



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

Proceedings of the
International Conference

Date:
March 31

Beijing, China 2022

上合组织国家的科学研究：协同和一体化
国际会议

参与者的英文报告

International Conference
“Scientific research of the SCO
countries: synergy and integration”

Part 2: Participants' reports in English

2022年3月31日，中国北京
March 31, 2022. Beijing, PRC

Proceedings of the International Conference
**“Scientific research of the SCO countries: synergy
and integration”** - Reports in English

(March 31, 2022. Beijing, PRC)

ISBN 978-5-905695-82-7

这些会议文集结合了会议的材料 – 学术论文和科学工作者的论文报告。它考察了职业化人格的技术和社会学问题。一些文章涉及人格职业化研究问题的理论和方法论方法和原则。

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俄罗斯远东温水养殖场养殖鳊鱼鱼种

**CULTIVATION OF FINGERLINGS OF CHINESE MANDARIN FISH
SINIPERCA CHUATSI IN A WARM-WATER FARM OF THE RUSSIAN
FAR EAST**

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抽象的。该论文提供了在俄罗斯远东南部的一个温水网箱养殖场条件下生长的鳊鱼产卵器的产卵数据。描述了 2021 季节在池、塘和网箱中采用联合方法从幼虫中培育出鳊鱼幼苗的结果。作为实验的结果，这个物种的大一岁幼仔平均体重为 142。

关键词: *Siniperca chuatsi*、产卵器、卵、幼虫、鱼种、水池、池塘、网箱、生长、生存

Abstract. *The paper presents data on the spawning of spawners of *Siniperca chuatsi* grown under the conditions of a warm-water cage farm in the south of the Russian Far East. The results of cultivation of fingerlings of *Siniperca chuatsi* from larvae by the combined method in tanks, ponds and cages in the season 2021 are described. As a result of the experiments, large fingerlings of this species with an average weight of 142.*

Keywords: *Siniperca chuatsi*, spawners, eggs, larvae, fingerlings, tanks, ponds, cages, growth, survival

The Chinese or mandarin perch *Siniperca chuatsi* is distributed throughout China and the countries of Southeast Asia. In Russia, it is common in the lower and middle reaches of the Amur, in the Sungari and Ussuri rivers, in Lake Khanka (Kucherenko, 1988). This is a voracious predator that eats mostly small, low-value fish. However, thanks to its huge mouth, it also attacks high-bodied fish that are less accessible to other predators.

Mandarin perch has been known since time immemorial, but gained extreme popularity in China during the Tang Dynasty (618-907). Court poets and writers praised the extraordinary beauty and taste of this fish in many books and poems (Kuanhong M., 2006). The first successful experiments on the artificial reproduc-

tion and cultivation of *Siniperca chuatsi* were carried out in 1975 by the Suzhou Municipal Farm in Jiangsu Province. Since then, rearing of this species under controlled conditions has become increasingly popular, and by now Chinese fish farmers are rearing large numbers of this fish in ponds, cages and enclosures (Chen J at al., 2010).

In 2020, about 380 thousand tons of marketable mandarin perch were grown in all fish farms in China (China Statistical Yearbook, 2020). In the northern Chinese province of Heilongjiang, adjacent to the Primorsky Territory, near the city of Jaohe on the border river Ussuri, there is a large fish farm for the cultivation of *Siniperca chuatsi*. At the same time, this species is considered rare in the rivers and lakes of Primorsky Krai and is still in the Red Book.

The aim of our research was to develop a technology for cultivating viable fry of *Siniperca chuatsi*, under conditions of a full-system warm-water farm to replenish its reserves in natural reservoirs and to grow commercial perch for sale in a trading network.

Material and methods

The work was carried out in May-October 2021 in the villages of Luchegorsk in the north of Primorsky Krai in the conditions of the research fish breeding station of the Pacific branch of TINRO. The station includes more than 100 cages with an area of 10 m² each, installed in the water supply channel of the thermal power plant, a workshop for incubation and rearing of any fish species in the tanks and fry ponds with an area of 0.2-0.7 ha, supplied with water from the power plant's cooling pond. The total amount of heat per year in the cages of the farm is 4630-4870 degree-days. The minimum water temperature in winter drops to 1-2 °C, in summer it rises to 28 °C, and in some years for several days it can reach maximum values of 33-35 °C. Active reaction of water pH varies from 7.3 to 9.2, oxygen content from 5.3 to 13.4 mg/l.

During the work, we were guided by well-known Russian recommendations (Strebkova T.P., Shabalina V.A., Bibikov, 1983) and publications of Chinese scientists.

Chinese fish farmers recommend paying special attention to the condition of perch spawners 40-60 days before spawning and feeding them intensively at this time (Liang Xu-Fang at al., 2008; Wei Li at al., 2021). Therefore, when the temperature rose to 15-16 °C, when the fish began to feed, 140 kg of live carp yearlings were introduced into the cages as food objects, which amounted to 60-65% of the ichthyomass of spawners. When the fish was eaten, they began to produce rationed feeding of predators with low-value fish at the rate of 4-5% of the fish biomass per day.

Before spawning, spawners were measured and weighed (Pravdin, 1966). The following designations were used to measure the length: AB - the length of the

fish from the end of the snout to the end of the caudal fin; AD - the length of the fish from the end of the snout to the end of the scale cover; $M \pm m$ - the mean value and its error; min-max - limits of feature variation; C_v is the coefficient of variation. To stimulate maturation, 2 females and 4 males were injected with the releasing hormone "Nerestin-6". Spawners spawned independently in two small tanks measuring $1.0 \times 1.0 \times 0.4$ m with a circular flow of water. Caviar from the tanks was selected with nets, weighed, and the average mass of eggs and working fecundity were determined.

Incubation was carried out in VNIIPRKH apparatuses with a volume of 120 liters, laying there from 1 to 2.5 kg of caviar. The hatched larvae rolled into receiving tanks $2 \times 2 \times 0.8$ m in size with a water level of 0.3 m. The yield of larvae from eggs and their mass at hatching were determined. Then, 2000 pieces were left in each of the tanks. (500 pieces/m²) of larvae that switched to active feeding and began to feed them 3-5 times a day with larvae of carp, carp, silver carp and grass carp, which were specially obtained and grown for this purpose. In the tanks, juveniles were reared for 25 days. Juvenile perch, grown in pools to viable stages, were seated in 450 pieces. in ponds with an area of 0.2 and 0.24 ha, where they were kept in polyculture with Amur carp and herbivorous fish, planted there by larvae before predators or simultaneously with them.

In the ponds, cyprinid fish were constantly fed at first with starter and then with production compound feeds. After 44 days, the ponds were caught, the predators were sorted out from cyprinids and put into a tank measuring $2 \times 2 \times 0.8$ m with a water level of 0.4 m. They were offered small live rejected fish from the ponds as food. The underyearlings of *Siniperca chautsi* spent 19 days in the tank, after which they were transferred to a cage, where they continued to be fed small carp fish for 18 days. Before wintering began in the third decade of October, fingerlings were measured and weighed. The obtained data was processed in a statistical program.

Results and its discussion

The broodstock of Chinese perch was formed from fingerlings caught in the Ussuri and Amur rivers. As food, predators received live and dead mass low-value fish, which were caught near the cages of the farm. These are the Korean wasp *Hemiculter leucisculus* and the prickly mustard *Acanthorhodeus asmussii*. The broodstock is represented by individuals aged 7-10 years weighing from 3.2 to 7.3 kg (table 1).

Table 1.*Size characteristics of Siniperca chautsi spawners from warm-water farm cages*

Floor	Sex Indicators	AB (TL), cm	AD (TS), cm	Height, cm	Thickness, cm	Girth, cm	Weight, kg
♀♀	M±m	61.4±0.6	55.2±0.6	22.0±0.2	9.4±0.2	53.4±0.5	5.2±0.2
	min-max	57.4-68.2	51.2-61.2	20.5-24.3	7.8-11.2	49.3-59.6	4.1-7.3
	Cv	5.1	4.9	4.2	8.2	4.8	14.6
♂♂	M±m	60.1±0.8	53.8±0.7	20.2±0.2	8.6±0.2	49.2±0.6	4.4±0.2
	min-max	53.2-68.2	47.2-61.0	18.5-22.7	7.4-10.7	44.4-56.8	3.2-6.7
	Cv	6.9	6.9	6.2	10.0	6.8	21.0

As can be seen from the table, all size parameters of perch females, as well as their weight, exceeded those of males.

During the first and second spawning rounds, all males secreted sperm with light pressure. Chinese perch females were well prepared for spawning, had a full, rounded abdomen and an inflamed genital opening. The first spawning of predators was carried out in mid-June at a water temperature of 24-26 °C, and the second at the end of June at a higher water temperature of 26-27 °C (tables 2, 3).

Table 2.*Fish breeding characteristics of Siniperca chautsi females used in spawning*

The weight of the female kg	Mass of swollen caviar, g	The mass of one egg, mg	Egg diameter, mm	Working fertility, thousand pieces	Relative working fecundity, thous.	Fertility, %	Exit of larvae from eggs, %
5.60	1620	5.77	2.0	280	50	96	85
4.85	2430	5.60	1.9	433	89	98	88

Table 3.

Terms of maturation of females after injections and terms of transition of larvae to active feeding

Weight of females, kg	Water temperature at maturation of females, °C	Time before spawning clock	Time until the end of spawning, hours	Transition period of larvae to active feeding, days
5.60	24-26	21.5	25	4
4.85	26-27	22	26	3

The female used during the second round of spawning at a higher water temperature showed significantly higher fertility compared to the larger female in the first round of spawning. She noted a greater yield of larvae from eggs and a shorter period before the transition to active feeding.

Hatching of the first perch larvae began on the second day of incubation and continued for a day and a half. Mass hatching was observed at the beginning of the third day of incubation. During incubation, part of the eggs died due to developmental anomalies and saprolegnia. Survival of one-day-old larvae was high (table 4).

Table 4.

*Results of incubation of eggs and obtaining larvae of *Siniperca chautsi**

Temperature during incubation of eggs, °C	Duration of incubation of eggs, day	Mass of one-day larvae, mg	Survival of day old larvae %
26-27	3	1.0-1.2	90

The hatching larvae were distributed mainly near the walls of the tank. The highest concentration of larvae was observed in shaded areas, i.e. their phototaxis was negative. Some larvae began to feed after 2.5 days of exposure. On the 3-4th day of keeping, all larvae switched to active feeding. In experiments on the cultivation of *Siniperca chautsi*, larvae from the 2nd round of spawning were used, when feeding larvae of cyprinids appeared in large numbers. *Siniperca chautsi* larvae ate carp, carp, silver carp and grass carp larvae weighing from 1.1 to 1.6 mg. Moreover, the size of the victim could exceed the size of a perch by one and a half to two times. The predator grabbed the larva from the tail, gradually swallowed it, and then bit off the head and chose the next prey. Forage cyprinids were reared in special tanks in parallel with *Siniperca chautsi*.

In one of the experiments, during complete starvation for 4 days, cannibalism began to actively manifest itself in the larvae of *Siniperca chautsi*. Moreover, quite often the larvae that swallowed their fellows died because of the sharp spikes located on their gill covers. With an abundance of food, cannibalism was not observed. But at the age of more than 20 days, with a mass of more than 500 mg, in the event of a lack of food, they could attack small juveniles of their own species. Juveniles of *Siniperca chautsi* weighing 200 mg consumed cyprinids weighing 50-100 mg. If juveniles of *Siniperca chautsi* captured juveniles of cyprinids much larger than themselves by the center of the body and could not unfold and swallow them, they often escaped and, as a rule, died. At the end of the experiment on growing juvenile mandarin perch, about 5% of forage fish died in this way.

Silver carp larvae, which *Siniperca chuatsi*, did not have time to eat, quickly grew in the tanks on phytoplankton supplied with water, and many of them escaped from the pressure of predators. For 1-2 days, the larva or juvenile perch destroyed from 2 to 5 feeding larvae of cyprinids. Perch were fed 3 to 5 times a day. When feeding fish were brought in, especially if they were a little stale and began to move erratically, the perches attacked with lightning speed. After 10-20 seconds, each predator had a fish in its mouth.

At night, when the lights were off, the perch's food stopped. But if the lighting was left on at night, the hunt continued. The daily cleaning of the tanks stressed *Siniperca chautsi*. Therefore, at the end of the experiment, the tanks were very carefully cleaned once every 5 days. Larvae and juveniles avoided artificial shelters made of plastic and had to be removed after 10 days. The most attractive for them were stones and tree branches with leaves, under which they preferred to gather in small shoals.

The most intensive growth of Chinese perch began from the 16th day of cultivation, when the mass of juveniles was 200-250 mg, and the water temperature exceeded 25 °C. By the end of the experiment on the 25th day of life, the juveniles of *Siniperca chautsi* had an average weight of 1.7 g, with fluctuations from 0.5 to 3 g.

Below is the growth dynamics of perch obtained in the second round of spawning (figure 1).

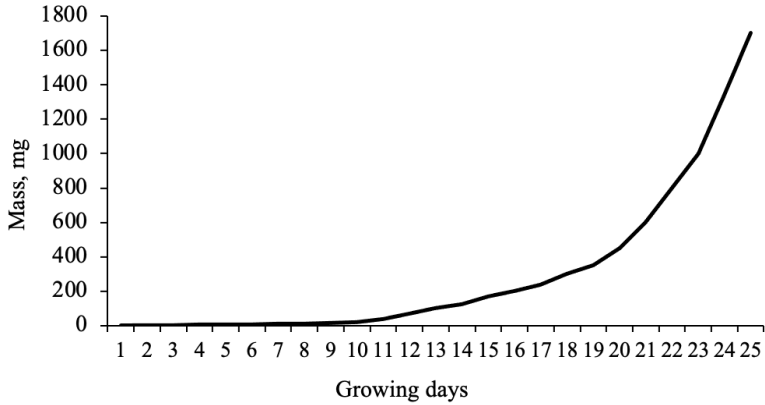


Figure 1. Growth dynamics of larvae and juveniles of *Siniperca chuatsi* in tanks

The main waste occurred at the stage of growing juveniles up to a sample of 200-250 mg. The output of juveniles from the landing of larvae by the end of the experiment was 45%.

Perch ignored zooplankton and artificial food and ate only live larvae and juveniles of cyprinids, which was repeatedly noted by Chinese scientists (Liang at al., 1998; Liang at al., 2008). Lack of food at the end of the experiment and an increase in temperature to 32 °C were the main reasons for transferring fish to ponds. The stocking density of juveniles was 450 pcs. for ponds with an area of 0.2-0.24 ha, or 1875-2250 pieces/ha.

For 44 days of growing in ponds, the weight of fingerlings increased to 111.5 g, with fluctuations from 46 to 274 g. The modal group was individuals weighing 100-120 g, which accounted for 77% of the total number of fish. Perch fingerlings were much larger in body weight than fingerlings of cyprinids and herbivorous fishes, which, when catching ponds, had a mass of 8 to 30 g. They were then sorted from cyprinids and spent equal periods of time in the tank and then in the cage (table 5).

Table 5.

Results of rearing fingerlings of Siniperca chuatsi in the tank and cage

Stage duration	Planting rate, pcs./m ³	Initial weight of fingerlings, g	Final weight of fingerlings, g	Average growth, g/%	Survival, %
19 days	143	111.5	114.1	2.6 / 2.33	99
18 days	15	114.1	142.0	27.9 / 24.5	100

In tank at a temperature of 23°C, perch generally began to feed two or three days after landing, but the feeding intensity was constantly low. Undoubtedly, this is due to the high stocking rate and the stress caused by the sudden change in habitat conditions and fish farming manipulations. It is known that under natural conditions, perches never stay in flocks and lead a solitary lifestyle. In the cage, the stocking rate was 9.5 times lower than in the tank. Perch began to actively feed throughout the entire water column almost immediately after the transfer from the tank.

The duration of keeping predators in the tank and in the cage was practically the same, but their increments differed many times. In the conditions of the growing shop tank, despite the abundance of forage fish, the increase in predators was minimal. In the cage, the growth rate of perch fingerlings increased significantly. Absolute and relative increases exceeded those in the tank by more than ten times.

Below are the size indicators of perch underyearlings before wintering (table 6, figure 2).

Table 6.
*Dimensional indicators of fingerlings of *Siniperca chuatsi**

Indicators	AB, cm	AD, cm	Height, cm	Thickness, cm	Girth, cm	Weight, g
M±m	20.0±0.5	17.4±0.4	6.2±0.2	2.5±0.1	15.0±0.4	142.0±11
min-max	15.6-25.0	13.6-21.5	4.5-8.2	1.7-3.3	11.4-20.6	60 -290
Cv	12.6	12.4	15.0	12.8	15.0	42.0

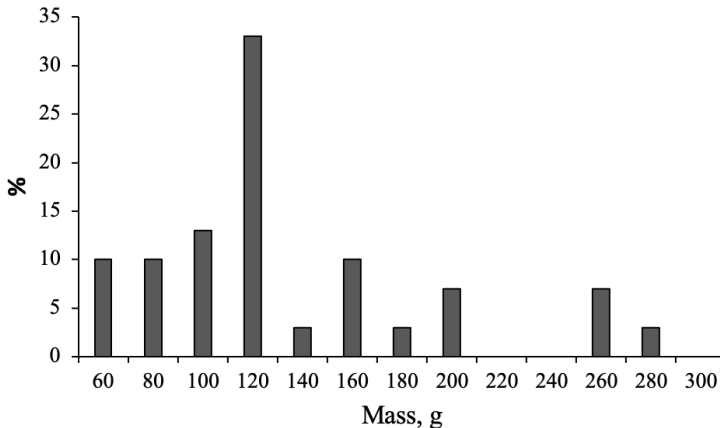


Figure 2. *Distribution of fingerlings of *Siniperca chuatsi* from the cage by body weight (16.10.21)*

Compared to fish caught from ponds, the ratio of size groups has changed. However, the modal groups were still individuals with a body weight of 100-120 g (46%).

The big difference in the size of perches is due to the fact that they were not sorted before planting in the ponds. To prevent cannibalism in the spring of 2022, before the onset of the period of active feeding, perch must be sorted into 2-3 size groups.

Conclusions

- Enhanced feeding of producers of *Siniperca chuatsi* for 1.5 months before spawning reduces the maturation period and improves the production performance of females and males;
- For sustainable maturation of producers during the spawning campaign, you can use the hormone-stimulating drug for carp "Nerestin - 6" of Russian production;
- For the incubation of perch eggs, it is possible to effectively use VNIIPRKH apparatuses with a volume of 120 liters with a flow rate of 7-10 l/min.;
- Under the conditions of warm-water farming, by the combined method, large underyearlings of *Siniperca chuatsi* weighing more than 140 g were grown in 106 days of the experiment.

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植物形态参数对胁迫条件的响应变化
**VARIABILITY OF PLANT MORPHOLOGICAL PARAMETERS IN
RESPONSE TO STRESSFUL CONDITIONS**

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抽象的。城市植物群具有形态和结构特征的显著变异性, 这是在城市不稳定的自然环境中的生存机制。该研究揭示了植物车前草和蒲公英 *Wigg s.l.* 的形态性状变异性增加。在技术污染程度较高的地区, 与污染程度较低的地区相比, 植物器官尺寸较小的表型占主导地位。同时, 在城市原生植物中形成了有活力的种子和幼苗。通过形态特征发展的稳定性来评估生物体的状态可以作为环境质量综合评估的方法之一。

关键词: 变异, 形态特征, 表型, 污染, 环境质量。

Abstract. *The urban flora is characterized by pronounced variability of morphological and structural features, which is a survival mechanism in the unstable natural environment of cities. The study revealed an increase in the variability of morphological traits in plants *Plantago major L.* and *Taraxacum officinale Wigg s.l.* In the areas with a high level of technogenic pollution, phenotypes with smaller sizes of vegetative organs prevailed than in the area with a low level of pollution. At the same time, viable seeds and seedlings were formed in plants of urban cenoses. Assessment of the state of living organisms by the stability of the development of morphometric features can be used as one of the methods for the integral assessment of the quality of the environment.*

Keywords: *variability, morphological trait, phenotype, pollution, environmental quality.*

Any plant individual is characterized by a certain set of features that act as parameters of its morphological status. Some of them have an obvious adaptive value

for the survival and reproduction of the species, while other traits act as adaptive in stressful situations, creating a reserve margin of safety [2, 5].

Urbanization affects the plants of urban ecosystems as a stress factor. The response to the action of increasing stress factors is a change in individual functions and parameters of plants [1, 6, 7]. The urban flora is characterized by pronounced variability of morphostructural features, which is a survival mechanism in the unstable natural environment of cities [3, 4]. One of the promising methods for the integral assessment of the quality of the environment and the vital activity of herbaceous plants is the assessment of the state of living organisms by the stability of the development of morphometric traits [5, 6, 7]. For the purpose of ecological monitoring of the urban environment, it is convenient to use the cenopopulations of the great plantain and dandelion officinalis, as the most common and anthropotolerant species.

Materials and research methods

The material was collected in July 2020. The study areas were ranked according to the degree of traffic load and the level of pollution, as control, medium and high. Control - the park "Gorkinsko-Ometevsky forest", the largest park in Kazan, occupying about 66.5 hectares, was formed naturally. The average level of pollution is in the central part of the city, where the passage of trucks is prohibited, the high level is in the industrial area of Kazan with heavy traffic. In total, 9 areas (100 m²) were laid out, on each of them a cenopopulation (CP) of the studied plant species was identified. In each CP, 20 individuals of the greater plantain (*Plantago major* L.) and common dandelion (*Taraxacum officinale* Wigg s.l.) of the young generative (g1) state were randomly seized. The impact of pollution on plants was assessed by changing the following morphometric parameters: plant height, number of leaves, length and width of the leaf blade, weight of 1000 seeds, inflorescence diameter, peduncle height, spikelet height. The measurements were carried out during the period of mass flowering. Additionally, in August, the seeds of the studied plant species were collected. Seed viability was assessed by laboratory germination and seedling root length [1].

The level of interpopulation and intrapopulation variability of traits was assessed by the value (CV , %). To characterize the vitality of the CP, the coenopopulation vitality index (IVC) was calculated [4, 5]. Comparison of the mean values of the samples was carried out by the method of one-way analysis of variance (ANOVA), the significance of differences was taken at $p < 0.05$. The index of phytocoenotic plasticity (I_p) was calculated as the ratio of the plasticity amplitude (the difference between the maximum average value of the morphological parameter, with the complete exclusion of the factor, and the minimum average value of the parameter) to the coefficient of free development [3].

Research results

Analysis of the quantitative and metric indicators of the vegetative and generative organs of *Plantago major* (tab. 1) and *Taraxacum officinale* (tab. 2) showed that in the CP with a high level of technogenic load, many of these indicators were significantly lower than in the control area. The minimum values of the traits are typical for dandelion and plantain specimens from the area with a high level of pollution.

Table 1.
Morphometric indicators of Plantago major L. depending on the level of pollution

Attribute	Pollution level					
	Control		Medium		High	
	IVC = 1,28		IVC = 0, 99		IVC = 0,97	
	M±m	C _v , %	M±m	C _v , %	M±m	C _v , %
Peduncle height, cm	30.1 ± 9.15	30	19.91 ± 5.57*	28	14.13 ± 5.49*	39
Number of leaves, pcs.	8.6 ± 4.65	54	8.9 ± 5.2	58	6.4 ± 1.65	26
Sheet length, cm	10.39 ± 1.69	16	8.87 ± 3.05*	34	8.85 ± 2.1*	24
Sheet width, cm	7.27 ± 1.24	17	6.51 ± 1.97	30	6.63 ± 1.58	24
Spikelet length, cm	16.04 ± 4.66	29	8.43 ± 2.91*	34	5.4 ± 1.88*	35
Weight of 1000 seeds, mg	65.3 ± 15.5	—	57.9 ± 8.6	—	49 ± 8.5	—

* Differences are statistically significant compared to control, at $p < 0.05$

An assessment of the variability of morphological parameters at the interpopulation level showed a high level of variability ($CV > 30\%$) for individual parameters. Thus, in *Plantago major*, in a plot with a high level of pollution, such parameters as the height of the peduncle and the length of the spikelet were characterized by high variability, in the plot with an average level of pollution, the number of leaves, the length of the leaf and spikelet, and in the plot without pollution, the number of leaves in the rosette. In *T. officinale*, all traits (except for the diameter of

the basket) were characterized by a high level of variability, especially under conditions of high technogenic load. It was revealed (tab. 1 and 2) that the vital state of cenopopulations, estimated by us according to the vitality index (*IVC*), in the CP of contaminated sites was on average 1.3 times lower than in the control CP.

Table 2.
Morphometric parameters of Taraxacum officinale depending on the level of contamination

Attribute	Pollution level					
	Control		Medium		High	
	<i>IVC</i> = 1,22		<i>IVC</i> = 1,01		<i>IVC</i> = 0,91	
	M±m	C _v , %	M±m	C _v , %	M±m	C _v , %
Peduncle height, cm	20.51 ± 1.3	36	17.74 ± 1**	32	11.66 ± 1.08*	49
Number of leaves, pcs.	8.63 ± 0.52	34	7.09 ± 0.35*	28	7.23 ± 0.61*	47
Sheet length, cm	15.34 ± 0.96	35	15.06 ± 0.69**	26	11.62 ± 0.88*	40
Sheet width, cm	3.57 ± 0.33	53	2.68 ± 0.14	29	2.65 ± 0.17*	36
Inflorescence diameter, cm	3.61 ± 0.07	11	2.68 ± 0.08*	17	2.62 ± 0.11*	23
Weight of 1000 seeds, mg	451 ± 12.5	—	312 ± 8.2	—	501 ± 5.5	—

* Differences are statistically significant compared to control,

** - significant compared to high levels of pollution, at $p < 0.05$

To assess the plasticity of the parameters, we used the phytocoenotic plasticity index (I_p), that is, the ratio of the amplitude of the trait values to the maximum trait value.

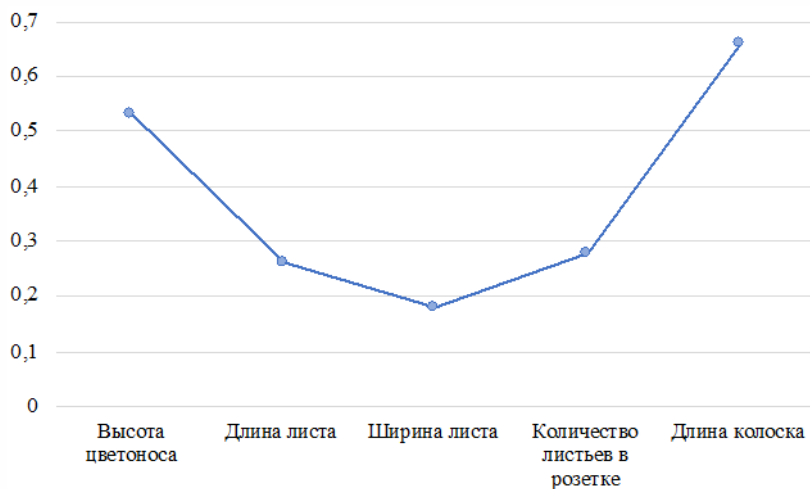


Figure 1. Profile of phytocoenotic plasticity of morphometric parameters of *Plantago major* (ordinate - plasticity index (I_p), abscissa - morphometric parameters)

From the analysis of phytocoenotic plasticity indices, it can be seen that in *P. major* (fig. 1) the most responsive to changes in habitat conditions are such traits as peduncle height ($I_p = 0.54$) and spikelet length ($I_p = 0.66$), and in *T. officinale* (fig. 2) - for the studied parameters, the values differed little ($I_p = 0.45-0.40$). The least plastic were the leaf width of the plantain ($I_p = 0.18$) and the basket diameter ($I_p = 0.34$) of the dandelion.

Plasticity usually manifests itself in reversible changes in the structures and functions of the body under the influence of new environmental conditions and ensures the preservation of the viability of individuals and their adaptation to adverse environmental factors [4, 5]. Thus, habitat conditions significantly affect both quantitative and linear morphological characteristics of plants of the studied species.

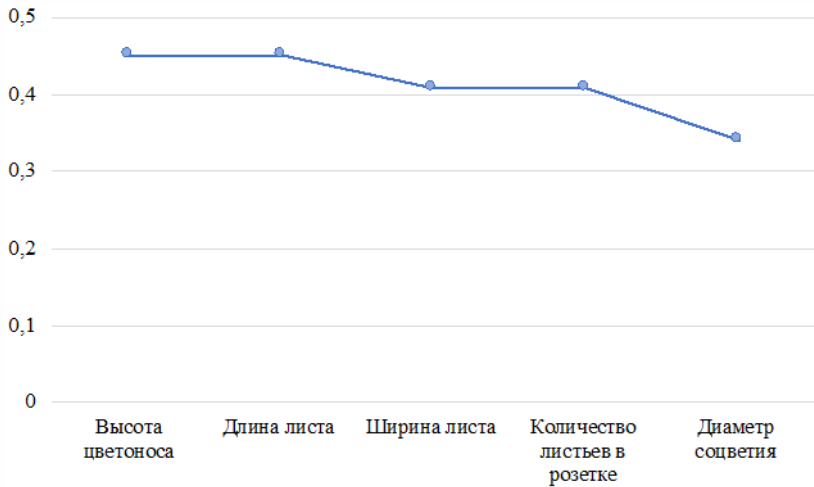


Figure 2. Profile of phytocenotic plasticity of morphometric parameters of *Taraxacum officinale* (along the y-axis - plasticity index (I_p), along the abscissa - morphometric parameters)

One of the leading factors that ensure the successful growth of plants in urban environments is the ability to produce viable seeds [1, 6]. The study showed (tbl. 1, 2) that at medium and high pollution levels in *P. major*, the weight of 1000 seeds decreased by 11 and 25%. For *T. officinale*, on the contrary, at a high level of pollution, an increase in this parameter by 10% was noted compared with the control. At the same time, in CP plants with a high level of technogenic load, the indicators of germination energy and germination in *P. major* decreased (by 40 and 28%, respectively), while in *T. officinale* they remained practically unchanged relative to the indicators of the control plot.

In terms of root length (cm) of seedlings in *P. major*, the parameters of the control area (1.16 ± 0.29) were higher than in the variants with contamination (1.04 ± 0.24), at $p < 0.05$; in *T. officinale*, the root length (cm) in the seedlings of the control plot (0.97 ± 0.35), with medium (1.12 ± 0.55) and high levels of contamination (0.89 ± 0.37) did not differ significantly. Thus, according to the sum of indicators (germination energy, germination and root length), the seeds of *Taraxacum officinale* were more viable than the seeds of *Plantago major*.

Conclusions

1. In the conditions of Kazan, in areas with a high level of technogenic pollution, we noted an increase in the variability of morphological traits in *P. major* and *T. officinale* plants and the predominance of phenotypes with smaller sizes of vegetative organs than in the control area.
2. In *Taraxacum officinale*, a relationship was found between the studied plant parameters and pollution levels (high values of the phytocoenotic plasticity index (I_p) for all studied parameters), which allows us to recommend it as a bioindicator of pollution.

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DOI 10.34660/INF.2022.39.81.003

以芥菜 (*Eruca sativa*) 鱼菜共生栽培为例，工业化生产条件下单株小青菜的栽培
**CULTIVATION OF MICROGREENS MONOCULTURE UNDER
INDUSTRIAL PRODUCTION CONDITIONS ON THE EXAMPLE OF
CULTIVATION IN AQUAPONICS OF RUCCOLA (*ERUCA SATIVA*)**

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抽象的。本文考虑了改进在封闭供水循环系统中使用的各种基质上种植芝麻菜微型蔬菜单一栽培技术的可能性。

关键词：微型蔬菜、鱼菜共生、芝麻菜、水化学指标、非生物因素、食品、沸石、栽培、活性过滤器、纺织品。

Abstract. *The paper considers the possibility of improving the technology of growing a monoculture of arugula microgreens on various substrates used in the system of a closed water supply cycle.*

Keywords: *microgreens, aquaponics, arugula, hydrochemical indicators, abiotic factors, food products, zeolite, cultivation, active filter, textiles.*

As you know, at present, there is an active fight against "harmful" foods and the transition to a healthy diet. At the same time, the development of "green" technologies for obtaining environmentally friendly food is an integral part of the process of its production. One of the main areas of proper nutrition is a balanced diet containing a full range of useful elements (for example, essential amino acids) and vitamins. All these requirements are met by a product that is gaining popularity - microgreens.

It should be noted that today Russia is a major supplier of food products to the international market. Taking into account the current environmental and economic situation, the role of microgreens in the world market is defined as promising.

Purpose of the work consisted in improving the technology of growing monoculture of microgreens in the conditions of industrial aquaponic production on the example of cultivating representatives of the genus *Indau* (*Eruca sativa*).

Tasks:

1. Evaluation and improvement of the existing methodology for the cultivation of microgreens, in relation to the conditions of aquaponics;
2. Evaluation of the role of abiotic factors on the growth and development of microgreen monoculture;
3. Analysis of the results of the implementation of the methodology for growing microgreens in aquaponics.

The work has been carried out in the laboratory of the Astrakhan Ecological and Biological Center from January 2020 to the present. Arugula microgreens were grown on two different substrates: a natural mineral sorbent, zeolite, under the conditions of a closed water supply system for aquaponics, which acts as an active filter, and natural textiles placed in a plastic tray in the upper aquaponics tank (figure 1).

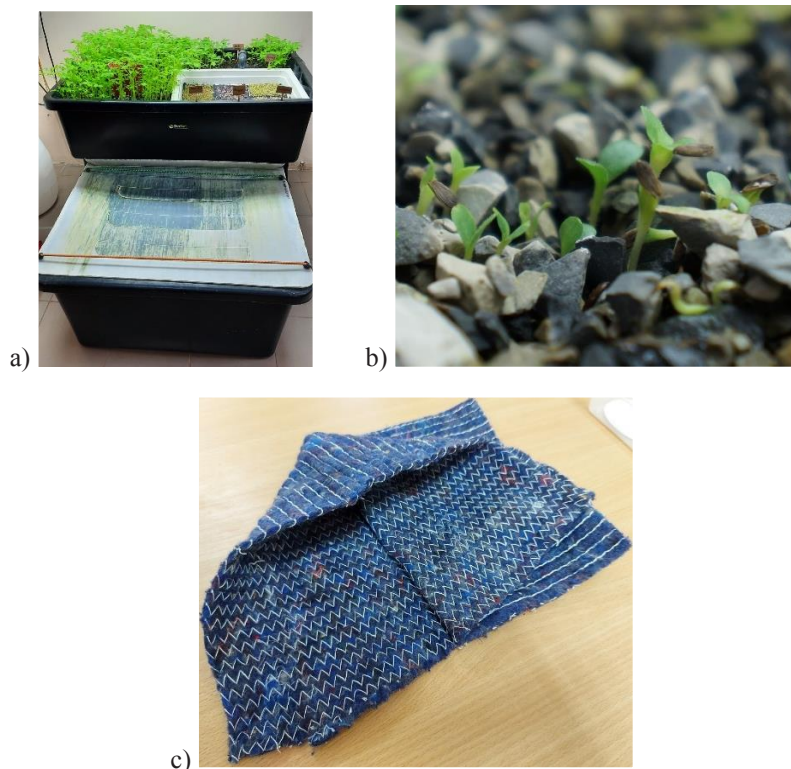


Figure 1. Substrates used for cultivation of microgreens: a) aquaponics system; b) arugula grown in the active filter of the aquaponics system; c) textiles

The hydrochemical parameters of the medium in the system were regularly monitored. PH, temperature, oxygen, nitrates and nitrites were monitored daily, phosphates, calcium, iron, etc. every ten days. Used additional phytolight during the day.

Watering was carried out due to the cyclic operation of the aquaponic system (filling-draining), and the plants cultivated both in the installation and in the tray installed in the active filter system were also sprayed twice a day.

Research methods are instrumental - a portable electronic laboratory SenseDisk with a set of sensors for carrying out complex environmental studies was used, and laboratory - a field research laboratory for determining the quality of the aquatic environment manufactured by JBL.

Microgreens - is the phase of a young plant that has a developed hypocotyl with unfolded cotyledons. In 1920, Professor Edmond Zekely put forward the concept of biogenetic nutrition. The title of the most useful product in it was received by seed sprouts. It is known that in the process of germination, seed minerals are converted into a chelated form, which is easily absorbed by the human body. The seeds contain a high concentration of nutrients, including antioxidants, bioflavonoids, proteins, potassium, iron, omega-3, and more.

Rucola (*Eruca sativa*) is a plant of the genus *Eruca*, *Brassicaceae* family. The spicy plant is rich in biologically active substances: it contains flavonoids, carotenoids, vitamins C, P, K and group B, it contains zinc, selenium, manganese, iron, phosphorus and sodium. Already in Antiquity, it was believed that greens help improve digestion and have an antitussive effect. Modern experts say that arugula is able, for example, to reduce the appearance of cholesterol plaques on the walls of blood vessels, it is good for diets because of the low calorie content, 100 grams of the product contains only 25 kcal.

The FishPlant aquaponics system (Shpagina E.V., Bolonin A.K., 2020) is an industrial installation of a closed water supply cycle and implements the synthesis of the production of fish products and food plants on an industrial scale.

Structurally, aquaponics (Egorov S.N., Shpagina E.V. et al., 2020) consists of two modules - the upper one (volume 250 liters), filled with an active zeolite filter (in the version modernized by us), and the lower one (volume 500 liters), which contained a monoculture of African catfish, a mechanical coarse filter built into the fountain pump, a supply pipeline with shut-off (dosing) valves, an active filter module, a siphon block, thermostatic and aeration equipment and a lighting module.

For the cultivation of arugula on textiles, a plastic tray was used, which had an irrigation hole in the center of the bottom, closed on top with a lid with slots for the inflow and outflow of process water. The bottom of the pallet is provided with perforations for uniform wetting of the substratum.

Zeolites are aqueous aluminosilicates of calcium, sodium, potassium, barium and some other elements, which are of natural volcanic origin. The natural mineral sorbent zeolite is relevant today in closed water supply systems (Shpagina E.V., Bolonin A.K., 2019) from the standpoint of water purification (Shpagina E.V., Bolonin A.K., 2019) from pollution and organic suspensions, hydrobionts formed in the process of vital activity (Shpagina E.V., Bolonin A.K., 2019). The sorbent has a microscopic porous structure, which makes it possible to adsorb pollutants of various nature in process water.

Analyzing the materials of scientific research and the positive experience of our practical use of the specified sorbent (Shpagina E.V., Egorov S.N., 2021), we can say with confidence that zeolite is able to play an important role in various water treatment systems, including as an effective substrate-forming element for growing various crops. In addition, given the local nature of the feedstock (Egorov S.N., Shpagina E.V. et al., 2020) and the proximity of the deposit to the technological production capacities of its processing, favorable economic conditions are created for the implementation of import substitution processes and the creation of new jobs in the region (Egorov S.N., Shpagina E.V. et al., 2020).

The main positive properties of textile materials are hygroscopicity, breathability, heat-shielding properties. The material used by us has a fibrous structure that does not prevent the flow of water and air to the roots, and is chemically inert.

The main factors of growth and development of plants are heat, light, air, water, nutrition. All these factors are equally necessary and perform important functions in plant life. The cycles of growth and development of cultivated flora are divided into certain stages of the phase. It has been established that the effect of low temperature on germinating seeds and heating of dry seeds can accelerate the development of plants and increase yield (Kosakovskaya I.V., 2008).

One of the most important factors influencing the rate of seed germination is temperature, which affects both productivity and seed quality during maturation. The biochemistry of the reaction of seeds to heat stress includes numerous processes that are difficult to regulate.

The content of oxygen dissolved in the water of a closed water supply system depends on the carrier temperature. The more intense the growth of plants, the more they absorb the oxygen dissolved in water by the roots.

In order for an artificially created system to be more suitable for the natural environment, you need to monitor the pH, KH, GH values. In fishery reservoirs (aquaponic system), the value of carbonate hardness should be 3-10 dH, and pH 6.5-8.8.

The acidity of the environment is an extremely important characteristic of solutions, since it not only affects the functioning of the root system, but also the availability of other ions for plants. For example, at pH <5.0, the absorption

of cations by plants is difficult, at $\text{pH} > 6.5-7.0$, insoluble compounds of calcium, manganese, iron, phosphates are formed in the solution (SanPiN 2.1.5.980-00. 2.1.5..., 2014).

As is known, the concentration characteristics of such nutrients as phosphorus and nitrogen in aquatic ecosystems are the most important indicators characterizing the course of production processes. Considering the quantitative data concerning the content of mineral and organic forms of phosphorus in water under RAS operating conditions, one should not forget that in a closed system the outflow of nutrients is extremely difficult due to their limited removal by the final biomass of consumers.

At the same time, high concentrations of nitrogen and phosphorus can be very toxic for representatives of aquatic biota, especially for the organic component. It is extremely important to maintain a sufficiently high concentration of mineral forms, since they are more intensively consumed by primary producers, against the background of a general stable balance.

Nitrites are formed during the oxidation of nitrogen-containing organic substances. With elevated nitrite levels, low levels of dissolved oxygen are usually noted. Technological standards allow the content of nitrites in closed systems at the level of 0.2 mg/l, and the permissible limit is 0.3 mg/l. Nitrates are much less toxic than nitrites. In fishery installations, the content of nitrates up to 3 mg/l is permissible, at a rate of up to 2 mg/l.

Depending on the pH, phosphorus compounds are present in water as HPO_4^{2-} or as PO_4^{3-} . Phosphates are of low toxicity, in aquaculture the norm of phosphates is from 0.2 to 0.5 mg/l, the permissible limit is 2 mg/l.

Iron in water is most often found in the form of Fe^{2+} and Fe^{3+} ions, as well as in the form of organic and inorganic compounds (colloids, suspensions). Plants need iron, for more efficient absorption, only in the chelated form (Hansen H., Grossmann K., 2000). The concentration of trace elements in the process water of an aquaponic installation is of equal importance for both plants and fish (Kovalsky V.V. et al., 1971).

Illumination duration, wavelength and intensity, as well as the distance of the light source to the crop are factors that determine the growth rate and the quality of the finished product. Leaf color may appear washed out when the light intensity is insufficient (Hansen H., Grossmann K., 2000).

In the experiment, the indau monoculture was cultivated under the conditions of a closed-loop aquaponics water supply system using a natural mineral sorbent zeolite and textiles as a substrate. The production cycle of one crop was 5-7 days.

The requirements for the thermal regime in the experiments were determined by biotechnical standards and were quite strict, since the catfish cultivated in the lower module of the system is a thermophilic organism.

Optimal conditions for plant growth were created: additional lighting was installed, the ambient temperature averaged 25 °C, pH 6.5-8.0, water was continuously circulated and aerated in the system.

The optimal values were maintained by the thermostating unit of the aquaponic installation and were in the range of 23-27 °C. This temperature was also favorable for most representatives of the microflora and higher vegetation.

The Table shows a fragment of the results of hydrochemical studies from January to April 2021

Table.

Fragment of monitoring data of hydrochemical indicators in the aquaponics system

Month	R min%	R org %	NO ₂ %	NO ₃ %	NH ₄ %	N min%	N org %	IV mg/l	OV mg/l	PO mg/l	BO mg/l	% PO BO	BO from OV	O ₂ mg/l	O ₂ %
1	50	50	9	75	17	18	82	24	21	8	28	31	28	8	89
2	39	61	2	82	16	21	79	22	25	10	34	30	34	8	93
3	49	51	4	76	20	26	74	14	29	8	39	20	39	13	126
4	52	48	2	78	20	21	79	14	21	7	28	25	28	13	100

It should be noted that the presented indicators made it possible to achieve a high intensity of growth of all parts of plants in a shorter production time.

Some time after sowing, the seeds swelled and mucus. The next day, sprouts of about 1 cm were observed, and after 5 days the greens reached 8 cm in length and were ready to be harvested. From an area of 0.07 m², 150 grams of plant products were collected. The green mass was cut 1.5-2 cm above the root system in order to avoid contamination of the finished product.

A high growth of arugula microgreens was recorded throughout the experiment, both on zeolite as a natural substrate, and on pallets with textiles. At the same time, it is preferable to cultivate microgreens in trays (figure 2), in order to eliminate the germination of the root system in the zeolite.

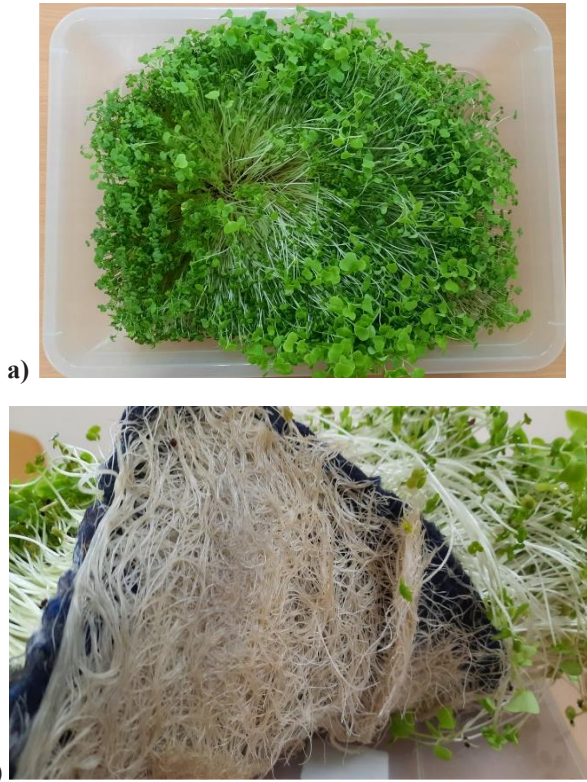


Figure 2. *Arugula* microgreens: a) finished products; b) root system

Thus, microgreens are a new class of specialized crop, defined as tender unripe greens obtained from seeds of vegetables, herbs or cereals, including wild species (Butenko R.G., 2018). To obtain high-quality products in aquaponics, it is necessary to monitor hydrochemical parameters.

The implementation of the work allowed to:

1. Improve the method of cultivation of arugula microgreens using an industrial aquaponics plant using zeolite as a substrate and easily accessible textiles, which turned out to be more preferable;
2. Obtain data indicating that the stability of hydrochemical parameters has a significant impact on the growth of microgreens in industrial conditions. During the experiment, all indicators were within the normal range;
3. produce environmentally friendly plant food products in a short growing period at minimal cost.

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最小作用原理和不变量

THE PRINCIPLE OF LEAST ACTION AND INVARIANTS

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抽象的。在足够长时间的摩擦载荷后，对硬化和磨损过程进行了全面研究，以跟踪晶格的结构转变直到临界点，并将结果与磨损强度联系起来。给出了在各种外界影响下，从时空对称性中寻找纳米材料在产生、演化和破坏过程中的不变量的实例，具有科学和现实意义。

关键词：结构；磨损强度；毛孔；铁磁共振；电子显微镜研究；摩擦载荷，不变量。

Abstract. *A comprehensive study of the hardening and wearing processes has been performed after sufficiently long periods of friction loading to track the structural transformations of the crystalline lattice up until the critical point and to relate the results to the intensity of wear. The substantiation of the search for invariants in the creation, evolution and destruction of nanomaterials from the symmetry properties of space and time under various external influences is given, which has scientific and practical significance.*

Keywords: *structures; wear intensity; pores; ferromagnetic resonance; electron-microscopic researches; friction loading, invariants.*

Introduction

The complexity of research in creating materials with new physicochemical properties is determined by the lack of scientifically sound fundamental principles that can be applied at the junction of various sciences (physics, mathematics, chemistry, mechanics, materials science, etc). The current state of the problem of creation, evolution and destruction of materials is characterized as a transitional period between the accumulation of experimental data and their interpretation in the categories of mechanics, physics, chemistry and the development of basic structural patterns [1].

Experimental Details

Polycrystalline nickel of 99.99% purity, armco-iron, bearing steel, bronze, and cast iron were investigated. The nickel samples in the form of thin disks were polished electrolytically and annealed in a vacuum of 0.133 mPa at 973 K. The friction test of Ni – Mo pair was carried out on the machine AE-5 according to the finger-disk scheme with precise setting of the contact area at a specific load of ≈ 84 kPa and linear speed of ≈ 0.5 m/s. Electron microscopic studies of nickel were carried out on a microscope EVM-100AK and Hitachi-H800 by the method of thin foils on "lumen". The resolution of the Hitachi-H-800 is ≈ 0.1 nm. The technique of preparation of nickel samples for transmission electron microscopy is given in work [2]. The dislocation structure in the nickel-molibdenum pair under friction loading was studied using the ferromagnetic resonance method (FMR) and electronic microscopy. FMR methods appear to be the most appropriate for the study of the dislocation structure in ferromagnetics. At external electromagnetic field frequencies of 9600 MHz ($\nu = 9600$ MHz), the broadening of the FMR absorption lines in a deformed ferromagnetic is caused by elastic stress fields, while small-scale defects (such as impurity atoms or vacancies) and large-scale defects (e.g. cracks or pores) lie outside the absorption spectrum [2]. In the above works, a linear relationship was established between the breadth of the FMR line (ΔH) and dislocation density (ρ). Another advantage of the method is that the depth of penetration in the skin metal layer (δ) is $10^{-7} - 10^{-6}$ m at external electromagnetic field density of 9600 MHz. This makes the method sufficiently selective and sensitive when used for the study of defect microstructures in thin surface layers, particularly under friction loading, when the depth of the surface layers affected by plastic deformation is comparable to the thickness of the skin layer [2]. Samples of bearing steel, bronze, cast iron were investigated by the roller-particle liner scheme, etc. on the SMT friction machine and other facilities [3].

Results and Discussion

Submicrocrystalline (SMC) and nanocrystalline structural states (NC) are formed in zones with strongly disoriented crystal areas, arising from the convergence of powerful dissimilar clusters of dislocations (dipoles) built during their polygonization into walls. The latter determines the stress state of the metals with the formation of a high gradient of misorientation between the formed structural elements, where the sliding band blocked by the grain boundary can be simplistically represented as a curved segment of fixed length L (Fig. 1, a).

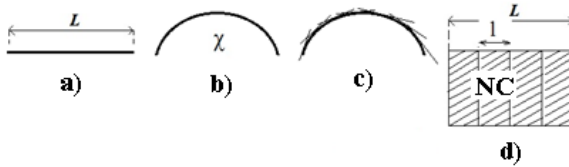


Figure 1. Scheme of formation of SMC and NC states: a) initial structure in the form of a segment; b) evolution of the structure in the form of a segment bending under the action of external influences; c) beginning of formation of SMC- and NC- states; d) formed SMC- and NC- states

The more curved the segment, the greater the local gradient of orientation of the structural elements in the crystal lattice or the curvature of the crystal lattice of the metal and, accordingly, the amount of stored energy in it (Fig. 1, b). Since the middle of the segment bends more and its ends bend less, the components of the curvature gradient will be different from zero. It is natural to assume that the structure of the crystal represented by the segment will tend to a state with minimal free energy, which is possible by its relaxation in accordance with energy profitability or the principle of least action (Fig. 2, where H is enthalpy) [4, 5].

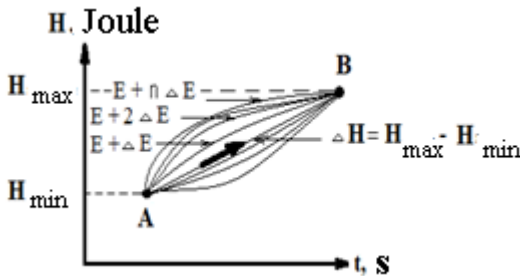


Figure 2. Kinetics of system transition from one structural state (A) to another (B) according to the principle of least action (Hamilton's principle)

Energy relaxation is carried out by shifting and rotating the corresponding segments [2], which make up the segment (Fig. 1, c), that is, it is energetically advantageous for the material to break into segments (straight sections) with zero or minimal possible (tending to zero) local curvature. The kinetics of the realization mechanism proceeds in accordance with the principle of least action with the simultaneous triggering of all possible channels of energy relaxation: absorption or release of heat depending on the energy advantage, changing the direction of point defects flows in a high gradient of elastic fields, which determines the energy

flow change through the local space zone and, respectively, the launch of phase transformations and chemical reactions. The complexity of material research under external influences is determined by the simultaneous course of several processes (heat conduction, diffusion, mass transfer, hardening, amorphization, fracture, etc.) and the correct choice of scale factor (load-rate parameters, etc.) of external influence, which allows to establish the course of the dominant process in their variety and, consequently, to reveal and establish the basic fundamental laws describing this process [1, 2]. The latter is confirmed experimentally by the existence of NC states characterized by a high dislocation density $\rho \approx 10^{18} \text{ m}^{-2}$ due to the boundaries of the block structure and the dislocation density $\rho \approx 10^{12} \text{ m}^{-2}$ inside the block, characteristic of annealed unstrained nickel [6, 7]. Inside the NC block of states, the dislocation density is very low and is similar to the cellular structure shown in Fig. 1, c. The segments or blocks that make up the segment are mutually disoriented, which is described by the local curvature or the ratio of the angle of disorientation between the segments to the distance between them. One of the main mechanisms of crystal structure fragmentation is the formation of inter-nodal bifurcation states [8]. A nanocrystalline material consists of a number of structures that are formed by intense plastic deformation in regions of high crystal lattice curvature in a certain volume, and the formation of one NC structure leads to a decrease in the local curvature of the crystal lattice directly in the local zone of formation. Relaxation of the stored free energy of plastic deformation in local zones will form a set of disoriented local zones, the union of which forms the volume of the nanomaterial.

The kinetics of metal wear intensity under tribo-loading was studied in connection with microstructural changes in the nickel surface layer [8]. The solution of this problem was carried out comprehensively using radiospectroscopic methods (FMR, EPR), transmission electron microscopy, electronography and optical method. As a result of the analysis of experimental data [2], it was found that the main microstructural elements of the dispersed surface layer are: 1) zones with high dislocation density, with loading time acquiring the form of thin bundles oriented along the slip direction; 2) slip bands and numerous thin twins on their boundaries, which are sources of small cracks nucleation; 3) numerous micropores inside and on grain boundaries; their coagulation leads to formation of foci of transcrystalline and intercrystalline fracture (Fig. 3). The porosity reaches $\approx 15\%$ of the entire observation area at triboloading time $t = 106 \cdot 10^3 \text{ s}$.

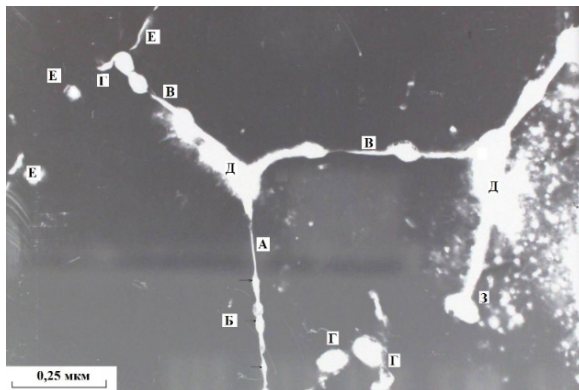


Figure 3. Inter- and transcrystalline fracture

Prolonged frictional loading leads to a progressive loosening of the surface layer associated with an increase in the number of fracture zones [9, 10]. According to literature data, nonequilibrium vacancies on the lattice nodes of nickel under conditions of plastic distortion form by the mechanism of coalescence microporosity, which is the precursor of plastic shifts of meso- and macroscale that determine the formation of wear particles [11, 12]. It was found that cyclically repeated outbursts of wear intensity coincide in time with areas of minimum dislocation density [2].

In a strongly deformed by rolling crystal lattice ($\varepsilon = 50\%$), high porosity develops, reaching $\approx 25\%$ of the material area observed on PEM images, and high concentration of microcracks and other violations of material continuity [2, 13]. The structure of the surface layer of nickel, formed at pre-rolling $\varepsilon \approx 50\%$, and the structure formed as a result of triboloading at time more than $10^9 \cdot 10^3$ s, have similar properties, namely: high fragmentation of the crystal lattice, its friability, special non-equilibrium state with loss of strength properties [13]. Intergranular sliding causes metal porosity and increases the wear rate by three orders of magnitude from 10^{-7} kg/m to 10^{-4} kg/m [10]. The degree of porosity during prolonged triboloading reaches $\approx 30\%$ of the entire observation area.

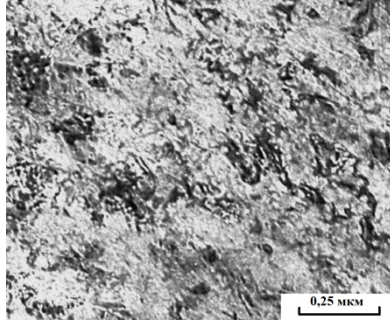


Figure 4. Dispersion and loosening of the surface layer ($t = 150 \cdot 10^3 s$)

Thus, with the time of frictional loading, the surface layer of the metal loosens and its porosity increases due to the increasing number of fracture zones [14]. The latter determines the amorphous properties of the material and increases the intensity of wear. At the stage of maximum plastic deformation, this loosening covers the deep layers and, in combination with developed brittleness, causes a stronger crushing of wear particles and a sharp increase in the flaking mass of the material [9, 10].

Based on the principles of energy profitability and least action, we propose a model for the formation and evolution of SMC and NC states of a nanocrystalline material, where multiscaling of the crystal lattice curvature plays the main role for the formation and evolution of all scale levels of deformation: nano-, submicro-, micro-, meso- and macro. It has been proved that the application of these principles determines not only the kinetics of evolution, but also the search and establishment of fundamental, invariant regularities in materials science, tribology, condensed state physics and other fields in which processes occur in the space-time continuum [1].

Conclusion

The main laws of formation and kinetics of deformation defects at the nano, micro, meso, and macroscale levels of plastic deformation of the nickel surface layer were revealed, which determines the main deformation mechanisms in hardening and fracture of metal surfaces under external influences (rolling, triboloading, etc.), namely:

– the invariant associated with the asymmetric kinetic dependence between dislocation density and fracture or wear intensity can be related to the time homogeneity property and the related energy conservation law, namely, an increase in the dislocation density to a certain critical value causes hardening of the surface layer, which in turn determines a decrease in the fracture intensity and vice versa [1]:

$$\rho \cdot I = const, \quad (1)$$

where ρ is dislocation density, I is wear intensity, $const \geq 0$;

– the invariant associated with the rate of increase and decrease of dislocation density under triboloading can be correlated with the homogeneity property of space and the momentum conservation law associated with it. The rate of increase and decrease of dislocation density is determined by the size of the preformed during hardening, rolling, triboloading structure and the misorientation of the internal interfaces. The rate of increase in dislocation density (K_1) during hardening of the nickel surface layer determines both the rate of decrease in dislocation density (K_2) and strain stress relaxation, respectively, for one, and each cycle of change in strength properties, which determines the major role of the size of structural elements on the rate of change in strength properties at each of the structural-scale strain levels [5]:

$$\frac{K_1}{K_2} = const. \quad (2)$$

where $K = \Delta H/\Delta t$, ΔH is the ferromagnetic resonance line broadening, $0 \leq const \leq 1$;

– isotropy of space and the associated law of momentum conservation can be correlated with the invariant associated with the mechanisms of deformation and destruction of the tribosystem surface or material at all mesoscopic structural and scale levels in accordance with the scale invariance. A possible implementation mechanism would be through inter-granular shear, relative rotation and slippage. According to the law of momentum conservation, the macro rotation should be compensated by the sum of all rotations in the hierarchy of mesoscale levels. This law is defined by the expression [15]:

$$\sum_{i=1}^N rot I_i = 0, \quad (3)$$

where I_i is the fluxes of defects at the i -th mesoscopic level. The formation of defect fluxes I_i is a kinetic process that requires periodic crack stopping to bring the material state before the crack apex to the critical level of nanostructural states.

Are there still other invariants? The laws of physics do not forbid this, even if they cannot be related to the properties of space and time due to our current understanding of physical processes. Here is another example of this invariant.

– analysis of experimental data on evaluation of wear (I -volumetric wear intensity, $[I] = m^2$) of nickel samples, subjected to preliminary deformation by rolling and prolonged tribon loading) and comparison of data on evaluation of pore area (S -pore area, $[S] = m^2$) of the same samples by transmission electron microscopy shows that there is a directly proportional relationship between these parameters, that is, the expression is executed:

$$\frac{I}{S} = \text{const}, \quad (4)$$

where $\text{const} \geq 0$. Determination of const values depending on the tribo-loading and wear regime requires further elaboration.

Thus, the kinetics of formation, evolution and destruction of the boundaries of structural elements under the action of external influences (rolling, tribo-loading, etc.) proceeds in the space-time continuum in accordance with the energy benefit or in a broader sense in accordance with the principle of least action, which determines the search and establishment of invariants, including the creation and evolution of nanomaterials [16].

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改进的用于评估糖质量的感官方法
**IMPROVED SENSORY METHOD FOR ASSESSING THE QUALITY
OF SUGARS**

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抽象的。开发用于评估食品质量的感官分析仪器方法的相关性得到了证实。提出了使用“电子鼻”装置进行感官分析的方法。该设备是一组选择性传感器，它们对作为产品一部分或在生产和储存过程中被它们吸附的挥发性成分敏感。传感器的选择取决于所研究的产品类型。传感器记录的气味印记与信息设备数据库中可用的标准气味样本进行比较。设备软件允许您对结果进行定性和定量分析，并以视觉打印或表格值的形式呈现它们。该方法的认可是对“额外”类别的白糖、黄色初始和精制和精制黄糖以及添加玫瑰果的样品进行的。获得的结果与产品的感官特征及其化学成分密切相关，通过其他方法确定。

关键词：感官分析，低选择性传感器，糖产品。

Abstract. *The relevance of the development of instrumental methods of sensory analysis for assessing the quality of food products is substantiated. The methodology of sensory analysis using the device "Electronic nose" is proposed. The device is a set of selective sensors that are sensitive to volatile components that are part of the products or adsorbed by them during production and storage. The selection of sensors is determined by the type of product under study. The scent imprint recorded by the sensors is compared with samples of standard scents available in the database of the information device. The device software allows you to conduct a qualitative and quantitative analysis of the results and present them in the form of visual prints or tabular values. Approbation of the method was carried out on samples of white sugar of the "Extra" category, yellow initial and refined and refined yellow sugar with the addition of rose hips. The results obtained correlate well with the organoleptic characteristics of the products and their chemical composition, established by other methods.*

Keywords: *sensory analysis, low selectivity sensors, sugar products.*

Introduction

Sensory analysis is used in many areas of everyday life. It is used to evaluate food or other products, as well as to evaluate the properties of smells present in the environment [1]. In the food industry, sensory analysis is a tool for making marketing decisions regarding product positioning relative to competitors, customer relationship management, advertising strategies and pricing policy [2]. At the same time, the product remains the starting point of any marketing decision.

In the context of food, sensory evaluation is one of the marketing management tools that has been gaining more and more recognition in recent years. For this reason, the systematic use of sensory benchmarking, sensory profile evaluation and analysis of competitive advantages in terms of sensory characteristics have been proposed.

Currently, sensory analysis is considered as an interdisciplinary science, built on scientific principles related to various fields of knowledge, such as food science, psychology, physiology, statistics, sociology, knowledge of product preparation methods. The purpose of sensory analysis is to obtain objective information about the perception of the product through the human senses: visual, olfactory, gustatory and tactile [3].

Organoleptic analysis plays an important role in various stages of food development. Sensory food science and taste analysis are key processes in the development of new products and are essential for consumer acceptance.

The commercial success of a food product in the consumer market implies not only that it has organoleptic characteristics, but also safety characteristics in use. When developing food control and quality assurance programs, it is necessary to apply objective analytical methods that are effective in detecting certain chemical compounds which can be the cause of unpleasant aftertastes with a low threshold for detecting taste and smell sensations.

Sensory analysis of food products is a process of collecting information and methods of processing it [4]. However, an organoleptic analysis based on taste and smell sensations in relation to a given product is quite subjective and largely depends on the individual characteristics of the taster. The development of instrumental methods of sensory assessment ensures the objectivity of research and allows you to provide more complete information about the composition, properties and safety indicators of the product.

One of the directions is the use of an array of potentiometric sensors that monitor changes, tested on probiotic fermented milk during storage [5]. For this, a potentiometric electronic module was used, consisting of seven sensors and a reference electrode. Smell plays a special role in shaping consumer preferences and organoleptic properties of the product. The evaluation was complemented by analytical measurements aimed at isolating and determining the concentration of

volatile components in the test product sample, which provides an understanding of the influence of individual components on the overall smell intensity and the final perception of the product [6].

Materials and methods

The objects of study were «Extra» category white sugar, initial and refined B-sugar and refined B-sugar with addition of rose hips [7].

The studies were carried out using the device «Electronic Nose», which is an alternative to gas chromatographs and contains a set of sensors that, in the course of studies, react to volatile components in the composition of the equilibrium gas phase over samples. The smell imprint recorded by the sensors is compared with samples of standard smells available in the system [8].

The «Electronic Nose» device consists of a sampling system, semiconductor sensors, an adapter-converter of the sensor signal into a digital code and micro-processor equipment (Figure 1).

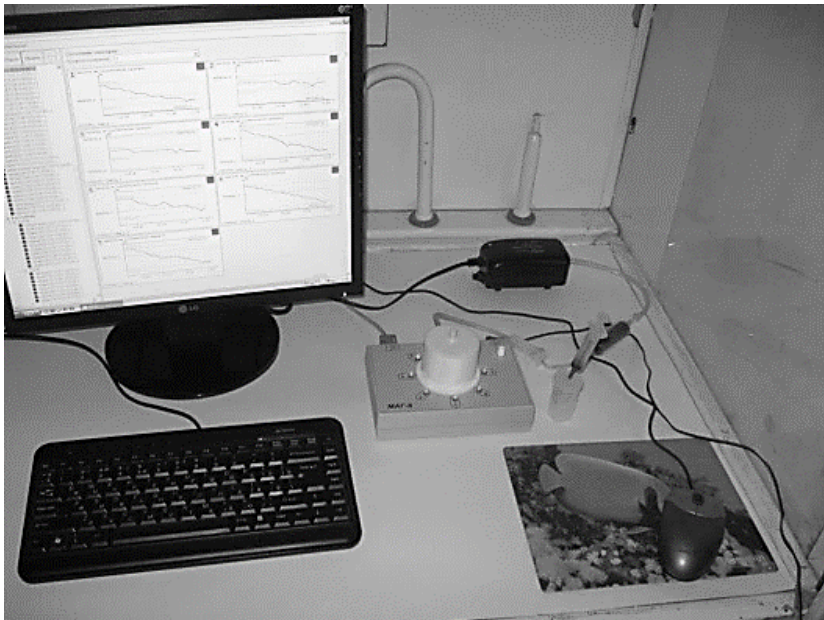


Figure 1. Workplace of a researcher with the device «Electronic Nose»

For measurements, 8 sensors with diverse film sorbents on electrodes based on opto-acoustic piezoquartz resonators with a base oscillation frequency of 10.0 MHz were used. Sensor coatings were selected depending on the object of study.

For the analysis of sugary products, we used: 1 – polyvinylpyrrolidone (PVP), 2 – bee glue (BG), 3 – dicyclohexyl-18-crown-6 (DCG18C6), 4 – bromocresol green (BCG), 5 – polyethylene glycol succinate (PEGS), 6 – polyethyleneglycol (PEG-2000), 7 – Tween-40, 8 – trioctylphosphine oxide (TOPO).

During the study, samples weighing 10.0 g were kept in glass bottles at a temperature 20 ± 1 °C not less than 30 min, after which the equilibrium gas phase over samples with a volume of 3.0 cm³ was taken through the membrane and injected into the detection cell. The measurements were carried out for 120 s, the maximum response values for individual sensors were recorded, the measurement error – 5 %.

Results and Discussions

The results of the analysis were obtained in the form of a «visual imprint» based on an integral signal processing algorithm for all sensors. The configuration of the figures is calculated in the software of the device and allows you to compare the composition of the equilibrium gas phase over samples. The criteria for comparison were quantitative and qualitative assessments.

Quantitative assessment is represented by the total area of the «visual imprint» based on the signals of all sensors and the maximum sensor signals processed by the normalization method (Table 1).

Samples of B-sugars differ statistically significantly from the intensity of the white sugar smell, which is due to the chemical composition of the samples.

Table 1.
Maximum sensor responses (± 1 , Hz) and the total area of the «visual imprint» ($S \pm 30$, Hz.s)

Sugar sample	S1 – PVP	S2 – BG	S3 – DCG 18C6	S4 – BCG	S5 – PEGS	S6 – PEG-2000	S7 – Tween	S8 – TOPO	S, Hz.s
«Extra» category white sugar	12	2	6	2	6	5	10	6	112
Refined B-sugar	17	2	7	2	8	5	10	7	147
Initial B-sugar	14	2	8	3	8	6	11	7	161
Refined B-sugar with addition of rose hips	20	2	9	3	8	5	12	7	181

Qualitative assessment is represented in the form of a «visual imprint» with a quantitative distribution along the response axes for each sensor (Figure 2).

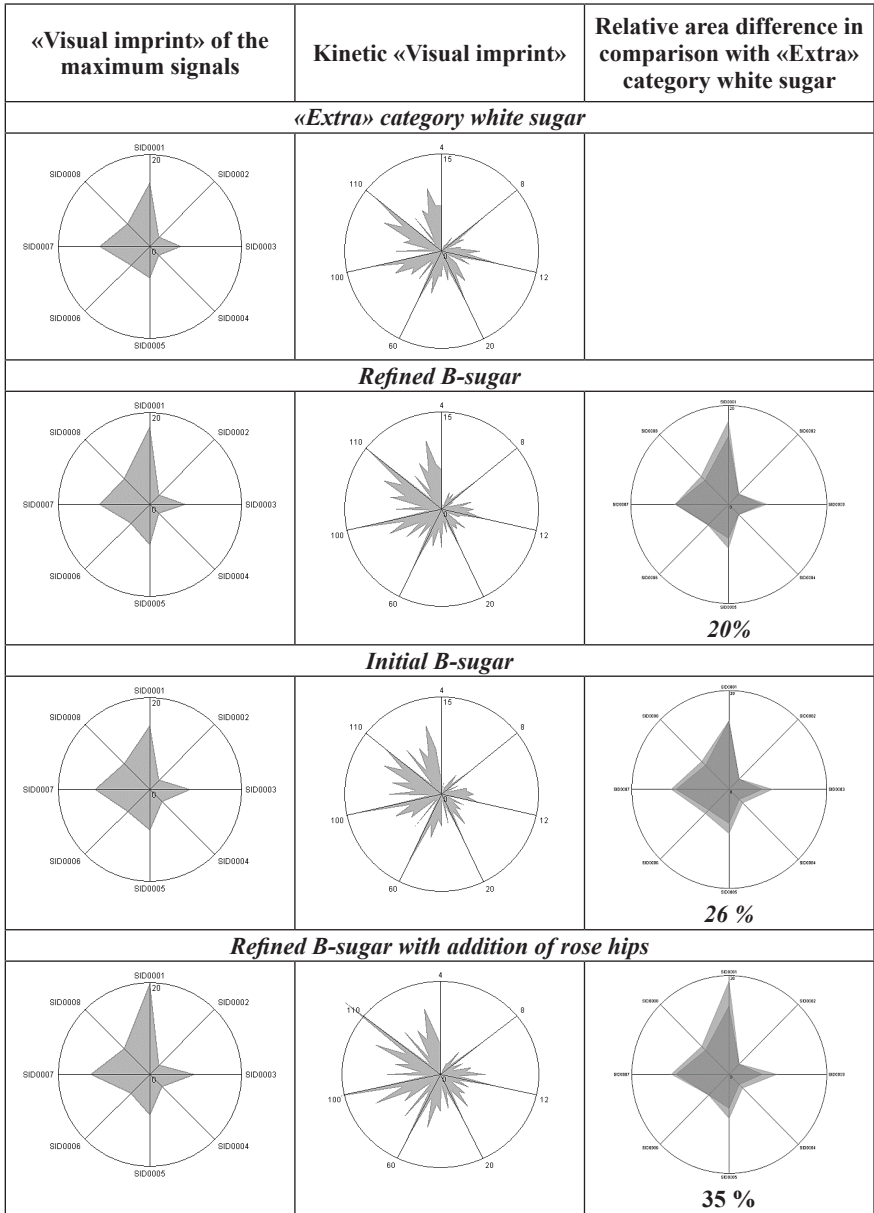


Figure 2. «Visual imprints» of the maximum signals of the sensors of the equilibrium gas phase over samples

Analysis of the form of «visual imprints» of sensor responses indicates a significant difference in the chemical composition of the equilibrium gas phase over samples, especially between samples of white sugar and refined yellow sugar with rose hips.

The conducted studies allowed us to quantify the difference in the component composition of volatile compounds in sugar samples (Table 2).

Table 2.

Component composition of volatile compounds in sugar samples, $\omega (\pm 0,2) \%$ by mass

Sensors	S1-PVP	S2-BG	S3-DCG 18C6	S4-BCG	S5-PEGS	S6-PEG-2000	S7-Tween	S8-TOPO
Sensors selectivity	Polar compounds incl. water	Alcohols and ketones	Alcohols, ketones and acids	Amines	Amines and etc.	Alcohols and acids	Acids	Aroma-containing compounds
«Extra» category white sugar	24.2	5.1	12.0	5.0	12.2	10.2	18.8	12.0
Refined B-sugar	26.3	4.4	13.1	5.7	13.1	10.2	17.5	11.7
Initial B-sugar	25.1	4.7	12.4	4.9	12.8	9.4	17.9	12.1
Refined B-sugar with addition of rose hips	27.4	4.2	13.6	5.6	13.3	8.3	17.6	11.0

Organoleptic parameters and instrumental measurements of the composition of volatile compounds were used to identify and semi-quantitate 35 volatile substances accumulated by the end of shrimp storage [9]. Assessment of the intensity of organoleptic indicators correlated well with changes in the concentration of volatile substances, determined using analytical methods.

The application and use of sensory analytical methods ensures the objectivity of professional wine tasting, whether they are aimed at characterizing the organoleptic properties of wine, maintaining the production quality or developing new styles of wine that meet the sensory preferences of consumers [10]. Organoleptic properties are critical characteristics that determine quality and can only be assessed by trained tasting commissions [11].

The stability of high fat baked goods was monitored using the OXITEST reactor and by sensory and chemical analyzes to validate the instrumental method. OXITEST data correlated well with sensory data [12].

Sensory analysis can be a good tool for developing new products. Consumer

response to organoleptic properties is an important factor in determining the products success [13].

Descriptive organoleptic analysis using fast sensory methods and subsequent mathematical processing of the results is used for forecasting in beekeeping [14].

Thus, organoleptic analysis remains one of the most important methods for determining the quality of food products. Given that this is a human-based assessment tool, studies should be conducted in triplicate or using descriptive methods and intensity scales to improve objectivity. The use of analytical sensory methods significantly reduces the error of determinations allows you to obtain a qualitative and quantitative assessment of product properties [15].

An analysis of literary sources indicates that a scientifically organized tasting analysis in terms of sensitivity can surpass laboratory studies in assessing taste, smell and texture. However, tasting analysis, supplemented, and in some cases replaced by instrumental sensory methods, provides high research accuracy at low labor intensity, makes it possible to determine low concentrations of components that pose a threat to the life and health of the consumer, and increase the products commercial success.

Conclusion

It has been experimentally established that the use of the sensory method of analysis using the «Electronic Nose» device to study the quality of sugar samples, including those with additives, makes it possible to obtain a detailed qualitative and quantitative characteristic that correlates well with the organoleptic assessment, to obtain objective and reproducible results. For this method, the patent RU 2678770 «Method for examining the sugar quality» was obtained. The method can be recommended for wide use, including the examination of other food products.

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DOI 10.34660/INF.2022.90.59.006

УДК 621.484

可再生能源隔离设施的综合供电系统
**INTEGRATED POWER SUPPLY SYSTEM FOR ISOLATED
FACILITIES FROM RENEWABLE ENERGY SOURCES**

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抽象的。该研究的相关性是由于现有技术方案中太阳能和地热能的使用效率低。

在这方面，本文旨在揭示利用太阳能和地热能从可再生能源中为孤立物体提供综合能源的可能性。

研究这个问题的主要方法是基于能源系统运行图理论的数学建模方法，这使得分析太阳能和地热能综合利用的有效性成为可能供应隔离物。

基于所开发的可再生能源隔离对象综合供能系统管理数学模型，利用图论构建，确定了当年的能源消耗和“高峰”模式下备用能源的功率。

文中的材料对孤立物体冷热供热一体化系统的设计人员具有实用价值。

关键词：孤立设施综合能源供应，可再生能源，替代能源。

Abstract. *The relevance of the study is due to the low efficiency of the use of solar and geothermal energy in existing technological schemes.*

In this regard, this article is aimed at revealing the possibilities of using solar and geothermal energy for the integrated energy supply of isolated objects from renewable energy sources.

The main approach to the study of this problem is the method of mathematical modeling based on the theory of graphs of the operation of the energy system, which makes it possible to analyze the effectiveness of the integrated use of solar and geothermal energies for heat and cold supply of isolated objects.

Based on the developed mathematical model for managing the system of integrated energy supply of isolated objects from renewable energy sources, built using graph theory, the energy consumption during the year and the power of the backup energy source in "peak" modes are determined.

The materials of the article are of practical value for designers of integrated heat and cold supply systems for isolated objects.

Keywords: *integrated energy supply of isolated facilities, renewable energy sources, alternative energy.*

The possibilities of using environmentally friendly, ubiquitous renewable energy from solar radiation and geothermal sources are attracting increasing attention. In accordance with forecasts, within the next 15–20 years, renewable energy sources (solar, geothermal, wind, biomass) should take a prominent place in the global energy balance, replacing dwindling reserves of fossil fuels and environmental improvement [1–3].

A distinctive feature of most renewable energy installations from traditional installations is the absence of energy costs for fuel supply during operation, which significantly reduces the cost. The main items of energy consumption during the creation and operation of such installations are the costs of equipment production and construction of buildings and structures. Moreover, for installations of small capacity, the construction of any facilities is often not required, so this item of expenditure is not always present.

As theoretical studies have shown, in summer the use of solar energy is carried out only for hot water supply, and the potential of the solar collector is underused, and in winter the potential of solar collectors is not enough for heating systems [4]. Since some types of energy consumption have pronounced fluctuations by months of the year (heating, ventilation and air conditioning), and others by hours of the day (electricity and hot water), a renewable energy installation must have a power reserve to cover "peak" loads, and a heat accumulator [5-7].

The authors have developed a technological scheme of the energy complex for year-round integrated energy supply of the building (heating, air conditioning and hot water supply), taking into account the efficient use of the system's capacity. The technological scheme of this energy complex is shown in figure 1.

The scheme includes the following elements: hybrid solar collector; electrical energy converter; inverter steam compressor heat pump; heat-removing pipes of an inverter vapor-compressor heat pump; petrothermal well; a substance with a phase transition temperature of 20 - 43 °C; fractures created by hydraulic fracturing, filled with a substance with a phase transition temperature of 20 - 43 °C; heat accumulator; electric accumulator; premises (heat consumer for heating and hot water supply systems; cold consumer for air conditioning systems); absorption heat pump; bivalent water heater. The diagram also shows the flows of: electrical energy, heat and coolant, tap water for the hot water supply system.

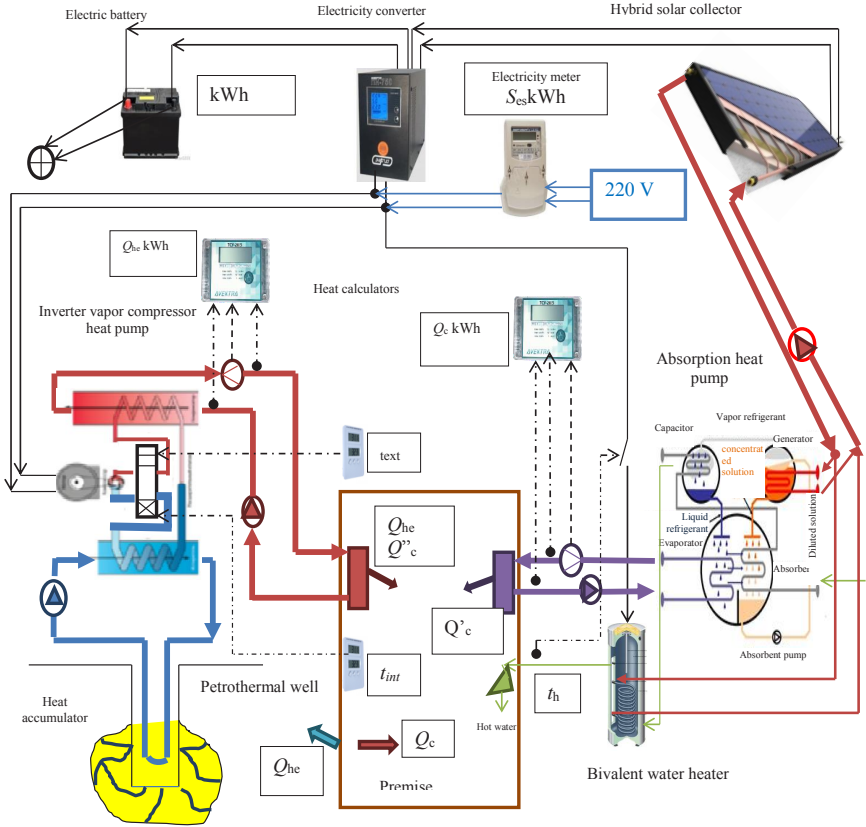


Figure 1. Integrated energy supply system for isolated facilities from renewable energy sources

Symbols for flows in the diagram:

- Q_c – load on the air conditioning system during the warm period, W;
- Q_{he} – load on the heating system during the cold period, W;
- Q'_c – production of cold for the air conditioning system using an absorption heat pump, W;
- Q''_c - cold production for the air conditioning system using an inverter vapor compressor heat pump, W;
- S_{es} – electricity consumption from a backup source with insufficient solar collector power, kWh;
- t_{int} – estimated room temperature, °C;
- t_h - design temperature of hot water in the hot water supply system, °C.

In a petrothermal well, up to 100 m deep, at a depth below 15 -20 m, hydraulic fracturing creates fractures into which a substance with a phase transition temperature of 20 - 43 °C is pumped, for example, mirabilite (Glauber's salt): melting point 20 - 32 °C, melting point (phase change) 251 kJ/kg) or paraffin: melting point 43 °C, heat of melting (phase change) 209 kJ/kg), and thus create a heat accumulator.

During the warm period, the electrical energy generated by the hybrid solar collector is supplied to the electrical energy converter, from where it is supplied to the inverter vapor-compression heat pump, and in case of excess electrical energy, to the electric accumulator. The surplus produced electrical energy, stored in an electric battery, can then be used at night for "standby" lighting. In addition, electrical energy is used for "peak" reheating of tap water in the hot water system in a bivalent water heater when the thermal capacity of the hybrid solar collector is insufficient. An inverter vapor compressor heat pump is used for a room air conditioning system by means of a vapor compression heat pump coolant. At the same time, the heat of air conditioning of the room from the condenser of the inverter vapor-compressor heat pump, by means of a heat-cooling medium, is simultaneously pumped into the heat accumulator (including the reservoir of a petrothermal well) with a substance with a phase transition temperature of 20 - 43 °C. The heat carrier of the inverter steam-compressor heat pump is supplied to the petrothermal well through the heat-removal pipes of the inverter steam-compressor heat pump and exchanges heat with the heat accumulator. During the cold period, the electrical energy generated by the hybrid solar collector is used by the inverter vapor compressor heat pump through the coolant of the heat exchanger pipes of the inverter vapor compressor heat pump to supply heat from the heat accumulator and reservoir (petrothermal energy) to the space heating system. Thus, the thermal accumulator "smoothes out" the uneven supply and consumption of thermal energy. Regulation of the thermal regimes of the complex is carried out from the sensors: t_{int} – temperature in the room; t_{ext} – outside air temperature; t_h – hot water heating temperature.

The heat of the hybrid solar collector is used by means of the heat carrier of the hybrid solar collector circuit: in a bivalent water heater for heating tap water in the hot water supply system during warm and cold periods; and also in an absorption heat pump for generating refrigeration in the room air conditioning system during a warm period, by means of the refrigerant of the absorption heat pump. The heat carrier that gave up its heat in the bivalent water heater and absorption heat pump is returned to the hybrid solar collector for heating.

The electrical energy produced in excess by the hybrid solar collector is accumulated in an electric battery and can be used at night for "standby" lighting.

In case of insufficient capacity of the hybrid solar collector, the system is con-

nected to an external power source. At the same time, due to the use of an inverter vapor compressor pump, this energy is used more efficiently than with "direct" heating in the heating system.

Intended scope: buildings with a variable thermal regime, i.e. with a thermal regime maintained not around the clock, but only during working hours (market and shopping complexes; administrative buildings). During non-working hours, the temperature in rooms of this purpose can be maintained at a lower level during the cold period, and at a higher level during the warm period, from the temperature established by regulatory documents (building codes and rules) [8-10].

Since the heat supply system based on renewable energy sources is low-potential, an air heating system is provided, which, at the same time, is used by the air conditioning system in the summer. The loads for the heat and cold supply system are taken in calculations according to aggregated indicators (for the city of Stavropol) - the construction volume of the building, the normalized specific consumption of thermal energy for heating buildings [21], specific heat emissions in the room, including heat input from the sun [4], the daily rate of hot water consumption (Based on the rate of hot water consumption for office space 20 l/(day person) and the average area of the room per person is 5 m²).

Calculations were made for a building with a construction volume of 900 m³, according to the average daily solar radiation and climatic characteristics of each calculated month of the year, for two values of the hybrid solar collector area of 30 m² and 50 m². The calculation results are shown in Figures 2 and 3, where S_o is the excess amount of energy (energy deficit) generated by the system to provide the building with energy based on the heat balance of the building, kWh/day, Q_{hsc} – is the energy generated by the hybrid solar collector, kW h/day, $\sum Q_{st}$ – stored energy, kWh/day.

As shown by the calculations carried out in accordance with the developed graph, the uneven use of renewable energy sources during the year on the basis of the developed scheme of the energy complex has significantly decreased (line $\sum Q_{st}$ in figures 2 and 3).

When selecting the hybrid collector area for the optimal system capacity, the probability of using a backup heat supply source (S_{es}) is determined by the formula:

$$p_{\tau} = 1 - n_{\tau} / 24 + (1 - \xi_{\tau}),$$

where n_{τ} – number of daylight hours of the period τ ;

ξ_{τ} – atmospheric clarity factor for period τ . The clarity coefficient can be determined by the formula $\xi = I_a / I_{Tn}$, where I_a - total solar radiation to the surface based on the results of long-term observations for a given area; I_{Tn} - is the total flux of solar energy entering a horizontal area outside the atmosphere for the same period of time, determined by the developed calculation program.

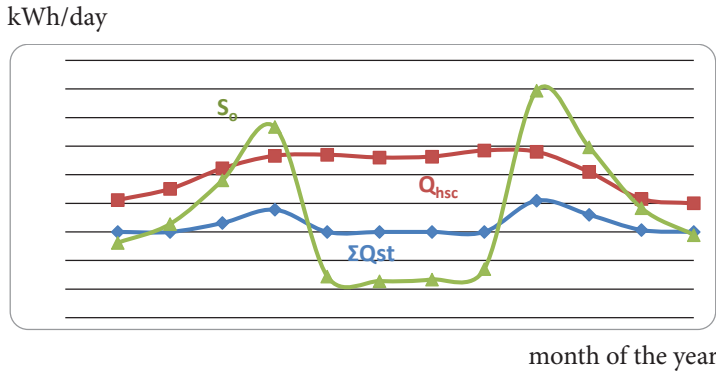


Figure 2. The results of the calculation of the system of integrated energy supply of isolated objects from renewable energy sources (the area of the hybrid solar collector is 30 m²)

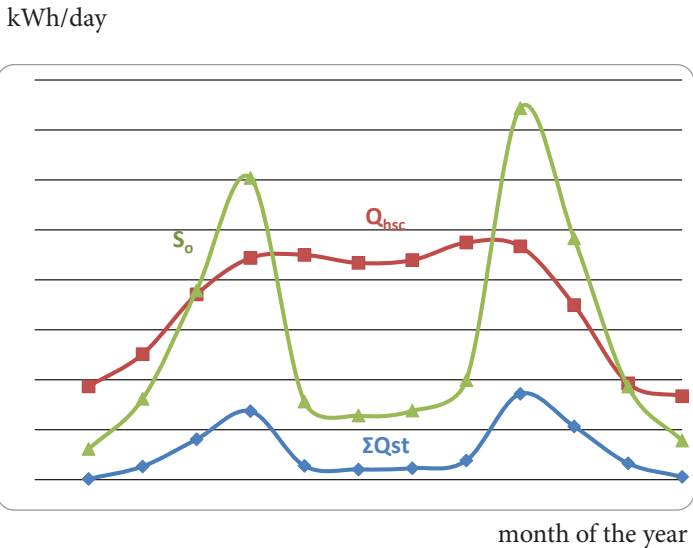


Figure 3. The results of the calculation of the system of integrated energy supply of isolated objects from renewable energy sources (the area of the hybrid solar collector is 50 m²)

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基于煅烧粘土和碳酸盐岩的矿物添加剂水泥体系的相组成
**PHASE COMPOSITION OF CEMENT SYSTEMS WITH MINERAL
ADDITIVES BASED ON CALCINED CLAY AND CARBONATE ROCKS**

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抽象的。本文介绍了基于煅烧多矿物粘土和碳酸盐岩获得的矿物添加剂对水泥石相组成的影响模式的研究结果。通过 X 射线粉末衍射已经确定,使用热活化粘土和碳酸盐岩有助于提高波特兰水泥的水合速率,并允许水泥石相组成的方向变化,它在于优化钙矾石浓度,减少最弱和暴露于腐蚀的波特兰石晶体的数量,通过将平衡转向增加 C-S-H(I) 型高分散低碱性相的含量而不是高基本的 C-S-H(II) 化合物,它决定了这些矿物改性剂在水泥体系中的化学效率。

关键词: 水泥, 添加剂, 煅烧粘土, 碳酸盐岩, 混合物, 水化, 微观结构, X 射线衍射, 相组成, 钙矾石, 硅酸钙, 硅酸盐。

Abstract. *The paper presents study results the influence patterns of mineral additives obtained on the basis of calcined polymineral clay and carbonate rocks on the phase composition of cement stone. By the X-ray powder diffraction it has been established that using the thermally activated clay and carbonate rocks contributes an increased hydration rate of Portland cement and allows for directional changing of the cement stone phase composition, that it consist in optimizing the ettringite concentration, reducing the number of the weakest and corrosion-exposed Portlandite crystals, increasing the density and strength of the bulk of calcium hydrosilicates by shifting the balance towards an increased content of highly dispersive low basic phases of C-S-H(I) type instead of high basic C-S-H(II) compounds, that it determines the chemical efficiency of these mineral modifiers in cement systems.*

Keywords: *cements, additives, calcined clay, carbonate rocks, mixtures, hydration, microstructure, X ray diffraction, phase composition, ettringite, calcium hydrosilicate, Portlandite.*

Introduction

Currently, one of the primary areas of technical progress in the field of construction is creating modern high performance concretes based on modified ce-

ment binders using various chemical and mineral additives that allow effective control of the structure formation and properties of material [1 – 6].

Out of many types of mineral modifiers for the high-strength cement systems, highly dispersive pozzolanic additives have increased efficiency, which contain amorphous silica or alumina and have high reactive activity such as condensed silica fume, high-dispersive fly ash of heat power plants with a minimal content of non-combusted residues, blast-furnace granulated slag, metakaolin, etc. [1, 2, 7 – 9], which is confirmed by the results of own studies [10 – 12].

However, the resources of the above additives do not meet the increasing needs of the construction industry. In this regard, expanding the raw material base for obtaining effective mineral additives based on available natural raw materials is an important task. One of the most promising in this respect for many regions of the Russian Federation are common raw materials such as polymineral clays [13, 14] and carbonate rocks [15, 16].

The purpose of this study was to establish the influence regularities of mineral additives (MA) based on calcined polymineral clay and carbonate rocks on the structure formation of plasticized cement systems with the identification of the most effective modifiers.

Materials and methods

The primary component of binder in cement system compositions was Portland cement 500-D0-N (PC) manufactured by Mordovtsement PJSC (Russian State Standard GOST 10178-85). Melflux 5581 F polycarboxylate superplasticizer was used as chemical modifier using in complexes with the following types of mineral additives:

1) calcined clay of the Nikitsky deposit (CCN) (temperature and duration of calcination: 700 °C and 2 hours; $S_{ss} = 7800 \text{ cm}^2/\text{g}$) located in the north-western part of Saransk, the Republic of Mordovia, the Russian Federation;

2) dolomite of the Yelnikovsky deposit (DY) ($S_{ss} = 4450 \text{ cm}^2/\text{g}$) located near the Budayevo village, Yelnikovsky district, the Republic of Mordovia, the Russian Federation;

3) calcined mixture of Nikitsky clay and chalk of the Atemarsky deposit (CM(CN+CA)) (clay to chalk ratio = 2/1; temperature and duration of calcination: 700 °C and 2 hours) located near the Atemar village, Lyambirsky district, the Republic of Mordovia, the Russian Federation.

The first stage included the study of the mineralogical (phase) composition of Nikitsky clay, Yelnikovsky dolomite, and Atemarsky chalk. The phase composition analysis of sedimentary rocks was done using X-ray powder diffraction (XRD phase analysis). X-ray structural measurements were conducted using an Empyrean automated diffractometer by PANalytical (Netherlands) with a verti-

cal goniometer in the radiation of a copper anode with a nickel filter ensuring suppression of the background and spectral line K_{β} together with the monochromator on the secondary beam. Shooting was done in the geometry according to Bragg-Brentano (θ - 2θ scanning) using a spectral doublet $Cu K_{\alpha 1,2}$ with weighted average wavelength $\lambda = 1.5406 \text{ \AA}$. X-ray powder diffraction patterns were obtained using PIXcel^{3D} two-coordinate semiconductor detector operating in the linear detector mode.

The second stage included the study of the effects of mineral additives based on thermally activated Nikitsky clay, Yelnikovsky dolomite, and Atemarsky chalk on the phase composition of cement stone aged 28 days using the X-ray phase analysis method. As study subjects, in addition to the non-modified composite of control composition, cement systems were selected, which had the dosage of mineral additives CCN, DY and CM(CN+CA) of 20 % of binder weight (PC + MA). The primary controlled parameters were as follows:

1) the level of Portland cement hydration (α) evaluated by the decrease in the intensity of one of the primary reflexes C_3S for $d = 1.76$ – 1.77 \AA ($2\theta = 51.6$ – 51.9°) in the hydrated powder samples of cement stone at the studied moment of time relative to the samples of the initial binder (Portland cement + mineral additive) until hydration;

2) the relative amount of Portlandite ($Ca(OH)_2$) evaluated by comparing the intensity of primary reflexes for $d = 4.94$ – 4.96 \AA ($2\theta = 17.87$ – 17.94°) and $d = 1.93$ – 1.94 \AA ($2\theta = 46.8$ – 47.0°) for powder samples of cement stone of modified and control compositions;

3) the relative content of ettringite ($Ca_6Al_2(SO_4)_3(OH)_{12} \cdot 26H_2O$) evaluated by the ratio of the intensity of one of the primary reflexes for $d = 9.80$ – 9.84 \AA ($2\theta = 8.98$ – 9.02°) for powder samples of cement stone of modified and control compositions;

4) the relative content of low basic (C–S–H(I)) and high basic (C–S–H(II)) calcium hydrosilicates evaluated by comparing the intensities of one of the primary reflexes α -CS ($d = 3.23$ – 3.25 \AA and $2\theta = 27.4$ – 27.6°) and β -CS ($d = 2.97$ – 2.99 \AA and $2\theta = 29.9$ – 30.1°) for C–S–H(I) and β - C_2S ($d = 2.79$ – 2.80 \AA and $2\theta = 31.9$ – 32.1°) for C–S–H(II) in powder samples of cement stone of modified and control compositions calcined at 980–1000 °C.

Results and discussion

Mineralogical composition of the initial sedimentary rocks

The results of qualitative and quantitative XRD phase analysis to determine the main crystalline phases and their relative concentrations for the Nikitsky clay are given in Table 1. It has been found that the phase compositions of the studied clay rock is represented predominantly by minerals of the kaolinite group and illite group (hydromicas), as well as by quartz modifications, feldspars, and gypsum at

their relative content in the overall mass of crystalline phases (wt. %): 39.8; 23.1; 19.8; 14.2 and 3.1, respectively, i.e. the represented clay is polymineral.

Table 1.
Phase composition of the Nikitsky clay (before calcination)

Crystalline phases [wt. %]				
Kaolinite	Illite group (hydromicas)	Quartz modifications	Feldspars	Gypsum
39.8	23.1	19.8	14.2	3.1

The mineralogical composition of the Yelnikovsky dolomite is represented by phases of the dolomite $\text{CaMg}(\text{CO}_3)_2$ and calcite CaCO_3 with the relative phase contents of 52 wt. % and 48 wt. %, respectively. The phase composition of the Atermarsky chalk is predominantly represented by calcite CaCO_3 with inclusions of quartz SiO_2 with the relative phase contents of 96 wt. % and 4 wt. %, respectively (Table 2).

Table 2.
Phase compositions of carbonate rocks (before calcination)

Carbonate rock	Crystalline phases [wt. %]		
	Calcite	Dolomite	Quartz modifications
Yelnikovsky dolomite	48	52	-
Atermarsky chalk	96	-	4

Influence of mineral additives on the cement stone phase composition

Figure 1 represents the X-ray diffraction patterns of cement stone powders aged 28 days for compositions containing 20 % of mineral additives CCN, DY, CM(CN+CA)), and for the control additive-free composition.

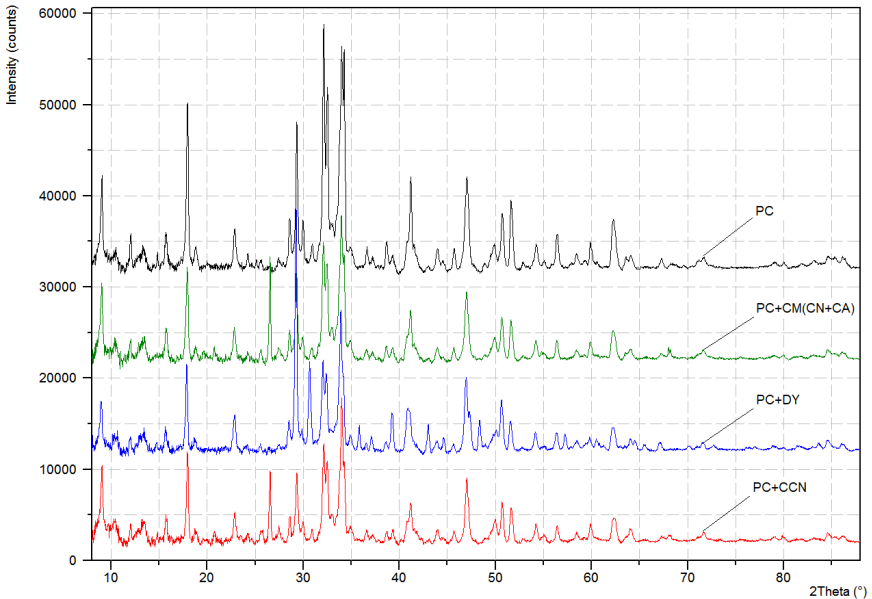


Figure 1. X-ray powder diffractograms of the researched cement stone compositions at the age of 28 days (with CCN, DY, CM(CN+CA) and control additive-free composition)

The qualitative analysis of the diffraction patterns (Fig. 1) showed that the crystalline part of the cement stone structure of both control additive-free composition and the compositions modified with mineral additives of CCN, DY, CM(CN+CA) was represented by the following minerals:

1) the phases of Portland cement clinker not subject to the hydration reaction: alite (Ca_3SiO_5) with number of inter-plane distances $d = [\dots; 3.04; \dots; 2.78; 2.75; \dots; 2.62; \dots; 2.19; \dots; 1.77 \text{ \AA}; \dots]$; belite ($\beta\text{-Ca}_2\text{SiO}_4$) with $d = [\dots; 2.89; \dots; 2.79; 2.75; 2.72; \dots; 2.62; \dots; 2.19 \text{ \AA}; \dots]$;

2) the hydrate phases: Portlandite ($\text{Ca}(\text{OH})_2$) with $d = [4.95; 3.12; 2.64; \dots; 1.93; 1.80; 1.69; \dots; 1.49 \text{ \AA}; \dots]$; ettringite ($\text{Ca}_6\text{Al}_2(\text{SO}_4)_3(\text{OH})_{12} \cdot 26\text{H}_2\text{O}$) with $d = [9.82; \dots; 5.65; \dots; 4.72; \dots; 3.89; \dots; 3.48; \dots; 2.78; \dots; 2.57; \dots; 2.21 \text{ \AA}; \dots]$.

Semi-quantitative X-ray phase analysis of cement stone powders aged 28 days (Table 3) showed that the introduction of mineral additives of dolomite, calcined polymineral clay and thermally activated mixture of clay and chalk in cement systems promoted increased of hydration levels of Portland cement as compared to the control composition without additives from 65 to 82, 79 and 77 %, respectively. Thus, the data show an intensified processes of Portland cement hydration in the

presence of mineral additives DY, CCN and CM(CN+CA) in the cement systems, which is due to both the capability of Yelnikovsky dolomite minerals to act as the crystallization centers of new formations, and the presence of reactive minerals (kaolinite and illite) in the phase composition of Nikitsky clay. The established regularities are consistent with the data of other authors, in particular [4, 13 – 16].

Table 3.
XRD results of cement stone powders at the age of 28 days

Composition of binder (Portland cement + mineral additive)	Hydration degree of Portland cement, %	Relative ettringite content $\text{Ca}_6\text{Al}_2(\text{SO}_4)_3(\text{OH})_{12}\cdot 26\text{H}_2\text{O}$	Relative portlandite content $\text{Ca}(\text{OH})_2$	Relative content of low basic calcium hydrosilicates C-S-H(I)	Relative content of high basic calcium hydrosilicates C-S-H(II)
100 % PC	65	100	100	100	100
80 % PC + 20 % CCN	79	80	73	255	59
80 % PC + 20 % DY	82	62	91	108	130
80 % PC + 20 % CM(CN+CA)	77	94	75	238	94

The analysis of experimental data represented in Table 3 showed the content of ettringite ($\text{Ca}_6\text{Al}_2(\text{SO}_4)_3(\text{OH})_{12}\cdot 26\text{H}_2\text{O}$) reduced by 6–38 % in the powders of cement stone with additives of calcined polymineral Nikitsky clay, Yelnikovsky dolomite and thermally activated mixture of Nikitsky clay and Atemarsky chalk relative to the control composition. Decreasing the concentration of the trisulfate form of calcium hydrosulfoaluminat in the presence of these modifiers may be associated with shift in the balance to the formation of compounds of an another chemical and mineralogical nature (calcium hydrosilicates, AF_m -phases, etc.).

The experimental results (Table 3) show that introducing mineral additives of calcined Nikitsky clay and thermally activated mixture of Nikitsky clay and Atemarsky chalk promotes a substantial quantitative change in the ratio between the primary hydrate phases of cement stone, in particular, Portlandite and calcium hydrosilicates of various basicity. As compared to the control composition, in the powder samples of cement stone with CCN and CM(CN+CA) additives aged 28 days, the contents of high basic C-S-H(II) and large low strength crystals of

Portlandite $\text{Ca}(\text{OH})_2$ are reduced by 6–41 % and 25–27 %, respectively, and the content of fine and high strength low basic C–S–H(I) is increased 2.4–2.6 times. In the same time the data given in Table 3 proves relative chemical inertness of the Yelnikovsky dolomite additive since the concentrations of Portlandite and low basic C–S–H(I) phases in the cement stone sample of composition with DY are close to those of the control composition without mineral additives.

Conclusions

The following results were obtained from experimental studies:

1) the mineralogical compositions of polymineral clay, dolomite and chalk (respectively, the Nikitsky, Yelnikovsky, and Atemarsky deposits, the Republic of Mordovia, the Russian Federation) were established;

2) the influence regularities of mineral additives based on calcined clay, dolomite and thermally activated mixture of clay and chalk on the phase composition of cement stone aged 28 days were identified.

The experimental results (Table 3) show that use of mineral additives based on calcined Nikitsky clay and thermally activated mixture of Nikitsky clay and Atemarsky chalk allows increasing the hydration level of Portland cement and consistently changing the phase composition of cement stone: optimizing the ettringite concentration, decreasing the number of the weakest and corrosion-exposed Portlandite crystals, increasing the density and strength of the primary mass of newly formed calcium hydrosilicates by shifting the balance towards an increased content of highly dispersive low basic C–S–H(I) phases instead of high basic C–S–H(II) compounds.

Acknowledgments

The research was supported by grant from the Russian Science Foundation (project No. 21-73-00228), <https://rscf.ru/en/project/21-73-00228/>.

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DOI 10.34660/INF.2022.46.59.008

MATHCAD环境中非线性问题的数值优化
**ON NUMERICAL OPTIMIZATION OF NONLINEAR PROBLEMS IN
MATHCAD ENVIRONMENT**

Sedov Roman Leonidovich

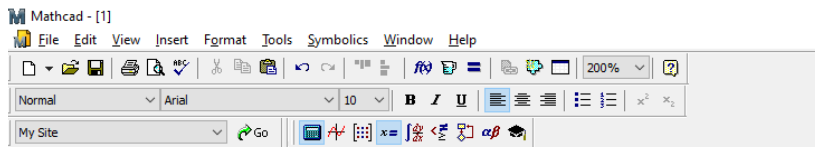
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Numerical optimization of economic and engineering systems and processes has always been a topical issue in mathematics, economic research and engineering. This article discusses an instrumental method for reducing the solution of a numerical optimization problem for a nonlinear problem in the mathcad 14.0 environment.

Given data of the problem: find the smallest and largest values of the function $Z(x,y)$ on a circle centered at the origin and with radius 4:

$$z = x^2 + xy + y^2 + x - y + 1, \quad D: x^2 + y^2 = 16.$$

The mathcad environment was chosen to solve the problem, which supports the solution of mathematical problems with graphical operators, including conditional optimization. Figure 1 shows the solution of the above problem in the mathcad window. The author wrote and defended a Ph.D. thesis in technical sciences on the topic "Mathematical modeling of the human three-vertebral complex and optimization of semi-rigid spine fixators", which is based on a system of differential equations built on the basis of theoretical mechanics of a biomechanical system consisting of three vertebrae, the middle of which has wedge deformity. The model is implemented as a calculation module in the mathcad package.



Целевая функция

$$Z(x,y) := x^2 + x \cdot y + y^2 + x - y + 1$$

$x := 0$ $y := 4$ Начальные приближения переменных

Given Условие для переменных

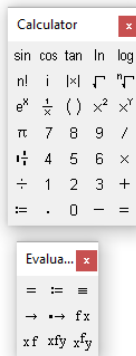
$$x^2 + y^2 = 16$$

$$X_{\max} := \text{Maximize}(Z, x, y)$$

$$X_{\min} := \text{Minimize}(Z, x, y)$$

$$Z_{\min} := Z(X_{\min_0}, X_{\min_1})$$

$$Z_{\max} := Z(X_{\max_0}, X_{\max_1})$$



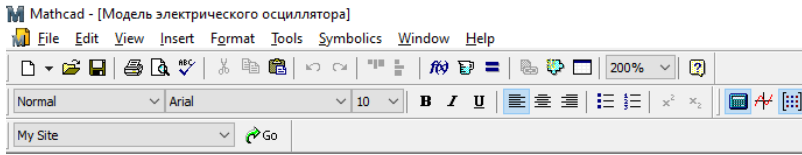
Вывод результата расчётов:

$$Z_{\min} = 25.5 \quad Z_{\max} = 0$$

$$X_{\min} = \begin{pmatrix} -1 \\ 1 \end{pmatrix} \quad X_{\max} = \begin{pmatrix} 3.284 \\ 2.284 \end{pmatrix}$$

Figure 1. Numerical optimization of a nonlinear programming problem

The figure shows that the function takes the smallest value at the point M(-1;1) Z=0, the largest value at the point N(3.284;2.284) Z=25.5. In conclusion, it can be noted that mathcad can solve almost any problem, including the numerical solution of ordinary differential equations and partial differential equations. Let's take a similar example.



Математическая модель электрического осциллятора

$$\omega := 0.5 \quad \beta := 0.2$$

$$y := \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$D(t,y) := \begin{pmatrix} y_1 \\ -\omega \cdot y_0 - \beta \cdot y_1 \end{pmatrix}$$

$$M := \text{rkfixed}(y, 0, 40, 100, D)$$

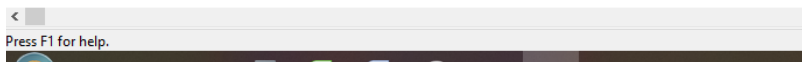
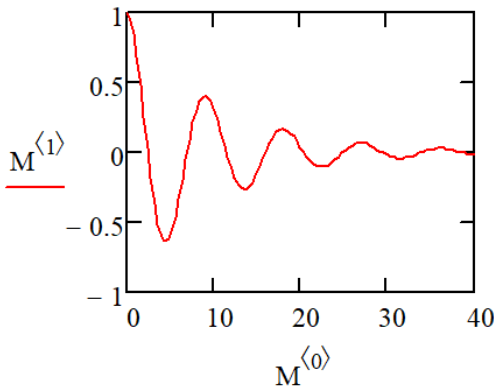


Figure 2. Solving the differential equation of a mathematical oscillator

Mathematical modeling at all times is implemented using functionals, differential equations, optimization models. The author teaches the course "Mathematical Modeling" for engineering specialties of higher educational institutions of St. Petersburg and Kaliningrad.

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DOI 10.34660/INF.2022.63.53.009

作业条件对矿用铲作业成本的影响
**THE INFLUENCE OF OPERATING CONDITIONS ON THE
OPERATING COSTS OF A MINING SHOVEL**

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影响矿井挖掘机作业时间大小的复杂因素的理论研究，获得这些因素对职业挖掘机成就的评级的算法。它提供了矿山挖掘机作业保存效率的综合指标。

费用计费根据岩体成本标准确定了影响 EKG-18R / 20K 运行效率的因素。

关键词：矿山挖掘机；资源；工作时间；潜力利用系数；运作效率比；可靠性；影响因素。

The theoretical study of a complex of the factors influencing the size of an operating time of mine excavators, an algorithm for obtaining the rating of these factors on the achievements of career dredges. It offers comprehensive indicators of preservation efficiency of operation of mine excavators.

Spend tariffing identified the factors influencing the efficiency of operation of EKG-18R / 20K on the criterion of the cost of rock mass.

Keywords: *mine excavator; resource; operating time; coefficient of use of potential; functioning effectiveness ratio; reliability; influencing factors.*

The intensification of the open pit mining of solid minerals is largely determined by the use of modern equipment complexes of large unit capacity, in which the excavator is the head. However, the discrepancy between the operating conditions and the unified output standards (UOS) causes a significant deviation of the operating time of excavators from its nominal value, contributes to the intensification of degradation processes leading to an accelerated decrease in their residual resource, which contributes to an increase in the number of failures, an increase in the complexity and laboriousness of repair work and an increase in the cost of

excavating the rock mass. At the same time, the actual operation of the excavator is not without drawbacks, both from the point of view of the organization of work and the functioning of the excavator itself.

So, to assess the reliability of mining excavators and the effectiveness of their work, non-standardized indicators are often used, for example, the coefficient of technical readiness K_{tr} and the coefficient of equipment utilization K_{eu} , which are subjective and are not included in the nomenclature of indicators according to GOST 27.002-89. And the methodology for determining them differs significantly in different enterprises. And given the fact that mining operations account for about half of the total energy costs of a mining enterprise, the task of a comprehensive assessment of the factors that determine the operating time and operating efficiency of mining shovels is relevant, especially in the context of creating a new line of domestic excavators of the EKG type, successfully competing with foreign-made excavator models [1, 2, 3, 4].

The coefficient of technical readiness is defined as the ratio of the difference between the calendar time fund and the actual time of repair downtime to the calendar time fund of the estimated period:

$$KTR = \frac{T_{\text{КФВ}} - T_{\text{ф.рем.}}}{T_{\text{КФВ}}}, \quad (1)$$

where KTR – coefficient of technical readiness, $T_{\text{КФВ}}$ – calendar fund of time, $T_{\text{ф.рем.}}$ – actual downtime of the excavator in repairs and waiting for repairs.

It should be noted that KTR is not regulated by general regulatory documents and is subjective, that is, the methodology for its assessment is different. The main differences are in the calculation of the repair downtime, namely the accounting for downtime associated with the replacement of consumables (teeth and bucket protection, ropes), since they cannot be clearly regulated and are highly dependent on conditions (mining and geological and mining technical) and modes (qualifications and methods of work of drivers) of operation.

At the competitive offer of IZ-KARTEX, the KTR value equal to 0.85 was announced according to the methodology that does not take into account the replacement of consumables.

In a number of cases at mining enterprises in Russia, the KTR estimation methodology includes the time to replace consumables. Thus, when performing all routine maintenance work on the maintenance and repair of an excavator according to the methodology, standards for performing work used at Karelsky Okatysh and sequential performance of work, the maximum achievable KTR per month in the absence of emergency repairs is equal to:

$$\begin{aligned}
 KTR &= \frac{T_{\text{КФВ}} - T_{\text{ост.}}}{T_{\text{КФВ}}} = \frac{T_{\text{КФВ}} - (T_{\text{ОСН}} + T_{\text{ОИ}} + T_{\text{ОЭЛМ}} + T_{\text{подъёмн.к.}} + T_{\text{напорн.к.}} + T_{\text{возврн.к.}} + T_{\text{зуб.}})}{T_{\text{КФВ}}} = \\
 &= \frac{720 - (0,5 \times 2 \times 30 + 1 \times 24 + 1 \times 12 + 1 \times 12 + 1 \times 12 + 0,5 \times 12 + 4 \times 4)}{720} = 0,844
 \end{aligned}$$

In the practice of maintenance departments of mining companies and service organizations, in order to optimize the time for performing maintenance and repair work, when planning the work schedule, certain types of work are combined. For example:

1. Every shift maintenance is carried out during the acceptance / delivery of a shift or during other organizational and technological breaks (when replacing teeth, ropes, waiting for vehicles), including without fail combined with other types of maintenance and repair work.

2. Monthly maintenance of the electrical part is carried out in parallel with the monthly maintenance of the mechanical part.

Thus, when optimizing the SPM schedule under conditions, work time standards and parallel repair operations, the maximum achievable KTR per month in the absence of emergency repairs is:

Conclusions

1. Methods for calculating KTR differ significantly in different enterprises.
 2. In the absence of emergency downtime, the maximum achievable KTR for sequential operations is 0.844, with optimization of the SPM schedule - 0.90.

2. Analysis of emergency failures of components and parts of excavators

During the operation of excavators № 63 and 64, the most significant downtime due to emergency failure, both due to the fault of the manufacturer, and a number of controversial cases (pressure axles) are noted for the following nodes: ropes; thrust axle; handle; tension wheels; casting marriage; onboard transmission.

The total time for restoration and waiting for repairs on the specified units for two machines № 63 and 64 amounted to 1054 hours out of 12384 hours of the calendar time fund (CTF). Thus, the given time of emergency downtime for the above nodes is about 65 hours per month (see tab. 1).

Table 1.

Troubleshooting time for individual components and parts of the excavator

Node name	Reduced monthly troubleshooting time, h	Share of emergency downtime, %CTF	Note
Pressure axles	27.7	3.85%	The design has been changed from factory № 4 EKG-20KM. At factory № 2 and 3, axles are in an irreducible supply
Final drive	10.6	1.48%	Ultrasonic testing of shafts and gears is introduced
Handle	10.4	1.45%	Structural reinforcements were made for plant № 2 and 3. Plant № 4 and 5 handle of a new design. Additional control introduced (X-ray, MPD)
Ropes (pressure, return, lift)	8.4	1.16 %	Changed the design of the suspension at factories № 4 and 5. Recommendations are given on the use of a rope d60.5mm
Idler wheels	4.1	0.57%	The lubrication system has been changed, incoming control over the quality of supplied bronze has been strengthened.
Casting marriage	No data	0.50%	Input control is enhanced
TOTAL	≈65	9.0 %	

In most cases, the manufacturer does not dispute his guilt as a manufacturer and is constantly working to improve individual components and adapt their design to the specific operating conditions of the machine.

There is no doubt that the operation of mining equipment is completely impossible without emergency exits. In the practice of mining enterprises in the Russian Federation, about 24-27 hours per month are allocated for unscheduled work to eliminate emergency failures, which is 3.3-3.8% of CTF. Currently, emergency repairs of the above nodes account for 9% of the CTF. Of these, a large proportion (42%) is occupied by emergency breakdowns of the pressure axle, the causes of which are controversial. It should be noted that emergency failures of pressure axles took place in the first six months of operation of excavators, which are characterized by running in and adaptation of drivers to work on a new (both in design and technical equipment) machine.

Conclusions

1. A high proportion of emergency downtime (9%) after making changes to the design of excavators tends to significantly decrease. It is planned that based on the results of all warranty work to improve the design of excavators, the share of emergency failures will be within acceptable limits (3.3 - 3.8%).

2. Pressure axle failures account for 42% of emergency downtime, and their causes are controversial.

3. Analysis of the time spent on maintenance and repairs of excavators

The time standards for the duration and labor intensity of maintenance and repair are given in the operating manual for excavators. The time standards are based on the practical experience of operating excavators, and are confirmed by the actual indicators achieved during company service.

Based on the statistical data of the operation of excavators № 63 and 64 provided in table 1, a comparison is made of the actual and achieved time spent on maintenance and repair work, as well as the planned indicators of the repair management of the mining enterprise.

Table 2.

Comparison of average planned, actual and achieved time spent on excavator maintenance and repairs

Type of repair work	Duration of repairs per month, h			Deviation of actual time spent from achieved	
	Fact	Plan "KO"	Service company standard	Time, h	% CTF
Shift maintenance (<i>not included in monthly total</i>)	No data	30	30	-	-
Monthly maintenance	61	24	24	+37	+5.1
Monthly electronic maintenance	12	12	12	0	0
Work on the replacement of consumables					
Tooth replacement	24.4	16	12	+11.5	+1.6
Replacement of protections	1.1		2		
Hoist rope replacement	17	12	8	+9	+1.3
Pressure rope replacement	18	12	8	+10	+1.4
Replacing the return rope	3	6	4	-1	-0.1
TOTAL	136	82	70	+66.5	+9.2

Conclusions

1. The average actual time for performing maintenance and repairs of excavators № 63 and 64 is 136 hours per month against 82 hours according to the repair management plan. At the same time, the service company achieved the duration of repair operations - 70 hours per month.

2. When performing maintenance and repair work on excavators, there is the potential to reduce repair time by 66.5 hours per month, which is equivalent to a KTR increase of 9.2 points. Thus, while observing the standard deadlines for the performance of work, a reserve of time is provided for the implementation of unscheduled and emergency work to repair the excavator.

4. Recommendations and wishes for the operation of excavators

4.1. In order to increase the operating time of the bucket teeth, reduce the time for their replacement, and also exclude cases of emergency tooth breakage, the manufacturer recommends using teeth tested by the manufacturer on EKG-20KM excavators. Currently, the mining company uses bucket teeth that do not comply with the design documentation, which have significant deviations in geometric dimensions and shape from the original design. The use of such teeth significantly increases the time for their replacement, since it is necessary to adjust and adjust the landing dimensions. The use of such teeth leads to an increase in the wear of seats on the bucket, thereby reducing the reliability of their fastening, increasing the incidence of emergency breakdowns and loss of teeth, which leads to a decrease in KTR.

4.2. It is recommended to provide free access to the service engineer to check the technical condition of the excavators and the conditions of its operation, to empower them to stop the operation of the excavator (during the warranty period) as soon as possible to eliminate developing defects.

There were cases when a service engineer (from the manufacturer) detected defects at an early stage of their inception, after which recommendations were sent for their prompt elimination. On the part of the mining enterprise, it was repeatedly refused to stop the excavator for operational repairs. Due to the postponement of repairs, an avalanche-like development of the defect occurs, which leads to an emergency failure of the excavator. This fact also has a significant impact on KTR.

Based on the analysis of the scientific and methodological base for assessing and ensuring the effectiveness of the operation and technical condition of mining excavators, depending on the conditions and modes of their operation, the factors affecting the performance of cyclic mining excavators have been established and classified [5, 6]. According to the proposed classification, the influencing factors are divided into six main groups: 1 - mining-geological and mining-technical factors; 2 - climatic factors; 3 - the quality of the preparation of the face and rock mass; 4 - excavator control; 5 - technical condition of the excavator; 6 - organization of mining operations.

These factors fully affect the performance of a mining excavator, changes in its technical condition and operational efficiency. They are not equivalent and to varying degrees affect the durability of a mining excavator and require both a rating assessment and billing according to the effect of their influence.

In order to implement a uniform approach in assessing the influencing factors on a mining excavator during its operation, the authors proposed to abandon the non-standardized indicators for evaluating the operation of excavators used at mining enterprises and replace them with the potential utilization factor K_{pu} and the performance efficiency factor K_{eff} , which correspond to a standardized integrated indicator of reliability - the coefficient of conservation of efficiency, and allow us to evaluate the reliability, maintainability and durability of the object under consideration [6]. The comparison is carried out in a relative way, which allows you to correlate different types of excavators in real operating conditions. The assessment is carried out in comparison with normal (basic or normal) conditions and operating modes, in relation to which the excavator is designed. Based on the assessment obtained, a forecast is made for changes in the technical condition of the object, its operating time and / or the remaining life of the excavator, taking into account the possible negative influence of factors leading to a decrease in its operational capabilities and optimization of the maintenance system.

The theoretical basic values of the K_{eff} and K_{pu} coefficients for the EKG-18R/20K excavator, when used under normal operating conditions, are set equal to 4.61 t/kWh and 1, respectively. When assessing the preservation of the efficiency of the operation of hydraulic excavators, the calculation is based on the consumption of diesel fuel.

The operating time of a mining excavator is estimated by its change from the above groups of influencing factors during the operation of the excavator. This approach makes it possible to assess the intensity of the resource depletion of both a specific excavator during its operation, and in the analysis of the operation of individual elements and systems of a mining machine.

The initial data for the rating assessment of influencing factors are: payload in the excavator bucket - P_{ayload} t; pre-repair/post-repair service life, years; driver experience, years; the actual coefficient of use of the calendar fund of time.

The theoretical base value of the operating time of the excavator under normal operating conditions [Q_{year}] is defined as the operational annual productivity.

The nominal service life before overhaul T_{ov} , obtained taking into account the formula of Rusikhin V.I., is proposed to be estimated by the expression:

$$T_{sp} = \frac{1,75(1,7P_{ayload} - 18)}{[Q_{гон}]} \quad (1)$$

The annual operating time of the excavator under actual operating conditions Q_{year} is determined as the product of the base value of this operating time and a set of operating conditions, consisting of indicators $K_{5,1}$, ... $K_{5,6}$, and maintenance and repair (fig. 1), characterizing the change in the amount of operating time from the degree of manifestation of influencing factors.

Figure 1. Algorithm for assessing the performance of an excavator

The algorithm for evaluating the excavator performance makes it possible to carry out a rating assessment of the influencing factors on the operating time of the excavator during its operation and to carry out their billing in the real conditions of the machine's operation [7].

In this case, the limiting $K_{5,x}$ are set, and the permissible value of inefficiency in relation to real operating conditions. Based on the results of comparing the actual corresponding values, organizational and technical decisions are made by way of directed adjustment of the conditions and modes of operation of the excavator.

Thus, the conditions for the rational operation of the excavator are provided, after which a list of measures for maintenance and repair is planned under the corrected conditions for its operation. After a given period of time, measures to assess and adjust the conditions and modes of operation are repeated. When the excavator reaches the limit state, a decision is made to carry out a survey, modernization, renovation or disposal.

So $K_{5,1}$ fixes changes in operating conditions and characterizes the influence of mining, geological and mining conditions, in particular, the category of rocks according to the difficulty of excavation, while the normal (basic) conditions are rocks of category III. When assessing climatic factors ($K_{5,2}$), it is necessary to take into account the conformity of the climatic design of a mining excavator and its equipment in relation to the climatic conditions in which it is operated. At the same time, it is necessary to take into account their influence not only on the machine, but, first of all, on the driver (operator) of the excavator. If the climat-

ic design of the mining excavator meets the conditions of its operation, as well as additional equipment to create comfortable working conditions for the driver, $K_{5.2} = 1$. In case of uncomfortable work of the driver, any deviations from normal conditions automatically transfer his qualification to a lower level.

Indicator $K_{5.3}$, which characterizes the quality of the preparation of the face and rock mass, is determined by the ratio of the operating time of excavators to the baseline (normal conditions) and is equal to: for the assessment of "Good" - 1.0; "Satisfactory" - 0.5; "Unsatisfactory" - 0.15.

The group of factors "Excavator control" is estimated by indicator $K_{5.4}$. The reduced number of loading cycles for experienced groups of excavator operators with more than 10 years of experience is taken as a unit. The fact that over time the qualification of the driver increases is taken into account. When driving an excavator by drivers with less than one year of experience throughout the entire period of operation (training excavator), the service life of the machine will be reduced to 6 years.

Evaluation of indicator $K_{5.5}$. The "technical condition of the excavator" is carried out according to the influence of the quality of original and non-original spare parts used in the repair of excavators. At the same time, $K_{5.5}$, carried out only on the main components of the excavator, affecting its performance, and is taken equal to: 0.2 - for non-original spare parts; 0.7 - original and non-original spare parts; 1 - original spare parts.

Influence of the factor "Organization of mining operations" and, as a result, the value of the indicator $K_{5.6}$ is determined by the magnitude of the deviation of the ratio of the coefficient of use of the calendar fund of actual time to the base one - equal to 0.6.

The indicator characterizing the maintenance system is defined as the ratio of the annual operating time of a mining excavator with a maintenance system different from the base one to the value of the operating time with a basic approach to the maintenance and repair of mining excavators (SPM according to the regulations).

An assessment was made of the change in the operating time of the EKG-18R/20K excavator before overhaul with a deterministic change in each of the influencing factors separately, in order to identify the degree of this influence on the change in operating time.

According to the simulation results, the degree of influence of individual factors in the operation of mining excavators was distributed in descending order as follows: the quality of the preparation of the face and rock mass (32%), the control of the excavator (29%), the technical condition of the excavator (27%), and mining, geological and mining technical factors (12 %). The simulation results are consistent with the expert assessment of the impact of operating factors on the operating time of excavators. The operating time under normal conditions is $90 \cdot 10^6$ tons.

Tariffication of the rating assessment of influencing factors is conveniently carried out according to the cost of excavating the rock mass. The results of such calculations for excavators EKG-18R/20K with a single change in influencing factors are shown in fig. 2. The maximum increase in the cost of excavation in case of deviation from the normal (basic) conditions of only the factor "Quality of preparation of the face and rock mass" leads to an increase in the cost of excavation up to 12.4 times.

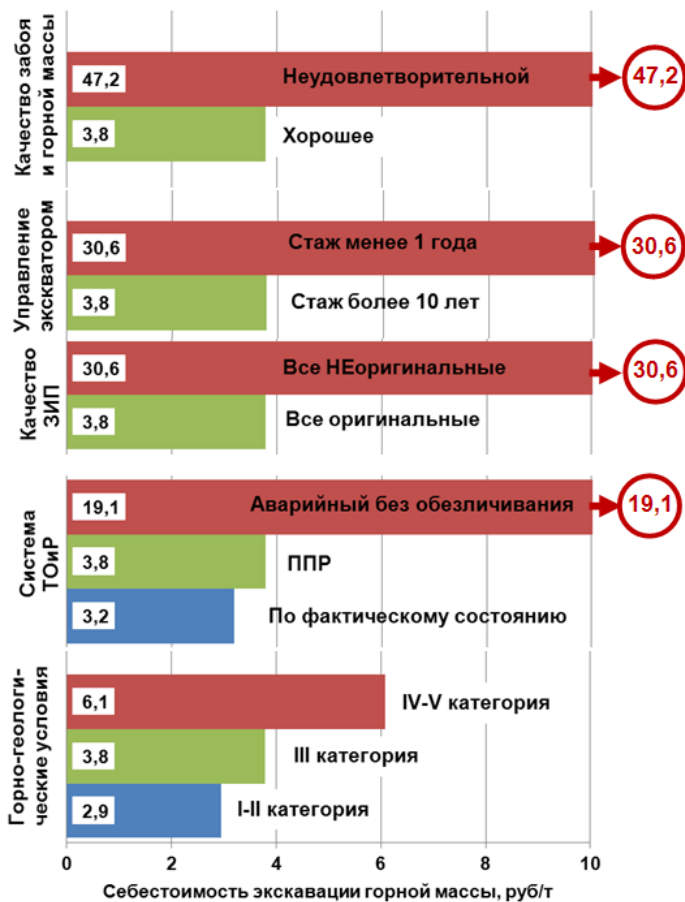


Figure 2. Cost of excavation of rock mass by excavator EKG-18R/20K with a single influence of operating factors

Having established the connection between external conditions and internal processes of operation of the excavator by the amount of its operating time before overhaul, a methodology was developed for determining the required reasonable amount of spare parts and materials for a mining excavator for the period of its operation and an algorithm for adjusting the maintenance schedule for mining excavators during maintenance and repairs according to the actual condition.

Conclusions

To improve the reliability of assessing the efficiency of the operation of a mining excavator, it is proposed to abandon non-standardized indicators, but to use the efficiency retention coefficients K_{pu} and K_{eff} , which determine the inefficiency of the operation of mining excavators according to the criterion of the full use of the excavator's potential. The proposed complex indicators evaluate the reliability, maintainability and durability of the excavator as a system.

Based on a comprehensive assessment of the factors, it was found that the following factors have the greatest influence on the operating time of EKG-18R/20K mining shovels: the quality of the face and rock mass preparation, excavator control, the technical condition of the excavator, and mining-geological and mining-technical factors. The results obtained correlate with expert assessments, and for the EKG-18R/20K excavator, the influence of a single factor reduces the operating time of the excavator by up to 85% and increases the cost of excavating the rock mass by up to 12.4 times.

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DOI 10.34660/INF.2022.25.24.010

UDC 541.64:665.58

开发基于天然来源的新型表面活性剂的化妆品和卫生洗涤剂
**DEVELOPMENT OF COSMETIC AND HYGIENIC DETERGENTS
BASED ON NEW SURFACTANTS OF NATURAL ORIGIN**

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抽象的。制定了柔软、安全、低过敏性的新型婴儿护理产品“婴儿泡沫-从头到脚的洗发水”的生产工艺序列的配方和工艺方案。以可再生植物原料为主要原料，制备了一种性能得到改善的新型非离子表面活性剂烷基多糖苷。在开发过程中，使用了单纯的 Scheffe 晶格方法，借助该方法确定了软表面活性剂的最佳平衡组合，以确保泡沫的特定性能和特性。由此产生的产品不仅符合国家全联盟标准 31696-2012和关税同盟技术法规009/2011的标准要求，而且具有改善的消费者性能，这是由一组消费者测试结果证实的10 名志愿者与该类别的市场领导者相比。已经实现了泡沫的高定性和定量特征，表现为以下指标：泡沫高度、泡沫稳定性、泡沫密度和泡沫的坚硬度。为确定“泡沫密度”指标，采用一种新的泡沫体积重量测定方法，该方法使用一种在较宽温度范围内测定泡沫体积重量的装置，提高了测定值的再现性和准确性。新方法考虑了现有方法的所有缺点。使用从向日葵二次加工产品中获得的原料产生了显著的经济效果，并可以解决油脂工业的废物处理问题。所得结果可作为开发高品质、安全的化妆品卫生产品的基础，供从出生到成人的儿童和成人日常使用。

关键词：个人护理产品；婴儿护理产品；公式；表面活性剂、烷基多糖苷、葵花壳。

Abstract. *The formulation and technological scheme of the sequence of the production process of a new soft, safe and hypoallergenic baby care product "Baby Foam-Shampoo from Head to Toe" has been developed. A new nonionic surfactant, alkyl polyglucoside with improved properties, obtained from renewable plant raw materials, was used as the main raw material. During the development, the method of simplex Scheffe lattices was used, with the help of which an optimally*

balanced combination of soft surfactants was determined to ensure the specified properties and characteristics of the foam. The resulting product not only meets the standard requirements of the State All-Union Standard 31696-2012 and the Technical Regulations of the Customs Union 009/2011, but also has improved consumer properties, which is confirmed by the results of consumer testing on a group of 10 volunteers in comparison with the market leader in this category. High qualitative and quantitative characteristics of the foam have been achieved, expressed in the following indicators: height of the foam, foam stability, foam density and flintiness of foam. To determine the indicator "Foam density", a new method of qualitative determination of the volume weight of foam was used using a device for determining the volume weight of foam in a wide temperature range with increased levels of reproducibility and accuracy of the determined value. The new methodology considers all the disadvantages of existing methods. The use of raw materials obtained from secondary sunflower processing products gives a significant economic effect and allows solving the problem of waste disposal of the oil and fat industry. The results obtained can be used as a basis for the development of high-quality safe cosmetic hygiene products for daily use by both children from birth and adults.

Keywords: *personal care products; baby care products; formulation; surfactants, alkyl polyglucoside, sunflower husk.*

Introduction

In recent years, there has been a significant increase in consumer demand for environmentally-friendly products among hygienic detergents, which belong to cosmetic products. On the one hand, this is due to the development and improvement of diagnostic methods, tools for instrumental assessment, and on the other hand, to the growing awareness of the environmental and medical consequences of the widespread use of chemicals of synthetic origin, the effect of which has not been fully understood and can cause irreversible adverse consequences to human health and the environment [1].

The basis of all cosmetic detergents are surfactants: anionic, amphoteric and non-ionic, which provide the necessary cleansing effect for skin and hair, and at the same time they should have a good foaming ability. It is necessary to remember that all surfactants have an irritating effect on the skin of varying degrees. Of all surfactants the most aggressive to the skin and mucous membranes are anionic, as when they come into contact with the skin surface natural fat particles are washed out more actively. Consequently, the skin becomes overdried, the hydrolipidic balance on the skin surface is upset, while the increased activity of the sebaceous glands is stimulated. As a result, this leads to the violation of the barrier function of the skin: its excessive sensitivity, irritation and peeling, a disruption of the

natural pH level and microbiota content. That is why in the process of developing foam cleaning agents (FCA) and especially products for children, it is necessary to choose an optimally balanced combination of moderate surfactants, the so-called mild surfactants [2,3,4].

It is important to note that huge quantities of synthetic surfactants in the hygiene products used on a daily basis are not biodegradable in natural conditions and, when they enter wastewater they pollute the environment. Currently, these substances are among the most widespread chemical pollutants of water. A promising area in the development of detergents is the use of non-ionic surfactants obtained from renewable plant raw materials.

The range of baby FCA is represented mainly by shampoos, shower gels and bath foams. All baby FCA shall meet the requirements of TR CU 009/2011 On Safety of Perfumery and Cosmetic Products, State All-Union Standard 31696-2012 Cosmetic Hygienic Washing Products and shall undergo the state registration procedure to confirm the safety in an accredited center. The formulation of the product shall be developed in accordance with the standard statutory requirements for the ingredient composition, including minimizing the risk of allergic reactions due to possible individual intolerance to the ingredients of the composition, as well as the absence of irritating effects on the skin and mucous membranes.

The best properties and softness can be achieved by developing a balanced formulation with the optimal combination of surfactants with various properties: with a reduced concentration of anionic surfactants by replacing them with amphoteric and non-ionic surfactants obtained from renewable plant raw materials, in combination with effective and safe superfatting additives.

Contemporary problem of the industry in our country is the lack of manufacturers of mild neonogenic surfactants which are necessary for the production of cosmetic hygiene detergents. The entire range of such products is manufactured on imported expensive raw materials, the cost and availability of which depend on a number of uncontrolled factors such as the seasonal factor (palm crop yield), transportation costs, the political situation, periodic sales restrictions in some countries (as the primary focus is the domestic market). All these have an adverse impact on the range of products in the Russian market, where most of the products available for mass consumption are produced using cheaper aggressive anionic surfactants manufactured in Russia.

The development of the daily hygiene products market requires the development of new affordable and cheap sources of raw materials of natural origin and final products based on them.

The expansion of the raw material base for the production of natural surfactants is largely facilitated by the development of oilseed production. Products of complex oil raw material processing are the most essential source of natural renewable

raw material. Thus, husk, a by-product obtained in the production of sunflower oil, contains glucose, which can be used together with the fatty acids of sunflower oil to produce a new surfactant of natural origin - alkyl polyglucoside [5].

The purpose of our work is to develop a mild, safe and hypoallergenic baby care product based on surfactants obtained from renewable plant raw materials.

Baby foam-shampoo from head to toe was chosen as the product for the development as it is a general and essential baby care product used from the newborn period and is one of the most promising and rapidly growing segments in the cosmetics market. The use of alkyl polyglucoside in the composition of baby care hygienic detergent products will enable to develop a mild, effective, safe and general baby care product even for newborns.

Materials and methods

During the development of a new product, it is necessary to achieve and provide the declared consumer properties, such as mild and safe cleansing, foam density, its flintiness and a pleasant feeling during its use. All these requirements can be achieved by the development of a balanced formulation, with the optimal combination of surfactants with various properties. Additionally, it is essential to include into the formulation the components which provide a set pH value, moisturizing properties, soothing properties for irritated skin and have a proven anti-inflammatory activity.

A brief description of the ingredients used in the composition of the Baby Foam-Shampoo from Head to Toe:

Alkyl Polyglucoside (APG) is a non-ionic surfactant with good cleansing and detergent properties. The source of raw materials is glucose obtained by hydrolysis of sunflower husks cellulose and C_{16} C_{18} fatty acids taken from the stage of sunflower alkali refining. Mild dermatological action allows to use APG in the formulations of baby care hygienic products. In combination with anionic surfactants alkyl polyglucoside has a favourable impact on the volume and stabilization of foam in solutions. Furthermore, alkyl polyglucoside has a thickening ability and the introduction of this surfactant regulates the required viscosity of solutions [6].

Sodium Cocoamphomonoacetate is a “green” surfactant (i.e. plant-derived ingredients). It has a minimal irritating action, therefore it can be recommended as the main surfactant for baby shampoos, bath foams and shower gels. It has a high foaming capacity, forms fine and creamy foam. Along with the washing abilities it also has conditioning properties. It is non-toxic and biodegradable [7].

Disodium Laureth Sulfosuccinate is succinic acid salt, anionic surfactant. Structurally, it is a larger molecule in comparison with other surfactants, so it can hardly penetrate the skin. It facilitates the reduction of skin irritation from other anionic surfactants. It has an excellent cleansing ability and easy to wash, produces rich thin foam. It is included in the composition of gentle and baby shampoos,

intime hygiene products [8].

Coco Glucoside and Glyceryl Oleate Lamesoft PO65 is a composite natural surfactant with a thickening effect that facilitates the protection of the lipid layer of hair and scalp.

Citric Acid is an oxypropanetricarboxylic acid, widely found in nature; it is obtained from natural plant sources or by fermentation of sugar. It is used in cosmetic preparations as a pH modifier and chelating agent [9].

Disodium EDTA is used in cosmetics as a calcium and magnesium complexing agent to soften water. It acts as antioxidants and preservatives synergist [9].

Glycerin is triatomic alcohol, characterized by high hygroscopicity. It can absorb up to 40% of water from the air in relation to the original mass. It provides moisturizing action in cosmetics.

D-panthenol is a B5 provitamin with pantothenic acid action. It produces a healing, moisturizing and smoothing effect.

Wheat Protein Hydrolysate is a low molecular wheat protein that penetrates into the hair, strengthens, protects and restores the hair from the inside. It is absorbed even during instant processing; the result is achieved within minutes. It soothes irritated skin, has proven to have anti-inflammatory activity.

PPG-3 Caprylyl Ester is made from natural fatty oils. It has excellent conditioning qualities.

Sodium Benzoate is a preservative.

Hydroxyacetophenone is an antioxidant.

Camomile extract produces anti-inflammatory, antibacterial and soothing effect. It is used in anti-wrinkle creams and for acne treatment. It is also used in many hair care products. It is widely used in the manufacturing of cosmetics, especially in baby products [10].

We have used three types of surfactants (Alkyl Polyglucoside, Sodium Cocoamphomonoacetate, Disodium Laureth Sulfosuccinate) in the formulation of Baby Foam-Shampoo from Head to Toe which, by their properties and with a certain percentage of introduction into the formulation, can provide the specified foam characteristics in the developed product. To determine the optimal percentage of surfactant application into the baby foam-shampoo formulation the method of simplex Sheffe lattices was used. Accordingly, the factors to be optimized were:

X_1 – Alkyl Polyglucoside content

X_2 – Sodium Cocoamphomonoacetate content

X_3 – Disodium Laureth Sulfosuccinate content

We will introduce and analyse these components within certain variation limits to obtain optimal results. Different combinations of surfactants were tested in aqueous solutions. The variation boundaries of the ingredients content in solutions are indicated in Table 1.

Table 1.
General formulation of prototypes

Name of raw materials	Content of the basic substance, %
Alkyl Polyglucoside	from 1 to 10
Sodium Cocoamphomonoacetate	from 1 to 6
Disodium Laureth Sulfosuccinate	from 1 to 8
Coco Glucoside and Glyceryl Oleate	1
Glycerin	1
D-Panthenol	0.3
PPG-3 Caprylyl Ester	0.2
Hypoallergenic Perfume	0.3
Wheat Protein Hydrolysate	0.1
Water-Glycerin Camomile Extract	0.1
Citric Acid	1
Disodium EDTA	0.1
Sodium Benzoate	0.5
Hydroxyacetophenone	0.3
Purified water	up to 100

The boundaries of the levels variation in experimental factors in the range from 1 to 10% are set out in Table 2. Levels variation is provided in coded and natural values.

Table 2.
Levels variation of experimental factors

Factors	Levels variation in coded values					
	0	0.25	0.33	0.5	0.75	1
Alkyl Polyglucoside, %	1.0	2.5	3.3	5.0	7.5	10.0
Sodium Cocoamphomonoacetate, %	1.0	1.5	2.0	3.0	4.5	6.0
Disodium Laureth Sulfosuccinate, %	1.0	2.0	2.6	4.0	6.0	8.0

All modern foaming agents should not only provide consumers with a high foam content and its long-term stability, but also such important additional quality characteristics as the foam density, its flintiness, pleasant feelings of ease of use. Currently, the standard indicators are State All-Union Standard (GOST) 31696-

2012, which do not allow us to evaluate the above mentioned factors. In this regard, for the purpose of the experiment we chose such indicators as foam height, stability and density according to a new method of qualitative determination of the volumetric mass of foam (foam density) [11].

The results of the experiment are shown in Table 3.

Table 3.
Planning and experiment matrix

Experiment Number	Coded			Natural			Y ₁ , H ₀ , mm	Y ₂	Y ₃ ·ρ·10 ³ , g/cm ³
	X ₁	X ₂	X ₃	Z ₁ , %	Z ₂ , %	Z ₃ , %			
1	1	0	0	10.0	1.0	1.0	135	0.95	67.8
2	0	1	0	1.0	6.0	1.0	76	0.70	40.3
3	0	0	1	1.0	1.0	8.0	98	0.80	40.5
4	0.75	0.25	0	7.5	1.5	1.0	130	0.88	65.6
5	0.25	0.75	0	2.5	4.5	1.0	126	0.90	54.2
6	0	0.75	0.25	1.0	4.5	2.0	116	0.81	40.9
7	0	0.25	0.75	1.0	1.5	6.0	124	0.85	39.1
8	0.75	0	0.25	7.5	1.0	2.0	140	0.92	62.2
9	0.25	0	0.75	2.5	1.0	6.0	121	0.83	61.0
10	0.33	0.33	0.33	3.3	2.0	2.6	145	0.97	70.4

We get a mathematical model of the dependency values, which are response functions. The dependency values of the foam height, stability and density are calculated by the equations:

$$Y_1 = 130,45X_1 + 81,18X_2 + 97,36X_3 + 118,30X_1 X_2 + 88,48X_1 X_3 + 163,88X_2 X_3 + 22,0X_1 X_2 X_3;$$

$$Y_2 = 0,926X_1 + 0,728X_2 + 0,796X_3 + 0,335X_1 X_2 + 0,075X_1 X_3 + 0,364X_2 X_3 + 1,82X_1 X_2 X_3;$$

$$Y_3 = 65,109X_1 + 41,07X_2 + 42,421X_3 + 36,32X_1 X_2 + 41,79X_1 X_3 + 9,31X_2 X_3 + 357,0X_1 X_2 X_3,$$

where Y₁ is the initial foam height, mm;

Y₂ – foam stability;

Y₃ – foam density, ρ·10³ g/cm³.

The implementation of mathematical calculations was carried out using Statistica computer program.

Due to the fact that there are three variable values in the equations, we make simplex Scheffe lattices in the form of 3D graphic images and two-dimensional models in the form of triangles to visualize the results and facilitate the determination of optimum zones by the dependency functions of the initial height, stability and density of the foam on the surfactant composition.

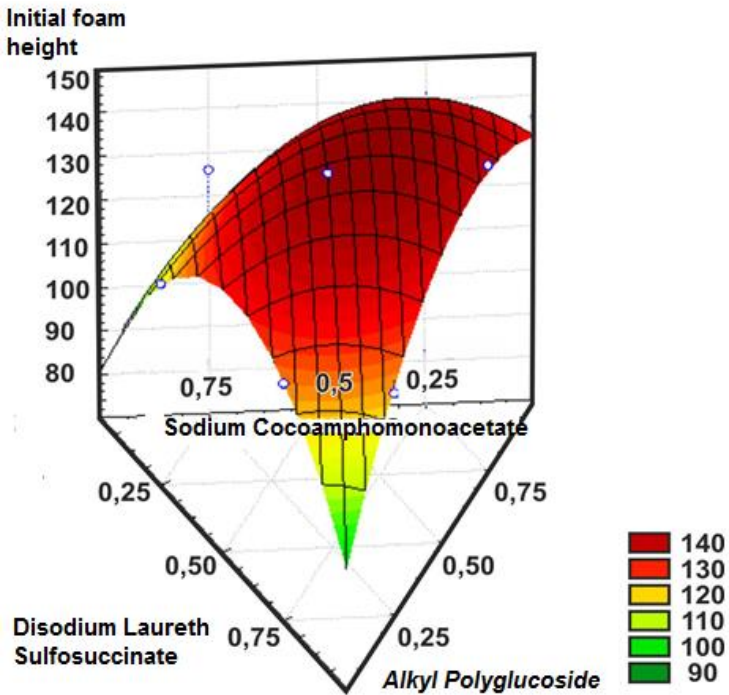


Figure 1. Graphical solution of the dependence mathematical model of the initial foam height on the composition of surfactants

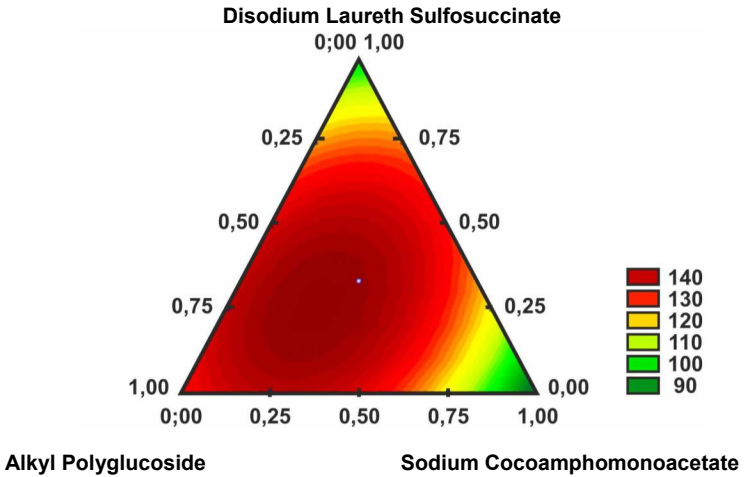


Figure 2. Torus lines of initial foam height dependence on the composition of surfactants

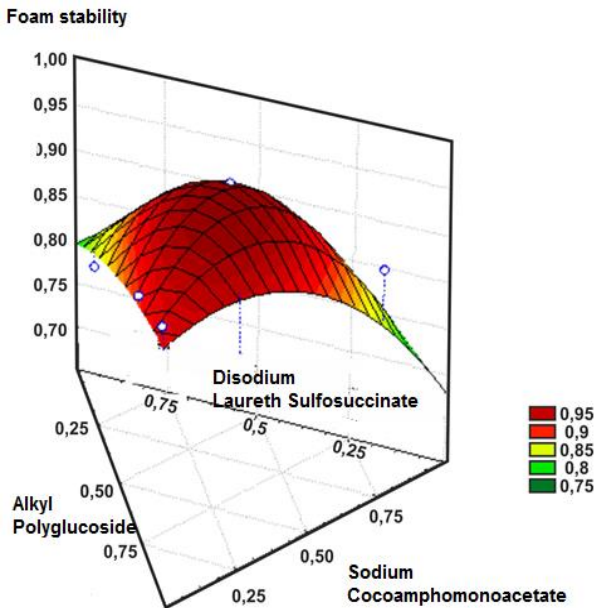


Figure 3. Graphical solution of the dependence mathematical model of foam stability on the composition of surfactants

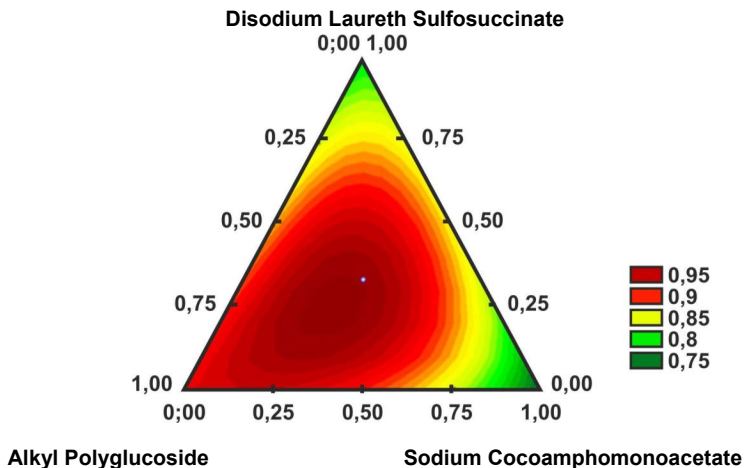


Figure 4. Torus lines of dependence of foam stability on the composition of surfactant

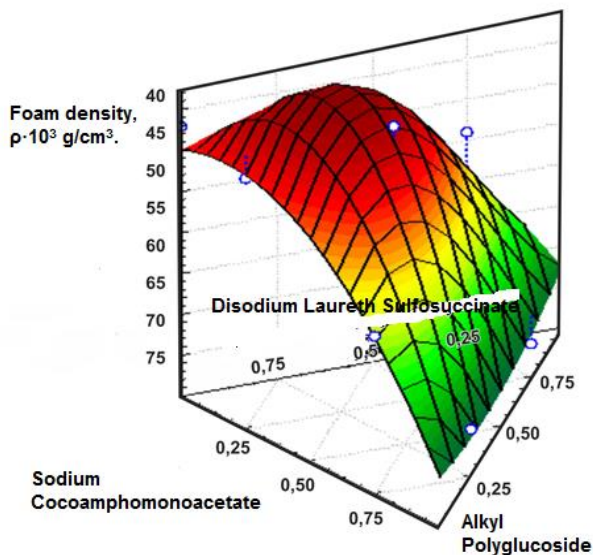


Figure 5. Graphical solution of the dependence mathematical model of foam density $\rho \cdot 10^3, \text{ g/cm}^3$ on the composition of surfactants

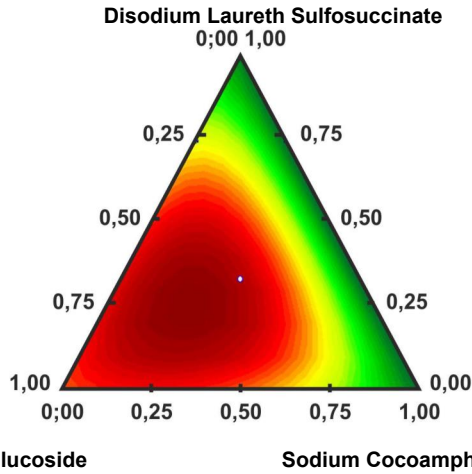


Figure 6. Torus lines of foam density dependence $\rho \cdot 10^3$, g/cm³ on the composition of surfactants

Table 4 reveals three functions with their optimum in coded and natural units.

Table 4.
Optimization values of dependency functions

Optimal function values	Range of factors					
	coded values			natural values		
	X ₁	X ₂	X ₃	Z ₁ , %	Z ₂ , %	Z ₃ , %
Y ₁ – initial foam height (140–150, mm)	0.60–0.75	0.25–0.45	0.20–0.25	6.0–7.5	2.0–3.6	1.6–2.0
Y ₂ – foam stability (0.9–0.95)	0.65–0.80	0.40–0.45	0.2–0.25	6.5–8.0	2.4–2.7	1.6–2.0
Y ₃ – foam density, $\rho \cdot 10^3$, g/cm ³ (65–70)	0.7–0.8	0.20–0.45	0.20–0.30	7.0–8.0	1.2–2.7	1.6–2.4

Based on the results obtained, it can be concluded that the optimum shall be the foam density function, and the natural values in it will be optimal for use in the developed formulation.

Later the formulation with the optimal ratio of surfactants was reproduced in the laboratory.

The technological scheme of foam-shampoo production sequence is presented in Figure 7.

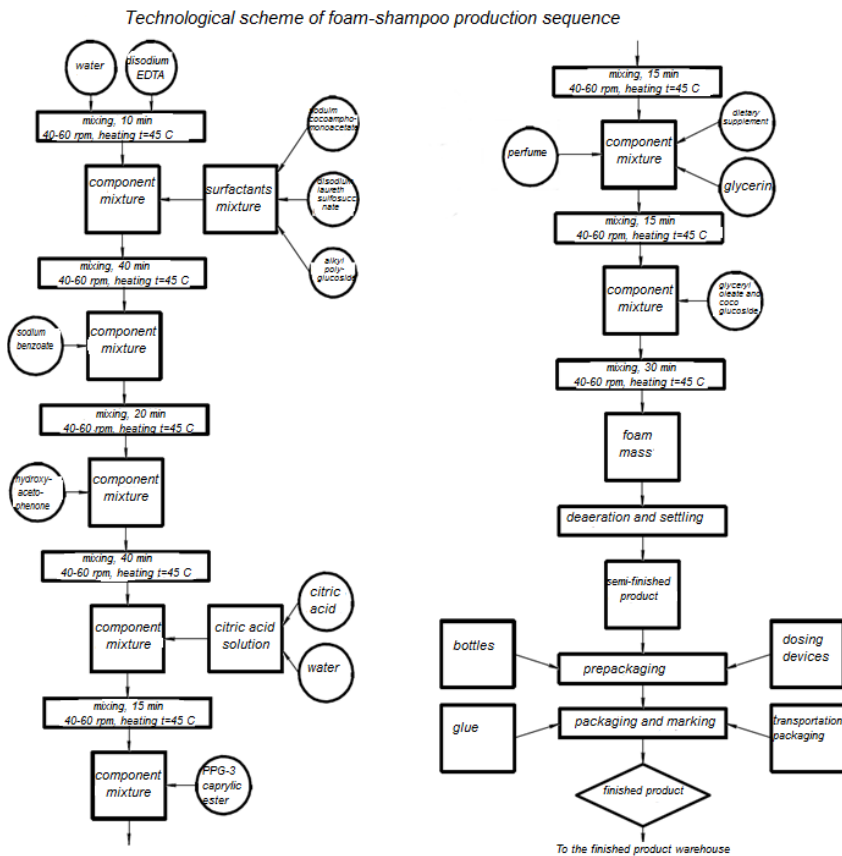


Figure 7. Technological scheme of foam-shampoo production sequence

Results and interpretations

Furthermore, the analysis of physico-chemical and organoleptic indicators according to GOST 31696-2012, microbiological safety indicators according to GOST ISO 21149-2020 was carried out. The results are depicted in Table 5.

Table 5.
Physico-chemical, organoleptic and microbiological safety indicators of the baby foam-shampoo

Identifiable indicators	Regulatory documents on test methods	Indicator values	
		according to the regulatory documents (GOST 31696-2012, TRCU 009/2011)	according to the test results
appearance	GOST 29188.0-2014	homogeneous single-phase or multiphase liquid (gel-like or creamy mass, liquid or thick) without foreign impurities	homogeneous thick gel-like mass without foreign impurities
colour	GOST 29188.0-2014	characteristic of the colour of the named product	light yellow
odour	GOST 29188.0-91	characteristic of the odour of the named product	compliant
hydrogen exponent, pH	GOST 29188.2-2014	5.0–8.5	5.7
foaming capacity, mm: • foam height • foam stability, minimum	GOST 22567.1-77	145 0.8	225 0.96
chloride mass fraction, %, maximum	GOST 26878-86	6.0	1.6
dry matter mass fraction, %, minimum	GOST 29188.4-91	–	23.4
Viscosity according to Brookfield, cPs, at T = 25 °C spindle No.3, speed 20 rpm	instruction of 170117	–	3820
foam density, g/cm ³ , ρ·10 ³	cl. 3.2	–	70
total number of mesophilic aerobic microorganisms, CFU/g	GOST ISO 21149-2020	≤ 1.0 · 10 ²	≤ 1.0 · 10 ¹

The sample complies with the requirements of GOST 31696-2012 and TRCU 009/2011 by the verified indicators, which confirms the safety and effectiveness of the baby foam-shampoo. It has been confirmed by test protocols in accredited testing laboratories of LLC Center for New Technologies Plus, LLC Testing Center for the Quality Control of Products, Moscow.

Evaluation of consumer properties of the developed product

Formulations of mild foaming products containing “natural” non-ionic surfactants are complex multicomponent systems and are often used to develop baby cosmetic and hygienic detergents. Such products require a thorough evaluation of their properties by various indicators. Such indicators include physico-chemical, organoleptic and consumer ones [12, 13]. The developers of such formulations shall consider a significant number of factors, one of the main ones is the skin and hair condition after applying the product (absence of irritation). Subjective methods of assessment through consumer testing can be used to evaluate these factors. Consumer characteristics are subjective, since it is impossible to provide their direct quantitative specification. In these cases, expert methods can be used that bring subjective laboratory assessment methods closer to scientific data and enable to carry out statistical analysis of the results obtained [14,15].

For a correct assessment, it is necessary to choose the optimal number of the product quality characteristics reflecting its main properties. For the developed baby foam-shampoo which contains a non-ionic “natural” surfactant alkyl polyglycoside we have chosen 8 indicators / characteristics depicted in Table 6. Point scales were used during the evaluation of the qualitative indicators / characteristics of the product. The distribution along the point scale is determined by the product developer. Interpretation of the point evaluation of the qualitative characteristics for the baby foam-shampoo is provided in Table 6.

Table 6.*Point evaluation of consumer properties of the baby foam-shampoo*

Name of the indicators	Points				
	5	4	3	2	1
feeling of irritation	totally absent	minor	light	average	strong
feeling of moisturizing	very good	good	satisfactory	bad	very bad
foam formation	very good	good	satisfactory	bad	very bad
ease of rinsing	very good	good	satisfactory	bad	very bad
cleansing ability	very good	good	satisfactory	bad	very bad
odour	very pleasant	pleasant	satisfactory, presence of chemical odour	unpleasant	very unpleasant
combability	very good	good	satisfactory	bad	very bad
cost-effectiveness of consumption	very cost-effective	cost-effective	satisfactory	not cost-effective	extremely large

For consumer evaluation we asked the parents of the children who used the samples in accordance with the description and directions for use provided.

Description of the detergent:

Very mild and safe bath product for babies based on a special combination of mild surfactants allows to softly cleanse the delicate baby skin and hair.

Directions for use:

Apply a small amount of the product to the body and hair of the baby, gently foam, then rinse with water. Or add a little amount of foam-shampoo to the baby bath; rinse the hair and body with warm water after bathing.

The results of the evaluation by a 5-point scale are entered into the tasting list and statistically processed.

The developed product was compared with the competitor for an objective evaluation. As a competitor, Bubchen bath product was used, since it based on mild surfactants. This product belongs to the premium segment and is very popular in its category.

All indicators of consumer characteristics of the product are arranged in the order of importance. Summary Table 7 contains the data for statistical processing.

Table 7.

Summary table of examination results processing of baby foam-shampoo for washing

Weight coefficient (α)	Features (X)	Ordinal number of the tasting list										Average statistical value of the feature	Average statistical value of the feature including weight coefficient	Average deviation of each feature from the average set of features (S)
		1	2	3	4	5	6	7	8	9	10			
0.2	feeling of irritation	5	5	5	5	4	5	5	4	5	5	4.8	0.96	3.85
0.15	feeling of moisturizing	4	5	5	5	5	5	5	5	5	4	4.8	0.72	4.09
0.15	foam formation	5	5	4	5	4	5	5	5	4	5	4.7	0.71	4.11
0.12	ease of rinsing	5	4	5	5	4	5	5	4	5	5	4.7	0.56	4.25
0.1	cleansing ability	5	5	5	5	5	5	5	4	5	5	4.9	0.49	4.32
0.1	Odour	5	5	5	4	5	5	5	4	5	5	4.8	0.48	4.33
0.1	Combability	5	5	5	5	5	5	5	4	5	5	4.9	0.49	4.32
0.08	cost-effectiveness of consumption	5	5	5	5	5	5	5	4	5	5	4.9	0.39	4.42
Average statistical value of the set of features (C)												4.81	–	–
Function (F)													4.80	–

Final evaluation of consumer properties is established by combining all the indicators into one function F based on the application of weight coefficients and is calculated by the equation

$$F = \alpha_1 \cdot S_{cp}^1 + \alpha_2 \cdot S_{cp}^2 + \dots + \alpha_n \cdot S_{cp}^n \text{ where } \sum_{i=1}^n |\alpha_i| = 1$$

Table 8.

Summary table of the examination results processing of Bubchen washing product

Weight coefficient (α)	Features (X)	Ordinal number of the tasting list										Average statistical value of the feature	Average statistical value of the feature including weight coefficient	Average deviation of each feature from the average set of features (S)
		1	2	3	4	5	6	7	8	9	10			
0.2	feeling of irritation	4	5	5	5	4	4	5	4	5	5	4.6	0.92	3.77
0.15	feeling of moisturizing	4	5	5	5	5	4	5	5	5	4	4.7	0.71	3.98
0.15	foam formation	5	5	4	5	4	5	5	5	4	5	4.7	0.71	3.98
0.12	ease of rinsing	5	4	5	5	4	5	5	4	5	5	4.7	0.56	4,12
0.1	cleansing ability	5	5	5	4	5	5	5	4	5	5	4.8	0.48	4.21
0.1	Odour	5	5	5	4	5	5	5	4	5	3	4.6	0.46	4.23
0.1	Combability	5	5	5	3	5	5	5	4	5	5	4.7	0.47	4.22
0.08	cost-effectiveness of consumption	5	5	3	5	5	5	5	4	5	5	4.7	0.38	4.31
Average statistical value of the set of features (C)												4.69	–	–
Function (F)												4.68	–	–

The conclusion on the effectiveness of baby foam-shampoo for washing based on the analysis of a single indicator value excludes the possibility of a subjective and incomplete evaluation of the quality of the analyzed product. This technique enables to develop a product with the most profitable properties for the consumer for a minimum period of time. The developed composition of the foam-shampoo received a high consumer rating and by the overall consumer evaluation it outrated the market competitor.

Conclusion

Thus, the developed formulation of baby foam-shampoo for washing, based on alkyl polyglucoside, obtained from renewable plant raw material with a special combination of mild surfactants meets the requirements of GOST 31696-2012 and TR CU 009/2011 by all physico-chemical and microbiological indicators, which confirms its safety and effectiveness. Very mild and safe baby product for bathing enables to safely cleanse the delicate baby skin and hair.

The combination of mild surfactants we have chosen makes it possible:

- to develop mild, completely safe, hypoallergenic, affordable baby care products from early ages;
- to expand the range of affordable mild, safe, environmentally-friendly foaming products with improved consumer characteristics (cleansing properties, foaming capacity, foam height, foam stability, density and flintiness), both for cosmetics and household chemicals;
- to obtain a significant economic effect through the use of surfactants obtained from secondary sunflower processing products, which is economically profitable to produce in our country, thereby increasing the profitability of fat-and-oil plants;
- to partially solve the problem of disposal of foaming products washdowns, thereby improving the environment;
- to declare the product as derived from natural raw materials, biodegradable and certify according to various organic standards.

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电网综合体电气装置的防雷保护

LIGHTNING PROTECTION OF ELECTRICAL INSTALLATIONS OF THE INTEGRATED POWER GRID

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抽象的。 本文讨论了在供电系统中保护电气装置免受雷电放电(闪电)的技术和方法。 闪电的种类和类型,它是什么,随着消费者数量的增加,闪电放电带来的后果,供电系统的巨大损失。 他还间接强调了闪电在社会日常生活中带来的危险。

关键词: 防雷, 电源, 保护方法, 系统, 电流。

Abstract. *This article discusses the techniques and methods for protecting electrical installations from lightning discharges (lightning) in the power supply system. The variety and types of lightning, what it is, what consequences lightning discharges entail with an increase in the number of consumers, what enormous losses in the power supply system. He also indirectly emphasized the danger that lightning entails in everyday life in society.*

Keywords: *Lightning protection, power supply, protection method, system, current.*

Objectives:

To develop an effective way to identify the previous moments of lightning discharges in the power supply system, including modern locations. Apply various methods of making and installing lightning rods, arresters, and, if necessary, relay protection. To implement standards that set out the principles of protection of buildings and structures of any purpose from surges, allowing competently designing building structures and lightning protection systems of an object, rationally placing equipment and laying communications. To curb this natural anomaly completely.

During a thunderstorm, people are used to seeing a sparkling bright flash in the sky, after which a loud roar is heard, as if a barrel of gas had exploded. And almost everyone will think that this is happening somewhere out there, but will never overtake him. After all, only 24,000 people die from lightning a year in the world, according to Wikipedia. At a time when 1.25 million people around the world die in car accidents a year. As for the flash, this flash is called lightning, one of the most dangerous types of current, which is also one of the most wonderful electrical phenomena, powerful, not entirely predictable, not fully understood and mysterious phenomena in the world.

The nature of lightning is closely related to electricity, but humanity has not yet been able to thoroughly study it and subdue it to its will, therefore thunderstorms and lightning remain a dangerous, uncontrollable and potentially destructive natural phenomenon, from which it is impossible to fully insure.

Lightning occurs at the moment when too many charges accumulate, its role is precisely to compensate for them by transferring part of the charge from one area to another. The average lightning voltage is 100 million volts, and the length can exceed 10 km at a plasma temperature higher than on the surface of the sun. Scientists divide all such high-voltage discharges into three large groups, depending on where their beginning and end are: lightning within one cloud, lightning between clouds, and cloud-to-ground lightning.

Protection of electrical installations in the power supply system is the main indicator in this article. The trouble-free operation of electrical installations in the aggregate is ensured by the implementation of a set of organizational and technical measures. Currently, the problem of lightning protection and surge protection is becoming increasingly important due to the fact that the number of consumers in electrical networks that are sensitive to surge impulses and electromagnetic interference is increasing. There are more and more simplifications of elements in electrical circuits that are vulnerable to small lightning bolts. The simplification of elements in the system is due to the need to lighten the weight and structure of existing electrical installations.

Lightning protection is an engineering system that includes a set of specialized equipment and materials designed to ensure the safety of an object (building, structure), life and health of people located there, as well as animals, material and other values, from direct impact and consequences of getting into the object lightning discharge.

Lightning protection for buildings and structures is divided into: external and internal.

External - this is a special system of devices designed to intercept an electric discharge, divert it to the ground through down conductors. A properly designed structure will protect the building, people and animals inside from harm.

External lightning protection of buildings is divided into two types:

Passive

- grid ("spatial cell"). It is mounted on the roof of the protected object;
- lightning rod. This is one or more separate metal rods connected to the ground loop by means of a cable;
- system of tension lightning rods. They are pulled along the perimeter of the protected zone.

Active

- generates high-voltage impulses, which allows not to wait until lightning strikes the protected structure, but to capture an electric discharge at a great distance, forcibly directing it to the ground.

Structurally, the external lightning protection of buildings and structures consists of:

- lightning rod (intercepts electric discharge);
- down conductor (intermediate part conducting electric current from the lightning rod to the ground electrode);
- grounding conductor (part of lightning protection in contact with the ground, dissipating the received current discharge).

Internal - is a system (SPD) for protecting electrical equipment from overvoltage caused by lightning (inductive and resistive couplings) in the network.

SPDs are devices that protect electrical networks from sudden surges caused by lightning, connecting or disconnecting power equipment, and short circuits. Mounted at the input of the supply line, or in switchboards. To discharge excess voltage, a grounding system is required that corresponds to the design of the building, the features of the electrical network, the purpose and power of the installed equipment.

There are three classes of SPDs:

1. Designed for current up to 60Ka. They take a lightning strike and extinguish the main part of the voltage, diverting it to the ground.
2. They catch and stabilize the residual voltage up to 20Ka, which the SPD of the first class could not extinguish.
3. Designed for impulses up to 10Ka, protect high-frequency equipment. Eliminate excess potential remaining in the network after the operation of devices of the first and second class.

Figure 1 shows the behavior of an SPD in a circuit when a pulse occurs.

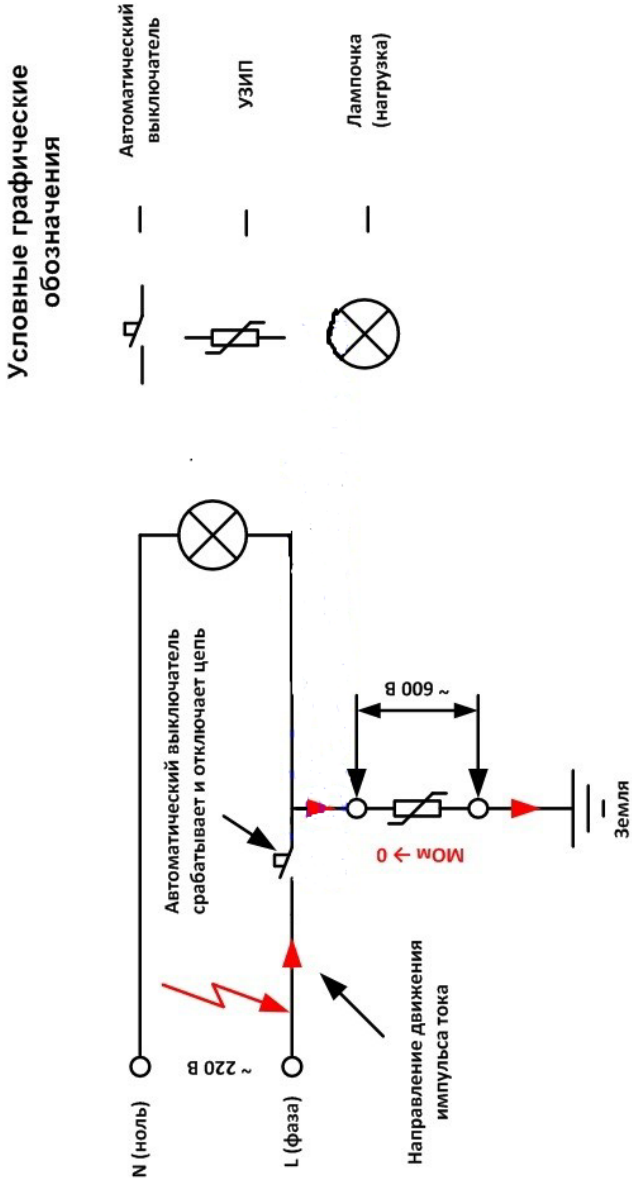


Figure 1.

Figure 1 shows a diagram that shows that when a pulse occurs in the circuit, the voltage increases sharply, which in turn causes an instantaneous, multiple decrease in the resistance of the SPD (the resistance of the SPD varistor tends to zero), a decrease in resistance leads to the fact that the SPD begins to conduct electrical current, shorting the electrical circuit to ground, i.e. creating a short circuit that trips the circuit breaker and disconnects the circuit. Thus, the surge stopper protects electrical equipment from the flow of a high voltage pulse through it.

Losses caused by lightning can be enormous, according to research results in Russia and abroad, it has been established that, depending on the location and season, up to 50% of forest fires can be caused by lightning discharges. If we take individual regions in the Moscow Oblast alone in April 2020, the number of emergency shutdowns increased by 42% in total (490 cases in 2020 against 345 in 2019).

The lightning current is always looking for the shortest path to go to the ground. Therefore, if lightning strikes a building without proper lightning protection, then the current most often spreads under the ridge beam along the electrical wiring (for example, related to the lighting network). In most cases, the consequences, if we are not talking about a fire, are associated with the destruction or damage of the attic structure, since instantaneous evaporation of residual moisture occurs in the wooden elements. The current of the lightning charge in one fraction of a second heats the electrical wiring to such a temperature that it simply burns out. This phenomenon applies to all copper wires whose diameter is less than 16 mm. For these reasons, grounding of antennas in accordance with the standards is prescribed to be carried out with copper with a diameter of at least 16 mm.

But even if the antenna is installed in accordance with the regulations, part of the lightning current penetrates the antenna screen and reaches the TV. If the antenna input to a TV, video or stereo installation is made without lightning surge protection devices, then there is an overlap in the wiring. Its consequence is the failure of almost all included electronic devices. They may even start a fire.

In a house without lightning protection, when a thunderstorm approaches, you need to unplug the antenna input and the power plugs of all electronic devices (TV, video, computer, washing and drying machines, dishwasher, etc.), if the network and electronic devices are not equipped with protection devices from overvoltage. Almost all electronic devices are very sensitive to lightning surges. Therefore, even a lightning strike at a distance of up to 2 km can disable them. If it is not possible to install a lightning rod in a private house, then at least make an effective protective grounding, since in the event of a lightning strike it is possible to remain unharmed.

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在车里雅宾斯克条件下使用太阳能电池的可能性研究 C.

**STUDY OF THE POSSIBILITY OF USING SOLAR BATTERIES IN THE
CONDITIONS OF CHELYABINSK C.**

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抽象的。根据对太阳能电池类型的分析,确定了最优选的使用方案。计算太阳能电池的发电量。进行了一项实验研究,开发了一个计算机模型,并得出了关于在南乌拉尔条件下使用该设备的可能性的结论。

关键词: 太阳能, 可再生能源。

Abstract. *Based on the analysis of the types of solar batteries, the most preferred option for use was determined. The generation of electricity by a solar battery is calculated. An experimental study was carried out, a computer model was developed, and conclusions were drawn about the possibility of using the equipment in the conditions of the Southern Urals.*

Keywords: *solar energy, renewable energy sources.*

Introduction

Recently, electricity in large cities is not enough and it is becoming more expensive. Traditional energy sources are limited in reserves and emit a huge amount of harmful substances, a peaceful atom has the possibility of a man-made disaster, and a hydroelectric power station requires huge flooded areas. Therefore, trends began to appear in the use of alternative energy sources, such as the sun, wind, hydrogen. After all, they are practically unlimited, and the cost of electricity and the payback period of these sources is decreasing every year.

Currently, Russia is increasing the amount of electricity produced by solar panels. Therefore, the goal was set: to explore the possibility of using solar panels in the conditions of the city of Chelyabinsk.

Theoretical studies

Photocells, which make up solar batteries, are divided depending on the type and are: single-crystal, polycrystalline, amorphous (flexible, film).

Directions for the use of solar batteries in world practice:

1. Portable electronics
2. Electric vehicles
3. Aviation
4. Energy supply of buildings:
5. Road facilities.
6. Space technologies

The use of solar panels in Chelyabinsk is currently carried out for the following purposes: power supply in private homes, lighting of pedestrian crossings.

Factors affecting the operation of the solar battery:

- High temperature (the higher the temperature, the worse the solar battery works);
- Partial or complete dimming of the panel;
- Cloudiness (if these are panels that use lenses to concentrate radiation).

We performed the analysis of batteries on two bases: on silicon and on film. Depending on the placement conditions, different ones may come up: if you need a certain size or shape, then a film-based SB will do, but if you need a more powerful and durable battery, then a silicon-based SB will do. The pros and cons of batteries are presented in the table:

Table 1.

	Silicon based SB	SB on a film basis
Pros	<ol style="list-style-type: none"> 1. Long-lasting batteries. 2. High efficiency. 3. Easy to purchase. 	<ol style="list-style-type: none"> 1. It can be cut into pieces. 2. Customized to any size and shape. 3. It can cover the roof with smooth curves. 4. It weighs much less than other types of solar panels.
Cons	<ol style="list-style-type: none"> 1. Big weight. 2. Not suitable for all roofs. 3. Can not be customized to the desired size and shape 	<ol style="list-style-type: none"> 1. Batteries are not as powerful as silicon batteries. 2. They are more susceptible to environmental influences. 3. It is not easy to find similar products for sale.

Based on the above comparative analysis, we conclude that it is preferable to use polycrystalline batteries, because they are cheaper than single-crystal silicon panels and are able to provide a home with enough electricity. However, if you need a battery with high efficiency, then it is better to use a single crystal battery.

Calculated part

Let us determine the characteristics of a solar module (SM) of the DELTA BST

300-24M type and calculate the power generation by a solar battery consisting of 9 modules on a site located at an angle of 0° to the horizon in a given period for the conditions of the Southern Urals. Let us draw conclusions about the expediency of using SM to obtain electrical energy in the conditions of the Southern Urals.

1. For the selected solar module, let's build the CVC. To do this, we will use the program, enter the CVC data into the results table (see Annex), noting the points of idling motion (i. m.) and short circuit (s. c.)

For each pair of voltage and current, we calculate the received power using the formula:

$$P=U*I \quad (1)$$

The calculation results are given in the appendices to the work.

Effective power P_{ef} is determined by:

$$P_{ef}=R*F_{sm} \quad (2)$$

Where R is the level of illumination, W/m^2 ; F_{cm} is the area of the SM, which is determined by the expression:

$$F_{sm} = F_{sc} * n * K_{fil} \quad (3)$$

Where F_{SC} is the area of one solar cell, m^2 , n is the number of solar cells in the module; K_{fil} is the solar cell fill factor of the solar module area.

$$F_{SM}=1.64*0.9*0.99*9=13.15m^2$$

In this way,

$$P_{ef} \approx 800 * 13.15 \approx 10520 \text{ W}$$

The results of the calculation for each point of the characteristic will be entered in the table of results

2. Electricity generation by the solar module during the period from March to August:

$$\mathcal{E}_i = \mathcal{E}_{\text{бай}} * F_{SM} * m * \eta_k * K_t * \eta_{\Delta P}^m * \eta_{\Delta \mathcal{E}}^m \quad (4)$$

where $\mathcal{E}_{\text{бай}}$ is the gross specific input of solar radiation to the site under consideration, $kW*h/m^2$ (see appendices); m is the number of modules in the solar panel; η_k - efficiency coefficient of silicon solar cell (the maximum value is taken according to the CVC SM); K_t - coefficient, taking into account the influence of the temperature of the solar module on its efficiency; $\eta_{\Delta P}^m$, $\eta_{\Delta \mathcal{E}}^m$ - respectively, power losses determined by the series connection of elements and energy transfer to the consumer.

Table 2.

№	Month	Electricity generation, kW*h
1	March	39,66
2	April	45,34
3	May	56,19
4	June	63,31
5	July	65,89
6	August	56,03

Based on the data obtained, we can conclude that our solar module generates enough electricity for the functioning of the forest house.

Calculate the gross potential using the formula:

$$И_i = \frac{\varepsilon_i}{\varepsilon_{\text{валі}}} 100\% \quad (5)$$

Table 3.

№	Month	Gross potential, %
1	March	32,75
2	April	32,7
3	May	32,7
4	June	32,7
5	July	32,7
6	August	32,7

That is, the efficiency of using solar energy to produce electrical energy using a solar module consisting of 9 elements is approximately 33%.

Experimental study

We conducted our pilot study in the Chelyabinsk Oblast near a house in the forest. It is located far from power lines, which means it requires them to carry out deforestation or install an electric generator that runs on gasoline. These methods of power supply require significant financial costs. Solar panels benefit from this: they do not require any wires or weekly costs for anything. As a result, solar panels are much cheaper and more convenient.

In the course of the study, we found out that on average there are 100 sunny days in Chelyabinsk, and we also found out the maximum and minimum heights of the sun at different times of the year

Table 3.
Data on the position of the sun for the Chelyabinsk Oblast

Season	Maximum sun height (in degrees)	Minimum sun height (in degrees)
Winter	26,33	11,4
Spring	56,53	26,67
	Maximum sun height (in degrees)	Minimum sun height (in degrees)
Summer	58,28	44,03
Autumn	43,67	13,46

We considered a silicon-based DELTA BST 300-24 M solar battery.

An experimental study of the influence of the following factors on the operation of solar batteries was carried out:

1. Influence of the position of solar panels relative to the sun

In this experiment, we changed the location of the solar battery relative to the sun.

During this experiment, we learned that the greater the angle of the solar panel to the sun, the more energy is generated.

	Voltage, Volt	Time, h	Date	Percentage
Perpendicular to the sun	2,2 V	13:55	02.03.20	100%
Rotation 90 degrees from the sun	1.6 V	13:57	02.03.20	72,7%
Rotation 45 degrees from the sun	2,1 V	14:07	02.03.20	95,5%
Readings in the shade	1,2 V	14:10	02.03.20	54,5%

1. Influence of cloudiness

In the second experiment, the readings of the solar panel were measured on a clear day, then the readings of the s.p. on a cloudy day. It turned out that cloudiness affects the generation of electricity.

	Voltage, Volt	Time, h	Date	Percentage
Fair	2,16 V	14:29	22.10.20	100%
Cloudy	1,8 V	15:13	20.10.20	83,3%

1. Influence of ice (imitation)

In this experiment, it would be possible to gradually pour snow on the solar battery, but since this experiment was carried out in early October, transparent files for documents were used instead of snow (1 file = 1 layer of snow). We then dripped water onto the solar panel to simulate rain. Also, for more accurate measurements, instead of a voltmeter, we took a multimeter.

	Volts	Time, h	Date	Percentage
No pollution	2,6 V	22:30	17.10.20	100%
	Voltage, Volt	Time, h	Date	Percentage
5 layers	1,72B	22:31	17.10.20	66,2%
10 layers	1,67 V	22:32	17.10.20	64,2%
15 layers	1,62 V	22:32	17.10.20	62,3%
20 layers	1,53 V	22:33	17.10.20	58,85%

1. Effect of dusting

	Volts	Time, h	Date	Percentage
No pollution	2,84 V	18:08	21.10.20	100%
With pollution	2,56 V	18:08	21.10.20	90,1%

2. Effect of falling leaves.

In this experiment, we sprinkled leaves on a solar panel and measured the energy produced.

	Volts	Time, h	Date	Percentage
No pollution	1,8 V	16:41	16.10.20	100%
With leaves	1,196 V	16:42	16.10.20	66,4%
With dust	1,640 V	16:43	16.10.20	91,1%

Computer model

A 3D model simulating the operation of the equipment was developed on the educational software package (Fig. 1):

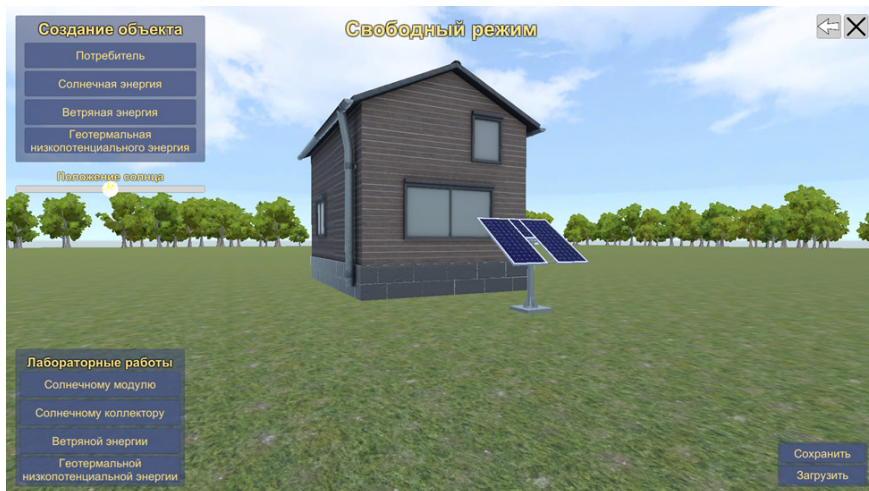


Figure 1. Computer model in 3D format

In the calculation part of the software package, data were loaded and processed simulating the operation of the installation in the conditions of the South Urals (Fig. 2 and Fig. 3):

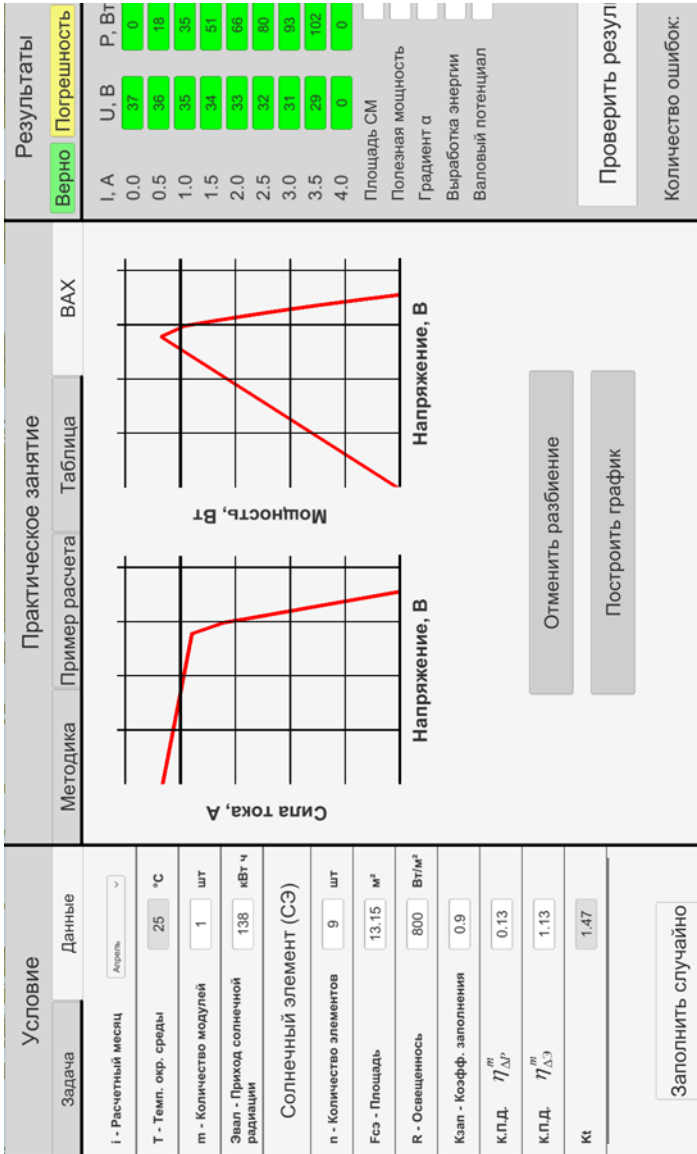


Figure 2. Calculation part of the computer model

Валовой удельный приход солнечной радиации на поверхность солнечного модуля в кВт ч/(м ² мес.) для различных углов наклона площадки β к горизонту					
Месяц	\mathcal{E}_{max} , кВт ч/(м ² · мес)				
	$\beta=0^\circ$	$\beta=28^\circ$	$\beta=43^\circ$	$\beta=58^\circ$	$\beta=90^\circ$
I	55,6	86,49	105,98	114,6	104,1
II	72,2	96,6	114,35	116,3	97,8
III	121,4	144,4	159,2	150,6	111,6
IV	138,8	145,5	149,69	129,1	76,8
V	172,0	171,7	163,35	128,2	66,7
VI	193,8	191,7	174,05	137,6	63,7
VII	201,7	191,7	181,32	145,2	65,2
VIII	171,5	174,8	178,03	147,5	80,3
IX	137,7	155,7	164,3	154,3	106,3
X	97,9	125,2	146,17	147,8	119,0
XI	53,0	75,3	92,8	97,9	85,8
XII	48,9	75,3	100,1	107,9	99,9
Год	1464,6	1634,4	1729,3	1576,1	1077,2

Figure 3. Computer model data

Conclusions

The generation of electricity by a solar battery in a given period is calculated for the conditions of the Southern Urals. The amount of electrical energy received is sufficient to supply a private house with low consumption.

The dependence of the voltage at the output of the solar panel on the influence of various environmental factors has been experimentally determined.

A computer model has been developed.

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哈巴罗夫斯克客运发展的问题与前景

**PROBLEMS AND PROSPECTS FOR THE DEVELOPMENT OF
PASSENGER TRANSPORT IN KHABAROVSK**

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注解。文章探讨了市辖区的客运问题,为什么市级企业无法与商业企业竞争,以及商业运营商为何不能提供优质的客运服务。我们研究解决问题和发展客运的方向。

关键词: 交通服务 客运 票价 城私合作 交通服务发展

Annotation. *The article deals with the problems of passenger transport in municipal districts, why municipal enterprises cannot compete with commercial ones and for what reason commercial carriers do not provide quality passenger transportation services. We study directions for solving problems and developing passenger transport.*

Keywords: *transport service, passenger transportation, fares, municipal-private partnership, development of transport service*

The issues of providing transport services to the population of municipalities are referred by Article 16 of the Federal Law of October 6, 2003 No. 131-FZ “On the General Principles of Organization of Local Self-Government in the Russian Federation” to issues of local importance. these issues are under the jurisdiction of local governments of municipalities.

Effectively solving the issues of meeting the needs for transport services for the population of municipalities, local governments, thereby, implement the directions of the social and economic policy of the Russian Federation in the field of improving the living conditions of citizens. To assess the activities of local governments in this area, you can use indicators that reflect the level of accessibility and quality of transport services.

According to such criteria as the cost of travel in public transport, the travel time along the route, the technical condition of vehicles, the waiting time for transport, it is possible to determine how effectively local governments approach solving the issues of providing transport services to residents of the municipality. It

can be noted that local governments do not always correctly assess the importance of improving the efficiency of the transport service system for residents of cities and towns. This is due to the fact that local governments do not assess the impact of transport services to the population on the development of the economy of the municipality as a whole. This is a mistake, since the system of transport services for the population of the municipality is an effective tool for ensuring the implementation of the social and economic goals of the development of the territory.

With an efficiently organized transport service, residents of cities and towns get to work, home, shops, hospitals faster, which is reflected in the saving of financial resources and time of households, and also leads to the stimulation of the development of small and medium-sized businesses. Also, through an effectively organized system of transport services for the population of the municipality, the satisfaction of the population with the comfort of urban space increases and the discontent and social tension of the population decreases.

One of the factors in the deterioration of the quality of transport services are traffic delays caused by constant and numerous traffic jams.

Here it should be taken into account that the motorization of the population is increasing from year to year. People are forced to change to cars due to the low provision of services by passenger transport. This increases air pollution, increases the load on the road network, increases the time and costs of the population for movement, resulting in increased discontent and social tension among the population. This also affects the level of trust in local governments.

According to the Department of Traffic Police of the Main Directorate for Internal Affairs of Khabarovsk Krai. There are currently about 280 cars per 1000 residents of the city. This is about 7 times more than according to the data for 1990 [1]

When the critical number of individual cars in the city is reached (according to foreign sources, 550-600 units per 1000 inhabitants), traffic will be practically limited, which cannot but affect the life support of the municipality, causing social tension in society. [1]

A long stay in a traffic jam contributes to the accumulation of so-called traffic fatigue both among passengers and drivers of vehicles, which can ultimately lead to a decrease in attention and a decrease in the level of traffic safety. [1]

No major city in the world has solved the problem of congested traffic only by increasing the capacity of the roads: "The demand for movement has always been so buoyant that the increase in the capacity of the roads only led to the emergence of new demand, which again gave rise to the problem of congested traffic". Therefore, the indicated problems of the functioning of the city passenger transport require an integrated approach to their solution. [1]

Today, in some municipalities, there is a sharp increase in fares for public transport, while the transport itself has a very low tendency to upgrade the rolling stock and improve quality characteristics. At the same time, there are often cases when drivers change the route of movement, do not comply with the traffic schedule, and the speed limit all this gives reason to think about why this happens and how to improve the quality of passenger comfort when using public transport.

Also, municipal transport companies are increasingly going bankrupt or are in a near-bankruptcy state. This is primarily due to the fact that enterprises experience a large tax burden and often this is also facilitated by inefficient management of enterprises. There is also a lack of funding, due to the deficit budgets of municipalities. And municipal enterprises cannot raise the tariff, since they work at regulated tariffs, which are usually determined by the regional authorities.

Meanwhile, municipal carriers fulfill the municipal contract and are obliged to comply with all the conditions of the contract: traffic schedule; a certain route, etc., while private carriers, according to 220 FZ, operate, as a rule, on unregulated tariffs, which allow them to determine the tariff as they see fit. At the same time, they often do not bear due responsibility for changes in the route path and traffic schedule. 220 federal law allows a private carrier not to carry out transportation for up to 3 days, and if the carrier does not go on the route for more than 3 days, then only then their route card is canceled.

Employees of municipal enterprises receive official wages; enterprises pay all necessary taxes. While commercial carriers, if they hire drivers officially, show the minimum wage with which they pay taxes. After all, drivers of commercial carriers often work on a piecework basis. Few people know this, but drivers of commercial carriers' wages depend on daily revenue, there is a certain plan, on each specific route, a certain amount that drivers must pay to the carrier per day. Everything else is the driver's and conductor's earnings. Therefore, drivers begin to fight for passengers for more money. So that, we see bus races, which often become participants in accidents in which people are injured and sometimes die.

Municipal and commercial carriers have their pros and cons. Municipal carriers often work unprofitably, but work steadily and responsibly. Commercial carriers are working to increase profits, at which time the quality of passenger service often suffers.

By combining the advantages of all carriers and minimizing the disadvantages, we can get a good organization of transportation based on municipal-private partnerships.

Municipal-private partnership in the transport industry will allow establishing a new transport system. Building a reliable transport system will increase the level of transport accessibility of citizens, reduce the level of transport discrimination of the population, increase the transport mobility of the population and improve

other indicators that characterize the efficient operation of public transport in the city as a whole. [2]

The implementation of a single dispatch control of public transport ensures the operational management of public transport and generates objective information about its functioning. For this, it is necessary, within the framework of the information and analytical system of public transport management, to informationally combine the central dispatch services of municipalities, dispatch centers at transport enterprises, railway stations and stations. Dispatch control of public transport will provide:

- improving the quality of transport services to the population through continuous automated traffic control in real time;
- coordination and synchronization of the operation of all types of public transport by linking traffic intervals by periods of the day on adjoining routes;
- increasing the efficiency of the use of rolling stock by reducing unproductive losses of time on the route and the rational use of rolling stock and reserve on the busiest routes;
- improving the safety of passenger transportation by promptly alerting vehicle drivers about accidents and emergencies on the route network and providing information support for measures to eliminate the consequences of road accidents and emergencies by organizing communication between vehicle drivers, participants in road accidents and representatives of operational services (ambulance, police, etc.);
- provision of information to the public on public transport timetables via the Internet information and telecommunications network, information kiosks, in Call-centers via urban and cellular telephone communications and through other means of informing the population;
- prompt informing of passengers at stops (stations) of public transport with the help of stop boards about the expected time of arrival (departure) of public transport, the route number and the actual time of arrival of the next vehicle.
- complete transition to automated accounting and control of the organization of the work of the transport complex by integrating railway stations, bus stations, transport enterprises and vehicles into a single information space.

Prospects for the development of transport services for residents are related to the fact that the development indicators of the municipality are changing and with an increase in the number of residents or a change in the transport network, it may be necessary to change the system for managing transport services for the population. It is possible to optimize the management of the transport service system by reorganizing the management structure of this system. The governing bodies include a body providing for the coordination of the activities of transport com-

panies providing transport services to residents of the territory.

The activity of this governing body of the transport service system for residents is aimed at coordinating the actions of the participants in the transport service system, establishing, improving and strengthening ties between these participants. Also, this body monitors the achievement of the goals set by local governments in the field of development of the transport service system by participants in the transport service system. The effectiveness of the introduction of this body into the hierarchy of the transport service management system for the population of cities and towns makes it possible to find the best ways of interaction between the participants in the public transport service system among themselves and with local governments. The speed of information exchange between the participants of this system increases. Organizers of transportation more accurately understand the goals set in the field of transport services to the population and, in turn, local governments quickly receive information about the problems of transportation.

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DOI 10.34660/INF.2022.85.33.014

梅德韦杰夫斯基铁钛矿床地质
**THE GEOLOGY OF THE MEDVEDEVSKY IRON-TITANIUM ORE
DEPOSIT**

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抽象的。本文提供了梅德韦杰夫斯基铁钛矿床的简要地质描述、发现和勘探历史、地理边界、储量和矿床的矿床性质。

梅德韦杰夫斯基油田仅限于梅德韦杰夫斯基辉长岩地块的南部。后者是库辛斯基辉长岩侵入体的一部分，位于南部的 Kopansky 地块和北部的 Kusinsko-Chernorechensky 地块之间的中间位置。

Medvedevsky 矿床的主要岩石是具有中度和浅色外观的诺长石和辉长岩。

矿区分布有中部和东部两个矿石分布区。中心带由两种浸染型矿石组成：钛铁矿和钛铁-钛-磁铁矿。钛铁矿分布在悬垂侧翼和该带的中部；钛铁矿 - 钛 - 磁铁矿矿石构成横卧面。沿中带走向，矿石的矿物组成是一致的。区内矿石矿物粒度为0.1~1.5毫米。平均晶粒尺寸从该区域的悬挂侧到横卧侧的方向增加。

东区由浸染钛铁矿组成，与中区矿石的不同之处在于球化略有增加。

关键词：钛铁矿-钛-磁铁矿，铁-钛矿，地质结构。

Abstract. *This article provides a brief geological description of the Medvedevsky iron-titanium ore deposit, the history of discovery and exploration, geographical boundaries, reserves and the nature of the deposit's ore occurrence.*

The Medvedevsky field is confined to the southern part of the Medvedevsky gabbro massif. The latter is part of the Kusinsky gabbro intrusion and occupies an intermediate position between the Kopansky massif in the south and the Kusinsko-Chernorechensky massif in the north.

The primary rocks of the Medvedevsky deposit are norites and gabbro-norites having a mesocratic and leucocratic appearance.

There are two zones of ore dissemination in the deposit area—Central and Eastern. The Central Zone is composed of two types of disseminated ores: ilmenite and ilmenite-titanium-magnetite. Ilmenite ores are found in the hanging flank and in the central part of the zone; ilmenite-titanium-magnetite ores compose the recumbent side. Along the strike of the Central Zone, the mineralogical composition of the ores is consistent. The grain size of ore minerals within the zone ranges from 0.1 to 1.5 mm. The average grain size increases in the direction from the hanging to the recumbent side of the zone.

The Eastern Zone is composed of disseminated ilmenite ores, which differ from the ores of the Central Zone by slightly increased spheronization.

Keywords: *ilmenite-titanium-magnetite ores, iron-titanium ores, geological structure.*

Introduction

The Medvedevsky field is located on the western slope of the Southern Urals within the territory subordinated to the city of Zlatoust in the Chelyabinsk region. From the north, the deposit is limited by the river Ay, from the south by exploration profile No. 47. The area of the deposit is 5 km². In 1930, the deposit was first mentioned in the works of V.P. Kazantsev as titanium-magnetite mineralization after a surface survey of the deposit area and the discovery of bedrock outcrops of titanium-magnetite.

In 1950, the Zlatoust geological exploration party of the Uralchermetrazvedka trust began prospecting works, and in 1958–1959, Kopan acid fracturing treatment under the leadership of N.N. Kuskov continued the assessment of the ore-bearing prospects of the Medvedevsky massif.

In 1962–1968, the Miass exploration team of the Chelyabinsk integrated exploration expedition carried out a detailed exploration of the ilmenite and titanium-magnetite ores of the Medvedevsky deposit (Novikov, 1968). The reserves of ilmenite and titanium-magnetite ores at the deposit as of 07/01/1968 were approved by the protocol of the State Committee for Reserves of the USSR No. 5444 dated 11/27/1968 (the Medvedevsky deposit, 1968). As of January 1, 2018, the reserves of ilmenite-titanium-magnetite ore in the A+B+C1 category were 20.7 million tons, and in the C2 category 9.5 million tons with an average TiO₂ content of 7.03% (State report, 2018).

In 1967, the Institute "Uralmekhanobr" under the leadership of T.P. Zakharova carried out industrial tests for the beneficiation of ilmenite-titanium-magnetite and titanium-magnetite ores (Zakharova, 1971). In 1973, in accordance with the decree of the Council of Ministers of the USSR, the Giredmet Institute compiled a feasibility study for the construction of the Medvedevsky GOK, which provided for the development of the Medvedevsky deposit by open pit mining with an an-

nual ore capacity of 7 million tons (the Medvedevsky deposit, 1973). Currently, the license for the use of subsoil belongs to the company Medvedevsky Rudnik, the purpose of using the subsoil is the extraction of ilmenite-titanium-magnetite ores and building stone. As of 2022, the deposit was not being developed.

Scientists of the “the Zavaritsky Institute of Geochemistry and Mineralogy”, “the Institute of Mineralogy”, “the Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry” and “the Fedorovsky All-Russian Scientific Research Institute of Mineral Resources” made a great contribution to the study of the mineralogy and the geological structure of the Medvedevsky deposit and the genesis of iron-titanium ores. These include the works of I.I. Malyshev, P.T. Pantelev, A.V. Pek, V.G. Fominykh, D.S. Steinberg, V.V. Kholodnov, G.B. Fershtater, V.A. Popov, V. S. Myasnikov, O.V. Karpova, G.M. Zaitseva, L.V. Chernysheva and others.

Geology

The Medvedevsky field is localized in the gabbro massif of the same name, which is part of the Kusinsky-Kopansky complex of gabbro intrusions, located on the western slope of the Southern Urals. The intrusion is confined to the eastern slope of the Kamenny (Shishimskie) mountains and the western slope of the Birch mountains. The Kusinsky-Kopansky complex, dated at 1.38–1.35 billion years old (Kholodnov et al., 2012, 2016), is localized within the Central Ural uplift along the deep Yuryuzan-Zyuratkul fault separating the Bashkir and Zilair meganticlinoria. The complex of gabbro intrusions is traced in a northeastern direction for 70 km and consists of four independent massifs (from north to south): Kusinsky, Medvedevsky, Matkalsky and Kopansky (Table 1). The rocks of the massifs compose lenticular-sheet-like bodies and have a single southeastern dip at an angle of 35–70° (Novikov, 1968).

Table 1.
Geometric parameters of the intrusive massifs of the Kusinsky-Kopansky complex (Novikov, 1968)

Intrusive massif name	Area, km ²	Length, km	Width, km	
			maximum	average
Kusinsky	15	15	0.8	0.37
Medvedevsky	4.7	12	1.5	0.39
Kopansky	31.0	28	2.2	1.16
Matkalsky	-	7	2.1	1.0

The massifs are associated with deposits of iron-titanium ores, which occur in the intrusions in the form of sheet deposits of solid and disseminated ores, alternating with gabbroids. According to the ratio of ilmenite and titanium-magnetite (according to Kuskov's classification) ilmenite, ilmenite-titanium-magnetite and titanium-magnetite types of ores are distinguished at the deposits (see Table 2) (Novikov, 1968).

Table 2.

Classification of iron-titanium ores of magmatic genesis (Novikov, 1968)

Igneous ore type	Mineral composition from the amount of ore, %		Chemical composition, %		TiO ₂ /Fe general
	Ilm	Ti-Mgt	Fe general	TiO ₂	
Ilmenite	>50	<50	Not limited	>50	<0.38
Ilmenite-titanium-magnetite	<50	>50	20–35	Not limited	>0.38
Titanium-magnetite	<50	>50	>35	Not limited	<0.38

Within the Kusinsky-Kopansky complex, a pronounced facies evolution of massifs and mineralization is observed from south to north, which is determined by their formation in a tectonically mobile rift structure (Kholodnov, 2008). The depth of massif formation increases from south to north from 3–4 km to 20–30 km. Accordingly, the physical parameters of the processes change: P = 1–3 kbar, T = 900–1100°C in the south (Kopansky and Matkalsky massifs) and P = 5–7 kbar, T = 600–900°C in the north (Kusinsky and Medvedevsky arrays). The temperature of the formation of rocks and ores of titanium-magnetite deposits according to magnetite-ilmenite and amphibole-plagioclase geothermometers is given by Novikova M.M. (1971).

With increasing depth in the composition of titanomagnetites, the titanium content gradually decreases: the Matkalsky and Kopansky deposits 15 wt% TiO₂, Medvedevsky 10 wt% and less, Kusinsky 1–6 wt% while the content of vanadium (from 0.5 to 1.5 wt%) and chromium (from 0.1 to 2.5 wt%) increases. In ilmenite, the amount of magnesium (from 0.7 to 1.4%) and the hematite end increases, which indicates a high value of oxygen fugacity. In the ores of the deeper northern deposits, the amount of initially isolated easy-dressing ilmenite is increasing (up to 20–40%). This leads to the predominant accumulation of titanium in shallower deposits and to an increase in the TiO₂/Fe₂O₃+FeO ratio (Kholodnov, 2012, 2016).

The intensity of rock change gradually decreases from north to south. Thus, the northern Kusinsky massif is composed of amphibolites resulting from the meta-

morphism of gabbro; the Medvedevsky massif of altered saussuritized gabbro, and only in the area of the eastern contact of amphibolites; the Kopansky and Matkalsky massifs are composed mainly of unaltered gabbro (Malyshev, 1934).

The Medvedevsky massif is characterized by a northeastern strike and dip to the southeast at an angle of 40–70°. The massif has a lenticular shape, its length is about 12 km its width is 1.5 km in the southern part, and 200 m in the northern part.

The massif is composed of a primary rhythmically layered series of rocks. In the recumbent side, pyroxenites and olivine labradorite-bitovite gabbro-norites occur; in the central part of the massif, they are replaced by olivine-free mesocratic labradorite gabbro norites. The hanging flank contains leucocratic andesine gabbro-norites. All rocks have undergone changes to one degree or another: amphibolization, saussurization, albitization, chloritization, martitization, and carbonatization in some areas (Novikov, 1968). The recumbent side of the southern part of the gabbroid massif, according to geological exploration data, is in direct contact with quartzites, quartzite-sandstones, quartz-mica and carbonate rocks of the Satka Formation of the Lower Riphean; the hanging flank borders on granites and granite-gneisses of the Gubenskaya intrusion (Kholodnov, 2012). The contact has a southeast dip, an angle of 50–60°. A characteristic feature of the Medvedevsky massif is rhythmic layering, formed by gabbro layers containing different amounts of nonmetallic (plagioclase, augite, hypersthene, olivine) and ore minerals. In general, there is a tendency towards an increase in the plagioclase content in the direction from the recumbent to the hanging side of the massif, and a decrease in the amount of augite and hypersthene in the same direction. Olivine is recorded only in samples from the recumbent side; in the direction of the central part of the massif, it gradually disappears (Novikov, 1968). It is important to note the presence of “hidden layering” of the Medvedevsky massif, expressed in a gradual change with depth in the elemental composition of rock-forming minerals—plagioclase, augite, hypersthene, and olivine. The composition of each mineral is transformed as it approaches the hanging flank, the rocks are gradually enriched with low-temperature members of the reaction series of solid solutions. Olivines and pyroxenes are enriched with iron, and plagioclases are enriched with sodium.

The structures and—to a lesser extent—the textures of rocks also undergo changes in this direction. In the recumbent flank, olivine gabbro-norites and mesocratic gabbro-norites have a predominantly poikilitic structure, which is replaced by an ophitic structure in the central part of the section. In the hanging side of the massif, the mesocratic gabbro-norites have a gabbro-ophite and gabbro structure, and the leucocratic gabbro-norites have a granular structure. Transitions of mesocratic gabbro-norites from fine- to medium- and coarse-grained varieties are also noted. The texture of the rocks of the recumbent side is predominantly massive,

the rocks of the central part of the massif exhibit a banded texture due to the orientation of the grains of the rock-forming minerals.

In the southern part of the massif, two zones of disseminated iron-titanium ores (Main and Eastern) were identified, characterized by the absence of clear boundaries with the host rocks. They were delineated according to sampling data. The Main zone is traced at 2700 m along the strike and 600 m along the dip. The thickness of the zone varies from 75 to 250 m. The lying side of the ore zone contains mainly disseminated titanomagnetite ores, and the hanging side contains disseminated substantially ilmenite ores with a transitional strip between them, disseminated ilmenite-titanomagnetite ores. In the composition of the Main ore zone, as well as parallel to the primary layering of the massif, there are sheet-like deposits of continuous titanium-magnetite ores (Novikov, 1968).

The Eastern ore zone is traced for 1500 m along the strike and 400 m along the dip. The thickness is from 10 to 150 m. It is located near the eastern contact of the deposit and the massif, almost entirely composed of disseminated ilmenite ores, and only in the recumbent side is a wedging out interlayer of titanium-magnetite ore observed. In the zones of disseminated titanium-magnetite ores and below, interlayers of massive titanium-magnetite ores are often noted. They have gradual transitions to densely disseminated and then disseminated titanium-magnetite ores. Ores occur in the form of sheet-like and lenticular bodies, consistent with the layering (banding) of the massif. Among the disseminated ores, there are thin layers of massive titanium-magnetite ores. The disseminated ilmenite and titanium-magnetite ores of the deposit are medium-grained mesocratic and melanocratic gabbros and gabbro-norites containing impregnated ore minerals—ilmenite, titanium-magnetite, hematite. Ilmenite ores are 75–95% ilmenite; titanium-magnetite accounts for 80–90% of the total titanium-magnetite ores.

Conclusions

The iron-titanium ores of the Medvedevsky deposit, characterized by high variability of structural features and material composition, are of practical interest from the standpoint of obtaining iron and ilmenite concentrates to provide metallurgical enterprises with raw materials.

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北极西部地区的天然气水合物: 前景和问题

GAS HYDRATES IN THE WEST ARCTIC SECTOR: PROSPECTS AND PROBLEMS

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抽象的。 本文考虑了天然气水合物研究的历史, 以及它们在西北极大陆边缘形成的可能模型。 讨论了天然气水合物的开发前景和环境风险问题。 根据地震声学资料, 给出了波莫尔斯基海槽内气体饱和和厚度单元的解释。

关键词: 波莫尔斯基海槽 西北极大陆边缘 连续地震声波剖面 陆坡 冲积扇 天然气水合物

Abstract. *History of gas hydrates study, possible models of their formation within the West Arctic continental margin have been considered in the paper. Prospects of gas hydrates development and problems of environmental risk have been discussed. The interpretation of gas saturated thickness unit within the Pomorsky trough according to seismic-acoustic data has been given.*

Keywords: *Pomorsky trough, West Arctic continental margin, continuous seismic-acoustic profiling, continental slope, alluvial fans, gas hydrates*

Introduction

Recently the continental margin basins generate more and more interest from the standpoint of hydrocarbon exploration. After the discovery in the mid-twentieth century of previously unknown properties of natural gases to form in the Earth's crust under certain thermodynamic conditions deposits in the solid state researches of gas hydrates in the oceans have been intensified.

Crystalline compounds are formed under certain conditions of temperature and

pressure of the water and gas. In the 1940s, Soviet scientists hypothesized the existence of gas hydrates deposits in the permafrost zone (Strizhov, Mokhnatkin, Chersky). In the 1960s, they discovered a first deposit of gas hydrates in the north of the USSR, and at the same time the possibility of formation and existence of hydrates in nature found its laboratory confirmation.

Since then, gas hydrates are regarded as a potential source of fuel. Their wide distribution in the oceans and continents of permafrost, the instability with increasing temperature and decreasing pressure are found out.

To some extent, gas hydrates are ice-like mass of white colour, formed by water and gas. In addition to methane (ethane, propane) gas hydrates contain carbon dioxide and hydrogen sulfide. Features of formation of gas hydrates and their distribution patterns in nature are detailed in the works of *Vasiliev et al.* (1970), *Ginsburg and Soloviev* (1994), *Zhizhchenko* (1972), *Efremova* (1979), *Makogon* (2003), *Trofimuk et al.* (1979) and others.

The growth of research activity is explained by the following factors:

- * the search for alternative sources of hydrocarbons in the countries that do not possess energy resources, as gas hydrates are non-conventional sources of hydrocarbon raw materials, research and industrial development of which may begin in nearest future;

- * the need to assess the role of gas hydrates in the subsurface layers, particularly in relation to their possible influence on global climate change;

- * manifestations of natural hydrates could serve as markers of a more deep-seated oil and gas fields;

- * intensive development of hydrocarbon fields located in the complex natural environment (the deep shelf, the Arctic regions), where the problem is exacerbated by man-made gas hydrates;

- * feasibility of reducing operating costs to prevent hydrate formation in the systems of commercial production of gas by switching to energy-saving and environmentally friendly technologies;

- * the possibility of using gas hydrate technology in the development, storage and transportation of natural gas.

Studies in the Western Arctic sector

In the Western Arctic sector gas hydrates are found to the north-west of Svalbard (*Posewang, Mienert, 1999*).

Their study was carried out with high-frequency seismic, with an analysis of travel-time curves and velocity.

However, the area of the West Spitsbergen continental margin and especially of the continental slope has been studied insufficiently. Systematic integrated geological and geophysical studies have been conducted here since 2003 by Marine Arctic Geological and Geophysical Expedition of Murmansk. As a result of

these studies information about the foundation has been obtained, the structure of the sedimentary cover and features of sedimentation reflected in the avalanche sedimentation rate of the formation of alluvial fans on the continental slope and the foot have been studied (Zakharenko, 2007; 2012; Zakharenko et al., 2007a,b; 2010).

Basing on seismic and geochemical studies, we highlighted a potentially promising area - along the shelf edge, within which much of the hydrocarbon gas is of epigenetic nature, suggesting the migration of hydrocarbons in these areas from the deeper horizons, and therefore, the presence of hydrocarbons. This work presents the results of studies of gas hydrates based on seismic activities of MAGE in the project "Integrated geological and geophysical studies in the Pomorsky trough of West-Spitsbergen continental margin", 2009 (Fig. 1).

The interpretation of the wave field by geophysical transects, as well as the construction of maps was carried out using a digital interactive system Kingdom Software 8.2 SMT.

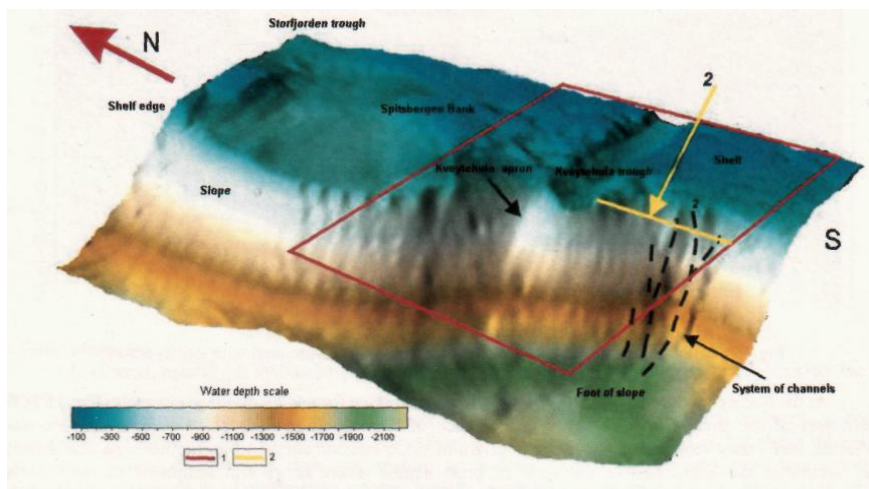


Figure 1. Map of the studied area

The presentation of the bottom topography 3D (Zakharenko, 2012):

1 - the research area, 2 - the system of erosion cuttings (channels) on the edge of the shelf and continental slope

Sedimentation model for the formation of gas hydrates

We are basing the sedimentation model of gas hydrates formation on the ideas about stream sedimentation, in particular, the turbidity currents that carry sediment material to the base of the continental slope or the bottom of the trenches.

If the body of landslides and avalanches giving rise to such flows contain the free gas, then, as it moves down the slope, the gas bubbles can (under favorable conditions) form a cluster of buried hydrate.

It is known that the cause of landslides can be not only the decomposition of hydrates, but also their formation, which can cause redistribution of stresses in the arrays of deposits and cause them to move -geodynamic consequence. Continental margins are areas of discharge of fluids, like moving from the land and the squeeze from the sediment under the influence of tectonic stress. A prerequisite for the formation of the rising fluid is a high rate of sedimentation on continental margins.

The wave field detected acoustically transparent body, which in combination with other indirect signs (sudden interruption of the correlation of reflecting horizons, dome-shaped "bulge" of overlying horizons, the presence of the characteristic noise "migrating" on the layers up the hill) indicate gas saturation in the Pleistocene strata area (Fig. 1,2).

On the plan this area is located in a decrease between two alluvial fans, and geological conditions are consistent with the above conditions of formation of gas hydrates. Comparison of the results of deep seismic data has shown a direct spatial connection with anticline uplift in the sedimentary cover, which was further confirmed by the results of gas hydro-chemical shooting and with zones of high concentrations of dissolved hydrocarbons.

Analysis of the power distribution of Quaternary sediments indicates the intense removal of terrigenous material on the chute Kveyteholá with the formation of young alluvial fan (*Zakharenko, 2012*).

In the southern area of the structure lower Pleistocene seismostratigraphic subcomplex acquires a specific character. On the profiles along the strike of the continental margin at the top and bottom of seismic complex some anomalies of the wave field are indicated. They are interpreted as erosion channels (amplitude of the "incision" to 200 ms) and probably representing the channel flow, cut during the oscillation of ice sheets and legacy from the late Pliocene (Fig. 3). These anomalies of the wave fields are marked between the alluvial fan Storfjorden and fan Bjornoyai. Erosion on the sides of cuttings is allocated to cross-bedded seismic facials pattern of seismic records interpreted as alluvial ridges.

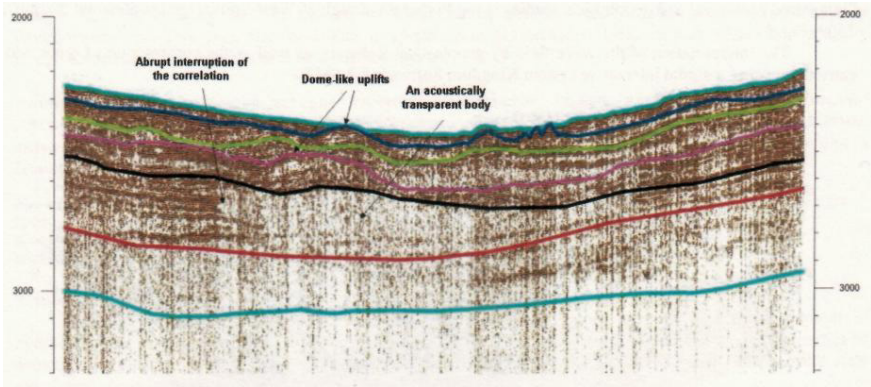


Figure 2. The example of an acoustically transparent body associated with gas hydrates

At the bottom topography we see a highly dissected surface formed by drainage channels (Fig. 1). In the eastern part of the studied area regressive appearance of deposits shows the prevalence of shallow-water conditions, here sandy sediments of terrigenous origin of slope incision are possible. Further west, the shallow-water sediments are distributed in the zone of great depths where in general sediments of more clayey composition dominate. Most of these complexes have been eroded by shelf glaciations of the last 0.8 million years. Shortly after the start of the cycle of the ice shelf formation in the Barents Sea, a huge landslide formed on the slope and shelf edge (Richardson *et al.*, 1992).

The landslide is characterized by the presence of both alternating blocks and more chaotic parts formed probably due to the collapse of the materials and debris and material transport by turbidity currents. To a great extent this process is reflected in the sediments of the Late Miocene and Pleistocene sediments observed in the slope of the cones. It is assumed that the cause of the landslide could be the factors such as high rate of sedimentation and the presence of gas in the sediments. An additional factor causing the formation of a landslide could be seismic effects.

Thus, analyzing the patterns of distribution and the formation of submarine gas hydrates on continental margins, we can identify common features:

- * Continental margins are areas of discharge fluid as moving from the land side, and squeeze of the sediment under the influence of tectonic stress.

- * A prerequisite for the formation of the upward-fluid is a high rate of sedimentation on continental margins (avalanche sedimentation).

- * Pleistocene period was characterized by development of turbidity currents formed in the degradation of the glacier, and possible presence of local desalinated water. Desalination of pore water is not evidence of indispensable presence of

gas hydrates in the areas of abnormal salinity; however, it can be regarded as an auspicious sign for the hydrate.

* Features of the wave field discovered in some areas according to the seismic work of MAGE mark gas saturation zone of Pleistocene precipitation.

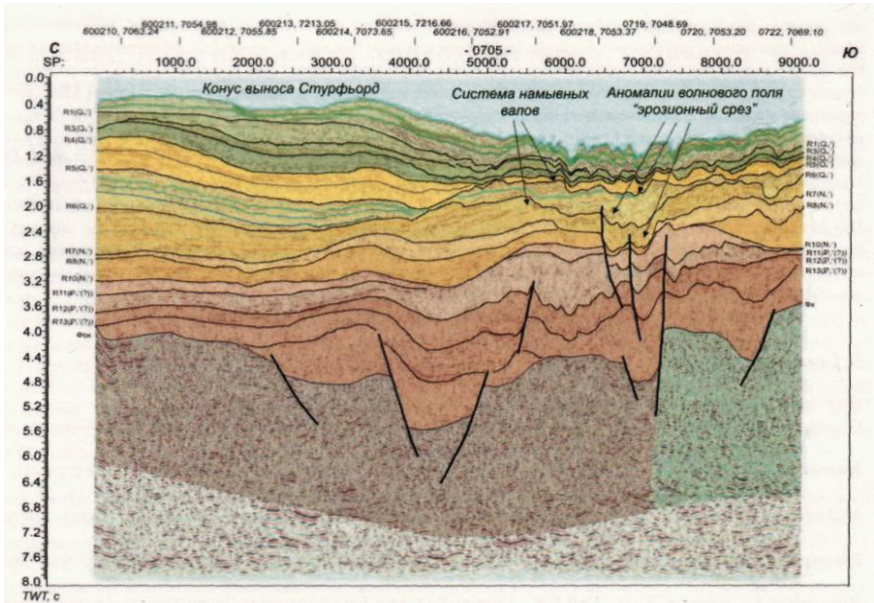


Figure 3. Section of profile 0705 (MAGE)

Conclusion

In general, natural gas hydrates represent a very complex multifactor problem. Let us consider the main factors.

Gas hydrates —fuel of the future. The potential energy concentrated in natural hydrates can provide clean energy for the world for more than 200 years. They are more evenly distributed on the planet than oil and gas sources. Their development does not require super-deep wells, complex and expensive system of transportation of products. Development of gas hydrate deposits can be successfully made using existing technologies for prospecting and exploration, drilling and production of hydrocarbon fuels. The economic indices of development of gas hydrates deposits can be even more effective than in the case of oil and natural gas.

The technological aspect The development of solid gas hydrate deposits has its own peculiarities which require serious consideration. The problem is that its production is technologically difficult, dangerous and therefore very expensive.

In the UK, a pilot plant is set up to produce hydrates with the productivity of 1 ton per day. This device is intended for testing technology for gas hydrates in the offshore platforms and their subsequent transport. In Japan there are plants for the production of "pills" from the ice-hydrate, which can be stored and transported at low temperatures (the results of these studies were actively advertised in the hydrate conference in Yokohama in 2002 and in Tokyo in June 2003 at the World Conference of gas).

The political aspect. Development of gas hydrate deposits in fact marks a new stage of redistribution of the world energy market. U.S.A. and Japan are planning to enter the commercial production of GH in 2010-2015. At the Russian Conference on Gas Hydrates (Novosibirsk, 2003) the need to create in the nearest future the Russian national program of research of gas hydrates was stressed (*Kuznetsov et al.*, 2003). In Gubkin Russian State University of Oil and Gas the international conference "Prospects of development of gas hydrate resource fields" was held in November 2009. The reports focused on the latest scientific results in the study of physical and thermodynamic properties of gas hydrates, geophysical methods to detect them, the possibilities of their industrial **use**.

Gas hydrates as a factor of environmental risk. Natural gas hydrates in some cases must be regarded as an undesirable circumstance. They can lead to technological complications in drilling and operating wells for oil and gas in the construction of floating platforms, etc. In addition, with relatively small changes in temperature

and pressure conditions, gas hydrates decompose to water and gas, which is accompanied by uncontrolled release of gas into the atmosphere. Such explosions are actually observed in the tundra and sometimes in the sea. For the Western sector of the Arctic environmental risk factor is dominant. This is due to: - First, the problem of climate change, which may lead to changes in temperature and pressure conditions in surface waters. There is the hypothesis shared by many researchers that global warming will cause the destruction of the centers of formation of cold deep ocean water, which will slow or even stop currents such as Labrador current - carrying cold water from high latitudes to low. This, in turn, will lead to a weakening or complete halt of such flows as Gulf Stream - carrying warm water from low to high latitudes. - Secondly, the problem of seismic activity in the young faults and the resumption of tectonic activity in the areas of old faults, which may cause local explosions of GH (West Spitsbergen continental margin, Strait Storfiord). - Third, study of the stability of the seabed at the prospect of building a pipeline under the Barents Sea. Nowadays various lines of GS research are devedoing quite separately and often in isolation. Therefore, of great importance is the creation of flexible data base systems of gas hydrates. Research in this area should be co-ordinated on a global scale.

We hope that our research is a contribution to the coordination of these problems.

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DOI 10.34660/INF.2022.85.24.016

废物处置设施境内复杂地球化学异常形成的主要方面
**THE MAIN ASPECTS OF THE FORMATION OF A COMPLEX
GEOCHEMICAL ANOMALY ON THE TERRITORY OF THE WASTE
DISPOSAL FACILITY**

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抽象的。生产和消费废物处理设施对环境有显著的负面影响，在邻近地区形成人为的地球化学异常[1, 2]。

污染物从废物处理设施的迁移是由于气团的移动，这是由于渗漏水溢出到下垫面，以及由于渗滤液的进入，水通过土壤和土壤层渗透的结果 进入地下水和地下水，然后污染物沿着它们的流动运动。

关键词：垃圾填埋场、城市固体废物、渗滤液、污染、土壤、地面、监测、地球化学异常、污染物、浓度系数、重金属、石油产品、氯化物、表面活性剂。

Abstract. *Production and consumption waste disposal facilities have a significant negative impact on the environment, forming man-made geochemical anomalies in the adjacent territories [1, 2].*

The migration of pollutants from the waste disposal facility occurs due to the movement of air masses, as a result of the spill of seepage water onto the underlying surface and the infiltration of water through the layers of soil and soil, due to the ingress of leachate into groundwater and groundwater, followed by the movement of pollutants along their flow.

Keywords: *landfill, municipal solid waste, leachate, pollution, soils, grounds, monitoring, geochemical anomaly, pollutants, concentration coefficient, heavy metals, oil products, chlorides, surfactants.*

In the first two cases, the depositing media for pollutants are soils and soils on the territory of the waste disposal facility and adjacent to it. In the third variant, pollutants can be deposited in rocks containing groundwater, as well as in bottom sediments of surface water bodies at groundwater discharge points.

It is soils and soils that reflect the cumulative effect of environmental pollution

averaged over a long period, so the ecological and geochemical study of soils and soils is very significant and indicative.

Objects and methods of investigation

The object of the study was the territory of the depleted deposit of refractory clays. The part of the quarry occupied by the landfill for municipal solid waste (MSW) is more than 42 hectares.

The facility functioned from 1986 to 2011. Numerous studies have established environmental pollution as a result of the operation of this facility [3, 4].

We have carried out a substantive analysis of the level and geographical distribution of soil pollution in the territory of the MSW landfill, as well as in the areas adjacent to it.

Results and discussion

The accumulation of pollutants by soils and soils at the border of the sanitary protection zone of the landfill was studied. The values of the concentration coefficients (Ki) were calculated from the start of construction and at the end of its operation - 19-22 years after the start of operation of the facility (tab. 1).

Table 1.

The value of the concentration coefficient (Ki) in soils at the boundary of the MSW polygon

	east side	southeast side	north side
Chlorides	from 2.4 up to 2.7	from 1.3 up to 2.3	from 0.02 up to 0.14
Ammonia nitrogen	from 0.24 up to 0.5	from 0.02 up to 0.45	from 0.002 up to 1.23
Nitrate nitrogen	from 0.2 up to 1.2	from 0.17 up to 1.7	from 0.2 up to 19
Oil products	from 0.8 up to 60.3	from 0.8 up to 13.9	from 0.2 up to 5.4
Anionic surfactants	from 0.39 up to 49	from 0.08 up to 52.5	from 0.2 up to 0.8

The prevailing winds and terrain with a slope to the east and southeast affect the processes of pollutant concentration, which is marked by an increase in the values of the concentration coefficient.

The near-surface soil layer from 0 to 20 cm at the border of the SPZ of the polygon differs in the accumulation of humic substances (in the northwest of the SPZ - 4.46%, in the west of the SPZ - 4.28%, in the southeast of the SPZ - 3.95%). In the background sample, the content of organic matter was 4.56%. The presence of organic substances in the surface layer of soils is due to the influx of organic products of MSW biochemical transformation. The accumulation of organic compounds in soils is largely determined by their absorption capacity. Sandy in terms of mechanical composition, the soil of the eastern and southeastern zones of the

object has a low absorption capacity and, accordingly, does not have the ability to glow organic matter. This significantly differs from clay and loamy soils in other areas of the landfill.

During the operation of the MSW landfill, accidental leachate spills were observed.

This led to significant contamination of soils adjacent to the landfill from the western, northwestern, and northeastern sides (tab. 2).

Table 2.

Pollutant concentration factors at leachate spill sites during the early stages of landfill operation

Pollutants	Concentration factor (Ki)
Gross content	
Oil products	1.5
Mobile form of metals (hazard class I)	
Lead	from 2.5 up to 14
Cadmium	from 1.3 up to 2.5
Zinc	from 2.8 up to 6.7
Mobile form of metals (hazard class II)	
Copper	from 8 up to 25
Nickel	from 1.4 up to 2.3
Mobile form of metals (hazard class III)	
Manganese	from 1.5 up to 2.2

In the period from 2013 to 2016, for 18-21 years of storage of MSW, the values of the coefficients of concentrations of pollutants in the soils of the base of the landfill were: for oil products ($K_{oil} - 21.8$), for anionic surfactants ($K_{Surf} - 129$), by mobile forms of lead ($K_{pb} - 1.3$) and cadmium ($K_{Cd} - 2.0$).

Within 10 meters from the filtrate evaporation pond during this period, concentration of ammonium nitrogen ($K_{NH4} - 1.4$), chlorides ($K_{Cl} - 2.8$), oil products ($K_{oil} - 1.5$), anionic surfactants ($K_{Surf} - 96$) and mobile metals ($K_{pb} - 1,75$; $K_{Cd} - 2$; $K_{Zn} - 1,04$).

Throughout the entire period of observation of the operated landfill, its impact on the chemical composition of soils and soils of adjacent territories was recorded. The gross content of heavy metals characterizes the total contamination of deposit media in the impact zone of the MSW landfill (tab. 3).

Table 3.

Gross content of heavy metals in soils of the sanitary protection zone of the landfill

Pollutants	Years of observation			
	1993	1994	2010	2011
Hazard class I				
Lead, mg/kg	1.5 – 18.5	1.1 – 15.0	6.2 – 7.9	5.1 – 14.5
Cadmium, mg/kg	0.2 – 1.5	0.1 – 1.2	< 0.01	0.05 – 0.26
Zinc, mg/kg	1.6 – 41.5	1.3 – 20	20.8 – 24.3	33.7 – 64.3
Mercury, mg/kg	0.008 – 0.083	0.01 – 0.621	< 0.1	< 0.1
Hazard class II				
Nickel, mg/kg	2.5 – 18.4	1.8 – 13.6	9.2 – 10.2	7.3 – 26
Copper, mg/kg	1.5 – 11.7	1.2 – 13.2	10.4 – 13.9	11.8 – 23.5
Hazard class III				
Manganese, mg/kg	6 – 115	18 – 131	320 – 498	116 – 414

It should be noted that at the final stage of the operation of the MSW landfill, the gross concentrations of heavy metals increase, which is explained by the cumulative effect of the geochemical impact of the facility on the adjacent territories.

Based on the calculations of the concentration coefficients of heavy metals in the soils of the territory adjacent to the polygon, a geochemical spectrum was compiled in descending sequence, which makes it possible to reflect the elemental composition of the identified technogenic geochemical anomaly (fig. 1).

North side	2005	$K_{Cu} > K_{Pb} > K_{Mn} > K_{Ni} > K_{Zn} > K_{Cd} > K_{Cr}$
	2006	$K_{Cu} > K_{Pb} > K_{Mn} > K_{Zn} > K_{Co} > K_{Cd} > K_{Ni} > K_{Cr}$
	2007	$K_{Cu} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cd}$
	2008	$K_{Cu} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cr} > K_{Cd}$
	2009	$K_{Cu} > K_{Mn} > K_{Zn} > K_{Pb} > K_{Ni} > K_{Cr} > K_{Cd} > K_{Co} > K_{Fe}$
	2010	$K_{Cu} > K_{Mn} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cr} > K_{Cd}$
	2011	$K_{Mn} > K_{Cu} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cd} > K_{Cr} > K_{Co} > K_{Fe}$
	2009	$K_{Cu} > K_{Mn} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cr} > K_{Cd}$
Northwest side	2010	$K_{Cu} > K_{Mn} > K_{Zn} > K_{Pb} > K_{Ni} > K_{Fe} > K_{Cd} > K_{Cr}$
	2011	$K_{Cu} > K_{Mn} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cr} > K_{Cd}$
	2009	$K_{Mn} > K_{Cu} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cr} > K_{Cd}$
	2010	$K_{Mn} > K_{Cu} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cr} > K_{Cd}$
	2011	$K_{Mn} > K_{Cu} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cr} > K_{Cd}$
	2009	$K_{Mn} > K_{Cu} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cr} > K_{Cd}$
	2010	$K_{Cu} > K_{Mn} > K_{Ni} > K_{Zn} > K_{Pb} > K_{Cr} > K_{Cd} > K_{Co} > K_{Fe}$
	2011	$K_{Cu} > K_{Zn} > K_{Pb} > K_{Mn} > K_{Cd} > K_{Ni} > K_{Cr}$
Southeast side	2006	$K_{Cu} > K_{Pb} > K_{Mn} > K_{Zn} > K_{Co} > K_{Ni} > K_{Cd} > K_{Fe} > K_{Cr}$
	2007	$K_{Pb} > K_{Zn} > K_{Ni} > K_{Cd} > K_{Cr} > K_{Cu}$
	2008	$K_{Zn} > K_{Ni} > K_{Cd} > K_{Cr} > K_{Cu}$
	2009	$K_{Mn} > K_{Cu} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cr} > K_{Co} > K_{Cd} > K_{Fe} > K_{Cr}$
	2010	$K_{Mn} > K_{Cu} > K_{Pb} > K_{Zn} > K_{Ni} > K_{Cd} > K_{Co} > K_{Fe} > K_{Cr}$
	2011	$K_{Cu} > K_{Mn} > K_{Zn} > K_{Pb} > K_{Ni} > K_{Cd} > K_{Fe} > K_{Co} > K_{Cr}$
	2006	$K_{Zn} > K_{Cu} > K_{Mn} > K_{Pb} > K_{Co} > K_{Ni} > K_{Cd} > K_{Fe} > K_{Cr}$
	2007	$K_{Pb} > K_{Cu} > K_{Zn} > K_{Cd} > K_{Cr}$
East side	2008	$K_{Pb} > K_{Zn} > K_{Cu} > K_{Ni} > K_{Cd} > K_{Cr} > K_{Co}$

Figure 1. Geochemical spectrum of the elemental composition of the technogenic geochemical anomaly on the territory of the waste disposal facility
 — the concentration of the element does not exceed the background

Based on the concentration coefficients and the geochemical spectrum of pollutants, it is possible to draw a general conclusion about the nature, level, and environmental hazard of the soil geochemical anomaly at the object under study.

Findings

The most contaminated soils are located on the southeastern side of the landfill, which is due to a decrease in the terrain, which contributes to the horizontal migration of contaminated water from the waste storage site.

Mobile forms of copper (hazard class 2) and manganese (hazard class 3) have a higher migration ability.

Conclusion

An analysis of the qualitative and quantitative characteristics of the technogenic geochemical anomaly formed by the MSW test site showed the dependence of the processes of its formation on the time stage of the object's existence and the geoecological conditions of the territory. A significant amount of pollutants entering the environmental components surrounding the object is observed in the initial and main operational period of the object's existence. At the final stage of the operation of the object, the cumulative effect of geochemical impact on the adjacent territories is manifested. The distribution and localization of pollutants by the components of the ecogeosphere is determined by the natural, climatic and geoecological characteristics of the area.

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DOI 10.34660/INF.2022.42.76.017

组箱中的照明系统
LIGHTING SYSTEM IN THE GROWBOX

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抽象的。基于对用于种植植物的照明设备类型的分析，开发了最有效的照明系统。提出了一个优化的种植箱系统模型，获得了标准版和现代化版本设备的运行特点，并得出了有关种植箱系统运行的结论。

关键词: growbox, 照明系统。

Abstract. *Based on the analysis of the types of lighting devices used for growing plants, the most efficient lighting system has been developed. A model of an optimized growbox system is presented, the characteristics of the operation of equipment with a standard and modernized version are obtained, and conclusions are drawn about the operation of the growbox system.*

Keywords: *growbox, lighting systems.*

Introduction

Modern technologies make it possible to grow vegetables and herbs necessary for proper nutrition in winter and summer.

The idea of growing greens and vegetables in an urban environment looks attractive. Fresh herbs are a good addition to a healthy diet. Growing greens all year round at home can make a big difference. Growbox provides such an opportunity. Growbox is equipment for growing plants that allows you to regulate the microclimate and maintain favorable environmental conditions (soil or hydroponic). As a rule, the growbox is equipped with a lighting system. Let's consider the possibility of upgrading the lighting system of the finished growbox in order to increase the efficiency of growing plants.

Technical device

Carbon dioxide and heat are easily produced, a person releases a certain amount of gas in the process of breathing, and all apartments are equipped with central heating. The problem is caused by a small amount of sunlight in winter, so

one of the main equipment systems of the growbox is the lighting system. White light is made up of different colors that have different wavelengths.

Plants need a certain wavelength of light, since blue light with wavelengths of 430-460 nm helps to strengthen plants and develop the root system. Red light is essential for flowering and fruiting. Spectra 430-460 nm for blue and 640-660 nm for red light are suitable for growing most plants. [2]

Types of lamps:

1. Incandescent lamps
2. Halogen lamps
3. Fluorescent lamps
4. Energy saving lamps
5. LED strips
6. Sodium lamps

Table 1.
Comparative characteristics of lighting lamps

Name	LED Strip Light	Fluorescent	Sodium
Light output	120Lm/W	50Lm/W	150-200Lm/W
Life time	50000 hours	40000 hours	up to 28500 hours
Range	a wide variety of spectrum selection allows you to choose the most suitable one.	yellow-green spectrum	orange yellow
Ecology	has no inert gases inside the flask	fluorescent lamps contain mercury and are therefore unsafe to use	has inert gases inside the flask
The heating	does not heat up	heats up but not too much	get very hot
Price	~200 rub.	~1500 rub.	>1000 rub.
Consumption	0.01 kW/h	0.021kW/h	0.023 kW/h

After analyzing table 1, we can conclude that the best lighting system for a growbox would be an LED strip.

LED lamps are effectively used for growing cultivated plants, since such lamps have the most balanced combination of red and blue spectrum rays, and also have monochromatic radiation. The phytoactive part of the spectrum is selected directly under the cultivated plant, which gives the advantage of the absence of excessive thermal and ultraviolet radiation, the risk of burns and dehydration is eliminated. [3]

A conventional industrial phytolamp consists of several LEDs with different wavelengths combined in one housing. At the same time, the lamp can be quite compact or have a larger size. It depends on how many plants it is planned to illuminate. [4]

Installation

After reviewing various ready-made grow boxes, we chose the LED Quantum Box.

*Table 2.
Characteristics of LED Quantum Box*

Description	Characteristics
Equipment: - Grow tent ProBox Ecopro 60x60x140 - 1 piece - Luminaire Quantum board 125 W KB-QB288X2-LM301B-3000K+ Epistar 660 nm - 1 pc - Air filter OZON (10) - 1 piece - Fan Dospel Euro 120 - 1 piece - Corrugation - 1 piece - Adapter - 1 pc - Wire with plug - 1 pc - Hangers - 1 piece - Mechanical timer - 1 piece	Seats 1 Lighting power 120 W Weight 10 kg DSHV, cm 60 × 60 × 140

Let's separately consider the characteristics of the luminaire Luminaire Quantum board 125 W KB-QB288X2-LM301B.

Power consumption 240 W

Spectrum 3000k; 660nm

Weight 4 kg

DSHV, cm 32 × 19 × 3

Conclusion on growbox lighting: This lamp has a predominantly red spectrum of light and a lack of blue spectrum. Let's add blue spectrum LEDs and calculate the energy and material costs.

Calculated part

Initial cost (investment): blue spectrum LEDs, which we will add to the panel in addition to the LEDs that are already there, the solar panel. There are already 90 diodes on the panel, which have an abundance of red and a lack of blue, so we will buy LEDs (GNL-3014BC) in the amount of 30 pieces, a solar panel, as a result we will get a minus of 19270 rubles.

Table 3.
Cost calculation

Equipment name	Price (rub.)
LEDs GNL-3014BC (30pcs)	6*30=180
Solar module JA solar JAM72S30-535	19090
Total cost	19270

a. The volume of electric power consumption:

$$A=P*t$$

A - the volume of electricity consumption for 16 hours

P - peak power consumption

t – consumption time [5]

Table 4.
Calculation of consumption

	Peak value	16 hours	30 days	12 months
Объем потребления электрической энергии	240 W*h+80 W*h.	5,12 кВт*ч	153,6 kW*h	1843,2 kW*h

b. Payback period calculation

$$C=T*A$$

C - the cost of electricity

T - electricity tariff

A - the volume of electricity consumption per month.

Table 5.
Calculation of cash savings

	tariff	30 days	12 months
Стоимость электрической энергии	5,95 rub/ kW*h	913,92rub*m	10875rub*y

Payback period of the installation: $T=K/S$

T - payback period

K - equipment cost

C - the cost of electricity costs per month.

$$T=K/C=19270/913.9=21.1 \text{ months. [6]}$$

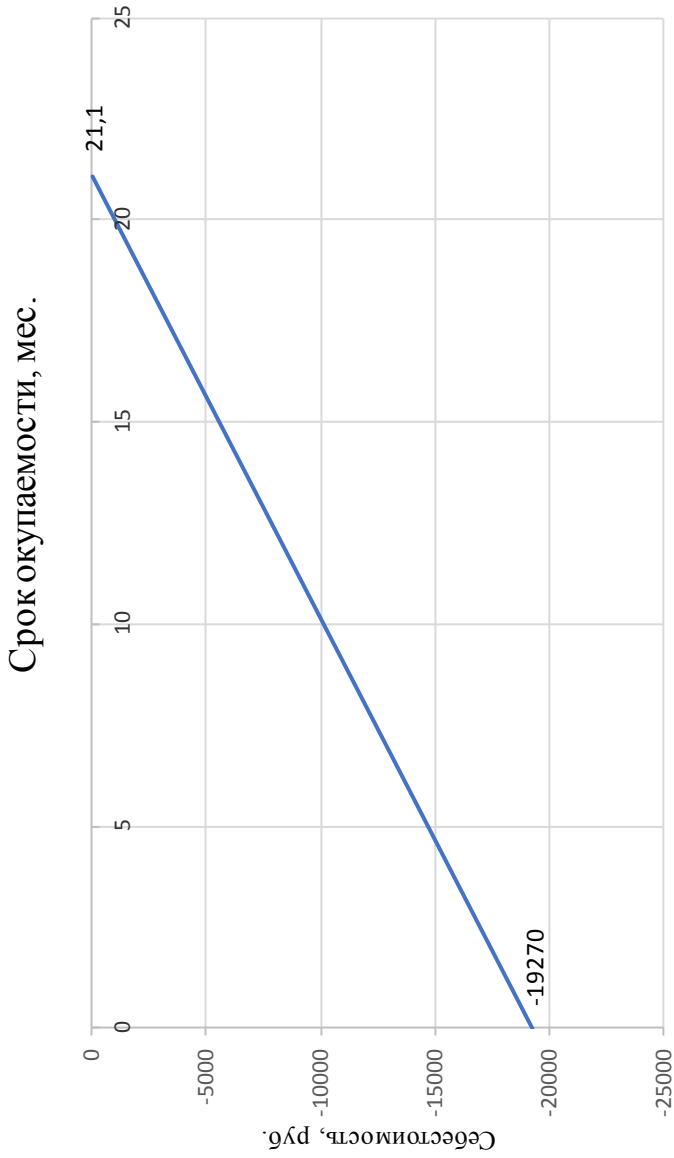


Figure 1. Equipment payback schedule

The initial investment consists of the cost of the solar panel and its components.

The subsequent payback of the project is achieved by saving on payments for electricity. Tariffs established as of March 2022 were used in the calculation. Subsequent tariff growth is not taken into account, but it is worth noting its inevitability. Accordingly, the actual payback period will be reduced relative to the calculated one.

Experimental study

Experience No. 1

Object of study: the initial lighting system of the finished grow box.

Equipment: growbox, plants - Beijing cabbage.

During the month from June 1 to June 30, 2021, two samples of Chinese cabbage were grown using a growbox with the original lighting system.

Conclusion: cabbage shoots are medium in size, there are 5 leaves, the color is light green.

Experience No. 2

Object of study: a modernized lighting system for a finished growbox.

Equipment: growbox, plants - Chinese cabbage.

During the month from July 1 to July 30, 2021, two samples of Chinese cabbage were grown using a growbox with a modernized lighting system.

Conclusion: Cabbage shoots are slightly above average in size, 7-8 sheets of pronounced green color.

Comparison: In the second case, cabbage shoots are better developed. Favorable conditions of the modernized lighting system of the finished growbox made it possible to more effectively and efficiently influence the life cycle of plants and the processes occurring in them, achieving better results.

Conclusions

The paper considered various types of lamps used in growing plants. It has been determined that LED-type lamps have the best characteristics.

A set of equipment for further research has been determined.

Calculations of the amount of electricity consumed and the payback period of the equipment were made.

The results of the study confirm the effectiveness of the considered set of equipment for growing plants, as well as its economic feasibility.

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母猪的生产力取决于第一次授精的年龄

PRODUCTIVITY OF BREEDING SOWS DEPENDING ON THE AGE OF THE FIRST BREEDING

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抽象的。对杂交猪的活重及其繁殖生产力随首次配种年龄的变化进行了分析。这些研究是在秋明州的“Lozovoye” SO 进行的。值得注意的是，6.5–7.5月龄猪的活重为146–153公斤。随着第一次授精年龄增加至 10.5 个月，活体重也增加至 214 公斤。已经确定在 1025 头杂交猪 (LxKB) – 第 II 组中，首次受精的年龄为 218–232 天 (7.3–7.7 个月)，平均活重为 153 公斤。怀孕中断 49 头 – 上半场 (0–32 天)，73 头 – 下半场 (32–114 天)，因各种原因被淘汰 – 64 头。产仔640头，产仔7765头，其中活头7282头。

在第 VI、VII 组中获得了最大的产量，其中第一次授精的年龄为 9.5 个月、10 个月。然而，活仔猪的数量为12.6–12.8小时。在较早授精的猪群中，该指标略有不同。年轻母猪中虚弱和体重过轻的仔猪的百分比没有增加。

关键词：后备母猪，活重，第一次授精年龄，分组，终止妊娠，分娩，仔猪数量，活。

Abstract. *The analysis of changes in the live weight of hybrid pigs and their reproductive productivity depending on the age of the first breeding was carried out. The studies were carried out in the "Lozovoye" SO in the Tyumen Oblast. It is noted that the live weight of pigs at the age of 6.5 - 7.5 months was 146-153 kg. With an increase in the age of the first insemination up to 10.5 months the live weight also increased to 214 kg. It has been established that out of 1025 hybrid pigs (LxKB) - group II, which were inseminated at the age of 218-232 days (7.3-7.7 months) at first time with an average live weight of 153 kg. Pregnancy was interrupted in 49 heads - in the first half (0 -32 days), in 73 heads - in the second half (32-114 days), casted out for various reasons - 64 heads. 640 heads farrowed, from which 7765 piglets were obtained, of which 7282 live.*

The greatest prolificacy was obtained in groups VI, VII, where the age of the first insemination was 9.5 months, 10 months. However, the number of live piglets was 12.6-12.8 h. In groups of pigs inseminated at an earlier age, this indicator

differed slightly. There was no increase in the percentage of weak and underweight piglets in young queens.

Keywords: gilts, live weight, age of first insemination, grouping, termination of pregnancy, farrowing, number of piglets, live.

Introduction

The high intensity of use of breeding sows depends on the correct technology for rearing and preparing young gilts. [4]

In this regard, the age of production use is of great importance. Too early use of them leads to weak offspring, reduced fertility, later - to increased costs for the production of piglets. [2,3]

The level of productivity, prospects and profitability of pig breeding depends on their age, state of health. [1]

Considering these circumstances and their significance in breeding work with parent breeds as the main means of production, we were faced with the task of determining the effect of the age of the first insemination and live weight on reproductive productivity.

In this regard, the **purpose** of the research was to study the dynamics of the live weight of hybrid gilts depending on the age of their first insemination and their productivity. The following **tasks** were set: to group gilts according to the age of the first insemination; analyze the age dynamics of live weight; determine the relationship between the age of the first insemination and live weight with subsequent productivity; to determine the optimal live weight and age of the first insemination.

Material and methods of research

The studies were carried out using the database of the "Lozovoye" HC ASS SO of the Tyumen Oblast. The studies were carried out in the period from 2019 to 2020. Hybrid gilts obtained from crossing Landrace and Large White sows were studied. The following indicators were taken into account: the age of insemination, live weight at insemination, interruption of pregnancy in different periods, culling, the number of born and live piglets.

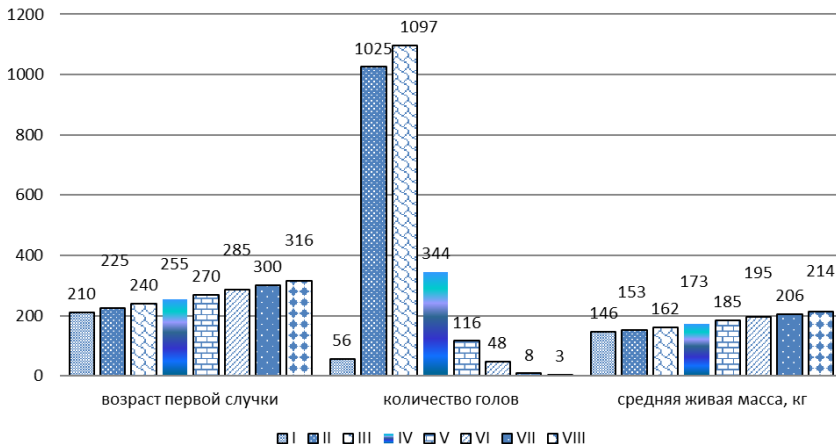
To identify the relationship between live weight and productivity, a grouping of gilts was carried out according to the age of the first insemination. Gilts were divided into 8 groups according to the age of the first insemination. The interval between groups was 15 days.

We used zootechnical methods, biometric research methods. The results were processed in the spreadsheet application M. Excel package "Data analysis", significance level $P \leq 0.95$. [2]

Research results

Hybrid gilts in the amount of 2697 heads were divided into 8 groups depending on the age of the first insemination (Fig. 1).

Distribution of gilts by age and live weight



The largest number of gilts 2466 heads got in these groups II, III, IV, that is, in which the age of the first breeding ranged from 225 to 270 days. The minimum age of the first breeding of a hybrid gilt (LxKB) was 203 days - group I, 56 heads - 2.0%. In group II (218-232 days) - 1025 heads, 38%, in group III (233-247 days) - 1097 heads, 40.7%, in group IV (248-262 days) - 344 heads, 12.7%, in group V (263-277 days) - 116 heads or 4.3%. In the VI group there are 48 heads, in the VII group - 8 heads, in the VIII group - 3 heads.

It is noted that the live weight of pigs at the age of 6.5 - 7.5 months was 146-153 kg. With an increase in the age of the first breeding up to 10.5 months, the live weight also increased to 214 kg.

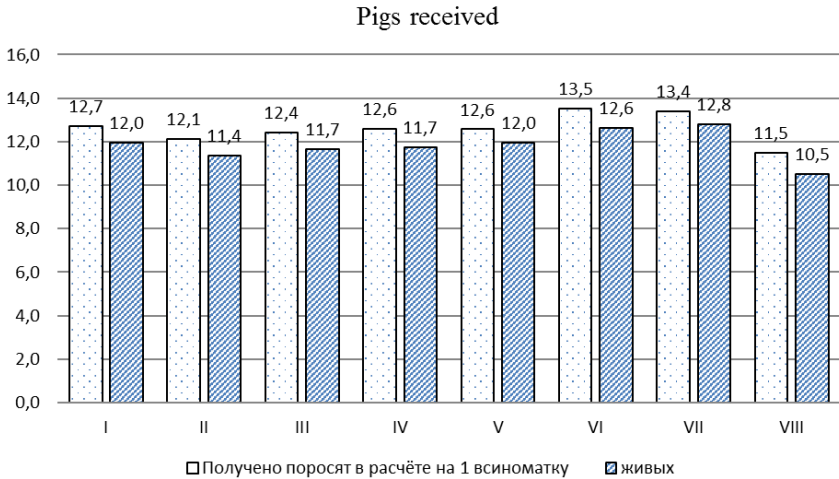
In order to assess whether the early age of the first breeding and body weight have an impact on the further productivity of sows, an analysis of the effectiveness of insemination was carried out. It has been established that out of 1025 hybrid pigs (LxKB) - group II, for the first time inseminated at the age of 218-232 days (7.3-7.7 months) with an average live weight of 153 kg, pregnancy was interrupted in 49 heads - in the first half (0 -32 days), in 73 heads - in the second half (32-114 days), culled for various reasons - 64 heads. 640 heads farrowed, from which 7765 piglets were obtained, of which 7282 live.

In group III, 1097 heads were inseminated for the first time at the age of 233-247 days (7.8-8.2 months) with an average live weight of 162 kg; -114 days for 68 heads, culled for various reasons - 69 heads. 798 heads farrowed, 9923 piglets were born, 9310 of them live.

Group IV gilts were first inseminated at the age of 248-262 days (8.3-8.7 months) with an average live weight of 173 kg. Pregnancy was interrupted in the period of 0-32 days in 10 animals, in the period of 32-114 days in 28 animals, culled for various reasons - 25 heads. 243 heads farrowed, 3058 piglets were born, of which 2851 live.

Of the 116 pigs of group V, there were first inseminated at the age of 263-277 days (8.8-9.2 months) with an average live weight of 185 kg. Pregnancy was interrupted in the period of 0-32 days in 3 animals, in the period of 32-114 days in 7 heads, culled for various reasons - 7 heads. 88 heads farrowed, from which 1106 piglets were obtained, of which 1052 were alive.

The results of farrowing of gilts inseminated at different ages were compared by the number of piglets received per 1 head (Fig. 2).



The largest number of piglets per 1 sow was obtained in groups VI, VII, where the age of the first insemination was 9.5 months, 10 months. However, the number of live piglets was 12.6-12.8 heads. In groups of pigs inseminated at an earlier age, this indicator differed slightly. There was no increase in the percentage of weak and underweight piglets in young queens.

Conclusions

It is noted that the live weight of pigs at the age of 6.5 - 7.5 months was 146-153 kg. With an increase in the age of the first insemination up to 10.5 months, the live weight also increased to 214 kg.

It has been established that out of 1025 hybrid pigs (LxKB) - group II, first inseminated at the age of 218-232 days (7.3-7.7 months) with an average live weight of 153 kg, pregnancy was interrupted in 49 heads - in the first half (0-32 days), in 73 heads - in the second half (32-114 days), culled for various reasons - 64 heads. 640 heads farrowed, from which 7765 piglets were obtained, of which 7282 live.

The greatest prolificacy was obtained in groups VI, VII, where the age of the first insemination was 9.5 months, 10 months. However, the number of live piglets was 12.6-12.8 heads. In groups of pigs inseminated at an earlier age, this indicator differed slightly. There was no increase in the percentage of weak and underweight piglets in young queens.

Based on the studies carried out, it can be concluded that early insemination of gilts at the age of 7.5 months - 8 months with live weight of 150-170 kg does not adversely affect the reproductive productivity of sows. But it should be emphasized that for the early use of pigs, it is necessary to apply feeding and maintenance technologies that contribute to the normal development of the reproductive organs and muscle and bone tissues.

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上合组织国家的科学研究：协同和一体化

国际科学大会的材料

2022年3月31日，中国北京

编辑A. A. Siliverstova

校正A. I. 尼古拉耶夫

2022年4月06日，中国北京

USL。沸点：98.7。 订单253. 流通500份。

在编辑和出版中心印制

无限出版社

