and statistics provided by the central banks of the BRICS countries were the statistical sources of the data used. The data cover the period from January 2009 to October 2019. All the estimated indicators were transformed into marginal indicators.

As a method of study, the vector error correction model, VECM, with estimates of the cointegration vector parameters, was used. Based on the estimates of the cointegration vector parameters obtained, a conclusion was made regarding dependence and the degree of the impact of the monetary policy parameters on the behavior of stock markets and on the economic growth in the BRICS countries.

To reveal long-term relations among the indicators, we took the following steps in the following sequence of actions:

- Firstly, we used the HP-filter (Hodrick and Prescott, 1997) to estimate the GDP gaps and the inflation gaps.
- Secondly, we determined the optimal lags using information criteria,

AIC (Akaike, 1974), and the likelihood test for lag-order selection, LR.

Thirdly, based on the Johansen cointegration test (Johansen, 1995), we determined the number of the cointegration vectors, reflecting the dependences of the variables under study for each of the BRICS countries.

Finally, the parameters of the cointegration vectors obtained were evaluated, which enabled us to make a conclusion regarding the character of the dependences obtained in the long-term perspective.

Instead of absolute values of the inflation and GDP indicators, we calculated their deviations from the trend, in accordance with the theory of business cycles. Indeed, a central bank strives to smoothen the sharp fluctuations of the economic variables, with a view to ensuring stable economic development of the economy; thus, calculating deviations is more correct. To calculate the GDP and inflation gaps, we used the HP-filter (Hodrick and Prescott, 1997), a highpass filter, which passes only the high (treble) frequencies. We described the concept of the filter in (Bekareva et al., 2019).

Results and discussion

We used the calculated GDP and inflation gaps in the subsequent steps of the study as dependent variables.

After evaluating the indicators based on the information criteria, AIC, and after conducting the likelihood test for lag-order selection, LR, we determined the optimal lags showing the limits of the short-term period (Table 1).

Table 1
Lag-order selection statistics

period	Brazil		Russian Federation		India		China		South Africa	
	LR	AIC	LR	AIC	LR	AIC	LR	AIC	LR	AIC
0		-11.25		-14.76		-14.34		-20.87		-13.11
1	435.17	-16.98	303.66	-17.17	519.66	-18.89	387.89	-23.46	771.82	-20.38
2	719.87	-19.88	319.48	-19.75	796	-24.50	416.77	-26.31	282.85	-22.51
3	811.79	-21.17	101.27	-20.05	408.47	-27.42	193.73	-27.13	207.46	-23.89
4	611.19*	-21.91*	103.07*	-20.69*	241.4*	-28.89*	52.51*	-27.54*	75.38*	-23.91*

LR – the likelihood ratio test for lag-order selection.

AIC – the Akaike information criterion.

*– meeting the criterion to determine the size of an optimal lag.

In accordance with the results obtained, the value of the fourth period proved to be an optimal lag for all the considered countries.

Based on the Johansen cointegration test (Johansen, 1995), we determined the presence of two cointegration vectors to be characteristic of all the BRICS countries.

The estimations of the parameters of the cointegration vectors are shown in Table 2 and Table 3.

The variables are indicated in Tables 2 and 3:

g_shares – the growth rate of the total share prices for all shares.

g_index – the growth rate of the import price index for nonmonetary gold, Index 2000=100.

g_oil – the growth rate of the global price of Brent oil.

g_sp – the growth rate of S&P 500 index, monthly, not seasonally adjusted.

g_m2 – the growth rate of M2 for the United States.

g_fer – the growth rate of the exchange rate (the national currency for one dollar).

g_ir – the growth rate of immediate rates: less than 24 hours.

g_m2 – the growth rate of M2 for a BRICS country.

c_cpi – the cycling component for the consumer price index, obtained as a result of exclusion from the original time series of the trend calculated on the basis of the HP-filter.

c_gdp – the cycling component for the GDP of the BRICS country, calculated on the basis of the HP-filter.

Table 2

Estimations for the cointegration vector (long-term dependence) для the dependent variable "the level of share prices" (g_shares – dependent variable)

	Brazil	Russian Federation	India	China	South Africa
g_index	-0.018* (4.11)	0.54 (0.19)	-0.012 (0.13)	-0.062* (-3.87)	0.11 (0.18)
g_oil	-0.011 (0.32)	0.91 (0.27)	-0.08* (-3.45)	-0.011 (-1.19)	-0.012* (5.01)
g_sp	-0.16 (0.18)	-0.071* (2.68)	-0.091 (0.28)	0.10 (0.39)	0.01 (0.11)
g_m2_ USA	0.012 (0.51)	0.018 (0.7)	0.011 (5.40)	0.012 (0.146)	0.091 (0.41)
g_fer	0.02* (7.01)	0.021 (0.16)	0.011 (0.46)	0.03** (2.86)	0.041 (0.09)

g_ir	0.02* (6.68)	0.016** (2.18)	0.021 (-0.29)	0.04* (4.94)	0.022** (2.74)
g_m2	0.098 (1.26)	0.021* (7.56)	0.045* (7.56)	0.011 (0.26)	0.05** (2.47)
c_cpi	-0.02* (4.18)	-0.017** (-2.49)	-0.014* (-4.09)	-0.07** (-2.86)	-0.032** (-9.13)
c_gdp	0.045 (1.25)	0.059* (5.82)	0.029 (0.849)	0.022* (16.01)	0.025** (2.57)
Const	0.19	0.19	0.49	0.46	0.89

*, ** - indicate significance at the 1 and 5% levels respectively
The t-values are indicated in brackets.

Based on the estimates shown in Table 2, one can conclude that the indicator of the deviation of the inflation rate from the trend line proved to be significant for the behavior of the stock markets in all the BRICS countries. This indicator reflects the investors' expectations regarding the condition of the economy as a whole. This fact confirms the importance of the inflation rate indicator for positive development of the financial sector in an economy. In accordance with the estimates obtained, negative values indicate the growing uncertainty for the investors under conditions of high inflation, which negatively affects the behavior of the stock markets.

It is to be noted that China, aiming at targeting the money supply, unlike the other BRICS countries, which are targeting the inflation rate, has certain orientation for the inflation rate figure and tries to maintain it.

As far as the other indicators considered are concerned, there are differences among the countries of the sample. For example, for the Russian Federation, the following indicators proved to be significant parameters included into the cointegration vector: the short-term interest rate, the money supply in the country, the GDP gap, and the US stock market index.

Table 3
Estimations for the cointegration vector (long-term dependence) for the dependent variable "economic growth" (c_gdp – dependent variable)

	Brazil	Russian Federation	India	China	South Africa
g_index	0.21 (0.91)	0.41 (0.31)	0.22 (0.89)	0.04 (0.53)	0.12 (0.22)
g_oil	0.31 (0.11)	0.33 (0.19)	-0.02 (-3.44)	-0.008 (-5.27)	-0.006** (-2.09)

g_sp	0.18 (0.02)	0.37 (1.02)	0.109 (0.53)	0.014* (7.36)	0.91 (0.02)
g_m2_USA	0.11 (0.13)	0.59 (1.31)	-0.01* (-5.71)	0.18 (0.03)	0.19 (0.31)
g_fer	0.019** (6.46)	0.015* (7.22)	0.01 (0.22)	0.006** (0.42)	0.018 (0.22)
g_ir	-0.02* (-6.42)	-0.014* (-4.32)	-0.028 (-0.13)	-0.005* (-3.39)	-0.047 (-0.286)
g_m2	0.02* (2.62)	0.08* (5.24)	0.049* (3.67)	0.04* (3.62)	0.03** (2.03)
c_cpi	-0.03* (-3.39)	-0.04* (-4.39)	-0.016* (-4.21)	0.03* (5.38)	-0.09* (-8.27)
Const	-0.09	0.04	-0.38	-0.049	0.086

*, ** indicate significance at the 1 and 5% levels, respectively.
The t-values are indicated in brackets.

The GDP change as the indicator of economic growth, represented in the model as the parameter of the GDP gap, demonstrated the connection with the inflation rate (deviation of the inflation rate from the trend line) for all the BRICS countries. This connection is negative for four countries of the sample. It is only in the case of China that we observe dependence of the change in GDP on the inflation rate growth, which may be related to the specific development of the country which carries out the policy of stimulating internal consumption of commodities.

In addition, significant for all the BRICS countries is the value of the change in the money supply in the economy, which may indicate the possibilities of the influence of central banks on the economy by way of employing the tools of monetary regulation in the country.

For three countries, Brazil, China and Russia, there are variables of the interest rate and of the national currency rate in the second cointegration vector. For China, the S&P500 index proved to be significant, for India, it was the change in the money supply in the USA, and for the RSA, the Brent oil prices.

Conclusion

The estimations conducted in this study have confirmed the influence of the monetary policies of the central banks of the BRICS countries on the behavior of the stock markets and the economic growth of these countries in the long-term perspective. The indicator of deviation of the inflation rate from the trend line is significant; its growth mainly negatively affects development of both the financial and real sector of the economy. This fact testi-

fies to preferability of the policy of price stability maintained by the central banks of all the countries. It is also important to indicate the significance of controlling such parameters as the money supply in the economy and the exchange rate of the national currency.

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STAKEHOLDER APPROACH BASED ON SUSTAINABLE DEVELOPMENT FACTORS

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Abstract. *In the article, the author substantiates the changes in the classical stakeholder theory under the influence of the sustainable development process, which suggests to take into account not only economic, but also social and environmental components during the course of determining the degree of stakeholder influence on a company and the strength of a company's dependence on a stakeholder.*

Keywords: *stakeholders, sustainable development, stakeholder maps, the impact of stakeholders on the company.*

The stakeholder theory was first introduced to the scientific community relatively recently - in 1984 by Edward Freeman, an American professor at the Darden School of Business in Virginia [1]. The first monograph, dedicated to the interaction of participants in corporate relations, was focused on the practical side of the issue, suggesting to highlight some key groups of people and determine the extent to which they are able to influence the company or a specific project in question. This analysis allowed the project curator or business owner to change the structure or the approach to management itself in such a way as to meet the interests of all its participants.

In a joint study by S. Miles and A. Friedman, the list of stakeholders was expanded: it included consumers, suppliers and distributors, the local community, representatives of the press, society as a whole, business partners, shareholders, past and future generations (emphasis added by the author), competitors, government authorities, civil society, academia, and investors. According to the researchers, a stakeholder is any party interested in the implementation of a project and capable of exerting a direct or indirect influence on activities of achieving its goal.

Despite the mentioning of past and future generations as stakeholders in classical approaches to stakeholder ranking, none of the existing stakeholder models take into account sustainable development. Russian timber

industry companies also do not demonstrate focusing on the interests of stakeholders in accordance with the principles of the sustainable development concept. The existing approaches to the analysis and classifications of stakeholders do not take into account the obligatory environmental component in this system. Considering the factors affecting the importance and level of influence of stakeholders on the business, ecology and changes in ranking due to its application are also not taken into account.

Therefore, a change in the approach to doing business using the concept of sustainable development strongly dictates a change in the approach to identifying people who most strongly influence the business stakeholders themselves. In the most approaches, the main parameters that are used are influence and significance, due to which a coordinate grid is drawn up, on which the location of each stakeholder is marked, depending on the parameter level. Previously, the values of the parameters "impact" and "significance" were determined based on economic and social considerations, however, the use of the concept of sustainable development determines the need to take into account the ecology and the importance of preserving the environment as was sais earlier.

In a standard analysis, it is necessary to assign each stakeholder the value of the parameters "impact" and "significance", however, the author has ranked the stakeholders by importance, making the assessment separately in three areas: economic, social and environmental. Each of the stakeholders was assigned an importance rank from 1 (not important) to 4 (very important).

In Table 1, stakeholders are assigned the rank values depending on their economic impact on the business.

Table 1 - Ranking of stakeholders depending on economic influence

Stakeholder Name	Assigned Rank	
	Impact	Significance
Shareholders	2	4
Management	3	4
Employees	2	3
Investors	4	4
Clients	4	3
Suppliers	2	4
Competitors	3	2
Government and other regulators	2	1
Business partners	3	2
Local communities	1	1

Scientific community	2	1
Media	1	2
Non-governmental foundations and organizations	1	3
Infrastructure organizations	1	3

Source: developed by the author.

In Table 2, the rank values are assigned to stakeholders based on their social impact on business.

Table 2 - Ranking of stakeholders depending on social influence

Stakeholder Name	Assigned Rank	
	Impact	Significance
Shareholders	2	3
Management	4	3
Employees	3	3
Investors	2	4
Clients	4	3
Suppliers	3	1
Competitors	4	2
Government and other regulators	3	3
Business partners	2	3
Local communities	3	4
Scientific community	2	3
Media	4	4
Non-governmental foundations and organizations	4	4
Infrastructure organizations	1	3

Source: developed by the author.

In Table 3, the rank values are assigned to stakeholders based on their environmental impact on the business.

Table 3 - Ranking of stakeholders depending on environmental impact

Stakeholder Name	Assigned Rank	
	Impact	Significance
Shareholders	2	3
Management	4	3
Employees	1	3
Investors	3	4
Clients	1	4

Suppliers	2	2
Competitors	1	2
Government and other regulators	3	4
Business partners	1	4
Local communities	4	4
Scientific community	3	4
Media	2	4
Non-governmental foundations and organizations	2	4
Infrastructure organizations	2	4

Source: developed by the author.

Table 4 shows the the summarized ranking indicators and compares the assigned ranks.

Table 4 - A summary of the ranks for the economic, social and environmental impact of stakeholders on the company

Stakeholder	Economic impact		Social impact		Environmental impact		Average	
	x	y	x	y	x	y	x	y
Shareholders	2	4	2	3	2	3	2	3,3
Management	3	4	4	3	4	3	3,7	3,3
Employees	2	3	3	3	1	3	2	3
Investors	4	4	2	4	3	4	3	4
Clients	4	3	4	3	1	4	3	3,3
Suppliers	2	4	3	1	2	2	2,3	2,3
Competitors	3	2	4	2	1	2	2,7	2
Government and other regulators	2	1	3	3	3	4	2,7	2,7
Business partners	3	2	2	3	1	4	2	3
Local communities	1	1	3	4	4	4	2,7	3
Scientific community	2	1	2	3	3	4	2,3	2,7
Media	1	2	4	4	2	4	2,3	3,3
Non-governmental foundations and organizations	1	3	4	4	2	4	2,3	3,7
Infrastructure organizations	1	3	1	3	2	4	1,3	3,3

Where x is the influence; y - significance.

Source: developed by the author.

As the table shows, the level of stakeholder influence varies greatly depending on the type of influence. In the standard analysis, the economic impact on the parameters is considered, however, if we also take into account the social impact and, in particular, the environmental impact, then many stakeholders change their positions and become more or less significant. The next step is to compare the location of stakeholders, assessed in terms of economic impact (Figure 1), with the location of stakeholders, assessed by the average of all three influenc**ing factors (Figure 2).**

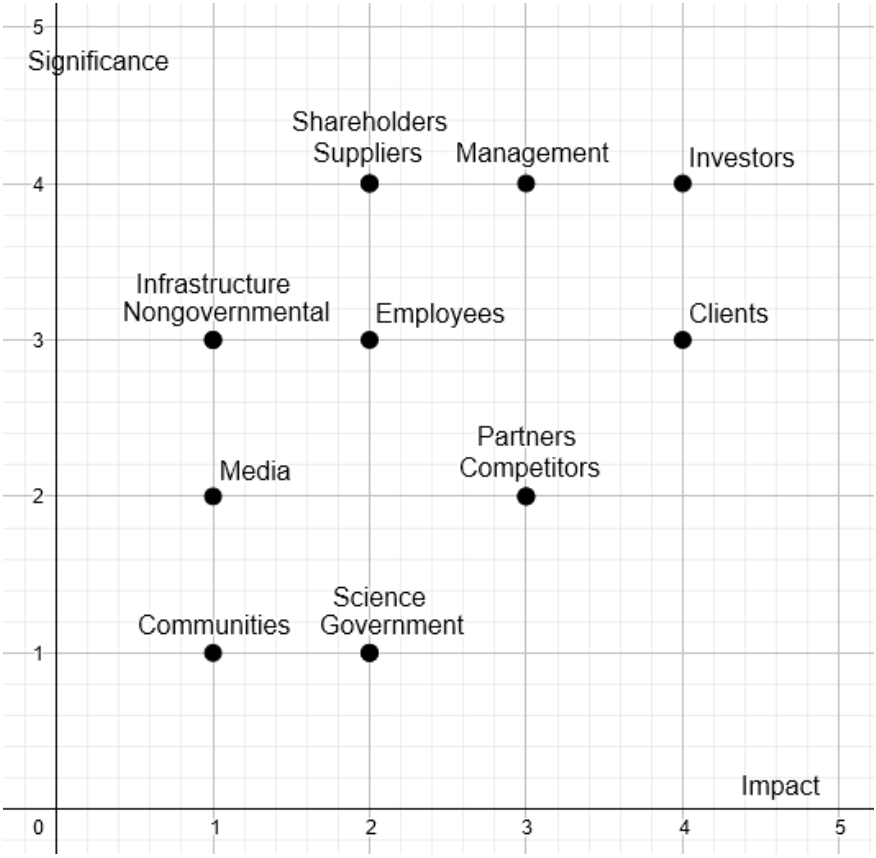

Figure 1 - Map of stakeholders with regard to economic impact

Source: developed by the author

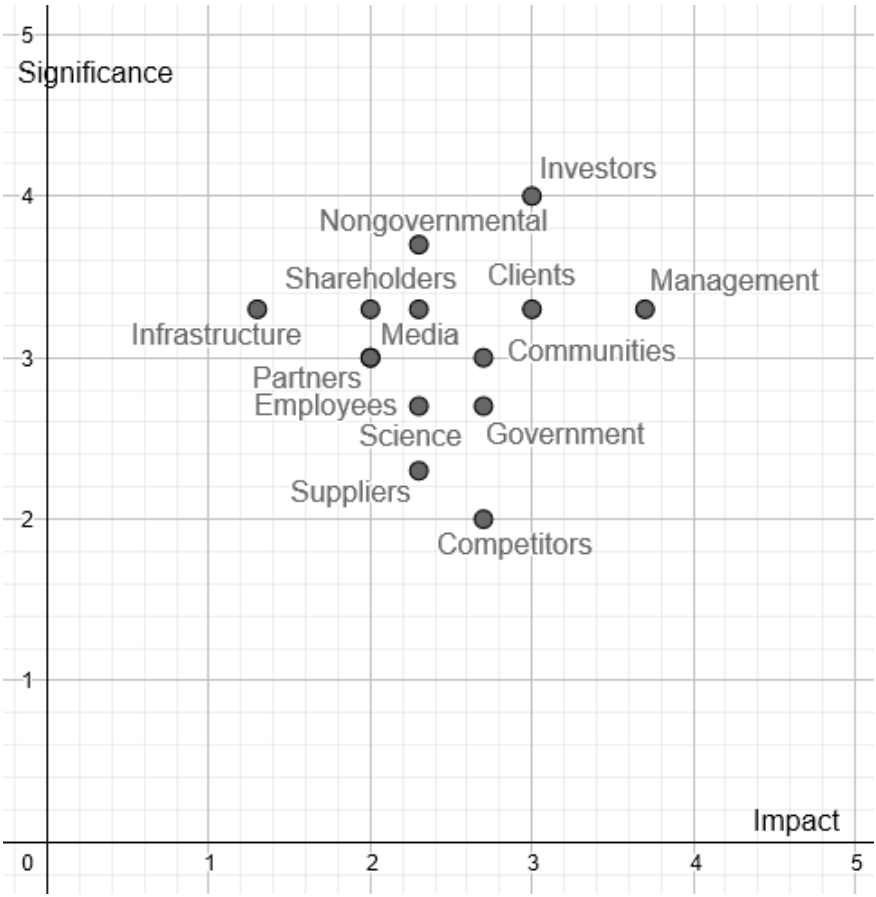

Figure 2 - Map of stakeholders taking into account three parameters of influence

Source: developed by the author.

Comparing the two figures, it is clearly seen that the importance of many stakeholders changes, which, accordingly, affects their importance for the company's business, as well as the importance of managing interactions with each of them. For example, you can see that the stakeholder "suppliers", who previously held a fairly high position, after a revaluation with the influence of three factors, is already much less significant. The company should look to the “local communities” stakeholder, whose importance has grown significantly for sustainable business conduct.

Thus, we can conclude that the application of the concept of sustainable development has an impact on each stage of the management of the entire business. Not only the approach to managing it is changing, but also the importance of the interests of stakeholders is being reassessed depending on the importance of sustainable development components for organizing effective corporate interaction.

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INVESTMENT ATTRACTIVENESS OF THE SERBIAN ECONOMY FOR RUSSIAN BUSINESS

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Annotation. *The paper presents the results of study of the investment potential of Serbia for Russian businesses interested in finding new opportunities to enter the international level in the face of economic sanctions from the United States, the European Union and other countries. The investment climate in Serbia and possible country risks were assessed.*

Keywords: *Investment attractiveness, investment climate, economy of Serbia.*

The five-year escalation of anti-Russian economic sanctions leads to the disintegration of domestic business in the world economy. Russian entrepreneurs are faced with the task of finding new opportunities to enter the international level and carry out foreign economic activities [5, p.1463]. The Republic of Serbia can become a direction for applying the efforts of domestic business.

The Republic of Serbia is one of the few European States that does not support anti-Russian economic sanctions, despite the political pressure exerted on it. On may 25, 2013, there was signed the Declaration on strategic partnership between the Russian Federation and the Republic of Serbia, which provides for large-scale cooperation in political, trade and economic spheres, development of business contacts and promotion of mutual investment. Russia and Serbia have an Agreement on the avoidance of double taxation. All this means special advantages for Russian entrepreneurs in the Serbian jurisdiction. It is important to note that the Serbs have a special respect for the Russian people, this is historically laid down at the level of mentality.

International economic cooperation with Serbia can open up new prospects for business activities, strengthen Russia's influence in Europe and boost the economies of both countries [4].

The information about the Republic of Serbia required for further analysis of the country's investment attractiveness is presented in Table 1.

Table 1 - General information about the Republic of Serbia

Geographical location	Europe, Central part of the Balkan Peninsula
Area	88,407 square kilometers
Length of borders / bordering countries	2,361. 7 km / Bulgaria, Romania, Hungary, Croatia, Bosnia-Herzegovina, Montenegro, Albania, Macedonia
Climate	Moderately continental
Capital	Belgrade
Form of government/ Political regime	Parliamentary Republic / Democratic regime
Participation in military blocs	Military neutrality
Population	7 million people
Official language	Serbian
Currency	Serbian dinar
Level of development / size of GDP (2018) / place in the world by GDP	Emerging economy / GDP is 50.51 billion US dollars / 82nd position in the ranking of 186 countries
Prospects for participation in international economic associations	Observer at the WTO, candidate for membership in the European Union

Since 2000, Serbia has been implementing a market reform program. At the moment, market mechanisms largely dominate the Serbian economic system and are combined with state regulation measures. The government has made progress in addressing issues such as budget consolidation, reducing public spending, conducting privatization, and developing measures to attract foreign investment.

In 2019 Serbia has become the fastest growing economy in Europe – the country's GDP growth rate exceeds both the EU average and the dynamics of the global economy. According to Serbian statistics, in 2019 country's GDP increased by 4% (with a growth forecast of 3.5%).The unemployment rate in the country is still high, but there is a positive trend: in 2016, 17% of Serbs were unemployed. In 2018, this figure dropped to 13%, and in 2020, according to the forecast of the European Commission, unemployment may reach a historic low of 10.9%. Measures to combat

inflation were also effective. At the beginning of the last decade its level was consistently double-digit, but since 2004 inflation in Serbia has not exceeded 4% per annum, and in February of this year the inflation rate was 1.1% in annual terms[1].

The acceleration of the economy has already significantly reduced the country's external debt. Last year, the international rating Agency Moody's recognized Serbia as the country with the fastest decline in the debt-to-GDP ratio in five years (by 21%) compared to countries with a similar credit rating. Serbia's public debt is expected to fall from 54.5% of GDP in 2019 to 46.2% in 2021.

The Republic's position has improved not only in credit ratings, but also in international business ratings, as shown in table 2.

Table 2 – Serbia's position in international business rankings

Rating/ Compiler	Subject of assessment	Serbia's Achievements
Global performance index of foreign direct investment (FDI) in new business structures (Greenfield FDI Performance Index) for 2019 / Financial Times[2]	Foreign direct investment in new businesses relative to the size of the country's economy	First place among the world's emerging economies, attracting almost 12 times more FDI than would be expected in view of economy size.
Ease of doing Business in the country in 2019 (Doing Business Report) / World Bank[3]	Ease of doing business from the point of view of legal regulation	It belongs to the group of countries where doing business is rated as "Very easy". Between 2015 and 2019, Serbia rose from 91 to 44 in the ranking of 190 countries in the world.
Global Competitiveness Index 2019 / World Economic Forum[4]	The ability of the national economy to create and maintain an environment in which a competitive business emerges	During the period from 2015 to 2019, Serbia rose from 94 to 72 in the ranking of 140 countries in the world, in 2018 it was ranked 65th.

[1]Economic indicators of Serbia. URL://https://ru.tradingeconomics.com/serbia/indicators

[2]FT: Serbia heads FDI world list, followed by Montenegro and Cambodia http://rs.n1info.com/English/NEWS/a507296/Serbia-tops-FDI-world-list-FT-says.html

[3]Doing Business Report 2019. URL:https://www.doingbusiness.org/content/dam/doing-Business/media/Annual-Reports/English/DB2019-report_web-version.pdf

[4]The Global Competitiveness Report 2019. URL: https://www.weforum.org/reports/how-to-end-a-decade-of-lost-productivity-growth

Important aspects of Serbia's investment attractiveness for Russian business include, first of all, Serbia's favorable geographical location, since the country is located on the most important route connecting Europe and Asia, which provides an optimal position for delivering finished products to markets around the world [1, p.58].

Secondly, a unique feature of the Republic of Serbia is the presence of a large number of concluded agreements on duty-free trade [2, p.120]. Serbian companies can sell goods and services without additional fees for a market with a population of 1.3 billion people, which includes the Russian Federation, Belarus, Kazakhstan, Eurasian economic Union, European Union, Turkey, countries of South-Eastern Europe, member countries of the Central European free trade Association (CEFTA), the European free trade Association (EFTA), USA. These duty-free regimes cover most key industrial products.

Third, Serbia's friendly relations with both Russia and the EU countries, so in the era of anti-Russian sanctions Serbia can successfully act as a link between these two economic blocs.

Important for the development of Russian business in Serbia is a reliable reputation of the Serbian jurisdiction (not offshore); short terms (5 days) and low cost of company registration - the minimum authorized capital of an LLC is 100 dinars (less than 1 Euro), state registration fees – about 50 euros; low maintenance costs and low tax rates for companies. Table 3 shows the rates of basic taxes paid by companies and individuals in Serbia in comparison with the minimum and maximum values of these taxes in Europe, as well as the level of the corresponding tax rates in Russia [3, p.24; 4].

Table 3 - Overview of basic tax rates in Serbia

Type of taxes	Tax rate in Serbia	Tax rate in Russia	Minimum tax rate in Europe	Maximum tax rate in Europe
Corporate tax (corporate income tax)	15%	20%	9%	35%
Sales tax (VAT)	20%	20%	7,7%	27%
Social insurance rate for companies	17,15%	30%	1,77%	45%

Personal income tax rate	10%	13%	9%	57,2%
Social insurance rate for employees	19,9%	0%	0%	35%

Based on the data presented above, we can draw a conclusion about the investment attractiveness of Serbia for Russian business and possible positive forecasts in the implementation of the strategy for its integration into the international economic space.

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CURRENT STATE AND PROSPECTS DEVELOPMENT OF FINNISH ENTREPRENEURSHIP IN RUSSIA

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Abstract. *The article examines the current state of Finnish business in the Russian market. The main trends in the processes of international investment in the Russian economy under the conditions of sanctions are revealed. The measures adopted by the Russian legislation aimed at improving the business and investment climate in the country are considered.*

Keywords. *International investments, international entrepreneurship, investment climate.*

Over the past decade, Russia and Finland have developed a stable practice of active political dialogue at high and the highest levels. The presidents of our countries usually meet twice a year. Regular contacts and meetings are held between the heads of government, heads of foreign ministries, and interdepartmental relations. Finland's Ministers of internal Affairs, agriculture and forestry, transport and communications, justice and the environment also make regular visits to Russia. A dialogue is being held between the leadership of the military departments. An Intergovernmental commission on economic cooperation (ICEC) has been established, whose efforts are aimed at establishing and strengthening business ties between the countries.

Russia continues to be an interesting market for Finnish businesses, represented by more than 600 companies with a total investment of more than 12 billion euros operating in various sectors of the domestic economy. At the same time, the vast majority of companies operate on a long-term basis and do not plan to leave the Russian market (table 1).

If we consider the sectors of the economy that are most attractive to Finnish businessmen, the largest share of investment is in the production, retail, logistics and distribution sectors (see figure 1).

Table 1 - largest Finnish investors in Russia, 2019

№	Company name	Year of launch in Russia	Industry	Revenue in 2018, billion rubles	Revenue dynamics compared to 2017, %	Key assets for November 2019	Investment amount at the end of 2019, million euros
1	**Fortuna**	**2008**	production	79,1	9,4	8 TPP, wind farm, share in TGC	5500
2	**Nokian Tyres**	2005	production	22,4	3,3	plant	1016
3	**Stora Enso**	1998	retail	22,1	16	petrol station chain	229,8
5	**YIT**	2001	real estate	20,3	-27	Bank, 2 techno parks	279,6
6	**UPM**	2003	production	17,97	17,5	plant	255,0
7	**Fazer**	1997	production	11,9	-4,5	4 plants	318
8	**Tikkurila**	1995	production	11,0	4,8	3 plants, warehouse	134,2
9	**SOK (Sokos, Prisma)**	2006	retail	10,5	-12,2	chain stores, hotel	220,15
10	**Huhtamäki**	1994	production	8,03	14,2	plant	125,0
11	**Posti (itella)**	2006	logistics and distribution	7,7	-1,7	10 warehouses	465,7
12	**Valio**	1994	production	6,9	11,6	plant	70
14	**Aspo**	1997	logistics and distribution	6,6	11,8	10 warehouses	15,5
15	**Atria**	2006	production	5,6	-08	2 plants	207,6
16	**Specta**	2007	production	5,4	-11,9	2 plants	35,0
17	**Paulig**	2008	production	3,8	-8,6	plant	28,2
18	**Reima**	2010	logistics and distribution	3,6	9,1	chain stores	0,66
19	**Teknos**	2010	logistics and distribution	3,6	12,5	plant	19,2

20	**Wärtsilä**	2007	logistics and distribution	2,74	5,8	plant	210

Source: compiled by the author based on data from the study "Finnish business in Russia 2019: Top 30 companies". https://www.fontanka.ru/longreads/finskiy_biznes2019

The pie chart shows that the construction and acquisition of production facilities account for 70% of all capital investment by Finnish investors. The largest contribution was made by Fortum, whose total investment portfolio at the beginning of 2019 amounted to 5500 million euros.

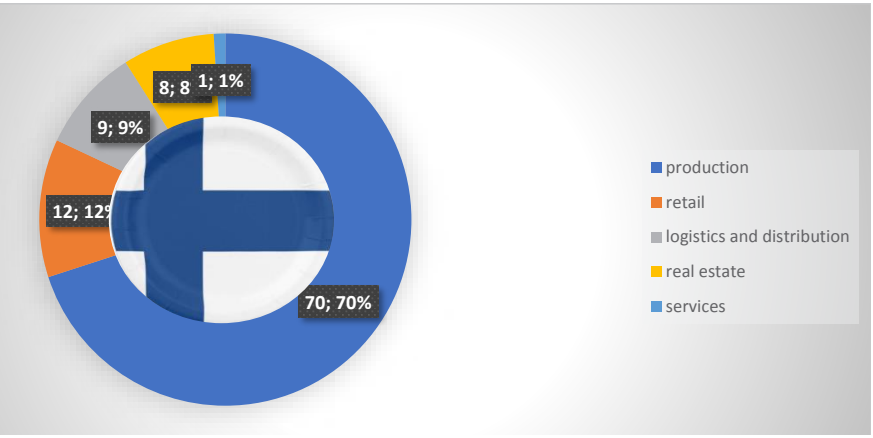

Figure 1 - distribution of investments of Finnish companies in Russia in 2019, %

Source: compiled by the author based on data from the study "Finnish business in Russia 2019: Top 30 companies" https://www.fontanka.ru/longreads/finskiy_biznes2019

These funds will be used for the construction of renewable sources of electricity generation: wind and solar power plants in 2020-2022. The company's assets in Russia already include 8 power plants, a wind farm, and a significant share in the share capital of TGC-1 (Territorial generating company No. 1). The second place with a significant lag in investment volumes is occupied by Nokian Tyres (1016 million euros), the company built an automated warehouse in Vsevolozhsk, where, thanks to the use of innovative technologies in logistics, it was possible to significantly reduce the cost of hiring staff. Stora Enso, which has been operating on the Russian market since 1998, closes the top three investors. Rich experience, combined with a strong production base consisting of 3 factories and 2 sawmills, allows the company to successfully develop and compete in the

Russian market for more than 20 years. The size of the investment of Stora Enso in 2019 amounted to 310 million euros. In addition to the main three, the author of the largest investment project is preparing to become the company Tikkurila, which by 2021 plans to launch a new plant for the production of construction and paint materials in St. Petersburg.

Fazer is represented in Russia since 1998, the company acquired a stake in the bakery "Khlebny Dom". In 2005, Fazer bought for $ 35 million Moscow bakery "Zvezdny". These factories produce not only bread, but also frozen semi-finished products, pizza and confectionery. Fazer's annual revenue in Russia is about $ 300 million, and the company's factories employ more than 4,000 Russians. While Fazer does not plan to return to the project to create a new plant, although it continues to invest in the modernization of existing sites, the development of the product line and the environmental friendliness of its production.

In 2019, Finnish companies have a new segment on the Russian market — service companies, which still occupy a modest 1% of the total investment volume. New players in the service sector are the Finnish company Lindstrom, which specializes in renting and caring for workwear, and the IT developer Tieto, which offers solutions in the field of big data processing and artificial intelligence. Judging by the profitability of companies, we can assume that in the near future the number of Finnish business structures in the Russian service sector will grow.

These examples show that Russia does not lose its relevance for Finnish investors and has a huge potential for further joint cooperation. Finnish companies do not stop investing in the development of existing businesses, and major players continue to increase localization and launch new products on the Russian market.

At the same time, the economic sanctions imposed on the Russian Federation have negatively affected the activity of Finnish businesses in the Russian market. According to statistical research in 2019, the largest Finnish companies are slowing down sales growth, reducing and/or freezing investments. Thus, in 2018, the revenue of Finnish companies in Russia amounted to 288.6 billion rubles (4.5% more than in 2017), and the growth rate of sales in 2017 compared to 2016 was at the level of 7% [1]. Total investments of the top 20 Finnish companies (see table.1) since entering the market amounted to 9.2 billion euros. In 2018 alone, Finnish companies invested 205.6 million euros, but in 2019, the volume of investments decreased by almost a third.

A number of large Finnish companies have left the Russian market. Thus, the Stockmann concern (revenue in 2018 - 1.8 billion rubles) sold

its last asset (the Nevsky center shopping center in St. Petersburg) to the Czech PPF group. Neste (revenue in 2018 — 22.1 billion rubles) sold the tank farm and its network of gas stations to the Russian company Tatneft.

The Russian market for Finnish entrepreneurs has a number of other negative features. So, Finnish investors consider the main obstacle to the development of entrepreneurship to be the imperfection of the Russian legislative sphere, since even large companies like IKEA have problems with engineering communications and connecting to electricity sources. There is also increased pressure from law enforcement agencies on businesses, more frequent inspections, and a growing number of criminal cases, including against foreign citizens [2].

To retain and attract foreign investors in the Russian market, a significant transformation of the investment climate is necessary. A large-scale project of the Ministry of economic development of the Russian Federation is dedicated to solving this problem [3], which provides a set of measures to improve the business climate and investment attractiveness of the country. The project provides such measures as: transition to electronic document management in the implementation of border, customs and other types of control at sea checkpoints; regulatory consolidation of a unified methodology for evaluating the effectiveness of tax benefits and other preferences, including taking into account their impact on achieving the relevant goals of socio-economic development; optimization of the number of mandatory requirements checked during scheduled inspections.

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POINT OF GROWTH AS A FACTOR IN THE FORMATION OF RESEARCH SKILLS OF RURAL SCHOOL STUDENTS

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Abstract. *The Paper is devoted to the problem of formation of natural science literacy of rural school students based on the work of the center "Point of growth»*

Keywords: *research skills, natural science literacy, digital profile.*

At present, there are quite a lot of changes in the system of national education, which are reflected in such documents as "Decree of the government of the Russian Federation No. 550 of July 13, 2009 on the competitive selection of University development programs, for which the category "national research University" is established", priority national project "Education", etc. To become one of the top ten countries in the world in terms of quality of education, our country participates in international comparative studies, the results of which allow us to identify the features of training Russian schoolchildren in comparison with students from other countries. And, if our students demonstrate high indicators of classical academic training, then according to the results of the international PISA study, Russian students have difficulties in solving practical problems.

Implementation of the national project, the global plans of entering the top ten leading countries in quality of education, require a transition to a qualitatively new form of organization of education, which puts students in the position of a pioneer, truth seeker, a person with knowledge and skills necessary for full participation in modern society.

The international PISA study includes three areas: "reading literacy", "mathematical literacy", and "science literacy". Special attention is paid to the ability of students to use their knowledge in practice.

Indicators of learning outcomes are not the degree of development of

educational programs, but the ability to apply subject knowledge and skills in situations that require the ability to generalize, reflect, draw conclusions, make decisions and act productively, that is, the formation of basic (basic) competencies, called literacy. In this regard, the development of research skills focused on research and project activities of students becomes an important task of education. The skills acquired in the course of research activities will allow them to learn to invent, understand and master new things, Express their own thoughts, be able to make decisions, formulate interests and realize opportunities, and most importantly, apply the acquired knowledge, skills and abilities in later life.

A retrospective analysis of psychological and pedagogical literature has shown that the problem of development of research activities and research training has a long history.

In medieval educational systems, it is difficult to find traces of research training. The teacher's monologue and reproductive assimilation of educational material dominated in pedagogical activity

The Renaissance is a time of great scientific discoveries, a time of true titans of thought. A keen interest in the study of the world around us affects the education and, first of all, the development of the child's cognitive activity. We can say that this era marked the beginning of what will be called research training in the future.

Currently, the idea of forming research skills has been widely developed. Much attention is paid to what is now commonly called competencies. In our opinion, when we call research skills research competencies, we do not change the essence of the above definition. And, due to the fact that a lot of attention is paid to competencies in Federal State educational standards, the development of competencies is one of the primary tasks of a teacher.

However, there are a number of obstacles to the widespread use of research-based teaching methods. This is confirmed by the lack of a state program to modernize the idea of research education; strict subject division of the content of education, class – based system and reproductive methods of teaching; lack of students ' research skills. Overcoming this difficulty is possible when creating certain psychological and pedagogical conditions that ensure the formation of research skills.

Considering the validity of the development of research skills of students, we rely on the position of O. V. Fedina, which States that "research skills is a complex system of practical and intellectual actions, allowing to carry out research work or its separate stages and generated by research activities with the appropriate knowledge and skills" No.1, Pp. 116-118.

As part of the research, we will be guided by the classification of K. P. Kortnev, N. N. Shusharina No.2, P. 366, who claim that the following research skills can be developed:

- ability to cover the entire problem as a whole;
- ability to correctly set a research task;
- ability to evaluate methods for solving an experimental problem;
- ability to plan an experiment;
- ability to find the optimal solution to the experimental problem;
- ability to implement experimental methods;
- ability to evaluate its information content and accuracy using laboratory and practical exercises.

Practice shows that the most favorable for the development of research skills are laboratory and practical classes, since such lessons can create conditions for a research situation, research activities, and lead students to the formulation of a research problem or problem.

However, the traditional method of conducting laboratory classes according to ready-made guidelines leads to the fact that, working according to a single template, the student, strictly following the instructions, can safely complete the work without fully realizing the essence of the experiment. At the same time, he does not develop research skills and creative abilities No.3, P. 239-242. In addition, there are a number of differences in the equipment of schools.

Thus, the resulting contradictions between:

- the need of society for research specialists, the social order for such specialists, and the real state of Affairs in mass schools, where a regulated approach to training prevails;
- the variability of the modern school, the learning process and the formation of the student's reproductive activity, which does not take into account the need to develop their research skills;
- the presence of opportunities in the educational process of the school for the formation of research skills of students and insufficient attention to creating conditions for their formation require the resolution of these contradictions.

Since the kolenovskaya secondary school of the Rostov district of the Yaroslavl region has a number of advantages over other rural schools, it becomes Possible to eliminate the above contradictions. For example, since 2020, within the framework of the national project "Education", the center for digital and humanitarian education "Point of growth" has been opened in the school, which is equipped with functional areas for training and project activities and is defined as the center of public life in rural schools. The

design of the "Points of growth" classrooms assumes a certain zoning, which will allow students to work comfortably and conveniently, both individually and in groups. Most of the furniture is freely transported and transformed if necessary. As part of extracurricular activities in digital, humanitarian and technical areas, students learn to use all the technical capabilities of this office, gain skills in teamwork and creating individual projects.

The new educational center, which provides training in digital and Humanities profiles, should provide an environment for students to choose their future professional activities based on their individual abilities and formed skills, including research. It is assumed that the use of such a center in the framework of the "Modern education" project will eliminate the gap between urban and rural, village schools.

The center also guarantees a high level of education that meets the requirements of modern society, since potential employers need highly qualified specialists. Therefore, the introduction of new educational technologies affects all General education organizations, including rural small schools.

A single educational space formed on the basis of interaction between the center and the school will function both at the regional level and show the first results throughout the country. Thus, the Russian Federation successfully solves pressing personnel problems, providing the Russian regions with highly qualified specialists with deep knowledge in the field of digital technologies. Since the goal of the Ministry of Education of the Russian Federation is to provide such training that will make it possible to enter the top ten countries with the best quality of education in the world. This is why they are introducing General education programs with a focus on digital skills.

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THE PROBLEM OF TRANSMISSION IN TRANSLATION A LANGUAGE PHENOMENA FROM ENGLISH TO RUSSIAN LANGUAGES

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Abstract. *This article deals with the problems of transmitting such linguistic phenomenon as somatic vocabulary in translation from English to Russian languages. The concept of "somatic language" in English is one of the most numerous phraseological groups, "somatic code of culture" and language in this phenomenon, the authors also give an overview of the classification of somatic vocabulary depending on the nature of the text.*

Keywords: *somatic vocabulary lexical group of the translation transformation, the linguistic phenomenon.*

In English, such a language phenomenon as somatic vocabulary is one of the universal lexical groups, which has led to the relevance of its research in comparative historical, structural-comparative and linguocultural works of domestic and foreign linguists. Scientists like N.M. Shansky, A.V. Kunin highlighted its usually importance in the lexico-semantic system of any language [4, 6].

One's awareness of oneself as a person began with sensations arising directly through the senses and parts of one's own body. VG Gak noted that “Man is self-centered, he sees in himself the center of the universe and displays the world in his likeness” [1, p. 702].

Man gradually realized his orientation in space and time, the expression of subjective evaluation by means of such universal “tools” of cognition as part of the body. Human sensitive correlation with various organs of his body is a universal property of all languages, “the difference between

specific languages is how exactly are distributed sensations on the naive "anatomical map" of man" [5, p. 155]. Historically, abstract thinking presages the unity of development of any language and the role of somatisms in the process of its formation cannot be overstated. Abstract meanings formed on their basis exist in all languages and prove the universality of the patterns of human thinking. V.V. Krasnykh introduced the concept of a "culture code", which he represented in the form of a "grid", sketched by culture on the world around him. Culture codes correlate with the oldest archetypal representations of man. [3, p. 232].

As a linguistic phenomenon, culture codes represent a universal formation corresponding to the human perception of the world around them. However, in a certain culture, their manifestation, significance, as well as the metaphors into which they are transformed, are always dependent on national culture. For example: in English linguoculture, the belly symbolizes bravery and determination: *have the stomach for something, a strong stomach, get enough guts to do smth*. In Russian linguoculture, the belly is (as the inside form of the word says) life. Hand means support: *To put your hand on your heart, To give a hand,* To raise a hand*, to rub one's hands, to take oneself in hand,be a firm hand, to be an old hand.*

The nose has a negative meaning in both English and Russian: *To look down one's nose at, to stick one's nose up in the air, to stick one's nose into somebody's business.*

In the scientific research consecrated to the linguogeographic analysis of somatic vocabulary in the dialects of Erzyan language, A.M. Kochevatkin divided all somatic vocabulary into below presented groups, depending on the nature of the object of nomination:

- somonymy vocabulary serving to refer to parts and areas of the human body (soma body + onima name, name) — head, neck, foot, shoulder, stomach, nose, back, finger, waist;
- osteonomic vocabulary serving to indicate bones of the human body and their compounds (from Greek osteon - bone) - bone;
- splachonymic vocabulary serving for the nomination of internal organs of the human body (from Greek splanchna - insides) — lever, gut, heart;
- angionomic vocabulary serving for the nomination of the blood system of the human body (from Greek angeion - vessel) blood, bloody, vessels, vein;
- sensonimic vocabulary serving to indicate the senses of the human body (from Latin sensus - sense,) eye, ear, skin, tongue, nose;
- vocabulary denoting diseases, ailments and manifestations of the

human body. [2]

This classification defines a strictly deterministic natural number of objects of nominations, which are characteristic of the human body and is common to all languages. In different languages there is a quantitative and qualitative difference between the specific composition of lexical units. Thus, being a component of the language picture of the world, the somatic code of culture is fixed in vocabulary, phraseology, paremiology and, contributes to the identification of universal and national-specific features, conceptualizing the outer and inner world of humans and their habitats. Spiritual sphere of man, moral essence, as well as volitional, emotional, intellectual actions and states, character traits, attitude towards other people, to oneself, to things is expressed in somatic metaphors and comparisons.

Thus, one can conclude that historically somatic culture code reflects the real and spiritual world of man in all cultures in general and in English-speaking culture in particular, based on human perception of organs of one's own body. Somatic vocabulary is one of the oldest lexical language phenomena, as the lexico-thematic union of words, historically influences the formation of somatic space in of every language.

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ANTAGONISTIC CLASSES IN THE USSR

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Abstract. *It is shown that the administrative strata in the USSR is a class. It is shown that the class of Soviet managers was antagonistic to the working class.*

Keywords: *Property, power, dispossession, armed uprising.*

Introduction

In 1923, the XII Congress of the RCPb, which took place without Lenin (the ailing Lenin was in Gorki), decided that the dictatorship of the proletariat is expressed in the form of the dictatorship of the party. Lenin, however, argued that the dictatorship of the proletariat is expressed in the form of Soviet power, a form found by the workers themselves (Speech at the 1st Congress of the Comintern, State and Revolution, etc.).

Thus, the party marked the trend of "separation from the masses", which was expressed in the stratification of society in the USSR already in the 30s and became obvious from secret in 1991.

What were the relations between the working class and the class of Soviet bourgeois managers in the USSR: the CPSU elite, general directors, etc.? Here are the results of privatization: Perm chemical plant "Kamtex" - 98% of the shares are held by the administration, 2% - by the labor collective. Perm "Vtorchermet" - 87% of shares owned by the plant administration. At Motovilikhinskiye Zavody, shop managers were granted privileges in purchasing shares, the vast majority of which ended up in the pockets of the administration. The general director of the Perm defense "Velta" Malmygin together with his son actually appropriated the plant, the general director of the "Motovilikhinsky plants" Bulaev fired 40 thousand of 50 thousand workers, and so on. Yeltsin, by his decree, gave the general directors 5% of the shares of the enterprises they manage for free.

Management as a property relation

What is the class point of view on the personality of Stalin, on the "red" directors, Soviet ministers, first secretaries of the regional committees of

the CPSU, etc.? Property, Marx wrote to Annenkov, is not a person's relationship to things, but the relationship between people about things. Already in Roman law, property relations are subdivided into use (as among the peasants of Russia after 1917), ownership (the Soviet state owned land) and disposal (management). Consequently, the manager of things is the owner.

The owner of the means of production is called a capitalist, a bourgeois. Consequently, the Soviet layer of managers headed by Stalin was a layer of capitalists.

“Classes are large groups of people that differ in their place in a historically defined system of social production, in their relation (mostly enshrined and formalized in laws) to the means of production, in their role in the social organization of labor, and, consequently, in methods of obtaining and size the share of social wealth that they have. Classes are such groups of people, of which one can appropriate the labor of another, thanks to the difference in their place in a certain structure of the social economy "(Lenin," Great Initiative").

The administrators of the USSR are an army of 19 million people, i.e. large group of people. The place of managers in a historically defined system of social production is quite distinguishable and is enshrined in laws. It is the managers who dispose of the means of production in the USSR; their role in the social organization of labor is defined. The size of the share of social wealth received by managers is much higher than the average level for the USSR, plus state dachas, plus the best sanatoriums and special hospitals with the best doctors, the best cars with personal chauffeurs, the best chefs and the best food, not to mention the "privileges" - about a special food distributor with or with judicial immunity of deputies.

Consequently, the Soviet party-state-economic nomenklatura was a class - according to Lenin's definition. And this class is the capitalist class.

In Marxist-Leninist theory, the antipode of the working class is the capitalist class. Consequently, the working people in the USSR and the class of Soviet managers are antipodes. Between these two classes there is a constant struggle in one form or another. Strikes and uprisings in the USSR prove that the working people and the managerial class in the USSR are antagonists.

Let us note only those episodes of the class struggle that took place during the reign of Stalin. We omit conflicts on ethnic grounds, conflicts that were of an anti-communist nature or were inspired from the outside in relation to the working people.

Riots and uprisings in the USSR up to 1941

1925-1929

In 1925, only in the Middle Volga region 11 strikes took place, in 1926 - 15, 1927 - 16, 1928 - 30, 1929 - 56 (Kamardin I.N. Labor conflicts in the Middle Volga region 1918-1929 (based on materials from Penza, Samara and Simbirsk provinces Diss. cand. of hist. sci. - Penza, 2001).

12.5.1927 - a one-day strike of workers of the open-hearth shop of the Verkh-Isetsky metallurgical plant, the largest enterprise in the city of Sverdlovsk (Ural Oblast). 200 people took part. The reason was the "insensitivity of economic leaders to the needs of the workers." The leaders of the strikers were a former Red Army soldier, a participant in the Civil War, and a member of the church council of the factory village, who had previously served with the "whites".

In the summer of 1927, according to a JSPD report on industrial strikes, there were on average more than 3 strikes a day across the country. Almost all of them arose spontaneously, 75% of them, as in any capitalist country, were associated with the demand to raise wages.

1928-1929 Stalin's permission in 1925 to peasants to sell and buy land (which led to the concentration of 60% of the land in the hands of 6% of peasant farms and thereby caused a crop failure), the curtailment of the NEP in 1927 (which, according to Lenin, was calculated for decades), the beginning of industrialization at the expense of the countryside, Accelerated collectivization and dispossession of the middle peasant, which ran counter to the Decree on Land, Lenin's speeches about the middle peasant and the decisions of the XV AUCPb Congress, led to an increase in the infant mortality rate (to the level of the first decade of the XX century). The peasants - it was easy to predict - responded with mass slaughter of livestock (the livestock was restored only by the end of the 50s), a reduction in crops and uprisings.

For example, 03.22.1928 - a peasant uprising in the Zyryansk district of the Tomsk Oblast, November 1 - a peasant protest in the village of Udelny Uty of the Vyunicheskaya volost of the Bryansk Okrug against the organization of a collective farm (in April, the organizers of the protest, the Kizikov brothers, received 10 years in prison). Let's compare. Number of peasant uprisings from 1900 to 1917: Year -Number: 1900 – 49; 1901 – 50; 1902 – 340; 1903 – 141; 1904 - 91; 1905 – 3228; 1906 – 2600; 1907 – 1337; 1908 – 931; 1909 - 933; 1910 – 1030; 1911 – 613; 1912 – 300; 1913 – 135; 1914-1915-1916-1917 - 5782. Total for **1900-1917: 17560.** That is, 944 per year. Reference: "The JSPD recorded more than **13,000** riots and mass demonstrations in villages from **January 1928 to December 1929.**"

That is: 6,500 per year.

In 1929, 244,000 peasants took part in the demonstrations.

The unrest of the lower classes against the policy of Moscow intertwined with the "friendship of peoples": September 26 - October 11, 1929 - Takhta-Kupyr uprising in Kazakhstan: Karakalpaks and Kazakhs at a gathering in the village of Andatkol decided to armed resistance to the authorities, seized the city of Takhta-Kupyr, causing a pogrom institutions. At the same time, an uprising began, engulfing the Syrdarya Okrug.

In November, a major uprising broke out in Chechnya in the Shalinsky and Urus-Martanovsky regions. On December 8-28, a large-scale operation of the North Caucasian Military District and JSPD units was carried out, during which 450 people were arrested, up to 60 were killed and wounded. The loss of government troops was 43 people, of whom 21 people were killed and died of wounds. Also in November - an uprising in the Batpakkarinsky region of Kazakhstan. The rebels took possession of the regional center, smashed the party and administrative institutions, the police, released the arrested and announced the overthrow of the government - but were soon defeated by the JSPD. About 200 people were arrested.

In December - an uprising in Bulun (Yakut ASSR) - "an armed protest against the policy of the district committee of the party." The rebels, supporting the Soviet regime, demanded a significant softening of the policy pursued and more attention to the opinion of the local population.

From 17.12.1929 to 14.2.1930 in the Central Black Earth Oblast 38 peasant demonstrations took place, in which more than 15,000 people took part.

1930. In the summer, a "Memorandum on Wages at State Enterprises" was prepared for the top leadership of the USSR by the INFO JSPD, which contained generalized data on the number of strikes and the number of participants in strike actions in the country from January 1929 to August 1930. From January to August 1929, 174 collective protest actions, in which 15 707 people took part. In January-August 1930, there was a decrease in the number of strikes to 147 cases, as well as the number of participants to 11,833 people. During the year, about 2.5 million peasants took part in 13.754 uprisings, riots and demonstrations against the regime, of which 3,712 were "women's uprisings". 176 riots were of an insurrectionary nature. Large peasant demonstrations (with up to 1000 participants) took place in the Volga region, Ukraine, Siberia, the North Caucasus, and Kazakhstan. According to the JSPD, about 20,200 people were sentenced to death.

Through the fault of the leadership, the entire textile industry stood idle for 4 months due to a lack of raw materials, a number of other light industry enterprises, hundreds of heavy industry enterprises worked at 2/3 and even half (M. Ryutin, “I will not kneel.” M.: Publishing house of political literature, 1992).

In January, 109,486 people took part in protests against collectivization.

In February, 214,196 people took part in the peasant unrest. Mass uprisings of Russian peasants and Kazakhs in Kazakhstan during collectivization: in Sozak of the Syrdarya Okrug, in Eastern Kazakhstan (Ust-Kamenogorsk and Zyryanovsk districts), in the Irgiz district of the Aktobe Okrug, in the Sarysu district. All uprisings were brutally suppressed by the JSPD troops (about 400 peasants died in Sozak). North Caucasus: mass unrest and uprisings in the villages and towns of Barashkovskoe, Veselo-Voznesenskoe, Konstantinovskaya, Novy Yegorlyk, Novo-Manychskoe. Armed demonstrations of the Kuban Cossacks in the villages of Stavropolskaya (under the leadership of the former red partisan Antonenko), Troitskaya, Uspenskaya, Petropavlovskaya, Novo-Maryevskaya and Novo-Troitskaya. Ukrainian SSR: peasant uprisings against collectivization in a number of districts of Shepetovsky, Tulchinsky, Berdichevsky and Odessa Okrugs. In March, the number of participants in anti-collective farm protests was 1,434,588 people. In the North Caucasus alone, there were 335 riots with more than 82,000 participants.

The insurrectionary movement covered a number of villages of Itum-Kalinsky, Shatoevsky, Chemberloevsky, Galanchezhsky districts and the Khamkhinsky village council of the Galashkinsky district of the Chechen and Ingush Autonomous Oblasts. The number of forces participating in the operation to suppress it by the troops of the North Caucasus Military District and the NKMD exceeded 5000 people. 9 detachments were defeated, 19 were killed in shootings, 122 people were arrested. The uprising in the Altai Krai, led by the authorized JSPD Dobytin: he freed and armed the arrested "kulaks". His detachment defeated administrative institutions and police stations in several villages, eliminated 10 of their workers. Some members of the Tujlei troops joined the rebels.

3-4 March - Bichurskoe armed uprising against collectivization in Chita Oblast. Suppressed by the JSPD squad.

March 7-8 - a peasant uprising in the village of Severnaya, Nizhnesaldinsky District, Ural Oblast The attempt to bring three "kulak" families to the assembly point in Salda provoked a strong protest from the entire village.

March 28 - April 1, in Lipovka, Losevsky District, Rossoshansky Okrug, Central Black Earth Oblast, the peasants prevented the eviction of their

fellow villagers - "kulaks".

March-April - Sarbaz uprising in Kazakhstan.

In April - a strike at the Telegin weaving factory in the Shuisky Okrug of the Ivanovo-Voznesensk industrial Oblast, the largest of all in the textile industry, which arose due to poor food supplies.

In April 1992, mass demonstrations of peasants were registered.

In total, according to INFO JSPD, in January-April there were 6117 anti-collective farm demonstrations, in which 1,755,300 people took part. 800 uprisings were suppressed with the use of weapons. 15,000 JSPD workers were injured, many of them killed and injured.

In May - workers of the Revda metalworking plant (Ural Oblast) went on strike due to non-payment of wages for 2 months.

Armed anti-collective farm uprising of peasants in Ashap, Oktyabrsky district, Perm Oblast.

In the Ukrainian SSR - 65 mass protests against the eviction of "kulaks" of the third category. The peasants demanded the return of the dispossessed from exile and the return of the confiscated property to them. In May-June - "kulak" uprising in the Bratsk region of Irkutsk Oblast. The peasants freed Antonovo, Dubynino, Ust-Vikhorevo and Sedanovo, and shot several people from the Soviet activists. Suppressed by parts of the JSPD.

May 18-19 - "woman's revolt" in Staro-Belokurikha, Altai Krai: during the eviction of kulaks, about 300 women gathered around the building of the village council, declaring that they would not surrender the "kulaks", beat several village councilors. After one of the activists was wounded by a shot from a Berdan gun, the riot subsided. The JSPD arrested 14 participants in the performance who were convicted.

In June - mass absenteeism of miners in the coal trust "Luganskugol".

During the month, 886 anti-collective farm actions were recorded in the country.

In July, workers from 7 coal mines of the Stalinugol trust (Donbass) went on strike.

618 anti-collective farm performances throughout the country. July 26-27 - an attempted uprising in Ust-Pristan, Altai Krai.

In August - 256 anti-collective farm performances across the country.

August 12 - the secret "Short instruction-list on the protection of state secrets in the press", according to which, "it is not allowed to publish information in the press about strikes, mass anti-Soviet demonstrations, as well as about riots and unrest in detention houses and concentration camps."

1931.

April 20 - the uprising of the special settlers of the Petropavlovsk timber

industry enterprise (Nadezhinsky district of the Ural Oblast).

June-September - Mangyshlak uprising in Kazakhstan.

From July 6 to August 1 - the Chumakov uprising - a large peasant uprising against the "dispossession". (Chumakovsky District of the West Siberian Krai, now Novosibirsk Oblast). The rebels captured 24 villages, towns and farms.

From July 26 to August 2 - the Chainskoye uprising, the performance of the special settlers of the Parbig commandant's office of Siblag (Tomsk Oblast), up to 1500 people participated. Caused by the dire financial situation of the peasants expelled from Kuzbass and Altai. The rebels captured one of the village commandant's offices, however, extremely poorly armed, were unable to resist the JSPD, police and party activists. August 27-31 - an uprising on the territory of the Mukhorshibir ayman of the Buryat-Mongolian Autonomous Soviet Socialist Republic, led by the Soviet worker Kravchenko, who managed to unite several underground peasant cells, which consisted mostly of middle peasants and poor peasants. Among the slogans - "Down with the dictatorship of the party, all power to the working peasantry!"

1932.

March 23 - another uprising on the border of Chechnya (villages of Shali, Goity, Benoi, Nozhai-Yurt) and Dagestan. The rebels blocked the Red Army garrison in Benoi, tried to seize the Sterech-Kertych oil fields, but by early April they were defeated by units of the NCMD Red Army. The population (especially women) took part in the uprising en masse. April-May - anti-collective farm uprising in Taimyr. It began with a speech by the indigenous population (Dolgans and Nenets), dissatisfied with the arbitrariness of the local authorities. The rebels began to kill officials, defeated the detachment aimed at suppressing the demonstration, and issued several appeals. JSPD units were thrown into the suppression, at the end of May the rebel leaders were killed or arrested, the local population ceased resistance.

Uprising of Vichuga weavers on April 5-12. Reason: On April 1, rationing norms for the issuance of bread were reduced (from 12 to 8 kg for workers and from 8 to 4 kg for dependents). The uprising engulfed the cities of Teikov, Lezhnev, Yuzh and other factory centers of Ivanovskaya Oblast and was suppressed by force of arms.

April 7-9 - anti-government demonstrations in the city of Borisov (Byelorussian SSR): large groups of residents destroyed grain warehouses, organized a demonstration and a procession of women and children to the Red Army barracks.

May 3 - a grain riot of 300 women from the village of Ustinovtsy (Okty-

abrsky district of Kostroma Oblast).

On May 5, a crowd of residents of the village of Chasnikovka (Poltava Oblast) destroyed a warehouse at the Sencha station. On the same day, at the Sagaydak station (Poltavkaya Oblast), about 800 people pushed aside two policemen and village activists who were guarding the bread, and took most of what was in the barns with them.

On May 6, about 400 peasants from the villages of Liman and Fedunki (Nikolaev Oblast) made an unsuccessful attempt to take away the bread.

1933. According to the JSPD, for 6 months (July-December), labor unrest occurred in 10 cities of the Urals, at enterprises in the Donbass, 8 factories in Leningrad, in Serpukhov, Novosibirsk, Sormovo, Balakhna, Odessa, Kherson, Nikolaev.

1934

According to the JSPD, during the period from March 1 to June 20, 80 collective protests were recorded at enterprises and construction sites in the USSR. They were attended by 3143 people. The total number of strikes and “AWOLs” among workers in industry and construction amounted to 185 cases, in which 8707 people took part. September 13 - USSR Prosecutor V.M. Bochkov sends a memo to the chairman of the Council of People's Commissars V.M. Molotov. It cites individual cases of collective protest actions at industrial enterprises and construction sites in the country: at the Kirovo-Chepetskaya CHPP, at the construction of a military facility in Sevastopol, at the Stalingrad Oblast Construction Trust, at a confectionery factory in the Byelorussian SSR.

During the years of the 1st five-year plan, workers went on strike at the Stalin plant, the plant. Voroshilov, Shostensky plant, at the "Krasnoye Sormovo" plant near Nizhny Novgorod, at the "Hammer and Sickle" plant of Machinotrest in Moscow, the Chelyabinsk Tractor Plant and other enterprises.

Riots and uprisings in the USSR after the war

1945

21 July. From the speech of the writer MS Shaginyan at the party meeting of the Union of Soviet Writers: "I was in the Urals, there 15,000 workers of the Kirovsky plant rebelled, a real riot, because the conditions were bad. The district committees and the regional committee of AUCP (b) learned about this only when they ran over during the riot. The director was not at the plant for two months. After this riot, he released 2 million rubles for the improvement".

August-September - unrest of workers was noted at the evacuated factories in Novosibirsk, Omsk, Kazan.

1946

September - Workers at the construction site of the Elfa electrical plant (Vilnius) declared a strike: at the beginning of the month, ration prices for food were significantly increased by the "decision of the party and government" and the workers announced that their salary of 200 rubles would not even be enough for lunch.

At the end of the month, unrest at the "Abrau-Dyurso" grape and wine plant (Krasnodar Krai) following the decision of the authorities to remove a large number of categories of workers, employees and dependents from the card supply.

1948. August - a powerful uprising ("mass self-liberation") of several hundred prisoners of the North-Pechora ITL on the construction of a railway Chum-Labytnangi (Komi ASSR).

1948 – after the arrival of the front-line soldiers in the Ege-Hai camp, uprisings began.

In the fall of **1952**, at night, a new uprising took place in the Ege-Hai camp № 6.

January 19 - a strike and an armed attack on the supervisory staff in Kamyshovy camp (Myskovsky district of Kemerovo Oblast. March 18 - in the 1st department of the Mountain camp (Norilsk, Krasnoyarsk Krai), the convoy was disarmed by prisoners "with the intention of raising an armed uprising in Norilsk."

From May to August **1953** - an uprising in the Norilsk camp.

Conclusion

All these conflicts were suppressed by force of arms, the captured rebels received a prison sentence, were sent to a concentration camp or shot.

After Khrushchev came to power, the uprisings continued, the most powerful was the workers' uprising in Novocherkassk in 1962. The condemnation of Khrushchev's policies and his removal from power did not change the picture, especially in 1967 there were many uprisings. Strikes and uprisings broke out in the 70s and early 80s.

In the official propaganda of the USSR, power is called the power of the workers, working people. Workers and peasants in the USSR went on massive strikes and rebelled, including with a weapon in their hands. Consequently, power in the USSR was not the power of the workers.

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ISSUES OF ACCULTURATION OF MIGRANTS FROM THE MIDDLE EAST IN GREAT BRITAIN

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The summary*. The article deals with the issue of acculturation of Arab refugees in the UK, the relevance of which is determined by intensity of migration flows from the Middle East. The purpose of this article is to identify problems that arise in the process of acculturation, as well as to analyze the measures taken by the UK in this sphere. This implies the following tasks: to characterize the policy of multiculturalism in Great Britain; to identify problems that hinder the process of acculturation of Arab refugees in this country; to identify prospects for the integration of Arab refugees into British society.*

Keywords: *multiculturalism policy, national identity, acculturation, intercultural communication, "Arab world".*

In the era of globalization, the problem of coexistence of different cultures deserves special attention, since objective processes caused by openness of borders and relatively free movement of people of different nationalities dictate new rules for behavior of a subject of social interaction. The idea of solving national conflicts by creating multicultural environment, which has become popular, like the term "multiculturalism" several decades ago, has not lost its relevance for a long time due to the development of migration processes.

According to V.A. Tremb for solving problems related to migration and its consequences, there are two popular approaches – multiculturalism and assimilation-are particularly popular. The goals of these models are the same – to create an integrated society in which conflicts based on non-ethnicity and non-culturalism are absent or minimal. The author highlights the main

principle of multiculturalism policy – preservation of national and cultural identity of migrants, which, in turn, often implies a certain distance between migrants and indigenous population. The policy of assimilation is based on the need to merge migrants with the host society [12, p. 2012-2016].

Studying influence of migrants on the of the country in which they settle, M. A. Shumenko supposes that migrants who have moved from their former place of residence to another region or country face the need to adapt to new socio - cultural conditions of existence - "adaptation". As a result of migration, a person moves from his natural and social environment that he has got used to into another one; he breaks a lot of previous connections and artificially creates them in a new place. M.A. Shumenko emphasizes that problems of overcoming ethno-cultural distance between the indigenous population and ethnic migrants are compounded by the need to adapt the latter to changes of socio-territorial status of a new place of residence, as well as adoption of new forms of social and cultural behavior. The extent to which a migrant successfully adapts to a new culture depends on effectiveness of its functioning in a new socio-cultural system of relations and interactions in a given society. In this regard, a person as a representative of one culture (conventionally, it can be designated as a donor culture) moves to another culture (recipient culture) [14, p. 23].

The level of development of cross-cultural communication between a recipient country and a donor country plays an important role in the policy of multiculturalism.

The concept of "intercultural communication" consists of two words: "intercultural" and “communication". The latter term has many different interpretations. As an example, we can highlight the definition of A.P. Panfilova: "Communication (from lat. communicatio – a message) is the process of transmitting meaningful information, its emotional and intellectual content from a sender to a recipient, i.e. from a person, group or organization to another person, group or organization" [7, p. 113-114]. Thus, cross – cultural communication is a process of transmitting meaningful information between representatives of different cultures. Cross-cultural communication can be compared to development of social norms by an individual.

When it comes to compatibility of a refugee or immigrant with a new cultural environment, the issue of acculturation should be raised. According to the definition given in the encyclopedic dictionary of K. M. Khoruzhenko, this term "is used to denote the process and a result of mutual influence of different cultures, in which everything or a part of representatives of one culture (recipients) adopt norms, values and traditions of another (donor culture)" [13].

If until recently in the scientific community assimilation was considered to be the best acculturation strategy, today, according to A. P. Sadokhin, "the goal of acculturation is to achieve integration of cultures, resulting in a bicultural or multicultural personality" [3, p. 148]. This option is conditioned by the need of voluntary acceptance of this strategy by both recipient and donor peoples. Here the evaluative nature of the acculturation phenomenon arises, which can be influenced by many factors.

These factors include the following: language differences, incorrect perception of non-verbal communication, stereotypes and prejudices, anxiety or tension. As A.P. Sadokhin notes, "the psychological mechanism for the emergence of stereotypes is based on the principle of saving efforts, which is a characteristic of everyday way of human thinking" [3, p.133]. It means that a person resorts to stereotyping when he can't interpret the phenomenon more deeply and adjusts it to the categories established in his mind. When a person meets a representative of their own culture, most often they evaluate it from the perspective of their own culture.

In this paper, we will look at the process of cross-cultural communication between the UK and the countries of the so-called "Arab world".

Despite the traditional view of the United Kingdom as a country where foreigners are treated with condescension, Britain is one of the most open to the world developed countries with a high level of economic development [4, p. 47].

In this regard, we consider it necessary to give a brief description of cultural and everyday features of the country of "foggy Albion", since the features of national identity in England are best manifested in the culture of everyday life of the British.

The population of The British Isles has always been represented by several different cultures, as the Scots, Welsh and Northern Irish are mainly descendants of the Celts, the English are descendants of the Anglo-Saxons.

Taking into consideration the significant number of cultural differences between the four Nations, as well as the diversity of cultures within these countries, it can be argued that the problem of national self-determination does not lose its relevance. There is an opinion that quite a large number of representatives of Great Britain do not judge themselves as "British", and raise the question of the national identity of representatives of each of the four countries in the UK - a multi-national and multi-racial country "integrated in the European Community, although "typically British" behavior was attributed to the entire population of the country since 1070, when Great Britain was formed» [https://ode2.susu.ru/].

"Since then, stability and centralization of the Institute of management have been invested in this concept without compromising the established national traditions. A unified political, social and state system was created, as a result of which all the inhabitants of the Islands began to feel like a single people. But this does not remove the issue of national contradictions from the agenda" [https://ode2.susu.ru/].

Thus, British citizens represent a diversity of cultures and defend their national identity, which, in its turn, is compounded by migrants and cultures they bring.

According to V. G. Sobolev, one of the main problems of multiculturalism implemented in the UK as a strategy of migration policy is the lack of any unifying principle other than economic. A society created according to this model does not have a basic culture that can unite all members of society on the basis of shared cultural values.

In this regard, it is important to note that the model of multiculturalism, which is often discussed as the optimal model, is good and effective only when cultures that combine into a single "organism" are close to each other.

According to the "You Gov" survey, there are currently growing concerns in the United Kingdom about the failure of British policy of integrating foreign-cultural migrants and growing potential for conflict in society. For example, according to the London-based independent research company YouGov, in 2016, about a third of Britons surveyed believe that violence-related conflict on ethnic grounds in their country is inevitable. The study also revealed disturbing trends regarding relations between representatives of different faiths [2].

Great Britain is the historical and cultural core of the so-called "anglosphere", i.e. the English-speaking cultural group, which also includes the United States, Canada, New Zealand and Australia. The influence of the anglosphere is still great in the former colonies of Great Britain around the world. Arabic-speaking culture in this case is the complete opposite of the anglosphere, and therefore the study of the process of intercultural interaction between these two groups is of particular interest.

Studying the countries of the "Arab world" as recipients, it should be noted that the East is a geographical term that includes parts of South-West Asia, South-Eastern Europe and North Africa. Most often, the term "Arab world" is used as an equivalent, but, for example, the name "middle East" appears on the website of the British foreign office. According to the UN migration data portal, the number of refugees from this sub-region in 2019 was about 48.6 million. The main migration routes from the Middle East to Europe are via Turkey and the Mediterranean Sea.

The factors that attract migrants are good job opportunities, good health care and favorable conditions for education, public order and civil liberties [8, p.274].

These factors are very important for the issue under consideration, since it is a stable and comfortable life in the UK that attracts migrants from the Middle East. The concept of "migrant" is now closely related to the concept of "refugee", i.e. a person forced to leave their native country due to a threat to their own lives; in general, it can be noted that in recent months and years, both refugees and migrants have been traveling to Europe, and it is sometimes quite difficult to distinguish them [9].

The consequences of cross-cultural interaction have some positive results: an increase in the population, improvement in a demographic situation, and cheap labor forces. However, there are many negative features for both Europeans and migrants, but they mostly affect the culture of Europe.

A negative factor is the off-putting attitude of local residents towards migrants in general. As you know, the cultural worlds of the West and the East are very different and differentiate from each other greatly. In recent years, the largest numbers of refugees arrive in Europe from Arabian countries such as Afghanistan, Iraq, Syria, and Libya. These are Muslim countries with their own special mentality, way of life, norms and values, in which religion plays a crucial role, as opposed to the liberal attitude towards religious issues on the part of Europeans. It is also important that the vast majority of refugees are young men who are very aggressive, which can increase the crime rate. In addition, an important difference is the general cultural level of arrivals to Europe, which is quite low [9]

Large-scale immigration to the UK has been going on for more than half a century and is reflected in the socio-demographic and national-ethnic structure of the British population, their image and their lifestyle. In the last decade, it has been particularly hotly debated. In British society, there is an opinion that immigrants create competition for indigenous people in the labor market, put strong pressure on the social security system, and also contribute to the growth of crime and the spread of radical movements [5, p. 3].

A. E. Ignatovich states that "the social aspect of an immigrant's adaptation is the development of optimal behavioral norms and values for a successful response to changes in the environment. Adaptation reduces the socio-cultural distance between immigrants and residents of the host society. When all other conditions are equal, their socio-cultural adaptation is more successful because of intensive immigrants' contacts with local population, the length of time they stay in the host society» [4]

Acculturation occurs in the process of adaptation to the conditions of migrants' life, i.e. the selection and careful preservation of usual norms and values of what that cannot be changed under any circumstances, in order not to lose identity, and what can be painlessly abandoned. Simultaneously with the process of immigrants' adapting to a new environment they acquire previously unfamiliar concept and ideas and find their life niche. The absolute majority of Muslims who have lived in the UK for many years identify themselves as British [1]. However, according to Z.I. Levin, changes that affect spiritual orientation of the immigrant are considered to be the last, if his religious affiliation does not prevent him from living [6].

Unfortunately, according to E. Rashkovsky, "neither acculturation nor assimilation of religious faith, in fact, does not affect the essence of the problem. Islam forms the daily behavioral skills, personal habits such as ablution, regular prayer, a month of fasting, etc. It is this "everyday" Islam that is the most stable [10, p. 21].

In turn, strengthening the position of Muslims in the UK assigns the task for the host society to strengthen its identity. Historically, some people perceived immigrants as a threat to British moral, social and cultural values, whose presence would radically change society.

The most preferable strategy for people entering the world is socialization. To become a full-fledged member of society, a person should learn the established patterns of thinking, models and behavioral skills in this society, necessary amount of knowledge, norms and values from the earliest childhood. Violation of the process of socialization threatens to marginalize the individual and can lead to his isolation. The personal level can be extrapolated to the level of cross-cultural interaction: the analogue of socialization here is acculturation, i.e. joining a new cultural group without losing your identity. Like socialization, acculturation is a two-way process, possible only if both sides are willing to cooperate.

Acculturation of migrants — attitudes, norms, patterns of behavior and other cultural traits perceived as a result of social interactions between representatives of different cultures (migrants and the host society). In contemporary science, acculturation is studied from the perspective of the host society, which is natural, since it is caused by the problem of integration of foreign-cultural migrants into society [15].

Acculturation of migrants from the point of view of participants of interethnic interactions is mainly polar in nature: positive and negative. Positive acculturation refers to attitudes, norms, patterns of behavior, and other cultural traits of the host society that are learned by migrants and understood by representatives of the host country and / or migrants. Accordingly, nega-

tive acculturation is attitudes, norms, patterns of behavior, and other cultural traits of the host society that are assimilated by migrants and perceived by representatives of the host country and (or) migrants as negative [11].

Migrants who demonstrate signs of positive acculturation in their behavior occupy an intermediate position between "strangers" and "their own" and do not arouse acute rejection. Fluency in the language of the host society by migrants and their representatives is defined as an indicator of positive acculturation.

A.E. Ignatovich emphasizes the fact that cultural communication between Muslims and the host society of the UK has its own characteristics, which are due to a number of factors:

1) declining role of Christianity in British society;

2) differentiation in views on Islam among Muslims;

3) high role of the media;

4) activity of Islamic youth;

5) problems of the Muslim community, aggravated manifestations of «islamophobia» on the part of the state, the media and the non-Muslim population;

6) the fact that surviving in a new, largely alien environment, Islam not only adapts to it, but also changes it in its favour [4, p.48].

Проанализировав литературу и источники по изучаемой проблеме можно сделать вывод, что процесс межкультурной коммуникации мигрантов из арабских стран и гражданами Великобритании может быть успешным, если принимающее общество Великобритании продолжит интенсивно укреплять свои национальные идентичности, проведет более продуманную государственно-конфессиональную политику, будет проявлять взаимное уважение к различности и сохранит собственные традиции.

After analyzing the literature and sources on the problem under study, we can conclude that the process of intercultural communication between migrants from Arab countries and British citizens can be successful if the host society of great Britain continues to intensively strengthen its national identities, conducts a more thoughtful state and religious policy, demonstrates mutual respect for this diversity and preserves its own traditions.

The combination of integration processes, mutually beneficial cooperation in various fields, and the preservation of elements of national and ethnic characteristics and ethno-cultural identity can create conditions for stability of a multi-ethnic and multi-confessional society. Intercultural dialogue should be an integral part of positive processes of intercultural communication and contingence of Nations.

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ACUTE VIRAL HEPATITIS A, B, C, D AND SOME ASPECTS OF THE CHRONIZATION OF VIRAL HEPATOTROPIC INFECTION

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The resume. *The acute viral hepatitis (AVH), caused by HAV and HBV, is one of the most widespread diseases over the world. In the Astrakhan region among chronic hepatitis (CH) and a liver cirrhosis (LC) patients more than 27,2 % of patients had the episode of icteric AVH-HAV 10-30 years prior to development of chronic liver disease. It allows to consider the formerly transferred AVH as the additional risk factor for the development of the LC and CH. The remote outcomes after AVH had shown the presence of evident recovering at 63,6 % of patients and appearing of CH or LC after 10-30 years at 36,4 % of patients.*

Keywords*: acute viral hepatitis (AVH), chronic hepatitis (CH), liver cirrhosis (LC), HAV, HBV, HCV, HDV.*

Actuality

The acute viral hepatitis (AVH), caused by HAV and HBV, is one of the most widespread diseases over the world. Among healthy Germans the antibodies (Ab) to HAV of class IgG were detected in 70 % (1). In the Astrakhan region the inspection of 42 volunteers had shown positivity for Ab to HAV class IgG in 71,4 % of all tests (2). In the Asian and African countries the prevalence of the above-mentioned Ab to HAV is up to 100 % (3). It is the evidence that the prevailing part of healthy persons had the former contact with HAV, usually in the form of asymptomatic or fable infection at young age (4). By the WHO data, the number of the persons having some markers of HBV, exeeds 2 billions over the world (5). The number of HBV carriers is not less than 300 million of persons, and HCV markers is about 200 million. (6). These data specify the actuality of the problem of viral hepatitis as the universal problem or the Public Health.

Materials and methods

The clinical investigation of 114 LC patients with the presence or absence of AVH anamnestically was performed. And in 39 persons with

AVH, selected in a random way, the state of health was assessed in the period of 10-30 years after the disease was diagnosed. All the patients were being observed for the period from 1 to 15 years. The medical documentation for the period of 1978 on 2010 from Central Infectious Hospital of the Astrakhan Regional and the gastroenterology department of the 1-st Regional Clinical Hospital was studied during the investigation. The detection of HAV, HBV, HDV markers was performed with the use of ELISA and PCR methods (test-systems produced by “Vektor-best”). The diagnostics of the acute and chronic hepatitis and LC was carried out according to the National Russian Standards.

Results and discussion

From 114 LC patients 31 ones had the evident information of the transferred icteric AVH, of A, B, C, D or neither A, nor B- the ancient equivalent for C- hepatitis. At 47 patients there was the exact data about the absence of AVH in the anamnesis. At 37 patients the data about transferred AVH were missed (no medical documentation and they answered "I do not remember" if they were asked). Thus, not less than 27,2 % of LC patients had previously AVH as the classical, icteric form long before the development of chronic liver disease. And 32,5% of the patients could have the AVH in the infancy as the inapparent form.

It is the extremely difficult problem to evaluate the etiological structure of AVH, according to the anamnesis data, as many patients had not authentic medical documentation, in particular if the illness took place in infancy, and there were also limited diagnostic possibilities in 1970-80th years. Etiological structure of AVH at LC patients according to the anamnesis and medical documentation was the following: AVH without etiology specification - 61, 3 %, AVH - HAV - 22,6 %, AVH -HBV - 12,9, HCV- 3,2 %.

It is known that in some part of AVH patients afterwards CH or LC developed. The etiology of AVH of 39 patients included in the investigation, was the following: HAV - 29 cases (74,4 %), including AVH in patients – conductors of HBsAg (1 case) or after AVH - HBV with persistance of HBsAg (1 case). AVH - HBV - 10 cases (26,5 %). AVH - HCV - 1 case (2,6 %). After the 1year period of follow up HBV was detected in 4 patients among 29 ones with AVH - HAV, including (in 1 case) the combination with delta - virus (HDV). In the group HCV was revealed in 1 patient. Thus, after the AVH of HBV origin, the markers of HBV were found in 17,24 % of patients within one year, as well as HCV, HDV with higher potential for the chronisity. The reasons of “no-detection” of HBV, HCV, HDV at the first investigation of AVH patients in the hospital were multiple. Some part of the patients was surveyed before the year of 1994, when HCV markers were

not regularly detected in the Astrakhan region. The investigation of HDV was carried out selectively among the patients for the scientific screening research purposes and did not cover all the AVH – patients. The viruses of HBV and HCV could penetrate into the patient`s organism later. At last, the interference of viruses is possible in case of the mixt – infections, when viral markers could be at any stage of illness almost not detected even by means of the modern methods.

Among the 39 patients who had had the AVH, 25 patients afterwards had the favorable currency of the disease without any complications and negative consequenses. After the first hospitalization, all the patients were observed for 1 year as out-patients and were excluded from the follow up. 14 patients (35,9 %) were observed for a longer period because of prolonged reconvalescence. The remote outcomes after AVH - HBV were the following: recovering in usual terms - 65,4 %, prolonged reconvalescence-15,4 % (4 patients) with preservation of changed laboratory - instrumental data over 1 year after disease (the increased levels of alanine aminotransferase-ALT, aspartate aminotransferase-AST, bilirubin, apparition of hepatomegaly); transformation in the CH of HBV and HCV etiology – in 15,4 % and the LC – in 3,8 % of cases. It is a well-known fact that AVH-HAV do not become chronic. Unexpectedly we have found a considerable frequent evidence of CH and the LC, caused by viruses HBV and HCV, in the remote period after AVH. There could be 2 explanations for this phenomenon. The first was the opportunity that in some cases the coinfection of viruses HBV and HCV could take place, not detected by the routine methods. It could be promoted by the mechanisms of the viral interference in case of mixt- infection, making the diagnostics more complicating. Secondly, the penetration of the hepatotropic viruses in the patient`s organism may occur later. At last, it is not excluded that if the person had been affected by the "harmless" AVH, the probability of development of the CH and even the LC afterwards is higher, than at the person, who never was affected by the HAV- AVH. The virus may reveal the genetic predisposition for the hepatotropic viral infection, independently caused by HAV, HBV or HCV, penetrating into the patient`s organism.

The long-term follow up after AVH – HBV had shown the evident recovering at 63,6 % of patients and the origination of CH or LC caused by HBV after 10-30 years at 36,4 % of patients. The cause of high frequency of CH or LC may be the high prevalence of the HDV in the Astrakhan region, that favours to the severe current of AVH - HBV and its transformation in CH and LC, with extremely high rate of progressing. It is probably that a part of patients had the coinfection by the HBV, HCV, HDV, not detected in all

cases, even after repeated investigations, including PCR testings.

Conclusions

The presence of AVH - HAV in the anamnesis of approximately ¼ part of the LC patients gives us the opportunity to assume that that former AVH - HAV may be an independent risk factor of LC and CH development of viral etiology in future.

In the temporally long lasting period high levels of revealing of CH and LC were found out in the patients who had AVH - HBV tearlier, that demands the special attention to the given category of patients, with their obligatory testing for markers of HDV.

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CHANGES IN CIRCADIAN RHYTHMS OF CENTRAL AND PERIPHERAL HEMODYNAMICS IN CHILDREN OVER SEVEN YEARS OF AGE WITH BURN TOXEMIA

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Abstract. *Combined trauma (carbon monoxide poisoning), burns of the upper respiratory tract significantly worsen the parameters of adaptive restructuring of hemodynamics, aggravating the condition of patients even with a 27% (p <0.05) less area than in group 1 with a depth of 3B degree, causing a tendency to hypodynamic type hemodynamics. The most vulnerable to hemodynamic indicator of the time of day for group 1 was the time at 17 o'clock, when a tendency to increase MBF due to an increase in TPVR was revealed. In groups 2 and 3, the round-the-clock negative correlation between the MBF and TPVR circadian rhythms mesors indicated a hyperdynamic type of hemodynamics regardless of the time of day. The severity and duration of displacements of the acrophase of the circadian rhythm MBF and TPVR in the period of burn toxemia were in direct proportion to the severity of burn toxemia.*

Keywords: *circadian rhythms, central and peripheral hemodynamics, children over seven years of age, burn toxemia*

Relevance. The loss of fluid on the first day can reach 2-4 liters in case of burns. Hypovolemia, which develops as a result of a decrease in the volume of circulating plasma (CPV), centralization of blood circulation are accompanied by a deterioration in blood flow in the terminal section of the vascular bed. A sharp increase in the tone of the sympathoadrenal system (SAS) leads to total vasoconstriction, an increase in blood viscosity,

aggregation of its formed elements, and impaired microcirculation. An increase in peripheral vascular resistance (PVR) leads to difficulty in returning blood to the heart, a decrease in cardiac output, myocardial hypoxia, a deterioration in the contractility of the heart, a decrease in minute blood flow (MBF), which further contributes to the disturbance of hemodynamics and microcirculation and, as a consequence, organ hypoxia. The authors (Datieva F.S., Dudieva L.Z., Tagaeva I.R. 2017) in patients with chronic burn toxemia revealed only single circadian rhythms, with a predominance of ultradian and infradian rhythms. Hemodynamic research data during the period of burn toxemia in children are very scarce. Intensive therapy during this period is the most specific and is an important determinant of the treatment outcome. In this regard, the relevance of the problem of studying central and peripheral hemodynamics during the period of toxemia of burn disease is obvious.

Purpose of the work. To study the dynamics of the circadian rhythm of systolic and diastolic blood pressure during burn toxemia in schoolchildren.

Material and research methods. The clinical material is presented by the data of hourly monitoring of the minute volume of blood flow (MBF), total peripheral vascular resistance (TPVR) in children admitted to the Republican Scientific Center for Emergency Medical Aid (RSCEMA) in connection with thermal burns at the age from 7.1 to 18 years. The indicators of the circadian rhythm MBF and TPVR were studied in 26 children aged 7.1-18 years with severe burns during toxemia. The main feature that determined the division into groups was the duration of intensive care in the conditions of the intensive care unit (ICU), due to the severity of the burn disease. In group 1, the monitoring data of the studied parameters were considered in 12 children (up to 10 days on average 7.3±1.1), in group 2 in 7 (11-20 days on average 12.7±1.2), 3 in 7 children (more than 21 days 28.8±4.8).

Table 1
Patient characteristics

	Age in years	boys	girls	Days at the ICU	Burn area and depth		IF, units
					2-3A degree,%	3B degree,%	
Group 1	11,4±3,2	10	2	7,3±1,1	41±11	6,6±6	57±11
Group 2	15±2	6	1	12,7±1,1*	55,1±14,4	4,8±3,5	86,3±15,7*
Group 3	9,7±1,5≈	4	3	28,8±4,8*≈	25,8±11,4≈	22,5±6,6*≈	95,8±19,1*

*- the difference is significant relative to the research data in group 1
≈- the difference is significant relative to the indicator in group 2

As presented in tab. 1, the average age of children in group 3 was 9.7±1.5 years, it turned out to be significantly less than in group 2 by 6 years (15±2), and in group 1 by 2 years (11.4±3.2). In all groups, male children predominated, accounting for 83% in group 1, 85% in group 2, and 56% in group 3. The average duration of intensive therapy in ICU conditions in group 1 was 7.3±1.1 days, in group 2 it was 77% longer, in 3 - 4 times longer than in group 1. The increase in the duration of intensive therapy was in direct relationship with the IF index and an increase in the area of thermal skin damage with a depth of grade 3B. Thus, in children of group 3, a 3B degree of burn with an area of 22.5±6.6% was revealed, which is 3 times more than in children of group 1 and 5 times more than in group 2. The IF indicator turned out to be the largest in group 3, amounting to 95.8±19.1 units, 9 units less in group 2, significantly less in group 1 by 38 units ($p<0.05$). The absence of a direct dependence of the IF change on the area of the lesion in group 2 is due to the fact that in 4 children the aggravation of the condition was caused by combined trauma - in 1, carbon monoxide poisoning, in 3 - burns of the upper respiratory tract.

Results of the study.

On the first day of burn disease, the MBF and TPVR indices differed depending on the severity of the condition upon admission. Thus, in group 1, the mesor of the circadian rhythm MBF was 4.2±0.3 l/min, in group 2, a decrease to 2.5±0.2 l/min was found, in group 3, a significantly increased to 6.0±0,6 l/min. was found. At the same time, the TPVR circadian rhythm mesor in groups 1 and 3 did not differ from the normative values (tab. 2), however, in group 2, there was a significant increase in the TPVR circadian rhythm mesor up to 1256±83 l/min dyn.s.cm^{-5}m.

Table 2.
Dynamics of MBF and TPVR circadian rhythms mesors in burn toxemia in schoolchildren

	Minute blood circulation, l/min			Total peripheral vascular resistance, l/min dyn.s.cm^{-5}m		
days	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
1	4,2±0,3	2,5±0,2*	6,0±0,6*‴	980±35	1256±83*	889±72
2	4,2±0,2	2,8±0,1*	5,9±0,4*‴	1029±28	1159±92	807±41
3	4,1±0,1	2,7±0,2*	5,5±0,3*‴	993±42	1217±124*	896±52
4	3,9±0,2	2,7±0,1*	5,3±0,4*‴	1011±45	1158±70	956±69
5	4,0±0,2	2,9±0,1*	5,5±0,3*‴	961±29	1063±64	878±49
6	4,4±0,2	2,9±0,3*	5,6±0,3*‴	970±45	1104±108	881±29
7	3,8±0,3	3,2±0,1*	5,6±0,3*‴	942±41	979±44	852±35

8	3,4±0,4	3,0±0,2	5,7±0,5*‴	889±50	1041±55	861±53
9		3,5±0,2	5,0±0,2‴		893±58	1023±157
10		3,6±0,4	5,4±0,2‴		921±148	914±34
11		3,3±0,3	5,9±0,4‴		1016±110	822±70‴
12		2,3±0,3	5,2±0,2‴		1280±139	913±36‴
13			5,7±0,4			854±40
14			6,6±0,4			793±43
15			6,3±0,4			834±41
16			6,4±0,4			807±43
17			5,6±0,4			953±78
18			5,8±0,4			947±90
19			6,6±0,6			811±61
20			6,3±0,5			829±74
21			6,2±0,4			818±63
22			5,9±0,5			864±77
23			5,7±0,7			915±115
24			5,3±0,8			1046±162
25			5,7±1,4			1065±234

*- reliable relative to the indicator in group 1

‴- reliable relative to the indicator in group 2

Table 2.

Dynamics of MBF and TPVR circadian rhythms mesors in burn toxemia in schoolchildren

	Minute blood circulation, l/min			Total peripheral vascular resistance, l/min dyn.s.cm^{-5}m		
days	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
1	4,2±0,3	2,5±0,2*	6,0±0,6*‴	980±35	1256±83*	889±72
2	4,2±0,2	2,8±0,1*	5,9±0,4*‴	1029±28	1159±92	807±41
3	4,1±0,1	2,7±0,2*	5,5±0,3*‴	993±42	1217±124*	896±52
4	3,9±0,2	2,7±0,1*	5,3±0,4*‴	1011±45	1158±70	956±69
5	4,0±0,2	2,9±0,1*	5,5±0,3*‴	961±29	1063±64	878±49
6	4,4±0,2	2,9±0,3*	5,6±0,3*‴	970±45	1104±108	881±29
7	3,8±0,3	3,2±0,1*	5,6±0,3*‴	942±41	979±44	852±35
8	3,4±0,4	3,0±0,2	5,7±0,5*‴	889±50	1041±55	861±53
9		3,5±0,2	5,0±0,2‴		893±58	1023±157
10		3,6±0,4	5,4±0,2‴		921±148	914±34
11		3,3±0,3	5,9±0,4‴		1016±110	822±70‴
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24			5,3±0,8			1046±162
25			5,7±1,4			1065±234

*- reliable relative to the indicator in group 1

‴- reliable relative to the indicator in group 2

As shown in tab. 2, the MBF circadian rhythm mesor in children in group 2 was significantly less than in groups 1 (by 25%, $p < 0.05$) and 3 (by 48%, $p < 0.05$), during the first seven days of toxemia. The indicator of the mesor of the circadian rhythm TPVR on the first day in children of group 2 was increased by 29% ($p < 0.05$) relative to the indicator in group 1 and by 41% ($p < 0.05$) higher than in group 3. That is, the most unfavorable indicators - a tendency towards a decrease in MBF and an increase in TPVR - appeared in the patients of group 2 already on the first day. Differences between central and peripheral hemodynamics in group 2 with a tendency to develop a hypodynamic type of hemodynamics persisted throughout the entire period of burn toxemia. The revealed differences in the central and peripheral hemodynamics of group 2 from groups 1 and 3 were due to the fact that in 4 children the aggravation of the condition was caused by combined trauma - in 1 (carbon monoxide poisoning), in 3 - a burn of the upper respiratory tract and persisted throughout the entire period of burn toxemia. Thus, combined trauma (carbon monoxide poisoning), burns of the upper respiratory tract significantly worsened the parameters of adaptive restructuring of hemodynamics, aggravating the condition of patients even with a 27% ($p < 0.05$) less area than in group 1 with a depth of 3B degree, causing a tendency to a hypodynamic type of hemodynamics.

Dynamics of the mesor of the circadian rhythm MBF in burn toxemia in children over 7 years old, l/min

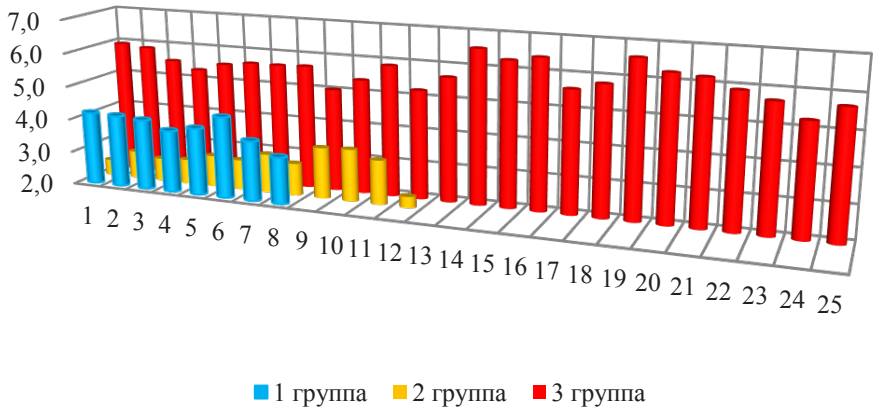

Fig.1

The latter is most likely due to a relatively more pronounced oxygen deficiency, energy-deficient state of the myocardium in children with combined injury and airway burns, which significantly reduce the adaptive capabilities of the cardiovascular system as a whole in severe burn injury.

The dynamics of the mesor of the MBF circadian rhythm in burn toxemia in children over 7 years of age (fig. 1) was a wave-like changes in the mesor of the MBF circadian rhythm. The highest values of the mesor of the circadian rhythm MBF in group 3 were associated with the compensatory orientation of the hyperdynamic type of hemodynamics, which made it possible to provide significantly increased tissue needs for oxygen and energy substrates. The confirmation is the correspondingly more reduced indicators of the mesor of the circadian rhythm TPVR (fig. 2) throughout the entire period of toxemia in children of group 3.

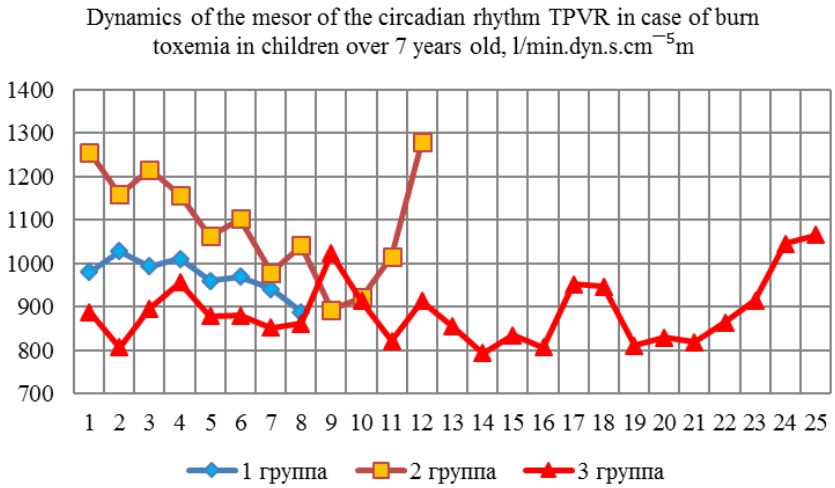

Fig.2

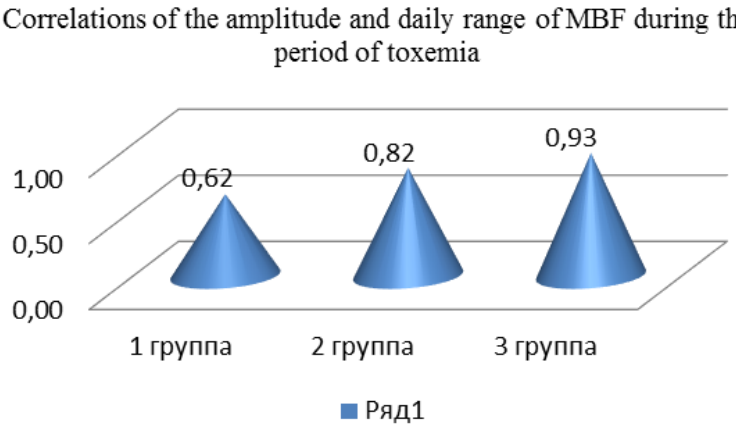

Fig.3

Remarkable is the direct correlation dependence of the MBF amplitude on the daily range of the MBF circadian rhythm; the strongest direct relationship was found in children of group 3 (fig. 3).

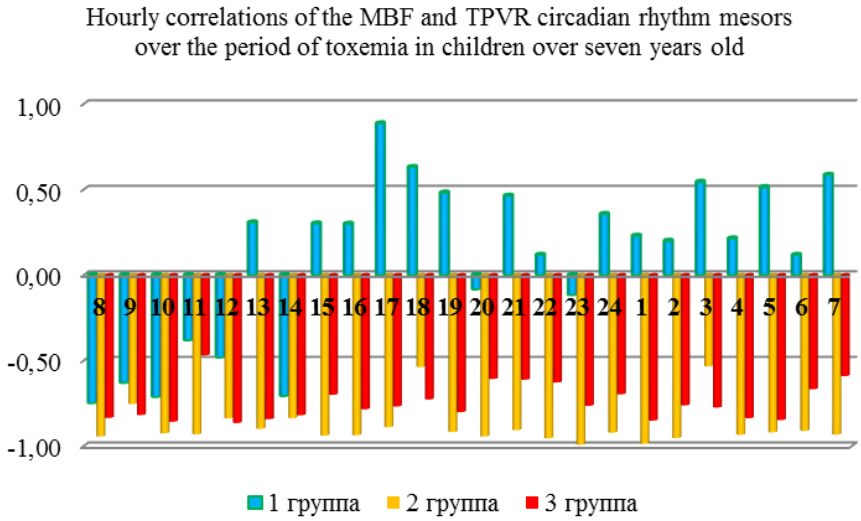

Fig.4

The search for the time of day most vulnerable to hemodynamics revealed some differences depending on the severity of the burn injury. So, in groups 2 and 3, the inverse strong correlation dependence between (fig. 4) the mesor of the circadian rhythms MBF and TPVR was constant, slightly weakening in group 3 at 11 (-0.47), 20 (-0.61) hours, and 7 (-0.59) a.m. While in group 2, the negative correlation between the circadian rhythm mesors of MBF and TPVR was stronger, weakened somewhat at 18 hours (-0.54) and at 3 hours (-0.53) at night. A significant difference was found in group 1, when a moderate negative correlation was found in the morning (8-12 hours) (from -0.75 to -0.48). At 17 o'clock, a reliably expressed direct correlation was revealed, which indicated an increase in MBF in connection with an increase in TPVR (+0.89) in group 1.

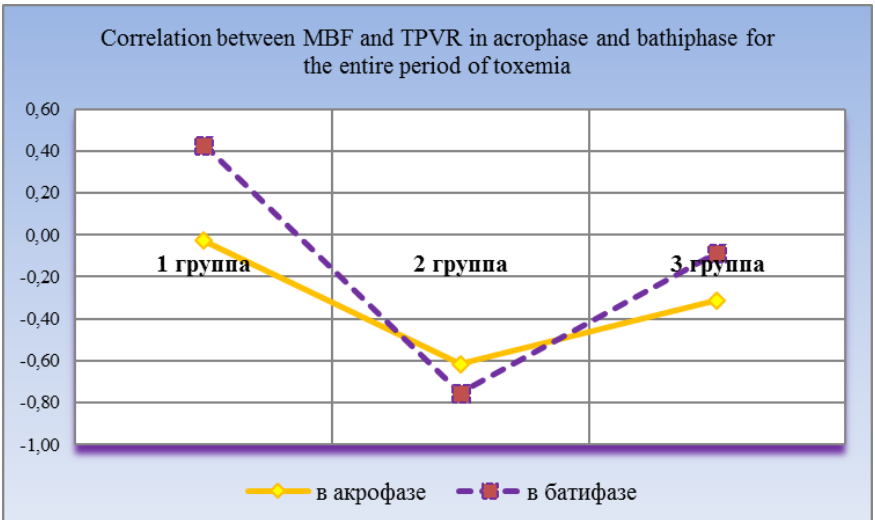

Fig.5

Over the entire period of toxemia, only in group 2 a significant inverse correlation was found between the indicators of the circadian rhythm MBF and TPVR (-0.76) in bathiphase (fig. 5).

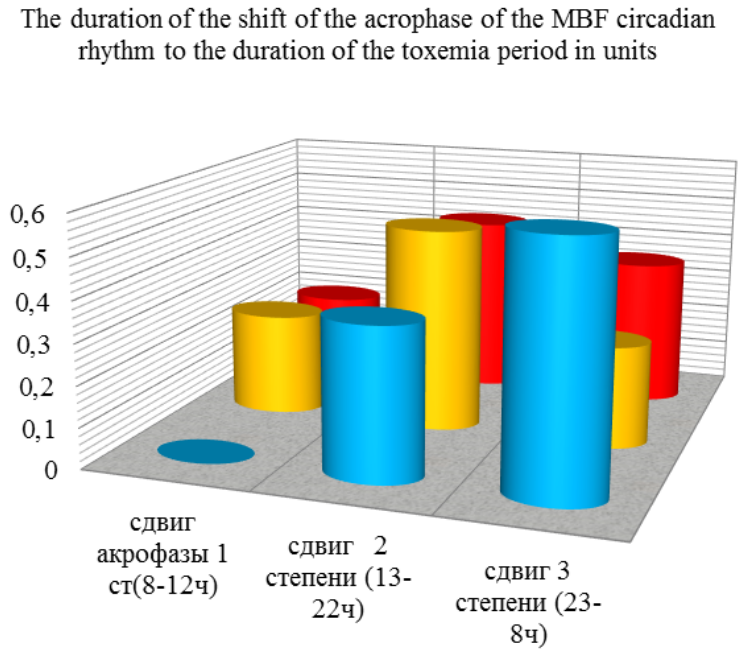

Fig.6

The longest (63% of the toxemia time) shift of the MBF circadian rhythm acrophase peak to night hours (23-8 hours) was revealed in injured children of group 1, the predominance of the duration of a moderate shift (by the 13-22 hour range) of the MBF acrophase peak (50% and 44 %) turned out to be in groups 2 and 3 (fig. 6).

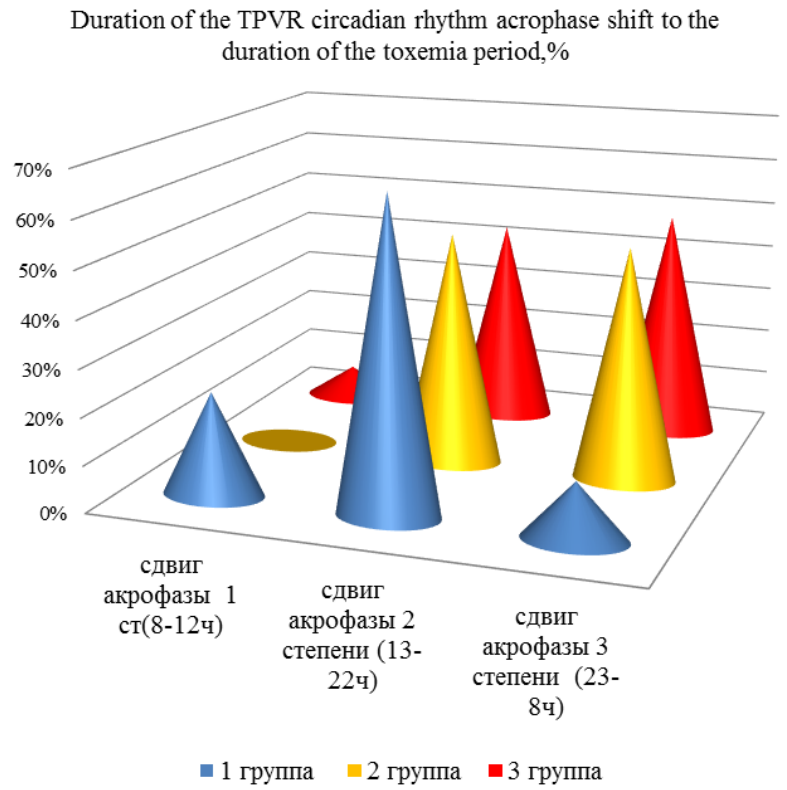

Fig.7

The longest duration of the displaced acrophase of the circadian rhythm TPVR within the light part of the day (moderate shift) was 66% in group 1, 50% in group 2, and 50% in group 3. The longest duration of the inversion was revealed for 49% in group 2, and 50% in group 3. Thus, the severity and duration of displacements of the acrophase of the circadian rhythm TPVR in the period of burn toxemia was in direct proportion to the severity of burn toxemia.

Conclusions. Combined trauma (carbon monoxide poisoning), burns of the upper respiratory tract significantly worsen the parameters of adaptive restructuring of hemodynamics, aggravating the condition of patients even with a 27% ($p < 0.05$) less area than in group 1 with a depth of 3B degree, causing a tendency to hypodynamic type hemodynamics. The most

vulnerable to hemodynamic indicator of the time of day for group 1 was the time at 17 o'clock, when a tendency to increase MBF due to an increase in TPVR was revealed. In groups 2 and 3, the round-the-clock negative correlation between the MBF and TPVR circadian rhythms mesors indicated a hyperdynamic type of hemodynamics regardless of the time of day.

The severity and duration of displacements of the acrophase of the circadian rhythm MBF and TPVR during the period of burn toxemia were in direct proportion to the severity of burn toxemia.

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FUNDAMENTALS OF PERSONALIZED DIET THERAPY FOR OBESITY AND CARBOHYDRATE METABOLISM DISORDERS

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Abstract. *Lack of a number of micronutrients, deficiency of dietary fiber, excess calorie content in home diets are the main nutritional disorders of modern humans, which significantly increase the risk of obesity and type 2 diabetes mellitus. In the treatment of patients with obesity and impaired carbohydrate metabolism, diet therapy plays an important role. The review provides data that must be taken into account when creating a balanced diet for patients with obesity and type 2 diabetes mellitus in order to achieve compensation for metabolic disorders and reduce the risk of developing vascular complications.*

Keywords: *nutrition, obesity, diabetes*

The rapid increase in obesity is currently associated not only with a genetic predisposition, but also with low physical activity and malnutrition [1]. A lack of a number of micronutrients, a deficiency of dietary fiber, and excess calorie content in home diets are the main nutritional disorders in modern humans, which significantly increase the risk of obesity and type 2 diabetes mellitus [2]. In the treatment of patients with obesity and impaired carbohydrate metabolism, diet therapy plays an important role [3-4]. According to the recommendations of the American Diabetes Association, the main objectives of diet therapy in type 2 diabetes mellitus are: achievement of compensation for metabolic disorders, normalization of the lipid spectrum and blood pressure parameters, and a decrease in the risk of developing vascular complications [5]. When building a balanced dietary diet, it is necessary to control not only the calorie content, quantitative and qualitative composition of protein, fat, carbohydrates, but also the adequate content of micronutrients that meet the needs of each individual patient [6]. The main principle of therapeutic nutrition for patients with type 2 diabetes mellitus is to limit the caloric content of the diet, the degree

of reduction of which is determined individually, depending on the age of patients, their physical activity, the severity of obesity, the presence of vascular complications and concomitant diseases [6]. A low-calorie diet promotes weight loss, resulting in improved insulin sensitivity [7]. Even a moderate reduction in body weight (5–10% of the initial body weight) in patients with type 2 diabetes mellitus is not only accompanied by a decrease in the level of glycemia and glycated hemoglobin, but also helps to reduce the risk of developing late vascular complications [8]. It has been established that the restriction of the caloric content of the diet should not exceed 40% (500–1000 kcal) of the physiological need for energy.

When building a dietary ration, great attention should be paid to its carbohydrate part, since in type 2 diabetes mellitus, carbohydrate metabolism is disturbed first of all. Currently, the recommended amount of carbohydrates is 50-60% of the total caloric intake with restriction or complete exclusion from the diet of easily digestible refined carbohydrates. Thus, a sharp increase in the level of blood glucose is observed after the consumption of glucose or sucrose, while fructose, which does not have a stimulating effect on the secretion of β-cells, leads to a smaller increase in postprandial glycemia [9]. However, in a number of studies, the development of insulin resistance was noted with excessive consumption of fructose, associated with a decrease in insulin-stimulated autophosphorylation and an increase in triglyceride secretion [10]. Instead of refined sugars, sugar substitutes (xylitol, sorbitol, aspartame, etc.) are widely used in diet therapy of obesity and type 2 diabetes mellitus, which cause a minimal increase in postprandial glycemia [11]. However, when prescribing these products, one should take into account their energy value, since the caloric content of xylitol and sorbitol does not differ significantly from the energy value of simple sugars. A prerequisite for a balanced diet for obesity and type 2 diabetes mellitus is a relatively even distribution of carbohydrates throughout the day, which helps to reduce insulin resistance. It has been established that insulin resistance and the level of postprandial glycemia are influenced not only by the amount of consumed carbohydrates, but also by their qualitative composition [12]. The ability of various foods to increase postprandial glycemic levels is characterized by their glycemic index. A number of studies have shown that diets with a low glycemic index contribute to the improvement of metabolic disorders, a decrease in the lipid spectrum of blood serum and reduction of body weight in patients with type 2 diabetes mellitus [13]. In order to increase the effectiveness of diet therapy, patients with type 2 diabetes mellitus are recommended to use carbohydrate-containing foods with a low glycemic index [13-14].

To improve glycemic control, the diet of type 2 diabetes mellitus and obesity patients is enriched with soluble and insoluble dietary fiber by the inclusion in the diet of natural plant products (cereals, grain, vegetables, legumes, fruits, berries) and additional sources of dietary fiber (wheat, rye, oat bran, pectin, etc.) [15]. There are works that have shown the effect of soluble dietary fiber on improving tissue sensitivity to insulin, improving the parameters of carbohydrate and lipid metabolism in patients with obesity and type 2 diabetes mellitus [16]. In the diet of patients with obesity and type 2 diabetes mellitus, the content of dietary fiber should be 25-50 g/day [17]. However, it is necessary to take into account the fact that with excessive consumption of soluble dietary fiber (more than 60 g/day), there is a decrease in the absorption of essential micronutrients - calcium, magnesium, iron, copper, zinc, water-soluble vitamins.

In the diet of patients with obesity and type 2 diabetes mellitus, the optimal protein content is 15–20% of the total caloric content of the diet, with an equal ratio of animal and plant proteins [17]. A number of studies have shown that the use of a high-protein hypocaloric diet contributes to a more significant decrease in the level of glycemia, triglycerides, and body fat compared to standard hypocaloric diets [18]. However, there are studies that have not established a positive effect from high-protein diets [19]. In the presence of nephropathy, a low-protein diet is recommended for patients with type 2 diabetes mellitus, which helps to reduce proteinuria and slow the progression of kidney damage in this group of patients [20]. Of particular interest are works devoted to the role of a plant protein affecting risk factors for vascular complications in type 2 diabetes mellitus [20]. It was found that replacing animal protein with soy protein leads to a decrease in the level of LDL in patients with cardiovascular diseases, and in patients with type 2 diabetes mellitus - to a decrease in the level of glucose and triglycerides of blood serum.

It is generally accepted that the modification of the fatty part of the diet plays an important role in correcting lipid metabolism disorders and reducing the risk of cardiovascular complications in obesity and type 2 diabetes. It has been proven that excessive consumption of fat, especially saturated fat and trans fatty acid isomers, is associated with the development of insulin resistance [21]. In this regard, the total fat content in the diet of patients with type 2 diabetes mellitus should not exceed 30% of the daily caloric intake, while the amount of saturated fat decreases to 7-10% of the total caloric value, cholesterol to 200-300 mg/day, trans- isomers of fatty acids less than 1% of the total calories. The ratio between saturated, mono- and polyunsaturated fatty acids (EFA: MUFA: PUFA) is considered optimal if

it is 1:1:1. The amount of PEFA, which have a pronounced hypolipidemic and hypotensive effect, in the diet of patients with type 2 diabetes mellitus increases to 10% of the total caloric content [22]. It has been found that elevated levels of PEFA omega-3 in skeletal muscle are associated with improved insulin sensitivity [23]. To reduce the risk of developing cardiovascular complications in patients with obesity and type 2 diabetes mellitus, it is recommended that PEFA omega-3 be included in the diet in an amount of at least 1% of the total calorie intake.

When constructing therapeutic diets, it is important to ensure an adequate content of vitamins and minerals in the diet [17]. It is known that type 2 diabetes mellitus is associated with a deficiency of a number of micronutrients, accompanied by impaired glucose utilization processes, impaired insulin secretion, and activation of free-radical oxidation of lipids [24]. It should be noted that the deficiency in this group of patients with vitamins such as B6, B12 affects DNA methylation and increases the risk of developing cardiovascular diseases. The use of B vitamins in patients with type 2 diabetes mellitus will help prevent the development of cardiovascular complications in this category of patients. It should also be borne in mind that due to the polymorphism of genes encoding the corresponding enzymes, individual requirements for certain micronutrients can vary significantly. For example, due to the T677C mutation of the MTHFR gene, the activity of the enzyme methylenetetrahydrofolate reductase, which reduces folic acid to its active form, decreases, as a result of which such patients need additional folic acid administration. In this regard, the elimination of micronutrient deficiencies should be considered as the most important part of the diet therapy of type 2 diabetes mellitus in order to prevent its many complications. However, there is concern about the regular use of vitamin-mineral complexes. Analysis of studies carried out at the FSBI "SRI of Nutrition RAMS" did not reveal any adverse effects with prolonged intake of vitamin-mineral complexes [6]. In addition, it should be noted that it is practically impossible to provide patients with all the necessary vitamins and minerals through a balanced diet in real conditions, since the bioavailability of micronutrients from various foods ranges from 10% to 80% of their total content [2]. Moreover, it is necessary to take into account the fact that for an optimal supply of vitamins and minerals, the consumption of large portions of food is required, which will inevitably lead to excess calorie intake. Against the background of a hypocaloric diet, there is a decrease in the provision of micronutrients for patients with obesity and type 2 diabetes mellitus [6], which can be prevented by regular use of vitamin-mineral complexes, additionally enriched with missing micronutrients in

doses corresponding to the physiological needs of the body [25]. The use of vitamin and mineral complexes should be considered as an integral part of personalized diet therapy for obesity and type 2 diabetes mellitus, which helps to reduce the risk of developing vascular complications in conditions of deficiency of vitamins and minerals [26-28].

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CONSTITUTIONAL FEATURES OF THE HEAD AND NECK AND RELATED ANATOMICAL VARIABILITY OF THE ORGANS

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Abstract. *The article provides an overview of the literature data on the study of the constitutional types of the head and neck, their anthropometric points, as well as the anatomical variability of the neck organs depending on the characteristics of the human constitution. The factors influencing the shape of the skull and neck are considered. Craniometric points of the skull and approaches to assessing morphometric parameters of the neck are described. The features of different constitutional types of the head and neck are discussed. The anatomical variants of the arrangement of organs and vessels of the neck were analyzed in accordance with its shape. The concept of the anatomical variability of organs depending on the type of constitution is relevant for surgical practice and helps prevent a number of intraoperative complications caused by individual variability in the location of organs.*

Keywords: *constitution, head shape, neck shape, neck organs, anatomical variability*

To date, the relationship between the anatomical variability of human organs and its constitutional features has been proven. The shape of the head and neck is distinguished by pronounced individual variations. It is known that the shape of the head, the type of neck and the constitution of a person are interrelated. The purpose of this work was to analyze domestic and foreign works devoted to the study of the constitutional types of the head and neck, their anthropometric points, as well as the anatomical variability of the neck organs depending on the characteristics of the human constitution.

The shape and size of the skull is influenced by gender, age, nationality, ethnicity [1]. In addition, Hummel P. et Fortado D. showed that the formation of the head shape is influenced by the position of newborns during sleep [2]. As the authors note, changes in the position of infants during sleep, in particular sleeping in the supine position, cause an increase in the frequency of positional plagiocephaly and torticollis. These data are consistent with the results of the work of Pomatto J.K. et al., who demonstrated that infant plagiocephaly is characterized not only by asymmetry, but also by an increased width of the skull [3]. In general, after the end of puberty, the growth of the skeleton, including the skull, stops. However, according to some reports, in childhood, the shape of the skull is not formed completely, but can change during life. In this regard, the results of the work of AV Pavlov, who carried out measurements of the head in people in different age groups, are interesting [4]. It turned out that with age, there is a significant increase in the transverse size of the skull and an increase in the number of mesocephals and brachycephals among men and women.

V.N. Shevkunenko and A.M. Geselevich for the first time identified two main forms of an individual constitution - dolichomorphic and brachymorphic, between which there is a large number of intermediate forms [5]. Subsequently, scientists proved the connection between the physique of a person and the anatomy of his organs and systems, and, thus, V.N. Shevkunenko became the founder of typical anatomy [6]. The scientist has convincingly demonstrated that the extreme values of the anthropometric parameters of a person tend to destabilize the compensatory mechanisms of the body and develop the disease.

The spatial relationships of the skull are well studied. For craniometric studies, a craniostereobasiometer is used, which allows you to calculate the distance from the standard points of the skull to each of the three planes [7]. To measure the skull, standard craniometric points are used [8]: Glabella, Metopion, Bregma, Lambda, Inion, Basion, Gonial, Occiput, Vertex, Nasion.

To assess the shape of the skull, its longitudinal, transverse and height dimensions are determined. The longitudinal size or length of the skull is calculated from the most prominent point of the forehead to the same point of the occiput; the transverse dimension (width) is set between the most prominent points of the lateral surface of the skull; the height of the skull is measured from the middle of the auricle to the top of the skull. Based on the length and width, the Cephalic Index (C.I.) is calculated - the ratio of the width of the skull to its length.

For the first time the term "cephalic index" was used in the 40s of the

XIX century by the Swedish anatomist Anders Adolf Retzius. According to the results of calculating the cephalal index, the dolichocephalic, brachycephalic and mesocephalic head shapes are distinguished. Dolichocephalic head shape is characterized by the ratio of the maximum width and length of the head from 75.9% or less ("narrow-headedness"); for brachycephalics, the ratio of the maximum values of the width and length of the skull is 81% or more ("broad-headedness"); mesocephals have average ratios of the maximum width to the maximum length of the skull - from 76% to 80.9% [9]. Correlations between craniometric and anthropometric parameters were revealed. In the study of Shchankin A.A. and Kosheleva O.A. the relationship between the transverse diameter of the head and the constitutional type of age-related evolution has been established [10].

Today, in surgical practice, interventions on the organs of the neck are widely performed, but the proportion of intraoperative complications remains quite high. This is largely due to the anatomical variability of organs, vascular and nerve formations in the neck region [11]. Therefore, the study of the variant anatomy of the neck organs is an urgent problem of modern medicine, and the data obtained from anthropometric measurements of the neck (columetry) are of great practical importance [12].

At the same time, the accuracy of determining the morphorometric parameters of the neck depends on which bony landmarks are used, on the degree of neck mobility, on the position of the head and upper limbs. Even more pronounced difficulties in neck anthropometry are noted in the case of a patient with traumatic edema and changes in the configuration of the neck.

To date, the literature describes several approaches to determining the constitutional type of the neck [13]. So, the shape of the lateral surface of the neck in the form of a truncated cone with a base up or down or a cylindrical shape determines the corresponding type of neck. Depending on the length, the neck can be normal, long or short. The horizontal and vertical elliptical neck, as well as the round neck, are determined by the shape of the horizontal section of the neck. According to the severity of muscle and adipose tissue, the neck is classified as thin, full and medium.

The most important anthropometric indicators of the neck are its length and thickness. However, standard points for assessing neck anatomy have not been established. Most often, morphometric parameters are measured on the anterior surface of the neck: neck length in front and width at different measurement levels. On the side of the neck, its oblique dimensions are determined from the angle of the lower jaw and from the mastoid process to the center of the jugular notch of the sternum. On the back of

the neck, its length is studied as the distance from the superior occipital protuberance to the 7th cervical vertebra.

V.N. Shevkunenko proposed to assess the constitutional type of the neck on the basis of the index method of assessment with the determination of the neck indicator - the ratio of the neck base circumference to the neck height. At the same time, a short and wide neck is typical for a brachymorphic type of constitution, a dolichomorphic physique is characterized by a long and narrow neck [14].

Currently, a large number of studies are devoted to studying the relationship between neck thickness and body mass index. For example, Patnaik L. et al. showed a positive correlation between neck circumference and body mass index in adolescents [15]. According to meta-analysis by KrollC. et al. neck circumference is an accurate parameter for assessing overweight and obesity in people of different ages and can be used in routine clinical practice or epidemiological studies [16]. The study of Anothaisintawee T. et al. Is of great practical interest. [17], who studied the correlation between neck circumference and waist circumference in 1534 patients with prediabetes. Neck circumference was measured from just below the laryngeal prominence perpendicular to the long axis of the neck. It was found that the neck circumference is reliably related to the waist circumference, both in women and in men. At the same time, the threshold values of the neck circumference for predicting central obesity were determined: ≥32 cm in women and ≥38 cm in men. In their work, the authors draw attention to the fact that the measurement of the waist circumference has significant variations and some limitations, while the neck circumference is a simple and reliable anthropometric instrument, therefore, it can be an alternative to measuring the waist circumference when screening for central obesity in persons with prediabetes.

It has been found that the shape of the neck can change with age. It is noticed that the variability of the neck length is due to the variable position of its lower border in individuals with different constitutions. Neck length is formed after the end of puberty, remains relatively stable in adulthood, and is shortened in geriatric patients [18]. Maleev Yu.V. et al. The body of the hyoid bone is considered the most informative anatomical landmark for studying the typical characteristics of the neck [12]. In their works, the authors distinguish a thin, thick and intermediate neck, and each of these types of neck is additionally divided into long, short and medium.

It has been established that the size of the neck has gender differences. Width, back length, sagittal size and neck circumference in men are higher than the corresponding parameters for women [19].

The neck is one of the most complex topographic and anatomical areas of the human body, where various options for the location of vascular formations are often found. In addition to arterial and venous vessels, vital organs such as the esophagus, larynx, pharynx, thyroid gland, as well as lymphatic ducts and nerve plexuses are located in the neck area. Therefore, when planning surgical interventions in this area in order to prevent serious intraoperative complications, it is important to take into account the individual topographic variability of vascular formations.

The constitutional differences in the location of the subclavian vein are described. People with a thin and long neck are characterized by a higher location of the subclavian vein in the interscalene space compared to people with a wide and short neck [20]. I.V. Kahn et al. studied the variant anatomy of the great vessels of the neck in men with different head shapes [21]. The authors demonstrated that with a brachycephalic head shape, the jugular veins are of the smallest length and largest caliber. At the same time, in dolichocephalic vessels, vessels with the greatest length and smallest diameter were revealed; mesocephalus had intermediate indicators of the length and diameter of the jugular veins. I.V. Kahn et al. determined that the ratio of the length and width of the carotid artery was inversely proportional - the increase in length was accompanied by a decrease in the diameter of the vessels and vice versa.

The thyroid gland is characterized by great anatomical variability, which, according to some authors, is the main reason for the development of intraoperative complications during surgical interventions in this area [22]. The literature describes the typical forms of the thyroid gland, depending on the constitutional characteristics of a person [22, 23]. The variability of the boundaries of the thyroid gland was determined depending on the length and width of the neck [24].

Thyroid arteries are distinguished by a wide variety of anatomical variants [25]. For example, the superior thyroid artery has three variants of location: it can be a bifurcation of the common, external or internal carotid artery [26]. The location of the parathyroid glands depends on the variant of the location of the thyroid gland [27]. Taking into account the variant anatomy of the parathyroid glands reduces the incidence of postoperative hypoparathyroidism caused by damage to the parathyroid glands during surgical interventions on the thyroid gland.

The relationship between anthropometric indicators of the neck and constitutional features of a person with the location of the pharynx, larynx and trachea has been established. For example, the length and volume of the pharynx are significantly larger in men than in women, and increase

with height [28]. If the neck is short and wide, then the pharynx in such people is wider and shorter in comparison with those with a long and narrow neck. The ascending pharyngeal artery with a long and narrow neck is characterized by a smaller caliber and is located at a lower angle to the midline compared to people with a short and wide neck. Newborn babies have a short and wide trachea, but as they grow older, the ratio of the length and thickness of the trachea changes, and in the adult state it is longer and narrower than in newborns [29].

Thus, the constitutional features of a person affect the anatomical location of the organs and vessels of the neck, which is important in real clinical practice. The results of anthropometric measurements of the patient complement the clinical examination, explain the individual characteristics of the symptoms of diseases, prevent the development of intraoperative complications during surgical interventions caused by individual anatomical variability of organs, contribute to the development of surgical approaches taking into account the modern patient-oriented approach. In addition, the measurement of neck circumference can be used in screening for overweight and obesity.

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REGIONAL SYSTEM OF MEDICAL CARE FOR VICTIMS WITH POLYTRAUMA

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Abstract. *The article discusses the organizational issues of the system of providing medical care to victims with polytrauma on the example of the Samara Oblast. On the basis of medical organizations of the Oblast, trauma centers of three levels have been created, routing and an algorithm for hospitalizing patients in trauma centers have been developed, depending on the place and severity of the injury.*

Keywords: *organization of medical care, polytrauma, trauma centers*

Samara Oblast is a large constituent entity of the Russian Federation with a population of almost 3.2 million people, located in the Volga Federal District in the middle reaches of the Volga River. The region has a high industrial, agricultural, scientific, cultural potential with a developed infrastructure, a network of roads, a high provision of residents with road transport, which, in turn, determines the needs of the population in providing specialized medical care in the field of "traumatology and orthopedics", including polytrauma.

On the territory of Samara Oblast, 36 trauma centers (trauma centers) provide specialized medical care to patients with polytrauma. Among them there are three trauma centers of the first (I) level, 11 - the second (II) and 22 trauma centers of the third (III) level.

We have developed the routing of victims with concomitant, multiple and isolated injuries, accompanied by shock, to trauma centers for emergency indications.

Level I trauma centers are deployed on the basis of large multidisciplinary hospitals traditionally dealing with the diagnosis and treatment of severe mechanical trauma. This is the state budgetary healthcare institution (SBHCE) "Samara Oblast Clinical Hospital named after V.D. Seredavin (SOCH)" (a regional trauma center was organized on the basis of it), SBHCE of the Samara Oblast (SO) Samara City Clinical Hospital № 1 named after N.I. Pirogov (SCCH) №1", SBHCE SO "Togliatti City Clinical Hospital №5 (TCCH №5)".

The zone of attachment to SOCH (Samara) is the territory of predominantly northern, eastern and central location: municipal rural areas of the Oblast (Alekseevsky, Bogatovsky, Borsky, Volzhsky, Elkhovsky, Isaklinsky, Klyavlinsky, Kinelsky, Krasnoyarsky, Koshkinsky, Neftegorsky, Pokhvistnevsky, Sergievsky, Shentalinsky); cities of the Oblast (Kinel, Neftegorsk, Otradny, Pokhvistnevo), as well as Oblast center areas - Samara (Krasnoglinsky, Kirovsky, Promyshlenniy).

SCCH № 1 (Samara) is attached to the Oblast zone which includes the territories of predominantly western, southern and central location: rural areas (Bezenchuksky, Volzhsky, Khvorostyansky); cities (Novokuibyshevsk, Chapayevsk); districts of Samara (Kuibyshevsky, Leninsky, Samara, Oktyabrsky).

TCCH № 5 (Tolyatti) has a zone of attachment of the western and north-western directions with rural areas (Stavropol, Syzransky, Shigonsky); cities (Zhigulevsk, Oktyabrsk, Syzran, Togliatti).

Level I trauma centers for the treatment of victims have been created on a functional basis to provide specialized, including high-tech, inpatient medical care to victims with concomitant, multiple and isolated injuries, including those accompanied by shock, their complications and consequences.

Level I trauma center provides:

- round-the-clock medical assistance to victims in accordance with paragraph 12 of the Procedure for rendering medical assistance to victims with concomitant, multiple and isolated injuries accompanied by shock
- evacuation of the injured "on oneself" with the use of resuscitation teams;
- advisory assistance to specialists of medical healthcare institutions located in the area of responsibility on the treatment of victims, including the introduction of new medical and diagnostic technologies into clinical practice.

At the level of the level I trauma center, coordination of the activities of the structural divisions of the health care institution in terms of organizing the provision of medical care to victims at all stages is ensured, interaction

with the level I-II trauma centers in the area of responsibility is carried out.

Level I trauma center based on the Samara Oblast Clinical Hospital named after V.D. Seredavina "is a regional trauma center and additionally carries out:

- organizational and methodological assistance to specialists of medical institutions of health care, regardless of the area of responsibility for providing assistance to victims of severe concomitant, multiple and isolated trauma, accompanied by shock;

- advisory assistance to specialists of medical institutions of health care, including those located in the area of responsibility, on the treatment of victims with concomitant, multiple and isolated injuries accompanied by shock, including the introduction of new medical and diagnostic technologies into clinical practice;

- maintaining statistical records and preparing reports on the provision of medical assistance to victims;

- analysis of the prevalence, structure, causes of injuries.

The regional trauma center coordinates the activities of the structural units of the hospital in terms of organizing the provision of medical care to victims at all stages, interacts with trauma centers at all levels, regardless of areas of responsibility.

Level II trauma centers are represented in Samara Oblast by large central district hospitals (CDH) in rural areas and city hospitals in urban districts. These medical organizations are entrusted with the functions of rendering assistance to victims with concomitant, multiple and isolated injuries accompanied by shock in stationary conditions.

Level II trauma centers are located on the basis of powerful medical organizations located, as a rule, in the cities of the Oblast, as well as in the three largest rural settlements - Kinel-Cherkassy, Krasny Yar, Sergievsk.

Level II trauma centers have been created on a functional basis in healthcare institutions that provide the entire volume of qualified medical care to victims in inpatient conditions.

Level II trauma center provides:

- round-the-clock medical assistance to victims in accordance with paragraph 11 of the Procedure for providing medical assistance to victims with concomitant, multiple and isolated injuries accompanied by shock;

- evacuation of the injured "on oneself" with the use of resuscitation teams;

- advisory assistance to specialists of health care institutions located in the area of responsibility.

The level II trauma center coordinates the activities of the structural

subdivisions of the healthcare institution in terms of organizing the provision of medical care to victims at all stages, interacts with the level III and I trauma centers in the area of responsibility.

Level III trauma centers in Samara Oblast are based primarily on the CDH of rural areas (Bezenchuksky, Bogatovsky, Bolsheglushitsky, Bolshechernigovsky, Borsky, Isaklinsky, Kamyshlinsky, Klyavlinsky, Koshkinsky, Krasnoarmeisky. Neftegorsky, Pestravsky, Privolsky. Stavropol-Vorshinsky. Shigonsky, 18 in total), while the areas of attachment of these trauma centers are the corresponding rural areas. The other four level III trauma centers are located in cities. Two trauma centers - in Samara on the basis of two outlying hospitals - SBHCE SO Samara City Hospital № 7 and SBHCE SO Samara City Hospital № 10, serving the population of Krasnoglinsky and Kuibyshevsky districts of Samara and Volzhsky district, respectively. Two more trauma centers are located in the cities of Zhigulevsk and Oktyabrsk on the basis of the corresponding city hospitals and serving the population of these cities.

Level III trauma centers have been created on a functional basis in healthcare institutions to ensure the organization and provision of emergency medical care to victims. At the same time, the level III trauma center carries out:

- provision of round-the-clock medical care to victims in accordance with paragraph 14 of the Procedure for rendering medical care to victims with concomitant, multiple and isolated injuries accompanied by shock;
- obligatory timely informing of specialists on duty at trauma centers of I or II levels to resolve the issue of transporting the victim to the above trauma centers;
- transportation of injured persons to trauma centers of I and II levels according to indications with carrying out the necessary amount of medical measures on the way.

The list of manipulations that the medical personnel of the level III trauma center must have: tracheal intubation, artificial ventilation of the lungs, defibrillation, chest compressions, puncture and catheterization of veins, conicotomy, intravenous and inhalation anesthesia, gastric intubation, intracardiac and intratracheal administration of medications, venesection blockade, transport immobilization, removal and decoding of ECG.

We have also developed an algorithm for hospitalization of victims with concomitant, multiple and isolated injuries accompanied by shock to trauma centers.

The algorithm assumes hospitalization in the trauma center of Samara Oblast, which is carried out in accordance with the areas of responsibility,

the severity of the injury and the condition of the victim.

The trauma center nearest to the place of injury is hospitalized:

- victims in serious condition, requiring immediate medical intervention, with a threat to the patient's life in the next hour or a forecast of the formation of irreversible pathological changes in the organs and systems of the victim in the next 3 hours;

- injured, admitted by "gravity", delivered by passing transport, and patients with injuries requiring a doctor's examination.

If it is impossible to provide effective medical care, the transfer and transportation of victims is carried out, taking into account the severity of their condition, to a higher-level trauma center by a resuscitation team of an ambulance by ambulance vehicles of class C.

Contraindications for transportation are conditions in which there is a threat of death of the victim during transportation: agonal state, hemodynamic instability, dislocation of the brain and signs of an increase in cerebral edema.

Taking into account the significant contribution of road traffic accidents to injuries of the population, including those with polytrauma, the areas of responsibility of medical institutions subordinate to the Ministry of Health of Samara Oblast, providing medical assistance to victims with concomitant, multiple and isolated injuries accompanied by shock, as well as institutions, providing ambulance, and emergency departments of institutions on highways in Samara Oblast.

The developed provisions on the system of medical care for victims with polytrauma were included in a number of provisions of the regulatory legal documents of the Ministry of Health of Samara Oblast, including on improving the organization of medical care for victims of road traffic accidents, including victims with multiple and isolated injuries accompanied by shock, on regional level.

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DISTRIBUTION AND DISINFECTION OF COVID-19

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Abstract. *A temporary model of the development of the epidemic in China and Russia is built. A general globalization equation for the development of epidemics is derived. The method for the destruction of the SARS-CoV-2 using the resonant extremely high-frequency electromagnetic field was investigated. The frequency of the high-frequency electromagnetic field for a generator is proposed to disinfection from COVID-19 of dry surfaces.*

Keywords: *metropolis, turnover, quarantine, multifactor, DNA, RNA, resonance, Ebola virus.*

Introduction

Data on the number of tested cases COVID-19 and died from the virus vary greatly due to 1) small coverage of the number tested, 2) incorrect diagnosis, which does not record the presence of coronavirus deaths from other causes, 3) the existence of many asymptomatic carriers. Data from Hopkins University and WHO differ significantly. At the same time, the COVID-19 pandemic is unique and has emerged for the first time. In addition, the spread of the epidemic depends on the climate, COVID-19 is destroyed by solar ultraviolet radiation, high temperatures are also unfavorable for it, so comparing different countries and parts of countries with different weather conditions is not quite correct. The analysis of the pandemic is complicated by the multiplicity of parameters and age-related morbidity.

To study the evolution of epidemics, SEI−SEIR models are used. age-related models are based on the Mckendrick-von Foerster population model. Depending on the properties of the disease, in differential equations sets of population groups different systems that describe the dynamics of infection spread are used. In SEI models, the total number of individuals in a population is divided into three classes: the number of susceptible individuals, the number of infected individuals who are not yet infectious, and the number of infected individuals who are capable of transmitting the

infection. In SEIR models, a class of individuals immune to the disease is added to the consideration. The difference between SI−SIR models and SEI−SEIR is that in the former, the class of people who are infected but are not yet infectious is removed from consideration. This is convenient when the incubation period of the pathogen can be neglected [1]. Models with age dependence of epidemics are also considered. In view of the uniqueness of the COVID-19 epidemic and the new opportunities for its spread, it is necessary to build a new mathematical model for it.

An important factor is that the virus is transmitted on items. For the treatment of hands, skin surfaces, household items when they are infected with SARS-CoV-2, 70% ethanol, 0.01% sodium hypochlorite and 1% chlorhexidine are used, these substances damage the capsid of the virus, and it cannot multiply. We also offer hand sanitizers based on 45% isopropanol, 30% n-propanol and 0.2% mesetronium ethyl sulfate; based on 80% ethanol; gel based on 85% ethanol; antiviral gel based on 95% ethanol. It is obvious that the decontamination of this type can be performed only in clinical or home environment.

For disinfection of surfaces infected with SARS-CoV-2, in conditions of wide communication , hard ultraviolet-C, EUV, UVC, FUV and short-wave, B: UVB are used. Its use limits the fact that ultraviolet light is absorbed by glass, plastic film and other materials, on the other hand, UV causes asthma, and its long-term exposure to the skin can provoke cancer. WHO notes that the use of UV lamps is only possible when people have left the premises. The use of ozonators is also limited to a safe human ozone dose of 0.2 mg/m^3.

Therefore, there is a need to consider other methods of disinfection, for example, using an extremely high-frequency electromagnetic field (EHF). It is obvious that we need theoretical justification for the method of disinfection of COVID-19 by EHF irradiation.

The bactericidal effect of SHF on *E. coli her' exz'*, *E. coli ATCC* 25922, *M. Avium 104*, and *Mycobacterium tuberculosis H*37*Rv* is shown in [2 - 5]. The mechanism of action consists in resonant excitation of torsional vibrations of the helix of the bacterial DNA molecule by an electromagnetic field. This process leads to the death of bacteria, interfering with DNA replication in the S-phase, as well as due to DNA destruction.

The frequency of torsional vibrations of the DNA helix is determined using the Lagrange formalism:

$$f = 21{,}75/N^{1/2} \quad (1)$$

where frequency is measured in THz and N is the number of base pairs.

The DNA or RNA molecules of viruses are much shorter than bacterial ones, so the frequency of waves required for their destruction is higher than the microwave and lies in the terahertz range or EHF.

The principal possibility of the inhibitory effect of high-frequency EMF on viruses inside the body is justified in [6], it is shown that the EHF of ultra-low, an order of magnitude lower than non-thermal, intensities can overcome the skin and suppress the development of viruses. At the same time, a method of disinfection without heating based on resonant absorption of EMF by macromolecules was developed [7]. In the case of SARS-CoV-2, surface disinfection does not require achieving an ultra-low or even non-thermal EMF power flux density. Thus, the use of EHF microwaves for disinfection specifically COVID-19 gets justification.

Factors affecting the spread of infection

Analysis of data on the incidence of COVID-19 shows that it depends on the population density, on the degree of severity of quarantine, and the death rate from COVI-19 – on the level of medical support.

It is also necessary to take into account correlations between statistics on the number of cases and the volume of testing.

The most favorable temperature for COVID-19 is +4 degrees, it keeps the virus intact for 14 days. Under favorable conditions, the" life " of SARS-CoV-2 is 48 hours. On paper, the virus is destroyed in 3 hours, on banknotes (there are fat spots) in 4 days, on wood and clothing in 2 days, on glass in 4 days, on metal and plastic in 7 days. On the inner layer of the used mask for 7 days, and on the outer surface of the mask virus is stored for more than 7 days. The data correspond to +22 °C and humidity ~65%. Testing was performed by a PCR test [9]. In other words, the virus is active on moving goods for several days.

We will select the countries that are the largest centers of infection and compare with their imports from China: the EU – 615.14 billion dollars, an increase of 9.9% over the year. the US – 555.12 billion, an increase of 6.6%. Japan 312.44 billion, growth - 0%. South Korea, 290.48 billion, growth of 5.9%. Russia - 95.28 billion, growth of 6.8%.

Italy: China is the 2nd import partner. 8.4%, after Germany – 14.7%.

Germany: China became Germany's most important trading partner for the second year in a row, with trade turnover (exports and imports) between these countries amounting to 186.6 billion rubles. euro.

Iran: imports from China – 17.4%, from Germany – 11.6%, from South Korea – 6.3%, from Italy – 4.2%.

Russia, 10th place – $ 110.75 billion, 3.4% growth.

The EU, the US, Japan, and South Korea are China's main trading partners.

Spain is secondary, the main import partners: Germany – 14.5%, France-11.1%, Italy – 7.4%, China – 6.2%.

France is also secondary, the main import partners: Germany – 18.5%, Italy – 7.9%, Spain – 7.1%, the United States – 5.2%. China – 5.1%. Similarly, the United Kingdom is secondary, as a trade satellite of the United States. Sweden, with a small number of cases and no quarantine, is outside the Euro zone, so at the two – month stage of the epidemic, the incidence in the country is lower.

In St. Petersburg, which is marked by a small number of cases, the population density is 77% of the population density of Moscow (3847.52). But Moscow is a much larger trade and transport hub.

This shows that the volume of trade is the main factor, and imported goods are the vector of infection. Thus, this pandemic is a consequence of the process of globalization.

Model

In [1], in the equations describing the evolution of the epidemic, the increase in the number of infected N is proportional to the number of infected, which corresponds to the Malthus equation.

To the number of infected people, one needs to add the number of infected people crossing the border per unit of time m. we Approximate the evolution of the number of infected people *M* by those who crossed the border, by Malthus ' law, then $dM/dt \sim mt, M \sim \exp(kmt^2)$. Assume that the rate of increase in the number of infected people is proportional to the volume of imported goods *V* and the population density *D*. We assume that the average volume of available imports remains unchanged: $V \to \overline{V}$.

Data analysis shows that the increase in the number of infected people is an increasing function (from time t in days and cases y in thousands), approximately of the form $N = 4 + 0{,}6t^2$. A similar dependence was observed in Russia. Without violating generality, one can represent the number of infected people as a power series, limiting its first members: $N = a_0 + a_1 t + a_2 t^2 + a_3 t^3$. We write out the Malthus equation and its solution, which decomposes into a power series:

$$\frac{dN}{dt} = kN, N \sim e^{kt}, e^{kt} = 1 + kt + (kt)^2/2! + (kt)^3/3! \ldots$$

Combining all the elements together, in the simplest model, we get the globalization equation for the development of the epidemic:

$$N = \exp(k_1 t) + \exp(k_2 m t^2) + (k_3 \overline{V} + k_4 D)t + const \qquad (2)$$

Here k_1 is the Malthusian parameter, k_3 is the integral coefficient that char-

acterizes the time of pathogen activity on the average product, the average transport time, the probability of infection upon contact with the product and the probability of infection of the product, k_2, k_4 are constants.

The equation shows that the influx factor across the border of infected people plays an even greater role than the Malthusian factor, in view of the additional increase in *mt* over time.

In the 5th month of the epidemic, the increase in the number of COVID-19 cases in the United States fits well into the curve (2) (at const = 0), since quarantine measures in the United States are relaxed.

Since it is impossible to eliminate trade turnover and migration between countries at different stages of the epidemic's evolution in the context of globalization, the character of the epidemic's spread should be undulating: from decline to increase with a fading amplitude.

Method of disinfection

It is interesting to consider the possibility of suppressing the Ebola virus by electromagnetic fields that exist in nature. The genus Ebolavirus includes five species: Zaire, Zaire, ivory coast, Reston, bundibugio, and Reston. The virus genome contains a single-stranded RNA of negative polarity. Various types of Ebola virus were studied in [10].

The frequency of natural torsional vibrations of the single-stranded RNA helix of viruses is calculated by the formula (1). Accordingly, the wavelength

$$l = c/f \quad (3)$$

where C is the speed of light. The complete genome of Zaire ebolavirus is 18,959 base pairs, which is a linear chain of unfragmented, negative semantic RNA. The RNA length of the Sudan ebolavirus is 18,875 base pairs. The length of the Bundibagio virus is 18,940 base pairs. The RNA length of Reston ebolavirus is 18,868 base pairs. Data analysis gives the following table:

Table 1
Mortality and wave length of RNA oscillations

Virus	Mortality, %	Wave length, mm
Zaire’	80	1,899
Sudan’	50	1,895
Reston’	0	1,894
Bundibugyo	30	1,898

Such a small difference should not be confused – the absorption peak is extremely narrow, so that the absorption is reduced by a factor of e, a deviation from the resonance of 0.05% is enough.

The calculated wavelengths are very close to the wavelength of background electromagnetic radiation, with a frequency of approximately 158 GHz. This radiation has a spectrum from 500 MHz to 500 GHz. The frequency of the maximum of background radiation is 160.4 GHz, respectively, the wavelength is 1.87 mm.

From Table 1, we can see that in a number of ebolavirus species, the closer the wavelength of the RNA's own torsional vibrations is to the peak wavelength of the relic radiation, the greater the probability of absorption, the lower the mortality rate. Therefore, it can be assumed that it is the influence of background radiation that explains the low morbidity and almost zero mortality.

The release is only on ebolavirus Bundibagio, perhaps this is caused by the biochemical features of this virus – after all, the differences between the genomes of individual types of the virus are about 40%.

The influenza virus has an absolute value of the total molecular weight of RNA, depending on the method of its determination, it varies from 4.86 106 to 5.9 106 Dalton for different authors. Since the mass of a single nucleotide is approximately 345 Da, the length of the RNA is from 7000 to 8500 bp, the frequency of DNA vibrations is 259.96 - 243.17 GHz (1.15 – 1.23 mm). The adenovirus genome contains a single double – stranded DNA molecule with a length of 34-36 thousand BP, a frequency of 118 - 114 GHz, and a wavelength of 2.54-2.62 mm. Coronaviruses occupy an intermediate place, the number of nucleotide pairs in RNA is 26-30 thousand, respectively, the necessary generator frequencies are 125.6-135 GHz.

Required power flow density > 0.1 W/cm^2 , exposure time - 5 seconds.

Conclusion

It follows from the above that urgent measures needed to limit the globalization epidemic include: 1) stopping imports from countries that are hotbeds of the epidemic; 2) comprehensive verification of border crossers and their forced isolation; 3) restricting movement across the territory.

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PECULIARITIES OF THE IMMUNE RESPONSE TO HELICOBACTER PYLORI INFECTION IN CHILDREN

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Abstract.

Introduction. *It is known that serological methods of infection verification used in epidemiological studies depend on age and state of immunological reactivity.* ***Purpose of the study*** *- assess the diagnostic significance of the serological method, the feasibility of its use in epidemiological studies and the interpretation of serological analysis data in terms of the characteristics of the immune response to H. pylori.* ***Materials and methods.*** *The study included 850 children aged 2-17 years, with an established diagnosis of chronic gastritis, duodenitis, esophagitis. In a gastroenterological hospital, all patients underwent a comprehensive examination, including general clinical analyzes of blood, urine, feces, biochemical blood tests, FEGDS, ultrasound of the abdominal organs. H. pylori was diagnosed by invasive and non-invasive methods: the latex fecal test for H. pylori; urease test; Serological test ELISA (enzyme linked immunosorbent assay, (BIOHIT, Finland)). Evaluation of immunological reactivity was carried out by standard methods. Statistical processing of the study was carried out using STATISTICA® software (Data analysis software system, StatSoft, Inc. 2008) version 8.0 in medium WINDOWS™.* ***Results of the study.*** *We have revealed ambiguous indicators of the sensitivity and specificity of the methods used for the diagnosis of H. pylori. The specificity and sensitivity of the "HELPIL" test (as a standard - fecal latex test for Hp) were 87% and*

68%, respectively. At the same time, 92% of the examined children under the age of 6 years with lesions of the upper gastrointestinal tract showed specific IgM-antibodies to H. pylori, while in children over 6 years of age, similar antibodies were detected only in 45% of children. The method for determining IgM-AT to H. pylori in children under 6 years of age had a high sensitivity (97%) with a specificity level of up to 67%. The indices of IgG-AT to H. pylori and IgA-AT to H. pylori had the lowest diagnostic value in this age group. Analysis of immunological reactivity showed an increase in Treg in the group of children under 6 years of age. Moreover, in the group of children over 6 years old, the pro-inflammatory activity of the immune response (IL8, TNFa) was higher than in the norm and in the group of children under 6 years of age. (67.56±13.60, 30.61±0.42, 30.26±3.4 and 4.04±0.74, 10.66±1.32, 7.64±0.95, p<0.05). The INFg level in the preschool age group was lower than that in the comparison group. Univariate analysis of variance made it possible to establish a causal relationship between IgM to H. pylori and Treg, INFg, IL-8 and IL-6 (r = -0.978; 0.834; -0.470; 0.870 p<0,05). ***Conclusion.*** *Diagnostic tactics should be chosen taking into account the age-related characteristics of the immune response. In preschool children, the serological method for determining specific antibodies to H. pylori IgM is highly sensitive, while the determination of specific antibodies to H. pylori IgG has low diagnostic value.*

Keywords. *children, immune system, H. pylori, IgG antibodies to H. pylori, IgM antibodies to H. pylori, epidemiological studies.*

Introduction. Currently, the most problematic issues in gastroenterology are the diagnosis of Helicobacter pylori (H. pylori). Some methods, due to their invasiveness, cannot be applied in certain age groups, for example, in childhood. The results of non-invasive tests, such as a breath urease test or a method for determining H. pylori antigens in feces or saliva [5] may be unreliable if the patient has been taking proton pump inhibitors, antibiotics, and other drugs. The serological method for determining specific antibodies to H. pylori cannot always be interpreted unambiguously. [1] For example, when examining 133 donor blood samples, specific IgM to H. pylori were detected in 21 samples (15.1%), specific IgA in 11 (8.7%), and positive IgG in 83 samples (62.4%). [2] The sensitivity of the serological test is age dependent. [3,4] At the age of 10 to 20 years, the detection rate of antibodies to H. pylori IgM class is 2.4% higher than at the age of 21-40 years, this indicator in the younger age group is, according to some authors, 31.2%. [5] When interpreting a serological test, it should be remembered that the intensity and nature of the immune response can affect

the diagnostic value of the method. There are very few research works devoted to the comparative assessment of the diagnostic significance of the serological method for identifying H. pylori in pediatric gastroenterology [4].

Purpose of the study - assess the diagnostic significance of the serological method, the feasibility of its use in epidemiological studies and the interpretation of serological analysis data in terms of the characteristics of the immune response to H. pylori.

Materials and methods

The study included 850 children aged 2-17 years, with an established diagnosis of chronic gastritis, duodenitis, esophagitis. The sample did not include children with gastric bleeding, with pronounced atrophic changes in the gastric mucosa, who took proton pump inhibitors and antibiotics for 4 weeks before the examination. In a gastroenterological hospital, all patients underwent a comprehensive examination, including general clinical analyzes of blood, urine, feces, biochemical blood tests, FEGDS, ultrasound of the abdominal organs. H. pylori was diagnosed by invasive and non-invasive methods: the latex fecal test for H. pylori Test (Novamed Ltd., Israel); urease test (using a rapid urease test "HELPIL" manufacturer St. Petersburg LLC "Sintana SM", Russia); serological test ELISA (enzyme linked immunosorbent assay, "BIOHIT" (Finland)). Immunological reactivity was assessed by two-color flow cytometry. Samples of cell suspensions were analyzed on a FACSCalibur flow cytometer ("Becton Dickinson") using the CELLQuest program. After treatment with H-thymidine, a "Harvester" apparatus was used to collect antigen-presenting cells on filters. The 3 H-thymidine level was measured on a "Wallac 1409" counter. FOXP3 mRNA expression was determined by reverse transcription-preliminary polymerase chain reaction (RT-PCR) [7].

The study was statistically processed using the STATISTICA® software (Data analysis software system, StatSoft, Inc. 2008) version 8.0 in the WINDOWS™ environment.

Results of the study.

The results of the diagnosis of H. pylori infection by different methods have been mixed. According to the latex fecal test, H. pylori was detected only in 43% of children with endoscopically verified gastroduodenal pathologies, a negative test was established in 57%. That is, the level of the indicator was lower than the population level in Russia (60-80%) [8]. The use of the "HELPIL" test made it possible to establish the presence of H. pylori in 73.6% of the examined patients. According to table 2, the highest percentage of infected people was determined by the "HELPIL" test during fibroesophagogastroduodenoscopy. (tab. 1)

Table 1. Diagnosis of H. pylori by various methods in the examined children

Presence of Hp (n=680)	Latex test for HP (feces) (n=630)	Serological analysis (n=180)			Test for urease activity of biopsy "HELPIL" (n=120)
		IgG-AT to Hp (n=180)	IgA-AT to Hp (n=180)	IgM-AT to Hp (n=180)	
Hp markers found	43%(271)	61,0%(110)	48,0%(86)	32%(57)	74%(89)
Hp markers not found	57%(359)	38,0%(70)	52,0%(94)	68%(123)	26%(31)

The specificity and sensitivity of the "HELPIL" test (as a standard - fecal latex test for Hp) were 87% and 68%, respectively.

The specificity and sensitivity of the remaining diagnostic tests were calculated according to the standard method, the test for the urease activity of the biopsy sample "HELPIL" was adopted as a standard (tab. 2).

Table 2. Sensitivity and specificity of diagnostic tests for H. pylori in the examined children.

	Serological analysis (n=180)			Test for urease activity of biopsy "HELPIL" (n=120)
	IgG-AT to H.pylori	IgA-AT to H.pylori	IgM-AT to H.pylori	
Sensitivity	86%	82%	32%	87%
Specificity	90%	92%	80%	68%

Taking into account the literature data on the dependence of serological test indicators with the determination of specific antibodies to H. pylori on age, we analyzed the spectrum of specific immunoglobulins IgG-AT to H. pylori and IgM-AT to H. pylori in groups of children from 2 to 6– age (44 children) and over 6 years old (76 children) (fig. 1).

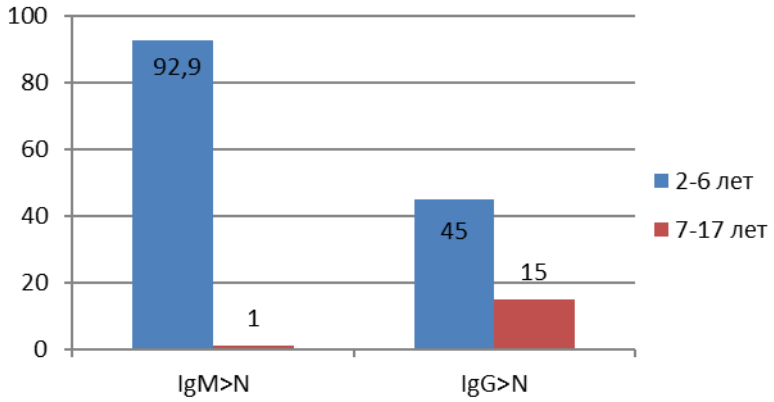

Figure 1. The number of serologically positive patients for H. pylori IgG-antibodies and H. pylori IgM-antibodies in children of different age groups.

In 92% of the examined children under the age of 6 years with lesions of the upper gastrointestinal tract, specific IgM-antibodies to H. pylori were detected, while in children over 6 years of age, similar antibodies were detected only in 45% of children.

Table 5. Sensitivity and specificity of methods of serological methods for the diagnosis of H. pylori in examined children aged 0-6 years.

	Serological analysis (n=38)		
	IgG-AT to H.pylori	**IgA-AT to H.pylori**	**IgM-AT to H.pylori**
Sensitivity	68%	82%	97%
Specificity	72%	36%	67%

Analysis of the sensitivity and specificity of the serological method for determining IgM-AT to H. pylori in children under 6 years of age allowed us to establish the highest sensitivity indicators (97%) with a specificity level of up to 67% (tab. 5). The indices of IgG-AT to H. pylori and IgA-AT to H. pylori had the lowest diagnostic value in this age group.

Treg in the group of children under 6 years of age is statistically significantly higher than in the comparison group (p = 0.03): the relative number of CD4 + CD25hi averaged 3.4%, compared to 2.01%.

Moreover, in the group of children over 6 years old, the pro-inflammatory activity of the immune response (IL8, TNFa) was higher than in the norm and in the group of children under 6 years of age (67.56±13.60, 30.61±0.42, 30.26±3.4 and 4.04±0.74, 10.66±1.32, 7.64±0.95, $p<0.05$). The level of anti-inflammatory interleukin IL10 did not statistically differ from the norm in both study groups. However, a lower level of INFg in the group of preschool children indicated relative immunosuppression, possibly helping to prevent the development of an active inflammatory response to the introduction of a bacterial agent. At a low level of INFg, the immune response will be directed towards the formation of acute phase IgM. Univariate analysis of variance made it possible to establish a causal relationship between IgM to H. pylori and Treg, INFg, IL-8 and IL-6 ($r = -0.978$; 0.834; -0.470; 0.870 $p<0.05$). At the same time, there was no causal relationship between the level of IgM to H. pylori and TNFa.

Discussion

A number of researchers believe that long-term persistence of H. pylori is associated with the phenomenon of bacterial escape from the immune system [9]. H. pylori infection is acquired during childhood and, if left untreated, persists for life. The peculiarities of the immune system in childhood are associated with the dominance of the processes of immunological tolerance, which prevents active inflammatory processes in the barrier tissues during the formation of microbial biotopes. [10] The entire cascade of immunological reactions to a bacterial agent requires a revision of the legality of using a serological method for the determination of specific IgG antibodies to H. pylori for epidemiological studies in childhood. In the modern scientific literature there is no information about the high sensitivity of the serological method for the determination of IgM in young children. We have established a high sensitivity (97%) of the serological method for determining acute-phase immunoglobulin M to H. pylori in children from 2 to 6 years old, while in the general group of the examined the same indicator did not exceed 32%. Our data are consistent with the literature, and indicate the presence in children under 6 years of age of a high level of Treg - cells, a low amount of interferon gamma, against the background of a relative decrease in proinflammatory cytokines (IL8, TNFa). Freire DE. et al. (2014) found that the immune response in children differs from that in adults by low levels of IFN-gamma and Th1 cells secreting IFN-gamma. In children infected with H. pylori, the concentration of Th1 cytokines in the stomach was lower than in adults; the concentration of Th1 cytokines in response to H. pylori infection increased gradually and much slower than in adults [11]. Bontems P. et al. (2003) proved that the migration of

neutrophils (lymphocytes CD3 + and CD8 + cells) in the gastric mucosa in children is less pronounced than in infected adults [12]. The activation of NF-kB transcription in children is low, which may be a direct consequence of a decrease in the number of neutrophils in the gastric mucosa and a more primitive inflammatory response on the part of innate immunity. [13] During H. pylori infection in children, Tregs activity predominates, and the standard adult cellular response of Th17 lymphocytes is absent. [11] A weaker immune response in a child plays a protective role and prevents the development of more serious damage to the gastrointestinal tract due to infection [14]. The relationship between circulating Tregs responses, Th1 and Th17 in the gastric mucosa in H. pylori-infected children explains the ability of gastric Tregs cells to suppress Helicobacter-induced T-cell proliferation, synthesis of IFN-g and IL-17, respectively, and the formation of memory cells CD4 + T- cells to H. pylori, and therefore the child does not synthesize specific IgG to H. pylori. [15] We also found that at a low level of INFg, the immune response is directed to the formation of acute phase IgM. Univariate analysis of variance made it possible to establish a causal relationship between IgM to H. pylori and Treg, INFg, IL-8 and IL-6 ($r = -0.978; 0.834; -0.470; 0.870$ $p<0.05$). At the same time, there was no causal relationship between the level of IgM to H. pylori and TNFa.

Conclusion.

Diagnostic tactics should be chosen taking into account the age-related characteristics of the immune response. We recommend mandatory determination of specific antibodies to H. pylori, both IgG and IgM, due to the fact that preschool children may lack IgG synthesis due to the peculiarities of the immune response to bacterial seeding of the mucous membranes of the gastrointestinal tract. In preschool children, a serological method for determining specific antibodies to H. pylori IgM has a high sensitivity, while the determination of specific antibodies to H. pylori IgG has a low diagnostic value. This pattern is associated with the functional characteristics of the immune system, which must be taken into account when choosing and interpreting the results of diagnostic methods.

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ANNUAL CYCLE OF B*ITHYNIA TROSCHELI* IN THE SOUTH OF WESTERN SIBERIA [1]

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Abstract. *This work is based on the results of a long-term (1994-2013) study of the ecology of bithyniid snails in the basin of Lake Chany, the largest in the south of Western Siberia. In the south of Western Siberia, the annual cycle of Bithynia troscheli (Paasch, 1842) consists of four main periods: winter diapause (from September to May); pre-reproductive (May-early June, less often from April); reproductive (June-July), and post-reproductive (August-September).*

Keywords: *bithyniid snails, Bithyniidae, Bithynia troscheli, annual cycle, south of Western Siberia*

Opisthorchiasis and mitorchiasis are dangerous, natural focal diseases (trematodoses), very common in the Novosibirsk region [3]. These diseases are caused by the marita flukes *Opisthorchis felineus* (Rivolta, 1884) and *Metorchis bilis* (Braun, 1890) [syn. *M. albidus* (Braun, 1893)]. At the stage of parthenite and cercariae, both of these species were found in the mollusks *Bithynia troschel*i (Paasch, 1842) [11, 12]. The *B. troscheli* species is included in the "*leachi"* group [14]. In the 50-70s of the XX century, the biology of *Bithynia leachi* was studied both in the European part of Russia and in Western Siberia [see reviews 13, 15]. We study the prevalence of bithyniid snails in Western Siberia, their biology, and infection with trematodes from 1994 to the present [5-12].

The purpose of this work was to show the features of the annual life cycle of *B. troscheli* in the conditions of water bodies in the south of Western Siberia.

Materials and methods

This work is based on long-term observations of bithyniid snails at the mouth of the Kargat River (Lake Chany basin, Novosibirsk region). The

[1]This work was carried out as part of the State Task (state registration number №№. AAAA-A16-116121410121-7.

counts were carried out 1-3 times a ten-day period from July to September in 1994; from April to September in 1995; from May to September in 1996-99 and 2005; June to September in 2000 and 2002-04; in May and June 2006; only in July 2007 and 2012; In June and August 2013, bithyniid snails were collected by hand from 4–6 plots, 0.25 m^2 in area, at a depth of 0.1 to 0.7 m. All collected mollusks were delivered to the laboratory, where their species was determined [14], age [7], and their fertility was also studied [9, 10]. The sex of the bithyniid snail and the infection with trematodes was determined by dissecting the mollusks. Observations of the reproduction of bithyniid snails were carried out from May to September in 1995-2005 in the estuarine areas of the Kargat River and under laboratory conditions, with *B. troscheli* kept in aquarium individually and in groups. In order to quantify the egg clutches of mollusks of the family Bithyniidae in the estuarine areas of the Kargat River, we selected four control plots with an area of 0.5 m^2. The control plots were located both in the flowing part of the river and in a backwater overgrown with macrophytes (common reeds - *Phragmites* or reeds - *Typha*). The clutches were counted from May 29 to July 30 in 1996, with an interval of 1-2 days. The discovered masonry was not removed from the reservoir. Since the number of clutches in the control plots did not differ significantly, the integrated mean values are given below. Data are presented per m^2. Mollusks of the family Bithyniidae were collected from the same sites to determine their species. The water temperature and its level in the Kargat River were measured three times a day (at 9^{00}, 15^{00}, 21^{00}) in all years of research. On the basis of this information, average daily and ten-day temperatures were calculated [6, 10].

Results

The *B. troscheli* population from the mouth of the Kargat River has been examined by us for more than 15 years. Over the course of ten years, of these, daily monitoring surveys were carried out, water temperature, level and every ten-day estimates of the number of bithyniid snails from June to August (inclusive). Based on long-term phenological observations of mollusks of the family Bithyniidae carried out both in natural and in laboratory conditions, taking into account information on the dynamics of their number, age and sex structure of the population, assessment of their fertility, and the timing of development in clutches, we are in the annual cycle of the adult part of the population The bithyniid snails distinguished four main periods: **winter diapause, pre-reproductive, reproductive and post-reproductive.** The calendar dates for each period have changed in different years, so we will list the main features by which we differentiated them.

1) the period of winter diapause, providing the species with the experi-

ence of the season unfavorable for an active lifestyle. There are no active bithyniid snails in the reservoir.

2) pre-reproductive period, includes - the transition of bithyniid snail from winter diapause to an active lifestyle. It begins in the spring from the moment the active bithyniid snail appear and continues until the first egg clutches of bithyniid snails appear in the reservoir.

3) reproductive period characterized by the presence of young clutches (freshly laid, 1-2 days old) egg-laying in the reservoir. At the initial stage of reproduction, egg-laying in the reservoir is rare. The stage of mass reproduction is characterized not only by an increase in the number of clutches per unit area, but also by the expansion of the breeding areas. At the final stage of reproduction, freshly laid ovipositions in the reservoir are sporadic (rare).

4) post-reproductive period – begins when there are no freshly deposited egg clutches of bithyniid snail in the reservoir and ends with the absence of active bithyniid snails in the reservoir.

Winter diapause period

Diapause is the longest period in the annual cycle of bithyniid snails, which allows them to endure all the negative phenomena of the under-ice regime - a decrease in dissolved oxygen in water, accumulation of hydrogen sulfide, free carbon dioxide, etc. It is characterized by the absence of active bithyniid snail in the reservoir. In August-September, passing into an inactive state (falling into suspended animation), the mollusks descend into depressions at the bottom of the reservoir (into pits from tracks) or, moving to the root parts of macrophytes, where they are carried by silt or plant debris. In these conditions, they hibernate. In the experiment, bithyniid snail, being on the surface of the soil, at a temperature of - 6 °C, suffered freezing for 2.5 months [1]. According to our observations, under the conditions of the south of Western Siberia, diapause in bithyniid snails can last 9-10 months, which coincides with the information previously noted in the literature [see review 13]. However, we observed that the transition to diapause can take place not only at the end of summer. Thus, at the end of June 2000, we recorded a significant increase in water temperature in the Kargat River up to 27 °C [10]. Since the concentration of oxygen in water decreases with increasing temperature, this can also be assessed as an unfavorable factor. After a few days, all adults passed into a state of suspended animation by the beginning of July, i.e. 1-2 months ahead of schedule. However, in all other years, the transition to diapause took place in August. During the wintering period, the youngest individuals are most

vulnerable - underyearlings (0+). We found that only individuals survive the winter, the shell height reaching 2.73-3.14 mm in females and 2.05-3.5 mm in males. We compared how the average increase in shell height before the first wintering is related to the average daily temperatures of the reservoir in the second half of summer. Our analysis showed that the average shell height correlated positively with the average daily water temperature in the reservoir in the second half of summer: in females (r = 0.875) and in males (r = 0.654) [8].

Pre-reproductive period

In the pre-reproductive period, the bithyniid snails become active after winter. As a rule, in the estuarine areas of the Kargat River, active bithyniid snail were found not earlier than the second ten-day period of May or even in June. However, the transition of bithyniid snails from winter diapause to active life is possible already at the end of April, as we observed in 1995, when by April 27 the water in the river warmed up to + 8 °C (in shallow water up to 11 °C). There is no doubt that one of the main factors stimulating the transition of poikilothermic organisms from physiological depression to an active lifestyle is an increase in ambient temperature, for prosobranch mollusks - water in a reservoir. The fastest transition of bithyniid snail from diapause to active life in the conditions of water bodies in the south of Western Siberia was noted in a week after the ice melted. Active bithyniid snail in spring at a water temperature of about + 10 °C were also noted by other researchers [review 13]. Ten-year observations in the estuarine areas of the Kargat River showed that the first ovipositions of bithyniid snails, indicating the beginning of the breeding period, were usually recorded in the 2nd ten-day period of June (in 1995, 1997-98, 2002-03 and 2005), less often in the last days of May (in 1996, 1999 and 2000) or early June (in 2004). Thus, in the Kargat River, the pre-reproductive period of *B. troscheli* lasted from 10 to 40 days, in different years, which depends on the temperature regime of the reservoir.

Reproductive period

In our opinion, the main feature characterizing the reproductive period of *B. troscheli* is the presence of freshly laid clutches in the reservoir, and their absence indicates the end of the breeding period. A quantitative assessment of the dynamics of the reproductive activity of bithyniid snails in the reservoir was carried out in 1996. Separately, the total number of clutches, the number of newly deposited and "abandoned" ones, from which the bithyniid snails had already emerged, were counted [in 6 fig. 1, p. 270]. The first clutches were found on May 29, and on June 17, the first

abandoned clutches were found in the same areas. The embryonic development of bithyniid snails under the conditions of a reservoir at a water temperature of 11.7 °C -20.9 °C lasted 20 days (345.9 degree days). Earlier in laboratory conditions, we showed that for the completion of the embryonic development of *B. troscheli,* 335-350 degree days are required [6]. The carried out quantitative accounting of clutches in the reservoir showed that the initial stage of the reproductive period lasted from the last days of May to the 2nd ten-day period of June. Over the next twenty day period, a massive reproduction of bithyniid snails was noted. In the 3rd ten-day period of June and the 1st ten-day period of July, the total number of clutches reached two hundred per 1 m^2, the number of freshly deposited and the number of "abandoned" clutches was approximately equal. In the second ten-day period of July, the dynamic equilibrium was violated, since the rate of formation of new clutches decreased. As a result, the total number of clutches containing bithyniid snail decreased by almost half. In the 3rd ten-day period of July, the appearance of new clutches was not noted at all. During the 1996 breeding period (from the 3rd ten-day period of May to the 2nd ten-day period of July), the bithyniid snails laid an average of 455 egg clutches per 1 m^2. In different years, the maximum number of clutches per 1 m^2 varied significantly. The range of variation in the maximum number of clutches ranged from 10 pieces/m^2 (1997 and 1998), 26 pieces/m^2 (1995), 36 pieces/m^2 (1999), about 100 pieces/m^2 (2003, 2005) and up to 200 pieces/m^2 (1996, 2002, 2004). However, in all years of observations, the mass number of clutches of *B. troscheli* was recorded from the 3rd ten-day period of June to the 1st ten-day period of July, inclusive. It can be assumed that this was determined by the temperature regime of the reservoir. Indeed, from the 2nd to the 3rd ten-day period of June, as a rule, the water temperature in the river increased by 1-3°, however, mass reproduction of *B. troscheli* at the same time was noted in 1999, when a decrease in average daily water temperatures by 5° was recorded and in 2005 with a decrease of 2°, or 2004, when there were no noticeable changes in temperature. The timing of mass reproduction in the studied population did not change in years with an earlier start of reproduction. However, they always coincided with the period when the duration of the light phase of the day is maximum. The final stage of reproduction lasts ten days on average and coincides from 10th to 20th of July. From July 10, the number of clutches of *B. troscheli* in the reservoir decreased in all years of the study. The average long-term water temperatures in the Kargat River were 22.2 ± 2.2°C in the 2nd ten-day period of July, and 21.7 ± 1.8°C in the 3rd ten-day period. The water temperature in the third ten-day period of July varied from

18.4°C (in 2003) to 24.4°C (in 1996), however, freshly laid clutches were not found, not once in twelve years of observation. Since the temperature regime of the reservoir was different in different years, another more stable factor is probably a signal for the end of reproduction. We assume that one of the most important factors regulating the process of reproduction of bithyniid snails may be the light regime, which is annually characterized by strict constancy and periodicity. The duration of the light phase of the day after July 20 decreases to 16 hours and 20 minutes. It should be noted that under laboratory conditions, with an artificial increase in the duration of the light phase of the day to 17-18 hours, single females are able to lay several egg capsules in late July or early August.

Post-reproductive period

Daily observations of bithyniid snails in the estuarine areas of the Kargat River during ten summer periods showed that the post-reproductive period is characterized by: 1-absence of freshly laid clutches in the reservoir; 2 - a huge number of juvenile underyearlings; 3 - a sharp decline in the number of mollusks of reproductive age, some of which go into diapause. In all the years of observations, the post-reproductive period, we noted from the third ten-day period of July to August-September (before the onset of diapause. At the end of July and the beginning of August in the reservoir, one can find single clutches of bithyniid snails (with large embryos ready to hatch or have already been abandoned by them). As a rule, the found egg clutches were laid in the middle of July. Two other characters are associated with the estimation of the bithyniid snail abundance. Previous researchers, characterizing the ecology of the bithyniid snails, unanimously noted their decrease in August [4, 13]. This opinion is only partially true. According to our data, in August, the *B. troscheli* population not only does not decrease, but increases several times. The increase in the population size in August was caused by the release of juveniles from all clutches. As shown above, in one reproductive season, up to 455 egg clutches of bithyniid snails develop on one square meter of the reservoir. Considering that one clutch of *B. troscheli* contains on average 12 egg capsules [5], by August 5414 juveniles/m^2 emerged from them. It should be noted that when counting the number, these newborn mollusks were probably overlooked by researchers. As for the adult part of the population, indeed every year, we also noted a decrease in their number. This was noted in all years of observation, although in the first ten days of August the water temperature is still quite warm from 18.7 °C (2004) to 23.5 °C (in 2000); average long-term 21.5 ± 1.59 °C. The reasons for the transition of bithyniid snails from active life to diapause are changes in the quality of the environment

(water in reservoirs). Many researchers have studied a number of abiotic factors [2, 4, 13], which can cause a decrease in the number of bithyniid snails in August. For example, there is an assumption that the main reason may be a decrease in the water level in the river, causing an increase in its mineralization [4, 13]. However, we observed a decrease in the density (and total number) of bithyniid snail in August both in years with low (in 1994-96) and in years with a high water level (in 1997-98). Earlier special studies of S.A. Beer et al. [2] of the seasonal dynamics of hydrochemical parameters in water bodies of Western Siberia showed that the content of oxygen dissolved in water decreases from 7 mg/l (in July) to 2 mg/l (in August). Prosobranch molluscs cannot breathe atmospheric air. We noted that "water bloom", which significantly reduces the amount of dissolved oxygen, also causes a decrease in the number of bitinids. After two days, their number decreases 14 times, and after a week, more than 20 times. Without rejecting the opinions presented in the literature, we assume that the decrease in the number of bithyniid snails in August was caused not only by abiotic, but also by biotic factors. The reproductive period is over, the body's reserves are running out, there are two ways, either diapause or death, and a change in water quality or photoperiod performs only a signal function. The low number of the adult part of the bithyniid snail population in combination with a huge number of young individuals may have an important biological significance. Although intraspecific competition for food among bithyniid snails is unlikely, competitive relations between adults and fingerlings are possible for oxygen dissolved in water, the content of which decreases in August [2].

According to E.G. Sidorov [13] the duration of reproduction of bithyniid snails in the conditions of Western Siberia is about 90 days from mid-May to mid-August, which is at odds with our data - 35-60 days. Suppose that the breeding period of bithyniid snail in Western Siberia really ends in mid-August, i.e. the last egg capsules were laid on 15 August. If we take into account that the embryonic development of bithyniid snail lasts about - 335-350 degree days [6], then even with a favorable temperature regime in the reservoir, newborn bithyniid snail can appear only on September 2-8. Since the juveniles leave the egg capsules, the shell height is from 0.8 to 1.0 mm. Having such a size, they have no chance to survive the winter, because before the onset of diapause, they must increase their body weight by 2-3 times, for this young bithyniid snails will need at least 30-40 days. The water temperature in the Kargat River by September 15-18, as a rule, drops to 10 °C and below, i.e. even under favorable weather conditions in the reservoirs of the south of Western Siberia, the bithyniid snail from the

clutches laid down in August are doomed to death.

Thus, the *B. troscheli* annual cycle consists of four main periods: winter diapause (from September to May); pre-reproductive (May-early June, less often from April); reproductive (June-July), and post-reproductive (August-September). The beginning of the pre-reproductive and reproductive periods are marked at different calendar dates, and depend on the temperature of the water in the reservoir. In contrast to the initial stage of reproduction of *B. troscheli*, the mass and final stages were observed every year at the same calendar dates, regardless of the weather conditions of the year. The reproductive period always ended in the 2nd ten-day period of July. It was shown that the decrease in the number of bithyniid snails in August is caused by biotic factors associated with the end of the reproductive period, and changes in water quality or photoperiod play only a signaling role. It is proved that the duration of reproduction of *B. troscheli*, in the conditions of the south of Western Siberia, is no more than 60 days.

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DEVELOPMENT OF CATALYTIC SYSTEMS FOR THE PURIFICATION OF HYDROCARBON RAW MATERIALS FROM SULFUR COMPOUNDS BASED ON PHTHALOCYANINE METAL COMPLEXES

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Abstract. *An increase in the share of sulphurous oils and gas condensates involved in processing, as well as a significant increase in the share of energy consumption in the cost of production, make it imperative to develop and implement catalytic energy and resource-saving desulfurization technologies.*

Keywords: *Hydrocarbon fuels, catalyst, desulfurization, phthalocyanine metal complexes.*

The depth of domestic oil refining over the past 30 years, despite the repeated adoption of state programs on this problem, practically did not increase and "froze" at the level of 64-65%. The rest of it in the form of sulfurous and high-sulfur boiler fuels was burned and continues to be burned at heat and power plants, throwing huge amounts of toxic oxides of sulfur and nitrogen into the air basin of Russians. At present and in the future, there is no alternative to the rational and comprehensive use of oil and its deep "non-residual" processing. [1].

It should be noted that the production of low-sulfur fuels with a sulfur content of less than 0.2% by weight is associated with losses of their resources and significant energy consumption for deep hydrotreating. During hydrotreating, natural antioxidant, antiwear, anticorrosion and other additives present in the original oil are removed from the fuel simultaneously with non-hydrocarbon hetero compounds. Therefore, in the production of commercial hydrotreated diesel fuels, it becomes necessary to use a large assortment and in sufficiently large quantities of synthetic additives [2].

In recent years, gas condensates have begun to be widely involved in processing. A characteristic feature of the chemical composition of gas condensates is the presence in them of abnormally high concentrations of mercaptan sulfur - within 0.1-0.7% by weight, with a total sulfur content of up to 1.5% [3]. Currently, due to the high content of both mercaptan and total sulfur in gasoline, kerosene and diesel fractions, they are hydrotreated or demercaptanized by Merox-type processes based on the extraction of mercaptans with alkali and subsequent regeneration of mercaptide-containing alkaline solutions. Salt water of ELDP, trap oil, oil sludge, oil products, chemical reagents, acid sludge, spent alkaline solutions, etc., enter the water bodies with the wastewater of the refinery. The following main directions in the implementation of environmentally friendly technological processes, including petrochemical ones, can be distinguished, namely, the integrated use and deep processing of raw materials. Production should be as resource-intensive as possible (resource-saving technologies), carried out with a minimum of raw materials and reagents costs per unit of production. The resulting semi-finished products must be transferred as raw materials to other industries and completely processed. [4].

An increase in the share of sulphurous oils and gas condensates involved in processing, as well as a significant increase in the share of energy consumption in the cost of production, cause an urgent need to develop and implement catalytic energy and resource-saving desulfurization technologies. This is especially true for those oil and gas processing enterprises where the purification of hydrocarbon raw materials from sulfur compounds is carried out by non-regenerative methods.

In this regard, the widespread introduction of catalytic regenerative desulfurization processes is becoming increasingly important. Catalysts based on phthalocyanine complexes of transition metals, in particular, catalysts based on cobalt phthalocyanine, which have a sufficiently high activity in the reactions of oxidative demercaptanization of petroleum products and in the neutralization of toxic sulfur-alkaline effluents, have found the greatest application in domestic and foreign practice for these purposes.

In recent years, the attention of scientists has begun to attract metal complex catalysts for oxidation-reduction processes. Phthalocyanine metal complexes (MPc), which possess chemical and thermal stability that are unique for organometallic compounds, most fully satisfy the requirements for this kind of catalysts. They can reasonably be considered as structural analogs of the prostatic groups of natural enzymes - hemoglobin, myoglobin, chlorophyll. The active centers of such complexes are ideally suited for reversible binding of small molecules and carrying out redox transfor-

mations with them. Catalysts of this kind are already used in a number of industrial processes (purification of hydrocarbon feedstock from sulfur compounds, oxidation of hydrocarbons) [5].

Of the phthalocyanine catalysts used in the practice of desulfurization, the most technologically advanced and convenient in operation have been shown to be heterogeneous catalysts prepared by depositing cobalt phthalocyanine in a mixture with salts of other metals of variable valence on a polymer support. These catalysts, made in the form of an effective packing element with a developed geometric surface, provide an efficient mass exchange of the oxidized product with an oxygen-containing gas.

The process of simultaneous purification of combustible gases from H_2S and HCN using CoPc, for example gases of thermochemical coal processing, in which the required degree of gas purification from H_2S and HCN will be achieved with sufficiently intensive regeneration of the absorption solution and sufficient stability of the purification process will also be competitive [6].

To obtain high-quality polymer-based catalysts, it is of great importance to use CoPc with a high concentration of the basic substance in their manufacture. A catalyst made on the basis of such cobalt phthalocyanine was introduced in 2000 and is currently being successfully operated at CJSC "Yarvaz" (Yaroslavl) in the process of regenerative-catalytic demercaptanization of olefin feedstock of a gas fractionation unit (GFU), which made it possible to obtain high-quality butane-butylene fraction - a feedstock for the synthesis of methyl tert-butyl ether (MTBE), which serves as an additive to increase the octane number of gasoline [7].

The incorporation of phthalocyanines into the polymer structure during polymerization using various organic compounds as a carrier makes it possible to obtain efficient catalysts characterized by high stability. In [8], the activity of TSCoPc in cationic polymeric colloids, which were considered as active cocatalysts for the oxidation of 2-mercaptoethanol, was studied; an “enzyme-like” behavior of the catalytic system was noted. Catalysts based on carboxy-substituted CoPc incorporated into a polycationic matrix were obtained in a similar way, which also showed high activity in this reaction [9].

Recently, the possibilities for the synthesis of various compounds, including catalysts, using sol-gel chemistry have been expanding [10, 11]. As noted in the works of Schubert et al. [12-14], this method has a number of advantages over traditional ones, the main of which is the ability to control the factors influencing the catalytic activity. It was found that sulfonic acids can react with titanium alkoxides, forming stable bonds with the TiO_2

matrix formed during the sol-gel synthesis.

The substances obtained by the sol-gel method, prior to the stage of matrix deposition, can be applied to various carriers. An attempt was made to use granules of unmodified SiO_2 for these purposes. It was shown that, using TSCoPc as the initial, samples are obtained that have a relatively low activity, are unstable in the reaction solution, and lose their activity with repeated cycles. And vice versa, using tetrasulfochloride CoPc, stable and efficient catalysts were obtained, the activity of which significantly exceeded the characteristics of the samples not supported on SiO_2 granules. The advantage of this method is the high specific surface area of the catalysts, therefore, a larger amount of the active component, and, consequently, the active sites of the reaction (tab. 1).

Table. 1
Purification of diesel fuel from mercaptan sulfur

Catalyst	Purification degree in 5 minutes,%	Catalyst	Purification degree in 5 minutes,%-
$CoPc(SO_3Na)_4$	44	$CoPc(4\text{-}NH_2)_4(SO_3Na)_2$	67
$CoPc(4\text{-}NO_2)_4(SO_3Na)_2$	45	$CoPc(4\text{-}Br)_4(SO_3Na)_2$	91
$CoPc(4\text{-}OH)_4(SO_3Na)_2$	66	$CoPc(4\text{-}Cl)_4(SO_3Na)_4$	96

The technology we propose to reduce the sulfur content is carried out by direct conversion of hydrogen sulfide and mercaptans in contact with the catalyst surface.

Due to the use of a metal complex catalyst, the oxidation process proceeds at a lower temperature in a mild mode, which leads to the formation of free sulfur, which is released during catalyst regeneration, rather than oxides that require their further disposal.

The developed catalyst significantly surpasses the usual ones in the main parameters - the proportion of mesopores, which determines the enormous sorption activity and expanded surface of this material. With its pyrolytic nature, it possesses excellent mechanical, thermal and chemical resistance and is capable of operating under severe operating conditions. The use as an active component of a catalyst, a compound having a metal-complex nanocrystalline structure, firmly bound to a support, possessing thermal and chemical stability, unique for organic compounds, and a high ability to reversible oxidation and reduction, determines unique catalytic

properties [15].

The technology for demercaptanization of hydrocarbon raw materials is based on the direct mild catalytic oxidation of sulfur compounds directly in gas-liquid or gas streams during the primary distillation process.

The widespread adoption of these catalysts is hindered by the lack of industrial production. At the same time, during the production of phthalic anhydride (FA) at JSC "Zapsibmetkombinat", a distillation head fraction containing 99.8% FA is formed, which has an increased color according to the platinum-cobalt scale, which is a waste product. The supply of the head fraction for secondary processing and distillation together with FA reduces its quality and yield.

It is proposed to process the top fraction of distillation on site in the phthalic anhydride facility (PAF) shop to obtain more expensive scarce commodity products - metal phthalocyanines (MPc), in particular phthalocyanine pigments and catalysts [16].

The synthesis of MPc was carried out by baking under laboratory conditions. For the synthesis of CuPc, the following copper salts were tested: carbonate $(CuOH)_2CO$, sulfate CuSO4*5H_2O, chloride $CuCl_2$*2H_2O, acetate $Cu(CH_3CO)_2$*H_2O in comparison with CuCl (I). For the synthesis of CoPc, the following cobalt salts were tested: chloride $CoC1_2$*6H_2O, sulfate $CoSO_4$*7H_2O, nitrate Co $(NO_3)_2$*6H_2O. Experiments showed that, in principle, all tested salts gave phthalocyanine complexes. The synthesis depended on temperature and duration: when using copper sulfate and chloride, CuPc was formed after 4 hours, while the use of carbonate and acetate led to the formation of a pigmented CuPc form with a longer synthesis time - up to 30 hours. The yield of CuPc when using CuCl (I) as a complexing agent was 56-69%, $CuCl_2$ (II) - 37.1, $CuSO_4$ - 35.0-43.0, for other reagents it did not exceed 18.0. The CoPc yield was 29–35% [17].

The synthesis of MPc in a medium of plasticizing agents (diluents), i.e., in a liquid medium, leads to an increase in the yield of MPc. In order to increase the yield, simplify, reduce the cost of synthesis technology and search for a domestic plasticizing agent, research was carried out to select the most affordable plasticizer from petrochemical products: AMT-300, transformer, compressor, turbine, spindle oils and kerosene. The choice is due to the boiling point within the temperature of the synthesis process of 190-225 °C, the availability and the possibility of utilization of the waste product within the CCP without its regeneration. It was found that during the synthesis of MPc in laboratory conditions in a liquid medium, the yield of CuPc in the case of synthesis with copper (I) chloride increased to 83-84%, and in some cases the value of selection of more accessible, cheap

raw materials produced by the domestic industry up to 92%; with copper sulfate - up to 66%. The CuPc yield substantially depended on the ratio of the plasticizing agent to the dry weight of the reaction mixture. The most acceptable in the synthesis of CuPc was shown to be transformer oil with a minimum kinematic viscosity (10-13 mm / s: at 50 °C and 3.0 mm/s2 at 100 °C), the boiling point of which is 190-300 °C. In order to increase the MPc yield in the practical implementation of the technology, the influence of the consumption of urea, complex-forming agents of copper salts - chloride (1), sulfate, catalyst - ammonium molybdate - on the yield of technical CuPc in the medium of transformer oil was studied. With respect to FA, the content in the reaction mixture was changed,%: urea from 47 to 162.0, copper salts - sulfate from 23.0 to 42.0, chloride from 15.0 to 27.0, catalyst from 0.55 to 1.7. Rational consumption rates of synthesis reagents in relation to FA have been established. The following composition of the reaction mixture is recommended for the production of CuPc,%: FA - 42.3, urea - 42.3, complexing agent - 14.8, catalyst - 0.6 [18].

Pilot and industrial tests confirmed laboratory studies and showed the possibility of producing MPc in a batch process with a technical product yield of 76-84%, a basic substance content of 92-94% (CoPc), 88-92% (CuPc).

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DYNAMICS OF GAS WELL DEVELOPMENT

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Introduction

Dynamic processes are one of the important aspects of gas well development. When the gas injected into the annular space (or annular space) to replace the liquid in this space completely fills it, gas inflow from the formation begins. In this case, liquid is displaced from the reservoir and the annulus through the central channel of the liquid, and the pressure at the bottom of the well begins to change. The flow of gas from the reservoir depends on this change.

Formulation of the problem

Gas movement in the annulus. The movement of gas flow in the annulus in the central channel and filtration of gas and liquid must be considered together.

Let us average the pressures, density, and axial velocity of the gas flow over the cross section of the pipe and assume that the pressure $P(x,t)$ in any cross section of the gas flow depends on the coordinate x and on the value of time t.

Then the equation of gas movement in the annulus and the equation of continuity will be [1-3].

$$-\frac{\partial P}{\partial x}=\frac{\partial Q}{\partial t}+2aQ \qquad -\frac{\partial P}{\partial t}=c^2\frac{\partial Q}{\partial x} \tag{1}$$

From equation (1) we obtain

$$\frac{\partial^2 P}{\partial t^2} = c^2 \frac{\partial^2 P}{\partial x^2} - 2a \frac{\partial P}{\partial t} \tag{2}$$

Having placed the origin of the x coordinate axis in the lower section of the pipe and directed it upwards for the initial and boundary conditions, we will have

$$P\big|_{t=0} = \psi(x) \tag{3}$$

$$\left.\frac{\partial P}{\partial t}\right|_{t=0} = 0 \tag{4}$$

$$P\big|_{x=0} = P_c(t) \tag{5}$$

$$P\big|_{x=l} = P_{yct}(t) \tag{6}$$

The solution to equation (5) and (6), taking into account the boundary conditions (5) and (6), will be sought in the form

$$P(x;t) = P_c(t) - \frac{P_c(t) - P_{ycm}(t)}{T_0} x + \sum \varphi_i \sin \frac{\pi i x}{l} \tag{7}$$

Where $P_c(t)$ is the downhole pressure.

$P_{ycm}(t)$ - wellhead pressure, *l* - pipe string running depth, $\varphi_i(t)$ – unknown, time-dependent function t.

From equation (2), taking into account (7) and initial conditions (4) and (5), we obtain

$$P = P_c(t) - \frac{P_c(0) - P_{ycm}(0)}{l} x + \sum (-(\frac{2}{i\pi} \frac{1}{\omega_i} \int_0^t \ddot{P}_c(\tau) e^{(-a(t-\tau))} \sin[\omega_i(t-\tau)] d\tau +$$

$$+ \frac{2}{i\pi} (-1)^i \frac{1}{\omega_i} \int_0^l \dot{P}_c(\tau) e^{(-a(t-\tau))} \sin[\omega_i(t-\tau)] d\tau - \frac{4a}{\pi} \frac{1}{\omega_i} \int_0^l \dot{P}_c(\tau) e^{(-a(t-\tau))} \sin[\omega_i(t-\tau)] d\tau +$$

$$+ \frac{4a}{\pi} (-1)^i \int_0^l \dot{P}_c(\tau) e^{(-a(t-\tau))} \sin[\omega_i(t-\tau)] d\tau)) \sin \frac{\pi i x}{l} \tag{8}$$

Where $\omega_i = \sqrt{a^2 + \frac{c^2 i^2 \pi^2}{l^2}}$

The gas flow rate is determined from the first equation of expression (1) taking into account formula (8).

Now consider the process of displacing fluid in the central tube.

The origin of the coordinate axis x_1 – is placed in the lower section of the pipe and directed upwards.

The mass of gas in the central pipe at any time can be determined by the formula

$$G_0 = f_m \int_0^{x_2} \rho_г dx_1 \tag{9}$$

We will assume that the inflow of gas from the reservoir has not begun to flow in an insignificant amount yet.

Consider ortropic gas.

Then $\rho_г$ is determined by the formula

$$\rho_г = \frac{P}{P_{атм}} \rho_{атм} \tag{10}$$

Where $P_{атм}$, $\rho_{атм}$ - is the pressure and density of the gas at atmospheric pressure, respectively.

The pressure P in any cross-section of the gas in the central pipe can be determined by the formula

$$P(x;t) = P_c(t) - \frac{P_c(t) - P_{c_1}(t)}{x_2} x_1 \tag{11}$$

Where $P_c(t)$ - bottomhole pressure, $P_{c_1}(t)$ - pressure on the cross-section of gas-liquid contact, x_1 - coordinate, x_2 - cross-sectional distance of gas-liquid contact. Substituting expression (10) and (11) into equation (9), we obtain

$$G_0 = f_T \frac{\rho_{атм}}{P_{атм}} \cdot \frac{x_2}{2} [P_c(t) - P_{c_1}(t)] \tag{12}$$

The mass flow rate of gas in the central pipe can be determined by the formula

$$G = \frac{dG_0}{dt} \tag{13}$$

Then, substituting expression (12) into formula (13), we obtain

$$G = f_T \frac{\rho_{amм}}{P_{amм}} \cdot \frac{1}{2} \{ \frac{dx_2}{dt} [P_c(t) - P_{c_1}(t) + x_2 [\dot{P}_c(t) - \dot{P}_{c_1}(t)] \} \quad (14)$$

As the liquid is displaced, its mass decreases

The decrease in the mass of liquid in the central tube in the first approximation is taken in the form

$$m = m_0 \left[1 - \left(\frac{1}{T} \right)^2 \right] \quad (15)$$

Where m is the mass of the liquid in the pipe at any moment of time, t - the time, T - the unknown time during which all the liquid is displaced. Then, taking the liquid from the condition of incompressible and continuity, we will have:

$$\frac{dx_2}{dt} = \frac{2lt}{T^2} \quad (16)$$

The movement of fluid in the central tube with variable mass occurs without reactive force.

Therefore, its motion is described by the equation

$$\rho_{ж} \frac{d^2 x_2}{dt^2} = \frac{P_{c1}(t) - P_{усm1}(t)}{l - x_2} - 2a\rho_{ж} \frac{dx_2}{dt} - \rho_{ж} g \quad (17)$$

Where $P_{усm1}$ - central pipe outlet pressure, *a* - drag coefficient.

From expression (17), taking into account formula (16), we obtain

$$\rho_{ж} \frac{2l}{T^2} = \frac{P_{c1} - P_{усm1}}{l(1 - \frac{x_2}{l})} - 4a\rho_{ж} \frac{lt}{T^2} - \rho_{ж} g \quad (18)$$

$\frac{x_2}{l} << 1$ so, given only one term $\frac{1}{1 - \frac{x_2}{l}} \approx 1 + \frac{x_2}{l}$

Then from expression (18) we obtain

$$\rho_{ж} \frac{2l}{T^2} = \frac{P_{c1} - P_{усm1}}{l} (1 + \frac{t^2}{T^2})$$

On the other hand, from formula (16) taking into account $G = -\frac{dm}{dt}$ we obtain

$$\frac{l}{2} = \dot{P}_c(t) + P_c(t) = -\frac{1}{2} t\dot{P}_{c1}(t) - P_{c1}(t) + \frac{2\rho_{ж}\rho_{атм}}{P_{атм}} \qquad (19)$$

Integrating differential equation (19) with respect to $P_c(t)$ we obtain

$$P_c(t) = -P_{c_1}(t) + 2\rho_{ж}\frac{P_{атм}}{\rho_{атм}} \qquad (20)$$

From expression (21) taking into account formula (18) at $t = 0$ we obtain

$$P_c(0) = -P_{уст_1} - 2\rho_{ж}\frac{l^2}{T^2} - \rho_{ж} l_0 g + 2\rho_{ж}\frac{P_{атм}}{\rho_{атм}} \qquad (21)$$

From formula (21), the well completion time is determined.

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HOLOGRAPHIC PROPERTIES OF CHALCOGENIDE GLASSY SEMICONDUCTOR (CGS) FILMS

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Abstract. *The paper considers the possibility of using chalcogenide glassy semiconductor films (CGS) for recording holographic information. The schemes and results of the study of the diffraction efficiency depending on the exposure time and the holographic characteristics of chalcogenide glassy semiconductor films under the influence of γ-irradiation are presented . It was found that the optical properties of CGS films and the diffraction efficiency of the recorded holograms do not change in the range of radiation doses ($10^3 - 10^9$ Roentgen, R). It has also been proven that the shelf life of recorded holograms under certain conditions is 10 years or more.*

Keywords: *CGS- chalcogenide glassy films, TPV-thin-film waveguides, holography, digital holography, interferometer, diffraction efficiency, holograms.*

One of the most important elements of holographic information recording is a recording medium, the requirements for which in real devices can vary over a very wide range in sensitivity, resolution, information storage time, recording time, diffraction efficiency, and other parameters of holograms. The property of reversibility (reversibility) determines the ability to quickly erase a recorded hologram and record a new one. Irreversible recording materials are suitable for use only in permanent storage devices. Reversible media include magneto- optical films, thermoplastic and photochromic materials, electro-optical crystals, chalcogenide glassy semicon-

ductors. Of great interest are materials with volumetric changes in optical properties, especially in the refractive index, which makes it possible to store information in three-dimensional matrices of superimposed volumetric holograms with high diffraction efficiency [1-5, 8].

Chalcogenide glassy semiconductors (ChGS) containing one or more chalcogenes (S , Se , Te) are promising recording materials for the transmission and processing of information by holographic methods. The very first studies of the properties of CGS showed that they have a high resolution , reversibility of recording and do not need any processes of manifestation or fixation, i.e. have properties very valuable for use in holography and optical information processing devices and, in particular, optical processors, holographic memory devices, and information input and output devices. On the other hand, the high refractive index of most CGSs allows them to be used as thin film waveguides (TPWs) in the near IR and visible spectral regions, in particular, based on bulk phase gratings. Such a unique combination of waveguide properties with the ability to record holographic gratings and other phase in homogeneities in the TPV volume make ChGS films promising materials for the development of lattice reflective filters of directional branches and surface wave converters on their basis. To determine the diffraction translational efficiency holograms , recorded on specimens optical setup was used, the circuit of which is shown in Figure 1.

The recorded holograms represented the interference of two plane beams. Convergence angle $\cong 30^{\circ}$. The radiation source was an LG-38 He-Ne laser.

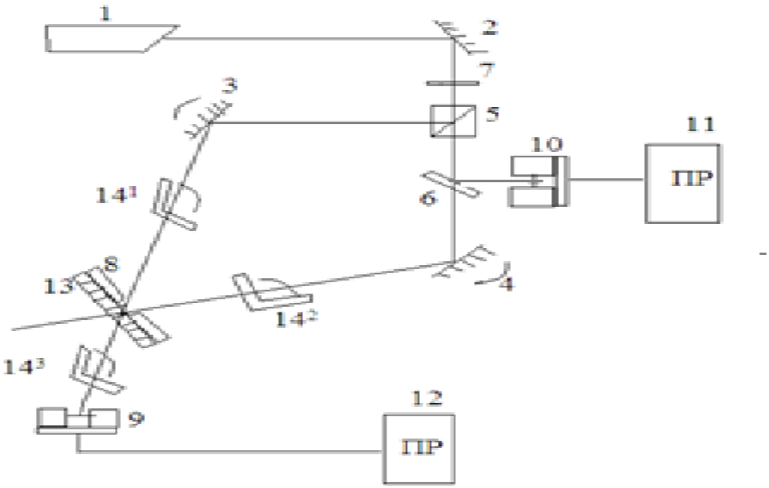

Fig.1 Experimental scheme for studying the holographic characteristics of materials.1-laser LG-38; 2,3,4-flat mirrors ; 5-cubic prism ; 6-translucent plate ; 7-Aperture; 8-masks; 9.10-photo sensors ; 11.12-recording devices ;
13- Registering Math Methods and material ;14^1,14^2,14^3– shutters.

The laser beam (Fig.1) (1) is divided by a cubic prism (5) into two beams, which are then converged on the sample surface (13). The hologram obtained in this way is a diffraction grating, the groove frequency of which depends on the setup parameters and can be adjusted. For our case $\nu = 1000\frac{\text{line}}{\text{mm}}$.

To obtain the maximum contrast of the fringes, a filter (7) was introduced to level the beams in intensity. The mask (8) is used to reduce errors associated with laser beam in homogeneity and inaccuracy of alignment. Photosensors (9.10) and associated recording devices (11, 12) are used to measure the diffraction efficiency of the transparency coefficient η of the sample T and the energy characteristics of the recording. The recording device is calibrated taking into account the diaphragm effect of the mask (8).

Thus, elementary Fresnel holograms (diffraction gratings) were recorded on CGS films, and their diffraction efficiency (η) was measured during the recording . The diffraction efficiency was estimated from the ratio of the radiation power of the reference beam, diffracted in the first order during

the reconstruction of holograms, to the radiation power of the reference beam itself.

The transmittance of the initial samples and substrates was measured before recording the holograms using a probe beam weakened twenty times by a light filter. Materials of the As-Se system in the form of thin films, deposited by vacuum deposition on glass substrates of various brands and sapphire, were γ-irradiated with various doses ($10^3 - 10^9$ R) . For irradiation, the samples were placed in an aluminum capsule, after which they were introduced into the active zone of the corresponding γ-irradiation channel - the installation CO^{60}(in this case, 83 R / s and 1100 R / s).

The range of irradiation doses was selected on the basis of a preliminary experiment that showed the influence of γ-rays on substrates of various brands of glass and sapphire. After irradiation, the studied samples were investigated for the preservation of holograms and the recording of new ones, and then, within one week after the irradiation, measurements of the diffraction efficiency and transmittance of the samples were carried out daily, since it is known that irradiation can induce a number of unstable color centers that can emit under the influence of temperature , scattered light, etc. The experimental results are shown in Fig . 2. It was found that the effect of γ-irradiation on the diffraction efficiency of the recorded holograms is largely due to the course of the transmission curve. Also shown are the dependences of the transmission both for samples with substrates and for the films themselves, as well as the diffraction efficiency of holograms on the radiation dose.

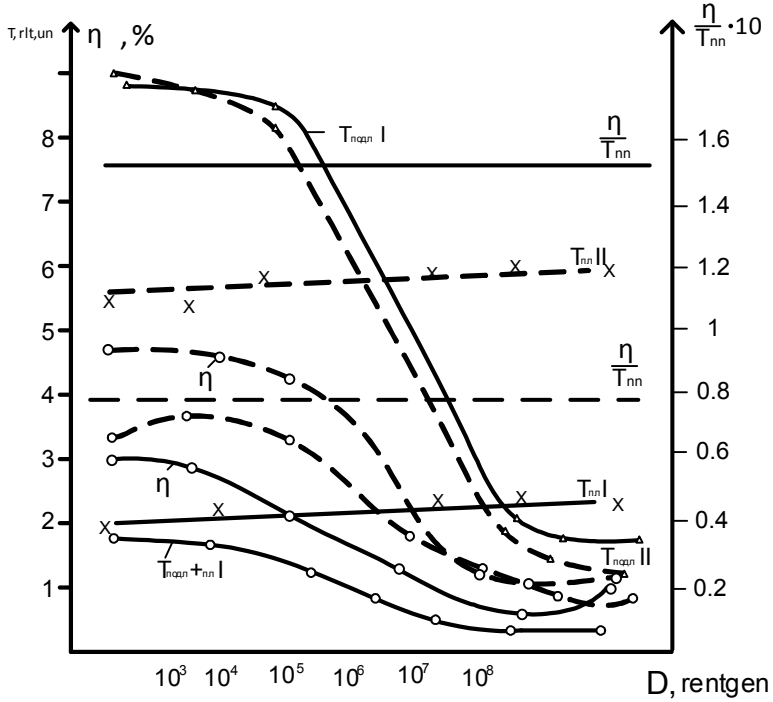

Fig.2 dose dependences of transmission and diffraction efficiency for film samples As_7Se_3 (dashed line) and $As_{60}Se_{40}$ (flat line): T_{sub} I, II - transmission of the substrate; T_{sub+t} I , II - transmission of the CGS substrate; T_t I , II - transmission of the CGS film; -dependence of the diffraction efficiency on the dose.

Certain relative values of diffraction efficiency and shift of the optical transmission edge in the 1st recording cycle are shown in Fig . 3.

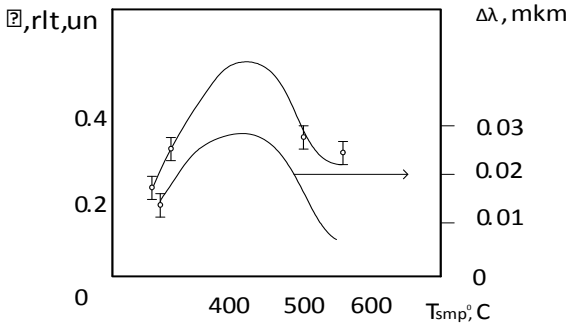

Fig3. Change in diffraction efficiency (η) and shift of the optical absorption edge ($\Delta\lambda$) of $As_{40}Se_{60}$ films obtained from bulk materials with different prehistory's.

The scatter in their values is obviously due to some in homogeneity of the film thicknesses. The maximum transmission was observed in the films obtained from the sample T_{tr}~500°C with. (fig. 4).

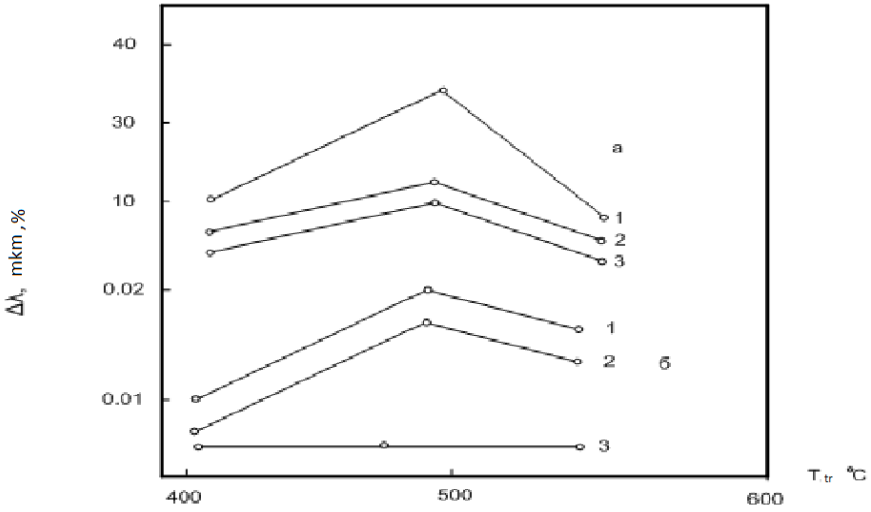

Fig. 4: Dependence of the optical properties of As40Se60 films on the heat treatment temperature of the initial bulk material: 3 - change in the optical transmission of As40Se60 films (1 - freshly sawn film, 2 - annealed, 3 - irradiation); change in the shift of the optical absorption edge (1 - after irradiation, 2 - after annealing, 3 - the resulting reversible shift).

It should be noted that the complete erasure of the history does not occur even after annealing the film at the erasure temperature (T_{er}), and a similar character of the dependences of the optical transmission and $\Delta\lambda$ on (although less pronounced) is retained for the irradiated annealed films. Notable is the fact that, as a result, the value of the reversible optical shift of the absorption edge after several “write-erase” cycles for all samples takes the same value. As for the diffraction efficiency (η), it should be noted that the observed dependences of it on the thickness of the samples have approximately the same character for all processing temperatures of the initial material. However, the absolute values η are different. They grow with increasing T, reaching a maximum value at T = 500. (Fig. 5) .

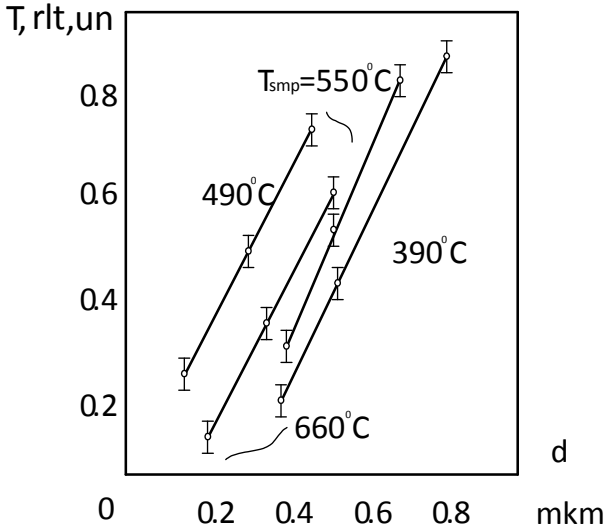

Fig. 5. The dependence of the diffraction efficiency of holograms based on the thickness of the sample and the processing temperature of the starting material.

It was found that the dependences of the values of the diffraction efficiency of holograms and the shift of the optical absorption edge of the films As_2Se_3 on the processing temperature of the starting material have an extreme character with a maximum value at T_{tr}= 500 °C . It is necessary to note a significant, more than twofold change in the diffraction efficiency with a change in the thermal history of the starting material.

Thus, the influence of ionizing radiation on the optical and holographic characteristics of films of the A s -S and A s - Se systems has been investigated. It was found that in the range of irradiation doses ($10^3 - 10^9$ Roentgen) the optical properties and diffraction efficiency of the recorded holograms do not change. It has also been proven that the shelf life of recorded holograms under certain conditions is 10 years or more.

The use of such chalcogenide glassy semiconductors allows achieving high operating speed and a large number of write-erase cycles. Studies of the optical and holographic characteristics of CGS films show the promise of using As-Se and As - S films in systems for optical processing and information storage.

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COMPACT INTERFEROMETER FOR DIGITAL SCREEN

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Abstract. *A scheme of a compact speckle interferometer - a shearograph for digital shearography is proposed and implemented. A software algorithm for obtaining shearograms has been implemented. The shearograph is designed to assess surface deformation, in particular, it can be used to assess the tightness of elements and assemblies of microelectronic devices.*

Keywords: *Shirography, speckle interferometry, sheirograph, surface deformation, non-destructive testing, tightness.*

One of the rapidly developing optical methods recently is the method of correlation speckle interferometry or the so-called shear speckle-interferometry (shearography) [1]. Shear speckle interferometry is based on a comparison of speckle structures formed by laser radiation reflected from the surface of the material under study with varying degrees of sample loading. Speckle formation occurs due to the use of optical schemes, which make it possible to obtain two images shifted relative to each other, which form speckle as a result of interference. When the value of the applied load changes, the surface layer of the sample is distorted, which changes the difference in the paths of the rays arriving at the detector, and as a consequence, the speckle structure under study changes. The difference between two images (without a loaded and under load) provide the phase distribution difference of arrival of rays in each point of the two-dimensional

speckle which is the primary carrier of information about the processes occurring in the sample material, such as determining the magnitude of the deformation gradient [1].

The main advantages of the method are higher accuracy of strain estimation, non-contact method of data acquisition, and ease of setup and operation, which allows direct measurement of strain gradients in real time. At present, the method of shear speckle interferometry (shearography) is widely used to measure surface deformation [2], measure outside planar displacements and inside planar stresses [3], measure residual stresses, study stationary vibrations and deformations in time [4]. For microelectronics shearography technique can be used for ICs with research elements microelectronic devices [5] during at different loadings time work.

One of the reasons for the failure of devices is the insufficient tightness of the cases, due to which moisture and other contaminants penetrate into the device case, which leads to malfunction of the microcircuits. Leak testing is currently performed using the helium leak detection method, which is time consuming. Shearography can be used to quickly study elements in microelectronics [5]. The assessment of the tightness of the enclosures is based on measuring the deformation of the enclosure surface over time using shearography. The test cases are placed in a closed volume in which the ambient pressure can be varied. When the pressure changes, the surface of the body is deformed. If the body is sealed, then the deformation at a given pressure remains constant over time, while in a leaky body the surface will gradually recover to its original state, which will manifest itself in deformation over a certain time. Therefore, by measuring the deformation of the housing surface over time using shearography, it is possible to identify leaking housings. This process is very fast, usually taking a few seconds, while the conventional method takes several hours. Thus, the methods of digital holographic interferometry used in shearography are a promising field of research in the problems of high-precision measurements and non-destructive testing.

The main goal of this work was to develop an experimental specimen of a speckle interferometer (shearograph). The optical layout and general view of the arrangement of the optical elements of the shearograph are shown in Fig. 1.

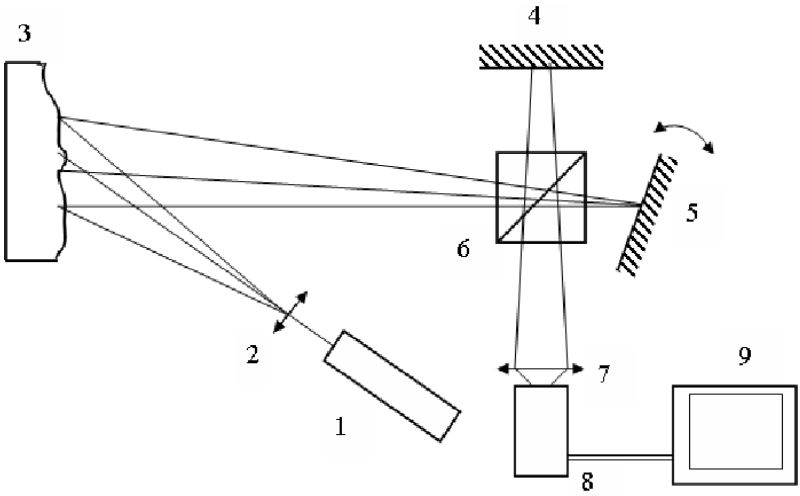

Figure 1. *Optical scheme for obtaining shearograms and the arrangement of optical elements of the shearograph layout. 1- laser lens extends 2-, 3- object -zerkala 4,5, 6 - beam splitter cube, 7- Helios 44 lens, 8 - SSD camera, 9 - computer.*

The shearograph is based on a Michelson interferometer. The radiation of laser 1 with a wavelength of 0.53 μm is expanded by lens 2 to illuminate the required surface area of the investigated object 3. The radiation scattered from the surface of object 3 forms an image in the form of a speckle pattern, which is transmitted through a Michelson interferometer consisting of mirrors 4, 5 and a beam splitting cube 5 through lens 7 on the SSD matrix 8 located in the image plane. Turning one of the mirrors of the Michelson interferometer at a small angle in the horizontal or vertical direction, we obtain a Michelson shifting interferometer, which divides the image so that two identical but offset images form an image in the SSD camera. Reflected from two points located at a distance δx on the surface of the object, the laser radiation beams in the image plane will combine into one point, where they interfere with each other, thus forming a speckle interferogram. The δx value is called the shear value.

The intensity of the resulting speckle interferogram is recorded by the SSD camera and loaded onto the digitization card (frame grabber), where the analog signal from the SSD matrix is digitized.

When an object is under load, a change in optical path occurs due to deformation of the object's surface. Changing the optical paths leads to a change in the phase difference Δ between the rays from the points with a shift value δx. Thus, the intensity distribution in the speckle interferogram changes slightly.

If the angle between the direction of incidence of the laser beam on the object and the direction of observation of the STS camera is very small, then the relative change in phase Δ is associated with the displacement gradient outside the object surface $\delta w / \delta x$ (if the shift is in the x direction) and with $\delta w / \delta y$, (if the shift is in the y direction), and this relationship is given by the following expression [1]:

$\delta w / \delta x = \lambda \Delta / 4\pi\delta x$ (shift in x direction) (1)

$\delta w / \delta x = \lambda \Delta / 4\pi\delta x$ (shift in y direction)

With the help of the developed device - shearograph, shearograms of loaded objects were obtained. Objects are fixedly fastened circumferentially metal plate diameter of 160 mm and a thickness of 1.5 mm in the load device, with the possibility of applying a point load in the middle of the plate. Speckle interferograms of the object were obtained sequentially without load and under load. The loading was carried out by moving the micrometric screw of the loading device by 10, 20, 30 μm. Then, using the developed special computer program, the intensity values of the corresponding speckle interferograms were subtracted pixel by pixel and the interference patterns of the distribution of intensity bands (shearograms) were obtained.

H and Fig. 2 shows the band distribution pattern (shirogrammy) obtained for the various values of load at different moving s micrometer screw device sample loading. These bands indicate the presence of out-of- plane deformations. Fig. 2 that the density of the observed

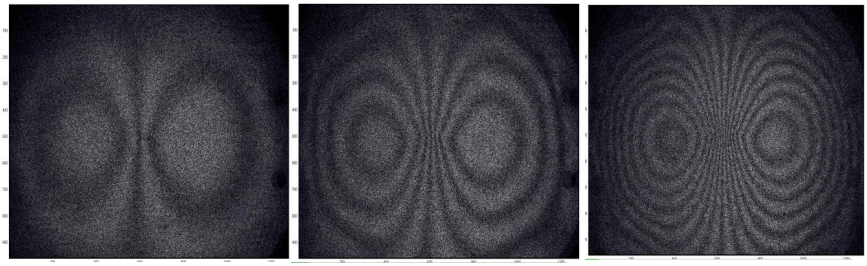

Figure 2. *Pattern of band distribution for different values of sample deformation.*

The interference fringes depend on the magnitude of the load on the sample, and, therefore, on the magnitude of the deformation. Thus, by the change in the density of the distribution of interference fringes in time, one can judge about the change in deformation, which makes it possible to study the elements of microelectronic devices.

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STRUCTURAL-THERMODYNAMIC MODEL OF THE MIXTURE

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Abstract. *A thermodynamic model of the functional-technological properties* (*FTP*) *mixture has been developed. The concept of a structural factor is introduced and methods for reducing the uncertainty of the FTP mixture are substantiated. A model "composition - structure - property" of the mixture has been developed, taking into account its structural heterogeneity and molecular interaction of the components.*

Keywords: *thermodynamic model, structural factor, mixture, functional-technological properties, heterogeneity, molecular interaction of components, potential energy.*

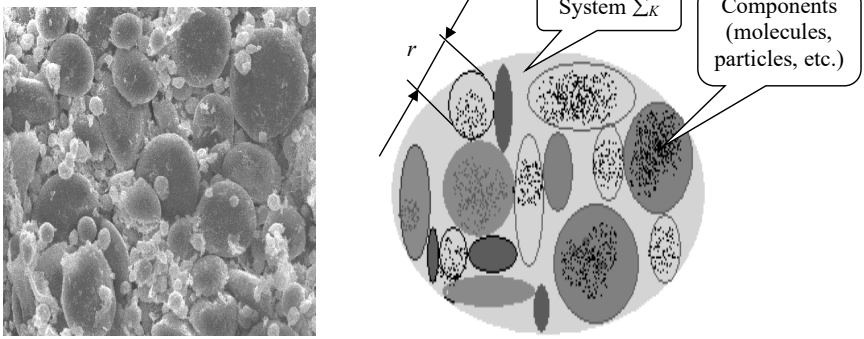
Spatial structure factor model

Modern food technology is based on almost all fundamental sciences. Complex processes occurring during the processing of raw materials in the production of food are based on the laws of physics, chemistry, biology, etc.

Let's introduce the concept of a composite.

A nonlinear composite joint (composite) is an artificially created inhomogeneous joint consisting of two or more components.

Any nonlinear composites - multicomponent compounds, or mixtures - are heterogeneous systems consisting of a large, but finite number of *K* complexes, combining partial components (molecules, particles and impurity inclusions) in a certain way and in different mass fractions. The structure of a real heterogeneous system is shown in fig. 1 a), and its model (system $\sum_K$) – is shown in fig. 1 b) [1, 2].



a) b)

Fig. 1. Structure of a heterogeneous system: a) micro-relief of wheat flour dough; b) microrelief model, or location of complexes in the composite (system $\sum_K$)

Heterogeneous (nano- and microheterogeneous) systems at the submicroscopic level (1 nm - 100 nm) have a complex structure due to the interaction of molecules. At the microscopic level (0.1 μm - 50.0 μm), their structure is due to various inclusions of inhomogeneous impurities. Functional-technological properties (FTP) - a set of various physicochemical, biological, rheological, optical, organoleptic (consumer) properties - such systems cannot be described based only on knowledge of the properties of individual molecules and atoms. The first attempts to describe them were considered in [3].

The concept of a large number of complexes is associated with the relationship

$$K = \frac{V_\Sigma}{V} >> 1, \quad (1)$$

here V_Σ – system volume $\sum_K$, V – effective volume of the complex.

This ratio eliminates the influence of boundary conditions on the FTP system.

To describe the inhomogeneities of composites, we will use the multidimensional function $\nu_K(r_m, F_n)$ of the distribution of various sizes r_m and physical properties $F_n = \{F_{1n}, F_{2n}, \ldots\}$ of the complexes of the $\sum_K$ system:

$$\nu_K(r_m, F_n) = \frac{K(r_m, F_n)}{K}, \sum_m \sum_n \nu_K(r_m, F_n) = 1, \quad (2)$$

here $K(r_m, F_n)$ – the number of complexes that have both the effective size

r_m and the physical properties of F_n; m = 1, 2, …, N; n = 1, 2, …, N; N – the number of components (the number of types of molecules).

Here is an example of a heterogeneous system consisting of four components (fig. 2) [1].

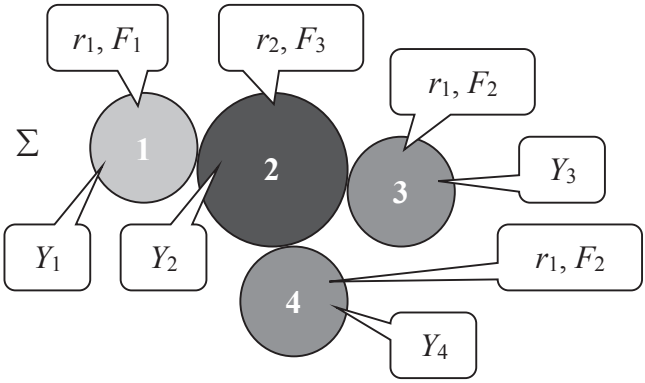


Fig. 2. An example of a heterogeneous system $\sum_4$

Table 1 shows the distribution of 4 complexes by two possible sizes $\{r_1, r_2\}$ and three sets of physical propertie $\{F_1; F_2; F_3\}$ of system $\sum_4$. Table 2 shows the two-dimensional discrete function $v_4(r_m, F_n)$ of the distribution of the sizes and physical properties of the system $\sum_4$.

Table 1

	F_1	F_2	F_3
r_1	1st complex	3rd and 4th complexes	
r_2			2nd complex

Table 2

$v_4(r_m, F_n)$	F_1	F_2	F_3
r_1	1/4	1/2	0
r_2	0	0	1/4

To characterize the uncertainty of composites' FTP due to their structural heterogeneity, we use the structural factor formalism. In the general case of multicomponent compounds, the structure factor is an *N*-component vector that determines the "weight" of the additive contribution of the *n*-th component (molecules or particles of the *n*-th type) to the FTP of the system $\sum_K$ (n = 1, 2, …, *N*):

$$S_n = \sum_m \sum_l \Gamma_{nml} v_K(r_m, F_l) = \sum_m \sum_n \gamma_{nl} \rho_{nm} v_K(r_m, F_l),\ 0 < S_n \le 1, \quad (3)$$

here $\Gamma_{nml} = \gamma_{nl} \rho_{nm}$ – structural tensor of the third rank, which determines the mass / volume or mole fraction of the *n*-th component per complex with the effective size r_m and the set of physical properties F_l ($\sum_m \sum_l \Gamma_{nml} = 1,\ 0 \le \Gamma_{nml} \le 1$); γ_{nl} – the share of the contribution of the *n*-th component to the *l*-th set of physical properties F_l; $\rho_{nm} = \rho_m = \frac{K_m r_m^3}{V_\Sigma}$ – the probability of the *n*-th component entering the complex with the volume $V_m \cong r_m^3$; K_m – number of complexes with effective volume r^3_m.

The structural factor (3) describes the structural heterogeneity of a heterogeneous system due to both the technology of preparation (mixing) of the mixture and the interaction of its constituent components.

In the case of an ideal homogeneous system $\sum_K$ (K_m = 1, $r^3 = V_\Sigma$), which is typical for ideal solutions, ρ_m = 1, Γ_{nml} = 1. In this situation, the structure factor S_n = 1, and the FTP of the $\sum_K$ system will be completely determined only by its composition.

In the case of a homogenized system $\sum_K$, consisting of *K* completely identical complexes ($K_m = K$, $r^3 = \frac{V_\Sigma}{K}$), ρ_m = 1, Γ_{nml} = 1. In this situation, the structure factor S_n = 1, and the FTP of the system $\sum_K$ will also be completely determined only its composition.

Hence it follows that in order to eliminate the uncertainty directly caused by the randomness of the structure factor S_n, in the production of composites, it is necessary to strive to obtain monodisperse structures, which can be achieved by grinding and mixing these systems.

Thermodynamic model of functional and technological properties of the mixture

Let us consider a nonlinear composite, which is a macrosystem $\sum_K$, consisting of a large number of particles of various *N* types with molar fractions of M_n (*n* = 1, 2, ..., *N*), interacting with each other in different ways. Not knowing the specific nature of the interaction (physical, chemical, biologi-

cal), we will describe these interactions with the help of classical statistical thermodynamics of equilibrium states [4].

Let $Y(Z)$ – be a physical quantity of a macrosystem (some indicator of its quality, which determines certain FTP mixtures), defined in the so-called configuration space Ω, in which each point corresponds to a set of three-dimensional configuration variables Z ($Z \in \Omega$). For example, in spherical coordinates $Z = (R, \Theta, \varphi)$, here $0 \le R < \infty$, $0 \le \Theta \le \pi$, $0 \le \varphi < 2\pi$, and $d^{(3)}Z = R^2 dR \sin\Theta\, d\Theta\, d\varphi$.

The average value of the physical quantity $Y(Z)$, denoted by $\langle Y \rangle$, is expressed as the average over the unit configuration space Ω ($[\Omega] = m^3$, for example) based on the Gibbs distribution $f(Z)$ [5]:

$$f(Z) = \frac{\exp\left\{-\frac{U(Z)}{kT}\right\}}{\iiint\limits_{\Omega} \exp\left\{-\frac{U(Z)}{kT}\right\} d^{(3)}Z},$$
$$\langle Y \rangle = \iiint\limits_{\Omega} Y(Z) f(Z) d^{(3)}Z = \frac{\iiint\limits_{\Omega} Y(Z) \exp\left\{-\frac{U(Z)}{kT}\right\} d^{(3)}Z}{\iiint\limits_{\Omega} \exp\left\{-\frac{U(Z)}{kT}\right\} d^{(3)}Z}, \quad (4)$$

here $U(Z)$ – potential energy of particles, much less than the average thermal energy of macrosystem ($U(Z) << kT$); k – Boltzmann constant; T – absolute temperature of the macrosystem.

We represent the potential energy of particles of the macrosystem $\sum_K$ as

$$U(Z) = U_0(Z) + \Delta U(Z) = U_0(Z) + \sum_{n=1}^{N} \sum_{m=1}^{N} \Delta U_{nm}(Z) M_n M_m, \quad (5)$$

here $U_0(Z)$ – the equilibrium part of the potential energy of the particles of the system without taking into account their interaction; $\Delta U(Z)$ – the equilibrium part of the potential energy of the particles of the system, taking into account their pair interactions; $\Delta U_{nm}(Z)$ – potential energy of pair interaction of particles of n-th and m-th types; M_n – molar or mole fractions of particles of various types (n = 1, 2, ..., N); N – number of particle types.

The potential energy $\Delta U_{nm}(Z)$ of interaction of the particles of the composite components is completely determined by their mutual positions and orientations.

If molecules, for example, of a liquid medium are spherically symmetric and only central forces act between them, then the equilibrium part of the potential energy of interaction of particles is expressed by the law of Mie and Lennard-Jones [6 - 8]:

$$\Delta U_{nm}(Z) = \Delta U(R_{nm}) = -\frac{\alpha_p}{R_{nm}^p} + \frac{\beta_q}{R_{nm}^q},\ q > p, \quad (6)$$

here the first term is the energy of attraction, and the second is the energy of repulsion of the molecules.

In many cases (for example, for many gases, approximately for liquid media), it is sufficient to take $p = 6$ and $q = 12$. In this case, the Lennard-Jones potential is transformed to a simple and convenient form

$$\Delta U(R_{nm}) = 4\varepsilon\left\{\left(\frac{\sigma}{R_{nm}}\right)^{12} - \left(\frac{\sigma}{R_{nm}}\right)^{6}\right\}, \quad (7)$$

here parameters ε and σ (Lennard-Jones force constants) have dimensions of energy and length, respectively, and depend on the kind of interacting molecules. The constant σ is the distance between molecules at which $\Delta U(R_{nm}) = 0$; ε – the minimum value of the potential energy at a distance between molecules equal to $\sigma\sqrt[6]{2}$ (fig. 3).

In the general case of spherically asymmetric molecules, the potential energy $\Delta U_{nm}(Z)$ of the interaction of molecules *n* and *m* is composed of a part that depends only on the distance R_{nm} between molecules and a part that depends on the orientation (Θ_n, φ_n) and (Θ_m, φ_m) molecules.

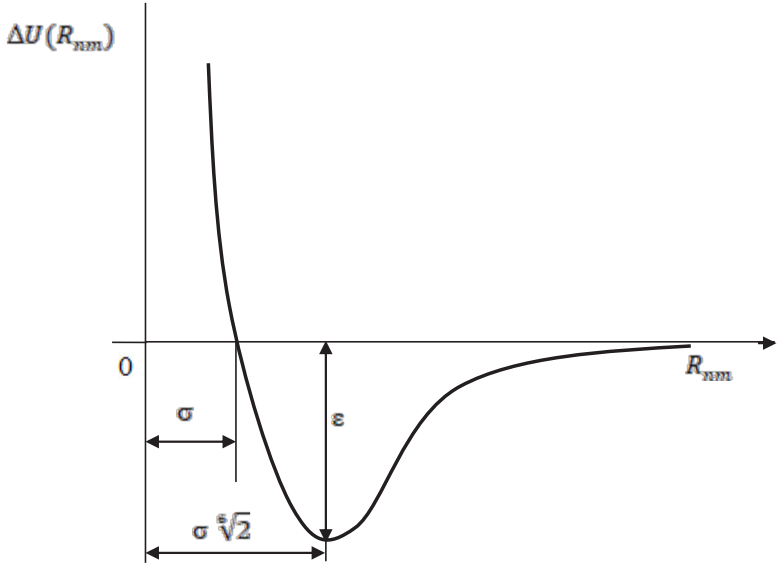


Fig. 3. Dependence of the potential energy $\Delta U(R_{nm})$ of interaction on the distances R_{nm} between molecules *n* and *m*

We expand the factor $\exp\left\{-\frac{U(z)}{kT}\right\}$ in a power series:

$$\exp\left\{-\frac{U(z)}{kT}\right\} = 1 + \left(-\frac{U(z)}{kT}\right) + \frac{1}{2!}\left(-\frac{U(z)}{kT}\right)^2 + \frac{1}{3!}\left(-\frac{U(z)}{kT}\right)^3 + \ldots . \quad (8)$$

We restrict ourselves to only the first two terms of expansion (8), since the subsequent terms rapidly decrease in accordance with the power law. Substituting (8) into (4), we obtain:

$$\langle Y \rangle = \frac{\iiint\limits_{\Omega} Y(Z)d^{(3)}Z - \frac{1}{kT}\iiint\limits_{\Omega} Y(Z)U(Z)d^{(3)}Z + \frac{1}{2(kT)^2}\iiint\limits_{\Omega} Y(Z)U^2(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z - \frac{1}{kT}\iiint\limits_{\Omega} U(Z)d^{(3)}Z + \frac{1}{2(kT)^2}\iiint\limits_{\Omega} U^2(Z)d^{(3)}Z} + H , \quad (9)$$

here H – error due to a finite number of terms in expansion (8).

Divide the numerator and denominator of the fraction (9) by $\iiint\limits_{\Omega} d^{(3)}Z$:

$$\langle Y \rangle = \frac{\frac{\iiint\limits_{\Omega} Y(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} - \frac{1}{kT}\frac{\iiint\limits_{\Omega} Y(Z)U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} + \frac{1}{2(kT)^2}\frac{\iiint\limits_{\Omega} Y(Z)U^2(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z}}{1 - \frac{1}{kT}\frac{\iiint\limits_{\Omega} U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} + \frac{1}{2(kT)^2}\frac{\iiint\limits_{\Omega} U^2(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z}} + H . \quad (10)$$

Since $U(Z) << kT$, then $\left| \frac{1}{kT}\frac{\iiint\limits_{\Omega} U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} - \frac{1}{2(kT)^2}\frac{\iiint\limits_{\Omega} U^2(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} \right| < 1.$

Then, denoting $\frac{1}{kT}\frac{\iiint\limits_{\Omega} U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} - \frac{1}{2(kT)^2}\frac{\iiint\limits_{\Omega} U^2(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} = A$, we expand the following function in a power series:

$$\frac{1}{1-A} = 1 + A + A^2 + \ldots \quad (11)$$

Therefore, equation (10) is transformed to the form

$$\langle Y\rangle = \left(\frac{\iiint\limits_{\Omega} Y(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} - \frac{1}{kT}\frac{\iiint\limits_{\Omega} Y(Z)U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} + \frac{1}{2(kT)^2}\frac{\iiint\limits_{\Omega} Y(Z)U^2(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} \right) \cdot$$

$$\cdot \left(1 + \frac{1}{kT}\frac{\iiint\limits_{\Omega} U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} - \frac{1}{2(kT)^2}\frac{\iiint\limits_{\Omega} U^2(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} + \right.$$

$$\left. + \left(\frac{1}{kT}\frac{\iiint\limits_{\Omega} U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} - \frac{1}{2(kT)^2}\frac{\iiint\limits_{\Omega} U^2(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} \right)^2 \right) + H .$$

Neglecting the terms of a higher order of smallness, we obtain

$$\langle Y\rangle = \frac{\iiint\limits_{\Omega} Y(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} - \frac{1}{kT}\frac{\iiint\limits_{\Omega} Y(Z)U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} +$$

$$+ \frac{1}{kT}\frac{\iiint\limits_{\Omega} Y(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z}\frac{\iiint\limits_{\Omega} U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} + H \qquad (12)$$

Introducing the notation

$$\langle Y\rangle_0 = \frac{\iiint\limits_{\Omega} Y(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} , \qquad (13)$$

presenting expression $-\frac{1}{kT}\frac{\iiint\limits_{\Omega} Y(Z)U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z}$, using formula (5), in the form

$$-\frac{1}{kT}\frac{\iiint\limits_{\Omega} Y(Z)U(Z)d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} = -\frac{1}{kT}\frac{\iiint\limits_{\Omega} Y(Z)(U_0(Z)+\Delta U(Z))d^{(3)}Z}{\iiint\limits_{\Omega} d^{(3)}Z} = \frac{\langle Y\Delta U\rangle}{kT} =$$

$$= \sum_{n=1}^{N} \sum_{m=1}^{N} \frac{\langle Y\Delta U_{nm} \rangle}{kT} M_n M_m ,$$

introducing another notation

$$X_{Ynm} = \frac{\langle Y\Delta U_{nm} \rangle}{kT} \qquad (14)$$

(whence it immediately follows that $-\frac{1}{kT}\frac{\iiint_{\Omega} Y(Z)U(Z)d^{(3)}Z}{\iiint_{\Omega} d^{(3)}Z} = \sum_{n=1}^{N}\sum_{m=1}^{N} X_{Ynm}M_nM_m$) and again neglecting the terms of a higher order of smallness, we obtain the final expression for the thermodynamically average values of the physical quantities of macrosystems of interacting molecules - the thermodynamic model of the FTP mixture taking into account the interaction (pair interactions) of its components:

$$\langle Y \rangle = \langle Y \rangle_0 + \sum_{n=1}^{N} \sum_{m=1}^{N} X_{Ynm} M_n M_m + H . \qquad (15)$$

The parameters of X_{Ynm} are called the second virial coefficients [9].

For the first time, virial coefficients (*A, B, C, ...*) were introduced by Kamerling-Onnes, who proposed to describe the state of real gases by the equation [6]

$$pV = A + \frac{B}{V} + \frac{C}{V^2} + \ldots , \qquad (16)$$

here *p* – pressure, and *V* – molar volume.

The virial method can be applied to an arbitrary value *Y* describing the properties of real gases

$$Y = A_Y + \frac{B_Y}{V} + \frac{C_Y}{V^2} + \ldots . \qquad (17)$$

Model "composition - structure - property" of a multicomponent mixture

Any indicator *Y* of the quality of a multicomponent mixture, which determines its FTP, is determined both by the equilibrium value of $\langle Y \rangle_0$ (i.e. the value without taking into account the interaction of the components of the mixture), and by pair interactions of the components that affect the second virial coefficients.

So, for example, for linear (by mole fractions) mixtures, i.e. mixtures in which $\langle Y \rangle_0 = \sum_{n=1}^{N} X_n M_n$ (here X_n – FTP of the n-th component of the mixture), any indicator Y of their quality (or FTP), taking into account the molecular interactions of the components, will be described on the basis of (15) as

$$\langle Y \rangle = \sum_{n=1}^{N} X_n M_n + \sum_{n=1}^{N} \sum_{m=1}^{N} X_{Ynm} M_n M_m + H =$$

$$= \sum_{n=1}^{N} \left(1 + \frac{1}{X_n} \sum_{m=1}^{N} X_{Ynm} M_m \right) X_n M_n + H \qquad (18)$$

This dependence - the model "composition - structure - property" of a multicomponent mixture - we write in the form

$$\langle Y \rangle = \sum_{n=1}^{N} S_{Yn} X_n M_n + H \ , \qquad (19)$$

here S_{Yn} – the n-th component of the structural factor due to molecular interactions,

$$S_{Yn} = 1 + \frac{1}{X_n} \sum_{m=1}^{N} X_{Ynm} M_m \, . \qquad (20)$$

The structural (nanostructural) factors of a real multicomponent mixture introduced earlier in (3) are completely determined by virial coefficients due to pair molecular interactions leading to spatially inhomogeneous distributions of their physical properties.

The structural factor can be controlled by bringing its value closer to 1, using special technologies of grinding and mixing (to compensate for the influence of spatial and intermolecular structural factors) and stabilizing additives (to compensate for the intermolecular structural factor).

Conclusion

A thermodynamic model of the FTP mixture was developed taking into account the pair interactions of its components. The concept of the structural factor is introduced and methods for reducing the uncertainty of the FTP mixture by its control are substantiated.

Considerable attention is paid to modeling using the laws of equilibrium statistical thermodynamics: a model "composition - structure - property" of a mixture has been developed, taking into account its structural heterogeneity and molecular interaction of components.

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QUANTUM ANTIGRAVITATION

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Abstract. *It is shown that the Universe is a quantum system, where zero-point oscillations play the role of negative mass. The potential of the vacuum field is determined. Disadvantages of scalar fields in various models are indicated. A new scalar field is introduced, the vacuum of which can generate antigravity, the field equation is obtained, and two classes of its solutions are found.*

Keywords: *Casimir effect, divergence of functions, Hubble's law.*

Introduction

Almost forty years have passed since the publication of Zeldovich's article "The theory of vacuum, perhaps, solves the riddle of cosmology", in which the author connects the critical density with the density of the vacuum [1]. Long before that, Sakharov assumed that the elasticity of the vacuum is capable of stopping the collapse of the Universe [2]

By definition, a vacuum is a quantum field system. A review of advances in the formulation of quantum gravity is presented in [3], in this article we are not talking about the quantization of gravity, but about the quantum source of antigravity.

According to Gliner, the recession of galaxies is caused by antigravity, which is generated by the negative density of the vacuum [4, 5].

But, since vacuum is a quantum field system, if we accept the hypothesis of vacuum antigravity, it cannot be anything other than a force such as the Casimir force.

The negative density of the cosmological vacuum, therefore, is a violation of the energy dominance condition $\mathrm{e} \geq 0; |p| \leq \mathrm{e}; \mathrm{e} + 3p \geq 0$ in the framework of quantum field theory.

Thus, the Universe is a quantum system, as Hawking believed, but not in the sense of the wave functions of many Universes.

However, for different fields, the Casimir energy density depends on the dimension of space and geometry, in addition, divergences arise that

cannot be removed by choosing a regularization method or temperature corrections [6, 7].

For example, for a massless scalar field inside a cube: $e = -0,015/a$, where a is the edge of the cube. For the energy of the vacuum of the electromagnetic field inside the sphere $e = 0,0916/2r$. When approaching the surface of the sphere *r* = *R* the Casimir energy density $\varepsilon \approx const / R\rho^3, \rho \equiv R - r \ll R$ increases indefinitely. The vacuum energy in the parallelepiped *a x b x c* is positive at *a* = *b* = *c*, but changes sign when the resonator is pulled out. For a square section b = c, the energy is positive in the interval 0.408 < *c/a* < 3.48, passes through zero at the ends of the interval and is negative outside the interval. For a spinor field between parallel plates $E = -7p^2 / 2880a^3$ [7].

Secondly, the Casimir effect - in a limited space, inside a sphere, in a crystal, in the Universe as a whole, but not between two galaxies. Even in the one-dimensional case model, galaxies cannot serve as walls. Therefore, the calculation of the vacuum effect cannot include regularization. The repulsion effect has a quantum basis, but a classical form: in view of the negative vacuum density and violation of the energy dominance, effective negative mass and gravity with the opposite sign appear. Third, in the era of Λ - dominance for fields, the Casimir energy density of which decreases inversely with the radius, this density is 17-18 orders of magnitude less than the density of the cosmological vacuum. Consequently, the vacuum of these fields cannot pretend to be a source of antigravity.

New scalar field

The scalar field in the Higgs model is described by the equation

$$\partial_m \partial^m j + w_0^2 j + l j^3 / 2 = 0$$

The solution to this equation has the form of a soliton, which is unstable with respect to plane longitudinal and transverse long-wave fluctuations, in addition, if $m^2 < 0$, the field amplitude becomes imaginary if the mass is large, and the self-constant is small, the imaginary mass leads to a tachyon solution, respectively, if we choose from solutions $\exp[\pm(iwt)]$ physically meaningful, then to the attenuation of the field [8].

Thus, the Higgs field vacuum cannot serve as a source of antigravity.

The scalar field equations in the Albrecht, Steinhardt, Linde model are:

$$H = \frac{\dot{a}}{a} = \sqrt{\frac{2pG}{3}} m j \quad , \ddot{j} + 3H\dot{j} + m^2 j = 0$$

With a large Hubble constant (large "friction") oscillations are absent, a scalar field cannot generate particles. The field amplitude rapidly decreases to zero, the field ceases to play a role.

The oscillatory regime is possible only when friction, on the contrary, is small, but in this case the field spectrum is limited by one frequency (one particle).

Realistic models of elementary particles assume many types of scalar fields. For example, in the unified theories of weak, strong and electromagnetic interactions, there are at least two other scalar fields. In this case, two or three particles.

If the Hubble constant began to decrease, it should have passed the critical attenuation point, at this point the field also attenuates and cannot switch to an oscillatory mode.

In the first case, the square of the natural frequency can be negative, as in the Higgs Lagrangian, then the regime will also be oscillatory.

If friction is also negative, then the solution is determined by a characteristic equation similar to the Phidias equation; it coincides with the case of high friction, with increasing and damping parts [ibid.], See also [9].

In addition, the Casimir energy of a given scalar field also decreases with radius.

Scalar fields with friction [10], where the frequency ω_n is expressed in terms of the square of the Hermite polynomial H_n^2, and, since $\int_{-\infty}^{\infty} H_n(x)H_m(x)e^{-x^2/2}dx = \sqrt{2\pi}\,n!\,\delta_{nm}$, it is clear that the sum of the frequencies diverges, does not fit similarly. We write the potential of vacuum fields in the form:

$$V = \hbar c\sum_i \frac{k_i}{r} - \frac{1}{2}H^2 r^2$$

where summation is performed over all types of fields. Here the second term on the right-hand side corresponds to the Friedmann equations, the first is the generalized potential in the Casimir effect, where the constants *k* characterize the type of the field. The specificity of this potential is that it is not described by the Poisson equation $\nabla^2 V \neq -4\pi\rho$, where ρ - is the field density, since it includes the Casimir energy, and secondly, there is no point "charge" for which $V \sim m/r$, and the vacuum mass grows with a radius.

Since we are considering long distances, the first term can be omitted. Then the KGF equation for the new scalar field can be written by analogy with the KGF equation with an external field $\frac{\partial^2\varphi}{\partial t^2} - \frac{\partial^2\varphi}{\partial r^2} + (m^2 - H^2 r)\varphi = 0$.

The vacuum density is already contained in *H*, so the m^2 term is superfluous:

$$\frac{\partial^2 \mathrm{j}}{\partial t^2} - \frac{\partial^2 \mathrm{j}}{\partial r^2} - H^2 r \mathrm{j} = 0 .$$

This equation is not invariant under transformations of the Poincaré group, i.e. is not relativistic invariant. Therefore, we can offer the following form:

$$\frac{\partial^2 \mathrm{j}}{\partial t^2} - \frac{\partial^2 \mathrm{j}}{\partial r^2} - \mathrm{b} H^2 r \mathrm{j} = 0; \mathrm{b} \equiv (1 - v^2 / c^2)^{-1/2}$$

We are looking for a solution at low speeds, when the relativistic factor is close to unity.

Let us single out the class of solutions in which $\mathrm{j} = f(t)u(r)$ (the Goursat problem, [11, p. 172]) Within the framework of the ideology of classical mechanics, a system of two bodies is described using the gravitational force and the Hubble repulsive force, however, since the Hubble force grows with distance, and the force of gravity falls, the oscillatory regime does not occur. In addition, the "stiffness" of the pushing "spring" is negative. Therefore, instead of harmonic functions - exponential decay or rise:

$f \sim e^{\delta t}$, depending on d. Then

$$u'' - (H^2 r + \mathrm{d}^2) u = 0$$

This equation is the Riccati equation and has a solution

$$u = c_1 Ai\left(\frac{H^2 r - \mathrm{d}^2}{H^{4/3}}\right) + c_2 Bi\left(\frac{H^2 r - \mathrm{d}^2}{H^{4/3}}\right)$$

where *Ai* – Airy function, *Bi* - functions that differ in phase on $\mathrm{p}/2$ from the Airy *Ai*- function, describing an almost sinusoid with increasing amplitude and decreasing frequency. For $x \to \infty$ the function *Ai* decreases monotonically exponentially, and *Bi* for $x \to \infty$ monotonically increases exponentially.

Thus, the complete solution is written as:
$\mathrm{j} = (c_1 Ai + c_2 Bi)(c_3 e^{\mathrm{d}t} + c_4 e^{-\mathrm{d}t} + c_5)$. This solution cannot correspond to a quantum field, it does not generate particles and does not have a ground state.

Another class of solutions are harmonic oscillations of $f \sim e^{i\omega t}$, in which case the solution also includes Airy functions and is expressed similarly: $\mathrm{j} = (c_1 Ai + c_2 Bi)(c_3 e^{i\omega t} + c_4)$. Since at large distances the field cannot decay exponentially, then $c_1 = 0$,

$$j = c_2 Bi(\frac{w^2 + H^2 r}{H^{4/3}})(c_3 e^{iwt} + c_4)$$

Thus, the density of a given scalar field at small radii is inhomogeneous and periodic; at large distances it grows exponentially.

Conclusion

The equation for *u* is found in the theory of elasticity, in particular, if the argument is time, it describes the torsional vibrations of the DNA helix in the S-phase, when rotating replicative forks appear on the helix with a swing that increases with time, due to which the moment of inertia about the helix axis increases. The energy source is the enzymatic reactions inside the dividing cell. The question of the source of the scalar field growth is from the same category where the energy for inflationary expansion comes from.

The new scalar field is devoid of the shortcomings of scalar fields in the Higgs and Albrecht, Steinhardt, Linde models in terms of the formation of the Hubble law, so the vacuum of this field can serve as a source of antigravity. It is possible that all three fields are the same.

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APPLICATION POSSIBILITIES ENVIRONMENTALLY FRIENDLY INTELLIGENT MATERIALS BASED ON NIOBATES OF ALKALINE METALS IN ECHOTACHOHEMOPHONES

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Abstract. *The Doppler sensors of the separate-combined type used in the echotachohemophone - an indicator of the blood flow velocity are considered. Piezoceramic based on the (Na,Li)NbO_3 system, which does not contain lead, was used as a material for the sensors. The main electroacoustic parameters of the created acoustic sensors are presented in comparison with the sensors made using traditional PZT-based piezoelectric ceramics.*

Keywords: *ferroelectrics; piezoelectric ceramics; alkali metal niobates; devices; echotachohemophones.*

Introduction. The greening of modern industrial production of ferroelectric piezoelectric ceramics requires the creation of materials that do not contain toxic elements, primarily lead. This makes it necessary to develop compositions that differ from those traditionally used in piezoelectric technology and based on media with the participation of complex lead oxides $Pb(Ti,Zr)O_3$ system. Niobate alkali metals can act as such.

New functional materials and devices based on alkali metal niobates created in the process of performing the work, are described, as well as some of their non-traditional applications in practice.

Research results

An examination of the composition-structure-property relationships in

niobate systems shows that, in terms of the variety of combinations of parameters, they are significantly inferior to systems based on lead zirconate-titanate (PZT). This is facilitated, in particular, by a smaller difference in spontaneous deformation in different phases and a change in the dielectric constant in one direction during the polarization of the ceramic. Unlike systems based on PZT, in which materials for various applications can be obtained within the same system by varying the concentration of components, the choice of materials within a separate niobate system is very limited. This is partly due to the low values of the electromechanical coupling coefficient outside its maximum compared to the PZT compositions. The variation of properties is carried out here, mainly due to the transition from one system to another, i.e. by replacing or introducing new components. At the same time, individual characteristics of niobate materials are unique and are not realized in other solid solution (SS) systems, which makes them very promising for certain areas of application.

The advantages of the latter are:

- high velocity of sound, which determines the high-frequency (HF) range of operation of the transducer and allows obtaining a given frequency on less thin plates, simplifies the technology of manufacturing HF devices due to the possibility of increasing their resonant dimensions (this, in turn, is beneficial in terms of reducing the capacitance converter);

- low density (4.5 g/cm^3), leading, on the one hand, to a significant reduction in the weight of products, and on the other, to a decrease in acoustic impedance ($Z_a = \rho V_3^D = 27 \times 10^6$ kg/(m^{2}s) to match the acoustic load;

- very low dielectric constant ($\varepsilon T_{33}/\varepsilon_0$) for electrical matching with the generator load;

- increased thickness coefficient of electromechanical coupling (K_t = 0.48 ÷ 0.51), which characterizes the efficiency of the transducer in the echo mode and the receiving mode;

- low dielectric - tan δ, and moderate mechanical - 1/QM losses, important for short pulses and uniform frequency response.

In addition, the reproducibility of the properties of niobate ferroelectric piezoelectric ceramics is not inferior to piezoelectric ceramics based on PZT and significantly exceeds the reproducibility of the parameters of materials based on titanate and lead metaniobate.

Currently, one of the main areas of application of ultrasonic transducers are non-destructive testing of materials and medical diagnostics. Trends in their development are manifested in an increase in the operating frequencies of ultrasonic transducers, miniaturization of devices and the creation of multi-element structures. In medical diagnostic equipment, this

is necessary, first of all, to identify small objects:

- in ophthalmology - ultrasound measurement of corneal thickness, analysis of small eye structures;
- in osteometry - examination of the state of the bones of patients: cracks, fractures, calcium leaching;
- in cardiology - monitoring the state of the walls of blood vessels and heart valves.

PZT-based piezoelectric ceramics are used as the main material for ultrasound transducers of medical devices. However, in some specific applications and under certain operating conditions, its properties are not optimal, which requires the search for alternative materials. These materials include lead titanate and metaniobate, various ceramic-polymer piezocomposites, and ferroelectric piezoelectric materials based on alkali metal niobates.

The main advantage of niobate ceramics, which in the foreseeable future may become decisive when choosing piezoelectrical materials for use in medical sensors, alkali metal niobates does not contain toxic lead, the technology of their production, elements and products is environmentally friendly.

We have developed a series of alkali metal niobates based on stoichiometric solid solutions of sodium-lithium niobate, as well as compositions with an excess and deficiency of A- and B-cations (i.e., alkaline elements and niobium). It is shown that solid solutions of the composition $(l\text{-}x)NaNbO_3$ - $xLiNbO_3$, at $0.11 < x < 0.13$, are the best for these applications. In particular, at $x = 0.125$, the electrophysical parameters of the alkali metal niobates turned out to be optimal (Table 1).

Table 1

Electrophysical parameter	Value
Curie temperature, T_C, °C	356
Dielectric constant, $\varepsilon T_{33}/ \varepsilon_0$	102
Losses: - dielectric, tan δ, % - mechanical, Q_M	 2,09 271
Electromechanical coupling coefficients: - thickness, K_t - planar, K_p	 0,51 0,32
Piezoelectric module, d_{31}, pC/N	16

Piezoelectric constant, $g_{31} \cdot 10^3$, V·m/N	17,7
Sound velocity, V_R, km/s	5,56
Young's modulus, E_Y, GPa	126,4

First of all, this ferroelectric ceramics belongs to highly sensitive materials, i.e. it is characterized by increased sensitivity to mechanical stress, which is provided by a high value of the piezoelectric constant g_{31}. It is these materials that are used in flaw detection and medical diagnostic devices for the effective operation of piezoelectric transducers in the echo and reception modes.

The piezoelectric ceramics considered above was tested in separate acoustic sensors intended for use as part of an echotachohemophone - Doppler blood flow velocity indicator operating in the continuous radiation mode.

Previously, these sensors used exclusively piezoelectric ceramics based on PZT brands STS-19 and PKR-1. The tests of acoustic sensors were carried out, in which the alkali metal niobates were used as the emitter and receiver. The main electroacoustic parameters of such a sensor are shown in Table 2. Tests have shown the full applicability of this environmentally friendly non-lead-containing piezoceramics in the indicated sensors.

Table 2

Parameter name	**Value**
1. Working frequency, f_P, MHz	2; 4; 8
2. Emitter area, not less, cm^2	1,2
3. Active resistance at operating frequency: - receiver, R_r, Ohm - emitter, R_E, Ohm	 from 50 to 500 from 50 to 500
4. Acoustic isolation of the receiver and the transmitter of the sensor □ the ratio of the excitation voltage of the emitter to the voltage of the receiver at the operating frequency, L, dB, not less	40

Operating conditions:

- ambient temperature, °C	from 10 to 35
- relative humidity of ambient air at 25 °C,%	80
- atmospheric pressure, kPa	100 ± 4

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