SCIENTIFIC RESEARCH OF THE SCO COUNTRIES: SYNERGY AND INTEGRATION

上合组织国家的科学研究：协同和一体化

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小儿急性肾功能衰竭无尿期水平衡特点

FEATURES OF THE WATER BALANCE IN THE PHASE OF ANURIA OF ACUTE RENAL FAILURE IN INFANTS

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抽象的。 根据对 40 例 10 个月至 3 岁 4 个月期间因无尿 1 至 5 天入住 RSCEM ICU 的急性肾功能衰竭患儿的体液水平衡数据的研究， 揭示了以下内容：在治疗第一天无尿的三组患者中，输注介质的引入存在临床显着差异，其特征在于考虑到损伤程度和功能偏差加重的高风险相关的局限性 重要系统（中枢、心血管、呼吸系统）。 在第 1 组（600-1100 毫升/天）、第 2 组 - 500-1250 毫升/天、第 3 组 - 450-1400 毫升的儿童治疗的前 10 天，维持相对较小的每日饮水量/天。 提请注意第三组中仅在第 4 天排尿的最新出现。 肠外给药的增加导致第 1 组中 TPR (-0.52) 和 DBP (-0.67) 的降低。在第 3 组患者中，即使保留了自主呼吸，也有随着体积增加而加快呼吸的趋势 静脉注射 (0.51)。

关键词：水平衡，急性肾功能衰竭，儿童。

Abstract. *Based on the study of the data on the water balance of the fluid in 40 children with acute renal failure who were admitted to the ICU of the RSCEM with anuria from 1 to 5 days at the age of 10 months to 3 years 4 months, the following was revealed: a clinically significant difference in the introduction of infusion media in three groups with anuria on the first day treatment was characterized by a limitation associated with taking into account the degree of impairment and a high risk of aggravation of deviations in the function of vital systems (central, cardiovascular, respiratory). A relatively smaller volume of daily water administration was maintained during the first 10 days of treatment for children in group 1 (600-1100 ml/day), in group 2 - 500-1250 ml/day, in group 3 - 450-1400 ml/day. Draws attention to the latest appearance of urination only on the 4th day in the 3rd group. An increase in parenteral administration contributed to a*

decrease in TPR (-0.52) and DBP (-0.67) in group 1. In patients of group 3, even with preserved spontaneous breathing, there was a tendency to quicken breathing with an increase in the volume of intravenous injection (0.51).

Keywords: *water balance, acute renal failure, children.*

Relevance. One of the leading pathogenetic mechanisms for the development of acute renal failure is hypoxia of the renal parenchyma, caused by spasm of peripheral, including renal vessels, ensuring the adequacy of compensatory centralization of blood circulation in conditions of dehydration (hypovolemia), other stress reactions of the body to external, internal extreme influences. A feature of the function of organs and systems in infancy is hyperreactivity and rapid depletion of resources under conditions accompanied by compensatory mobilization of the ANS function. However, there is not enough information in the literature on monitoring water balance parameters in the anuric phase in children under 3 years of age with acute renal failure, which served as the basis for this study [1-4].

Goal of the work. To study the features of the dynamics of water balance in children with acute renal failure in the period of anuria at an early age.

Material and research methods. The data of hourly monitoring of hemodynamic parameters, daily fluid balance in 40 children with acute renal failure admitted to the ICU of RSCEM with anuria from 1 to 5 days at the age of 10 months to 3 years 4 months from the ICU of regional children's hospitals and branches of RSCEM were studied. Prior to admission to the clinic, all patients received anti-inflammatory therapy aimed at the treatment of ARI-2, pneumonia 26, glomerulonephritis - 9, AII-3 patients. According to the indications, due to severe progressive respiratory failure, patients were provided with invasive mechanical respiratory support from the first day. All patients underwent hemodialysis, 4 patients underwent hemodialysis in combination with plasmapheresis under the control of hemodynamics, acid-base status (ABS), respiratory system, supportive, antibacterial, anti-inflammatory, syndromic corrective intensive therapy according to the recommendations in the literature. Oxygen therapy was an obligatory component of complex intensive care with almost constant insufflation of FiO2-0.4. The need to increase FiO2 was noted mainly in patients of group 3 on the 17th and 26th days of treatment, which was associated with a decrease in the effectiveness of intensive care for pneumonia, MODS. A favorable outcome with the restoration of full functional activity of the kidneys and discharge from the hospital was observed in 30 children (groups 1 and 2), an unfavorable outcome in 10 children (group 3). The first group consisted of patients with the duration of intensive care in the ICU up to 10 days (14), the second - children (16) with a favorable outcome after intensive care for 11-65 days.

As shown in Table 1, intensive care in children of groups 2 and 3 significantly exceeded the duration of treatment in the ICU in group 1 by 20 or more days ($p<0.05$, respectively). In group 2, the duration of mechanical respiratory support (MRS) was 18.6 ± 8 days, in group 3, a longer MRS, unfortunately, did not improve the outcome of the disease.

Table 1.

Characteristics of patients

Groups	Age, month	Start of IVL, days	Duration of MRS, days	In ICU, days
1	29±2,8	0	0	7,8±1,5
2	19±7,7	4,3±3,5	18,6±7,6	27,8±4,3*
3	30,5±6,5	5,5±0,5	25,5±6,7	30,7±6,8*

* - the difference is significant relative to the indicator in group 1.

Results and its discussion.

As can be seen from those presented in Fig. 1,2,3 data, on day 1, the average values of the total volume of water injected were 400 ml in group 1, 474 ml in group 2, and 278 ml/day in group 3 (Fig. 1). That is, a more severe condition on the day of admission to the clinic limited the possibilities of correcting deviations in rheological properties, perfusion of capillaries of parenteral infusion therapy due to the need to limit the amount of water injected. The difference is not statistically significant due to the large scatter of indicators. the smallest in the most severe group 3, in group 2 the volume of infusion already on day 1 turned out to be 74 ml more than in group 1, in group 3 it was 96 ml less than in group 2. It is logical to assume that the clinically significant difference in the introduction of infusion media in anuria was due to a limitation associated with a high risk of aggravating dysfunction of vital systems (central, cardiovascular, respiratory).

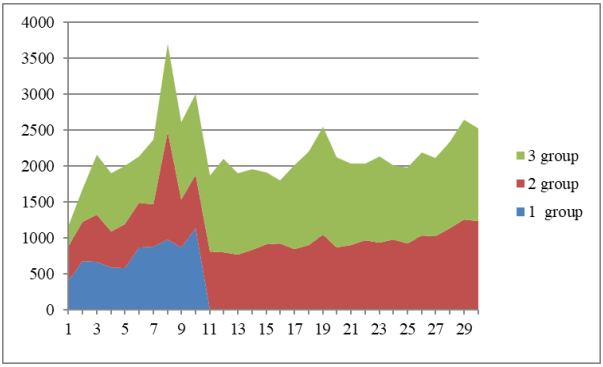

Figure 1. *Dynamics of the daily volume of infusion therapy depending on the severity of the condition up to 3 years, ml/day*

It is noteworthy that a relatively smaller volume of daily water administration remained during the first 10 days of treatment for children in group 1, amounting to 600-1100 ml / day (Fig. 2). While in 2 - 500-1250 ml / day, in 3 group - 450-1400 ml/day, characterized by a tendency to increase the introduction of daily volume in group 3 1050±191 ml/day.

Table 2.

Fluid balance in acute renal failure in infancy (from 10 months to 3 years 4 months) on the background of hemodialysis

Groups	Total, ml/day	i/i, ml/day	Inside, ml / day	Diuresis, ml/day
1	762±182	188±45	569±195	367±230
2	865±177	191±57	650±175	443±198
3	1050±191	178±56	870±171	292±152

Even more interesting was the almost complete absence of differences in the average volume of parenteral (intravenous) infusion therapy according to the severity of the condition by groups (Table 2). A larger daily volume of administration in group 3 was provided by a relatively large amount of enteral administration. It should be noted that this occurred in the complete absence of a targeted increase in water load in the most severe patients of group 3. Thus, the average amount of oral water in the 3rd group was 300 ml/day more than in the 1st group and 220 ml more than in the 2nd group. Despite the identified differences in water load, the average daily diuresis was the lowest in the heaviest children of group 3, that is, less than in group 1 by 75 ml/day, and 150 ml/day less than in group 2. Thus, it should be assumed that the opinion existing in clinical practice that an increase in the volume of oral fluid administration leads to an increase in the detoxification effect in critical conditions in children under 3 years of age is erroneous. This is confirmed by the relatively lower excretory activity of the kidneys in the heaviest children of the 3rd group.

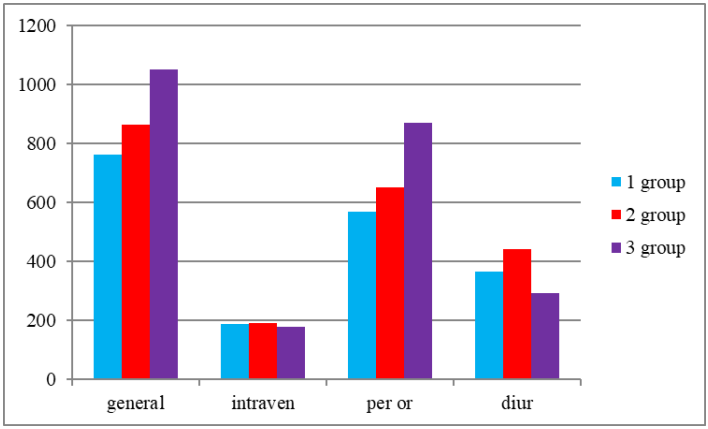

Figure 2. *Fluid balance in acute renal failure in infancy on the background of hemodialysis, ml/day*

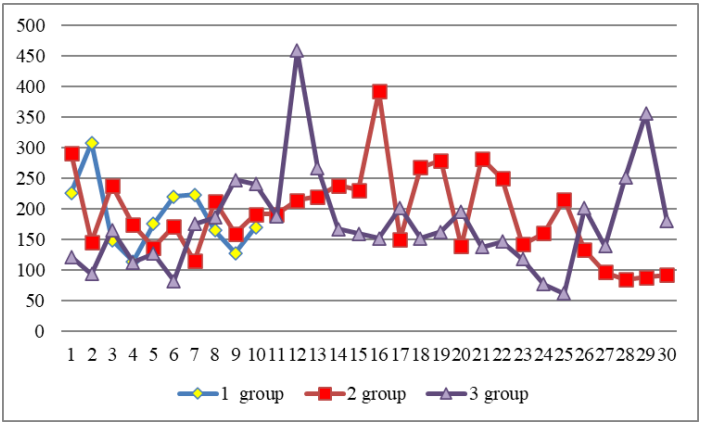

Figure 3. *Intravenous infusion therapy in the dynamics of acute renal failure up to 3 years, ml/day*

In group 1, the largest volume of intravenous infusion up to 300 ml was detected on day 2, in group 2, the volume of parenteral injection was the largest, amounting to 400 ml/day on day 16 with a gradual decrease to 100 ml/day on day 26 of treatment. While in group 3, an increase in intravenous injection was revealed on day 12 to 460 ml/day and again on day 29 to 370 ml/day (Fig. 3).

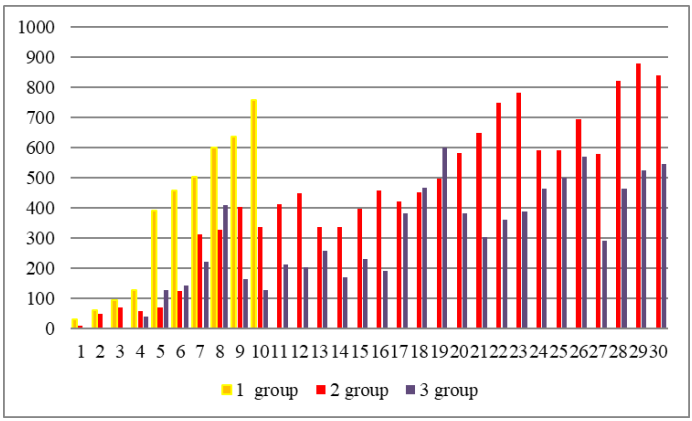

Figure 4. *Restoration of urinary activity in acute renal failure up to 3 years, ml / day.*

Gradual recovery of renal excretory function to normal in group 1 was detected on the first day in 2 patients, and on the 6th day in all children; -30 days with the restoration of diuresis in a volume of up to 800 ml / day. While in group 3, throughout the entire observation, urinary activity remained reduced with periods of fluctuation of 12, 9, 5 days. although diuresis appeared in a minimal amount already on day 1 (Fig. 4).

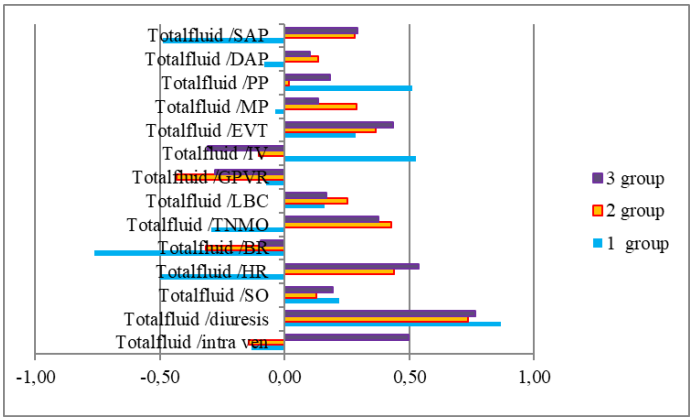

Figure 5. *Correlations of the dynamics of the daily volume of administration*

The found direct correlation between the change in the daily volume of fluid and the volume of diuresis characterizes mainly the hypovolemic genesis of anuria

in group 1, which is confirmed by a decrease in RR (-0.76) with an increase in infusion volume, a decrease in SBP (-0.5), heart rate (-0.5). In groups 2 and 3, the trend towards an increase in diuresis with an increase in the volume of daily water (0.73 and 0.76) also indicates the participation of dehydration in the pathogenesis of anuria. If in group 1 there was a tendency to a decrease in tachycardia with an increase in water load, then in group 3, on the contrary, an increase in infusion therapy increased the risk of aggravation of the tachycardia syndrome (0.54), in group 2 (0.44).

Only in group 1, a physiological reaction of hemodynamics to a change in the volume of intravenous infusion was revealed. Thus, an increase in parenteral administration contributed to a decrease in TPR (-0.52) and DBP (-0.67). In patients of the 3rd group, even with preserved spontaneous breathing in the first 6 days of intensive therapy, there was a tendency to increase, shortness of breath with an increase in the volume of intravenous injection (0.51) (Fig. 6).

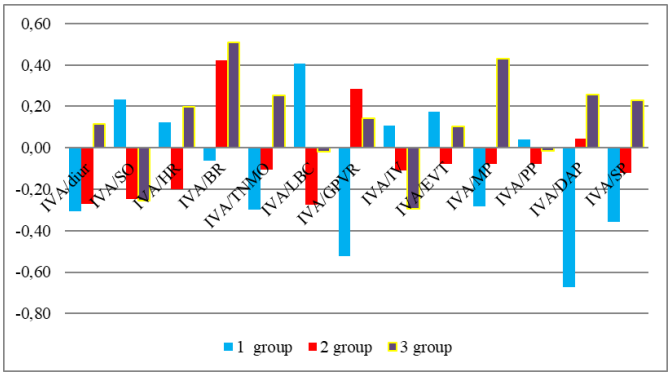

Figure 6. *Correlations of the dynamics of intravenous volume injection*

Conclusion. A clinically significant difference in the introduction of infusion media in the three groups with anuria on the first day of treatment was characterized by a limitation associated with a high risk of aggravating deviations in the function of vital systems (central, cardiovascular, respiratory). A relatively smaller volume of daily water administration was maintained during the first 10 days of treatment for children in group 1 (600-1100 ml/day), in group 2 - 500-1250 ml/day, in group 3 - 450-1400 ml/day. Draws attention to the latest appearance of urination on the 4th day in the 3rd group. An increase in parenteral administration contributed to a decrease in TPR (-0.52) and DBP (-0.67) in group 1. In patients of group 3, even with preserved spontaneous breathing, there was a tendency to quicken breathing with an increase in the volume of intravenous injection (0.51).

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儿童腹部手术后不良后果的预测因素
PREDICTORS OF ADVERSE OUTCOMES IN CHILDREN AFTER ABDOMINAL SURGERY

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抽象的。 鉴于儿童急腹症患病率高且术后并发症发生率高，本综述的目的是研究预测儿童腹部手术后并发症发生的问题。 该综述分析了有关寻找术后并发症预测因子的现有文献来源。 国内外作者发表的大量文章只涉及研究对象的狭隘方面，而没有涉及术后并发症这一关键的、系统性的问题。 这些情况决定了开展旨在制定系统性措施以减少急腹症儿童术后并发症及相关死亡率和残疾的综合研究的相关性。

关键词：急腹症，儿童，术后并发症，预后，预测因子，回顾。

Abstract. *Given the high prevalence of acute abdomen in children and the high frequency of postoperative complications, the purpose of this review is to study the problem of predicting the development of complications in children after abdominal surgery. The review analyzes the existing literature sources concerning the search for predictors of postoperative complications. Numerous publications by both domestic and foreign authors affect only the narrow sides of the object of research, without affecting the key, systemic issues of postoperative complications. These circumstances determine the relevance of conducting comprehensive studies aimed at developing systemic measures to reduce postoperative complications and associated mortality and disability among children with acute abdomen.*

Keywords: *acute abdomen, children, postoperative complications, prognosis, predictors, review.*

The urgency of the research is determined by the high frequency of acute abdominal pathology in children: 3% in the younger age group and up to 42% in the older children group in the structure of applications for surgical care. According

to the materials of contemporary literature, the incidence of post-surgical complications depends on the volume of surgical intervention and has a significant variability from 6% to 30%, which is explained by the lack of unified standards of classification and calculation methods of these complications.

In spire of the improvement of diagnostic techniques and the emergence of new surgical approaches, as well as preventive measures, including modern methods of antisepsis, perioperative rational antibiotic therapy, the complication rate in abdominal surgical interventions remains high and is about 4% - 17%. The complication rate requiring relaparotomy is 4% . The post-surgical complication rate only in uncomplicated appendicitis reaches 1.9%. In some chronic intestinal diseases, such as Crohn's disease, the post-surgical complication rate can reach from 25% to 30%.

The aim of this scientific review is to investigate the problem of predicting complications in pediatric patients after abdominal surgical interventions, which is an important aspect of preventive work.

The post-surgical complication is considered to be a new pathological condition, atypical for the normal course of the post-surgical period, at the same time not resulting from the progression of the main disease for which the patient has been operated on. Taking into account the current realities of practical medicine in the Russian Federation, it should be added that the development of this pathological condition occurs regardless of strict compliance with all approved clinical guidelines, quality criteria and/or temporary guidelines of the latest versions, and instructions to medical devices, instruments, products, and medications.

The post-surgery complications are differentiated into general, which are nonspecific and can occur after any type of surgical intervention, and specific, which are usually associated with the localization of surgical intervention and/or comorbid background.

The early post-surgical complications are likewise distinguished due to anesthetic factors associated with the toxic effects of narcotic substances on the respiratory system, circulation and disorders of acid-base, gas and water-electrolyte composition of blood, and the late complications, mainly related to the organs on which the surgical procedure was performed.

At present time, better system of the severity of post-surgical complications is developed which satisfies the requirements of standardization. This system is CCI (Comprehensive Complication Index) , which has undergone clinical validation . The Clavien-Dindo calculator and the related CCI calculator can be downloaded from www.assassurgery.com. This program can be installed on any electronic device and any physicians interested in improving the quality of surgical interventions can use this calculator completely free of charge in their research, complication severity assessments, medical and economic calculations and other standardized procedures.

The causes of post-surgical complications are divided into three groups: the first group of causes is associated with the patient's body and can be associated with individual characteristics, the constitution of the body, the influence of genetic and epigenetic factors, age - specific factors, growth and development, nutrition, environmental conditions, this group also includes factors of anesthetic risk, such as disorders of respiratory function during anesthesia, inhibition of mucociliary clearance and violation of lung drainage function etc. The second group of causes is associated with the organization of medical care, selection and training of medical personnel, violations of asepsis and antisepsis rules. The third group of causes includes directly the technique of surgical interventions and usually depends on the qualification of operating surgeons . It should be noted that the incidence of iatrogenesis associated with surgical treatment is 45%-48% and is divided into: diagnostic, organizational, tactical.

In addition to the causes of adverse outcomes and complications associated with surgical procedures, there is the concept of perioperative risk. Peri-surgical risk is defined as a multifactorial concept that can indicate the a priori probability of developing an adverse outcome or complication . In recent years, many modern authors in anesthesiology and surgery recommend assessing preoperative risk, which should be considered when making decisions on the management of patients, in order to improve peri-surgical outcomes .

The most popular peri-surgical risk assessment scale is the ASA (American Society of Anesthesiologists) scale , which is also used in pediatrics . However, in pediatric practice, this scale has shown low reliability due to subjective approaches based on the adult population. Modification of this scale to adapt it to pediatric practice has not yielded the expected results. In the Russian Federation, in addition to the ASA scale, the domestic pediatric MSSAR (Moscow Scientific Society of Anesthesiologists and Resuscitators) scale is also used in pediatric practice.

Assessing the risk of peri-surgical bleeding and acute massive blood loss is an important problem in pediatric surgery because children, especially young children, are prone to the rapid development of hemorrhagic shock. Risk assessment of hemorrhagic complications is mainly based on the assessment of the volume, nature and duration of surgical intervention. The criterion for massive intra-surgical blood loss is a bleeding rate of 2-3 ml/kg per minute or half of the circulating blood volume in 3 hours . The greatest risks of bleeding during abdominal interventions are observed during surgery for a large neoplasm, major vascular surgery, biliary sphincterotomy, hemorrhoid treatment, tissue biopsy of unclampable, puncture of arteries unclampable, endoscopic fine needle aspiration, any major surgery (duration over 45 min).

The incidence rate of thrombosis in children after surgery can be from 11% to 40%. The risk factors for increased thrombosis include the following: the age less

than 31 days; the age less than one year ; with past medical history of thrombosis ; the cardiac surgery or vascular interventions; the hepatic coagulopathy and related vitamin K-dependent peptide (protein C and S) deficiency ; the DVSC syndrome ; the increased complement activation time ; the acute kidney injury [30]; the congenital coagulopathy. The following are considered to be laboratory risk factors: elevated PAI-1 level; elevated levels of TAFI (thrombin activatable fibrinolysis inhibitor) and TGA; presence of cardiolipin antibodies; increased preoperative von Willebrand factor activity reduced antithrombin III activity ; elevated tPA level.

According to the literature, the large number of polymorphic gene mutations and their combinations, the presence of which can significantly increase the risk of thrombotic complications . For example, the relationship between single-nucleotide polymorphisms in PROC and PROS1 genes and deep vein thrombosis was revealed. Predisposition to venous thromboembolism has also been revealed in patients with factor V mutation . An association between genetic features of ADAMTS13 metalloproteinase, its level in plasma and predisposition to ischemic stroke in children has been established.

The role of genetic polymorphism of coagulation genes in the genesis of thrombotic complications in patients after abdominal surgery has not been studied sufficiently.

According to European studies, up to 1% of children operated under one year needed intestinal anastomoses; anastomosis failure in these patients reaches about 3.2% . It is generally accepted that suture failure in pediatrics is associated with surgical technique . The use of staplers has been suggested as a preventive measure. However, in adult surgical practice, attempts have been made to investigate predictors of anastomosis failure. The following predictors of anastomosis failure development have been identified: blood total protein concentration < 50 g/l, blood albumin content < 27 g/l, blood erythrocyte content < 3.1 × 1012/l, duration of surgery >140 min, combined and simultaneous interventions, COPD, anastomosis placement level < 6 cm relative to the dentate line, preoperative radiotherapy. Based on the identified prognostic criteria, the authors developed a scale, which allows to determine the probability of anastomosis failure and adjust the surgical intervention plan at the preoperative stage.

Hypoglycemia in the peri-surgical period is common in newborns and young children, and some congenital metabolic disorders may be noted in such children, such conditions as: chronic liver disease, parenteral nutrition, Beckwith-Wiedemann syndrome, diabetic embryo fetopathy, nesidioblastosis, congenital disorders of carbohydrate and fat metabolism, diabetes.

The risk group also includes children with the so-called “interrupted metabolic intoxication syndrome”, which is manifested by the fact that a child may be ad-

mitted to the intensive care unit with a diagnosis of "sepsis" without a septic focus and without bacteremia; however, against infusion therapy with glucose solutions with electrolytes, the condition rapidly improves and there may be even several such episodes during the life of the child\. When an "acute abdominal syndrome" develops in such a child, a consultation with a geneticist, biochemical screening for congenital metabolic defects, examination by tandem mass spectrometry and/or complete exome sequencing in order to establish the diagnosis accurately is indicated.

The various congenital genetic diseases also pose a risk of postoperative complications, which may be associated with abnormalities of the airway, chest shape, flabby muscles, decreased elasticity, phenomena of primary and secondary immunodeficiency. Such congenital diseases include: Down's disease, Turner's disease, Stickler's disease, Pierre Robin's disease, Mebius' disease, Marfan's disease, Morchio's disease, Ehlers-Danloh's disease and others.

In addition to obvious congenital malformations, one should pay attention to the stigmas of dysembryogenesis; in the presence of 5 or more stigmas, an extended diagnostic search should be performed to exclude congenital genetic or epigenetic diseases, and/or connective tissue dysplasia syndrome. Connective tissue dysplasia syndrome (CTD) is also a risk factor for post-surgical complications. In particular, it was found that children with STD syndrome are prone to develop postoperative adhesions . The following signs of connective tissue dysplasia were found most frequently in children with adhesions after appendectomy: decreased weight-for-height index according to the Varga index <1.5, hypermobility of joints and asthenic body type, flat feet, bad posture or scoliosis. Professor V.M. Yakovlev and his students calculated diagnostic and informative coefficients based on the data on the frequency of STD signs in adolescents and young adults to determine the possibility of "mathematical support" of the clinical diagnosis and prognosis of the course of dysplastic process in a particular patient. The Wald sequential recognition procedure, when summarizing the diagnostic coefficients and reaching the diagnostic threshold of +17, allows making a conclusion about the presence of the condition "connective tissue dysplasia".

Predisposition to the development of peritoneal adhesions disease (PAD) in children was also proposed to detect by the value of the average transmittance of infrared radiation in the wavelength range of 3500-3200 cm-1 through the blood of a patient. For this purpose, a hardware-software complex "IKAR" was developed. Special diagnostic rules were developed, and according to these rules the successful classification is 99.3% (priority certificate № 2004109173/14 from 26.03.04).

Under proper post-surgical anesthesia, timely recognition of post-surgical complications can also be difficult. Therefore, one of the promising areas of timely recognition of post-surgical complications is the early use of instrumental meth-

ods of investigation, which allow intensivists to work proactively, long before the development of significant clinical manifestations of post-surgical complications.

Nowadays, there is no register of complications in pediatric abdominal surgery, both at the federal and regional levels. Accounting, analysis, and prevention of early postoperative complications are carried out only in single medical organizations.

Among the organizational factors influencing the spread of post-surgical complications are the following: the ratio of nurses per patient is higher, the level of equipment is higher, the size of the hospital is 200 beds or more, the hospital is the clinical base of the university, the number of operations exceeds 50% in the region.

Thus, the main risks and possible complications of surgical interventions in children during abdominal surgical interventions are widely covered in the current literature; however, the analyzed material does not reflect a comprehensive approach to the treatment of patients, taking into account the specifics of the disease.

A comprehensive approach, including preoperative examination, intraoperative monitoring of the patient's condition and appropriate post-surgical management of the patient, close interaction of anesthesiology, surgery, and diagnostic services, a complete multidisciplinary approach, allows us to achieve an optimal result.

Conclusions:

1. There is no generally accepted and universal system for predicting the post-surgical course in pediatric abdominal surgery. This fact necessitates the development of a comprehensive approach to the prediction, diagnosis and prevention of post-surgical complications.

2. When predicting the risks of post-surgical complications, it is reasonable to take into account the patient's state of health that can be evaluated using all the data obtained by a physician at all stages of surgical treatment of the patient.

3. It requires specification of risks, assessment of causes and development of preventive measures, which is the basis for the development of patient management programs, depending on the pathological process model, aimed at eliminating undesirable outcomes, both at the preoperative and post-surgical stages of medical care.

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肝闪烁显像与SPECT/CT肝功能指标对比评估

COMPARATIVE ASSESSMENT OF LIVER FUNCTION INDICATORS ACCORDING TO HEPATOSCINTIGRAPHY AND SPECT/CT

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抽象的。 带有锝 99m 标记的亲肝放射性药物 (RP) 的动态肝脏闪烁扫描是评估肝脏功能状态和确定手术干预期间以术后肝衰竭形式出现严重并发症的风险的重要方法，尤其是广泛的肝切除术。 这篇文章致力于根据使用 99mTc-mebrofenin 和 99mTc-phytate 的动态肝闪烁显像确定肝功能定量评估的最具信息量的指标。 根据 Ekman 等人的分析，肝脏清除率指数之间存在很强的相关性。 (1996) 根据 SPECT/CT 数据，肝脏摄取放射性药物的百分比，证明其足以定量评估肝功能。 传统的幅值-时间指标表征肝区“时间-活度”曲线的增加速率及其幅值与背景的比值，与肝脏放射性药物摄取水平相关性弱，不能作为可靠的指标 评估肝功能的标准。

关键词：肝显像，99mTc-mebrofenin，99mTc-植酸盐，肝功能定量评估。

Abstract. *Dynamic liver scintigraphy with technetium-99m labeled hepatotropic radiopharmaceuticals (RP) is an important method for assessing the functional state of the liver and determining the risk of a formidable complication in the form of postoperative liver failure during surgical interventions, especially extensive liver resection. The article is devoted to determining the most informative indicators of the quantitative assessment of liver function according to dynamic hepatoscintigraphy using ^{99m}Tc-mebrofenin and ^{99m}Tc-phytate. The analysis showed*

a strong correlation between the liver clearance index according to Ekman et al. (1996) with the percentage of radiopharmaceutical uptake by the liver according to SPECT/CT data, which justifies its adequacy for quantitative assessment of liver function. Traditional amplitude-time indicators characterizing the rate of increase in the "time-activity" curve in the liver region and the ratio of its amplitude to the background, weakly correlated with the level of radiopharmaceutical uptake in the liver, so they cannot serve as reliable criteria for assessing liver function.

Keywords: *hepatoscintigraphy, ^{99m}Tc-mebrofenin, ^{99m}Tc-phytate, quantitative assessment of liver function.*

Introduction

Currently, the surgical method is the main one in the treatment of primary and metastatic liver tumors. Surgical interventions for primary liver cancer are performed in 20-35% of cases, and for metastatic cancer - in 20%. With extensive liver resections, the main complication is the development of liver failure, so determining the function of the liver as a whole, as well as its anatomical sections, is important [1]. In this regard, scintigraphic methods for examining the liver have a significant advantage over most other methods [2, 3]. For hepatoscintigraphy, technetium-99m-labeled hepatotropic radiopharmaceuticals with different mechanisms of absorption and transport in the liver are used. So ^{99m}Tc-mebrofenin is absorbed by hepatocytes and rapidly excreted with bile into the intestine, 99mTc-phytate accumulates in structures containing cells of the reticuloendothelial (macrophage) system, mainly in the liver. Domestic analogues of the above radiopharmaceuticals - ^{99m}Tc-mebrofenin and ^{99m}Tc-phytate - in the Russian Federation have the trade names ^{99m}Tc-Bromeside and ^{99m}Tc-Technefit, respectively.

Currently, to assess the functional state of the liver, when analyzing the results of hepatoscintigraphy, various quantitative indicators are used, including amplitude-time indicators that characterize the rate of accumulation of activity in the liver, the level of accumulation of radiopharmaceuticals in the liver relative to the tissue background, and others. In recent years, the most commonly used indicator of the functional state of the liver in hepatoscintigraphy with ^{99m}Tc-mebrofenin is liver clearance according to Ekman et al. (1996), based on a mathematical model [4]. The most accurate assessment of liver function is extremely important when planning surgical interventions, especially major liver resections, in order to avoid complications in the form of post-resection renal failure [1, 5, 6]. The choice of the most significant quantitative criteria for assessing liver function during hepatoscintigraphy can be based on the search for the best correlation with the uptake of radiopharmaceuticals by the liver, which can currently be determined from SPECT/CT data.

The aim of this study is to determine the most significant quantitative criteria for assessing hepatocyte and macrophage liver function by correlation analysis

of the most used quantitative indicators of dynamic hepatoscintigraphy with the amount of radiopharmaceutical capture according to SPECT/CT data based on paired hepatoscintigraphy with ^{99m}Tc-mebrofenin and ^{99m}Tc-phytate, performed sequentially with an interval within a few days in patients with a planned liver resection.

Materials and methods

Hepatoscintigraphy using ^{99m}Tc-mebrofenin (Bromeside) and ^{99m}Tc-phytate (Technefit) was performed in 54 patients with primary and metastatic liver cancer in order to choose treatment tactics. Thirty-four patients had liver metastases, 12 had hepatocellular liver cancer (HLC), and 8 had cholangiocellular liver cancer (CLC). All patients were examined at our Center from January 2020 to December 2022. The age of the patients ranged from 24 to 83 years (mean age 60.9 ± 12.4 years). According to the Child-Pugh scale, 45 patients were classified as Child-Pugh A, 7 as Child-Pugh B, 2 as Child-Pugh C. In 40 of 54 patients, a major liver resection was subsequently performed.

Radionuclide studies were performed on a Discovery NM 670 SPECT/CT system (GE Healthcare). All patients underwent liver scintigraphy using both radiopharmaceuticals (^{99m}Tc-mebrofenin and 99mTc-phytate) with an interval of 1-3 days between studies. After intravenous administration for 6 minutes, dynamic scintigraphy was performed at 10 seconds/frame. In the study with ^{99m}Tc-phytate, static scintigraphy and liver SPECT/CT (with absorption and scatter correction) were performed immediately after dynamic scintigraphy. Hepatic uptake of 99mTc-phytate was determined using Q.Metrix software. Also, the following amplitude-time indicators for assessing dynamic hepatoscintigraphy in the anterior projection were calculated: an increase in the count of impulses from the liver region in the intervals of 50-150 and 150-350 seconds, the amplitude/background ratio (by 350 s). Liver clearance for ^{99m}Tc-mebrofenin was calculated using the known formula of Ekman et al. [4]. In the study with ^{99m}Tc-phytate, an adapted formula was used that also took into account the absorption of radiopharmaceuticals in the spleen (accumulation in the bone marrow due to smallness was not taken into account), which consisted in the fact that the L(t) values describing the "time-activity" curve in the region of interest (ROI) of the liver were replaced by the total value of the ROI of the liver and spleen. This does not contradict the Ekman model, which in principle is universal and acceptable for various hepatotropic radiopharmaceuticals, adjusted for the features of pharmacokinetics, and completely coincides with the mathematical logic of the formula. Thus, the total radiopharmaceutical clearance was calculated according to the Ekman model (for the liver and spleen), to calculate the actual liver clearance, the total radiopharmaceutical clearance was multiplied by the proportion of radiopharmaceutical

capture by the liver relative to the amount with the spleen. Ekman liver clearance values were calculated in two versions: with and without normalization to the body surface (BSA). The correlation of the above quantitative indicators with the percentage of 99mTc-phytate uptake by the liver relative to the administered activity, obtained from SPECT/CT data, was further investigated. Correlation between variables was determined by calculating the Pearson correlation coefficient (r). The significance level was taken equal to 0.05.

Results and discussion

The results for the entire spectrum of quantitative indicators of hepatoscintigraphy with ^{99m}Tc-mebrofenin and ^{99m}Tc-phytate are presented in Table 1. Their analysis revealed no significant differences between the corresponding indicators of the rate of accumulation of radiopharmaceuticals in the "time-activity" curve from the liver region in the intervals of 50-150 and 150- 350 seconds, as well as Ekman liver clearance for both radiopharmaceuticals. The ratio of their mean values practically did not differ from unity. The mean value of the "amplitude / background" indicator (at 350 s) in the study with 99mTc-mebrofenin was higher than with ^{99m}Tc-phytate, their ratio was 0.862, however, the difference between these values did not exceed the level of statistical significance ($p > 0.1$).

Table 1

Quantitative indicators of hepatoscintigraphy with ^{99m}Tc-mebrofenin and ^{99m}Tc-phytate

Indicators of hepatoscintigraphy	Research with ^{99m}Tc-mebrofenin (n=54)		Research with ^{99m}Tc-phytate (n=54)		Ratio of averages (Meb/Phyt)
	M ± m	range	M ± m	range	
The rate of accumulation of radiopharmaceuticals in the liver (% / min):					
a) in the interval (50-150 s)	50,98±1,71	20,1-71,67	50,25±1,83	9,47-90,51	1,014
b) in the interval (150-350 s)	14,63±0,33	9,99-22,90	14,53±0,43	7,37-22,05	1,006
Amplitude/background ratio (for 350 s)	27,34±1,78	6,59-22,89	31,72±2,19	5,85-71.16	0,862
Liver clearance modeled by Ekman et al. (%/min)	11,28±0,44	3,73-19,02	11,33 ± 0,54*	1,02 -17,63	0,995

Ekman et al. Liver Clearance Normalized to Body Surface (BSA) (%/min/m^2)	6,09 ±0,256	1,58-10,02	6,01 ± 0,53*	0,91 - 9,51	1,013
Capture ^{99m}Tc-Phytate in the liver (%)	-	-	60,33 ±1,83	27,94 - 84,67	-
Capture ^{99m}Tc-Phytate in the spleen (%)	-	-	8,40 ±1,01	2,65 - 45,39	-

*Note: Liver clearance calculated from an adapted model from Ekman et al.

Correlation analysis showed that the traditional amplitude-time indicators characterizing the rate of increase of the "time-activity" curve from the area of interest of the liver showed no or weak correlation with the amount of ^{99m}Tc-phytate uptake by the liver at both time intervals within a 6-minute dynamic scintigraphy. The amplitude/background ratio at 350 seconds of the study showed a relatively higher correlation with the amount of ^{99m}Tc-phytate uptake by the liver (r = 0.482), that is, on the border of weak and moderate correlation (Table 2). The obtained results testify to the low reliability of amplitude-time indicators for assessing liver function.

Correlation with hepatic ^{99m}Tc-phytate uptake for all 99mTc-mebrofenin hepatoscintigraphy scores was very weak or absent. At the same time, for Ekman liver clearance values between ^{99m}Tc-mebrofenin and ^{99m}Tc-phytate, it was 0.639 and 0.591 for normalized and non-BSA values, respectively, indicating a moderate correlation.

Table 2

Correlation of quantitative indicators of planar hepatoscintigraphy with 99mTc-phytate uptake in the liver according to SPECT/CT data

Quantitative indicators of hepatoscintigraphy	**Units**	**Correlation coefficient (r)**	
		^{99m}Tc-phytate	**^{99m}Tc-mebrofenin**
The rate of accumulation of RP in the liver (in the range of 50-150 s)	%/min	0,303	0,072
The rate of accumulation of RP in the liver (in the range of 150-350 s)	%/min	-0,055	-0,328
Amplitude/background ratio (for 350 s)	rel. units	0,482	0,128
Liver clearance modeled by Ekman et al.	%/min	0,711	0,259
Liver clearance modeled by Ekman et al. normalized to Body Surface (BSA)	%/min/m2	0,641	0,176

Liver clearance according to the adapted model of Ekman et al.	%/min	0,542*	-
Liver clearance according to the adapted model of Ekman et al., normalized to the body surface (BSA)	%/min/m2	0,896*	-

***Note**: Correlation with total RP uptake in the liver and spleen

Analysis of the model adapted for ^{99m}Tc-phytate by Ekman et al. showed the following. Liver clearance had a strong correlation with the percentage of ^{99m}Tc-phytate uptake by the liver ($r = 0.711$,). The correlation between total radiopharmaceutical clearance and total ^{99m}Tc-phytate uptake in the liver and spleen was moderate ($r = 0.542$), but after normalization to body surface area, a significantly stronger correlation was obtained ($r = 0.896$, $p < 0.001$). The data obtained indicate the clinical validity of the mathematical model of Ekman et al. They are consistent with the literature data on a significant correlation between the Ekman liver clearance index and the clearance of ^{99m}Tc-mebrofenin measured by radiometry of blood samples [5,6]. The data obtained in our work show that normalization to the body surface can significantly improve its correlation with the uptake of radiopharmaceuticals by the liver. According to the literature, in adult patients with a planned liver residual threshold of 2.7%/min/m^2 on hepatobiliary scintigraphy with ^{99m}Tc-Mebrofenin, the risk of developing postoperative liver failure is minimal [2, 3.7].

Thus, between the capture of radiopharmaceuticals according to SPECT/CT data and planar scintigraphy, the strongest correlation was found for the Ekman liver clearance indicator, which justifies it as the most reliable indicator for assessing liver function.

Conclusion

A strong correlation between 99mTc-phytate uptake by the liver (according to SPECT/CT data) and liver clearance according to the Ekman model in dynamic hepatoscintigraphy with both radiopharmaceuticals (99mTc-phytate and 99mTc-mebrofenin) indicates the adequacy of the latter for assessing the rate of radiopharmaceutical uptake by the liver from the blood in planar dynamic scintigraphy and, therefore, the validity of its use for the quantitative assessment of liver function with hepatotropic radiopharmaceuticals. Normalization to the size of the body surface increases the accuracy of this indicator. Traditional amplitude-time indicators based on an isolated assessment of the “time-activity” curve of the liver area and the “amplitude / background” ratio weakly correlate with the uptake of radiopharmaceuticals by the liver and cannot serve as reliable indicators for assessing its function.

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言语发育障碍儿童的脑电图特征
EEG FEATURES IN CHILDREN WITH SPEECH DEVELOPMENTAL DISORDERS

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Abstract. *The paper presents the significance of electroencephalographic (EEG) examination in the diagnosis of speech developmental disorders (SDD) in children, taking into account the two-level screening of mental developmental disorders. Children with SDD undergo an EEG examination, including functional tests, and video monitoring of daytime sleep, which makes it possible to establish a diagnosis, select treatment and correction tactics. The most common features of the bioelectrical activity of the brain in children associated with the clinical manifestations of SDD, compared with healthy peers, are considered. The features characteristic of SDD are shown: a higher total power of the theta rhythm and a reduced total power of alpha, beta and mu rhythms, as well as the presence of benign childhood epileptiform discharges.*

Keywords: *electroencephalography, speech development disorders, diagnostics, children.*

Speech development disorders (SDD) in children are among the most common in the child population, and, according to various estimates, occur in 5-20% of cases of psychological development disorders (F80-F89 - ICD 10) [1]. The emergence of SDD is due to various factors, among which the most common are recognized: perinatal factors (75-85% of children with speech disorders had a his-

tory of negative antenatal risks) [2]; genetic factors (in families with a burdened history, the frequency of occurrence is 20-30%) [3]; gender - boys suffer 2-4 times more often than girls [4]; environmental factors (unfavorable social environment).

In this regard, early, high-quality diagnosis of SDD is extremely relevant, including complex examinations: electroencephalography (EEG), doppler ultrasound (DUS) of the arteries of the head, echoencephaloscopy (Echo-ES), magnetic resonance imaging (MRI), genetic diagnostics, as well as consultations of specialists, primarily a speech therapist and a neurologist. EEG allows you to determine the degree of maturity of the cerebral cortex and determine which structures are affected; on ultrasound of the arteries of the head, the state of the vessels of the brain is assessed; Echo-ES evaluates the structure and functional state of the brain, reveals the presence of its lesions; MRI of the brain (with special indications) allows you to clarify the diagnosis in difficult cases; genetic diagnosis: XMA or high-throughput sequencing (the "Mental retardation and ASD" panel) helps to identify hereditary factors that cause delayed speech development [14].

To diagnose SDD in children in Russia, a two-level screening of mental developmental disorders is used [12]. The first level of screening includes preventive examinations for children who have reached the age of two years and a survey of parents to identify risk groups for developing SDD. The second level of screening includes a physical examination, a general examination, a consultation with a neurologist and doctors of other specialties according to indications. If differential diagnosis with other mental disorders is necessary, electroencephalological examinations are recommended in young children: EEG diagnostics are performed with video monitoring during sleep and wakefulness. EEG makes it possible to determine the localization and degree of brain damage, as well as to identify epileptiform activity and signs of organic brain damage [13]. There are objective problems in the diagnosis of SDD in children, associated, for example, with age. So, when a diagnosis is made at an early age, at a later age, the indicators improve due to the natural development of the child. There are also certain difficulties in the differential diagnosis between SDD and mental retardation [5].

Currently, an EEG examination is a fairly effective method of instrumental diagnosis of SDD, which allows assessing the functional activity of the brain, excluding focal, organic pathology of the brain, identifying signs of epileptiform activity, and assessing the functional state of the mid-stem structures. As a rule, children with SDD undergo an EEG examination, including functional tests during wakefulness, and video monitoring of daytime sleep. Examinations are carried out according to the generally accepted methodology with the location of the electrodes in accordance with the international scheme "10-20". EEG video monitoring is carried out against the background of sleep deprivation, which includes a recording of daytime sleep lasting 2 hours. EEG examination allows timely diagnosis, selection of tactics for treatment and correction of SDD [6].

According to N.S. Rozinkova, in the group of children with SDD, general diffuse changes ($p < 0.01$), high-amplitude pointed unstable alpha rhythm ($p < 0.01$), single and group polyphasic delta waves ($p < 0.05$), acute slow waves ($p < 0.05$); Statistically significant changes were also revealed: general diffuse changes ($p < 0.01$), signs of interest in the mid-stem structures (MSS) ($p < 0.01$), high-amplitude pointed unstable alpha rhythm ($p < 0.01$). Statistically significant changes were also found in the registration of benign childhood epileptiform discharges (BCED), beta activity, and polyphasic theta waves ($p < 0.01$). The occurrence of BCED is associated with the immaturity of the cortex, these benign phenomena depend on age, and are due to the structural features and functions of the hippocampus, the amygdala, as well as the immaturity of the GABA-ergic system.

The alpha range is the dominant background pattern in the waking state with normal functioning of neural connections, however, its amplitude and temporal changes may indicate pathological manifestations. Thus, a high-amplitude pointed rhythm is found in children with moderate speech disorders. An increase in the amplitude of the alpha range reflects inhibition, and a decrease in the amplitude reflects release from inhibition. The reasons for the high-amplitude rhythm may be overexcitation of the cerebral cortex, dysfunction of the subcortical and stem structures, as well as morphological and functional immaturity of the cortical structures. The absence of a change in amplitude indicators may indicate a gross organic lesion of the brain, for example, a glial scar, since no bioelectrical activity is generated in the area of neuronal death. This observation will be relevant for differential diagnosis and mechanisms of development of severe and moderate speech disorders in children. The detection of slow-wave activity is associated with dystrophic processes, demyelinating and degenerative lesions of the brain, with compression of the brain tissue, hypertension, as well as with the presence of some lethargy, deactivation phenomena, and a decrease in the activating effects of the brain stem [14].

In addition, there are other signs and markers of SDD that can be identified on the EEG recording. Thus, the amplitude of the delta and theta range can be a marker of dyslexia [7]. At the age of 1-3 years, in children with SDD, the total power (TP) of the theta rhythm increases in the frontal and central regions and the OM of the alpha rhythm decreases, compared with healthy peers. A decrease in the TP of the alpha rhythm may be associated with a delay in the maturation of the cerebral cortex. With drug treatment of SDD, an increase in TP alpha rhythm is noted. The mu rhythm (sensory-motor or arcoid rhythm) is also a sign of cortical maturation. In children with SDD, there is a decrease in the mu rhythm. The beta rhythm of frontal localization is important for the syntactic processing of speech. For children with SDD, a decrease in the TP of the beta rhythm is also characteristic, in comparison with healthy children [8]. Children aged 4–8 years

are characterized by a higher TP of the theta rhythm in the parietal areas and a reduced TP of the alpha rhythm, in comparison with healthy children [9]. According to Kuznetsova E.A., according to the results of EEG examination and EEG video monitoring, 72% of children with SDD showed signs of epileptiform activity in the form of outbreaks of local and diffuse acute waves and spikes, despite the absence of epileptic seizures in history. In 30% of the examined, multiple sharp waves were found. According to EEG-mapping of the brain, in all cases, acute-wave activity prevailed in the frontal leads. The data obtained indicate a high incidence of dysfunction of brain stem structures and epileptiform activity in children with SDD [10].

Conclusion.

Thus, the need for early diagnosis of developmental speech disorders requires the use of objective, clinically valid methods of examination, such as electroencephalography. These studies (EEG and video-EEG monitoring) allow us to identify markers characteristic of speech developmental disorders, such as a higher total power of the theta rhythm and a reduced total power of alpha, beta and mu rhythms, as well as the presence of benign epileptiform ranks of childhood.

EEG examinations are a fairly effective method for diagnosing developmental speech disorders, since EEG changes, depending on the severity of the disorder, are recorded in 46-70% of children with SDD.

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细胞因子谱的变化作为服用 EGFRi 的癌症患者皮肤毒性表现严重程度的标准

CHANGES IN CYTOKINE PROFILE AS CRITERIA FOR SEVERITY IN THE MANIFESTATION OF SKIN TOXICITY IN CANCER PATIENTS TAKING EGFRI

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抽象的。 表皮生长因子（EGFR）受体的结合是治疗肺癌、结肠癌、胰腺癌、头颈癌的良好靶点。 由于治疗而出现的不良事件，以皮肤和粘膜病变的形式出现，是医生选择长期治疗策略的一个严重问题。 皮肤毒性的发展症状，因为患者的皮肤问题通常被称为，是令人担忧的，并且经常影响生活质量和对治疗方案的依从性。 因此，了解与使用表皮生长因子的酪氨酸激酶受体抑制剂相关的皮肤毒性的先决条件和方法对医生来说非常重要。 描述了 EGF 受体激活的机制和后果，以解释与抑制表皮生长因子受体相关的不良皮肤毒性的发展。

关键词：皮肤毒性； 表皮生长因子受体； 靶向药物； 肿瘤病理学； 信号通路。

Abstract. *The binding of epidermal growth factor (EGFR) receptors is a good target for the treatment of lung, colon, pancreatic, head and neck cancers. The adverse events that develop as a result of therapy, in the form of lesions of the skin and mucous membranes, is a serious problem for the doctor to choose a long-term treatment strategy. The developing symptoms of skin toxicity, as skin*

problems in patients are often called, are worrisome and often affect the quality of life and compliance with the treatment regimen. Thus, it is important for doctors to know the prerequisites and ways to manage skin toxicity associated with the use of tyrosine kinase receptor inhibitors of epidermal growth factor. The mechanism and consequences of EGF receptor activation are described to explain the development of undesirable skin toxicity associated with inhibition of the epidermal growth factor receptor.

Keywords: *Skin toxicity; Epidermal growth factor receptor; Targeted drugs; Oncopathology; signaling pathways.*

Introduction.

Undoubtedly, the treatment of cancer today is an urgent problem. According to the latest data, there were more than 2 million cases of cancer only in 2020. The third most common is colorectal cancer. Thus, in 2020, more than 1.9 million new cases and 930,000 deaths were detected. By 2040, the incidence rate is projected to rise to 3.2 million new cases and 1.6 million deaths, with the majority of cases occurring in countries with high or very high Human Development Index [1].

According to statistics, in 2022, 4.8 million cancers were initially diagnosed in China, of which colorectal cancer accounted for 592,232 cases, which is 12%. Cancer mortality is also high: of the 3.2 million cancer deaths, colorectal cancer accounts for 9.6%.[2]

EGFR inhibitors have become an integral part of antitumor therapy. Thanks to these drugs, the survival rate of patients has increased, and the treatment has become more tolerable in comparison with cytotoxic drugs [3]. However, during the action of EGFRi, keratinocyte proliferation slows down and their apoptosis is induced, and therefore cytokines accumulate in the skin. This leads to such undesirable phenomena as acne-like rash, xerosis, cracks, itching, paronychia, hypertrichosis, etc. Studies have shown that 75% to 90% of patients treated with EGFRi therapy , experience some form of skin toxicity, which often leads to a deterioration in the quality of life, which manifests itself in physical and psychological discomfort, and as a result, antitumor therapy becomesless effective due to interruptions in treatment, dose reduction or complete cancellation [4].

Understanding the correlation of the action of EGFRi, the immune response by cytokines and the resulting negative effects on the skin is the basis for the creation of complex therapy aimed atreducing the toxic effect on the skin and maintaining the effectiveness of treatment with anticancer drugs, the point of application of force of which is EGFR.

The aim of this work was to study the severity of skin toxicity in patients with EGFRi.

Materials and methods.

The analysis was carried out on serum taken from patients with severe skin lesions of 3 or more severity on the 5th day from the start of therapy with EGFR inhibitors. 57 patients had colorectal cancer and 24 lung cancer.

Multiplex analysis was used on 81 serum samples, based on flow fluorometry of polystyrene microspheres labeled with fluorophores in various ratios.

In this study, a panel of magnetic particles was used to determine human cytokines/chemokines MILLIPLEX MAP Human Cytokine/ Chemokin in conjunction with the Luminex xMAP plate. This technique allows us to focus on the therapeutic potential of cytokines and on the modulation of cytokine expression. The panel includes cytokines/chemokines:

sCD40L, VEGF, TNF-β, TNF-α, TGF-α, RANTES, PDGF-AB/BB, PDGF-AA, MIP-1β, MIP-1α, MDC (CCL22), MCP-3, MCP-1, IP- 10, IL-17A, IL-15, IL-13, IL-12 (p70), IL-12 (p40), IL-10, IL-9, IL- 8, IL-7, IL-6, IL-5, IL-4, IL-3, IL-2, IL-1ra, IL-1β, IL-1α, IFN-γ, IFN-α2, GRO, GM-CSF, G-CSF, Fractalkine, Flt-3 ligand, FGF-2, Eotaxin, EGF.

As the material 81 blood serum of patients were used, taken in the amount of two samples . After assigning the codes and entering them into the database, the sample drops were added with a pipette to a pre-washed sterile plate.

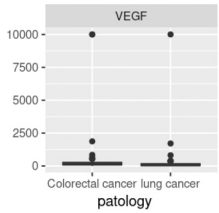
Further, Luminex used its own technologies for internal color marking of microspheres using a variety of fluorescent dyes. Using precise concentrations of these dyes, sets of 100 differently colored particles were created, each of which was coated with specific immobilized antibodies.

After capturing the analyte from the test sample and immobilizing it on the surface of the magnetic particles, a biotinylated antibody was injected for detection. The reaction mixture was then incubated with a report molecule of Streptavidin-PE conjugate to complete the reaction on the surface of each microsphere. The microspheres passed through a laser beam, which ˇexcited internal dyes, so that it was possible to identify the type of microspheres. A second laser excited a PE fluorescent dye on a reporter's molecule.

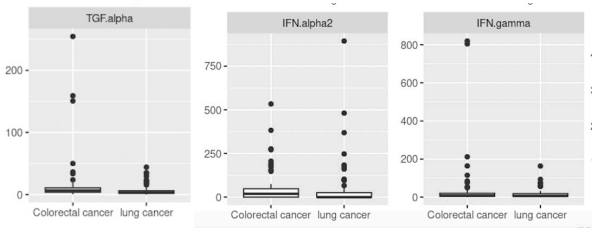
As a result, high-speed digital signal processors identified each individual microsphere and calculated the result of the bioassay based on signals from fluorescent reporters.

Results. Serum samples from 81 patients aged 18-80 years taking EGFRi for colorectal cancer and having manifestations of undesirable dermatological reactions (skin toxicity) of 3 or more severity were tested. When analyzing the data was obtained using SPSS software.

Inhibition of EGFR inhibits the expression and release of vascular endothelial growth factor (VEGF), which is the primary inducer of vascular neoplasm. The consequence of which is inflammation of the vascular endothelium of capillary vessels of the skin.



A significant increase in IFN gamma and a decrease in the level of IFN alfa2 were found in patients with manifestations of skin toxicity of 3 or more severity. Also as s significant criterion for the severity of the skin process was an increase in the level of TNFalfa



Conclusions.

A significant increase in IFN gamma and a decrease in the level of IFN alfa2 are characteristic of stimulation of the EGF receptor, which is necessary for STING-mediated gene induction. A significant increase in TNF betta production triggers a cascade of reactions leading to an increase in the concentration of pro-inflammatory cytokines IL 1, a, IL 3,5,6,7,9,10,17, which contributes not only to the maintenance of tissue inflammation, but also to the formation of a vicious circle leading to an increase in the severity of the inflammatory response against the background of continued use of EGFRi.

Determination of predictors of the severity of adverse dermatological reactions is extremely important for predicting the development of severity and further personalized tactics for correcting adverse events.

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主导院士学说的机制 A.A. Ukhtomsky 对 K.D. 教学方法的分析 乌申斯基

MECHANISMS OF THE DOCTRINE OF THE DOMINANT ACADEMICIAN A.A. UKHTOMSKY IN THE ANALYSIS OF PEDAGOGICAL METHODS OF K.D. USHINSKY

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抽象的。 目前，俄罗斯正在修改各个活动领域的教育方法，包括教育学和医学。 很自然，教育方法的发展和年轻一代的培养在很大程度上决定了我国未来多年的发展。 俄罗斯以拥有杰出的教育家而自豪，他们的方法值得学习。 分析各种教育系统的应用既可以具有实际意义，也可以具有理论教学科学意义。 19 世纪最著名的俄罗斯教师之一是 K.D. 乌申斯基。 我们深信，Ushinsky 的著作在实践部分预见了杰出的俄罗斯生理学家 A.A. 因此，Ukhtomsky 在本文中分析了 K.D. 作品的一些规定。 从 A.A. 的作品来看 Ushinsky 乌赫托姆斯基。 我们特别注意到实施教育和养育 K.D. 教学方法的生理机制。 从现代科学的角度来看，Ushinsky 还没有被详细研究过。 我们分析了 K.D. 的生理机制。 从 A.A. 院士的角度来看 Ushinsky 乌赫托姆斯基。

关键词：Ukhtomsky 的优势，Ushinsky 的教育学，教育学的生理机制。

Abstract. *Currently, Russia is revising the methods of education in various fields of activity, including pedagogy and medicine. It is natural that the development of methods of pedagogical education and the upbringing of the younger generation largely predetermine the development of our country for many years to come.*

Russia is proud to have had outstanding educators whose methods are worthy of study. Analysis of the application of various education systems can be of both practical interest and theoretical pedagogical scientific interest. One of the most famous Russian teachers of the 19th century was K.D. Ushinsky. We are deeply convinced that the works of Ushinsky in their practical part anticipated the doctrine of the dominant by the outstanding Russian physiologist Academician A.A. Ukhtomsky, therefore, in this paper, we analyzed a number of provisions of the works of K.D. Ushinsky from the point of view of the works of A.A. Ukhtomsky. We especially note that the physiological mechanisms for the implementation of pedagogical methods of education and upbringing K.D. Ushinsky from the point of view of modern science have not been studied in detail. We have analyzed the physiological mechanisms of K.D. Ushinsky from the point of view of academician A.A. Ukhtomsky.

Keywords: *Ukhtomsky's dominant, Ushinsky's pedagogy, physiological mechanisms of pedagogy.*

Relevance. The significance of any kind of education in our time is determined by the fact that those countries that are the first to create a functioning artificial intelligence will receive political and economic superiority. The creation of an artificial mind requires knowledge of the algorithms of the brain, in particular the principles of the dominant of the physiologist A.A. Ukhtomsky. We believe that the study of the principles of the work of the dominant can also take place when studying the work of the dominant in pedagogical practice.

In recent years, in our country, methods of pedagogical education and upbringing, proposed by one of the outstanding teachers of the 19th century, K.D. Ushinsky [38, 39, 40, 41, 42, 43], which were widely known in Russia, are effective and popular in our time and are studied and analyzed not only by teachers, but also by physiologists [2, 3, 9, 10, 11, 12, 13, 17, 19, 23. 24, 28, 33, 35, 47, 49].

On the relevance of the pedagogical ideas of K.D. Ushinsky in modern pedagogy, for example, we can judge by his statement: "Seriousness should reign in the school, allowing a joke, but not turning the whole thing into a joke, affection without cloying, justice without captiousness, kindness without weakness, order without pedantry, and, the main thing is constant reasonable activity. Then good feelings and aspirations will develop by themselves in children, and the beginnings of bad inclinations, acquired, perhaps, before, will gradually be erased ... "[Ushinsky K.D. On nationality in public education]. Describing the teacher as a person, he wrote that "The teacher, as a key figure in the educational process, contributes to the formation of modern society, what the teacher teaches - this is how society will be" [40].

Let us turn to the well-known saying of K.D. Ushinsky: "A child enters the spiritual life of the people around him only through the native language, and, con-

versely, the world surrounding the child is reflected in him with its spiritual side only through the same medium of the native language" [44]. It is necessary to ensure that the child consciously enters the spiritual life of the generation with which he had to live and work side by side during a certain period of earthly existence, therefore it is important that the world surrounding the child is more and more often reflected in the word, noted K.D. Ushinsky.

The significance of the works of K.D. Ushinsky, from our point of view, are predetermined by the fact that he apparently subconsciously succeeded in presenting his works on the basis of the real physiological laws of the brain, although at that time physiologists had not yet discovered them. We believe that the works of Ushinsky in their practical part of the factual material anticipated the teachings of A.A. Ukhtomsky about the dominant [2, 47].

Pedagogical research in recent decades has shown the need to study the neuronal mechanisms of training and education in modern educational systems [1, 6, 21, 52, 54, 55, 59, 60].

In our opinion, neuroeducation presupposes the existence of theoretical and methodological foundations that describe the process of human learning at different analytical levels, i.e., at the genetic, physiological, behavioral, phenomenological, and sociocultural levels.

In other words, we are talking about the rapid formation and development of a new integrative direction of pedagogical education - neuropedagogy, the development of which allows for more efficient professional training of students of pedagogical universities [14]. The methodology of neuropedagogy is based on the principles according to which the formation of higher mental functions of a child depends on the timely maturation of certain brain areas [20, 27, 31]. Therefore, we can agree with researchers who single out neuropedagogical competencies as a separate area of pedagogical training programs and consider neuropedagogy as a science about the theory and technologies of teaching and education [8, 25].

At the same time, from a methodological point of view, neuropedagogy remains a little-studied area of higher education pedagogy, and it would be interesting from a scientific point of view to use the accumulated practical experience of K.D. Ushinsky and integrate it into modern pedagogy. Modern publications show the relevance of the problem of visibility in the modern pedagogical process, as K.D. Ushinsky [34, 48]. And in our time, for the teachers of Russia, the works of Ushinsky are relevant and widely used for national education [7, 29, 51].

In recent years, neurophysiologists have been considering completely new, one might say, unique principles of the brain. So, for example, academician K.V. Anokhin [4, 5] for the scientific understanding of consciousness began to consider the brain not as a neural network, but as a cognitome - a neural hypernetwork consisting of neural groups with specific cognitive properties. He proved that the

structure of the cognitome corresponds to the structure of the mind, and consciousness is a specific process of large-scale integration of cognitive elements in this neural hypernetwork. We believe that K.D. Ushinsky, foreseeing the extremely complex mechanisms of the brain, demanded from teachers a variety of methods for the scientific educational process on the principles of an individual approach. We also assume that K.D. Ushinsky, one of the few teachers of that time, understood that only by knowing the complex physiological mechanisms of the brain, one can successfully conduct the pedagogical process. Ushinsky intuitively came to the realization of a number of mechanisms of the brain, for example, the formation of a dominant. That is why the works of Ushinsky gradually reveal to us all their deep pedagogical scientific essence [46].

Based on the foregoing, we analyzed the works of the teacher K.D. Ushinsky from the physiological point of view of A.A. Ukhtomsky. An outstanding achievement of physiology is that Academician A.A. Ukhtomsky [37] discovered one of the main principles of the brain - the dominant, which combines all the work of the central nervous system of the human body, aimed at achieving some useful result. All activity of the organism is subject to the dominant, all incoming information is processed from the point of view of the dominant, therefore any activity of the organism is ensured by the work of constantly replacing each other dominants.

Recently, great importance in the work of the brain during the pedagogical process of memorizing and processing information has been attached to mirror neurons, without which the educational process is impossible [2, 16, 26]. Mirror neurons were discovered in the 1990s in the ventral premotor area F5 of monkeys by a group of Italian scientists [56, 58]. These neurons were activated both when performing an action and when observing a similar action or hearing sounds accompanying it [53, 57].

Ushinsky's methods are aimed at developing a stable and useful dominant for a person, which determines his attitude to work and the progressive development of the student's personality. At the same time, we must clearly understand that many physiological mechanisms for the implementation of K.D. Ushinsky from the point of view of modern science have not been studied in detail.

The purpose of the study: analysis of the physiological mechanisms of pedagogical methods of K.D. Ushinsky from the point of view of the physiological doctrine of the dominant academician A.A. Ukhtomsky.

Research methods. Works by K.D. Ushinsky (1824 - 1871) - an outstanding educator of Russian pedagogical science and the folk school of Russia, the creator of an original pedagogical system based on the principle of nationality, a psychology that subtly understands the characteristics of a child's development, are relevant and in demand in our time. He is the author of books on which several generations of students of our homeland have been taught and brought up for

many decades, he is a wonderful “teacher of Russian teachers” and tens of millions of children [51].

Pedagogical successes of K.D. Ushinsky are huge and their useful result has been tested by time and, as we believe, is based on the subconscious application of the principles and properties of the doctrine of the dominant, the scientific concept of which was proposed by the Russian scientist, academician A.A. Ukhtomsky. We analyzed the mechanisms of successful teaching experience of K.D. Ushinsky and the doctrine of the dominant academician A.A. Ukhtomsky (1875 - 1942).

Research results. In this work, we studied the creative heritage of the teacher K.D. Ushinsky and analyzed it from the point of view of the physiological mechanisms of the doctrine of the dominant academician A.A. Ukhtomsky. Back in the middle of the 19th century, the founder of Russian pedagogy K.D. Ushinsky in the fundamental work “Man as a subject of education. The experience of pedagogical anthropology” [46] defined new approaches that reveal the relationship of pedagogical knowledge with other sciences, the role and place of pedagogy in the general system of scientific ideas about nature, society, and man. Ushinsky, in particular, pointed out: “If pedagogy wants to educate a person in all respects, then she must first recognize him in all respects too” [46]. Ushinsky K.D. for the first time analyzed and summarized the data of the science of anthropology from a pedagogical point of view, which later formed the foundation of scientific pedagogical knowledge [46].

The Russian physiologist Aleksey Alekseevich Ukhtomsky [37] was the first to introduce such a concept into scientific use as a dominant (first observation in 1904, first publication in 1923). He determined that the dominant is the excitability of the nerve centers, while in the rest of the nervous system, inhibition phenomena are widely observed.

Thus, the dominant is a huge mobile association of nerve cells, the final activity of which is aimed at achieving some physiological modality (any goal, for example, an unconditioned food reflex). When the goal is reached, the dominant disappears and makes room for a new dominant, as a result of which a narrowly directed concentrated nervous energy is released for the body to achieve various other goals. The main property of the dominant is the capture of motor pathways to the muscles in its subordination, which is easily explained by the need to move for the implementation of the dominant. In many cases, it is by motor activity that we can determine whether there is a dominant and which one, or not. For example, if a dog has a food dominant, then the dog runs and looks for food, asks for food, constantly sniffs everything (the muscles are subordinate to the food dominant and all muscle contractions act to satisfy it). The dominant is characterized by increased excitability, the summation of nerve signals, the dominant has a long inertia of existence, but quickly disappears only after satisfaction [37].

A person is largely represented by various psychological dominants, for example, desire, the goal of becoming a teacher, building a house, having a car, etc. In many ways, a person's ability to manage his dominants determines the success of a person's activity. If a student has a strong dominant (life goal), for example, to become a doctor, then the student achieves the goal, despite the obstacles. If a student has a weak dominant to become a doctor, the dominant cannot seize control of motor pathways, the student cannot regularly go to lectures, to the library, and cannot force himself to study regularly. In such a student, other dominants (various desires) take over the motor pathways, for example, the sexual dominant, such a student will often go on dates and, perhaps, he will not have enough time to study.

A.A. Ukhtomsky attributed the dominant not only to physiology and psychology, but considered it to be a universal human principle of the body's work, since all conditioned and unconditioned reflexes, the activity of all neurons of the brain and peripheral organs are subordinate to it [37]. Ukhtomsky believed that in some cases the dominant can bring a negative role for a person. So, if a person has formed dominant points of view on some events, then it is almost impossible to convince a person. That is why the principle of K.D. is very important. Ushinsky from the first days of education, to give the right points of view to students (to develop the right dominant), to educate them in kindness and diligence.

Discussion. Ushinsky K.D. considered obligatory knowledge for pedagogy, all those sciences in which the bodily or spiritual nature of a person is studied and is studied not in dreamy, but in real phenomena. He attributed psychology, physiology, human pathology, logic, anatomy to a wide range of anthropological sciences. So is geography, which studies the earth as a dwelling of man, and man as an inhabitant of the globe, literature, art.

K.D. Ushinsky demanded from the teacher a comprehensive education in various departments of science, since he was one of the first teachers from his extensive teaching practice to understand that the personality of each person is diverse and requires an individual scientific educational approach [45]. Currently, a huge number of scientific works are devoted to the study of personality, which proves the correctness of Ushinsky's reflections on the diversity of pedagogical approaches to the personality of each person.

These thoughts K.D. Ushinsky about the wide education of the teacher are in good agreement with the doctrine of the dominant A.A. Ukhtomsky, since the more extensive the education of the teacher, the stronger the teacher can form the dominant of knowledge in the brain of students. The more knowledge a teacher has, the faster he can destroy negative, harmful dominants in the brain of students, using logic and rational thinking [45. 46].

According to A.A. Ukhtomsky, the main properties of the dominant are the following: excitability, self-preservation, acceptance of afferent stimuli [37], which

correlates with the works of the teacher K.D. Ushinsky, where it is indicated that one cannot be forced to acquire knowledge, one cannot be physically punished, since learning should be a voluntary and creative process. Indeed, Academician I.P. Pavlov [30] wrote that the dominant must be gently nurtured, cherished, strengthened and strengthened, and then the dominant in difficult times will help overcome the sea of tears and lead to victory. This recommendation by Ushinsky about the prohibition of punishment is proved by the properties of the dominant, which say that a bad dominant can only intensify (in this case, the dominant of unwillingness to learn, and the dominant of the desire to ride a bicycle, but not to study, may arise) when they try to reprogram it to another dominant by brute force. . Ushinsky taught that it is necessary gradually, in accordance with the individual character and desires of the student, to give him the right knowledge, which the student would perceive as very pleasant and necessary for him.

For example, K.D. Ushinsky writes a story in the fourth volume of his works, when the brother and sister went to the grove, instead of going to school, they got bored there and decided to play. They asked the beetle to play with them, but he refused, saying that he had no time, he had to get dinner. The ant also refused to play, as he was dragging a straw. The squirrel also refused to play, she stored nuts for the winter. The children asked the bird to play with them, she scolded them, saying that they were lazy and interfered with everyone's work, that it was nice to relax when all the work was done. The children became very ashamed, and they ran to school and began to study well. Logically speaking, K.D. Ushinsky showed the fact that children realized the need for learning. At the same time, K.D. Ushinsky wrote that "the fact itself is nothing, only the ideal aspect of this fact is important" [50].

Therefore, we see how K.D. Ushinsky carefully and consistently develops the dominant to learn from simple examples of the functioning of wildlife. In this example, the logical transition is used that all animals work to survive, and children also have to do their duty to work, study. The selection of such stories by K.D. Ushinsky unobtrusively and consistently forms in children useful dominants for society to work and learn every day.

Ushinsky considered an imbalance in the work of the central nervous system of a person to be very harmful, especially for the state of a person's physical health. He correctly noted that the excited state of the nervous system depletes the resources of a person's physical health. Ushinsky also noted that with repeated excessive overstrain of the nervous system, a faster habitual lethargy and fatigue of the nervous system occurs (as we now know - a conditioned reflex pathological overstrain of the nervous system). Comparing these data of Ushinsky about the overstrain of the nervous system with Ukhtomsky's theory of dominance, we can conclude that Ushinsky correctly noted that the frequent change of various tasks in front of the student depletes the resources of the brain.

Experiments on animals academician I.P. Pavlov [30] proved that a sharp change in dominants can cause a breakdown in higher nervous activity. The fact is that Pavlov developed a first-order conditioned food reflex in the dog: a light bulb was lit, then after three minutes a small cracker fell into the feeder, the dog ran up to the feeder and ate the cracker. This was repeated 20 times, as a result of which a first-order food conditioned reflex was developed, when saliva and gastric juice were released after 3 minutes after the light bulb came on, although they did not give crackers. Here we see the main property of the conditioned reflex - an anticipatory reflection of reality (they didn't give a cracker, but after 3 minutes the gastric juice is already released into a virtual, mental cracker). Further I.P. Pavlov decided to study what would happen if the food dominant was quickly replaced by the self-preservation dominant (the dominants were pushed against each other). To do this, when a stable food reflex was developed, a light bulb lit up, the dog ran up to the feeder, licked it, and instead of a cracker, it received an electric shock. After that, all reflexes disappeared in dogs, reflexes were no longer developed, when the light bulb was turned on, many dogs turned over on their backs, howled, foam came out of their mouths, dogs refused food. Dogs have been shown to develop symptoms of neurasthenia similar to humans. I.P. Pavlov developed a method for treating neurasthenia with bromine in humans using this model of dog disease (after a year of treatment with bromine, many conditioned reflexes were restored in dogs). In other experiments, I.P. Pavlov showed that a simple electric shock, when dogs lick feeders during an exploratory reflex, does not lead to neurasthenia, the reflexes do not disappear.

A.A. Ukhtomsky showed that the dominant becomes the guiding core of all manifestations of the life of the organism in its norm and pathology. The nuclear concept of the dominant is associated with the concept of the chronotope as the principle of the temporal-spatial organization of the brain and the organism as a whole. In his writings, attention is drawn to the interpretation of the specific features of psychological ideas about space and time, the role of psychological time in the organization of human experience [15].

The dominant connects disparate elements into a single coordinated whole, moving harmoniously in one direction, and is present not only in physiology, but also in mental experiences, literature, and art [36].

Thus, it is obvious why in his writings K.D. Ushinsky paid special attention to the education of honesty and truthfulness. The change of one dominant, which a person expected, to another dominant, when he was deceived, and instead of the expected one, he receives a completely different one that he does not need, can lead to neurasthenia or prolonged exhaustion of the whole organism. K.D. Ushinsky noted that the child can only partially control the whole variety of the work of the nervous system, therefore the child's nervous system is very vulnerable and

sensitive to the costs of education, and hence it is clear that for the child's mental health the role of a teacher is even greater than the role of a doctor.

K.D. Ushinsky in stories for children not only very carefully and with kindness of heart programmed the brains of students in a peculiar way, thereby developing a dominant that is useful for society, for example, learning to acquire knowledge, work, be kind, etc. We fully agree with the opinion of V.I. Petrukhin, who noted "... that the knowledge to be mastered cannot be transferred in finished form, by simple communication or display. They can be learned only as a result of a certain activity of students, that is, when performing a certain system of actions" [32].

Despite the fact that Ushinsky did not know the doctrine of the dominant, he practically predetermined and developed a pedagogical method for the formation of useful dominants. A.A. Ukhtomsky had the scientific honor to describe the principles of the dominant. Without knowing it, the teacher K.D. Ushinsky used in his practice the property of the dominant to disappear from a stronger dominant when he wrote that it is necessary to give knowledge emotionally and interestingly (to form dominants). Here we must also recall his recommendations that a teacher should have as wide a range of knowledge as possible, that the more knowledge, the more opportunity to form a stronger dominant in the brain of students. From the standpoint of our time, it is clear that the more knowledge, the greater the opportunity to program the brains of students.

It is known that the change of dominants is effective when the body begins a pronounced muscular work, for example, chopping firewood, then the created new dominant weakens the previous dominant (previous desires). In this regard, we will refer to the works of Academician I.P. Pavlov, who convincingly proved that the change of dominants is the most costly process in the human body. Proceedings of K.D. Ushinsky sufficiently provide effective pedagogical approaches for the formation of dominants useful for society and their management in the pedagogical process.

Conclusions. The developed methods of pedagogical education K.D. Ushinsky in Russia are effective and popular in our time. In our work, we analyzed the physiological mechanisms of K.D. Ushinsky and proved that they are based on the physiology of the dominant academician A.A. Ukhtomsky, although the author was not familiar with the scientific problem of dominant. We have shown that in the works of K.D. Ushinsky contains invaluable scientific material, confirming and describing in detail many physiological mechanisms of functioning and formation of the dominant academician A.A. Ukhtomsky.

Our study indicates that the works on pedagogy K.D. Ushinsky and the doctrine of the dominant physiologist A.A. Ukhtomsky complement each other. A joint analysis of these works allows us to obtain completely new facts about the mechanisms of the functioning of the dominant and significantly expands the scientific and practical scope of the pedagogical scientific works of K.D. Ushinsky.

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评估胆囊运动排空功能在胆石症发展中的作用
ASSESSMENT OF THE ROLE OF GALLBLADDER MOTOR-EVACUATORY FUNCTION IN THE DEVELOPMENT OF CHOLELITHIASIS

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抽象的。 对 230 名肝胆系统病理患者胆囊运动排空功能不同模式下胆汁的成石特性进行了综合研究。 发现在低渗型胆囊运动功能障碍病例中观察到的胆囊排空率降低是胆结石形成发展的预后不利因素。

关键词：胆囊，胆汁的结石特性，运动排空功能，胆石症。

Abstract. *A comprehensive study was conducted on the lithogenic properties of bile in various patterns of gallbladder motor-evacuatory function in 230 patients with hepatobiliary system pathology. It was found that a decrease in gallbladder emptying rate, observed in cases of gallbladder motor dysfunction of the hypotonic type, is a prognostically unfavorable factor for the development of gallstone formation.*

Keywords: *gallbladder, lithogenic properties of bile, motor-evacuatory function, cholelithiasis.*

Cholelithiasis, due to its high prevalence and significant negative impact on quality of life, remains one of the pressing problems in clinical medicine. There is a clear trend of increasing incidence of cholelithiasis in recent years. According to the data from the 10th World Congress of Gastroenterologists, cholelithiasis currently affects more than 10% of the world population, and the number of affected individuals is increasing annually. If the current rate of cholelithiasis continues to rise, by 2050, one in every five inhabitants of the planet will suffer from this condition [1,3,4,8,12].

The formation of gallstones in the gallbladder is a prolonged and multi-stage process. To this day, there are discussions about the leading factor in the develop-

ment of cholelithiasis. Some researchers [6,7] believe that stone formation occurs due to the changes in bile metabolism and biochemical alterations in its composition. While others agree that lithogenicity of bile is important but not the sole factor contributing to stone formation, since a decreased evacuatory function of the gallbladder is a necessary condition [3,7,8,9,10].

The aim of this study was to examine the relationship between changes in gallbladder motor-evacuatory function and the biochemical properties of bile.

Materials and Methods: A total of 230 patients with various hepatobiliary system pathologies were examined, including functional disorders of the biliary system, chronic non-calculous cholecystitis, fatty liver disease, toxic hepatitis, and cirrhosis. There were 113 male and 117 female participants, ranging in age from 22 to 65 years old.

Alongside general clinical data, a range of modern laboratory and instrumental investigations were employed. The diagnosis was verified based on ultrasound examination of the hepatobiliary system using the S-DN-500 machine, computer tomography - using the "Universal max" machine (USA), and magnetic resonance imaging - using the "SRT-100" machine (Kiev). To assess the functional state of the gallbladder, cholecystometry was performed according to the standard methodology, which involved measuring the volume of the gallbladder before and after a choleretic breakfast at 10-minute intervals over a period of 1.5 hours. A choleretic breakfast consisting of 200 grams of white bread and 50 grams of sunflower oil was used. The volume of the gallbladder was calculated using the formula V = 3.14dh, where d is the largest transverse diameter of the gallbladder, and h - the length of the gallbladder. The following parameters were assessed: initial volume of the gallbladder, duration of the contraction phase of the gallbladder, degree of maximum contraction relative to the initial level, and relative gallbladder emptying rate (ratio of maximum contraction to duration of the contraction phase).

All patients underwent multistage duodenal probing with subsequent macroscopic, microscopic, and biochemical examination of bile. The total concentration of bile acids and cholesterol was determined in portions "B" and "C" of the bile [11], and the cholate-to-cholesterol ratio, which serves as an index of bile lithogenicity, was calculated.

The results of laboratory and instrumental investigations were compared with data from a control group consisting of 30 practically healthy individuals aged 20 to 25 years. The obtained results were analyzed using statistical processing software such as Excel and the sub-package scipy.stats for Python programming language. The data, presented as mean values (M) with their corresponding errors ($\pm$SE), were compared using correlation analysis. The significance was assessed using the Student's t-test for normally distributed samples.

Results of the research and their discussion. Ultrasonography of the gallbladder revealed wall thickening and densification in 62% of patients, a combination of this sonographic pathology with gallbladder deformation in 30% of patients, and the presence of biliary sludge (increased optical density, bile clumps) in 16% of patients.

Based on the cholecystometry results, patients were divided into three subgroups: those with hypo- and hypermotor disorders of gallbladder functional capacity and those with normal motor-evacuator function of the gallbladder. As shown by the obtained data (Figure 1), no significant difference in the initial volume of the gallbladder was observed between hypo- and hypermotor subgroups.

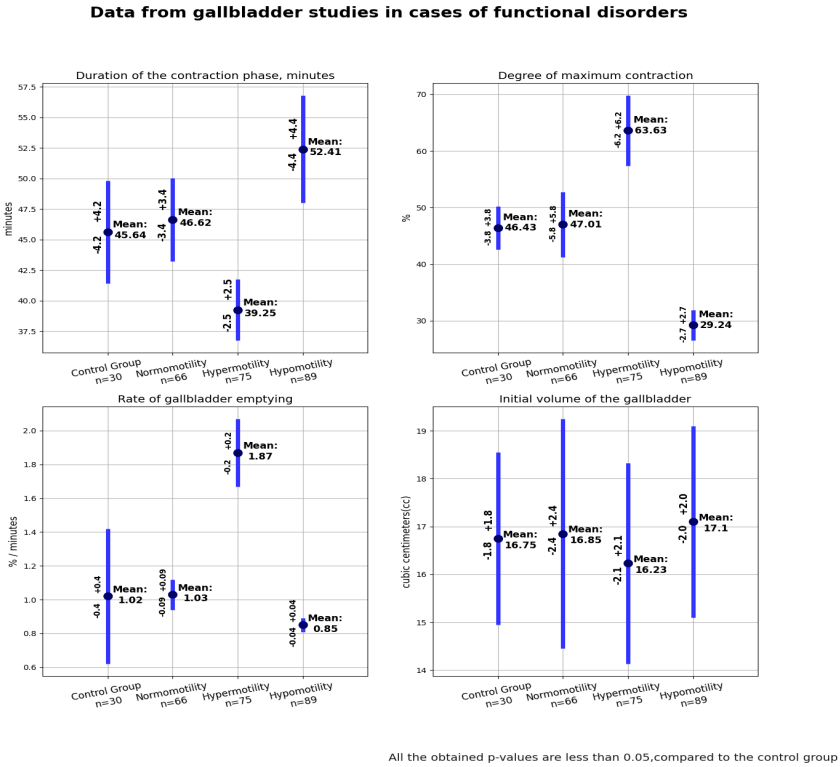

Figure 1. *Data from gallbladder studies in cases of functional disorders*

Hypermotility causes an increase in the speed of gallbladder emptying, not only due to an increase in the degree of maximum contraction but also due to a decrease in the duration of the contraction phase. In hypomotility, the decrease in

the speed of gallbladder emptying also occurs due to both a decrease in the degree of maximum contraction and an increase in the duration of the contraction phase (Figure 2).

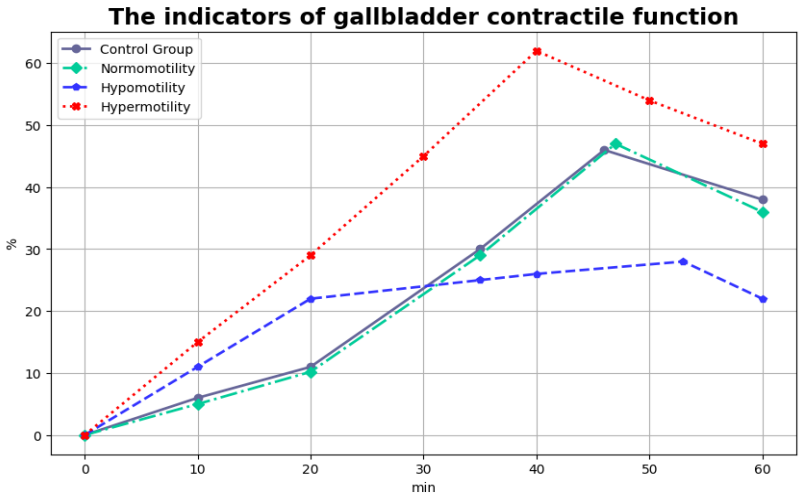

Figure 2. *The indicators of gallbladder contractile function*

In all patients, cholesterol and calcium bilirubinate crystals, characteristic of the initial pre-stone stage of cholelithiasis, were found in bile microscopy. The analysis of the biochemical composition of bile was conducted depending on the type of motor-evacuator function of the gallbladder. As shown in the data (Figure 3), the examined patients had elevated cholesterol levels in bile compared to the control group in both portion “B” and portion “C”. In contrast, the levels of bile acids were reduced in both portion “B” and portion “C” compared to the control group. A significant decrease in HDL cholesterol was observed in both portions of bile compared to the control group. The highest degree of lithogenicity of bile was observed in cases of hypomotor disorders.

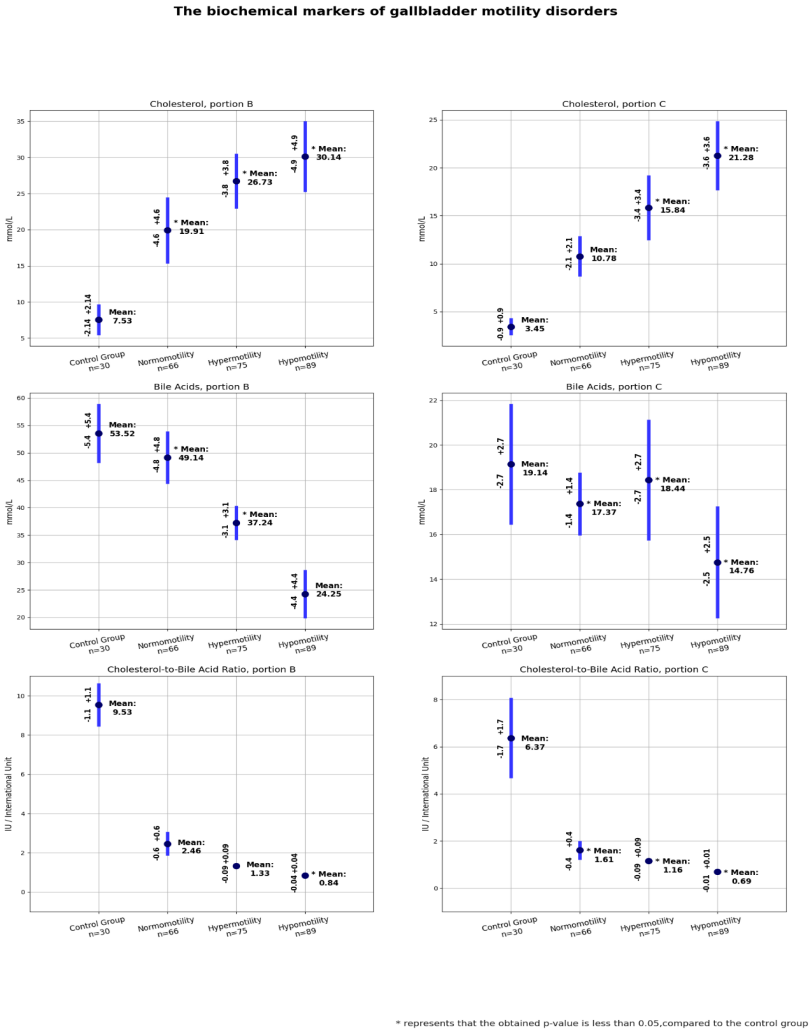

Figure 3. *The biochemical markers of gallbladder motility disorders*

The obtained data are consistent with the results of the conducted correlation analysis. A direct moderate correlation was found between the degree of gallbladder emptying and the cholate-to-cholesterol ratio in bile portion “B” (r=0.53), the cholate-to-cholesterol ratio in bile portion “C” (r=0.44). Additionally, a moderate positive correlation was observed between the speed of gallbladder emptying and

the cholate-to-cholesterol ratio in bile portion "B" (r=0.61), the cholate-to-cholesterol ratio in bile portion "C" (r=0.34).

Conclusion: Most hepatobiliary diseases are accompanied by various impairments in the motor-evacuator function of the gallbladder. Specificities in the development of lithogenic properties of bile have been established depending on the state of gallbladder emptying. It has been demonstrated that motor dysfunction of the gallbladder of the hypotonic type is a prognostically unfavorable factor regarding the potential formation of gallstones.

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宏观量子非局域性在活生物系统中的应用
THE USE OF MACROSCOPIC QUANTUM NONLOCALITY IN LIVING BIOSYSTEMS

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这些研究致力于通过实验证实宏观量子非局域性的存在，及其用于确定动物健康状况的可能性。 对根据 Alfa-Quartz 频率程序预处理的结晶二氧化硅对实验动物血清蛋白质组成的影响进行了探索性研究。

关键词：量子非定域性，天然矿物，Si02，盐水溶液，免疫电泳，气体放电可视化。

These researches are devoted to experimental confirmation of the existence of macroscopic quantum nonlocality, the possibility of its use to determine the state of animal health. Exploratory studies of the effect of crystalline silicon dioxide, pre-treated according to the Alfa-Quartz frequency program, on the protein composition of the blood serum of laboratory animals were carried out.

Keywords: *quantum nonlocality, natural minerals, SiO2, saline solution, immunoelectrophoresis, gas discharge visualization.*

At the moment, there is no unambiguous evidence for the use of the phenomenon of macroscopic quantum nonlocality (Mqn) in living biosystems. However, these processes at the level of interaction between atoms and molecules are the subject of active research [1]. Mqn refers to phenomena in which quantum systems are in a state where their properties cannot yet be described by classical laws. For example, the effect of quantum connectivity, when two particles become interconnected, and their states are inseparable. Also, research is currently ongoing on the impact of superweak forces on living biosystems, including the impact at the electron level. Superweak forces refer to physical forces that are typically of low intensity and range from piconewton to nanonewton. They can affect living systems through electrochemical processes interacting with electrons in cells.

Using low-intensity laser emitters with a silicon dioxide crystal working body, it is possible to influence living biosystems at considerable distances. Some of the potential mechanisms for this action include regulation of gene expression, activation of transcription factors, and protein phosphorylation, which may lead to modulation of immune system function. On the other hand, silica nanoparticles can interact with the immune system by modulating the release of inflammatory mediators and stimulating the immune response.

In connection with the foregoing, the purpose of this work was to study the effect of microcrystals on biological objects using SiO2 processed using the Alfa-Quartz frequency program.

Materials and methods. When processing SiO2 (α-quartz) by electromagnetic fields of ultra-weak intensity according to the frequency program "Alpha-Quartz", the excitation of silicon and oxygen atoms occurs. Analysis of studies obtained at the Institute of Biochemical Physics of the Russian Academy of Sciences. M.N. Emanuel, samples of processed minerals SiO2, showed a change in the spin-orbit interaction of electrons. There were also significant changes in the energy parameters of oxygen and silicon atoms inside the crystal (data of spectral X-ray microanalysis obtained at CIAM). In our previous studies [2], conducted on a bacterial culture, samples of deionized water (witnesses) located in the immediate vicinity of recipient objects significantly changed their polycrystalline structure determined by the method of differential conductometry (Zenin S.V., 2001) and bioenergetic parameters determined by liquid chromatography methods at an exposure (exposure) time of more than 21 days.

In this experiment, a non-local method of exposure to SiO2 for 4 weeks at a distance of 350 km was used on Romanov sheep at the age of 6 years and on physiological solution (PS), sequentially injected 4 times sequentially into rabbits of the Soviet Chinchilla breed, treated with SiO2 "Alpha -Quartz" for 6 weeks. After completion of exposure, blood was taken from laboratory animals. The protein spectrum of blood sera was studied by immunoelectrophoresis according to the standard method. Samples of experimental and control sera were introduced into the wells, and sera to blood proteins of sheep and rabbits were added to the trenches. The control of changes in the structural and energy parameters of the FR was carried out by optical density on a SHIMADZU UV-1800 spectrophotometer in the ultraviolet range and by the method of gas discharge visualization (GDV) on the GDV Camera software and hardware complex (Korotkov G.K., 2006) [3].

Results and discussion. Table 1 presents the results of a study of the optical density of the PS before and after non-local treatment of SiO2 «Alpha-Quartz» (t 200 C).

Table 1

Dependence of the optical density (D) of the PS on the quantum state of the internal environment

Object	Wave length λ, (nm)						
	200	**254**	**260**	**270**	**381**	**384**	**389**
D control	2,2815	0,0968	0,0942	0,0908	0,0511	0,0506	0,0503
D experiment	2,3403	0,1082	0,1056	0,1022	0,0524	0,0518	0,0515
Δ, (%)	102,6	111,8	112,1	112,5	102,5	102,4	102,4

From the data in Table 1 it can be seen that the saline sample that has undergone non-local exposure has a higher optical density. On the spectrum of 250 - 270 nm, this difference is significant - more than 10%. Since the measurements were carried out under absolutely identical conditions, the increase in the light absorption coefficient of the prototype could occur due to an increase in its energy and a decrease in the entropy of the internal medium.

Table 2 presents the processing data of GDV-grams of non-local action «Alfa-Quartz» on PS. Results of statistical comparison by Student's criterion of PS samples. Sample 1 - control sample - no effect, sample 2 - experimental sample - non-local effect.

Table 2

Results of statistical comparison of GDV parameters.

	Square	**Average glow intensity**	**Contour Shape Factor**	**Entropy along the isoline**	**Contour length**
Control	155	55	137	142	154
Experiment	55	155	73	68	56
Criterion	100	100	82	87	99
z-value	3,78	3,78	2,419	2,797	3,704
p-value	0,0001571	0,0001571	0,01556	0,005159	0,0002122

From the data in Table 2 it can be seen that the samples are reliably distinguishable. The data obtained indicate a higher degree of structuring and energy potential of prototypes of the PS subjected to the non-local action of «Alfa-Quartz». A higher glow intensity - electron emission in the experiment indicates a higher electrical conductivity of the liquid-phase object, and, consequently, its greater biological activity. The lower entropy of the prototype is the result of the ordering of structural elements, which can lead to a reduction in the energy consumed to

maintain the homeostasis of living systems and indicate the presence in the PS of information that probably determines biological effects.

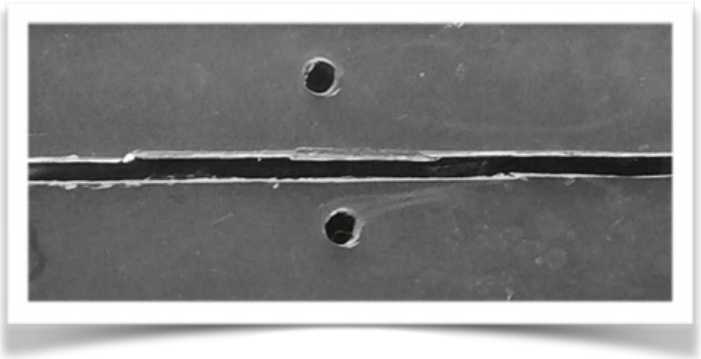

Figure 1. *Immunoelectrophoregram of sheep blood serum (1 - control; 2 - experiment).*

As can be seen in Fig. 1, the protein spectrum of sheep blood serum is represented by 3 precipitation lines (track 2) in the γ-globulin zone, in contrast to the control serum (track 1), where these precipitation lines are absent. A similar picture was in experimental rabbits, namely, 1 precipitation line appeared in the gamma globulin zone and a precipitation line in the albumin zone. Thus, the differences in immunoelectrophoregrams are due to the time and method of exposure to laboratory animals. Probably, the effect of SiO2 (α-quartz) on laboratory animals leads to changes in the process of protein synthesis. Further studies are needed to understand this mechanism associated with energy conversion in biological structures to maintain body homeostasis [1, 4].

Thus, as a result of the studies carried out, it was established that macroscopic quantum nonlocality is a real phenomenon, the nonlocal quantum effect of the «Alfa-Quartz» mineral on a remote macroscopic biological object causes a change in the protein composition of blood serum in laboratory animals and structural and energy changes in liquid-phase objects. Understanding the quantum properties of biosystems will help expand knowledge of body functions and provide new approaches to the diagnosis, treatment and management of diseases.

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中医与现代医学脉诊

PULSE EVALUATION IN TRADITIONAL CHINESE MEDICINE AND MODERN MEDICINE

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抽象的。 本文比较了脉诊的两个领域，中医和现代医学。 阐述了获取参数的基本原理及其在人体机体诊断中的应用。 每个方向都有权存在并被现代科学界听到和描述。

关键词：血液，血细胞，光电容积描记法，脉搏波，血液速度，脉搏参数，糖尿病。

Abstract*. This article compares two areas of pulse diagnosis, Traditional Chinese Medicine and modern medicine. The basic principles of obtaining parameters and their use in diagnostics of human organism are stated. Each direction has the right to exist and to be heard and described by the modern scientific world.*

Keywords*: blood, blood cells, photoplethysmography, pulse wave, blood speed, pulse parameters, diabetes.*

Introduction

The pulse is the most fundamental sign of life. Both Traditional Chinese Medicine (**TCM**) and modern medicine consider pulse evaluation as an essential component of patient consultation. However, the way the pulse is assessed depends on how it is interpreted.

Yin-Yang theory.

The earliest Chinese classic documenting Yin-Yang theory is the "I Ching", which is the oldest Chinese classic explaining change and constancy in the universe. **Figure 1** shows the famous "Tai Chi Symbol" which illustrates this theory.

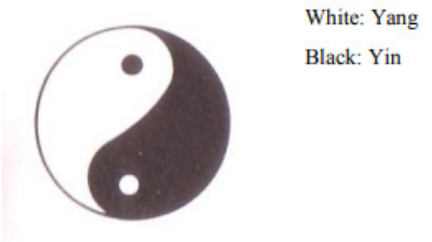

Figure 1. *Tai Chi symbol (borrowed from Maciocia, 1989, p.5)*[1]

This symbol encapsulates two relationships of the universe: the relationship between Yin and Yang and the relationship between the parts (Yin and Yang) and the whole (Tai Chi circle). Black symbolises Yin and white symbolises Yang. Yin and Yang are not mutually exclusive, but rather are the two poles of the continuum, together interpreting the nature of all matter in the universe.

The sinuous forms represent the dynamic movement of Yin and Yang. Yin and Yang are a complementary pair in all matters and are always relative to each other.

They pass from generation to generation, mutually support-consume, mutually transform and mutually limit (Maciocia, 1989)[1]. The small black and white circles symbolise the interpenetration of Yin and Yang. The whole, which is absolute in nature, is thus composed of both Yin and Yang and is represented by a large circle made up of black and white sinuous figures. Yin and Yang always seek balance, and the ultimate goal is Yin-Yang harmony. This theory deeply influences the concept of health and the pulse in TCM and in modern medicine.

Pulse in Traditional Chinese Medicine.

The concept of **CHI** (氣) in TCM derives from Taoism and embraces everything in the universe. Jing Yue Quan Shu stated that "Human life depends on this CHI" [2]. Health is perceived as a harmonisation of Yin Qi and Yang Qi. For example, Su Wen argued that "Disharmony between QI and blood causes all kinds of diseases" [3]. Thus, the principle of health management in TCM is to harmonise Yin and Yang.

The pulse encompasses CHI, blood and blood vessels. Si Yan Ju Yao stated that "Pulse is blood, the first of CHI and blood, the Tunnel of Blood…"[4]. CHI is

the basic substance for growth and development and refers to both purified nutrient substance and physiological activity in the body[33].

The purified nutrient substance is Yin-CI, which includes the essence, blood, body fluid and organs. Yin-CI is the physiological activity of the organs, which in TCM is classified as movement of CHI and transformation of CHI[2].

Movement of CHI is the flow of CHI in the four directions, i.e. upward, downward, outward and inward. This is the prerequisite for CHI transformation, which is the mutual transformation of essence, CHI, blood and body fluids.

The correct flow of CHI in these four directions depends on the interaction of the organs. The **liver, heart, lungs, spleen** and **kidneys** are the Yin form of CHI, while CHI movement and transformation are the Yang form of CHI and their functions.

Smooth flow of CHI and accumulation of blood is the function of the **liver**. The heart controls blood and blood vessels and pumps blood into the vessels. The lungs promote the movement of CHI and blood. The spleen mutually transforms CHI and blood, and the kidneys accumulate the necessary CHI, which is the basis for growth and development[5, 1, 2].

Blood, as the Yin form of CHI, is responsible for nourishing the body. Blood flowing inside the vessels depends on the support of CHI, and CHI flowing inside and outside the vessels requires nourishment from the blood. Thus, CHI and blood are a complementary pair of Yin and Yang, which has all the properties of Yin and Yang[5]. Two Chinese proverbs summarise their relationship: “CHI is the lord of blood” and “Blood is the mother of CHI”. The former explains the incipient, moving and holding action of CHI on blood, and the latter explains that CHI relies on blood for growth and development, and therefore also the physiological activity of the body. CHI is abstract and invisible, but crucial to life.

The **pulse** is a means of reflecting the harmony of Yin and Yang CHI in all parts of the body.

Wang, Chang, Wu, Hsu, and Wang[6] created the “Blood Pressure Wave Resonance Theory” to explain how the pulse reflects CHI and health.

Blood Pressure Wave Resonance Theory.

Blood pressure wave resonance theory was proposed[6] to explain the mechanism of TCM pulse diagnosis using the concept of aortic-organ coupling resonance. A physical model was created to explain the influence of organs on blood pressure waves in terms of harmonics, in which the blood pressure wave is the summation of the incident waves generated by the heart and their reflected waves from peripheral areas of the body.

Harmonics are the frequency components of blood pressure waves. Eleven harmonics have been identified, each referring to a specific organ. **Table 1** shows the eleven harmonics and their corresponding organs.

Table 1

Harmonics and corresponding organs (Wang, 2002)

	Heart	Liver	Kidneys	Spleen	Lungs	Stomach	Gallbladder	Bladder	Large intestine	Tripler burners	Small intestine
Harmonic	C_0	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}

The C_0-C_5 harmonics take up most of the pulse energy, indicating that the heart, liver, kidneys, spleen, lungs and stomach have a decisive influence on the pulse[7].

Resonance is a term used in physics to describe the tendency of a system to oscillate with maximum amplitude at a certain frequency[8]. When the circulatory system is in resonance with the organs, it greatly facilitates the propagation of the blood pressure wave through the arterial system, minimising resistance to the high frequency components of the wave. It subsequently increases blood flow through the organs and reduces the strain on the heart[9, 6].

Internal organ properties are important determinants of resonance in the circulatory system[6, 10, 11]. The number of arterioles and capillaries, the distribution of arterioles and capillaries within the organ, the tissues surrounding the organ, the length of the arteries connecting the organ to the aorta and the distance of the organ from the central arteries are all integral factors affecting the organ and its associated acupuncture points and hence human health, the frequency range of reflection and vibration by the aorta[6, 11].

Each organ and its associated acupuncture points transmit only a certain range of frequencies and are reflected from the central artery[12, 13, 14]. When healthy, the organ will oscillate with the aorta to reach a resonant state in its chosen frequency range. The reflected waves in this frequency range are strongly reflected from the aorta and thus facilitate the propagation of the blood pressure wave. However, when the health of the organ is impaired, it cannot oscillate with the aorta and the reflected waves in this frequency range are weakened, affecting the propagation of the blood pressure waves.

This theory explains the mechanism of TCM pulse diagnosis from a physical point of view and suggests that organ health can be assessed by pulse evaluation, because the pulse is composed of frequency components specific to the respective organs. Lu, Cheng, Lin Wang, and **Wang**[15] conducted a study to examine the correlations of eleven harmonics and people with abnormal liver function in 85 subjects and found that harmonic $\mathbf{C_1}$, $\mathbf{C_4}$ and $\mathbf{C_6}$ had significant correlation with abnormal liver function. **Lu**[16] conducted a similar study and confirmed these findings. Lu, Lin Wang, and Wang[17] investigated the correlations of harmonics and liver cirrhosis and found that $\mathbf{C_3}$ was a significant indicator of disease.

Triple burner, also called triple heater or triple energizer.

C_9 - The triple burner, also called triple heater or triple energizer, is one of the most elusive concepts of Chinese medicine. For centuries, Chinese physicians have debated whether it is a real organ or just a function, but to this day it remains one of the six official organs of Fu (also called Yang organs). The triple burner is like a large body cavity containing all the internal organs. Its main function is to unite all the organs into a single and harmonious system. The total activity of the organs Jang and Fu constitute the physiological functions of the Triple Burner.

As the name suggests, the Triple Burner consists of three burners.

The upper burner is the body cavity above the diaphragm which houses the heart, lungs, pericardium, throat and head. It controls breathing and distributes the collected Qi to all organs, tissues and skin. In this way, it is like a “mist” that disperses fluids throughout the body.

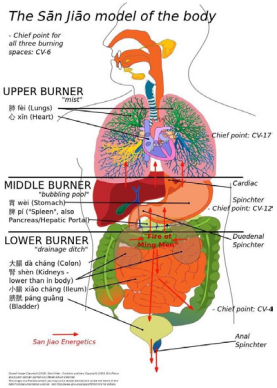

Figure 2. *Diagram of the* ***C_9*** *triple burner arrangement*

The middle burner is located between the diaphragm and the umbilicus. It contains the spleen, stomach and gallbladder. Its main function is to process and transport food and drink. It then distributes the extracted nutrition throughout the body. It is like a ‘foaming cauldron’, which means whipping and fermentation in the digestive tract.

The lower burner refers to the lower part of the abdomen below the navel. It includes the liver, kidneys, bladder, small intestine, colon and uterus. Despite its physiological middle location in the body, the Liver is actually part of the lower burner because of its close relationship with the kidneys. The lower burner is like a ‘swamp’, a chute or drainage ditch that filters clear water from turbid water. The clear liquid is directed upwards, and the turbid liquid is directed downwards to be drained out.

In terms of pathology, organ diseases can lead to dysfunction of other organs in this particular burner or other burners other than its own.

Eight elements.

Zhou Xuehai's (1856-1906) early attempt to standardise the pulse condition is a milestone in the quantification of TCM pulse diagnosis. He proposed that each pulse condition consisted of four elements[19]. He stated unequivocally that position, frequency, shape and trend (direction, flow) are the four basic elements of a pulse condition, and that every description of a pulse condition should contain these four elements.

Various scientists have developed this idea[20, 3, 18, 21, 22, 23] and expanded the original four elements to eight: depth, speed, regularity, width, length, smoothness, rigidity and solidity. Each heart rate condition must contain these eight elements with a different intensity.

Frequency is the number of beats per breath. The definition of regularity is similar to that used in modern medicine; it describes the rhythm of the pulse state.

Frequency and regularity give information about the nature of the condition, whether it is a fever or a cold[24].

Depth is defined as the vertical position of the pulse and indicates the localisation of the disease, whether internal or external[24].

Width and length describe the shape of the pulse, where width is defined as the intensity of the pulsation and length is defined as the range in which the pulsation can be felt through cun, guan and chi[20].

Smoothness is defined as the smoothness of the pulse, Stiffness is defined as the feeling of elasticity of the artery, and Strength is defined as the change in pulse force in response to a change in applied pressure[24].

Width, Length, Smoothness, Stiffness and **Strength** also describe the interaction of pathogen and healthy CHI in the body[20]. The eight elements thus described provide the basis for quantifying the pulse condition.

Pulse in modern medicine.

Pulse, blood pressure and blood pressure waves are interpreted differently in modern medicine and are terms used to describe blood flow. The **pulse** is perceived as "a rhythmic beating or vibrating movement"[25], **blood pressure** is "the pressure exerted on the walls of arteries, veins and heart chambers by the volume of circulating blood"[25] and **pressure wave** is a term used in physics to describe the type of elastic wave that spreads through elastic solids and fluids. In cardiovascular physiology, blood pressure waves are created by the rhythmic expansion and contraction of the heart during the cardiac cycle, the pulse is the product of the spread of a blood pressure wave through the arteries, and blood pressure is thus the pressure created by the heart on the arterial system during the spread of the blood pressure wave. The pulse or blood pressure comes from the circulatory system and

is regulated by other physiological systems. The process of regulating blood pressure in response to the internal and external environment is called ***homeostasis***.

Blood pressure regulation and homeostasis.

The concept of homeostasis emerged in the nineteenth century.

Kieser (1779-1862) believed that Yin and Yang were the two forces governing all living things[26].

Later in the nineteenth century, Claude Bernard (1813-1878) discovered that the body maintained itself in a constant state in relation to external and internal factors, and stressed the importance of maintaining a constant internal environment for maintaining good health[26].

Cannon (1871-1945) called this phenomenon homeostasis and defined it as the maintenance of static or constant conditions in the body's internal environment[26]. The sympathetic nervous system (SNS) and parasympathetic nervous system (PNS) form a complementary pair in the autonomic nervous system, similar to Yang and Yin, to regulate blood pressure.

Figure 3 shows the mechanism of blood pressure regulation within the body.

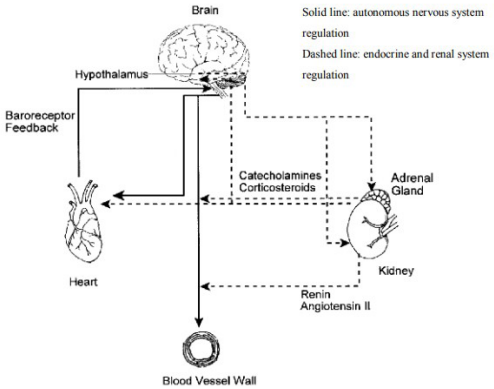

Figure 3. *Schematic representation of blood pressure regulation (modified from Larkin, Semenchuk, Frazer, Such day, & Taylor, 2008)[27]*

The main physiological systems involved in blood pressure regulation are the endocrine system, the nervous system and the renal system. Baroreceptors located in the carotid artery and aorta act as sensors of changes in blood pressure in the circulatory system. When the blood pressure is high, a neural signal is sent to the parasympathetic nervous system to lower the high pressure by reducing the heart rate. Similarly, when blood pressure is low, a nerve signal is sent to the sympathet-

ic nervous system to initiate vasoconstriction. The endocrine system is involved in the release of relevant hormones, i.e. catecholamines and corticosteroids from the adrenal glands, and renin and angiotensin II from the kidneys, in these processes to regulate blood pressure[27].

The pulse generated by the circulatory system.

Periodic contraction and relaxation of the left ventricle provides the mechanical force to push blood out of the heart into the arteries. The contraction of the left ventricle is known as systole, and its relaxation is known as diastole. The cardiac cycle refers to one complete sequence of ventricular contraction and relaxation[28].

Once blood enters the arteries, the viscoelastic properties of the arteries determine the contour of the blood pressure wave. There are two types of arteries: elastic and muscular. The main difference between them is the amount of collagen fibres present. The aorta is an elastic artery and has high tensile strength as it has fewer collagen fibres. Under normal conditions it expands strongly when intra-arterial pressure rises, but in some conditions in which the intra-arterial pressure exceeds the normal range, such as hypertension, collagen fibres gradually gain and the aorta becomes less stretchable.

Peripheral arteries, such as the radial artery, are muscular arteries that do not stretch much under any circumstances because they contain relatively more collagen fibres and are stiffer than elastic arteries.

The stiffness gradient of both the aorta and the radial artery decreases when the intra-arterial pressure exceeds the normal range[29] and this stiffness gradient thus affects the wave reflection rate.

Wave reflection.

Wave reflection can occur at any peripheral area of the body and is the reflection of incident waves from the periphery to the aorta. **Arterial pulse** is the sum of incident waves and reflected waves within the cardiac cycle.

The reflected waves depend on the size and nature of the branching of the peripheral arteries. Under normal circumstances, all reflected waves occur during diastole. This helps to increase blood pressure in early diastole and enhance coronary perfusion without increasing systolic blood pressure[30].

The upper and lower body are the two main areas where wave reflection occurs. Usually, the reflected waves from the upper body reach the aorta earlier than the waves from the lower body[30]. However, ageing and pathological changes cause the aorta to become stiffer. A stiffer aorta accelerates the reflection of waves and leads to earlier return of reflected waves. These early return waves gradually move into systole and increase systolic blood pressure. This is undesirable because increased systolic blood pressure increases ventricular workload and reduces coronary perfusion[30].

Blood pressure waveform.

In modern medicine, the frequency, rhythm and contour of the arterial pulse are assessed. **Frequency** is the number of beats per minute and **rhythm** refers to the regularity of the arterial pulse in terms of its contour and pulse interval. The contour of the arterial pulse is examined by the shape of the arterial pressure wave (**Figure 4**), which has four characteristic features: shock wave, tidal wave, incisor wave and dicrotic wave.

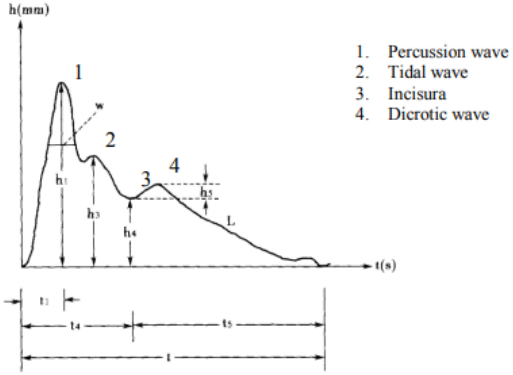

Figure 4. *Typical blood pressure waveform (adapted from Fei, 2003, p.163)*[20]

Shockwave is a sharp peak occurring at the beginning of systole which is associated with ventricular ejection[31].

Incisura is a sharp downward deflection associated with aortic valve closure at the end of ventricular systole, which occurs because a small volume of aortic blood flows backwards, filling the aortic valve leaflets as they close[28].

Both tidal and dicrotic waves are associated with reflected waves: the tidal wave is associated with reflected waves from the upper body and the dicrotic wave is associated with reflected waves from the lower body[31].

Systolic blood pressure is the pressure exerted on the artery wall during the systolic period, whereas **diastolic blood pressure** is the pressure exerted on the artery wall during the diastolic period. In addition to these two pressures, other physical parameters of the arterial pressure waveform can be used to assess heart rate and thus cardiovascular function. **Table 2** summarises the common physical parameters used to determine cardiovascular function and their physiological implications. [20, 32]

Table 2

Physiological consequences of the physical parameters of the waveform arterial pressure.

Physical parameters	Physiological implications
h_1	Systolic function Aortic compliance
h_3	Arterial stiffness
h_4	Peripheral resistance
h_5	Aortic compliance
t	Duration of one cardiac cycle
t_1	Duration of rapid systolic ejection
t_4	Duration of the systolic phase
t_5	Duration of the diastolic phase
A_T	Area of a cardiac cycle
A_S	Area of a systole
A_D	Area of a diastole
W	Duration of high systolic blood pressure
h_1/t_1	Systolic slope
h_3/h_1	Arterial stiffness
h_4/h_1	Resistance index
h_5/h_1	Arterial stiffness Function of the aortic valve
t_4/t_5	Related to pulse rate
W/t	Arterial stiffness
t_1/t	Systolic function
$(t_4-t_1)/t$	Related to cardiac output

Conclusion.

Modern researchers of pulse diagnostics started to use electronic apparatus as well. For example, as early as 1977 at the "V World Acupuncture Congress" held in Tokyo, reports were presented on pulse research by oscillography, advanced photoelectroplethysmography, etc.[33]

Of course, modern specialists of pulse diagnostics believe that no device can capture all the complexity of pulse ensemble, which is sensitively perceived by finger palpation, based on the best traditions of oriental and western medical schools. But progress is being made and technology is evolving....

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船舶全生命周期各阶段推进系统、航行和船体结构及船舶设备自动化智能监测系统的展望

THE PERSPECTIVE OF CREATING AUTOMATIC INTELLIGENT MONITORING SYSTEMS FOR PROPULSION SYSTEMS, NAVIGATION AND HULL STRUCTURES OF SHIPS AND MARINE EQUIPMENT AT ALL STAGES THE LIFE CYCLE OF THE SHIP

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抽象的。 本文致力于描述在设计和建造船舶上对船舶系统和船体承重结构状态参数进行连续自动监测的系统的开发和实施前景。 分析了解决这一问题的国际经验。 本文为监测系统的发展提供了有希望的机会。

关键词：自动测量、系统参数控制、智能监控、安装技术、船体变形、变形计算、推进系统。

Abstract. *The article is devoted to the description of the prospects for the development and implementation of systems for continuous automatic monitoring of the parameters of the state of ship systems and hull load-bearing structures on ships being designed and under construction. The international experience in solving this problem is analyzed. The paper presents promising opportunities for the development of monitoring systems.*

Keywords: *automated measurements, control of system parameters, intelligent monitoring, mounting technologies, hull deformations, accounting for deformations, propulsion system.*

During the construction of marine equipment, significant stress fields arise in the structures of their hulls from numerous welding and mechanical operations, as well as from the impact of the resulting masses during the assembly and installation operations. Such stress fields subsequently become sources of relaxation force effects on the hull structures of built ships, leading to their deformation as a whole, as well as to local spatial displacements of individual structural parts. It should be

noted that the relaxation process occurs continuously throughout the entire life cycle of the vessel, which means that it is necessary to systematically monitor the deformation components and from time to time center the propulsion systems, coordinate navigation systems, etc. Otherwise, individual parts and assemblies, mechanisms and even power plants will fail due to their misalignment with other links and systems. In addition, during the operation of a marine facility, hull structures: are gradually destroyed due to ongoing corrosion processes; their strength decreases due to the fatigue of the material itself from the effects of cyclic variable loads, etc. As a rule, in this case, the elastic line of the vessel changes, functionally depending on the above reasons. At present, the forecasting of the state of ship hull structures is carried out almost "blindly".

Local deformations of the vessel's load-bearing hull structures during completion afloat and its operation also appear under the influence of a complex of other factors, both temporary and permanent (waves of varying intensity, uneven heating of the vessel's hull, local loading of heavy equipment, filling/emptying of tanks, etc.). Such deformations occur, among other things, in the places where the precise construction bases of the vessel are located and, in the places, where radar and navigation systems are installed, as a result of which there is a mismatch of these systems, which reduces the possibility of accurately maintaining the set course (route).

Experience shows that the hulls of surface ships and ships can be bent along their entire length by up to 10', and the hulls of submarines - up to 5'. There is also a twisting of the ship's hull [1]. These values significantly affect the mismatch of ship complexes, for example, propulsion systems, which leads to increased wear of shafting bearings, a decrease in the efficiency of power plants, the occurrence of vibrations of the ship's hull and, most dangerously, to breakage, i.e., to the accident of the vessel during its operation.

At present, there are no scientifically substantiated provisions and methods for calculating deformation processes during the operation of marine equipment and, accordingly, it is not possible to give a reasonable forecast for the future. In this regard, in most cases, the terms for extending the operation of ships are assigned through a survey of specialists. In addition, it is not completely clear at what stage of operation the ship propulsion complexes, mechanisms, devices and systems should be re-centered. It is practically impossible to reasonably and accurately predict the implementation of a particular amount of repair work, because there is no adequate control of the ongoing processes of corrosion, deformation in the load-bearing elements of ship structures, which also depend on the operating conditions. In addition, it is necessary to take into account the current state of each node, mechanism and system as a whole. Quite frequent accidents arising during the operation of the vessel associated with the breakdown of mechanisms and de-

vices, the destruction of shafting bearings, the failure of hydraulic control systems, etc. sometimes lead to terrible possible consequences, up to the wreck of the ship.

JSC "SSTC" for a long time dealt with the impact of hull deformations on mismatches of ship systems, including navigation and propulsion systems, as a result of which a methodology for constructing a system of dynamic bases was developed and implemented on many ship projects, which provides for periodic monitoring of the position of these complexes. In this case, special periodic control equipment was used, which included autocollimating theodolites adapted for operation afloat, optical calibers or mirror-prism basic elements, quadrants or electronic differential levels.

To more effectively take into account hull deformations, several circuit-technical solutions for continuous monitoring during operation were developed, for example, based on optical-laser monitoring tools with the laying of light channels in the ship's hull. Also, based on the corrected strapdown gyroazimuthhorizon, ship hull deformation meters [2] and a complex of related sources were developed. Technical solutions based on the use of high-precision differential levels are also known [3]. However, these developments have not found wide application.

International practice shows the effectiveness of the use of systems for intelligent monitoring of the stress-strain state of pipelines operating under cyclic loads. For example, technologies for using optical fiber as a sensor for distributed monitoring are widely used to control deformations and movements of supporting structures.

Therefore, an extremely important direction in shipbuilding is the widespread introduction of automated systems for monitoring deformations of the ship's supporting structures, which allow obtaining information continuously and in real time also on the position and loading of each type of equipment, mechanism, including complexes as a whole [4].

Based on the above, at the first stage of development of this direction there is an urgent need:

– to modernize previously developed solutions for continuous monitoring systems based on the use of modern element base and highly intelligent programs and devices being created;

– to ensure their widespread implementation at the facilities under construction, operation and repair of marine equipment.[5]

The introduction of automated systems for monitoring ship hull deformations and the position of ship equipment, including propulsion and other systems, will make it possible to solve the following tasks:

– operational (in the future, in automatic mode) accounting for local deformations of the hull at the installation sites of ship equipment and navigation systems by performing additional (in the future, automatic) equipment realignment,

or introducing refined corrections based on the calculations performed, taking into account forecasting data;

– collection and analysis of statistical data on the nature and magnitude of deformations of the ship's hull (both a separate order and a representative of a specific project) during completion afloat and operation, which will allow predicting, taking into account the time factor, the behavior of the hull of a typical ship design in various conditions (when changing temperature conditions, at different degrees of loading, at different speeds, etc.). This will make it possible, in particular, to control the quality of the construction of serial ships (by tracking sharp changes in the values of deformations or their significant deviation from the average value for the series) and the degree of wear of the hull, as well as to take into account the probable magnitude of deformations when replacing ship equipment and navigation systems during repair and modernization;

– analyze the consideration of actual data on hull deformations by the designer when making decisions on the refinement / improvement of marine equipment structures (changing equipment locations, introducing reinforcements, etc.);

– analyze the accounting of actual data on the deformation of the body by technologists when calculating the accuracy of control and measuring operations during the installation of equipment;

– to develop in the future self-adjusting systems for centering propulsion systems, individual mechanisms and navigation systems, depending on the deformation changes in the ship's hull structures [6].

In recent years, in domestic and foreign shipbuilding, the requirements for the construction of hull structures, for the assembly and installation of the main and auxiliary power equipment, piping systems and control and navigation systems have significantly increased [7]. In addition, the requirements for the operational parameters of all ship systems, for their efficient and high-quality repair, have become tougher.

In order to ensure the implementation of the established requirements, foreign shipyards began to saturate almost all ships with various systems that allow monitoring heavily loaded units, mechanisms and individual ship systems during their operation, for example, temperature sensors are installed for bearings of propulsion systems, pumping mechanisms and a number of other power mechanical nodes. Marine pipeline valves are equipped with automatic diagnostics and monitoring systems that allow monitoring the current status of the valves (“closed”, “open”, “emergency”), the position of the stem of the shut-off / control element, the pressure and temperature of the medium, the developed force, operating time, vibration levels. The pressure in the pneumohydraulic systems, heat supply and equipment cooling is monitored directly on the vessel control panel. Similarly, diagnostic and automation systems are used in the electrical systems of ships, which

are designed to constantly monitor the loads in the electrical ship systems and, in the event of overload and failure, automatically switch to other modes or turn on spare (emergency) circuits.

In this regard, on some ships of foreign companies, automatic devices are widely used that are part of the control system, which are divided according to a number of functional features: control, signaling, protection and blocking devices, and in some cases regulation and even program control. Control devices serve to obtain information about the state of the object and the conditions of its operation. At the present stage of automation, preference is given to remote control devices, and local control devices are used only to start and adjust the process.

Signaling devices are designed to automatically notify maintenance personnel about the occurrence of certain events in a controlled object or in a system of objects by giving sound or light signals. In some cases, sound and light signals are used simultaneously.

To prevent accidents of ship equipment and mechanisms (overheating of bearings, excess of established pressure standards, etc.), foreign shipbuilding companies are already using automatic protection and blocking devices of various design and functionality. These devices provide the established modes of operation of the ship systems and, in case of special failures in the operation of individual units, mechanisms, they can take them out of the operating mode in time with an alarm being sent to the control panel [8].

Considerable attention is paid to software control systems and devices that ensure the maintenance of the necessary parameters of work processes during the operation of individual ship systems and equipment. The effectiveness of such systems has made it possible to significantly increase the operational safety of ships, reduce emergency situations to a minimum under difficult meteorological conditions of navigation, eliminate by an order of magnitude the number of accidents, failures of operating ship systems, and, most importantly, significantly extend the period of trouble-free operation of marine equipment as a whole.

Continuous monitoring of the technical condition, detection of deviations of controlled parameters from standard values, forecasting and recommendations for further actions are important components of the activity to prevent the development of many processes that can threaten the integrity of power plants, control systems, ship hull structures.

Given the need to improve the safety and reliability of the operation of modern ships, as well as the unique capabilities of modern digital measuring equipment, highly intelligent systems for ensuring effective control, it seems extremely important to move on to the development and implementation of automatic systems for monitoring and maintaining the design parameters of power plants, ship systems, devices, mechanisms, navigation systems and hull structures at all stages of the ship's life cycle.

Development and implementation of systems for automatic monitoring and maintenance of design parameters of ship power and auxiliary equipment, navigation complexes and control systems will allow:

– increase the operational reliability and service life of marine facilities ~ 1.5-2 times;

– reduce the duration and labor costs of repair and modernization of hull structures, mechanical installation works by 50-60%;

– increase by 2-3 times the reliability of the functioning of ship systems, mechanisms and devices;

– to increase the reliable accuracy of the functioning of navigation systems;

– to improve the accuracy of technological processes of installation of equipment and piping system;

– to increase the safety of operation of marine facilities;

– reduce the number of service personnel by 10-15%.

The implementation of systems for automatic monitoring and maintaining the design parameters of ship power and auxiliary equipment, navigation systems and control systems will be the first step towards creating automated ship control systems using artificial intelligence, capable of effectively solving more complex tasks and in a shorter time. In this case, any errors in the management of any objects of marine equipment, usually associated with the manifestation of the "human factor", are excluded.

In ensuring the successful implementation of high-performance ship monitoring and automatic control systems, the priority tasks of shipbuilding are:

– development of scientific foundations for the creation of: systems for automatic monitoring and maintenance of design parameters of ship power and auxiliary equipment; automated ship control systems using artificial intelligence;

– specialized, deeper training of engineering, technical and scientific personnel, working personnel;

– gradual transition to the design of ship equipment with a wide range of use of diagnostics and control automation systems;

– creation of production facilities for the manufacture of the element base, automation systems and measuring instruments.

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柴油发动机预启动加热系统
PRE-START HEATING SYSTEM FOR DIESEL ENGINES

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抽象的。 位于俄罗斯联邦乌法的巴什基尔国立农业大学开发了一种不消耗额外能源的柴油发动机预启动加热控制系统。 它是一种带有相变物质的蓄热器，带有可控的辅助驱动器以循环冷却剂和热传感器。 其工作原理是在发动机运转时将热能储存在蓄热器中，在发动机停机时储存能量，并发生相变“熔化-结晶”，并将其用于发动机的预启动加热。 它大大提高了汽车和拖拉机柴油发动机的运行效率。

蓄热器排放有一个数学模型，可帮助计算所需发动机温度对蓄热器温度的依赖性，并确定其必要参数。

发现蓄热器排放期间发动机温度的变化是非线性的。

实验研究的结果表明柴油机预启动加热控制系统的效率很高。

发动机加热到运行温度的时间缩短了 5.3 分钟，油耗降低了 26%。

关键词：内燃机，蓄热器，启动前加热，油耗。

Abstract. *A control system for pre-start heating of a diesel engine that doesn't consume additional energy has been developed in the Bashkir State Agrarian University, located in Ufa, the Russian Federation. It is a heat accumulator with a phase change matter provided with a controlled auxiliary drive to circulate coolant and a heat sensor. Its work is based on storage of heat energy in the accumulator during engine operation, energy reservation when the engine is being off and there is a phase transition "fusion-crystallization" and using it in pre-start heating of the engine. It considerably increases operation efficiency of a diesel engine in cars and tractors.*

There is a mathematical model for heat accumulator discharge that helps to calculate dependence of the required engine temperature on the temperature in the heat accumulator and determine its necessary parameters.

A change in engine temperature during heat accumulator discharge is found to be non-linear.

The results of experimental studies showed high efficiency of the diesel pre-start heating control system.

The period for engine heating-up to the running temperature has shortened by 5,3 minutes and fuel consumption has decreased by 26 %.

Keywords**:** *internal combustion engine, heat accumulator, pre-start heating, fuel consumption.*

Introduction

Studies conducted in agricultural enterprises of the Republic of Bashkortostan of the Russian Federation showed that car-and-tractor diesel engines are operated all the year round mostly in low temperatures. Fuel consumption per one operation season reaches 15 ... 20% [2].

Thermal condition of diesel engines is known to be one of the most important factors affecting their efficiency. During operation, before diesel engines take the load they must be preheated to get the operating temperature. Preparation of car-and-tractor machinery for load and starting diesel engines can last for 1 ... 3 hours [3].

This process requires a large amount of fuel, energy and additional funds. Many Russian and foreign scientists try to solve cold starting problems of diesel engines. These studies are conducted in two directions:

- assisting initiation of combustion;
- providing the required starting speed of the engine crankshaft.

For a reliable start of the diesel engine it is necessary that the temperature at the end of the compression stroke exceeds the self-ignition temperature of the fuel. Factors affecting ignition and combustion of the working mixture in the cylinders of the diesel engine are divided into controlled during operation and structural, that can not be controlled under operating conditions [2].

As the scheme shows, diesel engine starting problems can be solved by different ways and means.

Cold start strategies for diesel engines based on an integrated model of a pre-start heating especially for the Alps region with winter temperatures ranging from -30°C to 0°C are studied by Yuanwang Deng, Huawei Liu, Xiaohuan Zhao, Jiaqiang E, Jianmei Chen [11, 15].

Jian Song, Xue-song Li, Xiao-dong Ren, Chun-wei Gu present a new preheating system that uses high-temperature exhaust gas of the engine in the evaporator. This gas is further cooled in the preheating process along with low-temperature cooling water [12, 14].

In modern diesel engines there are glow plugs and a flame start system to heat the air at the intake stroke. Glow plugs are usually used for light diesel engines operating at ambient temperatures up to minus 15°C. They are installed in the combustion chamber. The most widely used glow plugs are of Bosch and Lucas-CAV companies.

Using starter fluid provides cold start of the engine at an ambient temperature down to minus 48°C. However, their widespread use requires compliance with safety measures during storage and application.

The coolant temperature is a very important factor to control fuel ignition.

One way to control the coolant temperature is diesel engine pre-heating by supplying hot coolant to the cooling system.

According to the thermal preparation control method diesel engine preheating can be autonomous and non-autonomous. The most widespread coolant heating with of non-autonomous electric heaters requires electric supply and is very costly [2]. In this case, the coolant is circulated by thermosyphon convection or by an additional installed circulation pump. In Russia foreign DEFA (Norway), Calix (Sweden) engine heating systems and Russian "Lider" are used. Despite the widespread use of such systems, they have a number of significant drawbacks: non-autonomy, fire danger, danger of electric shock, high power consumption [4].

Autonomous heaters (Webasto, Eberspacher, heatstroke, etc.) are also used as pre-start engine heating systems [2]. In this case, after the control unit starts the heater, the fuel pump supplies fuel from the tank of the tractor to the combustion chamber. In the process of fuel combustion the heater releases heat that is transmitted to the diesel coolant through the walls of the heat exchanger. Then, the circulation pump drives the coolant through the small circuit of the engine cooling system warming it up.

In [9] the authors consider the process of oil heating in the internal combustion engine by a self-regulating electric heating device powered with the on-board power system.

There are still no autonomous heaters of this kind in diesel engines of domestic tractors because of their high cost. Their major disadvantage is a fire hazard, high fuel consumption, complexity of installation, energy consumption of the on-board power system [8].

The aim of our research is to develop a control system for pre-start heat preparation of a diesel engine based on the efficient use of engine heat energy.

Materials and methods

The pre-start heat preparation control system of the diesel engine, developed at the Bashkir State Agrarian University, does not require additional energy [2,5]. It is a phase transition heat accumulator. Its work is based on storing heat energy in the heat accumulator during engine operation, its reserving while the engine doesn't operate on the basis of the phase transition "fusion-crystallization" and further heat energy using for pre-start heating of the engine.

The Canadian firm "Centauru offers similar pre-start heating systems based on heat storage. However, the pre-start heating system developed at our University provides higher efficiency of the heat accumulator by correcting the coolant flow

rate depending on the engine heat capacity, its temperature as well as the ambient one [6].

Sodium acetate trihydrates having the highest specific fusion heat (272,4 kJ/kg), storing heat by means of the fusion process in the phase transition "solid body-liquid" and satisfying all the operation efficiency and safety requirements is used as a heat-retaining material in the heat accumulator [3,4].

A key diagram of the pre-start heating system for a diesel engine with a phase transition heat accumulator based on sodium acetate trihydrate is shown in figure 1.

Charging takes place during the engine performance when it reaches the operating temperature. In this case, the temperature sensor 3, located on the thermostat 5, gives a signal to the electronic unit 8, that gives an impulse to the control valve 12 after processing the signal, thereby directing the flow of hot coolant created by the standard pump 7 through the heat accumulator 10 with sodium acetate trihydrate capsules. The charging process continues until the temperature sensor 3 at the head output 4 of the motor unit 1 is equal to the temperature sensor 3 inside the heat accumulator 10.

When the engine is not running, the heat accumulator switches to the storage mode. In this case, the control valve 12 closes the channel leading to the heat accumulator 10, thereby eliminating the phenomenon of thermosyphon convection.

For pre-start heating of the engine the heat accumulator discharge mode is activated. The electronic unit 8 before starting the engine gives a signal to the electric pump 2 and to the control valve 12, and thus liquid circulation in the cooling system is initiated until the temperature at the output of the heat accumulator 10 becomes equal to the temperature at the head output 4 of the motor unit 1. The electronic control unit 8 can change the coolant flow rate for more efficient heat intake from the heat accumulator 10 depending on the signal received from the ambient temperature sensor 9. Also, the accumulated heat can be used to heat the tractor cab by directing the heat flow to the interior heating radiator 11 [6].

The efficiency of the pre-start heating control system of the diesel engine depends on the discharge mode of the heat accumulator. To study the discharge process a mathematical model was developed. The model of pre-start diesel heating during the heat accumulator discharge is shown in figure 2.

To assess adequacy of the created model, comparative heating tests were conducted on a three-dimensional model as well as directly on the engine (diesel D-243 being the most common was taken as a prototype) using different schemes to connect the coolant to the engine.

To do laboratory tests an installation based on MTZ-82 tractor with D-243 diesel was assembled. The laboratory setting consists of a 75.3780.11.03 circulation pump produced by LLC "Avtoritm", a ZET210 analog-to-digital converter of ZetLab company, a SGV-15 flowmeter of LLC "BETAR", chromel-copel thermocouples, a 1.6 kW electric heater.

A number of assumptions were made to the mathematical model:

- at the initial pre-start heating time τ=0, when there is a discharge mode, the heat accumulating substance is in the liquid state. Its temperature is equal to the temperature of the phase transition $T_{ф}$ and is aligned in volume;

- transfer coefficient (heat conduction, heat capacity, heat transfer coefficient) and specific heat capacity of the materials involved in the heat transfer process, do not depend on the temperature;

- heat losses of the heat accumulator and connecting hoses to the environment are not taken into account;

- the thermal condition of the engine is estimated by the time-varying average temperature of its parts being in contact with the coolant $T_{ов}(\tau)$.

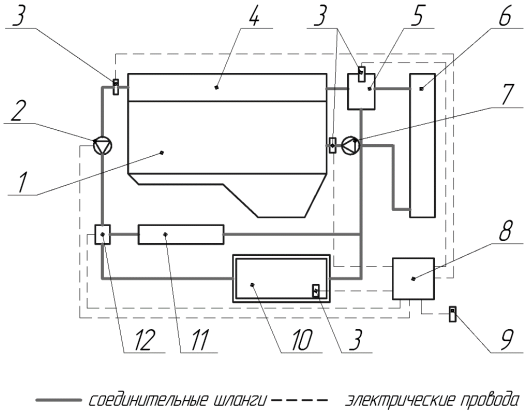

Figure 1. *A key diagram of the pre-start heating system for a diesel engine: 1 - engine, 2 – an electric pump of the cooling system; 3 – temperature sensors, 4 – head of the cylinder block; 5 - thermostat, 6 – engine cooler; 7 – standard circulating pump, 8 – electronic control; 9 – ambient temperature sensor; 10 – phase transition heat accumulator, 11 – interior heating radiator; 12 – control valve.*

Results

When an independent electric pump 2 starts (Figure 3) at the ambient temperature T_0, the cooling liquid circulates in the engine – heat accumulator closed circuit. Being characterized as $G_{ж}$=const, $T_{ж\,вх}(\tau)$ and $T_{ж\,вых}(\tau)$=var, it comes to the heat accumulator 3. There it gets some heat from the heat accumulating substance and with $G_{ж}$=const and $T_{ж\,вых}(\tau)$=var returns back to the engine 1 releasing the acquired heat. As the result of this process the heat accumulator 3 is discharged heating the diesel engine 1.

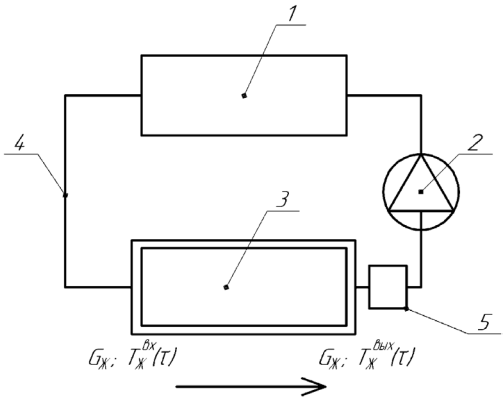

Figure 2. *Functional model of pre-start engine heating at the heat accumulator discharge: 1 – engine; 2 – pump; 3 – heat accumulator; 4 – connecting hoses; 5 – electronic control.*

Taking into account the changing temperature $T_{ж\ вх}(\tau)$=var, the average temperature of the cooling liquid inside the heat accumulator $T_{ж\ ср}(\tau)$ is calculated according to the formula:

$$T_{ж\ ср}(\tau) = \frac{T_{ж\ вх}(\tau)+T_{ж\ вых}(\tau)}{2} \quad (1)$$

Besides, when τ>0 the following equations are true:

$$q_{раз}(\tau) = \lambda_т^{тв} \cdot \frac{T_ф - T_{ст}(\tau)}{z(\tau)} \cdot F_ц \quad (2)$$

$$q_{раз}(\tau) = \rho_т^{тв} \cdot r_т \cdot \frac{dz(\tau)}{d(\tau)} \cdot F_ц \quad (3)$$

where $q_{раз}(\tau)$-heat output released by the cooling liquid, W;

$\lambda_т^{тв}$-heat conduction coefficient of the heat accumulating material in the solid phase, W/(m·K);

z(τ)-depth of the crystallized heat accumulating material layer at the time τ;

$\rho_т^{тв}$-density of the heat accumulating material in the solid phase, kg/m^3.

Diesel engines have an irregular shape of the cooling jacket due to the large number of different shaped and sized channels. It results in uneven flow of the cooling liquid through the cooling jacket cavities. In this case, the heat exchange process from the coolant to the walls of the cooling jacket $\alpha_{ро}$ taking place with a constant average heat transfer coefficient is better to be presented as a model. Then at τ>0 the following equation is true:

$$q_{раз}(\tau) = \alpha_{ро} \cdot F_{ро} \cdot (T_{ж\ ср}(\tau) - T_{дв}(\tau)) \quad (4)$$

where $F_{ро}$- heat exchange area in the cooling jacket cavities, m^2;

$\alpha_{ро}$ - heat capacity coefficient from the coolant to the walls of the cooling jacket, W/(m^2·K);

$T_{дв}$ - average engine temperature, K.

Given that supplied heat increases the internal energy of the diesel engine and brings in heat losses to the environment at τ>0 there is the following equation:

$$q_{раз}(\tau) = C_{дв} \cdot \frac{dT_{дв}(\tau)}{d\tau} + \alpha_{дв} \cdot F_{дв} \cdot \left(T_{дв}(\tau) - T_0\right) \quad (5)$$

where $C_{дв}$ - total heat capacity of the engine metalware being in contact with the cooling liquid, J/K;

$\alpha_{дв}$ - average heat transfer coefficient from the cooling jacket walls, W/(m^2·K);

$F_{дв}$ - engine surface area cooled with the outer air, m^2.

$$q_{раз}(\tau)=G_{ж} \cdot c_{ж} \cdot (T_{ж\ вых}(\tau) - T_{ж\ вх}(\tau)) \quad (6)$$

где $G_{ж}$ - weight output of the independent electric pump, kg/s;

$c_{ж}$ - heat capacity of the cooling liquid, J/(kg·K).

A system of equations (1...6) presents a mathematical model of the pre-start engine heating system operation at heat accumulator discharge. There are new functions there $q_{раз}(\tau)$, z(τ), $T_{дв}(\tau)$, $T_{ж\ вх}(\tau)$, $T_{ж\ вых}(\tau)$ и $T_{ст}(\tau)$. This system is closed because the number of unknown functions equals the equation number. It can be solved with initial and boundary conditions being different depending on these or those conceptions on the studied process. In the given case initial and boundary conditions can be formulated as follows:

$$\begin{cases} q_{раз}(0) = 0 \\ 0 \le z(\tau) \le \delta_т;\ z(0) = 0 \\ T_{cm}(0) \approx T_ф \\ T_{ж\ вх}(0) = T_{ж\ вых}(0) = T_{дв}(0) = T_0 \end{cases} \quad (7)$$

There is a system of two differential equations resulted from simple algebraic equation manipulations (1...6):

$$\frac{dz(\tau)}{d\tau} = \frac{E - D \cdot T_{дв}(\tau)}{N \cdot (W + B \cdot z(\tau))}; \quad (8)$$

$$\frac{dT_{дв}(\tau)}{d\tau} = \frac{E - D \cdot T_{дв}(\tau)}{Z + Y \cdot z(\tau)} - I \cdot T_{дв}(\tau) + M \quad (9)$$

To make equations 8 and 9 simpler, there are invariables, that influence on the system characteristics, where B, W, D, E, I, M, N, Z, Y are calculated with the formula:

$$B = \propto_{ж} \cdot F_{ц} \cdot \propto_{зп} \cdot F_{ро}; \quad (10)$$

where $F_{ц}$ - the sum of side cylindrical surfaces areas of a capsule, m^2;

$F_{ро}$- heat transfer surface area of the cooling jacket cavities, m^2;

$\alpha_{ж}$- heat capacity coefficient from the cooling liquid to the capsule walls, W/(m^2·K);

$\alpha_{зп}$- heat capacity coefficient from the cooling liquid to the walls of the cooling jacket cavities, W/(m^2·K);

$$W = (\propto_{ж} \cdot F_{ц} + \propto_{зп} \cdot F_{зп}) \cdot \lambda_{т}^{тв} \cdot F_{ц}; \quad (11)$$

where $\lambda_{т}^{тв}$- heat conduction coefficient of the heat accumulating substance in the solid phase, W/(m·K).

$$D = B \cdot \lambda_{T}^{тв} \cdot F_{ц}; \quad (12)$$

$$E = D \cdot T_{ф}; \quad (13)$$

where $T_{ф}$- temperature of the phase transition, K.

$$I = \frac{\propto_{дв} \cdot F_{дв}}{C_{дв}}; \quad (14)$$

where $C_{дв}$- total heat capacity of the engine metalware being in contact with the cooling liquid, J/K;

$\alpha_{дв}$- average heat capacity coefficient from the walls of the diesel engine to the environment, W/(m^2·K);

$F_{дв}$- the diesel engine surface area, cooled with the outer air, m^2.

$$M = I \cdot T_{0}; \quad (15)$$

where $т_0$- the ambient temperature.

$$N = \rho_{T}^{дв} \cdot r_{T} \cdot F_{ц}; \quad (16)$$

where $\rho_{т}^{тв}$- density of the heat accumulating substance in the solid phase, kg/m^3;

r_r- latent heat of the phase transition.

$$Z = W \cdot C_{дв}; \quad (17)$$

$$Y = B \cdot C_{дв}. \quad (18)$$

The developed mathematical model of heat accumulator discharge process taken as a unified equation system provides qualitative calculations. In particular, it is good to find peak values of the diesel engine heating temperature and time during the heat accumulator discharge process depending on the given data (invariables B, W, D, E, I, M, N, Z, Y). Differential equations are solved in the Mathcad system.

Calculated temperature change dependencies of the heat accumulating substance and the engine on the heat accumulator discharge timing are shown in Figure 4.

As one can see, the engine temperature change at the heat accumulator discharge process is not linear.

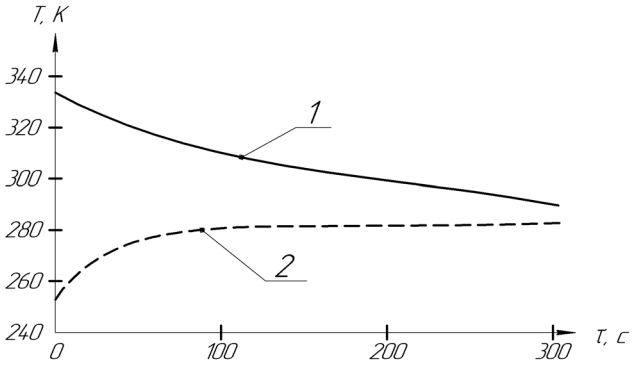

Figure 4. *Temperature dependence of the heat accumulating substance and the engine on heating timing during the heat accumulator discharge: 1- temperature of the heat accumulating substance; 2 – the engine temperature.*

The heat accumulator is characterized by the highest heat capacity at the beginning of the engine work (the engine temperature changes from negative to positive during the first minute). Then the charge level decreases.

Further experimental studies on the basis of D-243 diesel engine using the developed heat accumulator with phase transition substance for pre-start heating by storing and secondary use of the engine heat energy proved to be highly effective. Thus, even at positive ambient temperatures (+20°C) there is a significant reduction in the diesel engine heat preparation time until the operating temperature and consequently lower fuel consumption (Figure 5). The engine heating period reduced by 5.3 minutes, while the heat preparation system was switched on for only two minutes. When engine started without pre-heating 455 grams of fuel were consumed. With preliminary heat preparation fuel consumption decreased to 337 grams, that is 26% less.

The phase transition substance properties as well as good housing insulation of the heat accumulator provide heat conservation for up to 72 hours or more.

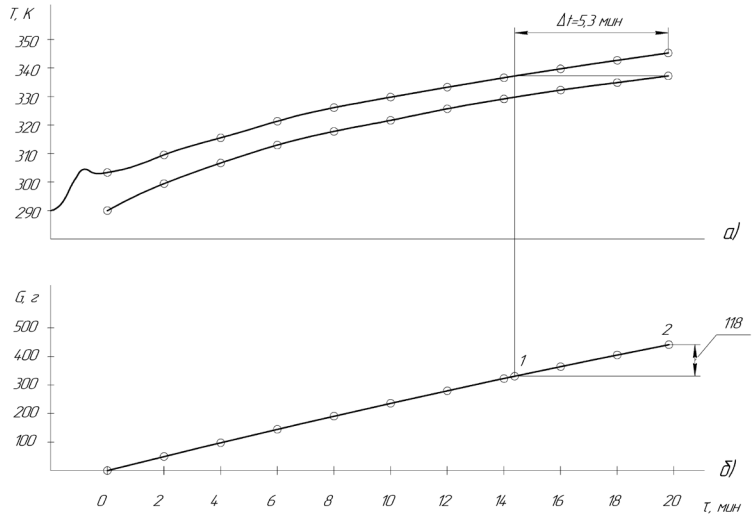

Figure 5. *Engine temperature dependence on: a) fuel consumption b) engine pre-start heating period: Point 1 –the cooling liquid heating time to the operating temperature with pre-start heating. Point 2 – heating period wihout pre-start heating.*

Discussion.

The conducted studies as well as result analyses of other scholars claim that pre-start heating is one of the best means of diesel engine heat preparation.

The most common technical developments in this field are independent heaters installed in different systems of the engine. However, they require additional energy and fuel and reduce operational safety.

The developed control system for pre-start heat preparation of a diesel engine based on the waste heat energy of the engine is very effective (scientific novelty of technical solutions is confirmed by the patent for the invention “pre-start heat preparation of the internal combustion engine” RU No. 2576603 of March 10, .2016). It provides reliable start-up of the diesel engine at low ambient temperatures, reduces the period to heat the engine to the operating mode and shortens fuel consumption up to 26% even at positive air temperatures. It has some advantages compared to other similar systems. Heat-accumulating material of the highest specific fusion heat (272.4 kJ / kg) as well as an additional coolant circulation drive with the control unit and temperature sensors provide easy control of the coolant temperature.

The developed mathematical model of the discharge process of the heat accumulator with the heat-accumulating material allows to make a qualitative calcu-

lation of the required engine temperature dependence on the temperature in the heat accumulator and to set its necessary parameters (the working volume of the accumulator and heat capacity of the phase transition substance).

By comparing the data obtained with the results of other authors, we can make the following conclusions. Using a phase transition heat accumulator in the engine cooling system is much more effective than using self-regulating heating devices that maintain the temperature through the engine lubrication system, fuel system or through the cooling system heated by an electric or on-board power system.

Thus, during the heat accumulator discharge the engine temperature change is nonlinear. It takes short time to conduct pre-start heat preparation. The temperature change dynamics of the motor oil in the crankcase oil pan (when the engine is being heated) is linear in nature that requires more time for pre-start preparation.

The research result reliability is achieved by the reasonable initial data, comparison of calculated and experimental values taking into account possible errors.

Experimental studies proved that the diesel engine heat preparation to the operating temperature (before opening the thermostat) when using a heat accumulator took 14.7 minutes. It is 5.3 minutes less than without heat preparation. When heat preparation of the engine is done by heating the engine oil it takes about 25 minutes [9].

Thus, the developed control system for pre-start heat preparation of the diesel engine based on a new technical solution –a heat accumulator with a phase transition substance provided with an additional controlled coolant circulation drive and temperature sensors can significantly improve efficiency of the diesel engine in car and tractor machinery.

Conclusion.

1. Using waste heat of the engine stored with the phase transition heat-accumulating material for pre-start diesel engine heating provides significant reduction in the heating time and fuel economy.

2. Compared to other systems the control system of pre-start heating of the diesel engine using the engine heat energy without any additional consumption of fuel and other energy is the most efficient.

3. There is a mathematical model of the discharge process of the heat accumulator with the heat storage material. It maintains a qualitative calculation of the required engine temperature dependence on the temperature in the heat accumulator and necessary parameters (the working volume of the accumulator and heat capacity of the phase transition substance).

4. Sodium acetate trihydrate is found to be the best heat-accumulating material for meeting all the requirements of safety and operational efficiency.

5. The diesel engine temperature change during the heat accumulator discharge is found to be nonlinear. It provides pre-start heat preparation for a shorter period compared to other heating systems.

6. The developed control system of pre-start heat preparation of the D-243 diesel engine reduces the period to heat the diesel engine to the operating heat mode by 5.3 minutes and, as a result, increases engine efficiency, reducing fuel consumption for engine start-up and its heating by 26%.

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MASV 技术测试的现代方法：测试概念
A MODERN APPROACH TO MASV TECHNICAL TESTING: THE TESTING CONCEPT

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抽象的。 本文涉及海上自主水面舰艇（MASV）测试的概念，它是设备监测、诊断和测试统一系统 （USMD&T） 的一部分，并根据船舶状况定义了所需的主要检查类型。 它描述了测试功能的实现，讨论了不同类型的 MASV 检查并探讨了测试功能与船舶状况的关系。 还讨论了对 MASV 的要求，例如具有统一的状态监测和诊断系统以及每个组件的自诊断功能。 文章还定义了船舶状态的主要模式：正常、异常和恢复。 所有这些都将确保 MASV 可靠且高效。

关键词：海洋自主水面舰艇，测试，状态图，操作模式，海洋技术，无人驾驶。

Abstract. *The article deals with the concept of testing of offshore autonomous surface vessels (MASV), which is a part of the unified system for equipment monitoring, diagnostics and testing (USMD&T) and defines the main types of checks required in accordance with the ship's condition. It describes the implementation of the test function, discusses the different types of MASV checks and explores the relationship of the test function to the ship's condition. Requirements for MASV, such as having a unified condition monitoring and diagnostic system and a self-diagnostic function for each component, are also discussed. The article also defines the main modes of ship state: normal, abnormal and recovery. All this will make sure that MASV is reliable and efficient.*

Keywords: *marine autonomous surface vessels, testing, state graph, modes of operation, marine technology, crewless navigation.*

Introduction

Offshore autonomous surface vessels are now among the most promising targets for the application of autonomous technology. This represents a new era for the maritime industry, which is becoming increasingly automated and for-

ward-looking in terms of modern technology. MASV have great potential for transporting cargo and performing various tasks at sea. However, before these vessels can be used for commercial purposes, the equipment must be thoroughly inspected to ensure its reliability and efficiency. The purpose of this article is to review the concept of MASV testing and identify the main types of inspections that need to be carried out according to the particular condition of the vessel.

The tasks to be accomplished to achieve this objective are:

- To describe the principle of implementation of the testing function;
- consider different types of MASV checks;
- to study the MASV state graph and the relationship of the testing function to the ship's state;

The main document for legal regulation of MASV in the Russian Federation is "Regulations on classification of marine autonomous and remotely operated surface vessels (MASV)". Russian Maritime Register of Shipping. The Regulations apply to the technical supervision of the design and construction, conversion of ships to MASV, as well as the manufacture of materials and products for MASV. [1]

The Maritime Register of Shipping of the Russian Federation defines the requirements for MASV and its systems. Consequently, based on the "provisions" it is possible to single out main ship systems necessary for proper functioning of MASV. [1] (Figure 1)

Requirements for MASV:

- each MASV must have a unified condition monitoring, diagnostics, and testing (ESM&T) system;
- each approved MASV subsystem must be linked to the main module of the ESMD&T;
- each component, equipment and device of subsystems approved for use in MASV shall have a self-diagnostic function;
- there must be a standard interface and data format for transmitting test commands and test results;

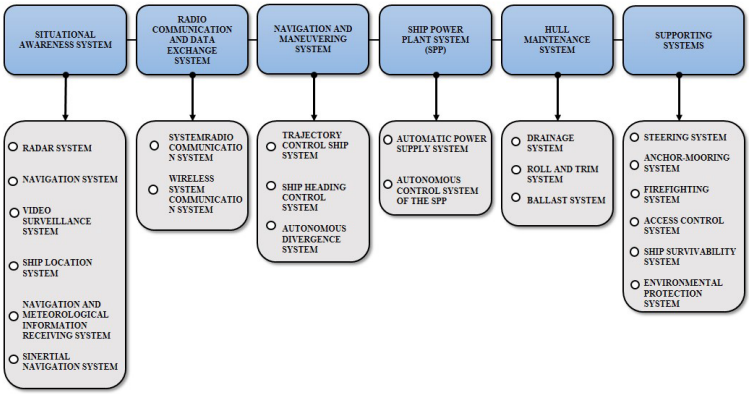

Figure 1. *List of ship subsystems according to RMRS*

Any ship is designed to solve a certain range of tasks. Accordingly, a ship can be regarded as an object which implements a certain set of functions within certain constraints. Thus, it is possible to connect vessel subsystems with functions of a vessel and restrictions within which they are realized. Then, it is possible for each ship's subsystem to associate components and their characteristics with the test function and constraints for its realization.

Principle of test function implementation

The testing function allows you to test technical equipment on the ship, check its performance in certain periods of time with the connection of components and their characteristics to the test function and the constraints on its implementation. Selective testing allows you to automatically make decisions in accordance with the selected type of testing. [2]

The system is able to select only those shipboard subsystems and devices that are used for a particular operation. Testing can take place at various levels of the system, ranging from checking individual devices to checking all of the ship's systems as a whole. When faults or problems are detected, the system generates an appropriate report that can be transmitted to the remote access center for further decision-making. [2]

The testing function should be implemented by using a defined set plan that includes a list of all the subsystems that need to be tested, as well as methods and techniques for testing them. According to this plan, the system independently determines which subsystems should be tested depending on the task. The results of testing are independently evaluated and analyzed by the system to assess the degree of its readiness for work. [2]

Types of inspections of MASV testing system

In order to evaluate the operability and efficiency of offshore autonomous surface vessels, the following types of checks should be performed:

T1 (initial testing) - this type of test is performed when new equipment is put into service. The purpose of this test is to verify the operability of the equipment and its compliance with the requirements specified in the technical documentation. During this test such parameters as operability, reliability, functionality and compliance with safety requirements are checked. The correct installation and connection of the equipment is also checked. Thus, the initial inspection determines the approved characteristics of the ship.

T2 (periodic testing) - this type of test is carried out periodically in accordance with the requirements of the Register or in case of changes in the construction of the vessel or its hull shape or substantial replacement of equipment. The purpose of intermediate testing: to confirm that the approved characteristics of the vessel have not changed or have changed and then the functionality of the vessel or restrictions for its use need to be changed.

T3 (routine testing) - this type of test is performed each time during the operation of the vessel prior to a change in the condition of the vessel under normal operation throughout the period of operation of the equipment. The main purpose of this test is to ensure that the equipment is operating smoothly and normally during the current period of time. It is assumed that if the equipment is in good working order, the vessel will be able to perform its functions within the limits set for it.

Offshore Autonomous Surface Vessel Status Graph

A set of T3 functions (current testing) can be defined using the state graph of a marine autonomous surface ship. (Figure 2)

The MASV ship state graph is a graphical representation of all possible ship states in different situations. The state graph allows you to determine which systems and equipment need to be tested depending on the specific state of the ship. **Autonomous ship can operate in 3 modes: A - normal, B - abnormal, C - recovery. (Figure 2)**

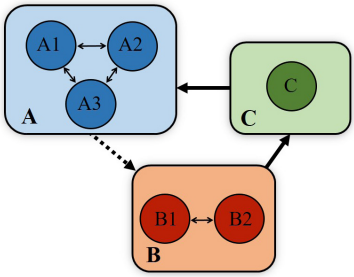

Figure 2. *MASV state graph*

In each mode the MASV can be in one of the states:

A1 (typical) - the MASV operates in normal mode and performs tasks in accordance with the program of most subsystems;

A2 (special) - the MASV switches to a special mode, for example, to perform complicated tasks requiring operation of additional subsystems;

A3 (limited) - the MASV continues functioning but with a limited set of functions;

B1 (standby) - the MASV enters standby mode when the main equipment fails, but spare systems allow to continue operation;

B2 (emergency) - the MASV enters emergency mode when a serious malfunction occurs, which requires immediate shutdown of operation and measures to eliminate the problem;

C (recovery) - MASV is in the process of recovery after malfunction or accident and prepares to return to normal mode;

Connection of MASV operation on the basis of a graph of states is that scenarios of ship operation depend on its current state.

For example, if a ship is in A1 (typical) state, it operates in the normal mode and performs tasks in accordance with the program. If the ship enters state B1 (standby), it continues to operate, but using standby subsystems or equipment. In this case, operation scenarios may be limited and defined only by the tasks that the ship can perform using standby systems. If the ship enters state B2 (emergency), the ship stops its operation and takes corrective action. In this state, the ship can perform only those tasks necessary to restore its performance. (Figure 2)

Conclusion

Offshore autonomous surface vessels are a new technological solution in the field of maritime transportation. However, before these vessels can be used commercially, the concept of the testing system that is part of the ECMD&T must be thoroughly investigated. Different types of tests have to be performed to test the equipment, which have an inextricable link to the ship's conditions and voyage scenarios. All of this will ensure the reliability and effectiveness of the MASV.

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钻井过程监测系统中无线传感器网络的信息安全问题
INFORMATION SECURITY PROBLEMS OF THE WIRELESS SENSOR NETWORK IN DRILLING PROCESS MONITORING SYSTEMS

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抽象的。 本文讨论了确保系统信息安全的选项之一，该系统使用特殊的信息安全模块在多口井的现场监控钻井过程。 该模块的操作基于 Diffie-Hellman 算法。 该模块的一个特点是参与无线传感器网络运行的设备的资源消耗低。

关键词：钻井过程监控，无线传感器网络。

Abstract. *The article discusses one of the options for ensuring information security for a system for monitoring the drilling process at a site with several wells using a special information security module. The operation of the module is based on the Diffie-Hellman algorithm. A feature of the module is low resource consumption from devices participating in the operation of a wireless sensor network.*

Keywords*: drilling process monitoring, wireless sensor network.*

Introduction

Monitoring systems are widely used in industry, including in the oil and gas industry and specifically in drilling [1]. Both passive monitoring (obtaining and forming a database of drilling parameters) and active monitoring are used, which

comprehensively assess the state of a drilling well to determine the current state of the process (object) and predict the moment of its transition to the limit state, as well as to develop control actions.

Digital systems for collecting information about the drilling process, for example, stations for geological and technological research (GTR), appeared quite a long time ago and initially made it possible to record all measured and calculated parameters in digital form, as well as present this information in a convenient graphical form. It was available both to direct participants in the production process (drilling crew) and to other specialists located at the drilling site via the local network. The use of operational remote access from the office to the mud logging data at the drilling rig was limited by the imperfection of the existing communication channels. It is noted in [1] that the world's first VSAT station with a range that provides communication with remote drilling rigs was developed in 1985 by Schlumberger Oilfield Research in collaboration with Hughes Aerospase, which can be considered the beginning of monitoring remote objects in relation to oil and gas wells.

Modern systems for monitoring the drilling process as sources of information use both data from various automated systems (GTR stations, MWD / LWD - systems, logging systems on drill pipes, video monitoring, etc.), and production reporting data (daily reports, summaries and etc.). In Russia, various companies are involved in the development and implementation of such systems, for example, "Petroviser" LLC, "Geofizika" RPC OJSC, etc. It should be noted right away that monitoring systems are complex and, as a result, expensive systems, for the implementation of which drilling site data transmission channel, server with specialized software, local area network of the drilling site, satellite communication channel, office server, high-speed local area networks, qualified personnel, etc.

The relevance of research

One of the problems in the development and practical implementation of monitoring systems with remote access via industrial networks is the information security of data transmission. Its provision depends on many components, such as directly technical means of protection, algorithms for processing and transmitting information, the organization of this process at the facility, etc. In this case, technical means of protection mean special additional information security modules (MIS) that protect the built-in information security measurement and automation software from unauthorized interference. Almost all of these tools included in the APCS do not have cryptographic protection (encryption / decryption, etc.), since it is not needed to perform their main function. Such modules act as a kind of protective screen that prevents changes in the settings of APCS technical devices and the data stored in their memory. The use of the same standard module for all oil and gas industry facilities is impossible due to the large difference in operating conditions, available infrastructure, required volumes and transmission rates, etc.

In”Geofizika” RPC OJSC, by order of “Bashneft” JSOC, a system for remote control and management of the well construction process has been developed, which allows the customer to quickly contact any remote drilling rig where the GTR station is installed via cellular communication or a satellite terminal, and in real scale time to view all current information [2]. This system provides full encryption of all external traffic, providing protection against unauthorized access to confidential information. For its use, a complete geotest-5 type mud logging station or its truncated version, Leuza-2, must be installed on the drilling rig. However, at the vast majority of drilling rigs, including those located in hard-to-reach areas, a wide variety of monitoring systems of different generations, both domestic and imported, are installed and used. It should also be noted that GTR stations of various domestic manufacturers historically have their own data format. In such systems, data encryption/decryption must be carried out using individual modules.

The monitoring system considered in the article combines several drilling sites and a single drilling control center (DCC), interconnected by a wireless sensor network (WSN) (Fig. 1). Each drilling site has a telemetry system for collecting and transmitting data from the bottom of the well to the earth’s surface and further to the automated process control and management system (APCS), as well as the transmission of control commands to the rotary control system (RCS) directly in the drilling process [3]. The telemetry system includes a set of downhole modules connected by a bottomhole-wellhead communication channel, a complex of upper-level software and hardware tools, which is part of the wellhead equipment (WE), and a radio channel “SH-operator’s workstation”.

Figure 1. *System for monitoring the drilling process*

BSS is a self-organizing, distributed, scalable network, which is a collection of sensor nodes that interact with each other via a radio channel. In this case, the BSS has a number of features.

Drilling sites controlled from a single drilling control center (DCC) are randomly located on the ground, because their location is tied to the internal structure of oil and gas reservoirs. Therefore, sensor nodes are unevenly distributed over a fairly large area. For such a BSS, network connectivity is an important requirement: if a local station fails, then the entire cluster node no longer participates in wireless transmission, i.e. the exchange of data on the state of sensors, actuators and devices with the operator's console is terminated, control actions are not generated, there is no information about the current state of the cluster zone.

Another problem in the construction of BSS for drilling sites is the presence of a large number of man-made interference, for example, interference from various electric motors, in particular, the electric motor of the top drive of the drilling rig, telemetry and control systems operating in the same radio frequency range, etc. In addition, if there are any obstacles in the signal path that do not transmit radio waves, it may be completely lost. Hence another requirement for sensor nodes: they must not only generate and deliver their own data, but also serve as a path for other sensor nodes to the base station, i.e. perform the routing function [4].

The UO modules are self-powered, which imposes an additional requirement on the BSS for low power consumption.

Currently, no security measures are used for information transmitted over wireless networks. At the same time, the vulnerability of the WSN in relation to information security is quite high. The main reasons are the following [5]:

– general availability of the transmission medium, which facilitates message spoofing;

– unsuitable for protecting such classical security systems as certificate authorities and central servers due to the lack of infrastructure. The dynamic network topology requires the use of complex routing algorithms due to the possibility of compromised nodes;

– the very nature of the radio signal, which allows any node in the coverage area of the radio signal, "knowing" the transmission frequency, modulation, encoding algorithm, to intercept and decode the signal, and neither the signal source nor the recipient will know about it.

In addition, the presence of the IIS mentioned above is directly provided for by such regulatory documents as GOST R ISO / IEC 27002-2012 and the Federal Law on Information, Information Technologies and Information Protection No. 149.

Statement of the research problem

To improve the reliability of the monitoring system, it is necessary to develop an information security module that increases the security of transmitted data. The requirements for such a module are two-level. The first level is the general requirements of digital security, which include minimizing the time for generating a key and encrypting a message, minimizing the complexity of mathematical operations

and decrypting a message, both in the presence of a key and in the absence of it, as well as the absence of a relationship between the security of the algorithm and its secrecy. (Kergoffs principle) [6].

The second level of requirements are special requirements for the encryption of data transmitted over the BSS, which are determined by a specific object. In this case, such requirements are the minimum energy and resource consumption due to the presence of self-powered devices (CU modules) and programming languages (C language for CU modules and Java for a mobile application) in the BSS.

Research results and their practical significance

At the first stage of research, a class of encryption algorithm was chosen. It was decided to abandon symmetric encryption, because. in this case, the sender and recipient share the same key, and the transmission is carried out over a dedicated secret communication channel, which is not feasible in drilling sites. Accordingly, asymmetric encryption was chosen. It uses different but interdependent keys called “private” and “open”. The public key is transmitted over an insecure, observable channel and is used to encrypt the transmitted information. The secret key is used to decrypt the message.

At the second stage, an encryption algorithm was chosen. The Kerchhoffs principle makes it possible to use well-known algorithms in such problems, which greatly simplifies the task.

The selection criteria were such characteristics as security, encryption complexity, decryption complexity, redundancy and implementation complexity, and alternatives were the four most common asymmetric encryption algorithms: the RSA algorithm, the Diffie-Hellman algorithm, the Rabin cryptosystem, and the ElGamal scheme [7]. For comparison, the method of analysis of hierarchies was used, by means of which it was found that the most appropriate algorithms for the tasks were the RSA algorithm and the Diffie-Hellman algorithm.

The purpose of the next stage of research was to analyze the two selected algorithms in terms of energy consumption. To do this, software was developed for a mobile device and one of the self-powered CM modules included in the telemetry system at the drilling site. Energy consumption analysis was carried out using the Advanced Energy Monitor (Simplicity Studio) and Android Profiler (Android Studio) tools. As a test task, the process of encrypting a parcel of the form “01 00 0A 00 64 CC DD 00 00 E8” (10 bytes in hexadecimal format) was taken into an encrypted message with a length of 2048 bits of the byte array format.

To assess the energy efficiency of the software, four criteria were selected: the consumption of battery resources, random access memory (RAM), the central processor, and the maximum current power consumption of the module.

The power consumption of any algorithm depends on the number of actions required for one act of transmitting an encrypted message. For the Diffie-Hellman algorithm, their sequence is shown in fig. 2. The lilac color shows the actions per-

formed by both participants in the communication (the stand-alone WE module and the mobile device), the blue color shows only the mobile device, and the beige

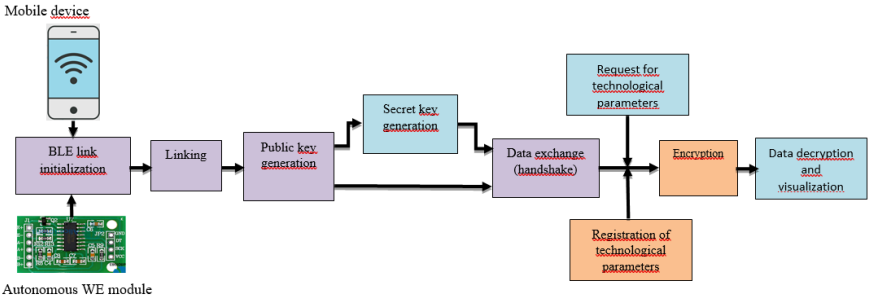

Figure 2. *Diffie-Hellman algorithm*

Estimation of the energy consumption of the RSA and Diffie-Hellman algorithms according to the criteria listed above for the encryption (E) and decryption (D) modes is shown in Fig. 2. 3. Battery consumption for both algorithms and both modes is rated light. In the background, the power consumption of the stand-alone WE module is 1.38 mA.

Conclusions

Systems for monitoring distributed objects, such as drilling sites, are based on the use of WSN, so they have problems of information security during data transmission. One of the solutions to such problems is the development of special information security modules. The proposed module based on the asymmetric Diffie-Hellman algorithm makes it possible to provide the necessary level of data protection while economically consuming the resources of the data source (autonomous DR module) and their receiver (mobile device based on Android OS).

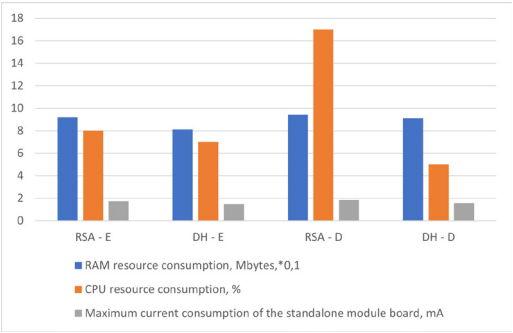

Figure 3. *Estimation of energy consumption by RSA and Diffie-Hellman algorithms in encryption and decryption modes*

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基于间接测量为具有状态延迟的对象构建稳健的控制系统
BUILDING ROBUST CONTROL SYSTEMS FOR OBJECTS WITH STATE DELAY BASED ON INDIRECT MEASUREMENTS

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抽象的。 解决了为具有状态延迟的线性固定设备构建鲁棒控制系统的问题，这允许通过间接测量来补偿干扰和噪声。 证实了控制系统在输入端未测无界扰动和输出端受限扰动作用下的可操作性。 主要结果是利用系统构造嵌套技术和辅助轮廓法得到的。 给出了计算机仿真的示例和结果，说明了所提出的控制方案的性能。

关键词：不变系统，系统嵌入，零因子，矩阵规范化，辅助轮廓。

Abstract. *The problem of constructing a robust control system for a linear stationary plant with a delay in state is solved, which allows compensating disturbances and noises by indirect measurements. The operability of the control system under the action of unmeasured unbounded disturbances at the input and limited disturbances at the output is substantiated. The main results are obtained using the technology of constructive nesting of systems and the auxiliary contour method. An example and results of computer simulation are given, illustrating the performance of the proposed control scheme.*

Keywords: *invariant systems, system embedding, zero divisor, matrix canonization, auxiliary contour.*

Introduction

Building a system that provides the required quality when the object is exposed to external and parametric disturbances is one of the main problems of modern control theory. At present, many methods and approaches have been developed for solving the problem of compensation for external disturbances. A sufficiently complete robust control theory and an extensive bibliography on it are presented in [1].

In the problems of process control, there are often objects that contain a delay in state. The synthesis of such systems requires taking into account the influence of the delay on the stability and quality of transient processes. Systems with delays are considered in most detail in [2].

In systems [3 – 5] with state delay, robust control algorithms that compensate for external influences are obtained using a modified Khalil filter. The control algorithm constructed using the internal model of harmonic disturbances was obtained in [6]. In [7], an external sinusoidal disturbance is identified, and then a control algorithm is synthesized. In [8 – 10], the auxiliary loop method is used, in which a signal is selected that carries information about external and parametric disturbances, which makes it possible to obtain the required estimates and, accordingly, compensate for the undesirable effect on the controlled parameters. However, in [3 – 9], the external perturbation acts only on the input of the systems, and is absent at the output.

Along with such a direction in solving this problem as robust control, the problem of system invariance to perturbations also deserves attention. The solution of the invariance problem [12] implies the determination of such structure and parameters of the control system under which the quality of the system operation does not depend on the disturbances acting on it.

For the first time, the possibility of creating a control system invariant to arbitrary external disturbances was pointed out by G.V. Shchipanov [13]. The structural condition for the realizability of invariance is formulated by B.N. Petrov the two-channel principle [14, 15]: a necessary but not sufficient sign of the feasibility of an absolutely invariant system is the presence in it of at least two parallel channels for transmitting a perturbing action between the point of its entry and the exit of the system, for which the invariance of the system is achieved. Later, the theory of invariance is extended to control processes that are invariant with respect to unknown parameters of the mathematical model [16,17]. The problem of double invariance was also posed as the independence of the behavior of the automatic system and its dynamic properties both from changes in the parameters of the mathematical model of the object and from external disturbances [17].

This article describes an approach to modifying existing methods of robust control, which follows from the results of studies on the embedding of systems, and which makes it possible to compensate for external and parametric disturbances acting both at the input and at the output of the system. The class of systems under consideration is limited to stationary systems with delay and without control restrictions. The main results were obtained using the technology of constructive nesting of systems [12] and the auxiliary contour method [8 – 10].

1. Statement of the problem

Let us consider a control object, the dynamic processes in which are described by the equation

(1) $\dot{x}(t) = Ax(t) + \Gamma x(t-\tau) + Bu(t) + Df(t), \qquad x(t_0) = x_0,$

(2) $z(t) = x(t) + S_1\xi(t),$

(3) $y(t) = Lx(t) + S_2\xi(t),$

where $x \in \Re^n$, $u \in \Re^m$, $z \in \Re^n$, $y \in \Re^r$ – vectors of state, control, measured and controlled parameters, respectively, $f \in \Re^l$ – vector of external disturbances, $\xi \in \Re^r$ – the noise at the output of the static link of the system model; x_0 – initial conditions; $A, B, D, L, S_1, S_2, \Gamma$ – numerical matrices of the corresponding orders, τ - unknown delay time.

It is required to obtain an algorithm for the functioning of the control system that ensures the fulfillment of the target condition

(4) $|Lx| < \delta$ at $t > T$,

where δ – sufficiently small value, T – the time after which the required dynamic accuracy should be ensured after the system is put into operation.

Assumptions:

i) pair (*A, B*) – controllable, and pair (*A, L*) – observable;

ii) disturbing action $\xi(t)$ – limited function;

iii) all matrices in (1) – (3) are known, matrices $A + \Delta A$, $B + \Delta B$ are not known;

iv) τ - unknown delay time

Other restrictions will be given in the terms of approval.

2. Solution method

The solution of the formulated problem consists of the following steps:

1. to stabilize the control object, as it can be unstable;
2. to construct a system that is invariant to external $f(t)$ and parametric perturbations ρ, where $\rho = \Delta A + \Delta BC$, ΔA и ΔB – and are constant perturbations of the matrices *A* and *B*;
3. Using the auxiliary contour method, construct the noise estimate $\xi(t)$;
4. to ensure the fulfillment of the target condition (4).

We will form the control vector in the form

(5) $u(t) = -C\tilde{y}(t) \qquad \tilde{y}(t) = z(t) + S_1 u_v(t),$

where $u_v(t)$ – the auxiliary measurement control; C – the numerical matrix of the controller. Thus, the invariance of system (1) - (3) to external perturbations $f(t)$ is associated with the fulfillment of the equality

(6) $W_y^f(\lambda) = L\left(\lambda I_n - A - BC - \Gamma e^{-\lambda\tau}\right)^{-1} D = 0,$

where $W_y^f(\lambda)$ – transfer matrix from the perturbation to the output, and its invariance to parametric perturbations ρ is associated with the fulfillment of the equality $L(\lambda I_n - A + BC)^{-1} = L(\lambda I_n - A + BC - \rho)^{-1}$.

2.1. Summary of Known Results of Embedding Technology

The embedding technology is based on the method of matrix canonization and methods of transformation of matrix quotients of a special form. Only the used results of these methods are briefly presented here.

If the matrix is incomplete (irreversible), it contains linearly dependent rows and/or columns. For an exhaustive formal description of the linear dependence and independence of the rows and columns of a matrix, it is convenient to use the matrix canonization procedure [12]. Canonization of an arbitrary matrix A of $m \times n$ size and rank r assigns to it, in the general case, a non-unique five of matrices, including the left $\overline{A}^L$ and right $\overline{A}^R$ zero divisors of the maximum rank, the left $\widetilde{A}^L$ and right $\widetilde{A}^R$ canonizers, and the summary canonizer $\widetilde{A}$, i.e.

$$A_{m\times n} \to (\overline{A}^L_{(m-r)\times m}, \widetilde{A}^L_{r\times m}, \widetilde{A}_{n\times m}, \widetilde{A}^R_{n\times r}, \widetilde{A}^R_{n\times(n-r)})$$

These matrices satisfy the equalities

$$\begin{bmatrix} \widetilde{A}^L_{r\times m} \\ \widetilde{A}^L_{(m-r)\times m} \end{bmatrix} A \begin{bmatrix} \widetilde{A}^R_{n\times r} & \overline{A}^R_{n\times(n-r)} \end{bmatrix} = \begin{bmatrix} I_r & 0_{r\times(n-r)} \\ 0_{(m-r)\times r} & 0_{(m-r)\times(n-r)} \end{bmatrix}, \quad \widetilde{A}^R \widetilde{A}^L = \widetilde{A}, \; A\widetilde{A}A = A$$

from which their main properties follow. Here and below I_r – the identity matrix of size $r \times r$.

An efficient method for the simultaneous formation of zero divisors and canonizers is described in [12]. It is based on the representation of zero divisors in canonical bases. Matrix A of $m \times n$ size and rank r is padded with two identity matrices on the left and bottom, so that a tablet-like construction is obtained.

$$\begin{array}{c|c} I_m & A_{m\times n} \\ \hline & I_n \end{array}.$$

Now, elementary transformations of the rows and columns of the matrix are performed with simultaneous transformation of the identity matrices included in the construction. The purpose of such a transformation is to bring the matrix A to canonical bases

$$\begin{array}{c|c} \begin{bmatrix} \widetilde{A}^L_{r\times m} \\ \overline{A}^L_{(m-r)\times m} \end{bmatrix} & \begin{bmatrix} I_r & 0_{r\times(n-r)} \\ 0_{(m-r)\times r} & 0_{(m-r)\times(n-r)} \end{bmatrix} \\ \hline & \begin{bmatrix} \widetilde{A}^R_{n\times r} & \overline{A}^R_{n\times(n-r)} \end{bmatrix} \end{array}.$$

Then the blocks of the initially identity matrices opposite (in rows or columns) the zero blocks of the upper right matrix will contain zero divisors of maximum

rank $\overline{A}^L$ and $\overline{A}^R$, and , and the blocks opposite the identity matrix –canonizers $\widetilde{A}^L$ and $\widetilde{A}^R$.

2.2. Synthesis of control under the conditions of invariance and given quality

Let's use the algorithm for determining the parameters of the controller (5), using the technology of embedding systems [12, p.473] . Let us formulate the following assertion.

Statement. *System (1) - (3) for given matrices* A, B, L *is invariant to external* $f(t)$ *and parametric perturbations* ρ *if and only if there is a nonzero gauge invariance matrix* π, *for which*

$$\overline{\overline{L^R_{\text{п}}}^L B}^L \overline{L^R_{\text{п}}}^L A\overline{L}^R{}_{\text{п}} = 0,$$

perturbation efficiency matrices belong to the sets

$$\{D\}_{\mu} = \overline{L}^R \pi\mu, \ \{\rho\}_{\mu} = \overline{L}^R \pi\mu,$$

where μ – an arbitrary numerical matrix of a suitable size, and a system closed by any controller $u(t) = -C\tilde{y}(t)$, $\tilde{y}(t) = z(t) + S_1 u_v(t)$ from multiplicity

$$(7) \quad \{C\}_{\chi,\gamma} = \left(\overline{L^R_{\text{п}}}^L B\right)^{\sim} \overline{L^R_{\text{п}}}^L A\overline{L}^R{}_{\text{п}}\left(\overline{L}^R{}_{\text{п}}\right)^{\sim} + \overline{\overline{L^R_{\text{п}}}^L B}^R \chi + \gamma\overline{L^R_{\text{п}}}^L,$$

where χ, γ – *matrices of suitable sizes with arbitrary elements.*

In this case, the control action of the form $u_v(t) = -\hat{i}(t) = -\dfrac{Q_0(P)}{R_2(P)}\varsigma(t)$, *where error signal* $\eta(t) = y(t) - \bar{y}(t)$, *a* $Q_0(P)\bar{y}(t) = R_1(P)u_v(t)$, *will ensure the fulfillment of the target condition (4) . In this case, the minimum-phase polynomial is required* $R_2(P) = L(I_n P - A_0)^+(-BCS_1) + S_2$.

Proof

We use the control law (5) with parameters (7), then the plant equation (1), (3) will take the form

$$\dot{x}(t) = (A - BC)x(t) + \Gamma x(t - \tau) - BCS_1(\xi(t) + u_v(t)),$$
$$y(t) = Lx(t) + S_2\xi(t),$$

where matrix $A_0 = A - BC$ Hurwitz, the eigenvalues satisfy the condition $\mathrm{Re}\lambda(A_0) < 0$. Now let's move on to the representation of the system in the form of input - output,

$$(8) \quad Q_0(P)y(t) = R_1(P)u_v(t) + R_2(P)\xi(t)$$

where P = d/dt – differentiation operator; $Q_0(P) = \det(I_n P - A_0 - \Gamma e^{-p\tau})$, $(I_n P - A_0)^+$ - transposed matrix of algebraic complements of the matrix $(I_n P - A_0)$;

$R_1(P) = L(I_n P - A_0 - \Gamma e^{-p\tau})^+(-BCS_1)$,

$R_2(P) = L(I_n P - A_0 - \Gamma e^{-p\tau})^+(-BCS_1) + S_2$.

In addition, it is required to take into account the presence of a retarded component. The transfer function (6) from disturbances to the output takes the form

$$W_y^f(\lambda) = \frac{R + \sum_{k=1}^{n} R_i e^{-\lambda \tau k}}{Q_0 + \sum_{k=1}^{n} R_{0i} e^{-\lambda \tau k}}$$

According to the Zhivotovsky criterion, if the polynomial $Q_0(\lambda)$ Hurwitz and the conditions [19]

$$\left|q_{n_i}\right| > \left|g_{n_i-1}\right|, \qquad \inf\left|Q_0(j\ \ )\right| > \sup\left|\Gamma(j\ \ )\right|$$

for any $\omega \in [0,\infty)$ where q_{n_i}, g_{n_i-1} - free coefficients of the polynomials $Q_0(\lambda)$ and $\Gamma(\lambda)$, then the quasipolynomial $Q_0(\lambda) + \Gamma(\lambda)e^{-\lambda\tau}$ has all roots in the left half-plane. And the regulator (7) provides stability Q_0.

Next, we use the auxiliary loop method [10] and select a signal that carries information about disturbances, for which we take a subsystem that is described by the equation

(9) $Q_0(P)\bar{y}(t) = R_1(P)u_v(t)$,

To implement (9), the polynomial must be Hurwitz $R_1(P)$.

and compose an equation for the mismatch signal $\eta(t) = y(t) - \bar{y}(t)$, subtracting (9) from (8):

(10) $Q_0(P)\eta(t) = R_2(P)\xi(t)$.

From equation (10) we select the signal $\xi(t)$

$$(11)\quad \xi(t) = \hat{\xi}(t) = \frac{Q_0(P)}{R_2(P)}\eta(t).$$

It is clear that the implementation of (11) requires the polynomial to be Hurwitz $R_2(P)$, which can be ensured by an appropriate selection of the matrix C. However, such a selection is not always possible. Thus, there must be a matrix C, ensuring that the polynomial is Hurwitz $R_2(P)$, which is an additional constraint not stipulated in the assumption. Since $\deg Q_0 = \deg R_2 = n$, then (11) is realizable, and having formed an auxiliary control signal $u_v(t)$ in the form

(12) $u_v(t) = -\hat{\xi}(t) = -\frac{Q_0(P)}{R_2(P)}\eta(t)$

we get the equation for the state vector of the object
$\dot{x}(t) = A_0 x(t)$,
from which the fulfillment of the stated target condition (4) follows.

3. Example

Let us consider the problem of stabilization for the control object, the dynamic processes in which are described by the equations (1) – (3), where $x \in \Re^3$, $u \in \Re^2$, $y \in \Re^1$, $f \in \Re^2$, $\xi \in \Re^1$

$$A = \begin{bmatrix} -1 & 1 & 0 \\ 1 & -2 & 3 \\ -1 & 3 & 0 \end{bmatrix}, \; B = \begin{bmatrix} 0 & 0 \\ 0 & 1 \\ 1 & 2 \end{bmatrix}, \; L = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix}, \; D = \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 1 & 2 \end{bmatrix}, \; S_1 = \begin{bmatrix} 1 \\ 1 \\ 0.5 \end{bmatrix}, \; S_2 = 2,$$

$$\Gamma = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ -3 & -3 & -3 \end{bmatrix} \quad \tau = 3 \quad \rho = \begin{bmatrix} 2 & 1 & 1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

The matrix C is chosen in accordance with formula (7) and takes the form $C = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & 3 \end{bmatrix}$. Then we get the matrix A_0 in the auxiliary circuit (9)

$$A_0 = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -2 & 0 \\ -3 & 3 & -6 \end{bmatrix}, \text{ with eigenvalues } \lambda_1 = -6, \lambda_2 = -2, \lambda_3 = -1,.$$

The matrix A_0 with parametric perturbations ρ takes the form

$$A_0 + \rho = \begin{bmatrix} 1 & 2 & 1 \\ 0 & -2 & 0 \\ -2 & 4 & -5 \end{bmatrix}$$

The identity is fulfilled:
$L(\lambda I_n - A + BC)^{-1} = L(\lambda I_n - A + BC - \rho)^{-1}$
Let us form an auxiliary control action $u_v(t)$ in (12)

$$u_v(t) = -\frac{\det(I_n P - A_0)}{L(I_n P - A_0)^+(-BCS_1) + S_2}(y(t) - \bar{y}(t)) = \frac{P+2}{2P+1.5}(y(t) - \bar{y}(t)).$$

.

Figure 1 shows the results of modeling the control system with the following initial data: initial conditions $x^T(0) = [1 \quad 5 \quad 2]$, disturbances at the input $f_1(t) = 2\sin 3t, \quad f_2(t) = 5\sin t$, noise at the output is a random signal.

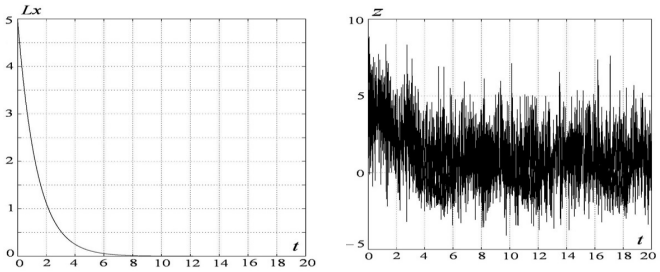

Figure 1. *Transient processes in the system when ξ(t) is a random signal*

In this case, the target condition is met after 7 seconds. Now let's see how the output processes in the proposed system will change if external disturbances change, namely: in Fig. 2, the noise will be a harmonic function *ξ(t) = sin05.t*. Comparing the results with Fig. 1, we can conclude that the goal of management is being fulfilled.

Figure 3 shows the simulation results when the external disturbances are unbounded functions, more precisely $f_1(t) = 2t, \quad f_2(t) = 5t$. Of course, in this case, an unlimited control action is obtained, which is inapplicable from the point of view of implementation.

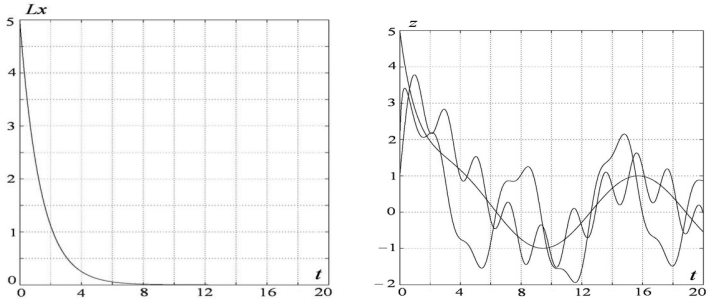

Figure 2. *Transient processes in the system when ξ(t) = sin05.t*

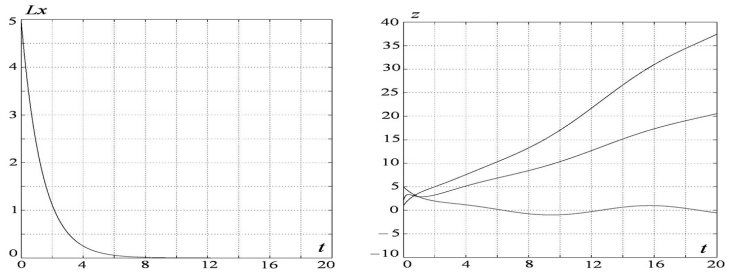

Figure 3. *Transient processes in the system when* $f_1(t) = 2t, \quad f_2(t) = 5t$

But since the quality of management has remained the same, i.e. after 7 seconds the set control goal is fulfilled, then the proposed control law can be used for a limited time range.

4.Conclusion

A method is proposed for constructing a control system for a linear plant with state delay, for which all parameters are known, and disturbances act at the input and at the controlled output, and these disturbances are different. The designed control system makes it possible to compensate for the influence of a disturbance on the controlled variables with a given accuracy and make them independent of disturbances at the system input, which is demonstrated by an example.

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通过低能电爆炸法估算获得纳米分散铜粉所需的最小能量，同时考虑活性损失
ESTIMATION OF THE MINIMUM ENERGY REQUIRED TO OBTAIN NANODISPERSED COPPER POWDER BY THE LOW-ENERGY ELECTRIC EXPLOSION METHOD, TAKING INTO ACCOUNT ACTIVE LOSSES

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抽象的。 该文章提出了一种计算通过导体的低能电爆炸合成纳米分散金属粉末及其化合物所需的最小能量的方法，同时考虑了活性损失。 最小能量的计算简化为容量恒定的电容器蓄电池的最小电压的计算。 建议根据爆炸回路的物理特性引入校正损耗因子。 给出了计算实现铜反应坯料快速电爆所需要的储能电容最小能量的例子。

关键词：低能电爆，电爆装置，电爆能量损失，金属升华，纳米材料合成。

Abstract. *The article proposes a method for calculating the minimum energy required for the synthesis of nanodispersed metal powders and their compounds by low-energy electric explosion of conductors, taking into account active losses. The calculation of the minimum energy is reduced to the calculation of the minimum voltage of the storage battery of capacitors with a constant capacity. It is proposed to introduce a correction loss factor depending on the physical characteristics of the explosive circuit. An example of calculating the minimum energy of a storage capacitor required for the implementation of a fast electric explosion of a copper reaction billet is given.*

Keywords: *low-energy electric explosion, electric explosion installation, energy losses of electric explosion, sublimation of metals, synthesis of nanomaterials.*

As is known, in order to transfer the conductor material into the gas phase using pulsed electrical heating, the energy W introduced into the conductor must exceed, or at least be equal to, the sublimation energy W_S of the conductor material [1-3].

To form a high-amplitude current pulse, which is necessary for high-speed heating of the conductor with subsequent explosion, as a rule, a high-voltage pulse capacitor or a battery of such capacitors is used. The energy accumulated by the capacitor is almost completely spent on heating the exploding conductor, with the exception of conduction and switching losses. This energy can be easily calculated using formula (1).

$$E = \frac{CU^2}{2} \quad (1)$$

From the above formula it is clearly seen that the accumulated energy is proportional to the square of the voltage, thus, by changing the voltage, it is possible to regulate the energy transferred to the exploding conductor in a wide range. This range is limited from below by the minimum voltage necessary to develop sufficient current density through the conductor, and from above by the maximum operating voltage of the capacitor bank.

The minimum required current density for an electric explosion in the fast mode for copper wire should exceed 10^{11} A/m^2 [4]. Using Ohm's law, it is easy to find the minimum voltage for the electric explosion of a workpiece made of M1 grade copper wire with a reaction length of 60 mm and a diameter of 0.3 mm. This voltage is approximately 101.99 V, provided that the capacity of the capacitor bank is capable of providing the necessary explosion energy.

Since the electrical circuit is not ideal, it is recommended to use the K_Leak margin for ohmic and switching losses in the discharge circuit and thermal losses in the sample. Therefore, based on formula (1), the required voltage can be calculated using formula (2):

$$U = \sqrt{\frac{2K_{Leak}W_S m}{C}}, \quad (2)$$

where K_{Leak} – loss factor, W_S – specific sublimation energy of the sample material, m is the mass of the sample.

The assessment of active losses in an electroexplosive circuit is based on the second Kirchhoff rule, which states that the sum of voltage drops in all successive sections of the circuit is equal to the sum of the EMF of these sections. Since, based on Ohm's law, the voltage on the element is directly proportional to its resistance at a given current, K_Leak will be equal to the ratio of the resistance of the parasitic elements of the circuit to the resistance of the exploding sample. Thus, the calculation of the active loss coefficient is reduced to the calculation of the division factor of a resistive voltage divider, in the upper arm of which is the sum of the resistances of parasitic circuit elements, and in the lower arm is the resistance of the sample to be exploded. For illustration, the described calculation

of active losses is given below on the example of an electroexplosive installation for obtaining nanodispersed metal powders, developed in the course of scientific and technical work.

The schematic diagram of the installation for obtaining powder nanomaterials by the method of electric explosion of metal wires, taking into account parasitic elements in the form of lumped parameters, is shown in Figure 1, where C1 is a battery of storage capacitors that accumulates energy to form a large-amplitude current pulse. It consists of two pairs of B43458-A9478-M capacitors with a capacity of 4700 uF and a nominal voltage of 400 V. In each pair, the capacitors are connected in series. Pairs of capacitors are connected in parallel. Thus, the total battery capacity is 4700 uF, and the maximum operating voltage is 800 V.

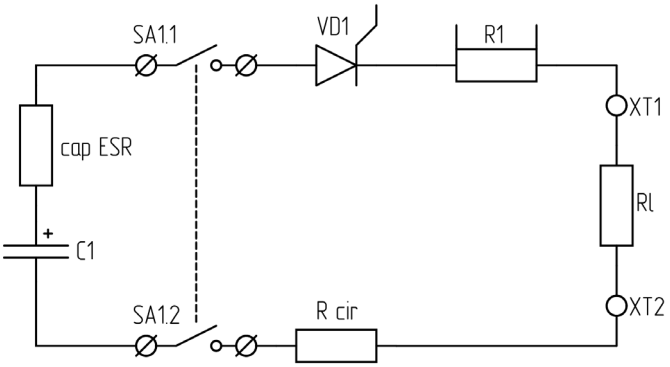

Figure 1. *Schematic diagram of an electroexplosive installation, taking into account parasitic elements in the form of lumped parameters.*

Cap ESR (ESR) is the equivalent series resistance of a capacitor bank. According to the manufacturer's documentation, for a single capacitor, the value of this resistance reaches 16 mΩ. Thus, cap ESR is 16 mΩ in the current configuration. Protective key SA1, designed for switching at zero current, is designed to reliably disconnect the capacitor bank from the discharge circuit during maintenance of the installation. High-speed impulse thyristor TBI343-630-14 (VD1) performs power switching of the circuit. After the opening of the thyristor VD1, the energy accumulated in the capacitor bank is transmitted through the measuring shunt R1 along the power path with resistance R cir, and is fed to the exploding sample Rl, through the clamps - contactors XT1, XT2.

Based on the foregoing and using Ohm's law, the active loss coefficient can be calculated using formula (3):

$$K_{Leak} = \frac{(R_l + ESR + R1 + R_{cir})}{R_l} \quad (3)$$

An attentive reader may notice that formula (3) does not take into account the resistance of the thyristor VD1. This is due to the fact that the thyristor, as a semiconductor device, has a characteristic resistance that depends on the current flowing through it. In addition, in the context of switching an electroexplosive circuit, it does not significantly affect the result. However, if desired, it is more convenient to take it into account in the form of a direct voltage drop at the peak value of the predicted current according to the manufacturer's specification. In this case, taking into account formula (3), the required minimum voltage of the capacitor bank, capable of providing acceptable explosion energy, can be calculated using formula (4):

$$U = \sqrt{\frac{2K_{Leak}W_S m}{C}} + v_f \quad (4)$$

where v_f – direct voltage drop across the thyristor at a given current.

We calculate the loss factor for the circuit shown in Figure 1 using formula (3). If the shunt resistance R1 = 1.5 mΩ, the equivalent series resistance of the capacitor bank ESR = 16 mΩ, the resistance of the power circuit R_{cir} = 7 mΩ, and the implosion resistance R_l = 15,3 mΩ, then K_{Leak} = 2,6. Then, the minimum voltage of the capacitor bank can be calculated by formula (4). If the battery capacity is C = 4700 μF, the maximum forward voltage drop across the thyristor is v_f = 6,35 V, the specific energy of copper sublimation is W_S = 5.6 kJ/g [5], and the workpiece mass is m = 0.038 g, then the minimum voltage is U = 491.35 V.

For practical verification of the calculations, an electric explosion of a copper wire of the M1 brand, a reaction length of 60 mm and a diameter of 0.3 mm, was carried out using an electric explosive installation, the schematic diagram of which is shown in Figure 1. The voltage of the capacitor bank was chosen closest to the calculated value and amounted to 495 V. This voltage, according to formula (1), corresponds to an energy of 575.8 J

Microstructural analysis of the explosion products using a scanning electron microscope "JEOL JSM - 7500F" in the SEM mode confirmed the successful production of copper nanoparticles at the calculated voltage of the capacitor bank. A micrograph of a copper nanopowder obtained by electric explosion of a copper wire in air using the described setup at a voltage of 495 V is shown in Figure 2.

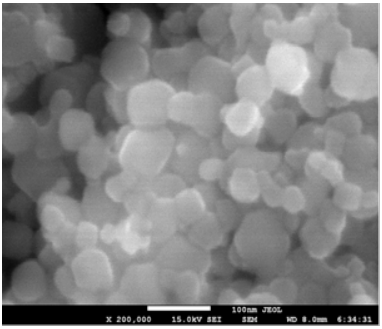

Figure 2. *Copper nanoparticles obtained by electric explosion in air.*

The results obtained allow us to conclude that the proposed method for estimating energy losses makes it possible to calculate the minimum voltage of the capacitor bank required for the successful synthesis of copper nanoparticles by the electric explosion method, provided that the capacitance of the capacitor bank is capable of providing the necessary sublimation energy.

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扩展发射器垂直表面的传热特性
HEAT TRANSFER PECULIARITIES OF EXTENDED EMITTER VERTICAL SURFACE

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抽象的。 考虑了垂直放热表面上的对流换热条件，提出了一种根据供热流强度的变化来均衡温度场的方法。
关键词：局部对流传热，温度场，等温条件，热辐射。
Abstract. *The conditions for convective heat transfer on a vertical heat-releasing surface are considered, and a method for leveling the temperature field due to the variable intensity of the supplied heat flux is proposed.*
Keywords: *local convective heat transfer, temperature field, isothermal conditions, thermal radiation.*

Introduction

Modern thermal imaging equipment is currently widely used for solving military problems, for diagnostic purposes in medicine, for examining buildings and structures, as well as for detecting and eliminating fires. Thermal imaging monitoring of forests and peatlands enables firefighters and rescuers to detect fires at an early stage, work in conditions of insufficient visibility and smoke, remotely assess the situation, determine directions and evacuations.

One of the key factors determining the reliability of information obtained with the help of thermal imagers is the calibration. Calibration allows you to bring the readings of the thermal imager into line with the actual value of the temperature of the observed object. This makes it possible to reduce the measurement error.

The purpose of this work is to calculate the heat transfer conditions for an extended radiator for calibrating thermal imagers and a method for forming the required temperature distribution. The requirements for the emitter are presented in GOST R 8.619-2006 GSI. Thermal imaging measuring instruments. verification

method. One of the key parameters that must be ensured for the normal calibration of thermal imagers is the formation of isothermal conditions no worse than ±0.07 K at a surface temperature difference of 10 K with the environment. The radiating surface of an extended radiator during operation exchanges heat with the environment due to thermal radiation and convection.

Experimental studies of heated flat vertical surfaces under conditions of free convective heat exchange with the environment show that the temperature gradient over their surface reaches values of 0.1 K/cm and more [1].

Such a temperature distribution depends on a number of factors, among them: the location and power of heat sources, the values of the local heat transfer coefficient at the object-environment boundary, and the thermal conductivity of the object material. To form the required temperature distribution, it is necessary to determine the corresponding values of the input and output local heat fluxes, select materials and the geometry of the object itself.

In this paper, we consider a method for forming the required temperature field of a vertical plate.

Convective heat transfer on a vertical surface

The essence of the method lies in the special distribution of the heat release density in the plate, since the free movement of air near its surface leads to an uneven distribution of the heat transfer intensity along the height.

To calculate the heat release density distribution, it is necessary to know the intensity distribution of the removed heat flux. Let us consider a free gravitational flow near a vertical heated plate.

The isothermal plate is in the air, its temperature is higher than the ambient temperature. In this case, an upward movement of the heated air layer occurs near the plate. Away from the plate, the air velocity is zero. The process is stationary. In this formulation, the problem of free convective heat transfer on a vertical heated surface was solved by many authors. From the review of sources on this topic, we will select several calculation formulas. Among them:

Isachenko V.P. [2]

$$Nu_x \equiv 0.473\sqrt[4]{(Gr_x \,\mathrm{Pr})}\,;; \tag{1}$$

2) Tsvetkov F.F., Grigoriev B.A. [3]

$$Nu_x = 0{,}6\left(\frac{\mathrm{Pr}}{1+2\,\mathrm{Pr}^{\frac{1}{2}}+2\,\mathrm{Pr}}\right)^{\frac{1}{4}} Ra_x^{\frac{1}{4}} \tag{2}$$

3) Dulnev G.N. [4]

$$Nu_x = 0{,}508\,\mathrm{Pr}^{\frac{1}{2}}\left(\frac{Gr_x}{0{,}952+\mathrm{Pr}}\right)^{\frac{1}{4}} \tag{3}$$

John H. Lienhard IV and John H. Lienhard V [5]

$$Nu_x = 0{,}508 Ra_x^{\frac{1}{4}} \left(\frac{\mathrm{Pr}}{0{,}952 + \mathrm{Pr}} \right)^{\frac{1}{4}} \tag{4}$$

Sokovishin Yu.A., Martynenko O.T. [6], [7]

$$Nu_x = \frac{1}{2} \mathrm{Pr}^{\frac{1}{2}} \left[\left(\frac{3}{\sqrt{2}} - 1 \right) + (\sqrt{2} + 1) \mathrm{Pr} \right]^{-\frac{1}{4}} Gr^{\frac{1}{4}} \tag{5}$$

$$Nu_x = 0.453 \left(\mathrm{Pr} + 0.453 \right)^{-\frac{1}{4}} \mathrm{Pr}^{\frac{1}{2}} Gr^{\frac{1}{4}} \tag{6}$$

Sebisi T., Bradshaw P. [8]

$$Nu_x = \frac{3}{4} \left(\frac{2\,\mathrm{Pr}}{5 \left(1 + 2\,\mathrm{Pr}^{\frac{1}{2}} + 2\,\mathrm{Pr} \right)} \right)^{\frac{1}{4}} Ra_x^{\frac{1}{4}} \tag{7}$$

As an example, Figure 1 shows the distribution of the heat transfer coefficient along the plate height according to formulas (1-7) under conditions of free convection when the plate is overheated above the ambient air temperature ϑ=10 K.

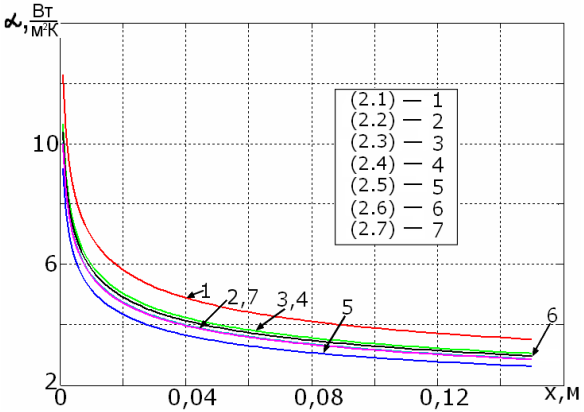

Figure 1. *Distribution of the convective heat transfer coefficient along the height of the plate. The numbers indicate the curves corresponding to formulas (1-7), respectively. Curves 3 and 4, 2 and 7 overlap in the figure.*

For calculations, we will use solution (6) from [7] - curve 6 in Fig.1. It can be seen that the heat transfer coefficient along the vertical plate is substantially uneven. On a plate 0.15 m high, it changes by more than 3 times. As a result, in the case of a uniform supply of heat flow, the bottom of the plate is colder than the top.

Ensuring a uniform temperature field

To form the required temperature field of the plate, a method for calculating and selecting parameters is proposed, which allows the corresponding change in the intensity of convective heat transfer along the height of the plate to be compensated by the variable local density of the supplied heat flux.

To calculate the required density distribution of the supplied heat flux $q_s(x)$, we compose a differential equation for the plate under the following conditions: the heat flux from the surface is dissipated into the environment (air) by convection and radiation; heat transfer from the ends is neglected; the origin of coordinates is the lower edge of the plate, the process is stationary:

$$\frac{d^2T}{dx^2} - \frac{\alpha_{кл}(x)\Pi(T-T_c)}{\lambda\delta L_2} + \frac{q_s(x)}{\lambda\delta} = 0, \tag{8}$$

The proposed method makes it possible to provide temperature fields of various types. As an example, the case of ensuring isothermal conditions, as the most common in solving practical problems, is given. In this case, equation (8) is solved taking into account that the first term vanishes for isothermal conditions. Then the expression for the heat flux density will take the form:

$$q_s(x) = \frac{\alpha_{кл}(x)\Pi(T-T_c)}{L_2}. \tag{9}$$

The calculation of the convective component of heat transfer is carried out from (6), and the radiant component from [9]:

$$\alpha_л = \varepsilon \cdot 5.67 \frac{\left(\frac{T}{100}\right)^4 - \left(\frac{T_c}{100}\right)^4}{t - t_c}. \tag{10}$$

Calculations have shown that it is possible to provide a uniform temperature field of the plate by creating a distribution of heat flux density on its surface, shown in Fig.2.

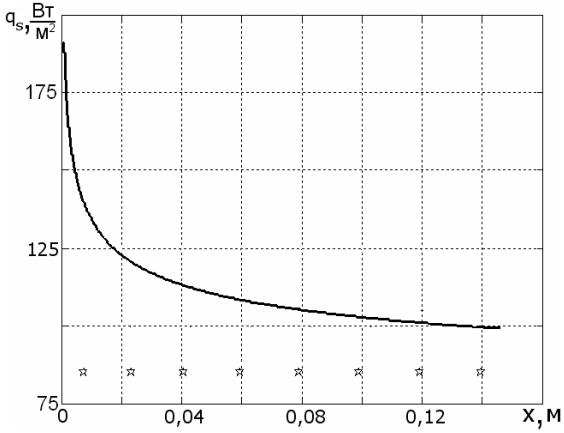

Figure 2. *The result of calculating the heat flux density distribution*

Figure 2 shows the result of calculating the density distribution of the supplied heat flux for the case when it is necessary to provide a uniform temperature field on a plate with a height of 0.15 m, having a temperature of 30°C at an ambient temperature of 20°C.

The pitch of the heater coils can be determined from the results of integrating the heat flux density over the plate surface, taking into account the ratios for the coefficients of convective and radiant heat transfer, as well as the values of the heat release power in one groove.

$$\Phi_i = \int_{x_i}^{x_{i+1}} L_2 \alpha_{кл}(x)(T - T_c)dx, \qquad (11)$$

where x_i, x_{i+1} - integration steps over the plate height.

Relation (11) is valid provided that the plate is isothermal and there is no heat transfer from one section to another. Equation (11) is solved with respect to x_{i+1}, and xi is determined from the previous integration step, which is carried out from the lower edge of the plate at x_i=0.

A preliminary assessment of the effectiveness of this method for implementing the proposed method of forming a temperature field was carried out on the basis of numerical simulation of heat transfer using the example of a vertical plate made of copper. In the Comsol multiphysics software package, its geometry, the location of the heater coils were specified in accordance with the results of calculations using formula (11), and the distribution of convective-radiant heat transfer along the height from formulas (6) and (10). Figure 4 shows the temperature distribution

over the surface of the plate when overheated above an ambient temperature of 10 K.

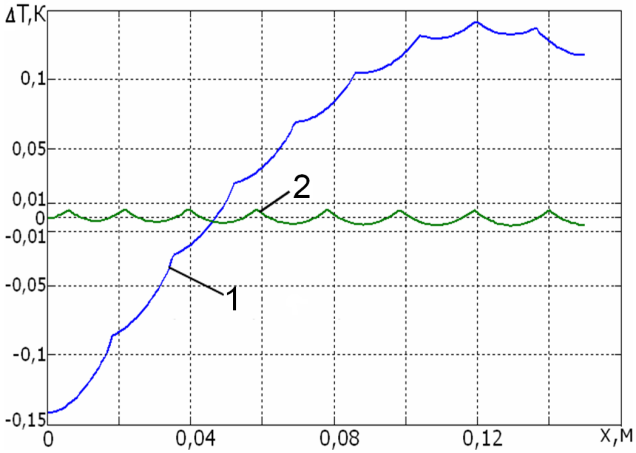

Figure 4. *Temperature distribution over the surface of a vertical copper plate 1 mm thick: 1 – uneven heater; 2 - uniform heater.*

It can be seen that the proposed method of forming the temperature field significantly increases the isothermality of the plate. Further experimental studies of the vertical radiator showed high isothermality (no worse than ±0.07 K).

Thus, the calculation of the conditions of heat exchange on the vertical surface of the radiator, as well as the presented method of forming a uniform temperature field, make it possible to provide the necessary thermal regime for an extended vertical radiator for calibrating thermal imagers.

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提高加工测量结果质量的若干问题
SOME ISSUES IN IMPROVING THE QUALITY OF PROCESSING MEASUREMENT RESULTS

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抽象的。 本文考虑在解决先验不确定条件下处理测量结果的问题时计算平稳随机过程的模式的方法。 进行的研究的结果使我们得出结论，要获得最准确的结果，有必要将模式计算和平均值计算结合起来，这样可以将其计算精度提高至少 2 倍。 提出了一种提高处理测量结果质量的算法。

关键词：Moda，数学期望，直方图，误差。

Abstract*. The paper considers methods for calculating the mode of a stationary random process when solving the problem of processing measurement results under conditions of a priori uncertainty. The results of the conducted research allowed us to conclude that to achieve the most accurate results, it is necessary to combine the calculation of the mode and the calculation of the average, which allows for increasing the accuracy of its calculation by at least 2 times. An algorithm for improving the quality of processing measurement results is proposed.*

Keywords: *Moda, mathematical expectation, histogram, error.*

Currently, when processing random stationary processes, in some cases there is a problem associated with the distribution of error in each of the cross sections of the set of implementations of the original samples. It is assumed that the error distribution obeys the normal law, but a more detailed analysis of the research results showed that the error distribution at the beginning and end of the sample differs significantly from the normal one and approaches the Rayleigh distribution, which may be due to the correlation of initial and final values.

A normal distribution is a continuous probability distribution with a peak in the center and symmetrical sides, which is given by the probability density function [22]:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} * e^{\frac{-x^2}{2\sigma^2}} \quad (1)$$

where the parameter μ is the mathematical expectation, σ is the standard deviation, σ^2 is the variance of the distribution.

The Rayleigh distribution is the law describing the range of values of a random variable and the corresponding probabilities of the occurrence of these values [22]:

$$f(x) = \frac{(x)}{\sigma^2} * e^{-\frac{(x^2)}{2(\sigma^2)}}. \quad (2)$$

where the parameter σ is the standard deviation, σ^2 is the variance of the distribution.

The algorithm for modeling random numbers distributed according to Rayleigh's law, according to [7], can be described by the following expression:

$$y = \sigma\sqrt{-2lnx}, \quad (3)$$

It is known that under the Rayleigh distribution law, the values of mode and mean differ significantly compared to the normal law, where they are equal. This difference is the source of the increase in the error of processing measurement results. To reduce the error, it is necessary to calculate not the average, but the mode in each of the sections of processing the measurement results. Recall that fashion is understood as the value of a random variable, the probability of which is the maximum. Thus, replacing the average with a mode will significantly improve the accuracy of processing measurement results.

To estimate the value of the mode, various methods can be used, discussed in the article [3]. The first method is the calculation of the value according to the analytical expression of the Rayleigh distribution law, which is equal to the derivative of expression (3), and it is equal to zero. The second well–known method [8-10] for calculating the mode by estimating the differential density of the distribution is histograms. There are 3 ways to find a fashion:

1- Construct a histogram and estimate the interval of values having the maximum value, the mode is defined as the average value of the extreme values of the interval.

2- building a histogram and estimating the interval of values having the maximum value, we select all the values of a random process that fall within this interval and build a new histogram based on these values. We determine the maximum interval, average over the extreme values, and consider it a fashion.

3- finding the mode by the modal interval

The following method of determining the mode is performed according to formula 4, which has great effectiveness [3]:

$$\sigma = \sqrt{\frac{1}{2n}\sum_{k=1}^{n} x_k^2} \quad (4)$$

We will conduct research on the comparative analysis of their effectiveness, to obtain recommendations on their practical use. Let's compare the results of determining the mode by formula 4 with the results of determining the mode by the histogram.

This Figure 1 shows three types of the spread of the difference of values relative to the mode found by the distribution law: 1– the spread of the values of the mode found by the histogram, 2 – the spread of the values of the mode found by the formula 4, 3– the spread of the values of the average value.

By changing the noise realization at its constant variance, we can observe that the spread of the values of the difference of the mode found on the histogram and the mode found by the distribution law is greater than the difference of the mode found by formula 4 and the distribution law.

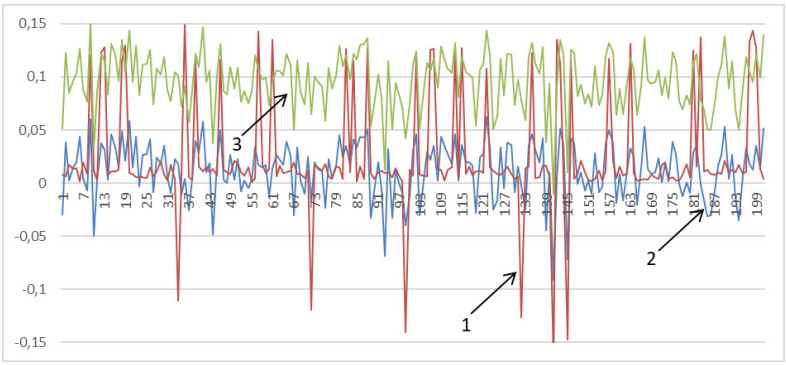

Figure 1. *The spread of the difference values under the Rayleigh distribution law*

The average value of 1000 implementations in the first case is 0.021463, and in the second case, it has a value of 0.012262, which is almost 2 times less. It is also worth noting that the average value of the difference between the mean value and the mode is 0.095780, which exceeds the average value of the difference between the mode found on the histogram and the mode found on the distribution by more than 4.5 times.

This study confirms the effectiveness of applying the formula for Rayleigh's distribution law. We will conduct similar studies by changing the Rayleigh distribution law to the normal distribution law in order to test the effectiveness of this method.

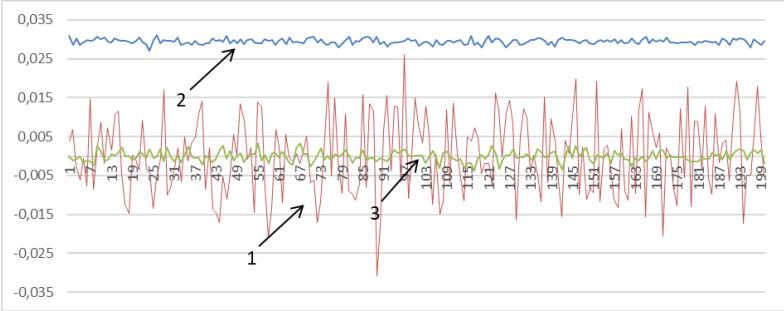

Figure 2. *The spread of the difference values under the normal distribution law*

This Figure 2 shows three types of the spread of the difference of values relative to the mode found by the distribution law: 1– the spread of the values of the mode found by the histogram, 2– the spread of the values of the mode found by the formula 4, 3– the spread of the values of the difference of the average value.

By changing the noise realization at its constant variance, we can observe that the spread of the values of the difference of the mode found on the histogram and the mode found by the distribution law is greater than the difference of the mode found by formula 4 and the distribution law. The average value of 1000 implementations in the first case is -0.000610, and in the second case, it has a value of 0.029457, which is almost 48 times more. It is also worth noting that the average value of the difference between the mean value and the mode is 0.000005, which is less than the average value of the difference between the mode found on the histogram and the mode found on the distribution, by more than 120 times.

After analyzing the data obtained, it can be concluded that this method is not suitable for normal distribution, since it is two-sided, and formula 4 turned out to be applicable only for one-sided distribution laws. The conducted studies have shown that for greater effectiveness it is necessary to apply the matching criterion, which will allow determining the distribution law with a high degree of probability, and only after determining the mode value or average, respectively.

Below is an algorithm for processing measurement results using this technique.

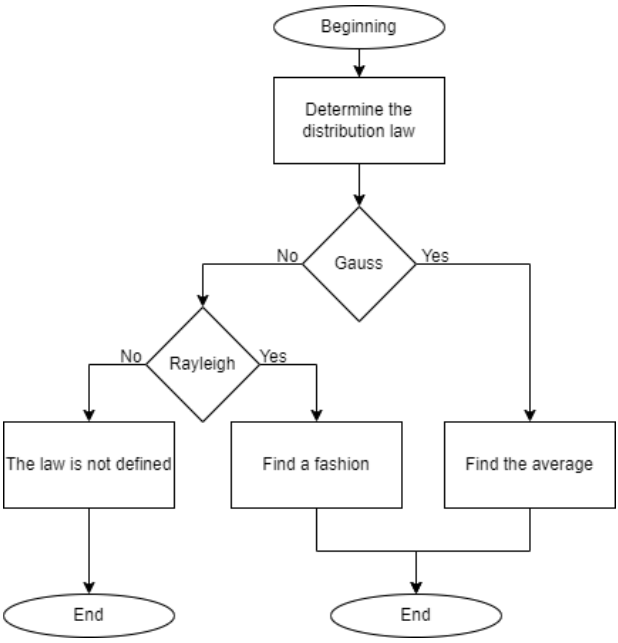

Figure 3. *Algorithm for improving the quality of processing measurement results*

Conclusions:

1. For the Rayleigh distribution, you need to use formula 4, in which the average spread of values is almost 8 times less than the average spread of values over the average, and for a normal distribution, the average value, in which the average spread of values is almost 6000 times less than the average spread of values according to formula 4.

2. Propose an algorithm to improve the quality of processing measurement results

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寻找有前途的方法使航空乘客座椅适应儿童的人体测量数据
SEARCH FOR PROMISING WAYS TO ADAPT AVIATION PASSENGER SEATS TO THE ANTHROPOMETRIC DATA OF A CHILD

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抽象的。 考虑到儿童的人体测量数据，本文探讨了经济舱飞机座位上儿童可靠和安全登机的问题。 对航空乘客座椅的发明和实用模型进行了专利检索，并分析了它们的优缺点。 提出了为儿童调整乘客座椅的新的有前途的方法。 评估标准已经制定，在此基础上对拟议的适应方法进行了评估。

关键词：飞行安全，航空乘客座椅，人体测量数据，固定系统，座椅面板，座椅靠背。

Abstract. *The article deals with the problem of reliable and safe boarding of children in economy class aircraft seats, taking into account their anthropometric data. A patent search for inventions and useful models of aviation passenger seats was carried out with an analysis of their disadvantages and advantages. New promising ways of adapting a passenger seat for a child are proposed. Evaluation criteria have been developed, on the basis of which the proposed adaptation methods have been evaluated.*

Keywords*: flight safety, aviation passenger seat, anthropometric data, fixation systems, seat panel, seat back.*

Improvement in the design of passenger aircraft and aircraft engines leads to a steady decrease in the cost of air transportation and an increase in their volumes. A significant proportion of the total number of all passengers are children. The requirements [1] indicate that for each person who has reached the age of two, a passenger seat must be provided.

The standard [2] requires that the length of the seat belts be adjustable to ensure that each occupant is securely restrained. At the same time, regulatory documents [1], [2] do not provide for the possibility of adjusting the passenger seat to the size of the passenger. The versatility of passenger seats does not guarantee absolutely identical safety conditions for both adults and children. Statistics [3] show that the

stages of takeoff, descent and landing, where the presence of a passenger in a seat with fixed seat belts is mandatory, account for about 72% of all aviation accidents in the world. Therefore, ensuring the possibility of adapting the aircraft seat to the anthropometric data of the child is a key element of its passive safety.

A patent search for technical solutions that provide the possibility of an equally safe and comfortable fit for both an adult and a child was carried out in search engines: USPTO (American Patent Office), PATENTSCOPE patent database, Google Patent, open registries of inventions of FSBI FIIP (Federal Institute of Industrial Property "). The findpatent.ru search engine was used to search by the IPC (International Patent Classification) code. The patents and utility models found on the topic were analyzed for the presence of prototypes and analogues. Consider the most interesting ways to transport a child in the cabin.

Patent [5] is for private and commercial aircraft. It offers a design of a child car seat, a detachable carry strap for attaching the child seat, two anchor anchors and two adjustable straps to secure the top of the child seat back to the passenger seat. The method is not applicable in the economy class cabin, since the movement of passengers in a row is limited, which is contrary to safety requirements [1].

The design (Fig. 1,a) of the child restraint seat [6], which is attached to the load-bearing frame of a stationary chair, also contradicts safety standards [1]. In addition, it has a restriction on the age of the transported child.

The patent [7] proposes the design of a composite waist belt (Fig. 1b). The adult is fastened with the first waist belt, then the child is attached to the adult. This design does not consider the adaptation of the chair for a child.

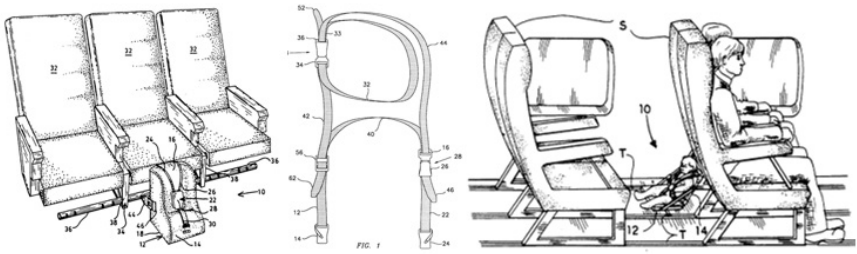

Figure 1. *Methods for transporting children in the aircraft cabin: in a child seat [6] (a); with fastening with a composite waist belt to an adult [7] (b); in a child seat with fastening to the rails of the seat block [8] (c).*

The method [8] is a child safety seat (Fig. 1c) attached to the guide structures of the passenger seat blocks and located on the floor at the feet of an adult. The disadvantages are similar to the method [5].

The most successful design is proposed in the patent [9]. A child seat is obtained by tilting the inner part of the back of the seat onto the seat by the loop. In the resulting niche, the seat belts for the child with five-point contact mounted in the niche of the backrest and the folding part of the seat open.

The invention [10] is intended to protect babies. The device has a tubular shape (Fig. 2a) with internal walls made of elastic material. An adult passenger fastens the device to their seat belt, preventing unwanted movement during an accident.

The invention [11] proposes a prefabricated structure for holding a child in a passenger seat (Fig. 2b). The design has the following disadvantages: the possibility of injury from a rigid structure in emergency situations; blocks the passage between the rows of seats, which is contrary to safety requirements [1].

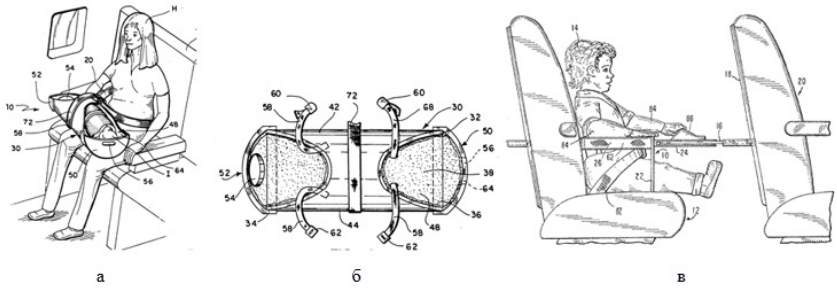

Figure 2. *Methods for transporting children in the aircraft cabin: in a device for babies [10] (a); device [10] (b); in a child restraint device [11] (b).*

An analysis of the designs of modern economy class passenger seats, regulatory documentation, numerous patents with child seating options showed that:

- modern passenger seats do not provide the required level of safety for children, since they do not adequately take into account their anthropometric data;
- there are practically no technical solutions for the design of seats that allow them to be adapted to the child;
- Available technical solutions do not provide safety requirements.

The following initial conditions were chosen for the development of new structures:

1. Developed designs of chairs should not affect the load-bearing frame of the chair to eliminate the cost of a full test cycle in accordance with the requirements of [1] and [12]

2. The dimensions of the parts of the seat correspond to those accepted in modern civil aviation in economy class cabins, since this is the basis of commercial transportation for most airlines.

3. To develop the design of the chair, the anthropometric data of an average boy 7 ... 9 years old with a height of 123.88 ± 5.40 cm were taken, since at the age of over 9 years, the height of the child approaches the lower limit of the height of an adult.

According to paragraph 4 [2], the design of the seats consists of: a power frame; tethered system; seat panels; chair backs; seat cushions and back cushions.

A classification of possible mechanisms and methods for transforming a passenger seat into a variant for a child is proposed, differing in:

1. Depth of transformation;
2. Connectivity of transformable movable elements relative to fixed ones;
3. Method of movement of transformable moving elements;
4. The mechanism of displacement of the transformed elements;
5. The method of fixing the achieved position;
6. Drive type transformation mechanism;
7. Possibilities of adjustment for the anthropometric data of the child;
8. The sequence of moving moving elements.

Criteria for evaluating the proposed structures have been developed:

- minimal changes in the design of the seat panel and backrest;
- simplicity of the mechanism, maintainability;
- minimum costs for modification, modernization, repair and operation;
- the possibility of easy transformation into an option for a child and vice versa;
- the ability to adjust to the anthropometric data of the child;
- safety, exclusion of the possibility of interference in the structure;
- the convenience of landing in a chair for both a child and an adult.

The following four ways of adapting chairs for a child have been developed and analyzed, taking into account the evaluation criteria. In method 1 (Fig. 3, a, b), the transformation is performed by the passenger manually by turning the cushions 3 and 4 by the loops (not shown) towards themselves and down until they come into contact with the surface of the seat cushion 1. In this position, the mechanism is fixed. The height of the cushions 3, 4 corresponds to the thickness S1 of the backrest 2. The length z in the position for the child is equal to the length of the seat cushion T. The width h2 is selected so as to ensure a comfortable fit for a child of a given build. Inside the pillows 3, 4 there is a frame, which forms a U-shaped rigid structure with the pivot of the pivot axis.

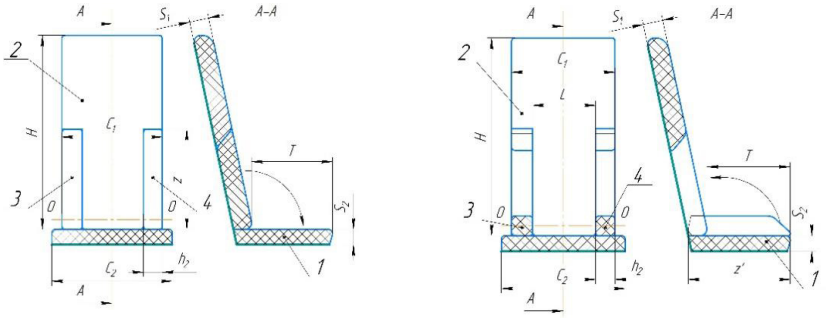

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Figure 3. *Method 1 of chair adaptation in the initial state (a) and after transformation (b).*

Advantages of method 1: simplicity of the transformation mechanism, maintainability; the possibility of easy transformation into an option for a child and vice versa; small costs for modifying a standard chair; design safety.

Disadvantages: the inability to adjust the width of the seat; lack of restrictive elements on the back.

In method 2 (Fig. 4, a, b), the transformation is performed after removing the rotary part of the cushion 2 from the lock. L for child seating. It is limited by the protrusions of the pivoting part of the cushion 2 of width h1. Return to the adult position: the pivoting part of the back cushion 2 is lifted up to the stop in the profile of the seat cushion 1. The position is fixed.

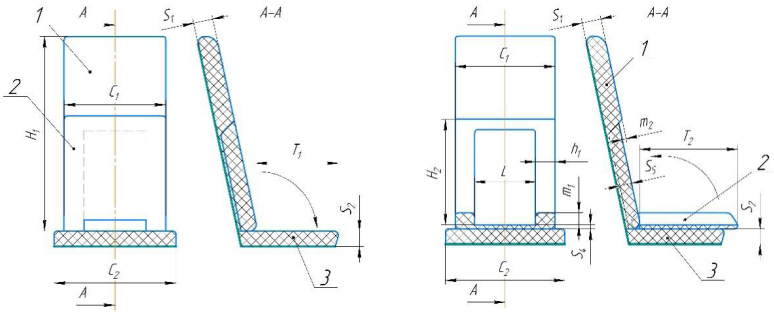

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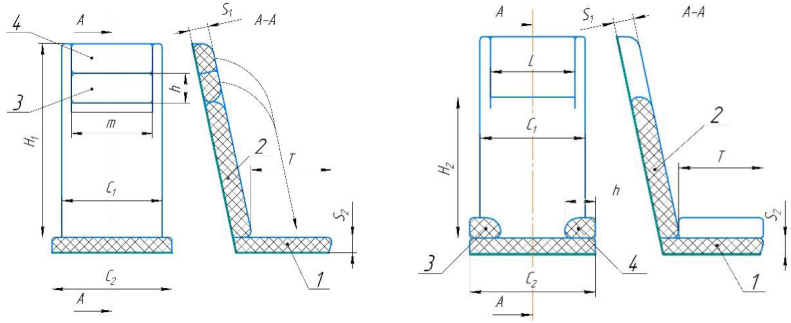
Figure 4. *Method 2 of chair adaptation in the initial state (a) and after transformation (b).*

Advantages of the method: the design of the seat panel and the back of the chair does not change; ease of transformation in one movement; increased thickness of the seat cushion; the possibility of easy transformation into an option for a child and vice versa; design safety.

Disadvantages: lack of adjustment of the seat for the child; due to the design, the supporting surface of the back cushions protrudes forward, there are no stops on the sides of the backrest, the stops on the sides of the seat are not high enough.

In method 3 (Fig. 5, a, b), the chair is transformed into a position for boarding a child after the Velcro fasteners of removable cushions 3 and 4 are unfastened. Velcro (hook and loops). To prevent damage to the clothes of passengers, the part of the fastener containing the hooks is located on the removable cushions 3 and 4.



а *б*

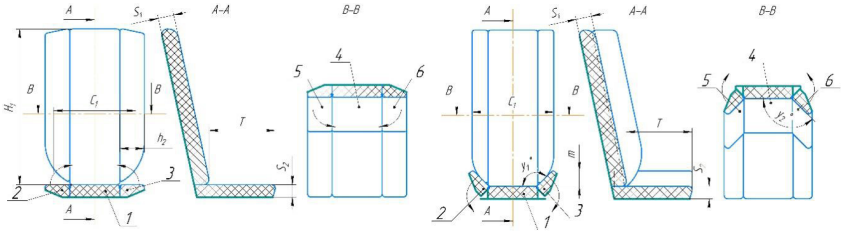
Figure 5. *Method 3 of chair adaptation in the initial state (a) and after transformation (b).*

Advantages of method 3: the design of the seat panel and the back of the chair does not change; simplicity of design and transformation; minimum costs for modification of a standard chair; the possibility of easy transformation into an option for a child and vice versa; design safety; the ability to adjust to the anthropometric data of the child.

Disadvantages: insufficient fastening of removable pillows on Velcro fasteners.

In method 4 (Fig. 6, a, b), the transformation is performed by turning the movable sidewalls 2, 3 of the seat panel with cushions attached to them and the movable sidewalls 5, 6 of the chair back in a swivel joint to the required angle. The proposed method of transforming a standard chair allows it to be adapted to any age category of a child. The rotation of the movable sidewalls 2, 3 of the seat panel is performed independently of the rotation of the sidewalls 5, 6 of the backrest. After the required amount of transformation, the required position is fixed by one of the known methods (spring-loaded latch, ratchet, etc.).

Advantages of method 4: simplicity of the transformation mechanism, its maintainability; low financial costs for modification of a standard chair, repair and operation; the possibility of easy transformation into a variant for a child and back into a variant for an adult; the ability to adjust the width of the supporting surface, the angle of inclination and the height of the limiting pads; the convenience of landing in a chair for both a child and an adult.



а *б*

Fig. 6. Method 4 of chair adaptation in the initial state (a) and after transformation (b).

The four options described above for adapting a standard passenger seat in economy class to a version for children with transformation mechanisms provide a safe and comfortable fit for both an adult and a child, but to varying degrees.

An analysis of the advantages and disadvantages of each of the options based on the proposed classification of transformation methods and the developed evaluation criteria showed that method 4 has the greatest advantages, providing, with a relatively simple design and transformation mechanisms, the ability to regulate the seating surfaces of the chair in the widest range, taking into account the anthropometric data of the child practically any age.

The introduction of the proposed designs of passenger seats with adaptation mechanisms for the child will not only increase the comfort of the seat, taking into account the individual characteristics of any passenger, but also ensure the required level of safety.

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木地板的耐水性和耐湿性研究
RESEARCH OF WATER RESISTANCE AND MOISTURE RESISTANCE OF WOODEN FLOOR COVERINGS

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One of the most important criteria when choosing wooden floor coverings for residential and non-residential premises is the stability of the form when changing climatic parameters of the environment, especially air humidity. In this article, we examine the effect of high humidity on the change in the shape of wooden flooring, such as engineered and parquet boards.

Keywords: engineering board, parquet board, water resistance, moisture resistance, high humidity, protective layer.

During the operation of wood flooring by a person, a change in temperature, as well as air humidity, entails a change in the size and shape of the elements of wooden structures, as a result of which a gap appears between one or more elements. Many design options have been developed and exist to stabilize the size and shape of wood floor elements. Such floor coverings include parquet board and engineered board [1].

The purpose of the study is to study the effect of changes in atmospheric humidity, as well as the impact of moisture on the dimensions and shapes of samples of parquet and engineered boards.

Experimental methodology: samples of several types of parquet and engineered boards made at the factory were used for testing in the amount of 12 pieces and 6 pieces, respectively (Fig. 1). Description of samples for research can be found below in Table 1.

For parquet boards, the top working layer is mainly made of oak wood, one-strip or three-strip, 3 mm thick, the bottom layer is peeled birch veneer, 1.4 mm

thick. The middle layer is made of pine slats 9 mm thick, with a radial arrangement of annual layers. In a parquet board, the direction of the wood fibers of the upper working layer is along the length of the parquet board, and the middle one is across.

At the engineering board, the top layer is a solid oak lamella with a thickness of 3 mm or more. The bottom layer is multilayer birch plywood, 10 mm thick. The alternating directions of fibers in plywood layers make this material more durable and stable. In an engineering board, the direction of the wood fibers of the upper working layer is along the length of the engineering board, and the lower one is across, except for samples No. 15, 16. All samples of engineering and parquet boards can be divided into three groups according to the method of protecting the upper working layer of boards: without facing, varnish , oil.

Table 1

Description of samples

Sample No.	Protective covering	Type	Overall width L, mm
1	Without cladding	3 layers 1 strip	178
2	Without cladding	3 layers 1 strip	178
3	Without cladding	3 layers 1 strip	178
4	Without cladding	3 layers 1 strip	178
5	varnish	3 layers 1 strip	178
6	varnish	3 layers 1 strip	178
7	Oil	3 layers 1 strip	178
8	Oil	3 layers 1 strip	178
9	Without cladding	3 layers 3 stripes	214
10	Without cladding	3 layers 1 strip	214
11	varnish	3 layers 3 stripes	210
12	varnish	3 layers 3 stripes	210
13	Without cladding	2 layers 3 stripes	198
12	Without cladding	2 layers 3 stripes	198
15	varnish	2 layers 3 stripes	198
16	varnish	2 layers 3 stripes	198
17	varnish	2 layers 1 strip	164
18	varnish	2 layers 1 strip	164

The methods described in GOST 16483.19-72 were taken as the basis for conducting moisture absorption tests. Two 440×630×190 mm desiccators were required, one of which contained the samples and the other was placed over the desiccator with the samples upside down and covered with a transparent film to keep the moisture in the enclosed space. Also, two boxes with dimensions of 330

× 230 × 125 mm were needed, where samples of wooden flooring were placed, and so that the samples did not touch each other, threads were pulled through the holes in the boxes through each row (Fig. 2). For moisture absorption studies, the lower surface of the samples was not immersed in water, the water level did not reach it; for this, two boxes were installed on stands, namely, on small glass jars (8 pcs.). We also needed a caliper, a small weather station with a remote sensor for humidity and air temperature, and a moisture meter [2].

Humidity data and sample measurements were taken every week for 5 weeks, namely, the study was carried out from April 14, 2023 to May 16, 2023. Water temperature 20 ± 1 °C at the beginning of the study. The moisture content of the samples was measured using a moisture meter, in accordance with the method of GOST 16483.7-71 [3]. After that, any changes in the shape of the samples were analyzed and conclusions were drawn.

Figure 1. *Samples of wood flooring*

Figure 2. *Desiccators with samples filled with water*

On the graph below (Fig. 3) we can see the change in moisture content of parquet board samples in % during the study period. It can be seen that all samples of parquet boards began to rapidly gain moisture W (%), regardless of the method of protecting the top layer. Before loading the samples into the desiccator, the moisture content W was ≦ 5%; after two weeks, the moisture content W increased by more than 4 times, and already amounted to 20%. A month after the end of the study, most of the moisture content W of the samples was 22%, but sample No. 10 absorbed the most moisture, the moisture content W of which was 25%.

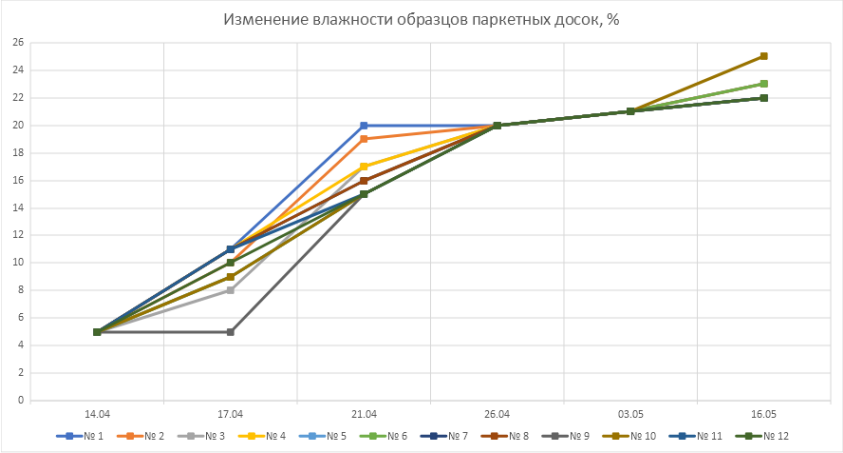

Figure 3. *Change in humidity of samples of parquet boards,%*

On the graphs below (Fig. 4, Fig. 5) we can see the change in moisture content W (%) of the upper and lower layers of engineering board samples during the study period. It can be seen that all samples of engineering boards began to rapidly gain moisture W (%), regardless of the method of protecting the top layer. Before loading the samples into the desiccator, the moisture content W was ≦ 5%; after two weeks, the moisture content W increased by more than 4 times, and already on average for all samples it was 20% for the upper layer and 35% for the lower layer. A month after the end of the study, the majority of the moisture content W of the upper layer of the samples on average for all was 25%, but the most moisture was absorbed by samples No. 17 and No. 18, the moisture content W of the upper layer of which was 36% and 35%, respectively.

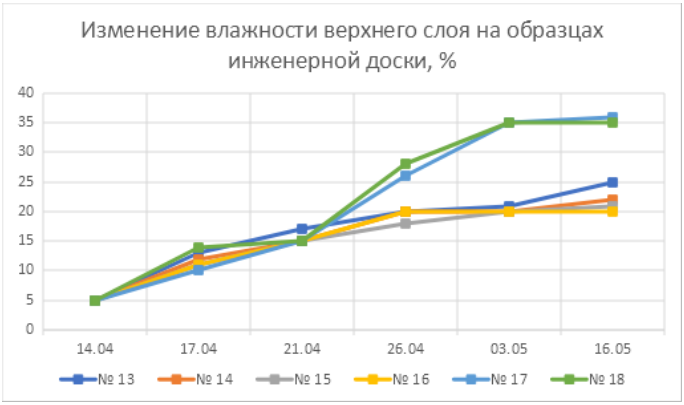

Figure 4. *Change in the moisture content of the top layer on samples of engineering boards,%*

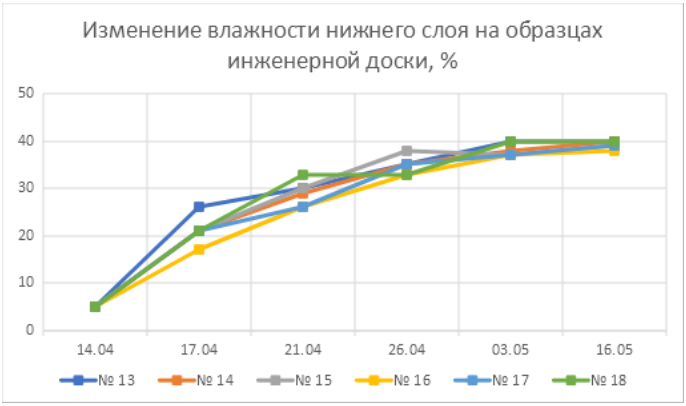

Figure 5. *Change in the moisture content of the lower layer on samples of engineering boards,%*

All samples of wood flooring, parquet and engineered boards absorbed moisture for 6 weeks without direct contact with water. All samples were very damp to the touch and covered with mold (Fig. 6), even at the interlock. All samples have a physical deformation in the form of a slight bend (1 - 3 mm). In samples of parquet boards No. 6, No. 9, No. 10, due to high humidity, the upper layer peeled off, in samples No. 7, No. 8, the lower layer peeled off (Fig. 7). The samples of engineered boards did not peel off one of the layers, however, it should be noted that all samples of wood flooring were produced on the same line by the

same manufacturer and had the same method and components for gluing all layers (AkzoNobel No. 1224).

Figure 6. *Formation of fungal infections (mold) on samples of engineering board No. 13 and No. 14*

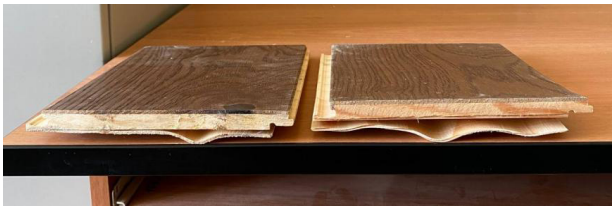

Figure 7. *Detachment of the bottom layer of samples of parquet boards No. 7 and No. 8*

Table 2 shows the results of measurements of changes in samples of wooden flooring after the study: the average deflection of the board, mm; % change (Δ) d, mm; external visible changes. An explanation is needed for the table below, that for specimens No. 7, 8, 9, 10, the average deflection was not calculated, because one of the layers peeled off and it was not possible to make an approximately correct calculation of this value.

Based on the results of parquet boards, it can be concluded that samples No. 4, No. 2, No. 6 were subjected to the least exposure to moisture. Samples No. 4 and No. 2 were not covered with a protective layer, have an average deflection of less than 0.1 mm, and the % change in board width d is 0.003 (0.5 mm) from the original data. Sample No. 6 was covered with a protective layer, namely varnish,

the average deflection was 0.3 mm, and the width of the board d did not change at all from the original data. It should be noted that in samples No. 6, No. 7, No. 8, No. 9, No. 10, due to an increase in humidity and its prolonged exposure, one of the layers of the structure peeled off, which can lead to sad consequences in human life.

According to the results of engineering boards, it can be concluded that samples No. 15 and No. 16 were subjected to the least moisture. Samples No. 15 and No. 16 were covered with a protective layer, namely varnish, have an average deflection of less than 1 mm, and % change in board width d is 0.005 (1 mm) from the original data. It should be noted that in samples of engineering boards, due to an increase in humidity and its prolonged exposure, one of the layers of the structure did not peel off.

Let's compare parquet and engineering boards with each other. According to the results, it can be concluded that the samples of parquet boards have undergone less deformation than engineered boards. For all samples of parquet boards, the average deflection was less than 0.5 mm, in contrast to the engineered board, in which this result reached 2.35 mm. According to the results of the changes in the width of the board, there are controversial points, samples No. 9 and No. 10, which increased by 7 mm, these are critical values in the life of these coatings, but still, in general, the parquet board showed itself better than the engineered board.

Table 2

Sample Changes

Sample No.	Bending deflection, mm	% Δ d	External changes
1	0,095	0,006	warping, mold
2	0,085	0,003	warping, mold
3	0,225	0,003	warping, mold
4	0,08	0,003	warping, mold
5	0,44	0	warping, mold
6	0,29	0	warping, mold, delamination of the lower layer
7	-	0,003	warping, mold, delamination of the lower layer
8	-	0,003	warping, mold, detachment of the lower layer
9	-	0,035	warping, mold, peeling of the top layer
10	-	0,035	warping, mold, peeling of the top layer
11	0,425	0,01	warping, mold
12	0,33	0,01	warping, mold
13	2,35	0,01	warping, mold
14	2,015	0,015	warping, mold
15	0,875	0,005	warping, mold

16	0,995	0,005	warping, mold
17	0,85	0,006	warping, mold
18	0,815	0,006	warping, mold

In this article, we conducted a study on the moisture absorption of wooden flooring (parquet and engineered boards), as a result of which we can conclude that the shape of parquet boards is more stable when samples are kept in conditions of high humidity for a long time, in comparison with the shape of engineered boards. A significant role is played by the method of protecting the top layer of the floor covering, among protective coatings with varnish or oil, varnish coating showed great moisture protection.

Humidity has a significant effect on wood flooring. It is recommended in the production and operation of wood floor coverings that their moisture content be from 7 to 11%, since in accordance with the data presented in the equilibrium moisture diagram (Fig. 8). This moisture content of wood corresponds to the temperature and humidity indicators of air in accordance with the requirements of SanPiN 2.1.2.2645-10 [5]. Sanitary and epidemiological requirements for living conditions in residential buildings and premises recommend that the room temperature be from 18 to 24 ° C and relative air humidity - 40-60%.

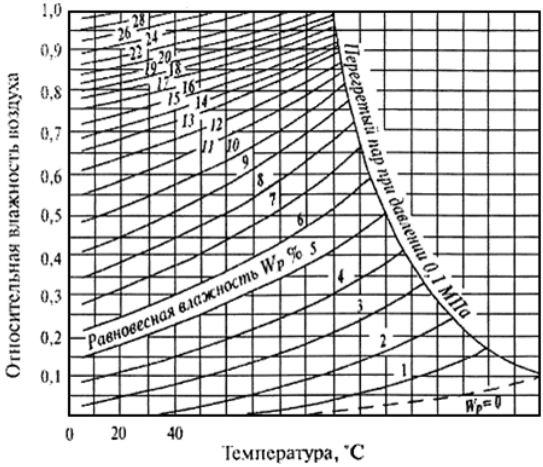

Figure 8. *Equilibrium humidity diagram [4]*

The reasons for these phenomena are related to the properties of wood as a material. Sudden changes in temperature should be avoided and the air exchange in the room should be sufficient. It is recommended to use ventilation and air conditioners that can maintain optimal conditions.

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具有非标准表面的楔形滑动支撑中的铁磁润滑剂
FERROMAGNETIC LUBRICANTS IN A WEDGE-SHAPED SLIDING SUPPORT WITH A NON-STANDARD SURFACE

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抽象的。 本文介绍了一种用于形成非标准轴承表面和支撑环表面易熔涂层的推力轴承计算模型的技术。 当可压缩铁磁流体和具有相似流变特性的涂层熔体被用作电磁场存在下的流体动力润滑模型时，考虑这种情况。 结果，获得了轴承承载能力和摩擦力的解析表达式。 评估表征轴承支承表面的非线性和弹性变形轮廓的参数的影响，以及由于存在熔体而产生的参数。

关键词：推力轴承，支撑环表面涂层，柔韧的滑块轴承表面，流体动力状态。

Abstract*. The paper presents a technique for the formation of a calculation model of a thrust bearing with a non-standard bearing surface and a fusible coating on the surface of the support ring. The case is considered when a compressible ferromagnetic fluid and a coating melt with similar rheological properties are used as a model of hydrodynamic lubrication in the presence of an electromagnetic field. As a result, analytical expressions for the bearing capacity of the bearing and for the friction force are obtained. An assessment is made of the influence of parameters characterizing the nonlinear and elastically deformed contour of the bearing bearing surface, as well as a parameter due to the presence of a melt.*

Keywords: *thrust bearing, support ring surface coating, pliable slider bearing surface, hydrodynamic regime.*

Introduction

Increasing the service life of plain bearings is an important task of great economic importance. In this regard, it is of interest to use a liquid lubricant and a melt coating of contact surfaces as a model for hydrodynamic lubrication.

The works [1–10], devoted to the hydrodynamic calculation of tribosystems, taking into account the rheological properties of the lubricants used, which have Newtonian or non-Newtonian properties in laminar and turbulent flow regimes, to increase the hydrodynamic lubrication regime for various operating conditions, prove the need to take into account additional factors.

An analysis of the operation of tribosystems with coatings of various antifriction composites [11–21], taking into account the stratification of a liquid lubricant, as well as studies of tribosystems with a non-standard working surface profile, revealed that taking into account the above factors improves the vibration-absorbing properties of plain bearings and reduces their temperature.

To reduce wear, in [22–28], tribosystems with a low-melting metal coating were studied, taking into account the rheological properties of the lubricant used and the coating melt under laminar and turbulent lubricant flow regimes, which makes it possible to effectively control the reliability and durability indicators of triboassemblies for various operating conditions.

This study is devoted to expanding the scope of ferromagnetic lubricants by developing mathematical models of a wedge-shaped sliding bearing, taking into account additional factors such as compressibility, anti-friction coating, electrical conductivity, elastic bearing surface of the slider.

Formulation of the problem

A steady flow of a compressible ferromagnetic fluid in the gap of a wedge-shaped sliding bearing is considered, the slider with a non-standard profile is stationary, and the coated support ring moves towards the narrowing of the gap at a speed u* (see figure). In addition, it is assumed that the adapted slider contour is also non-linear.

Design scheme

The contour equations 1)–5) (1) respectively characterize: 1) the contour of the slider adjacent to the rigid support surface; 2) deformed contour of the slider; 3) undeformed contour of the slider; 4) the contour of the guide to the melt; 5) Contour guide after melt. We write the equations of these contours in the form:

1) $y' = h_1 + x'\mathrm{tg}\alpha$; 2) $y' = h_0 + x'\mathrm{tg}\alpha - a'\sin\omega' x' + \beta'\varphi'\left(\frac{x'}{e}\right)$;

3) $y' = h_0 + x'\mathrm{tg}\alpha - a'\sin\omega' x'$; 4) $y' = 0$; 5) $y' = \beta'\varphi'\left(\frac{x'}{\mathring{a}}\right)$,

where the function $\beta'\varphi'\left(\frac{x'}{\mathring{a}}\right)$ is to be defined.

We will proceed from the following basic dimensionless equations: the equation of motion of a compressible ferromagnetic fluid, the continuity equation, the equation of state, the Lamé equation, and the equation describing the molten guide contour. Maxwell's equation must also be added to these equations. The indicated system of equations in the x'Oy' coordinate system will be written as:

$$\frac{\partial^2 \upsilon}{\partial y^2} - NB^2\upsilon + AB = \frac{1}{\Lambda}\frac{cp}{dx}; \quad \frac{\partial}{\partial x}(\rho\upsilon) + \frac{\partial}{\partial y}(\rho u) = 0; \quad p = \rho;$$

$$\frac{dH}{dx} = -K\int_{-\tilde{H}(x)}^{h(x)}\left(\frac{\partial \upsilon}{\partial y}\right)^2 dy;$$

$$\frac{\partial^2 u_y}{\partial y^{*2}} = 0; \quad \frac{\partial^2 u_x}{\partial y^{*}} = 0. \tag{1}$$

Here $K = \frac{2\mu u^*}{h_0 L'}$; $h(x) = 1 + \eta x - \eta_1 \sin\omega x + \eta_2 \Phi(x)$;

$\eta = \frac{L\mathrm{tg}\alpha}{h_0}$; $\eta_1 = \frac{a'}{h_0}$; $\eta_2 = \frac{b'}{h_0}$; $N = \frac{h_0^2 \sigma B^2}{\mu}$; $A = \frac{\sigma B^4 L h_0^2}{\mu u^*}$.

First, we solve the problem for the extreme case when $L' \to \infty \Leftrightarrow K \to 0$. In this case $H(x) = h_0^*$. In what follows, in the first equation of system (1), we will replace the velocity value by its maximum value *(υ = –1)*.

We solve the system of equations (1) under generally accepted boundary conditions:

$$\begin{gathered} u = 0, \quad \upsilon = 0 \ \text{при} \ y = h(x); \\ \upsilon_x = 0, \quad u_y = 0 \ \text{при} \ y^* = h_2(x); \\ u = 0, \quad \upsilon = -1 \ \text{при} \ y = \eta_3 \varphi(x); \\ M\frac{\partial u_y}{\partial y^*}\bigg|_{y^* - h(x)} = -\tilde{p}, \end{gathered} \tag{2}$$

where $\eta_3 = \frac{\beta'}{h_0}$; $M = \frac{G(1+\alpha^*)\tilde{u}^* h_0}{(1-\alpha^*)u^* \mu \delta_1}$;

$h_1(x) = \frac{h_0}{\delta_1} + \eta_4 x - \eta_5 \sin\omega x$;

$h_2(x) = \frac{h_1}{\delta_1} + \eta_4 x$; $\eta_4 = \frac{L\mathrm{tg}\alpha}{h_1}$; $\eta_5 = \frac{a'}{l_1}$;

α^* – Muskhelishvili constant;

$\tilde{p} = \max_{x\in[0,1]} p$.

$$H(x) = h_0^*; \quad h(x) = 1 + \eta x - \eta_1 \sin\omega x + \frac{\tilde{p}}{M}. \tag{3}$$

(1)

Taking into account (3), we will search for the exact self-similar solution of problem (1)–(2) using the well-known method [29–30], as a result, for the velocity field and pressure, using the method of successive approximations, we have:

$$\tilde{\psi}' = \frac{\tilde{c}^2}{2}(\xi_2 - \xi); \quad \tilde{\upsilon}(\xi) = \tilde{c}_1 + \left(1 - \frac{\tilde{c}_1}{2}\right)\xi - 1, \quad \tilde{c}_1 = -6.$$

$$p_1 = 1;$$

$$p_2 = \frac{\tilde{c}_1 \Lambda}{\left(1 - h_0^* + \frac{\tilde{p}}{M}\right)}\left(\frac{\tilde{\eta}}{2}(x^2 - x) - \frac{3\tilde{\eta}_1 x}{\omega}(\cos\omega - 1) + \frac{3\eta_1}{\omega}(\cos\omega x - 1) + \right.$$

$$\left. + \frac{2\eta_1 x}{\omega}(\cos\omega - 1) - \frac{2\eta_1}{\omega}(\cos\omega - 1)\right) + \tilde{\Lambda}\Lambda\left(\frac{3}{2}\tilde{\eta}x^2 - \frac{3}{2}\tilde{\eta}x - \right.$$

$$-\frac{3\tilde{\eta}_1 x}{\omega}(\cos\omega - 1) + \frac{3\eta_1}{\omega}(\cos\omega x - 1)\Big) + 1 \quad (4)$$

In conclusion, we note that at intermediate values of the specific heat of fusion (i.e. $L' \to \infty$) the expression for the load capacity and friction force remains valid in the case under consideration, if we replace h_0^* with $\tilde{h}_0^*$.

Tribological experimental studies of thrust bearings were carried out on a special stand for tribological studies (model HC12). The design of samples for experimental studies of thrust plain bearings consists of a flat support and a counterbody mating with it. The support has a coating of the working surface of Wood's metal alloy. The results of the study are summarized in the table.

Table 1

Comparative analysis of the results of the study of a slider with a metal coating of a wedge-shaped sliding bearing with a non-standard surface

№	Theoretical study			Pilot study		
	Metal plating	Coating and elastic bearing surface	Elastically adapted coated bearing surface	Metal plating	Coating and compliant bearing surface	yElastically adapted coated bearing surface
1	0,023	0,0229	0,025	0,0179	0,0154	0,0135
2	0,0195	0,0170	0,0161	0,0112	0,0081	0,0065
3	0,00167	0,00148	0,00141	0,0091	0,0072	0,0057
4	0,00188	0,00159	0,00148	0,0114	0,0091	0,0072
5	0,00213	0,00193	0,00169	0,0146	0,0116	0,0103

Conclusion

1. A new mathematical model has been obtained that makes it possible to establish the main regularities of the friction and wear processes of a wedge-shaped sliding bearing with a metal coating on the surface of the support ring and a nonlinear adapted slider contour, taking into account the compressibility of the lubricant and the electrical conductivity of the ferromagnetic lubricant.

2. As a result of numerical analysis, it was found that the use of such bearings, taking into account the above factors (compressibility, electrical conductivity, rheological properties of the lubricant and coating melt), increases their bearing capacity and reduces the friction coefficient by approximately 7–8%.

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作为现代武术的三宝
SAMBO AS A MODERN MARTAL ART

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抽象的。 这篇文章的作者触及了三宝的历史，其文化根源与俄罗斯文化的独特性和普遍性相关，试图理解三宝在现代世界的广阔前景，同时考虑到大规模的文化 危机以及向后工业社会过渡时代的可能性。 强调桑博是一种新的、现代的摔跤，它符合现代的要求，在这方面有很大的成就； 在推广 SAMBO 时应考虑到这一点，分析其作为一种帮助人们的文化现象的前景。

关键词：三宝、发展、现代世界、前景、后工业社会、公民社会、技术、可视化、自我发展、文化危机、哲学、克服、道德选择、新文化、现代、独特的俄罗斯文化。

Abstract. *The author of the article, touching upon the history of sambo, its cultural roots associated with the unique, universal nature of Russian culture, makes an attempt to comprehend the broad prospects of sambo in the modern world, taking into account the large-scale cultural crisis and, at the same time, the possibilities of the era of transition to a post-industrial society. It is emphasized that sambo is a wrestling of a new, modern type, it meets the requirements of modern times, has great achievements in this capacity; this should be taken into account when promoting SAMBO, analyzing its prospects as a cultural phenomenon that helps people.*

Keywords: *sambo, development, modern world, prospects, post-industrial society, civil society, technology, visualization, self-development, cultural crisis, philosophy, overcoming, moral choice, new culture, modern times, unique Russian culture.*

Sambo, as a syncretic type of wrestling of the modern type, based on the deep traditions of the past and bringing a lot of benefits at the stage of modern times, requires a broad and comprehensive consideration from the standpoint of its perspectives.

Surely, in the history of mankind there are many different types of struggle, which is caused by the eternal desire to survive. At the same time, those species that we now know about, remember, those that we value as an important contri-

bution to the treasury of human culture that influences descendants, are based not only on the desire to survive, but on the desire to remain human, to strengthen and improve spirituality. They are based on the ability to accept the challenge of the world in any of its forms, on the knowledge of how to respond to it in actual typical conditions (first of all, respond spiritually, because a person is strong in spirit [1]; first of all, this is important for a man). This is taught by the concept of martial arts as a phenomenon of true culture. At the same time, it is clear that the formation of such a system is a derivative of culture, in particular, of a specific national culture, a derivative of the needs of the era.

Returning to Russia, we must note its cultural universality, which has taken shape as a huge Russian world, friendly uniting a large family of ethnic groups in the process of a very difficult historical path. The openness of Russians to a variety of cultural influences and traditions helped create a unique Russian ballet, great Russian literature, and later the Stanislavsky system, etc. and sambo - as a syncretic wrestling based on the systems of judo, jiu-jitsu, on martial arts of the peoples that were part of the USSR (meaning, for example, the Uzbek “kurash”, the Georgian “chidaoban”, the Azerbaijani “gulesh”), on some traditions of Slavic, European wrestling. The Russians, being once again in the most difficult historical conditions of a huge forced modernization breakthrough of the 20th century, defending the world’s first state of workers and peasants, and with it their great culture, created a unique struggle, which was highly appreciated in the world. In a relatively short time, having gone from a new sports, cultural, social, political phenomenon to an Olympic sport, to great popularity[2], SAMBO never ceases to amaze with how organically it combines various traditions, never ceases to amaze with its economy, compliance with the rhythm of life , the style of thinking of the people of modern times. Compared to more traditional martial arts, techniques, the sambo system are simpler in the good sense of the word, they are quite comprehensible for an “ordinary person”[3]. This was greatly facilitated by hard work, dedication, patriotism, along with cultural depth, cultural susceptibility of V. S. Oshchepkov, V. A. Spiridonov, A. A. Kharlampiev, who are considered the founders of sambo[4].

The prospects of SAMBO as a multifaceted, profound phenomenon (having, in the spirit of real martial arts, its own philosophy - the philosophy of the struggle of a man of a new era ...), cannot be considered without the features of modern critical culture[5], without “similar cases” of major cultural shifts, related, for example, with a period of XIX - XX centuries. and so on. Modern times are associated with active democratization, social explosions due to the desire to get rid of the heavy inertia of much less democratic periods in the history of mankind. The newest time is a much more active movement of people, a more “simple” (less ritualized) way of life, appropriate clothing, manner of behaving, communicating,

working ... The role of mass education and science is immeasurably increasing. It is during this period that sambo arises, which determines the nature of its "style", techniques, and philosophy.

In such conditions, the positive phenomena of modern culture, for example, sambo, have prospects, moreover, in fact, they are in great need of a society that is undergoing a deep cultural crisis, from which, due to globalization, "there is nowhere to escape." At the same time, the "disgust" for real culture, which is observed in many modern people, interferes as a kind of syndrome of a terrible cultural disease. Of course, in the context of the scale of the crisis, the scale of many social processes, it is possible and necessary to think about global methods, forms of influencing people, including, for example, in the aspect of raising interest in SAMBO. However, due to these and other reasons, the political, "large" social component in our time is also experiencing a certain crisis[6]. Therefore, for the time being, one should probably rely more on a more "local" impact on contemporaries at the level of the family, the study group, the city, of course, at the level of self-education, self-development. Moreover, democracy presupposes a greater role for the individual and interpersonal relationships. In any case, you should use the advantages of the era - technologies, new means, methods of communication in order to contact like-minded people, convince people, present information vividly. Ultimately, the "macro-society" should also use the features of modern informatization in order to fight the cultural crisis, in particular, to promote sambo.

Sports, especially sambo, at the stage of loss of cultural reference points by many people, are intuitively and consciously perceived as a "beacon", signaling a healthy lifestyle, opportunities, purposefulness, will, the combination of physical and spiritual principles in culture. Given the positive moral choice of people, sambo, having played its great educational, cultural, combat role in our time, is likely to develop further, taking into account the further development of science, informatization, contact of cultures, and social relations in general. It is possible that on the basis of this martial art a new syncretic type of struggle will appear with its philosophical, cultural, educational, combat features, potential - corresponding to the time. Probably, it is the cultural-educational, philosophical principle that will manifest itself more noticeably here, especially since the passion for philosophy is characteristic of transitional eras, of a global society. Probably, even before the formation of a new type of wrestling, sambo, as a modern type of martial arts, will find the possibilities of actual accents in itself. But in order for this to happen, it is now necessary to find adequate ways to organize culture, social life - in order to get out of the "chaos" of the critical time in which we find ourselves (far from being fully aware of the "chaos").

In any case, it is clear that, based on the foundations of modern democracy, civil society structures[7] should play a significant role in progress at the post-in-

dustrial stage, which should be connected with SAMBO[8]. A bright informational, educational component should play a big role: good feature and other films about unique martial arts, about other types of wrestling; visible, organically perceived events; attractive sites; clear, meaningful, systematic training and the like. In fact, what we are talking about is not difficult for modern people.

Concluions

The spread of Sambo is connected with the position of Russia in the world, with the final recognition of its huge cultural and political role in the world community. This, of course, is connected with overcoming the global crisis, the excesses of capitalism in a culture of the Western type. Let us recall that the mass culture natural for the stage of industrialization in a socialist society, in the Soviet Union, was fundamentally different, progressive. It was she who led to the social, political phenomenon of sambo. Such results are connected both with the political system and with the nature of the culture of our country, as we discussed above. One way or another, overcoming the current crisis is possible based on the principles of true culture, on cultural achievements that are suitable for the current stage and have the potential for development. This should be relied upon when searching for methods, means of changing the situation both at the macro level and at the level of a more local society, the individual, and this should be relied on when spreading SAMBO in the world, contributing to its further development.

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俄罗斯及其合作伙伴：在文化价值观范式转变的背景下寻找合作轨迹
RUSSIA AND PARTNERS: SEARCH FOR A TRAJECTORY OF COOPERATION IN THE CONTEXT OF A PARADIGM SHIFT IN CULTURAL VALUES

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抽象的。 本文考虑了在区域结构的参与下创建可持续的世界秩序模型的可能性，其中之一是上海合作组织 (SCO) 框架内的国家统一。 简要介绍了上合组织成员国在普遍接受的国际法准则和和平共处原则基础上开展国际合作的主要方向，重点指出了最有希望的方向。 注意力集中在基于国际进程新出现的价值取向的合作的人道主义和文化组成部分。

关键词：上海合作组织，合作，一体化，伙伴关系，区域化，民族认同，文化认同，文化代码，社会共同体，民族，民族观念。

Abstract. *The article considers the possibility of creating a sustainable model of the world order with the participation of regional structures, one of which is the unification of states within the framework of the Shanghai Cooperation Organization (SCO). A brief description of the main directions of international cooperation between the SCO member states on the basis of generally accepted norms of international law and principles of peaceful coexistence is given, the most promising directions are highlighted. The attention is focused on the humanitarian and cultural component of cooperation as based on the emerging value orientation of international processes.*

Keywords: *SCO, cooperation, integration, partnership, regionalization, national identity, cultural identity, cultural code, social community, nation, national idea.*

The world is changing faster today than at any time in human history. The century-and-a-half triumphal march of globalization over the past few years has faced a number of systemic problems, solutions to which are often associated with the revision of the conceptual framework of this process. Guidelines, models and strategies of interaction within the human community as a global organism are being seriously tested for strength.

Objectively, we observe a tendency to change the course of the social world order from a globally oriented, universal, averaged one, characterized by leveling the cultural characteristics of national communities, blurring national and even state borders, to a new one. Of paramount importance in such a new society today are the concepts of mutually beneficial cooperation, parity, coherence while maintaining full political independence, national identity and cultural diversity. An important characteristic feature of this process is also the formation of several centers of attraction, around which a certain number of national cultural communities are united, similar in their cultural code and historical platform.

One of these centers of attraction, it seems, is the association of the SCO countries – an organization established in 2001, primarily to coordinate efforts in the development of economic and energy partnership, the fight against extremism and terrorism, drug trafficking. Russia and China were, along with 4 other states, members of the SCO founding countries, being, in turn, consolidating links between other members of this international structure, acting as guarantors of economic and political stability.

Over time, under the influence of a number of objective changes that have affected the entire planet over the past 20 years, it has gradually become apparent that not only the formal and officially accepted characteristics of the development and state of states and regions, but also the deep, spiritual, moral, culturally conditioned foundations of society have changed. In 2020-2023, following the rapid changes in the system of social, political and economic world order, the society subjected many of its beliefs and views to a global and profound revision. There was a steady demand not only for globalization, but also for cultural, national, ethnic identity. Many states have taken care of finding their own cultural code, national idea.

Over the past 3 years, both scientists and ordinary citizens can observe how the very paradigm of human existence in society is rapidly changing, how the value of personality, its manifestations, spiritual values, and cultural contribution that each individual is able to bring to society, where it is a fairly significant part, is growing. Such concepts as spirituality, morality, culture, self-awareness, awareness are becoming relevant and in demand again.

And there is an increasingly obvious split in the minds of people belonging to different social communities. Today we have an unprecedented opportunity to observe the formation, “recalibration” of these very communities, where the determining factor is not the social standard of living, geographical location, or even linguistic affiliation. The main markers of the new socio-cultural structure of society are the spiritual and moral core and national identity.

The unification of the SCO countries in this process acts as one of the centers of consolidation of socio-cultural and political forces. The basis for this circum-

stance was a number of reasons - from the unique geographical location of the participating countries to their historically and linguistically conditioned, complex, multinational, multi-confessional cultural code. It is this cultural code that, in our opinion, is the main element in the formation of the national idea of the state, the request for which is acutely posed today, in particular, to the Russian scientific circles. And it seems that the search for new trajectories of cooperation between states and social communities is associated with the search for points of contact and elements of harmony in the context of the cultural code and national identity.

In this article, we consider it appropriate to consider the meaning of the concepts of cultural code and national and cultural identity in Russian philosophical thought.

The problem of determining one's own cultural identity in Russian philosophy dates back to the 1930s, when socio-political thought was divided into Slavophiles and Westerners who argued about the essence and ways of the historical development of Russian society. P.Ya. Chaadaev, I.S. Turgenev, V.G. Belinsky, A.I. Herzen, N.P. Ogarev, K.D. Kavelin were, in fact, supporters of the globalization strategy [1], believing that Russian society should adopt and borrow not only the achievements of science in Western countries, but also adopt the political and social structure, considering it the only true and acceptable on the way to prosperity and prosperity. Another branch is the Slavophiles, represented by A.S. Khomyakov, K.S. Aksakov, P.V. Kireevsky, V.A. Cherkassky, as well as consonant with them S.T. Aksakov, V. And Dal, F.I. Tyutchev considered it impossible and wrong for Russia to move along the Western path [2], seeing the basis of development in reliance on religion, autocracy and the traditional way of society.

Russian Russian people are endowed with a special mission - the so–called Russian idea of historical uniqueness, a special vocation and a special historical path. The next stage of philosophical understanding and attempts to define national identity as a philosophical category belongs to the end of the XIX - beginning of the XX century, and such names as N. Berdyaev, N.Y. Danilevsky, L. Gumilev, who believed that the Russian people are endowed with a special mission - the so-called Russian idea of historical uniqueness, a special vocation and a special historical path. At the same time, the concepts of spiritual and cultural identity are introduced [3].

Later, this concept is clarified by D.S. Likhachev, L.I. Umansky, V.S. Stepin, etc., where the main emphasis is on the individuality of the historical path of each nation in line with the uniqueness of its cultural code [4, 5].

In the late 1990s and early 2000s, following the growth of global processes, there is an increase in research on cultural identity in direct connection with globalization. Such authors as V.N. Badmaev, Yu.A. Sukharev, S. Chistyakova in their works draw conclusions about the inevitability of the "blurring" of national

and cultural boundaries between societies, about the trend towards the formation of global culture and global identity [6]. At this time, a stable tendency to determine one's identity for a social unit, whether it is an individual or an entire nation, in the context of their historical, social, spiritual, cultural manifestation, becomes a guideline for the compatibility of these characteristics with global processes of total integration, universalization, so-called "embedding", and, ultimately, assimilation national and cultural native traits into an impersonal system of global manifestations.

In the 2010s and 2020s, objective changes in the social and political world order become the point of refraction of theoretical views, it is then that the reverse trend becomes noticeable – regionalization and the desire to isolate, preserve and even sacralize the unique features and features of a particular social community. At this time, the problems of interaction of cultures and globalization are being dealt with, in particular, E.O. Muravyeva, E.G. Koenig, noting that along with the global trend of globalization, processes aimed at preserving, multiplying, and isolating cultural traditions [7,8] on the scale of social groups, national communities, and nations in the socio-political understanding are beginning to be actualized.

In 2020-2023, under the influence of objective socio-historical and political processes, the question of the state and trends in the formation of the national identity of Russian society was raised. In March 2022, the Government of the Russian Federation proposed to the Institute of Philosophy of the Russian Academy of Sciences to develop a concept of a national idea for using it as a basis for the formation of value orientations of Russian society, including for use in the educational process in relation to the younger generation.

It seems that the solution to this issue should be sought in the concept of national identity as a criterion for the self-determination of a community, it contains the essence of the cultural and national moral foundations of such a community [9]. And it is cultural and national identity that should be considered the very cultural code that underlies the self-determination of the nation, which has been formed for centuries, containing language, religion, epic, music, painting, tangible and intangible cultural values, moral principles, ideological attitudes and much more that, with proper attitude, can and should be transmitted from generation to generation as the cultural code of the nation and as the basis for the formation of the national idea of the state.

Returning to the model of the emerging new world order and the steady trend towards regionalization, we consider it necessary to focus separately on the areas of cooperation within the SCO, since these areas can act as trajectories of sustainable development both for the participating countries themselves and for the entire aforementioned international structure as a single regional organism, a means not only of obtaining unilateral benefits, but also multilateral the synergy effect, when joint actions bring tangible positive results for all participants in the process.

Within the framework of the Shanghai Cooperation Organization, among the most promising areas of cooperation, it is worth highlighting cooperation in the field of security (countering separatism and extremism, anti-terrorism), trade and economic cooperation (regional economic cooperation and mutual investment, energy cooperation), cultural and humanitarian cooperation[10] (holding Days of Culture, participation of art collectives and artists, holding joint events dedicated to significant historical dates of the countries, SCO member states, exchange of students and teaching staff, creation of joint training centers). In 2008, the SCO University was formed as a single network educational space based on universities conducting research in the following areas: regional studies, information technology, nanotechnology, energy, ecology — currently these are 53 universities from 5 SCO countries[11].

A certain stabilizing factor affecting internal and external processes within the SCO, in our opinion, are also the principles of conducting the foreign policy of the organization's member countries, which have become the components of the whole concept of the organization, one of the main documents of which was the Agreement on Long-term Good-Neighborliness, Friendship and Cooperation. These are the main Chinese "5 principles of peaceful coexistence": mutual respect for territorial integrity and sovereignty, non-aggression, non-interference in internal affairs, equality and mutual benefit, peaceful coexistence [12], and the norms of international law, and numerous documents of each country that ensure stability, equality and order of mutual relations.

It is the Shanghai Cooperation Organization, as it seems, that can become a new regional core of political, economic and socio-cultural processes, thereby the center of the formation of a new community, around which the fundamental values of the future world order will be concentrated.

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