SOI: 1.1/TAS
DOI: 10.15863/TAS
Scopus ASJC: 1000

ISSN 2308-4944 (print)
ISSN 2409-0085 (online)

№ 06 (110) 2022

Teoretičeskaâ i prikladnaâ nauka

Theoretical & Applied Science

Philadelphia, USA

Teoretičeskaâ i prikladnaâ nauka

Theoretical & Applied Science

06 (110)

2022

International Scientific Journal

Theoretical & Applied Science

Founder: **International Academy of Theoretical & Applied Sciences**

Published since 2013 year. Issued Monthly.

International scientific journal «Theoretical & Applied Science», registered in France, and indexed more than 45 international scientific bases.

Editorial office: http://T-Science.org Phone: +777727-606-81

E-mail: T-Science@mail.ru

ISSN 2308-4944

9 772308 494225 06

International Scientific Journal

Theoretical & Applied Science

International Scientific Journal

Theoretical & Applied Science

ISJ Theoretical & Applied Science, 06 (110), 434.
Philadelphia, USA

Impact Factor ICV = 6.630

Impact Factor ISI = 0.829
based on International Citation Report (ICR)

The percentage of rejected articles:

ISSN 2308-4944

9 772308 494225 06

Impact Factor:					
	ISRA (India) = **6.317**	**SIS** (USA) = **0.912**	**ICV** (Poland) = **6.630**
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SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 01.06.2022 **http://T-Science.org**

Issue **Article**

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REFERENCE DATA OF PRESSURE DISTRIBUTION ON THE SURFACES OF AIRFOILS HAVING THE NAMES BEGINNING WITH THE LETTER I

Abstract: *The results of the computer calculation of air flow around the airfoils having the names beginning with the letter I are presented in the article. The contours of pressure distribution on the surfaces of the airfoils at the angles of attack of 0, 15 and -15 degrees in conditions of the subsonic airplane flight speed were obtained.*

Key words: *the airfoil, the angle of attack, pressure, the surface.*

Language: *English*

Citation: Chemezov, D., et al. (2022). Reference data of pressure distribution on the surfaces of airfoils having the names beginning with the letter I. *ISJ Theoretical & Applied Science, 06 (110),* 1-7.

Soi: http://s-o-i.org/1.1/TAS-06-110-1 ***Doi***: https://dx.doi.org/10.15863/TAS.2022.06.110.1

Scopus ASCC: *1507.*

Introduction

Creating reference materials that determine the most accurate pressure distribution on the airfoils surfaces is an actual task of the airplane aerodynamics.

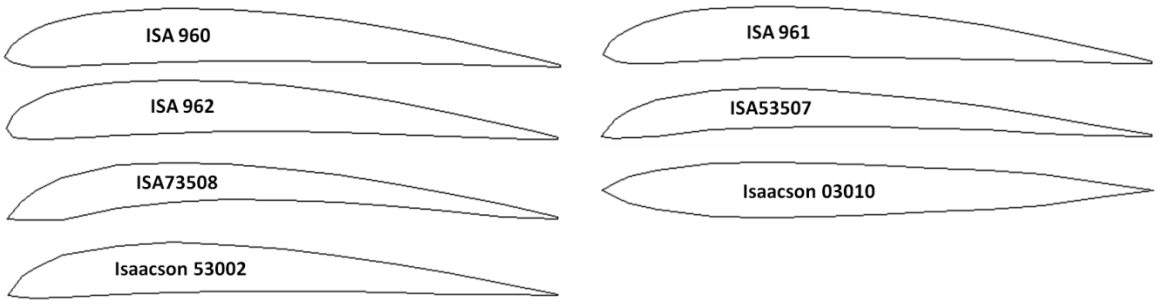
Materials and methods

The study of air flow around the airfoils was carried out in a two-dimensional formulation by means of the computer calculation in the *Comsol Multiphysics* program. The airfoils in the cross section were taken as objects of research [1-24]. In this work, the airfoils having the names beginning with the letter *I* were adopted. Air flow around the airfoils was carried out at the angles of attack (α) of 0, 15 and -15 degrees. Flight speed of the airplane in each case was subsonic. The airplane flight in the atmosphere was carried out under normal weather conditions. The geometric characteristics of the studied airfoils are presented in the Table 1. The geometric shapes of the airfoils in the cross section are presented in the Table 2.

Table 1. The geometric characteristics of the airfoils.

Airfoil name	Max. thickness	Max. camber	Leading edge radius	Trailing edge thickness
ISA 960	9.46% at 30.0% of the chord	5.71% at 40.0% of the chord	0.9136%	0.42%
ISA 961	9.27% at 20.0% of the chord	5.68% at 30.0% of the chord	0.8935%	0.37%
ISA 962	9.58% at 20.0% of the chord	5.93% at 40.0% of the chord	1.5408%	0.42%
ISA53507	7.1% at 20.0% of the chord	5.15% at 30.0% of the chord	1.4377%	0.3%
ISA73508	8.0% at 10.0% of the chord	6.75% at 40.0% of the chord	1.4514%	0.4%
Isaacson 03010	10.0% at 30.0% of the chord	0.0% at 0.0% of the chord	1.677%	0.0%
Isaacson 53002	9.0% at 30.0% of the chord	5.1% at 30.0% of the chord	1.5801%	0.2%
Note: *ISA 960, ISA 961, ISA 962* (ISA (Italy)); *Isaacson 03010, Isaacson 53002* (S. Isaacson (Sweden)).				

Table 2. The geometric shapes of the airfoils in the cross section.



Results and discussion

The calculated pressure contours on the surfaces of the airfoils at the different angles of attack are presented in the Figs. 1-7. The calculated values on the scale can be represented as the basic values when comparing the pressure drop under conditions of changing the angle of attack of the airfoils.

7 airfoils of the ISA and Isaacson series were studied in this work. All airfoils are asymmetrical except Isaacson 03010.

The Isaacson 03010 airfoil has the different values of negative pressure on the edges and the surfaces at the angles of attack of 15 and -15 degrees. This pressure difference, under the conditions of the airplane maneuvers, occurs at the maximum thickness of the airfoil with the pointed leading edge.

During horizontal flight of the airplane, the drag arises on the leading edge of the airfoils, which practically does not change in the value. This is true for the airfoils with both rounded and pointed leading edges.

Maneuvering the airplane leads to an increase in the drag by several times, compared with horizontal flight. For example, during the descent of the airplane with the Isaacson 03010 wing profile, maximum pressure of -94.7 kPa occurs near the leading edge. When the airplane climb, maximum pressure of -76.6 kPa near the leading edge is observed for the ISA73508 airfoil. For this airfoil, the minimum drag was also calculated at the angle of attack of -15 degrees. Thus, the climb of the airplane leads to the occurrence of the large drag on the airfoils.

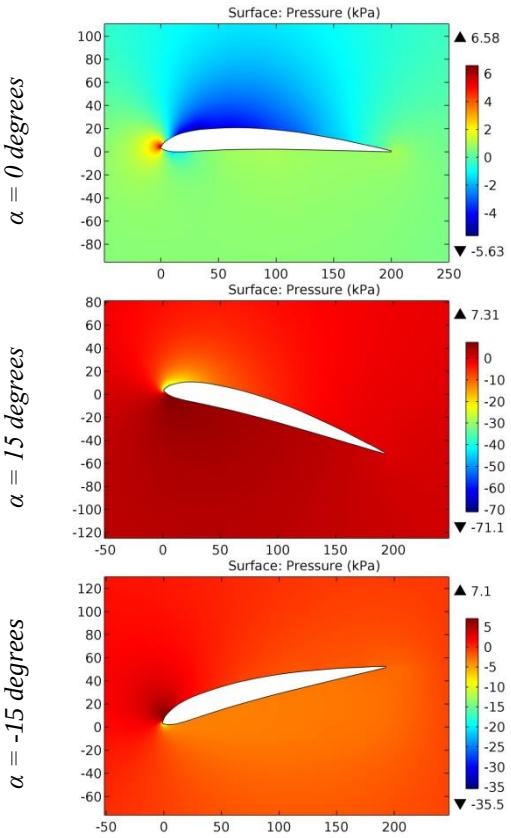


Figure 1. The pressure contours on the surfaces of the ISA 960 airfoil.

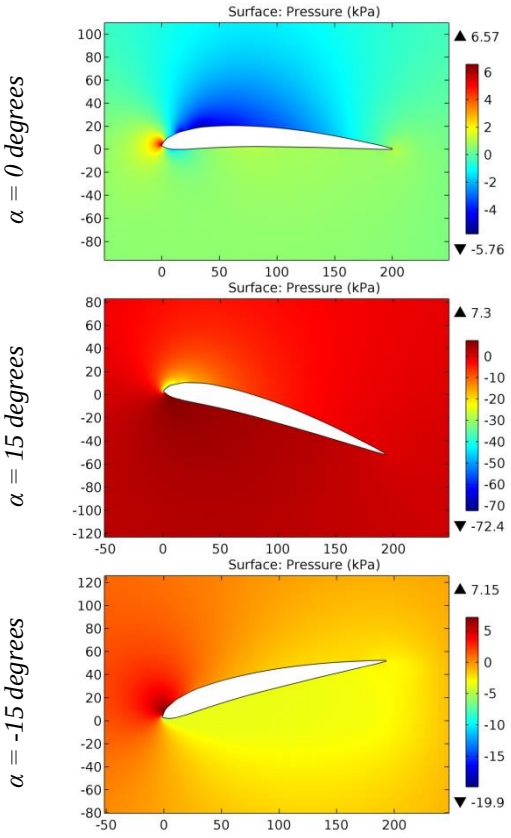


Figure 2. The pressure contours on the surfaces of the ISA 961 airfoil.

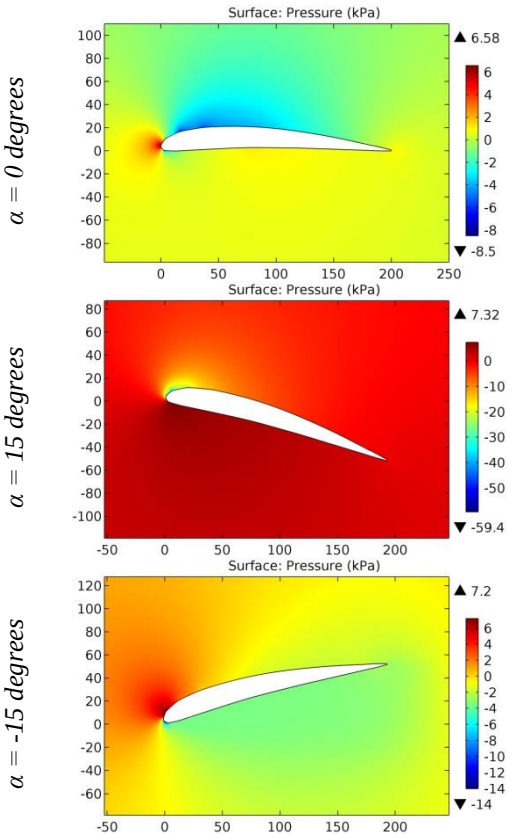


Figure 3. The pressure contours on the surfaces of the ISA 962 airfoil.

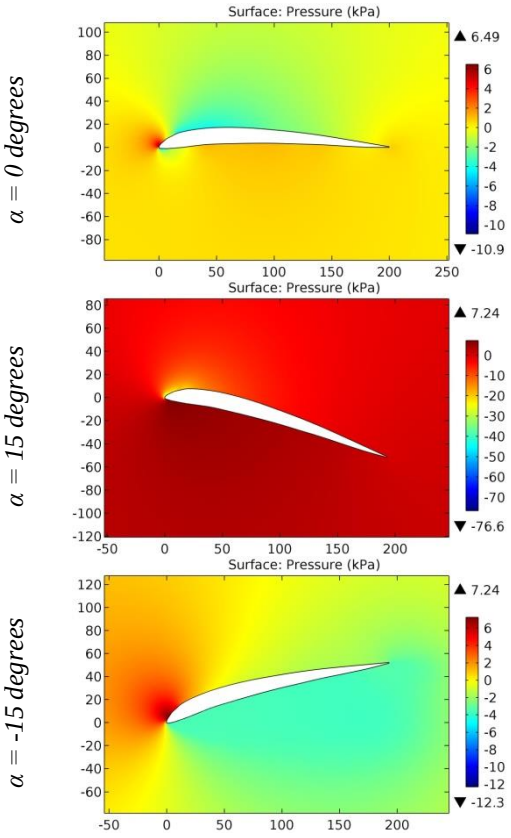


Figure 4. The pressure contours on the surfaces of the ISA53507 airfoil.

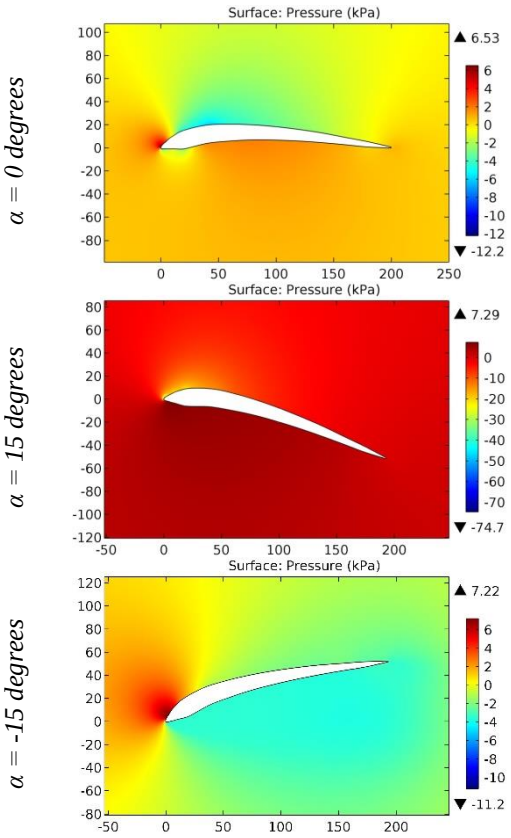


Figure 5. The pressure contours on the surfaces of the ISA73508 airfoil.

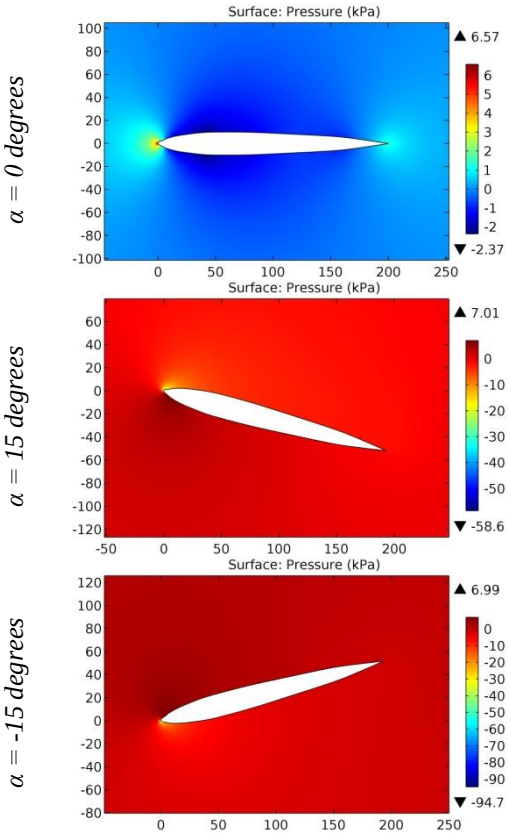


Figure 6. The pressure contours on the surfaces of the Isaacson 03010 airfoil.

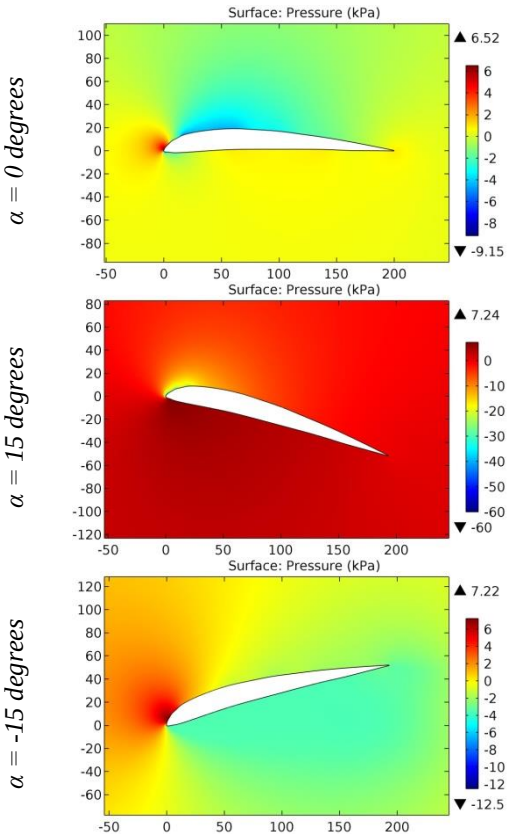


Figure 7. The pressure contours on the surfaces of the Isaacson 53002 airfoil.

The maximum camber of the Isaacson 03010 airfoil in the cross section creates the greatest wing drag during the airplane descent.

The maximum increase in pressure on the leading edge occurs at the angle of attack of 15 degrees for the following airfoils: ISA 960, ISA 961, ISA 962, ISA53507, ISA73508 and Isaacson 53002. The maximum increase in pressure on the leading edge occurs at the angle of attack of -15 degrees for the Isaacson 03010 airfoil only.

Conclusion

The camber of most of the considered airfoils affects the pattern of formation of the pressure intensity value, i.e. during the airplane climb the area of high negative pressure is formed, and negative pressure decreases by 3-5 times during the airplane descent. Positive pressure changes insignificantly with the difference of 1 kPa in all cases. The large drag on the leading edge and the small pressure difference on the upper and lower surfaces of the Isaacson 03010 airfoil reduce the aerodynamic quality of the wing during the airplane descent.

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SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 02.06.2022 **http://T-Science.org**

Issue Article

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A STUDY OF THE SCIENTIFIC AND EDUCATIONAL LEGACY OF SUFISM IN THE YEARS OF INDEPENDENCE

Abstract: *Approaches to the study of Sufism, in particular, the division of scientific research into groups, the study of the Nakshbandiyah tariqah in the years of independence, the activities of the Bukhara School of Sufism, the classification of dissertations in the field of social sciences and the humanities, as well as the large-scale celebration of anniversaries of scientists in our country and a new stage of reforms in this region is researched in this article.*

Key words: *Islam, Sufism, Bukhara, Nakshbandiyah, sheikh, scientific School, scientific research, reforms.*

Language: *English*

Citation: Khatamov, T. A. (2022). A study of the scientific and educational legacy of sufism in the years of independence. *ISJ Theoretical & Applied Science, 06 (110),* 8-11.

Soi: http://s-o-i.org/1.1/TAS-06-110-2 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2022.06.110.2

Scopus ASCC: *3300.*

Introduction

From the first years of independence, a number of innovations and reforms in the field of mysticism have been implemented in our country. In particular, from the first years of independence, mystical scholars and their heritage were highly respected. In 1993, the 675th anniversary of Khoja Bahauddin Naqshband was celebrated, the 910th anniversary of Khoja Abduhaliq Gijduvani, the teacher of Uvaysi, was widely celebrated in 2003, and the 600th anniversary of Khoja Ahror Wali was widely celebrated in 2004 [4: 410].

Since 2008, the scientific-educational, literary-educational magazine "Naqshbandiya" has been published every three months [8: 5]. Works on the life and scientific and educational heritage of our scholars have been translated and published. In particular, in 1993, the work of Muhammad Baqir ibn Muhammad Ali "Maqomati Khoja Bahauddin Naqshband", dedicated to the life and enlightenment of Khoja Bahouddin Naqshband, and in 2004, four works of Khoja Ahror Wali were published as a collection of "Holy Treatises". In 1991, the collection "Wisdoms" by Khoja Ahmad Yassavi, in 2003, the works of Hakim Termizi "Manozil ul-ibod min al-iboda" were published and presented to our people.

In addition, many historians, Islamic scholars, source scholars, literary critics, philosophers, orientalists, pedagogues, sociologists, and journalists have conducted a number of new research studies in the history of mysticism.

But, unfortunately, the original sects, elevated by mystical sheikhs and teachers, were misinterpreted during the former Soviet regime and portrayed as a community that propagated mystical ideas to our people, and in some cases sought wealth and power through religion [1: 252].

So what or how was mysticism actually?

Sufism was formed by Muslim nations on the basis of Islam over many centuries and has been recognized as an enlightened path that has stood the test of time and taken root in the hearts of nations, promoting high human qualities.

Main part

As a result of the reforms of recent years in our country, the attention to the heritage of mysticism has reached a new level. In particular, on November 30, 2017 by the order of the Office of Muslims of

Uzbekistan at the Mir Arab Higher Madrasah in Bukhara was established "Scientific School of Sufism" and on January 24, 2018 approved the Regulation on the "Scientific School of Sufism". continues its activities [10: 1].

The opening of a school of mysticism in Bukhara, where Naqshbandi was born, is also symbolic.

The school of mysticism teaches mainly in the following areas:

First, the lessons are taught from books on the way of life and lifestyle of mystical sheikhs, in particular, the sheikhs of Naqshbandi.

Second, the wise sayings of the teachers of the sect are interpreted and books on spiritual education are taught.

Third, students are taught Arabic and Persian, the rules of the language are explained in the process of reading historical sources, and their knowledge and skills are regularly strengthened. One of the most important aspects of this is the reading of historical manuscripts.

There is also a course on modern mysticism, which provides information about new scientific research, publications on mysticism in the XX-XXI centuries, modern theology. In particular, scientists A. Kayumov, O. Usmon, N. Kamilov, H. Islami, SS Bukhari, AR Bukhari, B. Bobojonov, E. Karimov, who grew up in Uzbekistan and contributed to the study of mystical heritage; Russian scientists O.Akimushkin, E.Bertels, N.Semyonov, A.Khismatullin; Turkish scientists N.Tusun, M.A.Joshan, H.K.Yilmaz; Information on the scientific research of Western orientalists Yu.Paul, H.Algar, J.Gross, J.Trimingham, A.Kugelgen is also provided for the audience [10: 1].

Students of the scientific school are issued a special certificate (permission) on completion of a certain work (waiting for the letter).

In addition to studying the teachings of Naqshbandi, students of the scientific school pay special attention to the study of the heritage of such sects as Kubroviya, Yassaviya, Qodiriya, which have a special place in the history of our country. Although these sects propagated their teachings according to different rules, in some respects they established mutual harmony, cooperation, and even teacher-disciple relations. In particular, the founder of the Yassaviya sect, Khoja Ahmad Yassavi, was educated in Bukhara by Sheikh Yusuf Hamadoni [6: 317], and the founder of the Khojagan (Naqshbandi) sect, Abduhaliq Gijduvani, was taught by the same teacher. Summarizing the above, we can say that the sects formed in Central Asia do not differ significantly from each other, because, as we have noted, the teacher-student relationship continues in the later sects, even the murshids who acted with the permission of several sheikhs at the same time. [7: 106-107].

At one time, in order to gain the prestige of mystics among the people, there were cases when some malicious individuals tried to distract the people from the original mysticism with "false claims". There have also been some conflicting approaches to mysticism as a result of the diversity of customs and lifestyles, science and culture of peoples in different regions and lands. It is also unfortunate in the pages of history that some murids exaggerate about their pir, sheikhs, denying the ways of other teachers, blaming, slandering and cursing them, knowing that their way is the most correct [5:87].

However, in spite of some problems and contradictions, Islamic scholars, intellectuals and students of the sciences treated the schools of mysticism, which established their sect on the basis of the tenets of Islam, with high courtesy and respect.

In this regard, it is worth mentioning Naqshbandi, one of the most popular sects in the Islamic world with many followers. According to some statistics, the number of Muslims practicing the Naqshbandi sect worldwide is said to be in the millions. However, it is a bit difficult to say the exact number of these data, because a person who enters the path of a sect will be very careful of his qualities such as hypocrisy and ambition to show off his condition to people. In this regard, a number of well-known recommendations have been made in the Naqshbandi sect, including the rule of "Khilvat dar anjuman" or the motto "Dil ba yoru - dast ba kor" [3: 20-21]. promotes engaging in the remembrance of the Truth while engaging in honest labor. For this reason, in some cases it is more difficult to distinguish them from ordinary people, which requires a strong knowledge and experience.

In our centuries-old history, the doctrine of Naqshbandi has been recognized by Islamic scholars, one of the main reasons for this respect is that the famous scholar, mystic Sheikh Imam Rabbani lists the following four conditions of the Naqshbandi path.

1. Mastering the Ahl as-Sunnah and the community's faith.
2. Following the Sunnah of the Prophet (s.a.v.).
3. Staying away from evil heresies and lusts.
4. Follow with as much azimat as possible.

The strict requirement of these conditions by the Naqshbandi teachers from the Taliban was one of the reasons why the sect gained great prestige among the Shari'a scholars and the Ahl as-Sunnah and the community.

Today, as in the Middle Ages, the teachings of mysticism are being studied by scientists, intellectuals, and researchers, and new information is being provided to our people [2: 400]. In this regard, it is expedient to divide the work on the study of the history and socio-religious content of mysticism during the years of independence into groups. Including:

The first group is the work done by scientists and intellectuals, which can include research work in terms of the implementation of various scientific projects and government programs;

The second group consisted of research papers defended in specialized councils, in which researchers defended their papers within a specific topic and object;

In the third group of research works, we can show the practical work carried out by representatives of the religious sphere. In this case, the religious-enlightenment and popular approach prevailed;

To the fourth group we can include the work done independently by people interested in the teachings of mysticism;

The fifth group should be noted for the pedagogical and didactic work written for educational institutions;

To the sixth group we can show the materials of scientific-educational, socio-ethical direction, studied in the journalistic interpretation and covered in the media.

Given that the analysis of the work on these groups will be a comprehensive study, we consider it appropriate to present the research work in all groups as a separate scientific article. In this article, we found it necessary to provide a brief analysis of the research work defended. In particular, the research work carried out in our country has been defended in specialized councils of universities and research institutions, and experts of the Higher Attestation Commission under the Cabinet of Ministers have given positive conclusions to this research. These dissertations apply to various fields of science. It should be noted that the scientific research on the teachings of mysticism is mainly reflected in the research defended in the field of social sciences and humanities.

The classification of defended dissertations in the field of mysticism in the field of social sciences and humanities in the following areas:

1) 07.00.01 - History of Uzbekistan

2) 09.00.03 - History of Philosophy

3) 10.01.03 - History of national literature (Uzbek literature)

4) 10.01.10 - Journalism

5) 13.00.01 - General pedagogy, history of pedagogy and education

6) 19.00.05 - Social psychology and ethnopsychology

7) 24.00.01 - Islamic history and source studies (on historical sciences)

In the works defended in these specialties, the priority of the following features was identified. In particular, the candidate's dissertation on the specialty 07.00.01 - History of Uzbekistan N.Khidirova (2006) "The role and place of Khoja Muhammad Porso in the development of the Khojagan-Naqshbandi sect (late XIV - early XV centuries)." 07.00.08 - M. Kh. Candidate's dissertation on "Sharh at-Ta'arruf" and its influence on the sources of mysticism in Movarounnahr and Khorasan in the XI-XV centuries".

09.00.03 - M.Jakbarov's (2000) "Problem of social ideal and perfect man in the philosophical thought of Movarounnahr of IX-XII centuries", G.Navruzova's (2002) "Naqshbandi mystical doctrine and upbringing of harmoniously developed man", M.Mamatov's (2018)) "Dissertation on the historical and philosophical essence of the teachings of mysticism" defended dissertations for the degree of Doctor of Philosophy, this research focuses on the conceptual disclosure of the topic.

Also, O.Tursunova's (2002) "Moral values in the teachings of Khoja Abdukholiq Gijduvani mysticism", N.Safarova's (2002) "Problems of spiritual and moral values in the teachings of Khojagan's mysticism", J.Kholmuminov's (2003) Based on the work "Sharhi ruboiyot"), Z.Isakova (2007) "Religious and philosophical interpretation of the concept of guardianship in the teachings of Sufism (based on the work of Alisher Navoi" Nasoyim ul-muhabbat "), S.Ismailov (2008)" The role of the Naqshbandi sect in the development of mysticism ", B.Namozov (2011) “Philosophical bases of mystical views of Abu Bakr Kalabadi”, N.Zaynobidinova (2011) “Problems of human spiritual perfection in the mystical teachings of Jaloliddin Rumi”, O.Safarbaev (2011) “Humanism and patriotism in the mystical teachings of Najmiddin Kubro” in his PhD dissertations in the sciences through the philosophical analysis of mystical teachings.

10.01.03 - History of National Literature (Uzbek literature) by I. Hakkulov (1995) "Formation and development of Uzbek mystical poetry (ideology, follow-up, the world of images)", A. Abdukadirov (1998) "Sufism and Alisher Navoi's creativity (Vahdat ul In the doctoral and candidate's dissertations of K.Mullahojaeva (2005) "The combination of mystical symbolism and art in the ghazals of Alisher Navoi (based on" Badoe'-ul-bidoya ")" interpreted on a scientific basis and presented in a simplified manner.

10.01.10 - In the dissertation of G. Togaeva (2007) "Coverage of mystical doctrine in the Uzbek press: problems, principles and forms" in the field of journalism scientifically analyzed articles on mystical doctrine in the media and many issues aimed at covering their content.

13.00.01 - K.Kilicheva's (2009) doctoral dissertation on "Formation of students' spirituality in the system of higher education through mysticism" in the specialty of general pedagogy, pedagogy and history of education and recommendations are provided.

19.00.05 - In the specialty of social psychology and ethnopsychology U. Kasimov's (2004) defended dissertation on a theme "Social psychological features of the perfect man (on the basis of A. Gijduvani's

doctrine)" focuses on psychological features of upbringing of the harmoniously developed person.

24.00.01 - Candidate's dissertation on Islamic history and sources (on historical sciences) I.Usmanov "Al-Hakim at-Termizi's work" Navodir al-usul "important source on the science of hadith and mysticism" (2005) and is one of the first studies to be conducted on source studies [11: 1].

If we briefly analyze the works defended in the above-mentioned areas of specialization, we will see different approaches to the doctrine of mysticism, which in turn show how comprehensive the subject of mysticism is. Since the analysis of this research work requires a great deal of responsibility and hard work, we consider it expedient to study the research in each field of specialization separately.

Conclusion

In conclusion, it should be noted that a lot of research is being conducted in our country on the history of mysticism and scientific and educational heritage, and today this research has reached a new stage. In particular, we can observe this situation in the analysis of our recent research. Including,

- If we pay attention to the comparative analysis of research work in the early years of independence with today's research work, we will see a positive improvement;
- We can also see the entry of new historical data and scientific ideas into scientific consumption;
- An analysis of scientific research has shown that the study of the Naqshbandi sect is a priority in research.

The fact that we have many great scientists and a huge scientific heritage in the history of our country gives us a sense of pride, but at the same time, this sense of pride imposes on us a great responsibility. This burden of responsibility, in turn, requires us to make a worthy contribution to the foundation of the "Third Renaissance" by living, developing, studying the thousands of years of historical heritage and passing it on to future generations.

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Impact Factor:	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 8.771	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)
Year: 2022 **Issue:** 06 **Volume:** 110
Published: 02.06.2022 **http://T-Science.org**

Issue Article

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INTERPRETATION OF PERFECT HUMAN IN NAKSHBANDIYA TARIQAH: APPROACHES AND ANALYSIS

Abstract: *The role of tasawwuf scholars in Islamic civilization and their scientific and enlightenment services is great, and in our sacred religion, the science of belief (aqaid), fiqh and morality (spiritual education) are recognized as the most basic sciences. The issue of morality is one of the most widely propagated sciences in Islam, and it is a practical program that encourages human perfection. Over the centuries, many well-known scholars have developed in this direction, who have established their own enlightenment pathways, on the science and practice of spirituality, such as schools of tariqah thought.*

During the years of independence, many books have been written and translated in our country, which promote human perfection. This work continues today. But if we look at the scale of the great scientific and enlightenment heritage left by our ancestors, we will see that thousands of sources of mysticism still need to be studied and passed on to our people. Of course, the implementation of this work requires a huge responsibility, which in turn imposes great responsibilities on scientists, intellectuals, researchers.

This article presents the approaches and analysis of the concept of perfect human education, that is, the eleven rules of Naqshbandi, developed by Khojagon-Naqshband scholars over the centuries.

Key words: *Islam, tasawwuf, Naqshbandiya, tariqah, eleven rules, sheikh, perfect human, sufism, scientific school, scientific research.*

Language: *English*

Citation: Khatamov, T. A. (2022). Interpretation of perfect human in Nakshbandiya tariqah: approaches and analysis. *ISJ Theoretical & Applied Science, 06 (110),* 12-17.

Soi: http://s-o-i.org/1.1/TAS-06-110-3 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2022.06.110.3

Scopus ASCC: *3300.*

Introduction

One of the sects that needs to be widely studied in our country is Naqshbandiyya, which was formed over many centuries and reached a high position during the reign of Hazrat Khoja Muhammad Bahauddin Naqshband (1318-1389). The fact that the Naqshbandi community has achieved great success among the schools of mysticism is emphasized in many historical works, manaqibs and tazkirs [12:3-15].

But, unfortunately, the Naqshbandi sect was misinterpreted during the former Soviet regime and was portrayed as a community that propagated mystical ideas to our people, and in some cases sought wealth and power through religion[8:252].

In fact, the representatives of the sect have always been a community of people who strive for perfection, knowledge, discipleship, carrying the burden of the people, gaining the approval of God, and sincere devotion to the Creator. The Naqshbandi school was built on the following four principles:

1. Purification of the appearance with the Shari'ah;
2. Purification of the heart with the sect;
3. Achieving Divine Power through Truth;
4. Achieving Allah through enlightenment [3:41].

There are a number of tax requirements for following the path of Naqshbandiyyah, first of all, repentance, strict adherence to the Sunnah of the

Prophet (peace and blessings of Allaah be upon him), abstinence from heresies contrary to the Shari'ah, strengthening piety in religious matters, not doing injustice, paying one's debts, asking for permission, praying mention [16:35-36].

Eleven rules played an important role in the process of step-by-step education of students in Naqshbandi, but in this process the same rule was not applied to all students in the same way, because each person has different character, ability, level of knowledge, generosity, obedience to the teacher. based on these differences, different methods have been used to implement the Eleven Rules in the education of students[12:149].

These eleven rules were formed over several centuries and the first four rules were established by scholars such as Khoja Yusuf Hamadoni (XI-XII centuries), the next four rules by Khoja Abduhaliq Gijduvani (XII century) and the last three rules by Khoja Bahauddin Naqshband (XIV century) [10:188].

1. Pleasant rest - taking every breath with vigilance and remembering Allah;

2. The stepping-stone is to be careful of one's gaze, to walk towards the toes while walking. He must also make sure that his every step does not lead to sin;

3. Safar dar vatan - to correct one's morals while abandoning one's bad qualities while traveling in one's homeland with devotion to Allah;

4. A private meeting is to be with the people outwardly and with the Truth inwardly. The heart is always to remember Allah and not to reveal his condition to anyone;

5. Yod kard - equal remembrance of the tongue and heart;

6. Boz Gasht - After reciting the dhikr, he should say, "O Allah, the purpose and the pleasure are desirable." introduced;

7. Nigoh dosht - to save the heart from various thoughts and temptations by saying "La ilaha ilallah";

8. Remembering is always remembering Allah with pleasure and being vigilant;

9. It is emphasized that the Vukufi is modern - the tax analyzes his situation, thinks that he should give thanks or forgiveness, and accordingly he is in the status of a slave;

10. Wuqufi adadiy - in murid dhikrs, the ability to follow the number (odd) and control one's mind, it is stated that this is the beginning of laduni science[14:60];

11. Wuqufi Qalbi - When the tax reaches this stage, he thinks of nothing but the Truth. Achieves the highest level of remembrance [5:138-150];

The main purpose of these rules was to bring the Taliban to perfection by cultivating their psyche, but we cannot say that all the people who joined the sect achieved great results [6:154]. The greatest struggle in mysticism is with this person's nafs, that is, with himself. The nafs ammora, by its very nature, encourages man to think of his own pleasures for evil, disobedience, which is pleasing to people whose will and knowledge are weak, and who easily surrenders to the desires of his nafs.

Many religious and historical sources have commented on these rules for the Taliban, and this article focuses on the analysis of the role of the eleven rules inherited from our Khojagon-Naqshband ancestors in the education of the perfect man.

Methods

The article was conducted using research methods such as historical, scientific, systematization, comparative analysis, objectivity.

Main part

In our study of historical sources, we see that a peculiar experience of the practical application of the eleven rules of the Naqshbandi sect has been formed. In particular, some people have mastered the eleven rules of this sect in a short period of time (a few years), and some disciples in a very long time (20-30 years) [5:216]. Of course, those who passed in a short time also had the ability to fulfill the conditions set out in these rules to some extent independently, and when it came to the sheikh, the murid's ability was systematized according to eleven rules, so it was much easier for the taxman to cross this path[22:80-82].

Given that these rules are comprehensive, it is worthwhile to consider and analyze each rule separately in our article.

The first rule is: "Khush dar dam" - this rule commands the taxman to be vigilant with every breath he takes, not to be ignorant, and to engage in the remembrance of Allah at all times. This rule requires a serious effort from the murid. According to Sufis, every breath is the last breath, so it is emphasized to be vigilant in inhaling and exhaling and to be with the remembrance of the Truth. It is said that zikr awakens every particle of the soul, in which a person prays with his breath. The rule also stipulates that some Sufis must resist the temptation to lose their control and live in a state of insanity, because the Islamic Shari'ah does not prescribe a state of insanity, a state of insanity in the name of religion, and it is forbidden by mystical scholars to do so. scientific refutations were made against him and books were written [13:75].

Some sources on true mysticism state that Sufis fainted and fell into various states, but these cases were considered defective. As an example of this historical event, when the death of Hoja Bahauddin Naqshband was approaching, one of his favorite disciples, Hoja Muhammad Porsoni, was recommended for his place, but in the incident the murids pledged allegiance to their second disciple Hoja Alouddin Attar, even Hoja Muhammad Porso himself gave Hoja Aloudd he was recognized as a perfect murshid. Hoja Ubaydullah Ahror states that Hoja Muhammad Porso had cases of fainting during tawajjuh and murakaba, in which Hoja Alouddin Attar

was aware of himself, and in this regard Hoja Muhammad Porso asserted that he had pledged allegiance to that person [5:188].

In conclusion, it can be said that the representatives of the original mysticism, including the Naqshbandi, accepted as a sign of maturity the fact that a person perceives himself in the passage of the status of the sect, not to lose consciousness and go to hell.

The second rule: "Nazar bar kadam" is a rule that means that the eyes of the Taliban are on their feet. What the eye sees occupies the heart - that is, when the eye walks on the road with remembrance and contemplation, if the eye sees something that is not, the peace in the heart, the wholeness within, will be shattered, and then it will be difficult to restore that peace and integrity. Keeping one's eyes down was also a sign of humility and modesty, and it was also intended to avoid arrogance, such as arrogance and fame [16:109].

However, in some periods, habits such as falling in love with non-mahrams or beautiful faces became commonplace in some Sufi communities, even pretending to be beautiful young children and watching it in the middle. These wrongdoings were justified by the fact that we were observing the manifestation of Allah by looking at beautiful faces [21:233] freed the disciples from the various indecent acts mentioned above. This rule is stated in the Qur'an: "Tell the believers to lower their gaze." (Surat an-Nur, 30) [7:353]. It should be noted that there have been liars, heretics, and heretics who have made various claims in the name of mysticism in each period, but they have been rejected by Shariah scholars and sheikhs of the original sect [20:3-93] and on the basis of Islamic tenets. Our historical sources confirm that the teachers of the Naqshbandi sect made great sacrifices in this regard [17:5-34].

The third rule: "Journey to the homeland" - the meaning of the journey in this rule is symbolic, where it is understood to "travel from the people to the Truth." That is, the emphasis is on the transition from the journey of man to the journey of angels - from the journey of evil to the journey of good. This principle teaches the murid to live like a stranger in his own country - that is, it is important for him to realize that the world is transitory and that he is a stranger in the world.

The rule also opposes city-to-city wandering and emphasizes living in one's homeland without the need for others. This is because those who make a living by begging, especially at the expense of begging, consider this to be against our religion. On the other hand, the original journey here implies the migration from the haram to the halal, and the end of the journey to the Hereafter.

The fourth rule: "Lonely meeting" - "loneliness" in Arabic - means loneliness, solitude. “Anjuman” is a Persian word meaning community, public place, gathering, gathering. "Narrow" means inside, in between.

Hoja Bahauddin Naqshband says that the basis of our sect is "Khilwat dar anjuman", that is, to be with the people on the outside and with the Truth on the inside. The motto "Dil ba yoru - dast ba kor" (your hand is in labor - your heart is in Allah) is also reflected in this rule. Indeed, there is a reference to this in the [7:355]. Haja Ubaydullah Ahror said, “If a person concentrates himself and gives himself in complete dhikr, he will attain a rank in five or six days, so that the speech and shouting of the people will appear as dhikr. Even his words seem to be dhikr ” [17:42].

It is relatively easy for a person to pray in private, to recite dhikr and prayers, to recite the Qur'an, but it is very difficult to control oneself and avoid sins when interacting with people, such as at work, in business, on the street, in the family. In the process of communicating with the people, there is an increased risk of lying, gossip and conspiracy, eating haram, looking lustfully at non-mahrams, and inclining to various sins. requires constant resistance to.

At the same time, it is stated that it is not permissible to be isolated from society [13:75]. It is even called heresy. Because when the Prophet (peace and blessings of Allaah be upon him) received the prophethood, they cut off communication with the people and did not retreat to any corner. They always apparently preached and taught religion to the people. In addition to conveying the commands of Allah to the people, they did not stop praying to Allah. Various superstitions that contradicted the tenets of Islam were opposed by the representatives of the Naqshbandi sect, who stood firm on the basis of pure Islamic faith and gained the recognition of the Ahl as-Sunnah wa'l-Jama'ah [12:121].

Four rules added by Abdukholiq Gijduvani: 5. “Yod kard” means to remember, the main condition of this rule is that the tongue and the heart are equally occupied with remembrance. However, it is also possible to mention it with the heart. One of the requirements of the Yad Kard rule is that if a murid is unable to perform the dhikr of the heart while reciting with the tongue, he must continue the dhikr, even if it is with the tongue in form or imitation. In order to achieve this, it is recommended to mention up to five thousand times a day [3:39].

6. “Boz gasht” - according to this rule, after performing a certain number of dhikrs, the tax says, “The divine anta is purposeful and the consent is desirable” - that is, “O Allah, You are my goal, my request is Your will” [1:34]. The purpose of saying this is so that the murid does not forget why he is reciting dhikr, because it is said that the main goal is to gain Allah's approval and love, and if he forgets and mentions it blindly, the benefit will be less and he may deviate from the original purpose. Sometimes the murids were ashamed to say the word because they did

not consider themselves to be the real claimants in this way, but the Naqshbandi teachers stressed the need to persevere in uttering the word, and that these words would eventually become ingrained in the human heart.

7. "Nigoh dosht" - this rule is understood to protect the heart of the seeker from things that distract him from Allah. Mawlana Sa'diddin Qashqari said about this rule: “Allah has made the heart a mirror for His beauty. Anxiety enters, and nothing is visible in the mirror. He cannot observe the beauty, the rays, the names, the attributes of the Truth, which does not protect the heart. The fact is that success on this path is very difficult. For this reason, the protection of the soul is the highest status in Naqshbandi” [5:146].

Salik tries to free his mind from various thoughts by thinking about the meaning of the dhikr of nafi and proof. A person who is able to keep this state for two hours or more will no longer have other memories in his heart.

8. "Yod dosht" - remember that the difference between this rule and "Yod card" is that it does not remember the tax, but rather does not forget. In other words, it is to constantly strive for the existence and oneness of Allah at all times and in all things. Muroqaba - how is it? The taxman removes all worries from his heart and thinks of God as one and all-encompassing. Thinking that this coverage is pure from things such as matter, size, color, shape, aspect, space, it travels in all things as a Divine light specific to His Being. It is emphasized that one of the main functions of the rule of iodine is to further deepen and apply the situation in Nigoh dasht [5:146].

Result

The article analyzes why Hoja Bahauddin Naqshband added three more rules to the eight rules and seeks answers to a number of questions in this regard. Including,

1. First of all, why were three more rules added to the rules of this sect by Hoja Bahauddin Naqshband?

2. Did this concept based on eleven rules become perfect after Hoja Bahauddin Naqshband?

3. Why haven’t new rules been added by the next generation of Naqshbandi teachers for 600 years?

4. Or were there no Murshids who introduced new rules?

Based on the analysis of the available data, we can say that this program of the sect was conceptualized by Hoja Bahauddin Naqshbandi with three rules, so there was no need to add new rules to the eleven rules formed by Naqshbandi teachers over the centuries, but to explain the existing rules to students. , the main focus was on explaining the subtle differences between each rule [18:13].

In general, there were many ideological debates, discussions and debates in mysticism, but this did not change the rules of Naqshbandiism. , which led to the emergence of the Pir, resulting in many problems in following the original mystical ideas, and even today there are many debates and contradictions on these issues [22:113-114].

If we look at the essence of the content of the three rules added by Hoja Bahauddin Naqshband, we see that the delicate issues raised in these rules are indeed relevant.

In particular, the ninth rule is "Wuqufi zamoniy" - according to this rule, the taxman should be aware of his situation at all times, use his time productively, express gratitude, repentance and forgiveness, and act accordingly. In this case, adherence to time is a priority, and it is important to strive to perform daily tasks, such as dhikr, virdi, in a timely manner. The murid had to keep track of his daily activities every evening, thinking about the morning in the evening and the evening in the morning. He had to think about what to do, be alert, intend to live in peace, be determined and attentive. At the same time he had to calculate how the previous evenings and mornings had worked or not. Of course, time does not return, but he is encouraged to do what he could not do, to live in a state of peace that he could not live from now on [11:145].

Hoja Bahauddin Naqshband says in this regard: It is necessary for a person to know his state at all times, to ask for forgiveness, and to be thankful in case of prosperity. Attention and adherence to these two conditions is considered to be modern” [5:148].

The tenth rule is “Wuqufi adadiy” - this rule was introduced into the Naqshbandi sect as the tenth rule by Hoja Bahauddin Naqshband, but in fact historical sources state that this science was taught by Hoja Yusuf Hamadoni to his disciple Abduhaliq Gijduvani [12:146].

In Wuqufi adadiy, it is commanded to follow the sanaq (odd recitation), and in this regard, we see in our Shari'ah that the dhikr is commanded to follow a certain number, for example, it is stated to recite the dhikr 33 times after the obligatory prayers. Why is the focus on reciting dhikrs in accordance with the number, the main purpose of which is to avoid mental confusion when the heart is engaged in dhikr, to control one's thoughts, and to focus one's attention on one point calmly. In this case, the Taliban's heart repeats the Kalima Tawhid 3,5,7 or 21 times in one breath. According to Hoja Alouddin Attor, observing the number alone does not give a complete result. Hoja Bahauddin Naqshband states that the science of Wuqufi adadiy is the starting point of Laduni [12:146

The eleventh rule, "Wuqufi qalbiy," means that the soul is aware of the Truth, and in this position the heart thinks of nothing but Allah. It is also the last of the dhikr etiquettes and has two meanings.

In the first sense, every moment of remembrance must know Allah, leaving no room for anything else in the heart.

In the second sense, the dhikr turns to the heart during dhikr. He looks at the truth of the heart with insight, focusing on the heart.

In Naqshbandi, Wuqufi is the highest level of heart remembrance.

Discussion

We can see that the eleven rules of the Naqshbandi sect were developed by the most famous teachers of this sect, formed and developed over a thousand years. The fact that these rules, developed at the Naqshbandi school, have reached not only Central Asia but also India, China, Afghanistan, Pakistan, Bangladesh, Indonesia, Malaysia, Iran, Turkey, the Caucasus, Russia, the Middle East, Africa and the Arab world shows how popular the sect is [4:147].

In these eleven rules we can see the following five distinct aspects:

1. Representatives of the Naqshbandi sect were not separated from society, that is, they could live by these rules without leaving the world, which played an important role in the rule of "Khilvat dar anjuman";

2. In following these rules, the tax is obligatory to know the Shari'ah sciences and to be a follower of the Sunnah, which has played a major role in preventing various conspiracies, heresies and misguidance among Muslims [15:3-255];

3. It is obligatory for a murid to have a profession, because living by begging without an excuse is strongly condemned in Islam. In Allah);

4. In Naqshbandiyya, one of the most preferred deeds is to serve the people, alleviate their burdens, and make sacrifices for the people in general in finding the approval of the Truth. We can cite as a vivid example of the nationalist activity of Khoja Ahror Wali during the Timurids [17:387-400];

5. The followers of this path were very careful not to disclose their prayers and deeds to the people as much as possible, not to be hypocritical, ambitious, not to claim governorship [2:8-9], and to strive for wealth and power.

Conclusion

In conclusion, the idea that man can reach perfection, their directions, methods and stages are propagated in almost all religions, while the representatives of religion, doctrine and culture considered their path to perfection as the most correct way. Humans have lived on a single planet for thousands of years, and although many wars and massacres have taken place in history, scientists and intellectuals who have always strived for peace and harmony and have conducted various researches along the way have brought people to maturity through science and enlightenment. considered possible [19:8-9];

The teachings of Sufism have also been studied by scholars, scholars, intellectuals, and teachers on the basis of Islam for centuries and have been recognized as one of the most developed mystical ways. Despite certain ups and downs, people still feel the need for these schools and are still exploring the legacy of this scientific-educational school. After all, relying on the heritage of our ancestors in the upbringing of a harmoniously developed generation has a positive impact on the future of our youth.

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SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 03.06.2022 **http://T-Science.org**

Issue Article

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REFERENCE DATA OF PRESSURE DISTRIBUTION ON THE SURFACES OF AIRFOILS HAVING THE NAMES BEGINNING WITH THE LETTER J

Abstract: *The results of the computer calculation of air flow around the airfoils having the names beginning with the letter J are presented in the article. The contours of pressure distribution on the surfaces of the airfoils at the angles of attack of 0, 15 and -15 degrees in conditions of the subsonic airplane flight speed were obtained.*

Key words: *the airfoil, the angle of attack, pressure, the surface.*

Language: *English*

Citation: Chemezov, D., et al. (2022). Reference data of pressure distribution on the surfaces of airfoils having the names beginning with the letter J. *ISJ Theoretical & Applied Science, 06 (110),* 18-25.

Soi: http://s-o-i.org/1.1/TAS-06-110-4 ***Doi***: https://dx.doi.org/10.15863/TAS.2022.06.110.4

Scopus ASCC: *1507.*

Introduction

Creating reference materials that determine the most accurate pressure distribution on the airfoils surfaces is an actual task of the airplane aerodynamics.

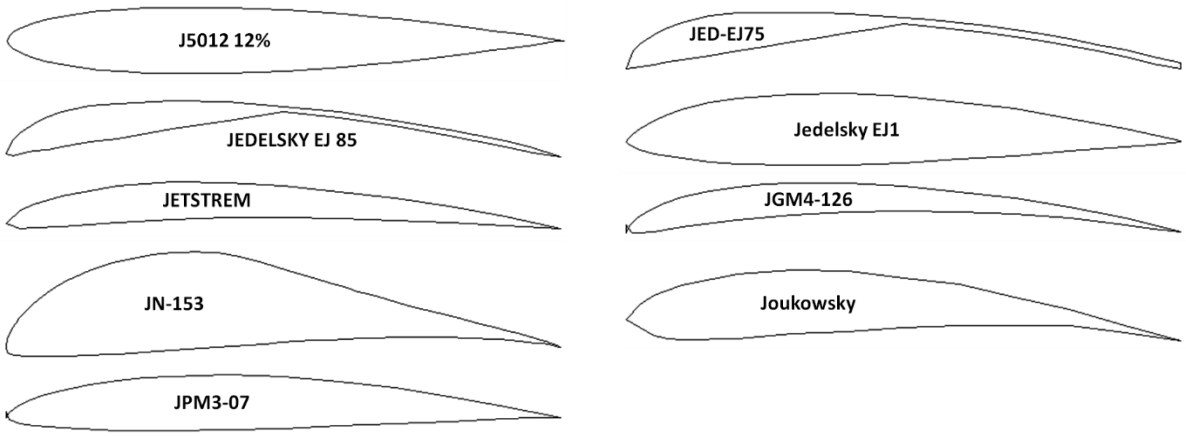
Materials and methods

The study of air flow around the airfoils was carried out in a two-dimensional formulation by means of the computer calculation in the *Comsol Multiphysics* program. The airfoils in the cross section were taken as objects of research [1-24]. In this work, the airfoils having the names beginning with the letter *J* were adopted. Air flow around the airfoils was carried out at the angles of attack (α) of 0, 15 and -15 degrees. Flight speed of the airplane in each case was subsonic. The airplane flight in the atmosphere was carried out under normal weather conditions. The geometric characteristics of the studied airfoils are presented in the Table 1. The geometric shapes of the airfoils in the cross section are presented in the Table 2.

Table 1. The geometric characteristics of the airfoils.

Airfoil name	Max. thickness	Max. camber	Leading edge radius	Trailing edge thickness
J5012 12%	12.0% at 34.5% of the chord	0.0% at 83.5% of the chord	1.1982%	0.0%
JED-EJ75	7.03% at 15.0% of the chord	8.6% at 50.0% of the chord	1.59%	1.0%
JEDELSKY EJ 85	6.5% at 15.0% of the chord	8.5% at 50.0% of the chord	1.0103%	0.0%
Jedelsky EJ1	12.9% at 40.0% of the chord	2.21% at 40.0% of the chord	0.3876%	0.165%
JETSTREM	6.7% at 30.0% of the chord	5.05% at 40.0% of the chord	1.3601%	0.0%
JGM4-126	6.32% at 21.1% of the chord	6.68% at 42.1% of the chord	0.761%	2.5%
JN-153	17.57% at 29.9% of the chord	8.35% at 38.0% of the chord	3.3605%	0.0%
Joukowsky	11.53% at 20.0% of the chord	7.05% at 40.0% of the chord	1.5472%	0.0%
JPM3-07	10.66% at 42.1% of the chord	2.83% at 42.1% of the chord	0.4162%	2.0%
Note: *JEDELSKY EJ 85* (d'apres Modele Mag n°379 de 1983); *Joukowsky* (I. Joukowsky (Germany)).				

Table 2. The geometric shapes of the airfoils in the cross section.



Results and discussion

The calculated pressure contours on the surfaces of the airfoils at the different angles of attack are presented in the Figs. 1-9. The calculated values on the scale can be represented as the basic values when comparing the pressure drop under conditions of changing the angle of attack of the airfoils.

9 airfoils of different series were studied in this work. All airfoils are asymmetrical except J5012 12%.

The drag coefficient of the airfoils of the airplane wings depends mainly on the value of the radius of the leading edge. The drag coefficient is calculated from the positive pressure values near the leading edge of the airfoil during horizontal flight of the airplane. With an increase in the contact surface of the leading edge with air, the drag also increases. However, with an increase in the radius of the leading edge by 8 times, the drag coefficient increases by 1.017 times. Negative pressure occurs on the upper and lower surfaces of the airfoils. An increase in the negative pressure value is observed for the airfoils with the camber in the cross section.

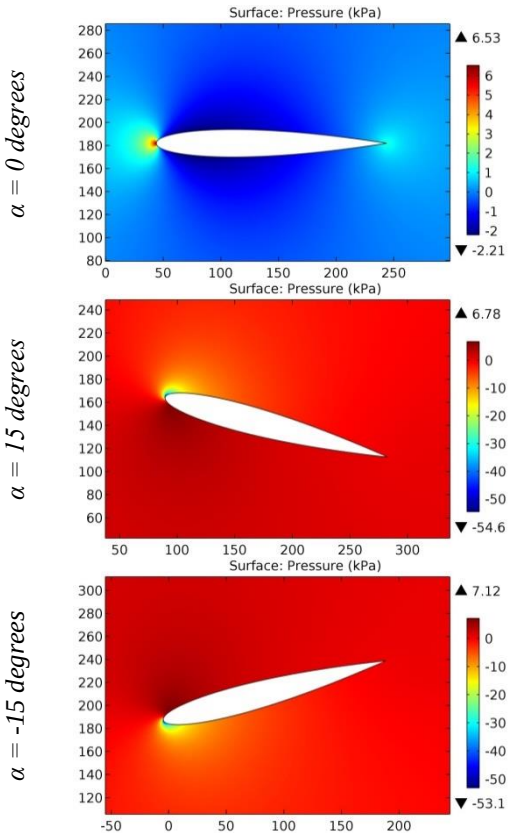


Figure 1. The pressure contours on the surfaces of the J5012 12% airfoil.

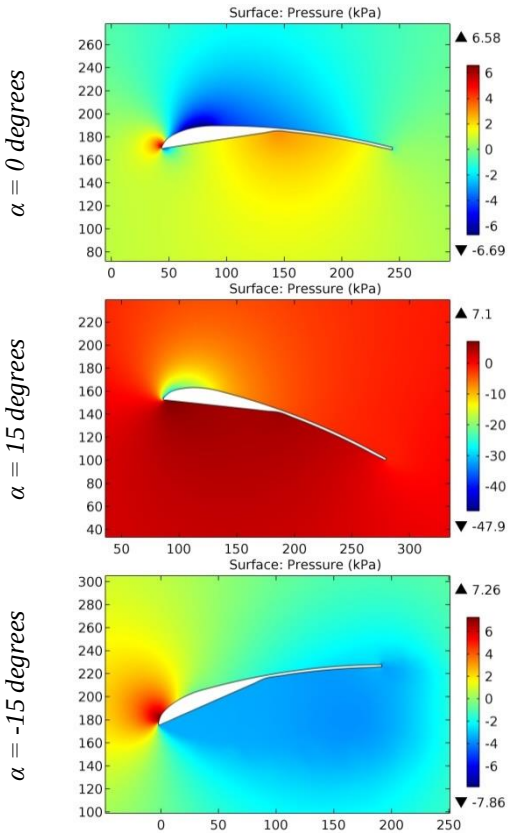


Figure 2. The pressure contours on the surfaces of the JED-EJ75 airfoil.

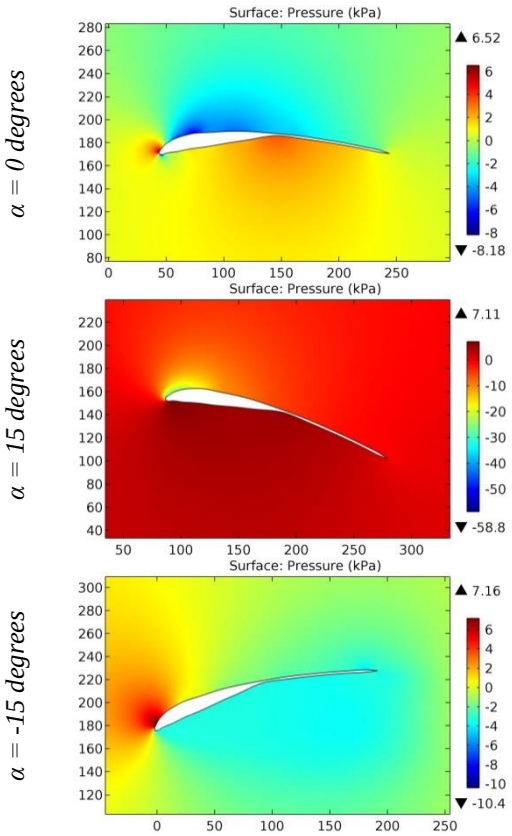


Figure 3. The pressure contours on the surfaces of the JEDELSKY EJ 85 airfoil.

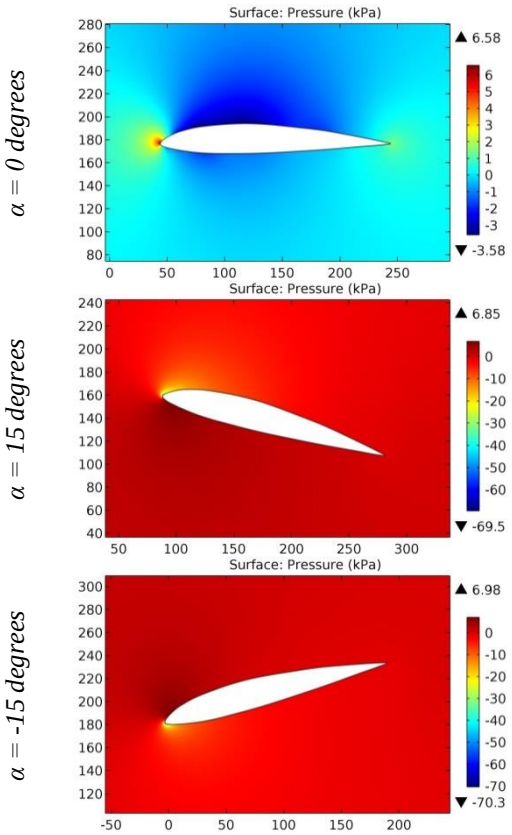


Figure 4. The pressure contours on the surfaces of the Jedelsky EJ1 airfoil.

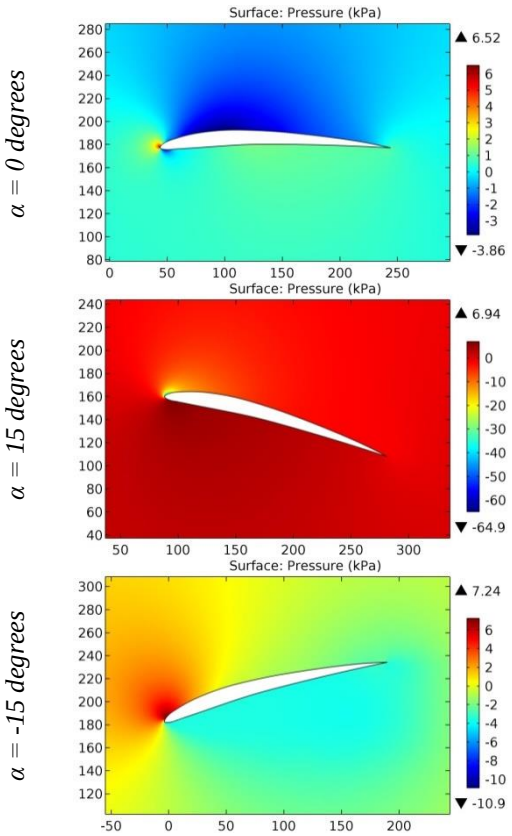


Figure 5. The pressure contours on the surfaces of the JETSTREM airfoil.

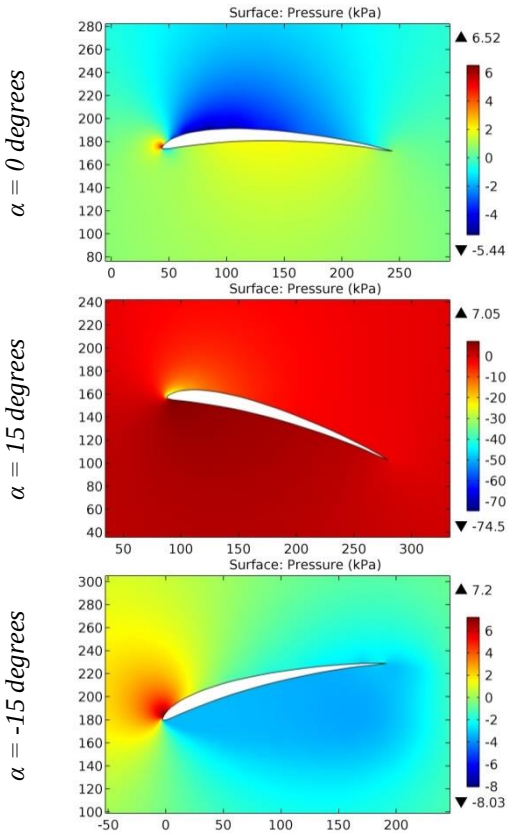


Figure 6. The pressure contours on the surfaces of the JGM4-126 airfoil.

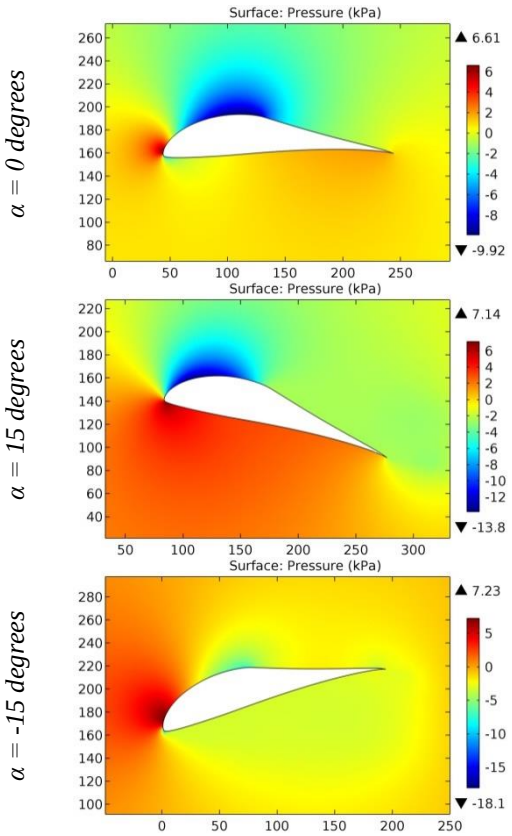


Figure 7. The pressure contours on the surfaces of the JN-153 airfoil.

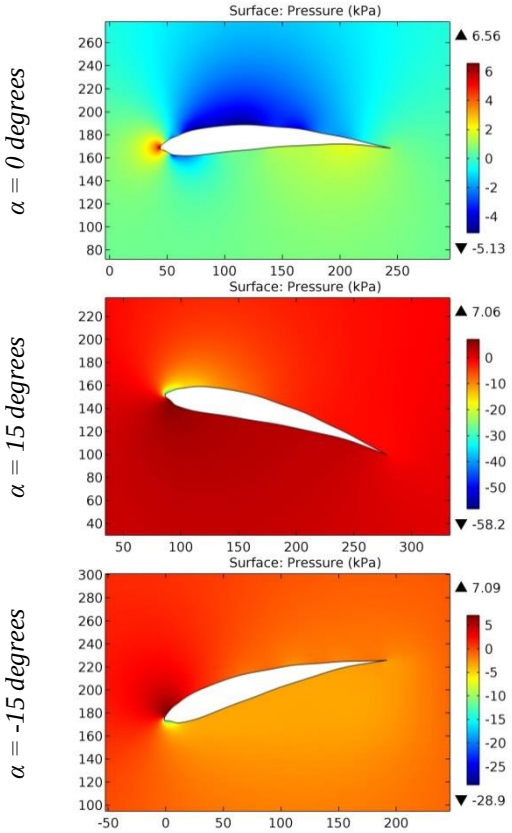


Figure 8. The pressure contours on the surfaces of the Joukowsky airfoil.

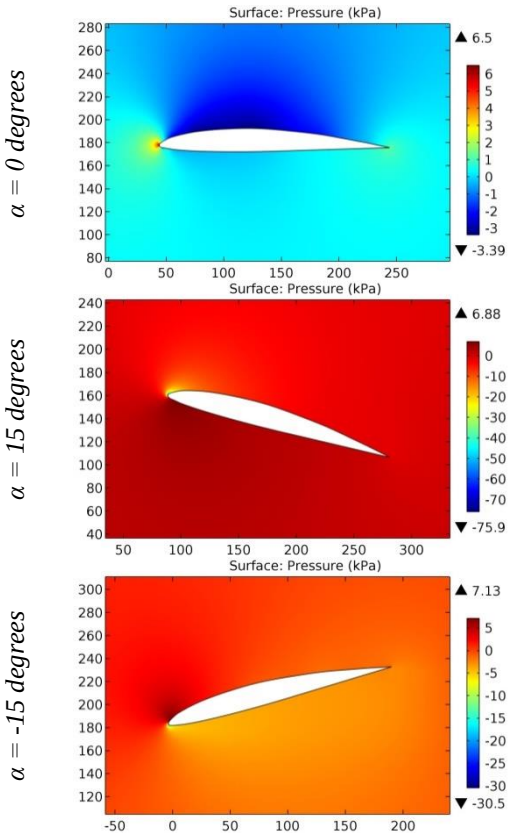


Figure 9. The pressure contours on the surfaces of the JPM3-07 airfoil.

The climb and the descent of the airplane lead to an increase in the negative pressure value on the surfaces and edges of the airfoils. At the same time, the maximum values of negative pressure under the conditions of the airplane maneuvers are determined for the asymmetrical airfoils with the minimal camber, for example, Jedelsky EJ1 and JPM3-07. It is noted that the airfoils with the greatest thickness and camber provide a decrease in the value of negative pressure on the surfaces and edges during the airplane descent. The JED-EJ75 and JN-153 airfoils have such properties.

The JED-EJ75 and JEDELSKY EJ 85 airfoils are almost identical in the cross section. On the JED-EJ75 airfoil, areas of negative pressure of greater intensity, but the less value, are formed than on the JEDELSKY EJ 85 airfoil.

The maximum increase in pressure on the leading edge occurs at the angle of attack of -15 degrees for the Jedelsky EJ1 and JN-153 airfoils. The maximum increase in pressure on the leading edge occurs at the angle of attack of 15 degrees for all other airfoils.

Conclusion

To improve the aerodynamic characteristics, the airfoil must be made with the certain camber, the small radius of the leading edge and the large thickness relative to the chord in the cross section. The more convex upper surface of the JPM3-07 airfoil results in the large drag on the leading edge, which reduces the lift-to-drag ratio of the airplane wing.

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SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 03.06.2022 **http://T-Science.org**

Issue **Article**

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DEVELOPMENT OF THE CLIENT PART OF THE MULTIPLAYER ONLINE GAME ABOUT LABYRINTHS

Abstract: *This paper is devoted to researching the theory of mazes and developing a cross-platform game for mobile and desktop devices. Different algorithms for solving mazes were analyzed and the mathematical basis of the developed method of drawing mazes using computer graphics was considered.*

Key words: *solving mazes, mazes drawing, online games, Java, Android, iOS.*

Language: *English*

Citation: Kozhevnikov, V. A., & Loginov, A. A. (2022). Development of the client part of the multiplayer online game about labyrinths. *ISJ Theoretical & Applied Science, 06 (110)*, 26-34.

Soi: http://s-o-i.org/1.1/TAS-06-110-5 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2022.06.110.5

Scopus ASCC: *1700.*

Introduction

Currently there is a huge variety of games, including online games. Programming games for mobile devices is considered one of the most popular and growing area in development and is distinguished not by its bulk 3D models or the complexity of drawing all the textures, but by its original ideas, dynamism and, of course, the desire spend the user time interesting and in a quick format.

This article describes the development of an online game for mobile devices based on the theory of mazes. The main idea is that users will compete - who can pass a randomly generated maze faster. Each player starts the maze in his corner and must get to the opposite corner faster than his opponent. The players have one maze, but since the maze is automatically generated, it may turn out that for one user the path is more obvious. That's why it was a requirement for the game to add the ability to use different skills, to restore the game balance for each user.

The relevance of this work is that now in the app stores GooglePlay and AppStore there are no games with the passage of mazes with friends or in competitive mode. This idea extends the concept of a very popular theme in games - puzzles, or to be more precise - the theme of solving mazes.

Problem statement, analysis game development technologies, analysis of source code security methods

Since the goal is developing a client part of the cross-platform online game for mobile devices, as well as programming the algorithm of bot-opponent, to be able to play offline, then to achieve this goal it is necessary to perform the following tasks:

1. Analyze existing applications on similar topics, identify shortcomings, and formulate the competitive advantages of the future game;
2. Based on the analysis of competitive applications, develop a design that will appeal to the game's target audience;
3. Determine the stack of developing technologies;
4. Set up data retrieval from the server using WebSocket;

5. Design and implement player skills mechanics;
6. Develop an algorithm for solving the maze, by a bot-opponent;
7. To ensure the security of the application's source code;
8. Test the application with a focus group;
9. Publish the application on GooglePlay.

After review existing maze games, it was noticed that there are currently no apps in the Android and iOS app stores that combine genres such as racing and maze solving. Most apps have pre-generated levels and position themselves as a classic puzzle game. The disadvantages of existing applications (the games "Labyrinths and More" by Maple Media, "Labyrinth" by InfinityGames.io, "Maze" by WEGO Global studio were considered) are usually outdated design, lack of control over player movements, large number of ads, lack of online mode, lack of different game modes. Therefore, the creation this game is relevant.

When researching game development technologies, the libGDX framework was chosen to develop this game. LibGDX is a framework for cross-platform Java game development. Note that it is a framework, that is, it provides some basic tools package, but it is not an engine in its pure form. It differs in those developers can take care of resource storage and customize animations with code themselves. Only basic UI components are given. On the one hand, this slows things down at first because there is no visual interface for scene editing. On the other hand, it allows developers to learn game programming at almost the lowest level and customize everything as needed for a specific purpose. libGDX was chosen precisely because of the large amount of complex and specific logic involved in solving a maze, its generation, and the development of unusual game animations that are tied to the maze object. To meet these requirements, you need a very flexible tool, which libGDX is.

An important part is the analysis of source code security techniques, because when developing client applications, you should always keep in mind the security of user data and source code. Since the application is cross-platform, the security for both the iOS version and the Android version was considered in detail.

The first thing every developer should do before publishing his application is to add source code obfuscation [1]. The most common tool now for code obfuscation in Android applications and many other Java-based applications is ProGuard [2]. It is an open-source command-line tool that compresses, optimizes, and hides Java code. All ProGuard manipulations with bytecode can be divided into 3 main categories: Code shrinking, Optimisation and Obfuscation [3].

Code shrinking – the process of getting rid of code not used by the application. This process looks for unused methods, classes, variables and removes them from the bytecode, but we should not forget that some things can be triggered by the reflexive approach. For such cases you should use your own configuration rules for this process.

Optimization – the process of code optimization, to improve performance [4]. It does a huge number of things, each of which makes the code at least a little bit more productive. For example, if a class has only one subclass and the base class has never been created, Proguard combines these classes into one. Also removes methods which are used once, replacing them with inline constructs. Replaces enum with integer constants, removes inline constructs, and more.

Obfuscation – in a broad sense - reducing the source or executable code of a program to a form that preserves its functionality, but hinders analysis, understanding of algorithms and modification during decompilation.

In this application, communication with the server side is implemented using WebSocket technology [5]. It is widely used in modern web applications, initiated via HTTP, and provides long-term connections with asynchronous communication in both directions. To protect the data transmitted over the network using web sockets was used secure protocol wss, which works on top of the TLS protocol.

Introduction to Labyrinth Theory

A labyrinth is a structure, in two- or three-dimensional space, consisting of tangled paths to an exit [6]. In this paper, we will consider ideal labyrinths. An ideal labyrinth is a labyrinth without any loops and consisting of a single connectivity component. From each point there is exactly one path to any other point. The labyrinth has exactly one solution. In computer science terms such a labyrinth can be described as a spanning tree over a set of cells or vertices [7].

There are many types of labyrinths, in this work will be discussed only a few types, namely:

- Orthogonal-Labyrinth;
- Delta-Labyrinth;
- Sigma-Labyrinth.

An orthogonal labyrinth is a maze which is a standard rectangular grid in which the cells have passages that intersect at right angles. In the context of tessellation, it may also be called a gamma maze.

A delta maze is a maze that consists of intersecting triangles, where each cell can have up to three passages connected to it.

A Sigma Labyrinth is a labyrinth that consists of interconnected hexagons, where each cell can have up to six passages connected to it.

All these mazes are similar in that they are composed of regular polygons. This idea was applied to the software architecture to set up a more abstract visualization of the labyrinth on the screens of devices.

In addition to the fact that users will be able to compete, it is necessary to add the ability to play offline, that is, in the absence of an Internet connection. In order to keep the concept of a competitive mode instead of creating levels, it was decided to implement an opponent bot. There are several fundamental ways of completing mazes, each of which has its own features.

Recursive retrieval is an algorithm based on recursive depth-first search in a graph [8]. This algorithm will always find a solution, but not necessarily the shortest one. When choosing the direction of movement, the usual random is used, and the cell is marked as passed, if the chosen path turned out to be a dead end (does not lead to an exit), then the algorithm recursively returns to the cell where the choice was made and repeats the action again.

Deadlock filling is a simple algorithm for solving a maze that focuses on the maze, is always very fast, and does not use extra memory [9]. The idea is to scan the maze in advance, find all dead ends, and fill passages in the opposite direction until an intersection is found. It is also necessary to mark, those intersections to which other dead ends lead. This algorithm works well for a perfect maze, because eventually you will find that one solution. For regular mazes this algorithm will find several solutions, but for mazes without dead ends it will be useless.

Wall follower is maze solving algorithm which focuses on the player, always works quickly, and does not require the use of additional memory. The essence of the algorithm is that you must always turn in one direction when choosing a direction, which is very similar to the way people go through mazes. This method looks for any solution, not necessarily the shortest one in the case of a non-ideal maze. The algorithm will not work when the final goal is in the center of the maze and there is a closed loop around it, because the robot will bypass the center and eventually return back.

Now we describe the mathematical basis of the labyrinth drawing algorithm. When describing the algorithm, the following types of mazes will be considered:

- Orthogonal labyrinth (consists of square-shaped cells);
- Delta maze (consists of cells shaped like regular triangles);
- Sigma labyrinth (composed of cells shaped as regular hexagons).

It is easy to see that all current maze types are a set of regular polygons. This property of cells was taken as the basis for the implementation of the labyrinth drawing algorithm. Namely, the property of a regular polygon, which says that any regular polygon can be inscribed into a circle. Accordingly, to dynamically calculate the size of the cell, it was decided to count the radii of the circles circumscribed around the cell.

First of all, it became clear that it is necessary to know the values of the angles for each type of labyrinth, namely the angle between the radii that lead to neighboring vertices (Fig. 1) and the starting angle from which the calculation of the coordinates of a particular wall will begin (Fig. 2).

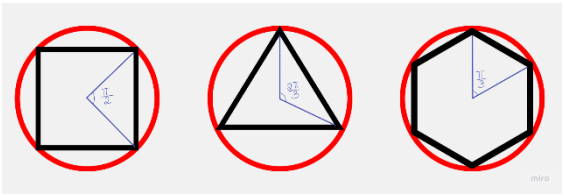

Fig 1. The angle between the radii that lead to neighboring vertices

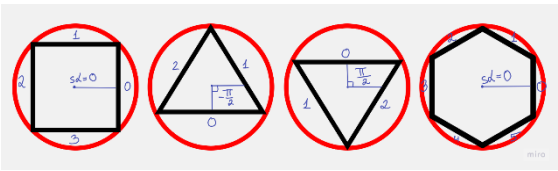

Fig 2. The starting angle between the abscissa axis and the perpendicular to the zero side of the polygon

Each side has been numbered, the starting angle is the angle between the abscissa axis and the perpendicular dropped on the zero side.

The problem with triangular mazes is that two types of cells must be supported at once. A triangle whose horizontal side is at the bottom and whose horizontal side is at the top. Accordingly, the base starting angle was chosen as -π/2, and the second starting angle is shifted by π if the sum of the cell coordinates is odd.

Knowing the starting angle (startA), the angle between the radii (dα) drawn to the neighboring vertices and the wall number (number), you can uniquely determine the angles relative to the perpendicular to the zero-side using the following formulas:

$$\alpha_1 = startA + number \times d\alpha - \frac{d\alpha}{2}$$

$$\alpha_2 = \alpha_1 + d\alpha$$

Then it is necessary to calculate the coordinates of each vertex. To do this, you need to know the radius of the circle circumscribed around the cell and its center.

The length of the radius is calculated dynamically depending on the size of the maze in X and Y. The basic idea is to divide the corresponding View size (width or height) by the number of cells on the same axis. And this idea is slightly different from the maze implementation. After the X and Y radii have been found, the minimum of them is taken and the labyrinth is centered relative to the parent View. The formulas for calculating the radius of different types of labyrinths look like this:

1) Orthogonal labyrinth:

$$rX = \frac{screenWidth}{M \times xCoef}$$

$$rY = \frac{screenHeight}{N \times yCoef}$$

$$r = min(rX, rY)$$

2) Delta labyrinth:

$$rX = \frac{screenWidth}{(M + 1) \times xCoef}$$

$$rY = \frac{screenHeight}{N * yCoef}$$

$$r = min(rX, rY)$$

3) Sigma labyrinth:

$$rX = \frac{screenWidth}{(M + 0.5) \times xCoef}$$

$$rY = \frac{screenHeight}{(N + 0.5) \times yCoef}$$

$$r = min(rX, rY)$$

where M – horizontal maze size, N – vertical maze size.

The formulas for calculating the radius use some coefficients xCoef, yCoef, which are responsible for the ratio of the distance between the centers of the cells to the radius of the circle circumscribed around the cell (Fig. 3). They are calculated using primitive trigonometric formulas from the triangles that make up the radii of the circles circumscribed around neighboring cells.

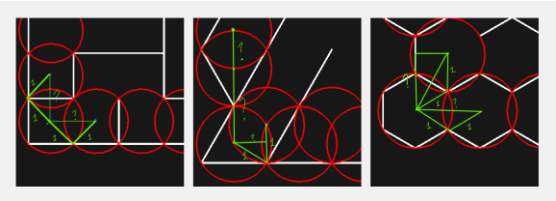

Fig 3. Distances between adjacent circles

To calculate the coordinates along the abscissa and ordinate axes of a particular vertex, the following formulas are used:

$$x = centerX + r \times cos(\alpha)$$

$$y = centerY + r \times sin(\alpha)$$

The latter formulas use the coordinates of the center of the cell (centerX and centerY). The following formulas are used to calculate the center basically, and are expanded for each implementation:

$$centerX_{ij} = j \times r \times xCoef$$

$$centerY_{ij} = i \times r \times yCoef$$

In the case of a triangular labyrinth, the center of each vertex that stands on a place where the sum of the indices is odd is shifted additionally vertically by half of the radius. In the case of a labyrinth consisting of hexagons, on odd rows the center is shifted horizontally by $r \times cos(\frac{\pi}{6})$.

Software implementation

As noted, the game was developed in Java using the libGDX framework, which allows you to develop cross-platform applications, making a simple scalable design.

To ensure that during the game all the players' movements were as natural as possible and it was easier to control the mechanics of movement and collision of objects, it was decided to use the physics engine Box2D [10], which allows you to easily add physical properties of objects in declarative form.

For communication with the network, we chose the WebSocket network communication protocol, because it is necessary to keep a constant connection to the server during the game, to transmit data as quickly as possible in a convenient format. As the serialization, the text format of JSON data representation was chosen, which is notable for its security and simplicity.

The project consists of several modules, namely:

- Android module;
- iOS module;
- Core module.

The android module contains only the configuration of the game, as well as the launch of the application itself for the Android system. There is not much code in this module, because Java is the development standard for this system and the Core module is fully embedded in the application.

The iOS module requires additional customization of some components because Java does not compile for iOS in its classic form. In order to make the application work cross-platform, RoboVM

technology is used, which translates the main iOS SDK libraries into Java code, allowing you to write classic native code using Java.

The Core module is basic and describes the main logic of the application. All screens are reproduced using the built-in SDK libGDX - Scene2d [11]. Complex components need to be drawn on the screen using classical methods. The architecture of the module follows the basic principles of SOLID and is split into several modules so that the use of different types of mazes does not complicate the work [12].

The mobile application communicates with the server using the WebSocket communication protocol. All data are serialized in JSON. Thus, data about the coordinates of the user will be transmitted to the server, and the server in turn broadcasts this data to the opponent. To make the coordinates equivalent for different screen resolutions, a technology is used to scale the screen to a predetermined size so that the entire design of the application and the labyrinth itself looks adaptive.

UI layout in libGDX is not very powerful, because first of all this framework is designed for game components development. If native UI development for Android or iOS has a huge number of built-in components that can easily reproduce even the most complex design, here there are only a few such objects, so many UI components were custom written in-house.

First of all, it was necessary to think about how the navigation between the screens of the application will be implemented and how to store the state of the screen [13]. For this purpose, the auxiliary abstract classes SimpleScreen and RootScreen were written, which described the basic logic for screen configuration, namely:

- Initializing auxiliary tools;
- Configuring adaptivity;
- Configuring OpenGL;
- Clearing memory;
- Working with the keyboard.

Using the principle of dependency injection each screen is passed to the ScreenManager object, which implements the navigation between screens.

To keep the layout simple, we developed a simple implementation of the Constraint Layout analog from Android, which allows you to bind screen components together. It did not consider possible mathematical operations for stretching and dynamic determination of object coordinates, but it allowed writing UI in a much more flexible way.

Since there are many different similar components in the application design, an auxiliary class was written in which the styles for the main elements are described.

To communicate with the server using the WebSocket protocol, several layers of abstraction were written over the core solution provided by the LibGDX package. This allowed the WebSocket implementation to be substituted into the core module as needed. This measure was necessary because the iOS module only allowed to implement the connection using native methods.

It was almost impossible to write a WebSocket implementation for iOS using native methods. In order to achieve this, we decided to use RoboVM framework, which made it possible to write native iOS code, using Java [14]. This is achieved by the fact that inside the framework the bridge of communication with iOS system is implemented using Objective-C. However, a very limited number of functions are available.

After a basic WebSocket implementation for the iOS platform was written, a bug was discovered that by default iOS methods do not send a Pong frame, to a Ping message from a server. As a result, server was closing the connection after some delay. That's why Pong message sending was implemented separately.

Once the labyrinth data have been obtained from the server, it was needed to learn how to display it on the screen, and give it physical properties in this way, observing the following requirements:

- Ability to abstractly display all types of labyrinth;
- Ability to scale on new labyrinth types;
- The corners of the labyrinth walls should not hinder the player's movement.

First of all, a class was written that contains the necessary characteristics of cell angles for each type of labyrinth: orthogonal, delta labyrinth, and hexagonal labyrinth.

The second step was to write a class with the following abstract methods, the implementation of which depends on the specific type of maze:

- Getting the center of a cell by coordinate;
- Calculation of the radius of the circle circumscribed around the cell, depending on the size of the labyrinth and the space provided to it;
- Obtaining the ratio of the distance between the centers of neighboring cells to the radius of the circumscribed circles.

After that the method of creating a physical polygon, which consists of maze walls, was implemented. Its main feature is that the corners of the maze are small circles with a radius of half the wall thickness. This was done so that players could effortlessly pass the joints between the walls and make turns at high speed.

Since the game is cross-platform, it is necessary to support control in different ways for different systems. To do this, the InputController abstraction was written, and a factory pattern was implemented, which substitutes the necessary implementation depending on the environment.

To control from the computer, the arrow keys are used, which allows the user to conveniently direct the player in the desired direction, but because of this the user cannot control the strength of the impulses

transmitted to the player and he moves always at the same speed.

To control from mobile devices, a joystick was implemented, which appears in the place where the user pressed the screen. Thanks to this solution, it is possible to control the player's speed, which greatly simplifies the control for experienced users.

To describe the physics of the player's movement, as well as his interaction with other objects in the maze, we used the Box2d library. For example, the player's object was matched with the parameters of density and friction force in order to make all its movements on the screen seem real and physical. And only the walls of mazes are static objects, through which you cannot pass, and they cannot move.

All movements in the system are non-linear and are realized by impulses and forces that act on objects in a certain way. In order to set impulses in Box2d library, it is necessary to pass a vector object with values of impulse projections on abscissa and ordinate axes [15]. It is always necessary to remember about memory optimization and not to allocate objects in frequently called methods. For this purpose, each class of "moving" object has a temporary vector object, to which certain values are set if necessary. This solution allows you to allocate less unnecessary memory and reduce the load on the garbage collector.

The entire code was designed to scale to new implementations of the various objects in the system, that's why there is an abstraction for each object. Obtaining the coordinates of the opponent is one of the most important parts of the program, and there are two implementations for it: online and bot. If the user takes too long to find the game or does not have access to the Internet, he is automatically offered to compete with the bot, which logic is on the client.

The basis of the algorithm is set by emulating communication with the network. This is achieved using the basic multithreading techniques available in Java. First, in a separate thread pool, the maze, and the path, which bot will follow are generated, and then information about this data is sent to the event listener.

Then the bot starts to send the coordinates of the opponent to the event listener in a separate thread with some delay. The delay and speed constants were calculated empirically by testing on devices with different power.

The main goal when writing the code for the bot was to achieve maximum physicality of its movements, imitating human errors and inaccuracies in movement with a certain probability. Thus, the speed of the bot is non-linear and varies within certain limits.

The bot should not move from cell to cell exactly evenly, so the movement from one cell to another was divided into several steps. With each step the bot tends to the center of the next maze cell, but with some probability it gets a deviation from the course by a small number of degrees.

A modified recursive return algorithm was used to implement the maze solution for the bot. The main difference from the basic algorithm is that the bot can detect a dead end ahead of itself with a certain probability. This modification was added in order to emulate human attempts to look at the path it is moving ahead of itself and predict when to change the direction of its movement. To achieve this, the recursive pathfinding function returns the length to a dead end or the end of a maze, as well as a flag about whether the path is victorious. If the path is victorious, the bot can also, with a certain probability, either choose it or make a mistake and go the other way first. In this way human errors are simulated. The probability of right and wrong choices depends exponentially on the length to a dead end or a winning square.

The game provides the ability to add player skills that allow the user to interact with an opponent. First, an abstract PowerUp class was written, which describes the general logic for all abilities.

Every characteristic power up has a duration and a cooldown time. Common ability methods include:

- Getting the current status of the ability (started, in progress, finished);
- Getting the current progress from 0 to 1, where 0 is the beginning and 1 is the end;
- Getting the current cooldown progress from 0 to 1;
- Drawing with basic geometric shapes or with complex animations using pre-generated sprites;
- Skill launching.

It was also provided for further development of the application, namely the addition of monetization through the purchase of in-game goods. And each ability has the possibility of a certain number of levels. At a basic layer, the higher level gives the longer duration, and the shorter cooldown, but this logic can be extended for a specific implementation.

Now in the game already implemented 3 different types of abilities, some of which give pluses to the player, and some add to the difficulty of solving the maze opponent, namely:

- Darkening the opponent's screen;
- Freezing your opponent;
- Illuminating the right path.

Screen darkening works like this: that after activating the ability the opponent can only see a small area of the screen around himself, so he can't view the path far and he must move at random. The player who triggered the ability continues to see the entire maze.

To achieve this result, filled rectangles are first drawn on top of the maze, at some distance from the opponent on each side. After that the remaining corners are painted by consecutive drawing of circles.

Freezing the opponent does not allow the opponent to move for a while. This is accompanied by an animation of the formation and subsequent destruction of ice on the opponent's character. In this

case a sprite animation was used, which is different in that from an image with a large set of frames each time a new one is cut out, in a predetermined sequence.

Since all skills run for a certain amount of time, the animation must run gradually, according to the time of the ability. Therefore, the basic sprite animation algorithm was adapted as follows:

1. Gets the current progress of the ability action time;
2. Calculates the frame number that corresponds to the current progress;
3. Crops the frame with position that was calculated in the previous step.

Illuminating the correct path allows the user to see several nearby cells of the path to victory. The constant of the number of illuminated cells depends on the level of the ability. This ability is good because it allows the user to find the exit even if the screen darkening ability was used on him.

To implement this ability, it is first necessary to find the correct path to the end of the labyrinth. In this case, as well as with the bot, the recursive return method was used as the algorithm for solving the maze. Also, as with any other animation, it is necessary that the path is highlighted gradually, depending on the current progress of the ability action.

This animation changes the transparency of the color so that the path disappears and appears smoothly. In order not to allocate a lot of unnecessary memory, the color array is generated in a static application context.

Approbation and testing

When the user enters the application, he sees the main screen of the app with the following menu items (Fig 4.):

- Play;
- Choose skin;
- Settings.

Also a randomly generated labyrinth is displayed on the main screen each time.

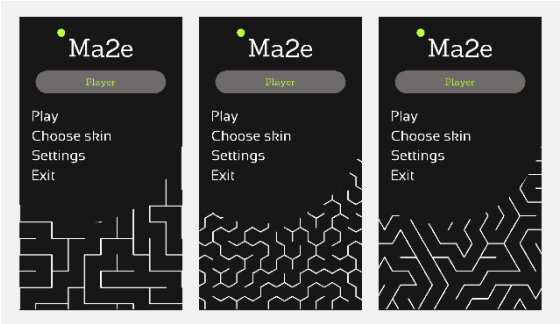

Fig 4. Main application screen with different types of mazes.

The user can pick the color of his character from the preselected options. All colors have been chosen so that the player is perfectly visible on the screen.

Once the user has chosen his color and entered his nickname in the text box, he can start the game. He is given several types of game to choose from (Fig. 5):

- Play online (the opponent is selected automatically);
- Play with friend;
- Play with bot.

In the case of the game online and the game with the bot further are the same steps, namely the loading screen appears, during which the maze is loaded, the initialization of the resource and all other preparatory work.

In the case of choosing the game with a friend, the user is shown his unique code and invited to enter the code, which is shown on the friend's screen. After entering the code on one of the devices the game process begins and then it does not differ from the format of the game online or with a bot.

Fig. 5. The sequence of screens after the start of the game

For testing the game, it was decided to use the testing method with the help of a focus group. The first step was to publish the application on Google Play in internal testing. A minor number of users were invited

by mail in order to test the application for bugs and to fix the most global ones before a larger testing.

After internal testing, the app was published into beta testing with link access. A Google form was designed for users to collect feedback and understand where the game should be improved, what users lacked, what users pay more attention to during the game.

After analyzing the results of the survey, it was decided to add a learning system to the game in the first place, in the form of videos or hints for the first games. Many users could not intuitively understand how certain skills work. In the future, an ability store will be added, as well as a player inventory, so that you can always clearly see how and why to use certain power-ups.

Conclusion

We have developed a mobile and desktop application of the game. In the course of the work, to achieve the set goal, the following tasks were completed:

- The games available on Google Play and the App Store with a similar theme – maze walkthroughs - were analyzed. Currently, we found that there is no game that allows you to compete with other players in real time, and there is no opportunity to play against a bot. All games are aimed at passing specific levels, which are compiled in advance by the developers;
- Developed a design that contains a harmonious color scheme, thoughtful UX for the user, so that it was clear how to play, and what are the possibilities of the game;
- Different methods for developing cross-platform games were analyzed and based on this analysis, a framework for Java, LibGDX, was chosen. The choice was explained by the flexibility of this framework, as well as by the specificity of the application, which was difficult to overlap with other solutions;
- Connected to a remote web server using WebSocket technology. Written our own wrapper over the basic implementation provided by the LibGDX library package to setup iOS support for the application;
- Based on the analysis of competitive applications and other games, we developed abilities for characters that set the interest of the game and make it more dynamic. The structure of abilities was designed in such a way as to allow you easily expand the set of available abilities;
- An opponent bot algorithm was implemented to play without an Internet connection. This was a necessary requirement, because the concept of the application does not include levels, and you need to be able to play even in places remote from the Internet;
- The application was tested by a focus group, information was gathered for its further development. After that the first version of the game was uploaded to Google Play. Before the app was published all the source code was obfuscated with the Proguard tool. There were also configurations for automatic code optimization.

At the moment we are working on publishing the application to AppStore and alternative platforms for publishing Android applications. Also, we are considering the idea of monetizing the application based on the addition of in-app purchases. Additionally, various ideas for improving the game mechanics, adding different skills, and other user interaction with the game are being considered.

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	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 03.06.2022 **http://T-Science.org**

Issue Article

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THE ECONOMIC EFFICIENCY OF APPLICATION OF COMPOSITE MATERIALS IN GAS TRANSPORTATION

Abstract: *Composite pipes made from materials such as fiberglass, polymers, carbon fiber are becoming one of the most promising for use in the oil and gas industry. Characteristics such as increased reliability, reduced installation and repair costs, and long service life make them the best replacement for metal pipelines. In this paper, an analysis is made of the use of composite materials, in particular fiberglass, in pipeline gas transport using the example of a section of the Dzharkak - Bukhara - Samarkand - Tashkent line. The calculation of economic efficiency from the use of new technologies was carried out using the method of constructing a financial model of the project.*

Key words: *Fiberglass pipes, gas pipelines, transportation, steel pipes, corrosion, financial model.*

Language: *English*

Citation: Khairova, D. R., & Najmiddinova, K. (2022). The economic efficiency of application of composite materials in gas transportation. *ISJ Theoretical & Applied Science, 06 (110),* 35-42.

Soi: http://s-o-i.org/1.1/TAS-06-110-6 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2022.06.110.6

Scopus ASCC: *2000.*

Introduction

Pipeline transport is currently one of the most efficient and affordable means of transporting liquid and gas. It provides delivery of natural gas, oil, products of its processing both at long distances by trunk pipelines, and within the territory of production, storage and processing of products. Thus, 49.8 billion cubic meters of natural gas are produced in the Republic of Uzbekistan, the capacity of gas processing is 50 billion cubic meters. The gas transport system consists of 13,250 km of gas pipelines, 939 gas distribution stations, 25 compressor stations with 250 units [9]. The installation of gas pipeline systems requires large capital investments, and every year the costs of installation, repair and elimination of corrosion effects increase. Due to the prolonged use of pipes exceeding the standard service life, cases of failure and loss of products transported by pipe lines increase, corrosion, paraffin and resin deposits on the internal walls of the pipes are risen, and the capacity of pipes are reduced. These problems require immediate solutions, one of which is the use of fiberglass composite pipes. Moreover, the relevance of this issue is confirmed by the Resolution of the President of the Republic of Uzbekistan 4388 of 09.07.2019 «On measures to provide the economy and the population with energy resources, financial recovery and improvement of the system of management of the oil and gas industry», which emphasizes the need to modernize Uzbekistan's gas transportation system. [1]

One of the most important and old lines of the main gas pipeline is the line Djarkak - Bukhara - Samarkand - Tashkent (DBST). This line was put into operation in 1959 and marked the beginning of the creation of the Central Asian line of gas pipelines. Thus, steel pipes have already been operated for more than 60 years, although their service life is half as much. [2] The capacity is 7 million cubic meters per day, so more than 2.5 billion cubic meters of gas is pumped through these pipes per year.

One of the most promising applications of modern composite materials, in particular fiberglass, is the oil and gas industry. The qualities that distinguish this material among the rest are increased strength, a long service life with correct application, reduced installation and repair costs of pipelines, high protection against the consequences of corrosion. In this work it is proposed to use fiberglass pipes for gas transportation on the section of the main gas pipeline Djarkak - Bukhara - Samarkand - Tashkent Gallyaaral Gas Distribution Station (GDS) - South - Western GDS, the economic effect has been calculated, the advantages and possible problems in the application of new technology have been identified.

Methods

The primary task of calculation of economic efficiency in the application of new technologies is the method of construction of financial model, with calculation of technical and economic indicators. The list of economic indicators includes revenue from sales, capital investments, operating expenses, gross financial result, period costs, net profit, discounted cash flow, pay-back period of the project.

Results and discussion

Currently, the main gas pipelines are made of the following materials: steel, cast iron, high density polyethylene (HDP), polyvinyl chloride (PVC) and fiberglass. One of the most common and affordable types are steel pipes. Steel gas pipelines are divided into two categories: seamless hot and cold transformations and welded pipes. Due to the high exposure of steel pipes to corrosion, there are several ways to protect against it: passive, active and reduced corrosion of the medium. These methods also require certain costs, which should be carried out at least once every 2-3 years.

The passive way involves:

• the use of special methods of laying the highway - between the metal surface of the pipes and the soil, an air gap is left, which prevents the effects of groundwater, salts and alkalis;

• protective coatings - the outer surface of the pipes is painted with compounds that are not destroyed from the effects of soil salts and alkalis, for example, alkyd enamels, protective anti -corrosion mastics.

• processing with special chemical compositions - covering pipelines with a thin layer of phosphates, which form a protective film on the surface of steel pipes.

The active method consists in the use of electric current and electrochemical reactions of the ion - intensive type:

• electroderate protection of pipelines from corrosion - a set of measures that allows you to deal with wandering currents - installation of drainage protection, isolation of flanges and installing electric ones;

• anode protection against corrosion of pipelines - the use of magnesium anodes, which, under the influence of electric currents, secrete magnesium ions, slowing down the processes of metal destruction;

• cathode protection of pipelines from corrosion. The method is based on the phenomenon of cathode polarization of metals under the action of direct current. The object of exposure turns into a cathode with low potential, which eliminates the likelihood of corrosion. [4]

Moreover, low - pressure polyethylene pipes have been very popular. The term “low pressure” applies to the method of production of material and is not related to the characteristics of the pipeline. Such pipes for gas pipelines are suitable for transporting gas under pressure up to 12 bar, safe, reliable and more widely used in the oil and gas sphere.

This work considers the use of fiberglass pipes for gas transportation. Fiberglass is a composite material, which in turn means a material that is obtained by connecting two or more components in the general system in which each component separately retains its properties. Fiberglass are easily mechanical processing, have high strength, resistance to thermal shocks and alternating loads, radio transmission, corrosion resistance. The use of multi - layer fiberglass increases the inter -layer strength of the plastic, simplifies the assembly of the workpiece of the product, reducing the number of manual operations. Such composites are widely used in the oil and gas industry, shipbuilding, aviation, in space equipment, automotive, in the manufacture of some household appliances. [6]

Fiberglass pipes in the oil and gas industry can be used for the following purposes:

• pipes for geological exploration and production of oil and gas;

• pumping and discharge pipeline systems;

• pipelines of transportation of oil and gas, collecting, transportation and pumping of reservoir water;

• pipelines for transporting chemically dangerous fluids and mixtures;

• high -pressure water pipelines of system maintenance systems;

• magistral linear pipelines for transporting oil and gas [7].

Thus, fiberglass covers the entire technological chain of the oil and gas industry, starting from geological exploration to transportation of products to consumers. However, the choice in favor of fiberglass pipes should be carried out taking into account the insignificant probability of damage or in the case when the degree and nature of the destruction is evaluated as insignificant.

Table 1 clearly describes the advantages of pipes depending on the material of manufacture. [10]

Table 1. The advantages of pipes depending on the material of manufacture

Steel	Polyethylene	Fiberglass
High strength indicators	High strength and elasticity	Maintain pressure from 2 to 272 bar
Minor indicators of linear expansion	Corrosive resistance	High corrosion resistance. The life of more than 30 years. High speed and ease of installation
Reliable sealed connection, subject to the rules of the docking and the lack of defects	Does not need special electrochemical protection	Do not require the use of electrical and chemical protection, do not require insulation and related costs
The ability to work with a hot environment having high pressure	Constant throughput	Small coefficient of thermal conductivity. High mechanical strength to shock and bending loads
Long life of pipelines – 30 – 50 years	Chemical resistance, immunity to the transported environment	High resistance to the effects of formation water, gas condensate, acids, alkalis, bacteria, there is no “overgrowing” with salt and other deposits
	Environmental Safety	Ecologically and hygienically safe. Do not require the use of welding. Lack of influence of weather conditions on the installation process (from +50°C to -50°C)

On the basis of the information presented in Table 1, it can be concluded that glass-plastic pipes are practically equal to steel and polyethylene pipes in terms of predominant characteristics. However, each type of pipe also has drawbacks, which are presented in Table 2 [10]

Table 2. Drawbacks of pipes depending on the material of manufacture

Steel	Polyethylene	Fiberglass
Resilience	Combustibility of the material, which makes it impossible to lay pipelines in open areas	Insufficient number of suppliers and manufacturers
Laborious welding installation	Lack of clear regulatory framework for pipe operation and maintenance	Absence of a State regulatory framework regulating the operation of glass-plastic pipes
High susceptibility to corrosion	Pipe fares	High cost of pipes and connecting elements
Condensation due to high thermal conductivity, which, when deposited on the walls of pipes, reduces their capacity	Low pressure limits at which the pipe can be operated	
Mass of pipes causing problems when transporting from production point to operational point		

Comparison of the technical characteristics of the pipes is presented in table 3:

Table 3. Comparison of the technical characteristics of the pipes

Indicator	Fiberglass pipes	Steel pipes with epoxy coating	PVC pipes	Polyethylene pipes
Corrosive stability	Good	An internally epoxy coating, an external coating with a protective layer, cathode protection is required	Bad in the alkaline environment	Good

Service		Not required	Periodic maintenance is required due to peeling of the outer layer	Periodic service is required	Periodic service is required
Lifetime		More than 50 years	Due to corrosion of pipes is 20-25 years, but it is possible to extend	15 - 20 years, depending on operating conditions	20 - 30 years, depending on operating conditions
The weight		A light weight	3-4 times heavier fiberglass	1.5 times heavier fiberglass	1.5 times heavier fiberglass
Tensile strength	3000 - 3750 bar	The minimum 4200 bar	500 bar	350 - 600 bar	
Elastic modulus	35 GPA	210 - 240 GPA	3 GPA	5 GPA	

The production of fiberglass products is engaged in quite a few foreign companies. However, it is worth noting that problems are possible during transportation due to the far arrangement of manufacturing plants from the operation of pipes. A striking example is Future Pipe Industries, the headquarter of which is located in Dubai, is engaged in the design and production of system pipes made of fiberglass and operates in oil and gas, water and industrial sectors. The company has 13 factories scattered around the world, and laid more than 190,000 km of pipelines. In 2021, the company completed 829 projects, 40% of which concerned the oil and gas sphere. [5] One of the examples of the use of fiberglass manufactured by this company is the 2018 project of the Central Production System of Hamlin, which was developed for the large American oil and gas company Surge Energy engaged in exploration and gas production. Future Pipe Industries delivered Surge Energy to more than 8.5 km of pipelines with a diameter of 230 mm with a nominal pressure of 52 bar to support its central production enterprise in Hamlin [11].

Of particular interest for this work is a composite fiberglass pipe produced under the brand Bondstrand. In the product range under this brand are 8 series of pipes that meet the standards of glass plastic pipes, each of them is used in the production of oil and gas, depending on the operational requirements. Bondstrand 2400 series is used for transportation of oil, gas, water, reactive units. Such fiberglass pipe with integrated conical internal connection and projection, integral mechanical connection with internal and external thread for connection with other pipes, available in a wide range and suitable for use in environments with high pressure and higher operating factors. The diameter of the pipes is represented in the range from 50 to 1000 mm, the pressure inside the pipe can be from 10 to 50 MPa, can be used at temperatures from -43°C to 93°C. The length of each pipe is 12m. In order to reconstruct 243 km of the pipeline, 20,250 pieces of pipes will be needed to implement the project.

The diameter of the pipe of the DBST Line Gallaaral GRS South-West GRS is 720 mm, the pressure inside the pipe is 50 MPa, the operation temperature is 20-30°C.

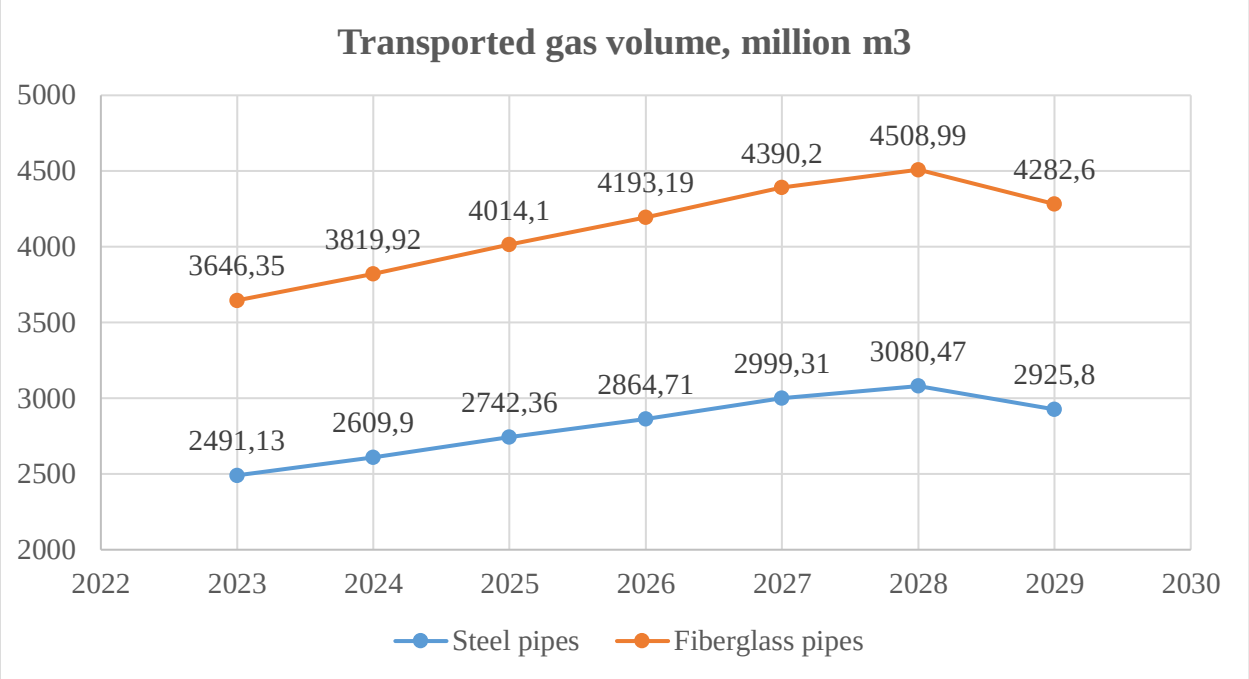

Figure 1. Transported gas volume

The financial model was built for the period from 2022 to 2029. To calculate the forecast volumes of gas transportation, gas consumption has been analyzed over the past 8 years, an annual increase in 5% was revealed. A similar dynamics was projected for the next 8 years.

Analyzing the gas transport volumes shown in Figure 1, it is worth noting that the annual performance when using glass plastic pipes is higher than when using steel pipes by 46.4%. The reason for the growth is the high throughput of fiberglass pipes, which is due to the smooth inner surface of the pipes, which do not accumulate corrosive, paraffin and resin deposits, as well as reduction of regulatory volumes of natural gas on own need and losses up to 0.1%.

Table 4. Projected technical and economic indicators for 2022-2029

Indicators	Steel pipes	Fiberglass pipes	Comparison, %
Capacity, million m^3	44 804,00	64 005,72	43
Own needs and losses, (2,5%; 0,1%), million m^3	505,47	28,88	0,06
Volume of transported gas, million m^3	19 713,48	28 855,34	46,4
Sales revenue, $ million	239,52	350,59	46,4
Capital investments, $ million	0	20,15	-
Structures (fiberglass pipes)	0	12,15	-
Construction and installation work	0	1	-
Equipment	0	1	-
Other (oils, resins, transportation costs)	0	6	-
Operating costs, $ million	92,66	133,44	44
Gross financial result, $ million	146,86	218,79	49

Indicators	Steel pipes	Fiberglass pipes	Comparison, %
Expenditures for the period, $ million	74,47	74,62	0,2
Net profit, $ million	61,52	122,55	99,2
Cash flow, $ million	61,52	115,5	87,7
Discounted cash flow, $ million			
10%	42,26	66,66	57,7
15%	35,90	51,67	44
Project payback period (year)	0	1	

Source: Calculated by authors in MS Excel

Given that the transportation rate remains unchanged at $5 per 1,000 m3 per 100 km, the revenue is calculated as follows:

Sales revenue for 2023 = $5 * Volume of transported gas * Transportation distance / 100000 = $5 * 3646,35 million m^3 * 243 km / 100000 = $44,3 million.

Total revenue is $350.59 million. The total investment will be $20.15 million and will include the following:

Purchase of fiberglass tubes at a price of $500 and connecting elements at a price of $100: $500 * 20250 + $100 * 20250 = $12.15 million.

Cost of construction and installation work = $1 million.

Cost of pipe transportation equipment = $1 million.

Cost of oils, resins required for pipe operation = $1 million.

Transport costs = $ 5 million.

The operating costs for the entire period will amount to $133.44 million. The operating costs for the period are estimated at $13.4 million. In addition, the cost of labour will be reduced by half as a result of the reduction in the number of personnel involved in welding work, as the use of fiberglass tubes does not require them. They also include the depreciation of capital expenditures of $1.64 million each year.

The net profit (Figure 2) in the first year of operation of fiberglass pipes will be 83% higher than that of steel pipes, which in absolute terms is $6.5 million. Then, in the following years, the net profit from the use of fiberglass tubes will be on average twice as high as the net profit from the operation of steel pipes, reaching a peak of $19.37 million in 2028. In 2029, net profit will decrease slightly by 6%, which is due to a decrease in the volume of transported gas by 226.4 million m3. The cash flow obtained by subtracting the capex from net profit and depreciation is $115.5 million. The cash flow discounted at 10% to $66.66 million, at 15% to $51.67 million.

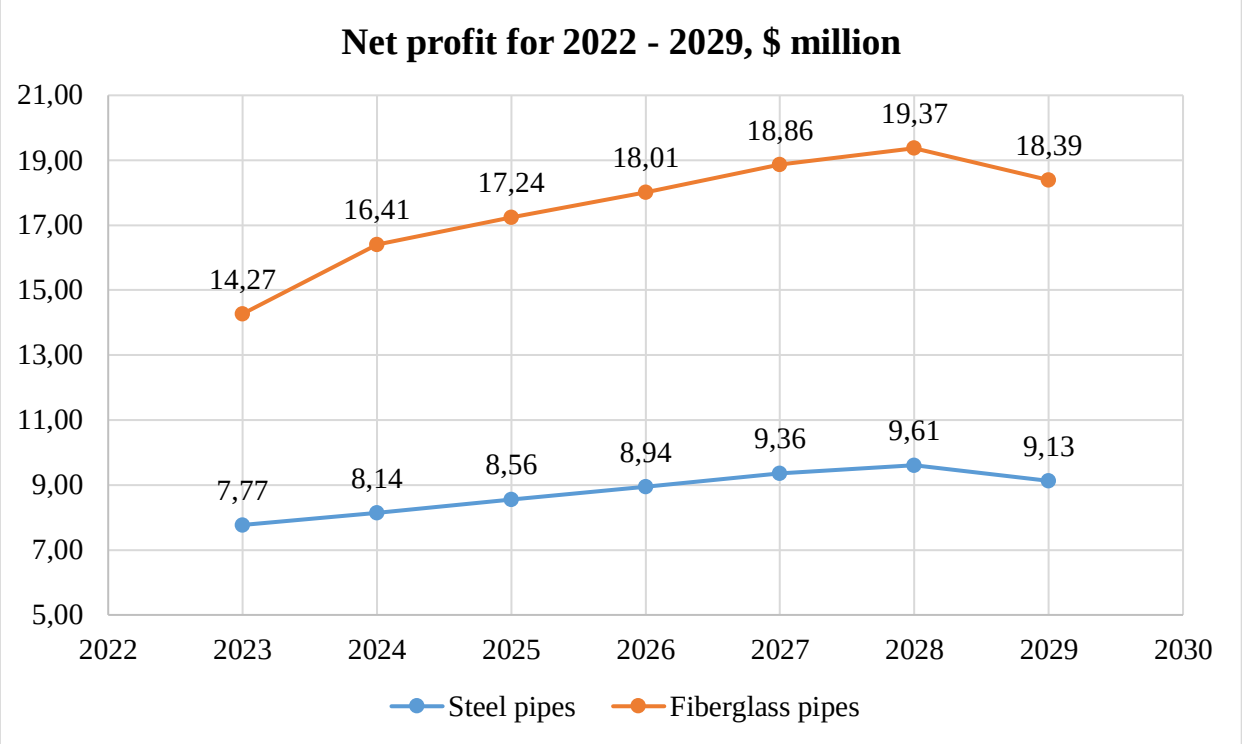

Figure 2. Net profit for 2022-2029

Taking into account that investments will be invested in 2022 and construction and installation works will start, which will take a year, during this period the accumulated cash flow will be negative of $18.51 million. Therefore, the payback period of the project will be one year.

Summing up, it should be noted that the conducted comparative analysis of techno-economic indicators in the operation of steel and fiberglass pipes showed that the revenue from the sale of products will increase by 46,4%; although the share of wages in operating costs will decrease, their total volume will increase by 44%; the net profit will double and the cash flow will increase by 87.7%.

Conclusion

In conclusion, it is worth noting that composite materials increasingly win the market of materials necessary for the manufacture of products used in the oil and gas industry throughout the production chain of oil and gas production, from exploration pipes to oil and gas collection and storage systems. The study concluded that:

1. Steel tubes on the DBST line have been in use for 60 years since 1959 even though the standard life of steel tubes is on average 25-30 years;
2. There are many alternative materials for the production of gas pipeline systems. A comparison of steel, fibreglass, polyethylene and polyvinyl chloride pipes concluded that fiberglass material is an excellent alternative to steel pipes because of similar process parameters;
3. There are many manufacturers and suppliers of pipes made of composite materials, a wide range of products, differing in diameter, pressure, pipe length and other technological features. Most of the plants are concentrated in the United States and China, which may cause problems in the transportation of pipes;
4. Calculation of the economic efficiency of the project to replace steel pipes with fiberglass on the line DBST, from Gallyaral GRS to South - Western GRS (243 km), shows the expediency of the project due to the increase in the volume of transported products by 46,4%, reducing transportation losses to 0.1%, and doubling net profit.

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SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 05.06.2022 **http://T-Science.org**

Issue Article

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DEVELOPMENT OF THE SERVER PART OF A MULTIPLAYER ONLINE GAME USING WEBSOCKET

Abstract: *This article is devoted to the development of the server part of the online game. A comparative analysis of various algorithms for generating labyrinths has been carried out. The implementation of the software product, the main structures, their methods and interactions between the main modules of the application, and the process of orchestrating services are described.*

Key words: *server development, administration, continuous integration and delivery, websocket protocol, mazes, maze generation algorithms, Golang.*

Language: *English*

Citation: Kozhevnikov, V. A., & Akhmedov, A. S. (2022). Development of the server part of a multiplayer online game using websocket. *ISJ Theoretical & Applied Science, 06 (110),* 43-49.

Soi: http://s-o-i.org/1.1/TAS-06-110-7 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2022.06.110.7

Scopus ASCC: *1700.*

Introduction

Recently, video games have evolved greatly - with the advent of mobile phones for video games, completely new opportunities have opened up. With the development of network technologies and the general increase in the average speed of information transfer between two devices, new ideas and tools for developing network games have appeared. This article discusses the development of the server part of a mobile online game, the main idea of which is to pass the labyrinth at speed. Players start the game in two opposite cells of a procedurally generated random maze. The game ends when one of the players reaches the cell from which his opponent started the game.

The relevance of the work lies in the creation of a unique game in the theme of passing labyrinths. The uniqueness lies in the fact that the mazes are procedurally generated, and each time the user is offered a new maze to play, instead of one of the pre-designed finite set of mazes. It is also based on a competitive idea - users play in the same maze against each other in real time and see the movements of the opponent.

Problem statement, mazes theory

The aim of the work was to develop the server part of the game, as well as delivering the finished application to the server and creating an environment for its administration.

To achieve this goal, it was necessary to perform a number of tasks:

1. Analyze similar games, identify the main shortcomings;
2. To study the theory of labyrinths and algorithms for creating labyrinths;
3. Determine the technology stack that will be used in the development of the application;
4. Create a planned architecture design;
5. Implement the software part of the application;
6. Implement a bot. Make the bot behave like a human;

7. Compile documentation for public interfaces;

8. Set up CI/CD tools;

9. Configure a reverse proxy, set up a production and test environment;

10. Secure access to the server.

When reviewing existing games with labyrinths, the following common features of applications related to the theme of labyrinths were noted: as a rule, they differ from each other cosmetically and in the way of control, in all applications the set of labyrinths for passing was generated in advance, and these games, as a rule, are intended for a single game.

The labyrinth of the ancient Greeks and Romans meant a more or less vast space, consisting of numerous halls, chambers, courtyards and passages, arranged according to a complex and intricate plan, in order to confuse and prevent a person ignorant of the labyrinth from escaping. Labyrinth is a Greek word that, in a stricter definition, means any structure (usually in two or three dimensions) consisting of intricate paths to the exit (and / or paths leading to a dead end). An exit is any vertex, cell or face of the maze.

Labyrinths (and therefore algorithms for creating labyrinths) can be organized into seven different classifications [1]. These are: dimension, hyperdimension, topology, tessellation, routing, texture, and focus. The maze can take one item from each class in any combination.

In this work, we considered two-dimensional, ideal labyrinths and algorithms for their generation for various types of tessellation. Two-dimensionality means two-dimensionality in the mathematical sense of the word. A "perfect" maze means a maze without any loops or closed circuits, and also without any inaccessible areas, it is also called a simply connected maze. From every point there is exactly one path to any other point, the maze has exactly one solution. In computer science terms, such a maze can be described as a spanning tree over a set of cells or vertices.

There are three main types of tessellation or tiling:

An orthogonal maze is a standard rectangular grid in which cells have passages that intersect at right angles.

Delta Maze - The delta maze consists of interconnected triangles, where each cell can have up to three passages connected to it.

Sigma Maze - The sigma maze consists of interconnected hexagons, where each cell can have up to six passages connected to it.

There are other types of tessellation, but in the framework of this work, we considered the types of tessellation described above. It can be noted that the types of tiling differ in the number of faces of one cell of the labyrinth or the number of passages from this cell.

There are several ways to create perfect mazes, each of which has its own characteristics. Most of these are described as creating a maze by cutting out passages, however, unless otherwise noted, each can also be done by adding walls.

The main algorithms for generating labyrinths:

- Kruskal's algorithm. This algorithm is based on the creation of a minimum spanning tree. It's interesting because it doesn't "grow" the maze like a tree, but rather carves out passage segments throughout the maze randomly, but still ends up with a perfect maze.

- Prim's algorithm. This algorithm is based on creating a minimum spanning tree that works with unique random edge weights. Kruskal's algorithm, which also creates a minimum spanning tree, can be considered the best because it is faster. In fact, given the same initial value of random numbers, it is possible to create identical mazes using Prim's and Kruskal's algorithms.

- Aldous-Broder algorithm. The most interesting thing about this algorithm is that it is universal, which means that it generates all possible mazes of a given size with equal probability. The bad side of this algorithm is that it is very slow, as it does not perform any reasonable search for the last cells. In fact, it's not even guaranteed to be completed.

- Wilson's algorithm. This is an improved version of the Aldous-Broder algorithm because it creates mazes with exactly the same texture as the Aldous-Broder algorithm (algorithms are unified with all possible mazes generated with equal probability), but Wilson's algorithm is much faster.

- Eller's algorithm. This algorithm is special because not only is it faster than all the others with no obvious offsets or flaws, but its creation is also the most efficient in terms of memory usage.

Technology stack

The compiled multi-threaded programming language Golang [2], developed internally by Google, was chosen as the main programming language. The main advantages of the language are its speed and ease. Golang is a fast compiled language [3]. Using the Go language, it is convenient to write network applications. The standard distribution of the language contains a large number of convenient tools and libraries for working with the network, in particular, the “net/http” package covers all the functionality of the HTTP protocol.

Object-oriented programming tools are limited to interfaces. This allows programming with abstractions. Golang provides tools for multi-threaded programming. The language has a “goroutines” mechanism, which is a lightweight thread, as well as a means for communication between threads: channels.

The Java language and the Spring framework were considered as the main alternative. The main disadvantage is the high entry threshold. Since Spring is a full-fledged framework, to work with it, you must

be fully familiar with the principles of working with this tool. Also in Java, working with multithreading and networking is more complex compared to similar work in Golang.

"Clean Architecture" was chosen as the main design pattern. The main ideas of this pattern are to separate the logic into the immediate logic (or business logic) and the transport layer. Thus, with the help of dependency injection, we abstract from the way we receive data from the client.

The choice of communication protocol was dictated by the main objectives of the online game. To support the completion of the maze in real time, it is necessary to open a tunnel with the client and keep it open for the required time, for example, until one of the players has completed the maze. Ultimately, a full-duplex communication protocol over a TCP connection was chosen - WebSocket [4].

The convenience lies in the fact that to search for a game and for the game itself, it is enough to open one websocket and send messages with different commands to it. All that is needed to support this approach is command handlers on both sides: the client side and the server side.

The Wire library was chosen for dependency injection. This library allows you to conveniently inject all the necessary dependencies. The main tool is code generation. To implement the necessary dependency, it is enough to write the so-called provider of this dependency, which creates and configures it. The very task of introducing this dependency into all the necessary consumers is taken over by Wire.

Architecture overview, software implementation

The central objects of the system are: client, game, queue (Fig. 1).

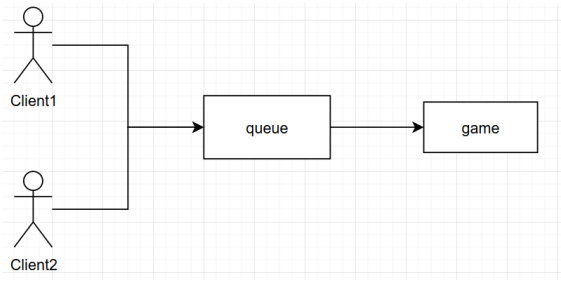

Fig. 1. Architecture diagram.

Client is a structure responsible for the player. This structure stores information about the player: name, color, as well as other technical information for the correct rendering of the labyrinth on the client side. To search for a game, the client sends a request to another object of the system - a queue.

Queue is a framework for creating games. This structure handles client requests for queuing, as well as creating a game for clients.

Game is a game structure between two clients. Handles all the information that clients provide during the game, such as their coordinates. This structure is also responsible for calculating whether any client went through the maze, that is, ended up in the cell he needed.

The central structure in an application is the Application structure. The Wire library from Google is responsible for dependency injection. As a product develops, the number of code blocks that are linked together grows. At the same time, dependency management becomes more difficult. Dependency injection systems come to the rescue. They can be divided into two types: based on code generation and based on reflection. Systems based on reflection provide the necessary structures during program execution. This negatively affects the speed of the program, since reflection is a slow tool. Products based on code generation generate all the code necessary for the program to work at the compilation stage. This approach also has its disadvantage: the program compilation time increases.

Wire is a tool based on code generation. To work with Wire, you need to write a dependency provider function for each of the dependencies, such a function is called Provider. Providers must have a specific signature. They must return strictly 3 parameters: any structure (interface), a resource release function, and an error.

Next, you need to collect all the providers together by calling the wire.Build () function. Providers should be passed to this function in a strictly defined order: first, all providers that do not require other dependencies to initialize the structure are passed. Next, all functions are passed to consumers of dependencies provided by providers. In Wire terms, such functions are called Consumer.

Multiplexing or routing of requests is carried out using the Gochi library [8]. There are multiplexers in the standard distribution of GoLang, but their functionality is very limited.

There are only two endpoints registered in the application. The /generate endpoint takes the size of the maze as input and generates it. The response to the request comes in json format. The second endpoint is used to open a WebSocket. This happens with the help of the Upgrade mechanism [10]. A web socket connection begins with an HTTP GET request from the client to the server. The request contains a special header to tell the server that it wants to create a WebSocket connection. The client should send a Sec-WebSocket-Key header containing base64-encoded random bytes, and the server responds with a hash of the key in the Sec-WebSocket-Accept header [11].

The Client structure represents a client in terms of a client-server interaction. The game also has bots. The Client layer abstraction allows you to organize the code in such a way that it does not matter to the application what type of client is participating in the game. The part of the code directly responsible for the game does not distinguish between a real person and a bot. The Client structure has two methods: read() and write(). The read() method tries to read messages from the WebSocket in an infinite loop. If successful, it send this message to the Game structure for further processing. The write() method reads messages from the Send channel in an infinite loop and sends them to the WebSocket. When creating a client, you need to run two goroutines: on read() and write().

The GameQ framework is for registering clients and creating games between clients. The main method of this structure is the Run() method. The Run() function works according to a simple principle: if a client was sent to the register channel and there is a client in Clients, then we create a game, otherwise we put the client in the queue. The Run() method must be run in the goroutine after the GameQ structure has been initialized.

The Game structure is the central structure of a game between two clients. This is where all messages from clients are processed. All the main logic for processing commands, like the rest of the structures described above, is in the Run () method.

The Message structure is used to send messages from the client to the server and back.

The Bot structure is used to design a bot. In the application, the bot is designed to mimic the game of a real person. This is done so that the user does not know whether he is playing with a bot or with a real user. The client starts the game with the bot after waiting for a certain period of time specified in the config, from the moment of queuing. This logic was implemented to ensure that the client does not stay in the queue for too long. To simulate the humanoid movements of the bot, it was decided to add random fluctuations to the bot's trajectory. Also, logic was added that deploys the bot if there is a dead end in front of it with a length equal to the value of the variable in the config. The main method of the bot functioning is the solveMaze() method. This method takes as input the generated maze in the form of an array of cells. A cell is characterized by indices X and Y in the maze matrix, as well as an array of length N, where N is the number of edges in the maze cell (takes values 3, 4, 6).

First, using the depth-first search, the bot solves the maze. In the course of the search in depth, the cells in which the search took place are written to the array, thus forming the trajectory of the bot in the maze. It remains to walk along the already formed trajectory of movement.

Since the clients in the system have usernames, it was necessary to implement the generation of random names for the bot. It was decided to implement a simple scheme with a set of adjectives and nouns.

There are many different approaches to application programming. One such approach is TDD, which stands for Test Driven Development. The main idea of this approach is to formulate the specification, define interfaces, write tests with the expected behavior of code sections, and only after that write the code that executes the logic. It is difficult to overestimate the importance of writing tests during development. Properly formulated test cases (a set of code usage scenarios) allow you to reduce a lot of time for debugging and fixing errors in the future.

As part of the development of this product, it was decided to use unit testing. A feature of unit testing is the testing of small, independent sections of code or modules. Typically, units of testing are functions, methods, procedures, modules, or objects. A typical test function structure has two parts. The first part is setup or preparing test input for the unit of code being tested. The second part is asserting or checking the correctness of the output of the unit of code being tested.

Unit testing in Go is just as arbitrary as any other aspect of the language, such as formatting or naming [9]. The syntax deliberately avoids the use of asserts and places the responsibility of checking values and behavior on the developer. Go has a built-in test command called go test and batch testing, which together provide a minimal but complete testing tool.

For tests, a separate file is usually created with the name of the file being tested and the _test suffix. Since the standard distribution of the language does not provide tools for checking values, the testify library was used. This library provides a large set of out-of-the-box functions for checking the values of structures and primitives.

Developing an application in a client-server architecture implies development from two sides: from the client side and from the server side. This entails some organizational problems, especially in terms of direct interaction between parts of the system. In the course of development, requirements, specifications, functionality may change. This is why

it is so important to write and maintain consistent documentation for all public interfaces.

The Swagger tool was chosen to compile the documentation. This is a code generation based product that allows you to create a description of requests, as well as various information transfer models that are used between the client and the server. The convenience lies in the fact that the creation of documentation occurs by commenting on sections of code that the developer wants to document.

In the modern technological world, there are a large number of different devices. Different architectures, operating systems, versions of installed libraries - all this dictates new standards in application delivery. To simplify and speed up the delivery of the product, Docker containerization technology was invented. A rough definition of a container sounds like a lightweight virtual machine. This approach allows you to write a product assembly description once (this description is called an image) and use it as many times as you like without thinking about the OS, architecture, and other characteristics of the host machine.

There are two main resources that separate the containers and the host machine - the network and the file system. Docker provides the ability to flexibly manage both. This allows you to create a large number of virtual networks for a secure, isolated connection to a network of different containers.

Running a single container on a server is not a big deal, but when the number of services (and with it the containers) that need to be started and administered at the same time increases, so does the complexity of management. To solve this problem, orchestration systems were invented. The description of the container interaction process is a file with the .yml extension. It describes all the containers, the order in which they are launched, the virtual networks used by the containers, the areas of the file system to be shared between the host machine and the container. Using the orchestration system, it is convenient to set environment variables for the container, as well as set the rules for restarting the container in case of an unexpected termination of work.

When developing with small changes and a large number of commits, there is a need for frequent manual testing of the application. To do this, you need to deploy the program in a test environment. The principles of continuous integration involve automating the process of delivering an application to the required environments. In reality, manually integrating and configuring the application would take a significant amount of time.

Github Actions [7] was chosen as the CI/CD tool. The integration process is executed on the Github servers. To describe the rules, you need to create a file with the .yml extension in the .github/workflows directory. A pipeline consists of a list of tasks or jobs. Tasks run in parallel. Each task consists of a list of steps. Steps within a single task are performed sequentially. Also in this file, you must specify the event trigger - an event that will launch the pipeline. Github offers a huge variety of all kinds of events. For the pipeline that deploys the application to the test environment, an event was selected on the push of the testing tag.

A reverse proxy server is used to relay requests from the external network to any servers / services of the internal network (for example, web servers, databases or file storages) and allows (Fig. 2):

- to ensure the concealment of the structure of the internal network and the details of the services located in it;

- perform load balancing between instances of the same service or servers with the same tasks;

- provide an encrypted (HTTPS) connection between the client and any service, in this case an SSL session is created between the client and the proxy, and an unencrypted HTTP connection is established between the proxy and the service on the internal network, if the service supports HTTPS, then you can organize an encrypted connection on the internal network;

- organize access control to services (client authentication), as well as install a firewall.

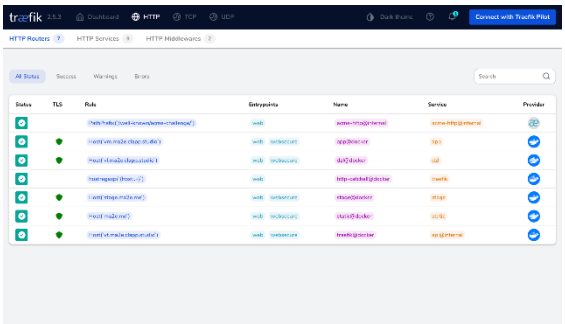

Fig. 2. Reverse proxy control panel

During the development of the application, there was a need to set up two isolated environments: a working (production) and a test (dev) one. The purpose of this event is to keep the stable version of

the product working as the application is in release. Testing new functionality and fixing bugs can serve as a potential threat to performance. To prevent possible problems, some restrictions on system administration have been introduced, namely:

- Separation of application versions at the image level. The main image ma2e (production environment) with the latest tag is the actual release build of the application. A mobile client located in the Google Play Market application store at the api.ma2e.me domain sends its requests to the container of this image.

- The image for testing functionality (test environment) has a "-stage" suffix. The container of this image is not used by the actual users of the application, but is needed only for debugging by developers. Requests to the data container are proxied through the stage.ma2e.me domain.

- To update the release build of the application, you must first test its performance in a test environment. You need to manually make sure that there are no critical errors, namely, the application was successfully compiled and launched. Next, you need to run all the tests and make sure that they all pass successfully. Only after these steps can you update the release build.

It often happens that users find a bug in a working stable version of an application. In order to effectively correct such errors, it is necessary to understand what user steps led to this error. To do this, it is important to configure entries in the event log. Logs (log files) are files containing system information about the operation of a server or computer, in which certain actions of a user or program are recorded. The open source program Dozzle was chosen as the log collection tool. This product is especially useful when building logs from docker containers. Dozzle works on the principle of serving a web page to view the contents of container event logs. For ease of development, a subdomain was also created for the Dozzle service. Requests are proxied for log.ma2e.me domains. Since information about the operation of the program is classified as sensitive, as well as the fact that Dozzle is hosted on a public network, it is necessary to protect access to this resource. This was done using traefik tools [12]. In particular, the bauth interceptor was used, which requires the presence of the Authorization header for all requests to this container.

There is a set of rules that can help secure the connection to the server via SSH [6].

- Change the default SSH port. Port 22 is reserved for the SSH protocol, but you can use any of the available ones. It's worth noting that changing the port won't make connections secure, but it can prevent automated attacks that typically assume the server is listening on port 22.

- Using a pair of keys for authorization. The standard SSH authentication method is a password, but the password can be easily compromised, for example, through a man in the middle attack. To avoid this, you can use asymmetric encryption algorithms and perform authorization using a key pair.

- Prohibition of connection to the server with superuser rights.

- Prohibition of connections, the means of authorization of which is a password.

- Restrictions on IP addresses from which you can connect to the server.

The ability to connect to the server via root has been disabled (for this, you need to edit the ssh configuration file). In the same file, the ability to log in with a password was disabled.

The system has two panels designed for private developer access, however, the presence of one server does not allow proper protection of the panels at the network level. The correct way to do this is to keep all internal services in the gray subnet. The gray subnet refers to addresses on the local network, that is, services do not listen on public interfaces.

To protect technical panels within one virtual private server, a protection method was chosen using a login and password for authorization. Authorization occurs by means of a traefik reverse proxy. In the standard distribution there is a bauth request interceptor. This interceptor checks the Authorization header for each request to the required service. The value of the Authorization header is a base64 encoded combination of username and password separated by a colon. Valid login and password combinations are specified in the userfile. For security purposes, the password has been hashed.

Conclusion

We have developed a server part for an online game. Based on the results of the work, the application is deployed on the server, configured and ready to receive and process client requests.

To achieve this goal, a number of tasks were performed:

1. The most popular maze-themed apps in the Google Play Market app store were analyzed. The analysis revealed the main shortcomings of the games.

2. The theory of labyrinths, their classification, the main types of labyrinths according to the type of tiling have been studied. A comparative analysis of the labyrinth generation algorithms was also carried out, the main criteria were identified and determined when comparing the generation algorithms.

3. Technological stack for application development formulated and justified.

4. The design of the application architecture has been created in terms of the interaction between the modules and structures of the program.

5. The software part of the game was implemented. All the main structures in the application were described, their methods, as well as

interaction with other structures. A tool for configuring game parameters has been created.

6. Implemented a bot to reduce the user's expectation of finding a new game. The bot was designed in such a way that it was difficult to distinguish it from a real person. A fluctuation was added to the movements of the bot, the bot turned around at the sight of a dead end, and did not rest against it. A random name generator for the bot was also implemented.

7. All public interfaces were documented using the Swagger tool. All models for communication between server and client have been described. Access to the documentation in the form of a web page has been created.

8. CI/CD Github Actions tools were used to automate the delivery process and integrate new versions of the software product.

9. To route requests to the right containers, a traefik reverse proxy was deployed. To isolate the release and test versions of the program, a semblance of a production and test environment was created.

10. Access to the server is via SSH. Access to the server was protected, as well as access to technical web panels with public access.

At the moment, the main steps for monetizing the application are being considered, since this requires users to have accounts, and technical aspects are also being considered. There is a certain set of tasks that have been formed to technically improve the game, such as implementing client move validation to make sure the user does not go through the walls of the maze.

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SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 05.06.2022 **http://T-Science.org**

Issue Article

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METHODOLOGY OF CASE SELECTION FOR TEACHING FOREIGN LANGUAGE SPEECH TO STUDENTS OF NON-LINGUISTIC SPECIALTIES

Abstract: *This article discusses the advantages of case technology, as well as its possibilities in the formation of motivation for learning English among students of non-linguistic specialties. To teach future specialists to speak a foreign language, it is advisable to use cases published in foreign language periodicals and create on their basis exercises and tasks of a speech nature in accordance with the requirements of the developed case technology for teaching foreign language communication to students of the linguistic faculty. In the course of the study, the main criteria for the selection of cases for the successful teaching of linguistics students to speak a foreign language are highlighted.*

Key words: *communicative competence, case method, foreign language speaking, criteria, authenticity.*

Language: *English*

Citation: Toshmukhammedova, G. Z., Rakhimova, Z. S., & Nasrullaeva, D. R. (2022). Methodology of case selection for teaching foreign language speech to students of non-linguistic specialties. *ISJ Theoretical & Applied Science, 06 (110)*, 50-53.

Soi: http://s-o-i.org/1.1/TAS-06-110-8 ***Doi***: https://dx.doi.org/10.15863/TAS.2022.06.110.8

Scopus ASCC: *3304.*

Introduction

Active informatization of modern society requires changes both in the process of general education and in the higher school education system. The volume of knowledge is constantly increasing, the requirements for specialists of both narrow and wide specialization are changing. Today it is not enough for a specialist to have technical knowledge and skills, to apply them qualitatively and fully in his practical professional activity. It is necessary that he be able to competently operate with the received data, analytical indicators, and most importantly – have a high degree of logical thinking, which would allow him to:

– solve problems of any level of complexity;

– faced with a problem that has no analogues in his previous activity, competently and professionally cope with it;

– constantly develop self-education skills and abilities for professional reorientation.

An English teacher should not only be proficient in the subject, methods and forms of organization of the educational process, but also use modern teaching technologies in his/her work. To date, teachers of the Samarkand State Institute of Foreign Languages actively use the project method, computer modeling, business and role-playing games. Along with them, a method based on the activation of the process of independent decision—making, creative thinking, as well as the motivational and emotional background of

trainees, the case method, has become increasingly popular.

This method was first developed and tested in the United States of America, namely at the Harvard Business School. Edwin F. Gay, dean of the Harvard School, advised teachers to introduce into the educational process, in addition to traditional classes — lectures and workshops — additional ones held in the form of discussions with students. For the first time, the case method was applied in 1924 while teaching a fairly local professional field - management disciplines. Currently, two classical Case-Study schools coexist — Harvard (American) and Manchester (European). Within the framework of the first school, the purpose of the method is to teach the search for the only correct solution, the second one assumes a multivariate solution to the problem [1].

A case study is a method of teaching, the essence of which is to comprehend, critically analyze and solve specific problems or cases. A case is a description of a situation that has taken place in a particular practice and contains some problem that requires resolution. This is a kind of tool through which a part of real life, a practical situation that needs to be discussed and an informed decision is introduced into the classroom. Cases are usually prepared in writing and are based on real factual material or are close to the real situation. Due to the high concentration of roles in cases, this technology is close to game methods and problem-based learning.

The case is formed from the general problems of the task, the relevance and the need to solve similar problems in the field of their activities. Initially, the case method began to be used in law, where real cases from legal practice were taken, and students showed an individual approach to solving the problem. Thus, the case method includes specially prepared training materials and a special technology for using these materials in the educational process.

This method involves the following stages:

– a case developed by a teacher from practice (official activity);

– independent acquaintance with the case of trainees (possible discussion in subgroups);

– development of a solution to the case by trainees;

– discussion of the proposed solution together with the teacher, and the discussion process is sometimes more important than the decision itself.

If we consider case technologies in the broadest aspect, then we can say that the task of the teacher is to teach the student:

1) analyze and sort information;

2) identify key issues;

3) generate and evaluate alternative solutions;

4) choose the optimal solution, justify it and form an action program;

5) develop communication and management skills that allow effective interaction in a team;

6) develop expert skills and abilities.

There is a problem in the case itself in one form or another. The problem is a contradiction between the need for any actions and insufficient conditions for their implementation. The formulation of the problem presupposes the definition of this contradiction.

But even if we identify contradictions, we do not fully define the problem, for this it is necessary to highlight its main components:

1) the internal foundations of the problem (why it arose);

2) requirements for the methods of its resolution;

3) conditions for the occurrence and solution of the problem;

4) the activity of the staff to solve the problem, depending on the work performed and job responsibilities.

The case method is complex and allows to implement all types of speech activity: reading, speaking, writing, listening. Students have a real opportunity to communicate in a foreign language in the process of interacting with other group members and the teacher.

The solution of cases is recommended to be carried out in 5 stages:

The first stage is familiarization with the situation, its features;

The second stage is the identification of the main problem (main problems), the identification of factors and personalities that can really affect;

The third stage is the proposal of concepts or topics for brainstorming;

The fourth stage is the analysis of the consequences of making a decision;

The fifth stage is the solution of the case — the proposal of one or more options (sequence of actions), an indication of the possible occurrence of problems, mechanisms for their prevention and solution [2, 258].

Currently, the case technology is actively used by the teachers of our institute in the process of teaching English to students of language specialties.

As the results of an experiment conducted with first-year students of the linguistic faculty of the specialty "Joint educational programs" have shown, both the activity approach and speech interaction are best implemented through case technologies. Students were asked to solve structured mini-cases selected from such authentic sources as European Psychologist, Acta Psychologica. The students reacted positively to the Case Study, and in the process of using it in their activities, they managed to achieve certain results:

1. The control of oral and written speech showed that the students' vocabulary increased;

2. The motivation of students to learn English has increased;

3. More and more students understand the practical importance of the ability to communicate in English.

However, in the process of working on the use of case technology, the problem arose of selecting cases suitable for teaching future linguists to speak a foreign language. There is no shortage of publications in print and electronic publications of cases that have occurred and described in various world centers of linguistic assistance. The abundance of this kind of information dictates the need to determine the criteria for the selection of cases with sufficient linguistic and didactic potential. During the application of the case study method, it was found that it is advisable to use cases that meet such criteria as authenticity, compliance with program requirements, information capacity, language accessibility, and problematic nature for teaching linguists to speak a foreign language. Let's consider these criteria in more detail.

1. Authenticity of the case content. Despite the fact that the vast majority of publications on linguistics in print and electronic publications of the world are in English, not all of them are written by native English speakers. We are primarily interested in authentic speech material as a basis for teaching speaking.

2. Compliance of the content of the case with the curriculum of the discipline. Only in this case the case can be organically integrated into the educational process and contribute to the achievement of educational and practical goals of training future linguists.

3. The informational feasibility of the case, achieved by matching the information contained in the case to the level of students' knowledge in the field of science being studied (in our case, linguistics). It should be borne in mind that a foreign language is taught to students of the linguistic faculty only in all courses along with specialized disciplines, and students have a complete understanding of the various tasks and possibilities of their solution. However, already at this stage of training, students have a sufficient level of knowledge in such subjects as, for example, philology, linguistics, phonetics, grammar, which gives them the opportunity to participate in the discussion of cases corresponding to their level of professional awareness.

4. Language accessibility, which assumes that the cases intended for teaching foreign language speaking correspond to the level of language training of students. It should be noted that the grammatical material used in English-language cases, as a rule, does not go beyond the framework of the general secondary education program. On the contrary, the lexical content of cases can cause certain difficulties of understanding due to the abundance of terms. It is permissible to have terminological vocabulary that students can semanticize independently, however, the designated phenomenon should be familiar to students in accordance with the criterion of informational feasibility.

5. The problematic nature of the case is a necessary condition for motivating students to speak. The histories of linguistic science published in English newspapers and journals on linguistics are always complete, i.e. they include mandatory parts for publication: information about the language, a description of the problem itself, research data, study, outcome, discussion and conclusions. Of course, the case is of professional interest, but it does not contain a problem for discussion. The task of the teacher is to highlight the problem in the existing case, keeping in mind the requirement of informational feasibility. This means that first-year students, not having a sufficient level of professional knowledge, are not yet able to establish an accurate analysis, more or less accurately predict the outcome of the problem. However, they can already assume the cause of this problem, determine the risk factor or make a decision from a moral and ethical point of view.

To conclude, the cases for teaching students of the linguistic faculty to speak a foreign language have the necessary linguistic and didactic potential if they meet all the above criteria.

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Impact Factor:					
	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 8.771	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 05.06.2022 **http://T-Science.org**

Issue Article

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FREQUENCY OF USE OF GENRES OF THE NEWSPAPER «ҚАРАҚАЛПАҚ ӘДЕБИЯТЫ» («KARAKALPAK LITERATURE») AND THE LANGUAGE OF THEIR DESCRIPTION

Abstract: *The language and style of the newspaper are studied on the example of newspaper genres. Informational, analytical and artistic-journalistic genres are used in local newspapers. The frequency of interviews, articles, letters, and review genres has significantly increased. Along with journalists, special correspondents, experts and external authors, local newspapers also participate in the training. Materials of the newspaper «Қарақалпақ әдебияты» ("Karakalpak literature") for 2018 and 2022 were studied.*

Key words: *genre, interview, article, letter, scientific review, review verbs, quote, animation, comparison, stamps, circulation, motto, style.*

Language: *English*

Citation: Kallibekova, G. P. (2022). Frequency of use of genres of the newspaper «Қарақалпақ әдебияты» («Karakalpak literature») and the language of their description. *ISJ Theoretical & Applied Science, 06 (110),* 54-59.

Soi: http://s-o-i.org/1.1/TAS-06-110-9 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2022.06.110.9

Scopus ASCC: *1200.*

Introduction

The newspaper «Қарақалпақ әдебияты» ("Karakalpak Literature") has been published since January 2011. The motto of the newspaper is "If literature lives, a nation will also live." It has been publishing by the organization of Writers' Union of the Republic of Karakalpakstan. The chief editor of the newspaper is Gulistan Annaklycheva. This newspaper is published once a month in A-3 format with a circulation of 992 copies.

When we study the language and style of the newspaper, the first thing we pay attention to is the genre of the newspaper. Informational, analytical and artistic-journalistic genres are used in local newspapers. In their work, we also observe a significant increase in the frequency of coverage of certain genres in these newspapers.This is due to the fact that in the regional newspapers, along with journalists, special correspondents, field experts and external authors also participate in their education.

Researchers are constantly learning the language and stylistic differences of journalism genres, the processes of their use in newspapers. There are a number of scientific studies. For example: N. Mirzaeva in the article "Analysis of materials in the genre of interviews in children's publications" [6, - P. 108-112] newspaper "Tong Yulduzi" ("Morning Star"), magazines such as "Bilimdon" ("Knowledgeable"), "Dono word" ("Wise word"), "Gulhan" ("Fire"), "Yosh Kuch" ("Young Power") were analyzed the frequency of the interview genre. Z.Mamashakirova in the article "Interview genre in modern journalism" [7, - P. 64-48] classified the interview genre according to the specifics of its use. “There are different classifications of interviews: by character and topic (informant, expert, puzzling, interview-acquaintance); purposeful (news, quick, portrait, interview, conversation), form (monologue, dialogue, polylogue, questionnaire, blitz); organizational type (press conference, briefing, telephone, face-to-face, roundtable discussion)”. M. Artikova in the article "Classification of genres in the Uzbek and Spanish electronic media space" [1, - P. 148-156] learned in a comparative way the classification of genres in the Uzbek and Spanish electronic media. In her opinion genres have also made a comparative study of language and style. In Uzbek journalism, information genres include news, interviews, reports while in Spanish, news genres include news, evidence-based reporting, and

evidence-based interviews. Analytical genres include correspondence, articles, reviews, letters, interviews in Spanish journalism, review reports, and article reviews. Fiction genres include essays, feuilletons, descriptions, reviews, editorials in Spanish journalism, commentary articles, commentaries, blogs, reviews, and letters to the chief editor. B.Akmalova in the article "Genre features in the preparation of PR-materials" [2, - P.417-420] also studied genres.

When we study the issues of the newspaper «Қарақалпақ әдебияты» ("Karakalpak Literature") in 2022, the interview materials and letter genres in the newspaper materials attract the attention of the reader with the language, subject matter, title and heading. The main difference between the genre of an article in a newspaper is that it is written for a book, a textbook or a collection of poems. Such articles and literary letters make up the majority in the newspaper. You can find them in the selected rubrics and topics. In particular, in the rubric "Friendship of literature - friendship of people" («Әдебиятлар дослығы – халықлар дослығы») E. Bekturganov's article "The genius who served the people" (read K. Kamalov's book "In the service of the country"), in the rubric "Memory" («Яднама») T.Masharipova's "Keep up spirits… or letters to the poet Ulmambet" («Кеўил кусым ушып… ямаса Улмамбет шайырға хатлар»), in the rubric "Meet - a new book" («Танишинг: янги китоб») the article "Spirit of Time - the soul of the work" («Замон руҳи – асарнинг жони») by Rustam Musurmon, Honored Worker of Culture of Uzbekistan, People's Poet of Karakalpakstan, an article by Gulistan Matyakubova, a Karakalpak folk poet and cultural worker who has served in Uzbekistan, is based on the book "Light in the heart" («Кўксимдаги нур»). The genre of interviews is also well covered in the newspaper. In the rubric "Our conversation" («Бизиң сәўбет») there is an interview of D. Kamalova "Looking through the papers of love" («Муҳаббат дәптерин бетлегенде») (A look at the work of the writer Marat Tawmuratov). In this rubric there is an interview with A. Bekbergenova entitled "It is difficult to live without writing a play, says the writer, playwright, artist of the Republic of Karakalpakstan Polat Aitmuratov" («Қарақалпақ әдебияты» 2022, №1-2). In the rubric "Our conversation" («Бизиң сәўбет») Z. Bekbergenova's interview entitled "The Eighth bus station" («Қарақалпақ әдебияты» 2022, №3) is also well covered. In the rubric "New translations" («Жаңа аўдармалар») K. Reimov's translation was an interview entitled "In order to save the society - it is necessary to save the book" (interview with the national poet of Kazakhstan, academician Olzhas Sulaimanov) («Қарақалпақ әдебияты» 2022, №4).

In the 2018 issues of the newspaper, we noticed that the genres of interviews, articles, literary reviews, scientific reviews and reviews were also used effectively. For example: in the rubric "Literary review" («Адабий тақриз») N.Allambergenova's "When students write…" (review of poems published in Uzbek in the newspaper "Nukus Pedagogical Institute" («Нукус пединститути») in the 2018 issues), in the rubric "Literary review" («Әдебий сын») J.Uteniyazov's review "Read choosing with taste...About poetry collections published in publishing houses in 2017" («Қарақалпақ әдебияты» 2018, №3), in the rubric "Literary conversation" («Әдебий сәўбет») I.Dilmanov interviewed "The great personality of Turkic people" (Chingiz Aitmatov's works are in Karakalpak language) («Қарақалпақ әдебияты» 2018 №10). In the rubric "Literary Conversation" («Әдебий сәўбет») there was an interview with B. Genzhemuratov "There is one literary scale" («Қарақалпақ әдебияты» 2018, №1). In the rubric "Theater" there was an interview with G. Nurlepesova entitled "Hearth of invaluable education" («Қарақалпақәдебияты» 2018, №1). In the rubric "We read and comment" there was an article by A. Zhuzimbetov "The most appreciated story" (Thoughts after reading the book by Gulistan Matyakubova "Leaders of the world of Karakalpak music") («Қарақалпақ әдебияты» 2018, №9). In the rubric "Literary Studies" («Әдебияттаныў») there was a scientific review of Zh.Xoshniyazov "Sparrow's flight" (A look at the songs of the folk poet of Karakalpakstan Kenesbay Karimov) («Қарақалпақ әдебияты» 2018, №8). In the rubric "Literary Studies" G. Begmuratova's article "The content of life is the search for happiness" (Sh. Seitov and the Karakalpak novel) («Қарақалпақ әдебияты» 2018, №8), in the rubric "Tribune of young literary critics" F. Avezova's article "A white ship is an honest ship"(thoughts on Sh. Aitmatov's story "White ship") («Қарақалпақ әдебияты» 2018, №7), H. Utemuratova and A. Bekbergenova's "Folk wisdom is a source of knowledge («Қарақалпақ әдебияты» 2018, №7) were given. In the rubric "Yadnama" there is a scientific review of K. Allambergenov "Writer who embraced the world" (on the example of prose of T. Kaipbergenov's period of independence) («Қарақалпақ әдебияты» 2018, №5).

The narrative language of the scientific review given in this newspaper is wide, rich in facts, and the obvious figures are striking. In particular, in the rubric "Memory" («Яднама») K. Allambergenov wrote a scientific review "Writer who embraced the world" (on the example of prose of T. Kaipbergenov's period of independence) («Қарақалпақ әдебияты» 2018, №5) devoted to the oeuvre of T. Kaipbergenov. Example: Қарақалпақ халқының мәдений тарийхына сер салып қарасақ, жазба реалистлик прозаның оғада кеш раўажланғанын көремиз ("If we look at the cultural history of the Karakalpak people, we see that written realist prose developed too late") The word "look at" is a phraseology. The meaning of this word is explained in special

dictionaries as follows: «сер салды - қарады, бақлады, кеўил бөлди» (“look at - look, watch, care”) [5, P.138]. The following example: «Мине, усындай көркем тәжирийбеси ҳәм әдебий дәстүрлери оғада жас прозаны буннан былай да раўажландырыў, оны пүткил аўқамлық, ҳәттеки жәҳән әдебияты көлеминдеги проза менен тайталасып, бәсекилесип жарыса алатуғын, солай етип, усы прозаның идеялық-көркемлик өсиў дәрежеси арқалы қарақалпақ әдебиятын да жәҳән әдебияты халықлары қатарында мақтаныш пенен тилге дәрежеге жеткериў өткен әсирдиң 50-жылларының басларында шайыр сыпатында әдебиятқа кирип келген, сол ўақытлардағы жас жазыўшы соң Өзбекстан Қаҳарманы, Өзбекстан ҳәм Қарақалпақстан халық жазыўшысы, *әдебиятымыздың кәрўан басысы* болып жетилискен, көрнекли прозаик *Төлепберген Қайыпбергеновтың* пайына тийди» (“*Tolepbergen Kaipbergenov*, a young writer of that time, who entered *the literature as a resin* in the early 50s of the last century, later became the Hero of Uzbekistan, the People's Writer of Uzbekistan and Karakalpakstan, the caravan leader of our literature developed artistic experience and literary traditions of the further development of young prose, its ability to compete with the prose of the whole union, even the literature of the world, and thus the development of the idea of prose. Thus, through the level of ideological and artistic development of this prose, Karakalpak literature became a source of pride and language among the people of world literature”). «Т.Қайыпбергенов ҳәзирги дәўирде де «Саҳра бүлбили» («Бердақ», 1997), «Айдос баба» («Мың тиллаға тигилген гелле») (2001), «Қарақалпақпан. Тәўекелшимен» (2003), «Кеўлимниң қамусы» (2008) сыяқлы бир қатар повесть, роман, драмалар жазып, ғәрезсизлик дәўири әдебиятында *прозамыздың кәрўан басысы* сыпатында нық қәдем менен тартып киятыр» ("On writing number of short stories, novels and dramassuch as “A desert nightingale” (“Berdah”, 1997) («Саҳра бүлбили» («Бердақ», 1997)), "Aidos baba" (“Head for 1000 gold”, 2001) «Айдос баба» («Мың тиллаға тигилген гелле» 2001),“I am Karakalpak. I'm risky” (2003) («Қарақалпақпан. Тәўекелшимен», (2003)), “My heart’s reed” (2008) («Кеўлимниң қамусы» (2008)), nowadays T.Kaipbergenov is still taking a firm step as *a head of caravan of prose* in the literature of themodern era"). Т.Қайыпбергеновтың «О дүньядағы атама хатлар» дөретпесиниң жазылыў себеплери, ондағы ой жуўмақлары бул шығарманы Дантениң «Илаҳий комедия»сына *типологиялық жақтан бираз жақынластырады* ("The reasons for writing T. Kaipbergenov's "Letters to the late father", the ideas contained in it *bring this work a little typologically closer to* Dante's "Divine Comedy"). Жазыўшының дөретиўшилик лабораториясына *сер салсақ*, «Хатлар» 1992-жылы Ғәрезсизлик дәўиринде жарық көргени менен, оның жазылыў тарийхы, яғный, жазыўшының бул дөретпени жазыўға таярлығы 90-жылларға дейин-ақ басланғанын көриўге болады (If we *look at* the author's educational laboratory, we can see that although the "Letters" («Хатлар») were published in 1992 during the period of independence, the history of its writing, that is, the writer's readiness to write this work began as early as the 90s). *Биз билемиз*, жазыўшы шығармасына сүўретлеў обьекти етип алған 70-80-жыллар тек Республикада емес, пүткил бурыңғы аўқамда зорабанлық-бюрократлық басқарыў методының күшли ҳүким сүрип турған дәўири еди (*We know* that the 70s and 80s, which became the object of the writer's work, were a period of violent and bureaucratic rule, not only in the Republic, but also in the former Soviet Union). Ең жоқарғы минберлерден айтылған гәплер де самалға ушқандай гүўилдеп, *тыңлайтуғын қулақ таппады* (Even the words from the highest pulpits sounded like the wind and *could not be heard)*. In the descriptive language of the scientific review, stamps were used, which formed the verbs to meet the requirements of a number of genres. K. Bekbergenov, who conducted a special study of scientific style, explains such verbs as follows: “Scientific words can be used several times in the texts of scientific literature. While such repetitions are considered in other texts (stylistic error in the style of fiction), stylistic error, defect, in the scientific style it is a regular phenomenon, a stylistic feature of the scientific literature. For example, verbs that are used in most scientific literature and have been included in the list of scientific words, such as *билдиреди ("means"), аңлатады ("explains"), аталады ("names"), есапланады ("calculates"), болады ("can"), табылады ("find"), қаралады ("are considered")*, can be repeated in a small scientific text" [3, P. 91]. The language of narration of scientific reviews in newspapers is quite mature. The author feels free to express his views and suggestions. We can see them in the stamps used as special lexical units of the genre. For example: *пайда болды (appeared), миясар болды (reached), мақсетке муўапық болады (gained), жаратты (created), дөретти (made), жаңа белгилер киргизди (added new marks), арнаўлы изертлеў жумыслары да жүргизилди (special scientific works were made), сәўлелендирип бериў керек еди (should have been described), жақынластырады (makes closer), жар салды (declaimed), пүкта пайдаланады (uses accurately), болып көринеди (seems), болып есапланады (is considered), ибарат (contains), утымлы сәўлелениўин табады (luckily described), сүўретленбейди (can’t be described), ҳәрекет еткен (tried), биз билемиз (we know), қулласы (overall), автор (author), сырттан қарағанда (looking outside), булардың бәри (all of them), улыўма (commonly), ҳәрекет етеди (tries),*

жалықпайды (can't feel boredom), ушырасады (meets), безетилген (decorated), толғанады (thinks), сөз етеди (talks).

In the rubric "Literary Studies" («Әдебияттаныў») there is a scientific review of Zh. Xoshniyazov "Sparrow's flight" (A look at the songs of the poet of Karakalpakstan Kenesbay Karimov) («Қарақалпақ әдебияты» 2018, №8). In the descriptive language of the genre, the facts are clear. The series of additions from the collection of poetry, their main idea, content and form are well explained based on the facts. The scientist used modal words to convey the idea."Through modal words, the scientist expresses his objective-subjective attitude to the subject and phenomena, so their various forms of emotional-expressiveness, which are characteristic of the spoken language, are not used effectively in the scientific style. Modal words in the scientific style mean that the idea is not questionable, it is factual and reliable: *in fact, really, in the right way, it is right, of course"* [4, P. 98]. Example: «*Дурыс*, Кеңесбай Каримовтың қосықлары оқыўшылар тәрепинен бирден қабылланып, тез түсиниле қоймайды» ("In fact, Kenesbay Karimov's poems are not immediately accepted by students and are not easily understood") In the scientific review, nouns and pronouns are also used productively. For example: *he, they, himself, my, this, we, we also, our, poet, Kenesbay's, K. Karimov's*. «*Ол* не айтсада, не жазса да өзиниң руўхый мүмкиншиликлерин, дүнья таныў имканиятларынан нәтийжели жуўмақ шығарыўда ҳәрекет етеди» ("No matter what *he* says or writes, he tries to use his spiritual potential to make an effective impression on the world"). «*Ол* тәбият тилсимлерин сөз бояўлары менен безеўде бәрқулла жаңа образлар излеўге жалықпайды» ("*He* never tires of looking for new images in the decoration of nature with words"). «*Ол өз* шеберлигин арттырыў ушын фольклорлық ҳәм классикалық усылларды өз орнында қолланыўда терме-толғаўлар, нақыл-мақалларды, Мақтумқулы, Әжинияз сыяқлы шайырларды өзине үлги тутады» ("*He* uses folklore and classical methods in order to improve his skills moreover, in using proverbs and thermae accurately he considers Makhtimkuly and Adjiniyaz as his mentor"). «*Биз* бул пикирлеримизди шайыр Кеңесбай Каримовтың қосықлары арқалы дәлиллеп бериў имканиятына ийемиз» ("We have the opportunity to prove our point with the help of the poet Kenesbay Karimov"). «*Бизде* усындай жақсы нийет пенен Бозторғайдың қанаты талмасын, пәрўазың бәлентлей берсин демекшимиз» ("With such good intentions, we want to wish strong wings to Sparrow and fly higher"). «*Кеңесбайдың* философиялық ой-пикирлерин сәўлелендиретуғын қосықларының барлығында дерлик классикалық үлгиде жазылған ҳәм оның қосық дөретиўшилик тәжирийбелериниң тийкарғы бөлегин қурайды». ("Almost all of *Kenesbay's* philosophical ideas are written in a classical style, and his poems are an integral part of his pedagogical practice"). «*К.Каримовтың* қосықларында түсиңки кейпияттағы қатарларда ушырасады» ("*In Karimov's* poems, we also can see pale lines"). «Шайырдың шығармаларының тематикалық шеңбери кең» ("The thematic range of poet's works is wide"). «Шайыр дөретпелериниң формалық тәреплеринде де жаңалықлар көп» ("There is a lot of news in the formal aspects of the poet's works"). A number of lexical units are used regularly to confirm and compare opinions. For example: *бизиң пикиримизше, (in our opinion), мәселен (for example), бәлким (maybe), бирақ (but), ал, деген менен (let's say), бир сөз бенен айтқанда (in a word), себеби (because), мине, бул пикирлеримизди (let's take these opinions), алып қарайық (let's take a look)*. «*Бизиң пикиримизше*, ескини жаңалаў әдиўли ис. *Себеби* ҳәзирги әўладлар ески емес, олар жаңа дүньяның адамлары» (*"In our opinion*, it is fair to renew the old," he said. "*Because* today's generations are not old, they are people of the new world"). «*Бәлким*, соның ушында ол өзиниң дөретиўшилик қәбилетлеринен қанаатланбайды» ("*Perhaps*, that's why he is not satisfied with his creative abilities"). «*Бирақ*, олар тиккелей турмыс тәшўишлерине наразышылықлардан ибарат емес» ("*However*, they do not consist of direct protests against the carriers of life"). «*Ал*, ескертиў характериндеги мүмкин болған қыйыншылықлардың алдын алыў нийетлери менен қандырылған қосықлардан ибарат» ("*But* it consists of additives saturated with the intention of preventing possible troubles of a warning nature"). «*Мәселен*, шайыр «Таўлар таман» деген шығармасында символикалық образ жәрдеминде адамның қандай жағдайда да мақсетине умтылыў кереклигин сөз етеди» ("*For example*, in his work"To the mountains" («Таўлар таман») the author speaks of the need to pursue one's goals in any situation with the help of a symbolic image"). «*Мәселен*, ол верлибр, окку сыяқлы қосық түрлери бойынша поэтикалық изленислер арқалы миллий сезим туйғыларымыздың өрисин кеңейтиўди нийет еткен» ("*For example*, he intends to expand the field of our national feelings through poetic research on such types of poets as verlibr, hokku"). «*Алып қарайық*: Қуслар яңлы баўыр басқан уяға, Бир мәрте келиппиз жақты дүньяға, Қәдирин билгил ҳәр бир мәўрит зыяда, Саған буннан өзге заман табылмас. Бул қатарлардағы ритмлик ҳәм рифмалық үйлесимликлер айтылажақ ой-пикирдиң нәтийжелилигин тәмийинлеў менен бирге, санамыздан орын алған өз түсинигимиздиң көркемлескен келбетин көриўимизге имкан жаратып береди» ("*Let's take a look:* come to the nest closer like birds, Once we came to the world, Every moment is worthless, You will not find another time.

The rhythmic and rhyming combinations in these lines not only ensure the effectiveness of the thought being expressed, but also allow us to see the artistic form of our own understanding of what is going on in our minds").

M. Khudaikulov, the author of a special textbook on the genres of journalism, commented on the genre of letters: "Literary letters are one of the most important types of letters in the press and in the written literature. Or epistolary journalism. The word "epistolary" in Latin "epistola" means letter, sent information. This genre is a literary or journalistic work in the form of a letter. In other words, well-known writers convey their thoughts, feelings, and suggestions in the form of letters to the public.The work of the great medieval poet Alisher Navoi "Munshaot" («Муншаот»), Furkat's letters abroad to the "Turkistan regional newspaper" («Туркистон вилоятининг газети») and poetic letters to friends, the article "Letter to Gogol" by the great Russian critic V.G. Belinsky, the great Russian writer L.N. Tolstoy's open letter "I can't stand still" and others can be mentioned. The authors of these letters look at the most important socio-political, educational and spiritual exercises of their time" [8, - P. 205-206].

Today, the newspaper «Қарақалпақ әдебияты» publishes open letters. It seems that their ultimate content is aimed at guiding young people to read books, improving their education, the ability to properly analyze the events around them or to make a conclusion. In the rubric "Yadnama" ("Memory") in the newspaper «Қарақалпақ әдебияты» the narrative language of the literary letter of T. Masharipova entitled «Кеўил қусым ушып… ямаса Улмамбет шайырға хатлар» ("Keep up spirits… or letters to the poet Ulmambet) («Қарақалпақ әдебияты») 2022, №1-2) attracts he attention of the newspaper readers. This is because the journalist was able to make effective use of *каратпалардан (quotes), үндеўлерден (appeals), анық ҳәм риторикалық сораўлардан (clear and rhetorical questions), теңеўлерден (similes), салыстырыўлар ҳәм жанландырыўлардан (comparisons and animations)*. For example: «*Улмамбет аға!* Жумыстан келсем, ақлықларыңыз Айзада менен Шахзада Сизиң берип жиберген китабыңызды (У.Хожаназаров. Кеўил қусым. «Қарақалпақстан», 2010) әкелип берди» ("*Uncle Ulmambet!* When I came home from work, your grandchildren Aizada and Shahzada brought the book you gave me (U. Khozhanazarov. Keep up spirits. "Karakalpakstan" («Қарақалпақстан»), 2010). ««Қуралбай» менен «Мураттың тили», «Қус жолы» ертеңге қалады. Бул қосықлар бизлердиң үйимизге қаншелли куўаныш ҳәм заўық бағышлағанын *көрсеңиз еди!*» ("Kuralbay" and "Murat's language" («Қуралбай» менен «Мураттың тили»), "Bird's way" («Қус жолы») will be left tomorrow. *I wish you could see* how much joy and pleasure these songs bring to our house!"). «Шылпық» *мунарланған* Қаратаў, кең жазық далалар, бул күнлери әдеўир тыншып қалса да Жәйхундәрья кеўлимизди *таўдай* көтереди» ("Karatau with *the tower* "Shylpyk", wide plains, and the Jaihundarya river lifts our spirits, even if it is very *quiet* these days"). «Сонда да ким туўылған жер туўралы қосық жаздым десе, негедур *Әжинияздың «Еллерим барды»сы менен Аяпбергенниң «Тәрипи» қатарында Сизиң «Туўған жериңизге»* салыстырғым келе береди…» ("However, if someone says that I have written a poem about the place of birth, for some reason I would like to compare *Azhiniyaz's "I have my country" («Еллерим барды») with Ayapbergen's "Discription" ("Тәрипи") lines to your "Homeland" («Туўған жериңизге»)*). «*Бундай сулыў қатарлар мийиңизге қалай қуйылды екен!?*». «Бир қызығы, бул қосықлар қәлеген оқыўшының ядына *қуйыла береди!*» (*"How did you get such beautiful lines in your brain?"* "It's interesting that these songs *will be remembered* by many readers!"). «Меннен сизиң үй телефоныңызды, адресиңизди анықлап бериўимди сорады. *«Не қылажақсаң?»* десем, «сөйлесежақпан, айырым қосықларының кимлерге арналғанын билежақпан, сен де жаз, ағамыз қуўанып калсын» деп усыныс етти». ("I was asked to find out your home phone number and address). *"What are you going to do?"* I said, "I am going to talk who he has devoted some of his songs to. He also suggested him writing letting him be glad"»). «*Шынында да?* Усы гәп қамшы, неге енди әпиўайы оқыўшы сыпатында нәзик лирикаңыз себепли оянған гөззал туйғыларымды, сезимлеримди хатқа сала алмас екенмен, деп ойладым» ("*Really?* I wondered why I couldn't write down my beautiful feelings and emotions, which I had awakened as a reader because of your delicate lyrics"). «Усындай поэзия сыншысы болмағаныма *қуўанаман!*» ("I'm glad I wasn't such a poetry *critic!*"). «Сондай етип неге өзиңиздиң де көп ғана тамаша қосықларыңыздан халық алдында оқый *бермейсиз?*» ("So why don't you read a lot of your wonderful songs *in public?*"). «Бул поэманы телевидениедегилер жаңадан өшпес ленталарға қайта жазып алса, жанларына саўап *болар ма еди?*» ("Would it be heartbreaking if this poem could be rewritten on television on *indelible tape?*"). «Буған өзиңиз *не дейсиз?*». «Буннан азлап юмор-сатираның самалы еспей ме?!» ("What do you say to *that?*" "Isn't that a bit of humor and *satire?*"). «Қәдимги қарақалпақ аўылларының буннан артық сулыў сүўрети бар ма екен?!» ("Is there a more beautiful picture of the ancient Karakalpak *villages?!*"). «Баланың нәзик жүреги, келиншектиң, анық образы, қарақалпақ аўылларының пейзажы, аўыл адамларының нағыз қарақалпақы минез-қулқы, психологиясы *не деген тәсирли!*» ("The child's tender heart, the clear image of the bride, the landscape of the Karakalpak villages,

the real Karakalpak behavior and psychology of the villagers are very *impressed!")*. Therefore, through the narrative language of the letter, the reader of the newspaper understands every detail, every fact, idea and content. Because its author is an experienced journalist. Each context is made up of simple sentences, and the point is given more clearly.

In short, the materials presented in the newspaper «Қарақалпақ әдебияты» ("Karakalpak Literature") were able to choose the topics to attract the attention of the newspaper's reader, to work with external authors, that is, experts in the field. Interview genre was well-organized by writers, professors, candidates of science, and doctoral students. The genre of articles, letters, reviews are mainly focused on poetry collections, textbooks, revealing the final content of works of art and literature. It is noteworthy that in addition to the stereotypes of scientific reviews in the descriptive language, the scope of the use of verbs in free expression has expanded.

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Impact Factor:					
	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 8.771	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)
Year: 2022 **Issue:** 06 **Volume:** 110
Published: 06.06.2022 **http://T-Science.org**

Issue Article

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THE ROLE OF SOCIAL AND ENOMOMIC GROWTH OF SMALL BUSINESS AND PRIVATE ENTREPRENEURSHIP IN THE REPUBLIC OF UZBEKISTAN

Abstract: *The article describes the current stage of economic reforms in Uzbekistan, the development of small business and private entrepreneurship, providing it with broad economic freedom. In this regard, special attention is paid to the development of small business and entrepreneurship in the country. Since this issue is considered as a strategic task of the economic policy of our state, currently, this sector is leading not only in accelerating economic growth, but also in solving the issues of employment and income growth that are extremely important for our country. Information is also provided on the share of small business and private entrepreneurship in GDP in recent years.*

Key words: *small business, private entrepreneurship, Uzbekistan, entrepreneurial activity, employed population, percentage, development, market economy, favorable business climate, favorable business climate.*

Language: *English*

Citation: Khozhalepesov, P. Z., & Kalimbetova, A. K. (2022). The role of social and enomomic growth of small business and private entrepreneurship in the Republic of Uzbekistan. *ISJ Theoretical & Applied Science, 06 (110),* 60-62.

Soi: http://s-o-i.org/1.1/TAS-06-110-10 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2022.06.110.10

Scopus ASCC: *2000.*

Introduction

The Government of Uzbekistan pays special attention to the development and implementation of a set of measures aimed at stimulating the development of small businesses and private entrepreneurship by creating a favorable business climate. At the same time, the current policy is comprehensive and covers almost all aspects of small business and private entrepreneurship.

As a result of the measures taken, the role of small business and private entrepreneurship in the structural transformation of the economy of Uzbekistan is growing from year to year.

First, the development of small business has become one of the main factors of economic growth. This is evidenced by the high growth rates of production in this sector, as a result of which its share in GDP in 2017-2021 reached an average of 58.9% against 54.0% in 2011.

Secondly, the development of small business creates new jobs and provides income for a significant part of the population. In 2017-2018, the economically active part of the population amounted to 77.1%, while in 2011 it was at around 75%.

Thirdly, the development of small business has become an important factor in accelerating structural adjustment. In particular, the share of the industry sector in 2017-2021 reached an average of 31.8%, and in 2011 28.6%, the share of the construction sector in 2017-2021 reached an average of 71.4%, and in 2011 amounted to 67.6% . And the volume of agriculture in 2021 reached 307,280.2 billion soums against 46,704.5 billion soums in 2011.

Fourth, in recent years, small business has become an important factor in the development of

exports and increasing the export potential of the country, diversifying its structure, optimizing imports and accelerating the integration of the country's economy into world economic relations. As a result, compared to 2011, export indicators for 2017-2021 increased on average from 18.8% to 23.8%, and in total imports - from 34.3% to 54.3%.

A mixed economy is being formed in Uzbekistan, where the leading role is given to small businesses and private entrepreneurship. The implementation of measures to stimulate the development of small businesses, a significant simplification of the procedure for its registration, and most importantly, the introduction of an effective mechanism for protecting the rights and interests of an entrepreneur contribute to the further development and strengthening of this most important sector of our economy.

In order to stimulate an increase in the production of export products and support exporting enterprises in the conditions of the global financial and economic crisis, complex benefits and preferences have been created. As a result, despite significant fluctuations in world market conditions, the export of products of small businesses over the past 5 years has increased by 4.1 times.

It should be noted that the reliable provision of guarantees of freedom of entrepreneurial activity, the creation of favorable conditions for business entities in Uzbekistan and the development of legislation in this direction indicate a priority that unites our efforts on the path to achieving new goals, developing existing and creating even greater potential for future accomplishments. Since it is small business and private entrepreneurship that contribute to the formation of healthy competition, quickly respond to market conditions, filling it with demanded and high-quality goods, create new jobs and, accordingly, increase the well-being of people. One of the main tasks in this direction is the creation and improvement of the legislative framework for economic reforms and the legislative framework for guaranteeing the freedom of entrepreneurial activity.

Thus, the Law "On Family Business" defined a new organizational and legal form of business - a family enterprise. This form of business organization in our country is fully consistent with the established national traditions of doing business and the objective realities of economic activity. The creation of a legislative framework for his organization, undoubtedly, has made it possible to increase the legal guarantees of family business, create conditions for the rapid and widespread development of family business in various sectors of the economy and the creation of new jobs.

In 2019, the President of the Republic of Uzbekistan signed a decree “On additional measures to strengthen the protection of private property and guarantee the rights of owners, fundamentally improve the system for organizing work to support entrepreneurial initiatives, as well as expand the access of business entities to financial resources and production infrastructure”, which clearly defines the goals of further strengthening the protection of private property and guarantees of the rights of owners, creating an additional impetus for the development of entrepreneurship, supporting entrepreneurial initiatives and projects, expanding the access of business entities to financial resources, increasing the level of social inclusiveness, ensuring freedom of economic activity and entrepreneurship, protection from encroachment, creating all necessary conditions for the preservation and enhancement of private property.

The laws adopted in our country are an important step in cardinally denouncing the business climate, liberalization and accelerated progress along the path of in-depth market reforms and providing greater freedom to entrepreneurship, eliminating barriers and obstacles to the development of small businesses and private entrepreneurship, increasing their role and share in the country's economy, development of export potential, provision of employment and income of the population.

It is appropriate to note that from time immemorial, entrepreneurship has occupied a special place in the history of our country. Much can be said about the entrepreneurial traditions of our ancestors, their respectful and careful attitude to the land, property, crafts, business qualities of people. Here it is appropriate to mention once again the wise words of Amir Temur : “One decisive, enterprising, vigilant, courageous and courageous person is preferable to a thousand inactive and indifferent people.”

In the context of global competition, it is entrepreneurs who make the most significant contribution to the development of industries and services, filling the domestic market with competitive and high-quality products, creating new jobs, especially for young people, which is one of the pressing issues of today, and providing on this basis increasing incomes and improving the well-being of the people.

We are well aware that at present in Uzbekistan there is still a lot of untapped potential and opportunities for the development of this area, and in the developed countries of the world small business and private entrepreneurship occupy the main place in the structure of GDP, it becomes clear what large-scale work we still have to do in this direction .

First of all, in order to protect the rights and interests of small businesses and private entrepreneurship, it is necessary to pay special attention to the critical assessment of the current regulatory framework, the adoption of new legislative acts. The Chamber of Commerce and Industry of the Republic of Uzbekistan supports the mechanism of public-private partnership, which makes it possible to

conduct a constructive dialogue with business representatives and carry out public examination of draft legal acts regulating entrepreneurial activity.

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Impact Factor:					
	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 8.771	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 06.06.2022 **http://T-Science.org**

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MODEL AND NUMERICAL ALGORITHM OF THE PROCESS OF TRANSFER AND DIFFUSION OF ACTIVE FINE HARMFUL PARTICLES IN THE ATMOSPHERE

Abstract: *The article discusses the relevance of solving the problem of monitoring and forecasting the ecological state of industrial regions, where there is a violation of the balance of the sanitary norm of the environment due to a large number of emissions of harmful finely dispersed active aerosol particles and carbon dioxide into the atmosphere. A mathematical model of the process of distribution of pollutants released into the environment from production facilities is presented, which is described by a system of differential equations in partial derivatives with appropriate initial and boundary conditions. The main parameters that play a significant role in the process of transfer and diffusion of harmful substances in the atmosphere are indicated: wind speed and direction; terrain; absorption coefficient of harmful aerosol fine particles in the atmosphere, etc. In this work, a differential equation is obtained for calculating the settling rate of fine and aerosol particles propagating in the boundary layer of the atmosphere, when the main parameters affecting the particle settling rate are taken into account: the mass and radius of aerosol particles, the density of the atmosphere, and the air resistance force. For the numerical solution of the problem, an efficient numerical algorithm based on the "method of lines" is proposed. The algorithm makes it possible to reduce a multidimensional problem described by a partial differential equation to the integration of an ordinary differential equation.*

Key words: *mathematical model, transfer and diffusion of harmful substances, weather-climatic factor, hydromechanics, numerical algorithm.*

Language: *English*

Citation: Muradov, F. A., Kucharov, O. R., & Ravshanov, I. A. (2022). Model and numerical algorithm of the process of transfer and diffusion of active fine harmful particles in the atmosphere. *ISJ Theoretical & Applied Science, 06 (110),* 63-88.

Soi: http://s-o-i.org/1.1/TAS-06-110-11 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2022.06.110.11

Scopus ASCC: *2604.*

Introduction

Construction and launch of industrial facilities and the growth of their capacities, without taking into account the sanitary standards, the development and commissioning of new oil and gas fields, the extraction of ores from the bowels of the earth, the increase in transport systems in cities and metropolitan areas, etc. violate the ecological balance of the region and the adjacent territory. The imbalance arises as a result of an increase in the gas content of the atmosphere and the concentration of harmful fine particles in its surface layer. These "negative" effects adversely affect the living system - the flora and fauna of the region, and at the global level contribute to climate change on the globe.

As noted by the International Committee on Health, the number of cases of cancer, asthma, allergies, etc. has sharply increased in recent years. diseases due to the deterioration of the ecological state of the environment around the world.

In ITAR TASS reports for the month of December 2016 г. critical levels of air pollution have been declared in China, France, Mongolia, the Balkans and other regions. In particular, in Beijing, measures to eliminate the environmental threat included stopping the operation of industrial facilities for several days, classes in schools, children's institutions, and restrictions on the movement of vehicles within the metropolis.

Based on the foregoing, the issues of monitoring, forecasting and assessing the pollution of the atmosphere and the underlying ¬surface of the earth by passive and active aerosol emissions and fine impurities; placement of industrial ¬enterprises in compliance with sanitary standards ; determination of the amount of suspended particles over the region and their distribution into the environment are relevant in the tasks of environmental protection.

The problems of mathematical modeling of the processes of transfer, diffusion and transport of harmful substances (carbon dioxide, fine aerosol passive and active particles) are studied in scientific schools created under the direction of G.I. Marchuk, V.V. Penenko, A.E. Aloyan, L.T. Matveeva, V.P. Dymnikova I.E. Naatsa, E.A. Zakarina, I.A. Kibel, L.N. Gutman, F.B. Abutaliev, as well as foreign scientists WJ Layton, JH Ferziger, JW Deardorff, M. Germano, U. Piomelli, LC Berselli, GS Winckelmans, WC Reynolds, H. Zidisk, K.A. Welds, K.I. Nappo, J. Gothaas, M. Müllioland, S. Trap, M. Mathies, W. Edelman and others.

Developed under their leadership are widely used in monitoring, forecasting and assessing the impact of anthropogenic impacts on the environment.

When deriving mathematical models of the above objects of study, scientists took as a basis the basic laws of hydrothermodynamics, conservation of mass and momentum, energy and motion.

A significant contribution in this direction was made by A.A. Samarsky, A.A. Tikhonov, G.I. Marchuk, R. Temam, V.V. Penenko, A.E. Aloyan and others. They proposed new efficient numerical algorithms for carrying out computational experiments and solving problems on a computer.

In particular, in [1-3], mathematical models and numerical algorithms and their software were developed for predicting and monitoring the movement of a multicomponent air environment and the transport of pollutants in the atmosphere, as well as the problem of the movement of a multicomponent air environment in the atmosphere, taking into account vaporization and condensation .

The work [4] is devoted to the study of the process of transfer and diffusion of active aerosol particles in the atmosphere, taking into account chemical transformations in the air. The chemical reactions occurring with aerosol particles in the atmosphere are given.

In [5], the processes of transformation of substances during the process of transfer and diffusion of harmful substances in the air over long and medium distances were studied. The methods and results of measuring the concentration of aerosol particles in the atmosphere emitted from various sources and involved in long-range transport are presented. The paper also studies trajectory and evolutionary models of the propagation of aerosol particles in the atmosphere and compares the results of calculations with field measurements.

To describe the physical process of transport of suspended particles in the atmosphere, there are also a number of works that present various approaches. These include methods for studying the process using statistical models based on the Gaussian distribution function [6–8].

In [9], problems and principles of mathematical modeling, a numerical algorithm and a software tool for macroscale physical processes in the atmosphere are considered. The article describes the modeling of atmospheric pollution by biogas released during the decomposition of waste.

The work [10] considers the non-stationary process of transport of bioaerosol harmful substances, taking into account the particle size, as well as the physical processes of condensation and evaporation of gaseous substances.

The work [11] is devoted to the development of a mathematical model of the dynamics of a two-velocity granular medium, including the phase equilibrium of temperature and in the absence of phase equilibrium of pressure. The authors assess the ecological state of the atmospheric air of the oil and gas condensate field. The assessment is made according to the data of continuous monitoring of atmospheric air, obtained by means of an automatic post of environmental control. 14 parameters are

measured in this field: concentrations of hydrocarbons, nitrogen oxides, carbon monoxide, ozone and meteorological parameters such as temperature, pressure, wind speed, exposure dose, and oxygen content in the atmospheric air.

In [12-19], a mathematical model was developed for calculating and predicting the transfer of pollutants in the Akhangaran industrial zone of Uzbekistan; local hydrodynamic model and design scheme for the distribution of pollutants in the atmosphere for an industrial region; a three-dimensional numerical model for assessing air pollution in the Akhangaran Valley by industrial emissions of sulfur dioxide (SO2) and arsenic compounds (As); a new approach that makes it possible to use experimental data on the wind regime in one of the Western Tien Shan valleys for other valleys with similar morphometric characteristics. The authors assessed the state of the air basin of the Akhangaran valley under various types of circulation in the warm and cold half-years ; the values of wind speed were established, providing favorable and unfavorable conditions for the purification of the atmosphere from emissions of harmful substances in the valley; connection of favorable and unfavorable conditions of air purification with the types of synoptic processes in Central Asia was revealed; a monitoring scheme is proposed, which includes a short-term forecast of the state of the air basin.

The study of the process of spreading harmful substances into the environment showed that the main factors that directly affect the course of the process are: the speed of movement of the air mass in the atmosphere; diffusion coefficient and vertical turbulent mixing coefficient; wind rose with time and depending on the orography of the area; taking into account the phase transition of the substance due to changes in the temperature regime in the layers of the atmosphere, as well as the rate of settling of fine and aerosol particles propagating in the boundary layer of the atmosphere.

Considering the above factors affecting the process of transfer and diffusion of harmful emissions in the atmosphere, it is necessary to develop an easily implemented effective tool - a model, a numerical algorithm, a software and instrumental complex for monitoring, forecasting and making management decisions to prevent negative consequences for the environment.

Statement of the problem

To study and predict the process of propagation, aerosol emissions into the atmosphere, taking into account the above factors, a mathematical model of the object has been developed, which is described by the equation of transfer and diffusion and based on the law of conservation of mass, momentum:

$$\frac{\partial \theta_1}{\partial t}+\left(w-w_g\right)\frac{\partial \theta_1}{\partial z}=\mu_1\left(\frac{\partial^2\theta_1}{\partial x^2}+\frac{\partial^2\theta_1}{\partial y^2}\right)+\frac{\partial}{\partial z}\left(k\frac{\partial \theta_1}{\partial z}\right)+\delta Q_1+F_1+\Phi_1\ ; \tag{1}$$

$$\frac{\partial \theta_2}{\partial t}+\left(w-w_g\right)\frac{\partial \theta_2}{\partial z}=\mu_1\left(\frac{\partial^2\theta_2}{\partial x^2}+\frac{\partial^2\theta_2}{\partial y^2}\right)+\frac{\partial}{\partial z}\left(k\frac{\partial \theta_2}{\partial z}\right)+\delta Q_2+F_2+\Phi_2; \tag{2}$$

$$\frac{dw_g}{dt}=\frac{mg-6\pi krw_g-0.5c\rho Sw_g^2}{m}; \tag{3}$$

$$\theta_1\left(x,y,z,\dot{0}\right)=\theta_1^0\left(x,y,z\right);\quad \theta_2=\theta_2^0\left(x,y,z\right);w_g(0)=\ w_g^0\ \text{при}\ t=0; \tag{3}$$

$$\left.\frac{\partial \theta_1}{\partial x}\right|_{x=0}=0;\quad \left.\frac{\partial \theta_1}{\partial x}\right|_{x=L_x}=0;\quad \left.\frac{\partial \theta_1}{\partial y}\right|_{y=0}=0;\quad \left.\frac{\partial \theta_1}{\partial y}\right|_{y=L_y}=0; \tag{4}$$

$$\left.\frac{\partial \theta_1}{\partial z}\right|_{z=0}=\eta_1\theta_1;\quad \left.\frac{\partial \theta_1}{\partial z}\right|_{z=L_z}=0; \tag{5}$$

$$\left.\frac{\partial \theta_2}{\partial x}\right|_{x=0}=0;\quad \left.\frac{\partial \theta_2}{\partial x}\right|_{x=L_x}=0;\quad \left.\frac{\partial \theta_2}{\partial y}\right|_{y=0}=0;\quad \left.\frac{\partial \theta_2}{\partial y}\right|_{y=hy}=0; \tag{6}$$

$$\left.\frac{\partial \theta_2}{\partial z}\right|_{z=0}=\eta_2\theta_2;\quad \left.\frac{\partial \theta_2}{\partial z}\right|_{z=L_z}=0, \tag{7}$$

where

$$F_1^{n+1}=\left(\alpha_2\theta_2-\beta_1\theta_1\right);\quad \Phi_1^n=u\frac{\partial \theta_1^n}{\partial x}+v\frac{\partial \theta_1^n}{\partial y};$$

$$F_2^{n+1}=\left(\alpha_1\theta_1-\beta_2\theta_2\right);\quad \Phi_2^n=u\frac{\partial \theta_2^n}{\partial x}+v\frac{\partial \theta_2^n}{\partial y}.$$

Here θ_1, θ_2, is the concentration of the first and second components of the harmful substance propagating in the atmosphere, *t* is the time, *x, y, z* are the coordinates, *u, v, w* are the components of the wind speed in directions *x, y, z*, respectively, w_g is the particle settling velocity, *k* is the turbulent mixing coefficient, is μ the *i-1* diffusion α_i, β_i coefficient *i*, *i+1*-th type (i =1,2), η_1, η_2 - coefficients of interaction with the underlying surface of the earth, $Q_i(x, y, z, t)$ - power of the sources of the first and second components, *m* - mass of aerosol particles, *r* - particle radius, *c* - dimensionless value equal to 0.5, ρ - atmosphere density.

Problem solving methods.

Since problem (1)-(7) is described by a multidimensional partial differential equation, it is difficult to obtain its solution in an analytical form. To solve the problem, we use a semi-implicit finite-difference scheme in time and obtain [20-23]:

$$\frac{\theta_1^{n+1}-\theta_1^n}{\Delta t}+\left(w-w_g^{n+1}\right)\frac{\partial\theta_1^{n+1}}{\partial z}=\mu_1\left(\frac{\partial^2\theta_1}{\partial x^2}+\frac{\partial^2\theta_1}{\partial y^2}\right)^{n+1}+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_1}{\partial z}\right)^{n+1}+\delta Q_1^{n+1}+F_1^{n+1}+\Phi_1^n;$$

$$\frac{\theta_2^{n+1}-\theta_2^n}{\Delta t}+\left(w-w_g^{n+1}\right)\frac{\partial\theta_2^{n+1}}{\partial z}=\mu_1\left(\frac{\partial^2\theta_2}{\partial x^2}+\frac{\partial^2\theta_2}{\partial y^2}\right)^{n+1}+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_2}{\partial z}\right)^{n+1}+\delta Q_2^{n+1}+F_2^{n+1}+\Phi_2^n;$$

$$\frac{\theta_1^{n+1}-\theta_1^n}{\Delta t}+\left(w-w_g^{n+1}\right)\frac{\partial\theta_1^{n+1}}{\partial z}=\mu_1\left(\frac{\partial^2\theta_1}{\partial x^2}+\frac{\partial^2\theta_1}{\partial y^2}\right)^{n+1}+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_1}{\partial z}\right)^{n+1}+\delta Q_1^{n+1}+F_1^{n+1}+\Phi_1^n;$$

$$\frac{\theta_2^{n+1}-\theta_2^n}{\Delta t}+\left(w-w_g^{n+1}\right)\frac{\partial\theta_2^{n+1}}{\partial z}=\mu_1\left(\frac{\partial^2\theta_2}{\partial x^2}+\frac{\partial^2\theta_2}{\partial y^2}\right)^{n+1}+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_2}{\partial z}\right)^{n+1}+\delta Q_2^{n+1}+F_2^{n+1}+\Phi_2^n.$$

Since equation (3) is nonlinear, we use the iterative method to solve it

$$\frac{w_g^{n+1}-w_g^n}{\Delta t}=\frac{mg-6\pi krw_g^n-0.5c\rho S(2\tilde{w}_g w_g^n-\tilde{w}_g^2)}{m},$$

and the convergence conditions of the iterative process have the following form:

$$\left|w_g^{(s+1)}-w_g^{(s)}\right|\le\varepsilon,$$

where ε is the given value (10^{-6}), S is the number of iterations.

From the statement of problem (1) - (7) it can be seen that the coefficients of equation (1) - (2) do not depend on *x* and *y*, therefore, the method of lines can be used for integration [24].

To solve the problem in leading the grid over the variables *x* and *y*

$$\omega_x=\left(x_i=ih_x,\ i=0,1,3,\mathrm{N}_1+1;\ h_x=\frac{L_x}{(\mathrm{N}_1+1)}\right);$$

$$\omega_y=\left(y_j=jh_y,\ j=0,1,2,3,\mathrm{N}_2+1;\ h_y=\frac{L_y}{(\mathrm{N}_2+1)}\right).$$

Further, writing equations (1), (2) for , $x=x_i$ we obtain a system of linear equations

$$\frac{1}{\Delta t}\theta_{1,i}+\left(w-w_g^{n+1}\right)\frac{\partial\theta_{1,i}}{\partial z}=\mu_1\frac{\theta_{1,i-1}-2\theta_{1,i}+\theta_{1,i+1}}{h_x^2}+$$
$$+\mu_1\frac{\partial^2\theta_{1,i}}{\partial y^2}+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_{1,i}}{\partial z}\right)+\delta_i Q_{1,i}+F_{1,i}+\Phi_{1,i}+\frac{1}{\Delta\tau}\bar{\theta}_{1,i};\quad(8)$$

$$\frac{1}{\Delta t}\theta_{2,i}+\left(w-w_g\right)\frac{\partial\theta_{2,i}}{\partial z}=\mu_1\frac{\theta_{2,i-1}-2\theta_{2,i}+\theta_{2,i+1}}{h_x^2}+$$
$$+\mu_1\frac{\partial^2\theta_{2,i}}{\partial y^2}+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_{2,i}}{\partial z}\right)+\delta_i Q_{2,i}+F_{2,i}+\Phi_{2,i}+\frac{1}{\Delta\tau}\bar{\theta}_{2,i},\quad(9)$$

there

$$\Phi_{1,i}=\left[\frac{U+|U|}{2}\left(\bar{\theta}_{1,i}-\bar{\theta}_{1,i-1}\right)/h_x\right|+\frac{V+|V|}{2}\frac{\partial\bar{\theta}_1}{\partial y}\Bigg];$$

$$\Phi_{2,i}=\left[\frac{U+|U|}{2}\left(\bar{\theta}_{2,i}-\bar{\theta}_{2,i-1}\right)/h_x\right|+\frac{V+|V|}{2}\frac{\partial\bar{\theta}_2}{\partial y}\Bigg].$$

For convenience, equation (8)-(9) can be written in a compact form

$$\frac{1}{\Delta t}\theta_{1,i}+\left(w-w_g\right)\frac{\partial\theta_{1,i}}{\partial z}=\mu_1\frac{M_1}{h_x^{\,2}}\theta_{1,i}+\mu_1\frac{\partial^2\theta_{1,i}}{\partial y^2}+$$
$$+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_{1,i}}{\partial z}\right)+\delta_i Q_{1,i}+F_{1,i}+\Phi_{1,i}+\frac{1}{\Delta t}\bar{\theta}_{1,i}; \quad (10)$$

$$\frac{1}{\Delta t}\theta_{2,i}+\left(w-w_g\right)\frac{\partial\theta_{2,i}}{\partial z}=\mu_1\frac{M_1}{h_x^{\,2}}\theta_{2,i}+\mu_1\frac{\partial^2\theta_{2,i}}{\partial y^2}+$$
$$+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_{2,i}}{\partial z}\right)+\delta_i Q_{2,i}+F_{2,i}+\Phi_{2,i}+\frac{1}{\Delta t}\bar{\theta}_{2,i}. \quad (11)$$

Here

$$M_1=\begin{pmatrix}-2 & 1 & 0 & \dots & \dots & 0\\ 1 & -2 & 1 & \dots & \dots & 0\\ 0 & 1 & -2 & 1 & \dots & \dots\\ \dots & \dots & \dots & \dots & \dots & \dots\\ \dots & \dots & \dots & \dots & 1 & -2\end{pmatrix}$$

Since the matrix M_1 is a matrix of simple structure, it can be represented as $M_1=B_1\lambda_{1,i}B_1^t$, $\lambda_{1,i}=B_1^tM_1B_1$, $B_1^{-1}=B_1^t$, λ a diagonal matrix whose elements are the eigenvalues of the matrix M_1, i.e.

$$\lambda_{1,i}=\begin{pmatrix}\lambda_1 & 0 & 0 & 0 & \\ 0 & \lambda_2 & 0 & 0 & \\ 0 & 0 & \lambda_3 & 0 & \\ 0 & 0 & \dots & \dots & \\ & & & & \\ 0 & 0 & 0 & \dots & \lambda_{N_1}\end{pmatrix},$$

$\lambda_{1,i}$ and matrix elements are B_1 calculated by the formulas:

$$\lambda_{1,i}=-2\left(1-\cos\frac{i\pi}{N_1+1}\right);\quad b_{1,i,j}=(-1)^{i+j}\sqrt{\frac{2}{N_1+1}}\sin\frac{ij\pi}{N_1+1};$$
$$\left(i,j=\overline{1}N_1\right).$$

The resulting equations (10) and (11), multiplying by the matrix on the left B_1^t and introducing the notation $B_1^t\theta_1=\theta_1^{(1)}$, $B_1^t\theta_2=\theta_2^{(1)}$ we get:

$$\frac{1}{\Delta t}\theta_{1,i}^{(1)}+\left(w-w_g\right)\frac{\partial\theta_{1,i}^{(1)}}{\partial z}=\alpha_i^2\theta_{1,i}^{(1)}+\mu_1\frac{\partial^2\theta_{1,i}^{(1)}}{\partial y^2}+$$
$$+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_{1,i}^{(1)}}{\partial z}\right)+\delta_i Q_{1,i}^{(1)}+F_{1,i}^{(1)}+\Phi_{1,i}^{(1)}+\frac{1}{\Delta t}\bar{\theta}_{1,i}^{(1)}; \quad (12)$$

$$\frac{1}{\Delta t}\theta_{2,i}^{(1)}+\left(w-w_g\right)\frac{\partial\theta_{2,i}^{(1)}}{\partial z}=\alpha_{1,i}^2\theta_{2,i}^{(1)}+\mu_1\frac{\partial^2\theta_{2,i}^{(1)}}{\partial y^2}+$$
$$+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_{2,i}^{(1)}}{\partial z}\right)+\delta_i Q_{2,i}^{(1)}+F_{2,i}^{(1)}+\Phi_{2,i}^{(1)}+\frac{1}{\Delta t}\bar{\theta}_{2,i}^{(1)}. \quad (13)$$

Here $\alpha_{1,i}^2=\frac{\gamma_{1,i}\mu_1}{h_x^{\,2}}$.

Similarly, in equations (12) and (13) y, replacing the differential operators with respect to by finite-difference operators, we obtain:

$$\frac{1}{\Delta t}\theta_{1,i,j}^{(1)}+\left(w-w_g\right)\frac{\partial\theta_{1,i,j}^{(1)}}{\partial z}=\alpha_{1,i}^2\theta_{1,i,j}^{(1)}+\mu_1\frac{M_1}{hy^2}\theta_{1,i,j}^{(1)}+$$
$$+\frac{\partial}{\partial z}\left(k\frac{\partial\theta_{1,i,j}^{(1)}}{\partial z}\right)+\delta_{ij}Q_{1,i,j}^{(1)}+F_{1,i,j}^{(1)}+\Phi_{1,i,j}^{(1)}+\frac{1}{\Delta t}\bar{\theta}_{1,i,j}^{(1)}; \quad (14)$$

$$\frac{1}{\Delta t}\theta^{(1)}_{2,i,j}+\left(w-w_g\right)\frac{\partial\theta^{(1)}_{2,i,j}}{\partial z}=\alpha_i^2\theta^{(1)}_{2,i,j}+\mu_1\frac{M_2}{hy^2}\theta^{(1)}_{2,i,j}+$$
$$+\frac{\partial}{\partial z}\left(k\frac{\partial\theta^{(1)}_{2,i,j}}{\partial z}\right)+\delta_{ij}Q^{(1)}_{2,i,j}+F^{(1)}_{2,i,j}+\Phi^{(1)}_{2,i,j}+\frac{1}{\Delta t}\bar{\theta}^{(1)}_{2,i,j}. \quad (15)$$

matrix M_2 in the form $M_2=B_2\lambda_2B_2^t$ and $B_2^t=B_2^{-1}$. Equations (14) and (15) also multiplying by the matrix on the left B_2^t and introducing the notation, $B_2^t\theta^{(1)}_{1,i,j}=\theta^{(2)}_{1,i,j}$; $B_2^t\theta^{(1)}_{2,i,j}=\theta^{(2)}_{2,i,j}$ we get:

$$\frac{1}{\Delta t}\theta^{(2)}_{1,i,j}+\left(w-w_g\right)\frac{\partial\theta^{(2)}_{1,i,j}}{\partial z}=\left(\alpha^2_{1,i}+\beta^2_{1,j}\right)\theta^{(2)}_{1,i,j}+$$
$$+\frac{\partial}{\partial z}\left(k\frac{\partial\theta^{(2)}_{1,i,j}}{\partial z}\right)+\delta_{ij}Q^{(2)}_{1,i,j}+F^{(2)}_{1,i,j}+\Phi^{(2)}_{1,i,j}+\frac{1}{\Delta t}\bar{\theta}^{(2)}_{1,i,j}; \quad (16)$$

$$\frac{1}{\Delta t}\theta^{(2)}_{2,i,j}+\left(w-w_g\right)\frac{\partial\theta^{(2)}_{2,i,j}}{\partial z}=\left(\alpha^2_{2,i}+\beta^2_{2,j}\right)\theta^{(2)}_{2,i,j}+$$
$$+\frac{\partial}{\partial z}\left(k\frac{\partial\theta^{(2)}_{2,i,j}}{\partial z}\right)+\delta_{ij}Q^{(2)}_{2,i,j}+F^{(2)}_{2,i,j}+\Phi^{(2)}_{2,i,j}+\frac{1}{\Delta t}\bar{\theta}^{(2)}_{2,i,j}. \quad (17)$$

Here

$$\beta_j^2=\frac{\alpha_{2,k}\mu_1}{h_y^{\,2}};\ \alpha_{2,k}=-2\left(1-\cos\frac{i\pi}{N_1+1}\right);$$
$$b_{2,i,j}=(-1)^{i+j}\sqrt{\frac{2}{N_2+1}}\sin\frac{ij\pi}{N_2+1},$$
$$\left(i,j=1,2,....,N_2\right).$$

After some transformation for the boundary conditions (5) and (7) we get:

$$k\frac{\partial\theta^{(2)}_{1,i,j}}{\partial z}=\eta_1\theta^{(2)}_{1,i,j}-\Phi^{(2)}_{1,i,j};$$
$$k\frac{\partial\theta^{(2)}_{2,i,j}}{\partial z}=\eta_2\theta^{(2)}_{2,i,j}-\Phi^{(2)}_{2,i,j}.$$

Here $\Phi^{(2)}_{1,i,j}$ and $\Phi^{(2)}_{2,i,j}$ are calculated using the formulas:

$$\Phi^{(2)}_{1,i,j}=\begin{cases}U\dfrac{\theta^{(2)}_{1,i,j}-\theta^{(2)}_{1,i-1,j}}{h_x}\ npu & U\ge 0\\ U\dfrac{\theta^{(2)}_{1,i+1,j}-\theta^{(2)}_{1,i,j}}{h_x}\ npu & U<0\end{cases}+$$
$$+\begin{cases}V\dfrac{\theta^{(2)}_{1,i,j}-\theta^{(2)}_{1,i,j-1}}{h_y}\ npu & V\ge 0\\ V\dfrac{\theta^{(2)}_{1,i,j+1}-\theta^{(2)}_{1,i,j}}{h_y}\ npu & V<0\end{cases};$$

$$\Phi^{(2)}_{2,i,j}=\begin{cases}U\dfrac{\theta^{(2)}_{2,i,j}-\theta^{(2)}_{2,i-1,j}}{h_x}\ npu & U\ge 0\\ U\dfrac{\theta^{(2)}_{2,i+1,j}-\theta^{(2)}_{2,i,j}}{h_x}\ npu & U<0\end{cases}+$$
$$+\begin{cases}V\dfrac{\theta^{(2)}_{2,i,j}-\theta^{(2)}_{2,i,j-1}}{h_y}\ npu & V\ge 0\\ V\dfrac{\theta^{(2)}_{2,i,j+1}-\theta^{(2)}_{2,i,j}}{h_y}\ npu & V<0\end{cases}.$$

Combining the obtained equations (16), (17) and the corresponding boundary conditions, we finally obtained ordinary differential equations that describe the process of transport and diffusion of harmful substances in the atmosphere in the vertical direction, with respect to the variable z.

For the final numerical integration of the problems, we introduce a grid with respect to the variable z

$$\omega_z=\left(z_k=z_{k-1}-h_z;\ k=2,3,4,5,6\right),$$

replacing the differential operators of the differential equation with difference operators

$$\left(\frac{\partial\theta^{(2)}_{1,i,j}}{\partial z}\right)_\xi=\begin{cases}\dfrac{\theta^{(2)}_{1,i,j,\xi-1}-\theta^{(2)}_{1,i,j,\xi}}{hz},\ npu\ \left(W-W_g\right)\ge 0\\ \dfrac{\theta^{(2)}_{1,i,j,\xi+1}-\theta^{(2)}_{1,i,j,\xi}}{hz},\ npu\ \left(W-W_g\right)<0\end{cases}; \quad (18)$$

$$\left(\frac{\partial\theta^{(2)}_{2,i,j}}{\partial z}\right)_{\xi}=\begin{cases}\dfrac{\theta^{(2)}_{2,i,j,\xi-1}-\theta^{(2)}_{2,i,j,\xi}}{hz}\ ,\ npu\ \ \left(W-W_g\right)\geq 0\\ \dfrac{\theta^{(2)}_{2,i,j,\xi+1}-\theta^{(2)}_{2,i,j,\xi}}{hz}\ ,\ npu\ \ \left(W-W_g\right)<0\end{cases};\tag{19}$$

$$\frac{\partial}{\partial z}\left(K\frac{\partial\theta^{(2)}_{1,i,j}}{\partial z}\right)_{\xi}=\left[K_{\xi+0.5}\theta^{(2)}_{1,i,j,\xi+1}-\left(K_{\xi+0.5}+K_{\xi-0.5}\right)\theta^{(2)}_{1,i,j,\xi}+K_{\xi-0.5}\theta^{(2)}_{1,i,j,\xi-1}\right]\Big|h_z^2;\tag{20}$$

$$\frac{\partial}{\partial z}\left(K\frac{\partial\theta^{(2)}_{2,i,j}}{\partial z}\right)_{\xi}=\left[K_{\xi+0.5}\theta^{(2)}_{2,i,j,\xi+1}-\left(K_{\xi+0.5}+K_{\xi-0.5}\right)\theta^{(2)}_{2,i,j,\xi}+K_{\xi-0.5}\theta^{(2)}_{2,i,j,\xi-1}\right]\Big|h_z^2,\tag{21}$$

releasing the indices i, j and grouping the same terms of the equation, we obtain

$$\begin{aligned}&\frac{1}{h_z^2}k_{\xi+0.5}-\theta^{(2)}_{1,\xi+1}-\frac{1}{h_z^2}\left(k_{\xi+0.5}+k_{\xi-0.5}\right)\theta^{(2)}_{1,\xi}+\frac{1}{h_z^2}k_{\xi-0.5}-\theta^{(2)}_{1,\xi-1}+\\&+\begin{cases}\left(\dfrac{\left(w-w_g\right)}{h_z}\theta^{(2)}_{1,\xi-1}-\dfrac{\left(w-w_g\right)}{h_z}\theta^{(2)}_{1,\xi}\right)\ npu\ \ \left(w-w_g\right)\geq 0\\ \left(\dfrac{\left(w-w_g\right)}{h_z}\theta^{(2)}_{1,\xi+1}-\dfrac{\left(w-w_g\right)}{h_z}\theta^{(2)}_{1,\xi}\right)\ npu\ \ \left(w-w_g\right)<0\end{cases}=\\&=q_1\theta^{(2)}_{1,\xi+1}-q_2\theta^{(2)}_{1,\xi}+q_3\theta^{(2)}_{1,\xi-1}+\begin{cases}\left(q_4\left(\theta^{(2)}_{1,\xi-1}-\theta^{(2)}_{1,\xi}\right)\right)\ npu\ \ \left(w-w_g\right)\geq 0\\ \left(q_4\left(\theta^{(2)}_{1,\xi+1}-\theta^{(2)}_{1,\xi}\right)\right)\ npu\ \ \left(w-w_g\right)<0\end{cases};\end{aligned}\tag{22}$$

$$\begin{aligned}&\frac{1}{h_z^2}k_{\xi+0.5}-\theta^{(2)}_{2,\xi+1}-\frac{1}{h_z^2}\left(k_{\xi+0.5}+k_{\xi-0.5}\right)\theta^{(2)}_{2,\xi}+\frac{1}{h_z^2}k_{\xi-0.5}-\theta^{(2)}_{2,\xi-1}+\\&+\begin{cases}\left(\dfrac{\left(w-w_g\right)}{h_z}\theta^{(2)}_{2,\xi-1}-\dfrac{\left(w-w_g\right)}{h_z}\theta^{(2)}_{2,\xi}\right)\ npu\ \ \left(w-w_g\right)\geq 0\\ \left(\dfrac{\left(w-w_g\right)}{h_z}\theta^{(2)}_{2,\xi+1}-\dfrac{\left(w-w_g\right)}{h_z}\theta^{(2)}_{2,\xi}\right)\ npu\ \ \left(w-w_g\right)<0\end{cases}=\\&=q_1\theta^{(2)}_{2,\xi+1}-q_2\theta^{(2)}_{2,\xi}+q_3\theta^{(2)}_{2,\xi-1}+\begin{cases}\left(q_4\left(\theta^{(2)}_{2,\xi-1}-\theta^{(2)}_{2,\xi}\right)\right)\ npu\ \ \left(w-w_g\right)\geq 0\\ \left(q_4\left(\theta^{(2)}_{2,\xi+1}-\theta^{(2)}_{2,\xi}\right)\right)\ npu\ \ \left(w-w_g\right)<0\end{cases}.\end{aligned}\tag{23}$$

Now using relations (22) and (23) instead of (16) and (17) we obtain

$$\begin{aligned}&\frac{1}{\Delta t}\theta^{(2)}_{1,\xi}+q_1\theta^{(2)}_{1,\xi+1}-q_2\theta^{(2)}_{1,\xi}+q_3\theta^{(2)}_{1,\xi-1}+\begin{cases}\left(q_4\left(\theta^{(2)}_{1,\xi-1}-\theta^{(2)}_{1,\xi}\right)\right)\ npu\ \ \left(w-w_g\right)\geq 0\\ \left(q_4\left(\theta^{(2)}_{1,\xi+1}-\theta^{(2)}_{1,\xi}\right)\right)\ npu\ \ \left(w-w_g\right)<0\end{cases}=\\&=\left(\alpha^2_{1,i}+\beta^2_{1,\mathrm{j}}\right)\theta^{(2)}_{1,\xi}+\delta_{\xi}Q^{(2)}_{1,\xi}+F^{(2)}_{1,\xi}+\Phi^{(2)}_{1,\xi}+\frac{1}{\Delta t}\bar{\theta}^{(2)}_{1,\xi};\end{aligned}\tag{24}$$

$$\begin{aligned}&\frac{1}{\Delta t}\theta^{(2)}_{2,\xi}+q_1\theta^{(2)}_{2,\xi+1}-q_2\theta^{(2)}_{2,\xi}+q_3\theta^{(2)}_{2,\xi-1}+\begin{cases}\left(q_4\left(\theta^{(2)}_{2,\xi-1}-\theta^{(2)}_{2,\xi}\right)\right)\ npu\ \ \left(w-w_g\right)\geq 0\\ \left(q_4\left(\theta^{(2)}_{2,\xi+1}-\theta^{(2)}_{2,\xi}\right)\right)\ npu\ \ \left(w-w_g\right)<0\end{cases}=\\&=\left(\alpha^2_{2,i}+\beta^2_{2,\mathrm{j}}\right)\theta^{(2)}_{2,\xi}+\delta_{\xi}Q^{(2)}_{2,\xi}+F^{(2)}_{2,\xi}+\Phi^{(2)}_{2,\xi}+\frac{1}{\Delta t}\bar{\theta}^{(2)}_{2,\xi}.\end{aligned}\tag{25}$$

To determine the boundary conditions at $z=0$ on the underlying surface of the earth, we integrate equations (16) and (17) from 0 to $h_{z/2}$ and obtain

$$\int_0^{h_z/2}\left[\frac{\partial}{\partial z}\left(k\frac{\partial\theta_{1,i,j}^{(2)}}{\partial z}\right)-\left(w-w_g\right)\frac{\partial\theta_{1,i,j}^{(2)}}{\partial z}+\left(\frac{1}{\Delta t}-\left(\alpha_{1,i}^2+\beta_{1,j}^2\right)\right)\theta_{1,i,j}^{(2)}\right]dz=\int_0^{h_z/2}\bar{G}_{1,i,j}^{(2)}dz, \tag{26}$$

$$\int_0^{h_z/2}\left[\frac{\partial}{\partial z}\left(k\frac{\partial\theta_{2,i,j}^{(2)}}{\partial z}\right)-\left(w-w_g\right)\frac{\partial\theta_{2,i,j}^{(2)}}{\partial z}+\left(\frac{1}{\Delta t}-\left(\alpha_{2,i}^2+\beta_{2,j}^2\right)\right)\theta_{2,i,j}^{(2)}\right]dz=\int_0^{h_z/2}\bar{G}_{2,i,j}^{(2)}dz, \tag{27}$$

where

$$\bar{G}_{1,i,j}^{(2)}=\delta_{i,j}Q_{1,i,j}^{(2)}+F_{1,i,j}^{(2)}+\Phi_{1,i,j}^{(2)}+\frac{1}{\Delta t}\bar{Q}_{1,i,j}^{(2)};$$

$$\bar{G}_{2,i,j}^{(2)}=\delta_{i,j}Q_{2,i,j}^{(2)}+F_{2,i,j}^{(2)}+\Phi_{2,i,j}^{(2)}+\frac{1}{\Delta t}\bar{Q}_{2,i,j}^{(2)}.$$

Taking into account the boundary conditions, equations (26) and (27) can be written as:

$$\int_0^{h_z/2}\frac{\partial}{\partial z}\left(k\left(z\right)\frac{\partial\theta_{1,i,j}^{(2)}}{\partial z}\right)dz=k\left(z_{1/2}\right)\frac{\partial\theta_{1,i,j}^{(2)}}{\partial z}\bigg|_{1/2}-k\left(z_{1/2}\right)\frac{\partial\theta_{1,i,j}^{(2)}}{\partial z}\bigg|_0=$$

$$=k\left(z_{1/2}\right)\frac{\theta_{1,i,j,2}^{(2)}-\theta_{1,i,j,1}^{(2)}}{h_z}-\eta_1\theta_{1,i,j,1}^{(2)},$$

$$\int_0^{h_z/2}\left(w-w_g\right)\frac{\partial\theta_{1,i,j}^{(2)}}{\partial z}dz=\left(w-w_g\right)_{1/4}\left(\theta_{1,i,j,1/2}^{(2)}-\theta_{1,i,j,0}^{(2)}\right)=$$

$$=\left(w-w_g\right)_{1/4}\frac{\theta_{1,i,j,1}^{(2)}-\theta_{1,i,j,0}^{(2)}}{2}-\theta_{1,i,j,0}^{(2)}=\left(w-w_g\right)_{1/4}\frac{1}{2}\left(\theta_{1,i,j,0}^{(2)}-\theta_{1,i,j,1}^{(2)}\right),$$

$$\int_0^{h_z/2}\bar{G}_{1,i,j}^{(2)}dz=\bar{G}_0^{(2)}\frac{h_z}{2},$$

$$k\left(z_{1/2}\right)\frac{\theta_{1,2}^{(2)}-\theta_{1,1}^{(2)}}{h_z}-\eta_1\theta_{1,1}^{(2)}-\left(w-w_g\right)_{1/4}\frac{1}{2}\left(\theta_{1,0}^{(2)}-\theta_{1,1}^{(2)}\right)-$$

$$-\left(\frac{1}{\Delta t}-\left(\alpha_{1,i}^2+\beta_{1,j}^2\right)\right)\theta_{1,1}^{(2)}=\bar{G}_{i,j,0}^2$$

or

$$2k\left(z_{1/2}\right)\left(\theta_{1,2}^{(2)}-\theta_{1,1}^{(2)}\right)-2h_z\eta_1\theta_{1,1}^{(2)}-\left(w-w_g\right)_{1/4}h_z\left(\theta_{1,0}^{(2)}-\theta_{1,1}^{(2)}\right)-$$

$$-2h_z\left(\frac{1}{\Delta t}-\left(\alpha_{1,i}^2+\beta_{1,j}^2\right)\right)\theta_{1,1}^{(2)}=2h_z\bar{G}_{i,j,0}^2.$$

Then we finally get

$$2k\left(z_{1/2}\right)\theta_{1,i,j,2}^{(2)}-\left[2K\left(z_{1/2}\right)+2h_z\eta_1+\left(w-w_g\right)h_z+\right.$$

$$\left.+2h_z\left(\frac{1}{\Delta t}-\left(\alpha_{1,i}^2+\beta_{1,j}^2\right)\right)\right]\theta_{1,i,j,1}^{(2)}-\left(w-w_g\right)h_z\theta_{1,i,j,0}^{(2)}=2h_z\bar{G}_{1,i,j,0}^{(2)},$$

and for $\theta_{2,i,j,\zeta}^{(2)}$

$$2k\left(z_{1/2}\right)\theta_{2,i,j,2}^{(2)}-\left[2k\left(z_{1/2}\right)+2h_z\eta_2+\left(w-w_g\right)h_z+\right.$$

$$\left.+2h_z\left(\frac{1}{\Delta t}-\left(\alpha_{2,i}^2+\beta_{2,j}^2\right)\right)\right]\theta_{2,i,j,1}^{(2)}-\left(w-w_g\right)h_z\theta_{1,i,j,0}^{(2)}=2h_z\bar{G}_{2,i,j,0}^{(2)}.$$

Also integrating equations (16) and (17) from $\left(N+1/2\right)h_z$ to $\left(N+1\right)h_z$ we obtain

$$\int_{G_H-\frac{1}{2}h_z}^{G_H}\frac{\partial}{\partial z}\left(k(z)\frac{\partial\theta_1^{(2)}}{\partial z}\right)dz=\left[k\left(z_{G_H}\right)\frac{\partial\theta_{1,i,j,N}^{(2)}}{\partial z}-k\left(z_{G_H-\frac{1}{2}h_zN}\right)\frac{\partial\theta_{1,i,j,H-\frac{1}{2}h_zN}^{(2)}}{\partial z}\right]=$$

$$=k\left(Z_{\frac{1}{2}}\right)\frac{\theta_{1,i,j,N+1}^{(2)}-\theta_{1,i,j,N}^{(2)}}{h_z}=k\left(Z_{G_H-\frac{1}{2}h_z}\right)\Big/h_z\,\theta_{1,i,j,N}^{(2)}+k\left(Z_{G_H-\frac{1}{2}h_z}\right)\Big/h_z\,\theta_{1,i,j,N+1}^{(2)};$$

$$\int_{G_H-\frac{1}{2}h_z}^{G_H}\left(w-w_g\right)\frac{\partial\theta_1^{(2)}}{\partial z}dz=\left(w-w_g\right)_{z_{G_H-\frac{1}{2}h_z}}\left(\theta_{1,i,j,N-1}^{(2)}-\theta_{1,i,j,N+0.5}^{(2)}\right).$$

And thus, when $z=G_H$ we have:

$$\frac{k\left(z_{G_H-\frac{1}{2}h_z}\right)}{h_z}\theta_{1,i,j,N}^{(2)}+\frac{k\left(z_{G_H-\frac{1}{4}h_z}\right)}{h_z}\theta_{1,i,j,N+1}^{(2)}+\left(\frac{1}{\Delta t}-\left(\alpha_{1,i}^2+\beta_{1,j}^2\right)\right)\theta_{1,i,j,N}^{(2)}-$$

$$-\left(w-w_g\right)_{z_{G_H-\frac{1}{4}h_z}}\left(\theta_{1,i,j,N-1}^{(2)}-\theta_{1,i,j,N+0.5}^{(2)}\right)=G_{1,i,j,N}^{(2)}$$

or

$$\gamma_1\theta_{1,i,j,N}^{(2)}+\gamma_2\theta_{1,i,j,N+1}^{(2)}+\gamma_3\theta_{1,i,j,N}^{(2)}-\gamma_4\theta_{1,i,j,N-1}^{(2)}-$$

$$-\gamma_4\frac{\theta_{1,i,j,N}^{(2)}+\theta_{1,i,j,N+1}^{(2)}}{2}=G_{1,i,j,N}^{(2)}$$

finally

$$\left(\gamma_2+\gamma_4/2\right)\theta_{1,i,j,N+1}^{(2)}+\left(\gamma_1+\gamma_3+\gamma_4/2\right)\theta_{1,i,j,N}^{(2)}+-\gamma_4\theta_{1,i,j,N-1}^{(2)}=G_{1,i,j,N}^{(2)}.$$

Here

$$\gamma_1=\frac{k\left(z_{G_H-\frac{1}{2}h_z}\right)}{h_z};\quad\gamma_2=\frac{k\left(z_{G_H-\frac{1}{4}h_z}\right)}{h_z};\quad\gamma_3=\left(\frac{1}{\Delta t}-\left(\alpha_{1,i}^2+\beta_{1,j}^2\right)\right);\quad\gamma_4=\left(w-w_g\right)_{z_{G_H-\frac{1}{4}h_z}}.$$

Similarly for $\theta_{2,i,j}^{(2)}$, we finally have the expression

$$\left(\gamma_2+\gamma_4/2\right)\theta_{2,i,j,N+1}^{(2)}+\left(\gamma_1+\gamma_3+\gamma_4/2\right)\theta_{2,i,j,N}^{(2)}-\gamma_4\theta_{2,i,j,N-1}^{(2)}=G_{2,i,j,N}^{(2)}.$$

So, as a result, to determine $\theta_{1,i,j,\xi}^{(2)}$ and $\theta_{2,i,j,\xi}^{(2)}$ we get a system of algebraic equations

$$\begin{cases}-b_{i,j,1}\theta_{m,i,j,1}^{(2)}+c_{i,j,1}\theta_{m,i,j,2}^{(2)}=-\bar{G}_{m,i,j,1}^{(2)};\\ a_{i,j,2}\theta_{m,i,j,1}^{(2)}-b_{i,j,1}\theta_{m,i,j,2}^{(2)}+c_{i,j,1}\theta_{m,i,j,3}^{(2)}=-\bar{G}_{m,i,j,2}^{(2)};\\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\\ a_{i,j,N_1}\theta_{m,i,j,N_3-1}^{(2)}-b_{i,j,N_1}\theta_{m,i,j,N_3}^{(2)}+c_{i,j,N_1-1}\theta_{m,i,j,N_3+1}^{(2)}=-\bar{G}_{m,i,j,N_3}^{(2)};\\ a_{i,j,N_3+1}\theta_{m,i,j,N_3}^{(2)}-b_{i,j,N_3+1}\theta_{m,i,j,N_3+1}^{(2)}=-\bar{G}_{m,i,j,N_3+1}^{(2)}.\end{cases}$$

where takes the value $m=1,2$.

Solving system (28), we find $\theta_{1,i,j,\xi}^{(2)}$, $\theta_{2,i,j,\xi}^{(2)}$ at $i=0,1,2,...,N_1+1;\quad j=0,1,2,...,N_2;$ $\xi=0,1,2,...,N_3$. Then, using relations (16), (17) and from the desired values $\theta_{1,i,j,\xi}^{(2)}$, we $\theta_{2,i,j,\xi}^{(2)}$ pass to the desired values $\theta_{1,i,j,\xi}^{(1)}$, $\theta_{2,i,j,\xi}^{(1)}$. With the help of (12), (13) from $\theta_{1,i,j,\xi}^{(1)}$, $\theta_{2,i,j,\xi}^{(1)}$ we pass to the numerical solution of problems (8) and (9) at the moment of time $t=t_{n+1}$.

Methods for solving the problem

Since problem (1)-(5) is described by a multidimensional non-linear partial differential equation with appropriate initial and boundary conditions, it is difficult to obtain its solution in an analytical form. To solve the problem, we use an implicit finite-difference scheme in time with the second order of accuracy in time [14-15].

Computational experiment

To monitor and predict the ecological state of the industrial region, a web -oriented software tools using

which computational experiments were carried out on a computer.

To enter the main parameters of the process of transfer and diffusion of aerosol particles and to carry out calculations on a computer, a graphical interface has been developed (Fig.1,2). With the help of the developed interface, the following is entered: types of harmful substances emitted from industrial facilities; number of potential sources of emission of harmful substances; problem number (1 - when the direct problem is solved, 2 - when the adjoint problem is solved); coefficient of absorption of harmful substances in the atmosphere; horizontal component of wind speed; Direction of the wind; atmospheric stratification; initial particle settling rate; calculation time; source power.

As can be seen from the numerical calculations performed on a computer (Fig. 3), with an increase in the horizontal component of the wind speed, aerosol particles ejected from industrial facilities are transported in the direction of the wind. The area of distribution of harmful substances in the surface layer of the atmosphere expands with an increase in the speed of the air mass of the atmosphere (Fig. 3-5). This can be especially observed at H=200- 300 м.

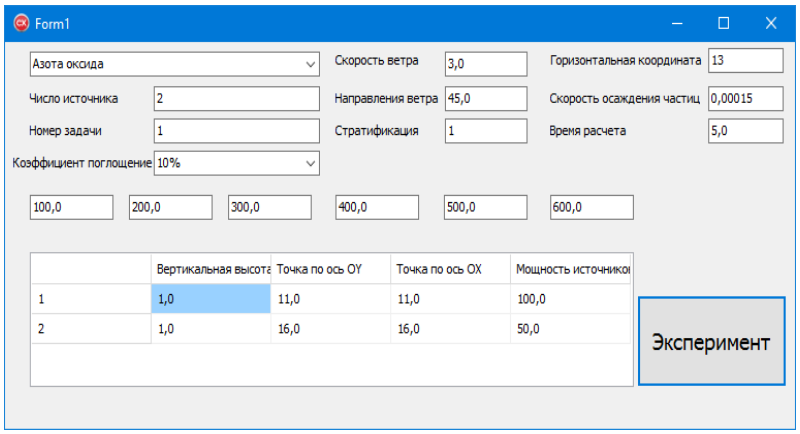


Fig.1. Form for entering the main process parameters

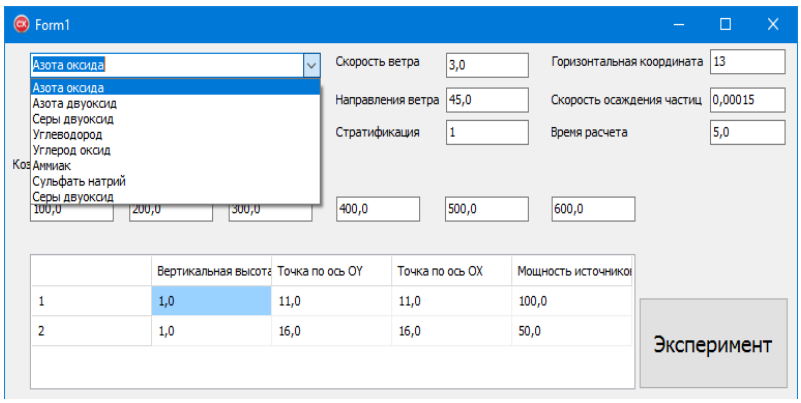


Fig.2. Form for entering the main process parameters

The results of the computational experiments carried out on a computer are shown in Figures 3-11.

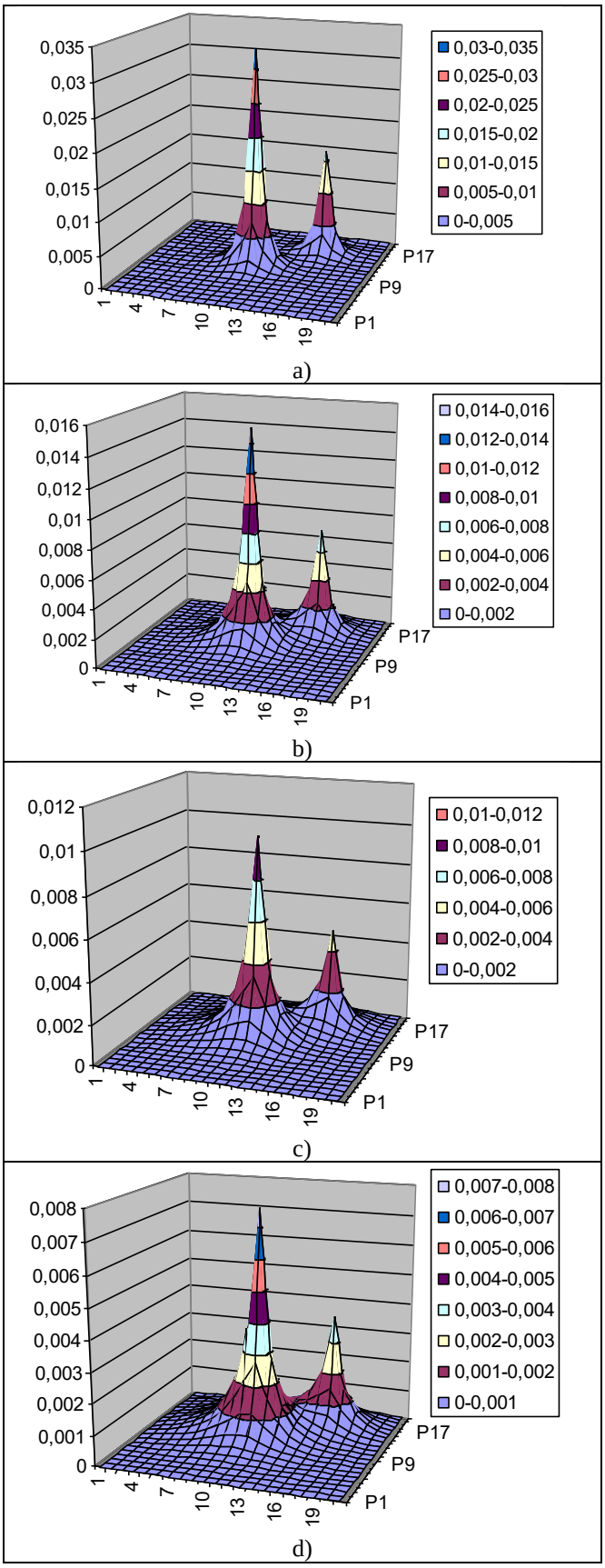


Fig.3. Change in the concentration of harmful substances in the first layer of the atmosphere (H = 100m) at wind speed: *a) u = 1 m/s.; b) u = 3 m/s; c) u = 4 m/s; d) u = 5 m/s.*

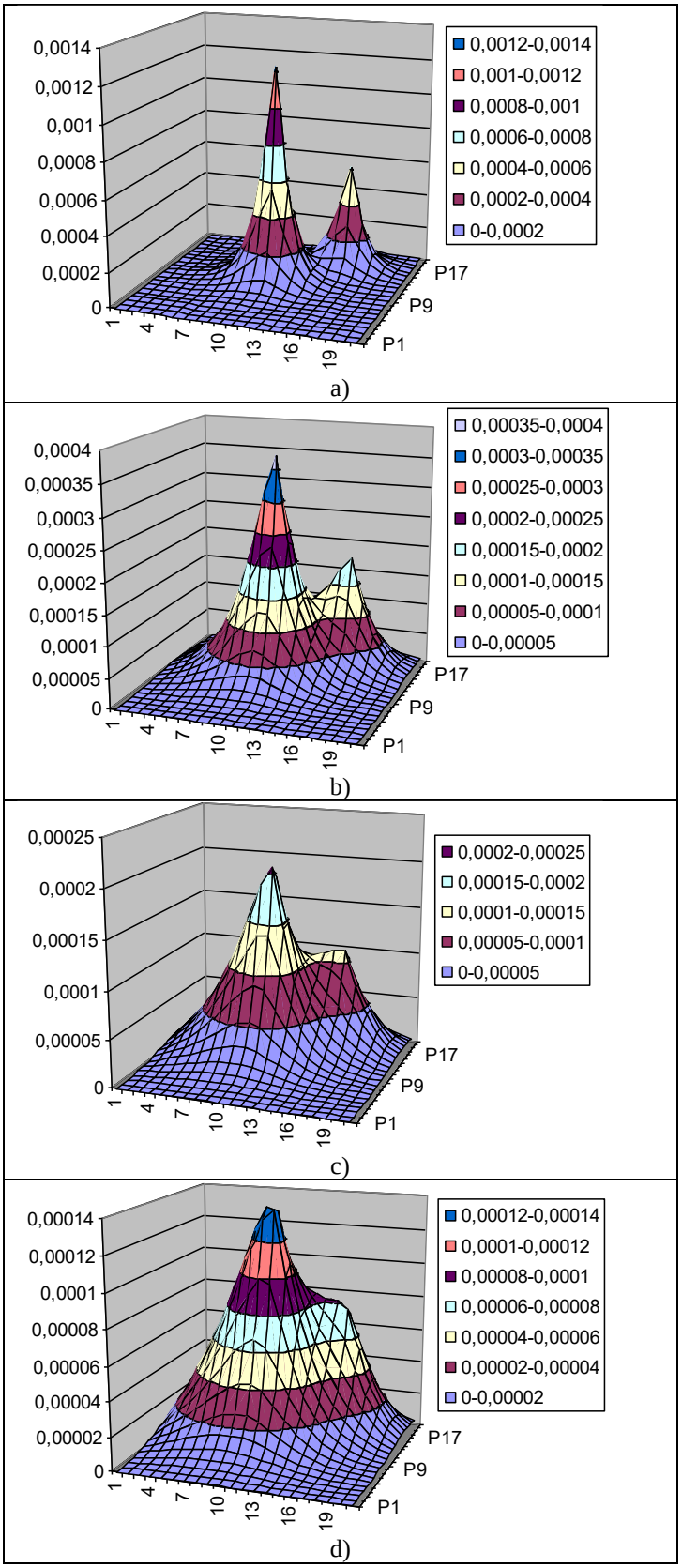


Fig.4. Change in the concentration of harmful substances in the first layer of the atmosphere (H = 200m) at wind speed: *a) u = 1 m/s.; b) u = 3 m/s; c) u = 4 m/s; d) u = 5 m/s.*

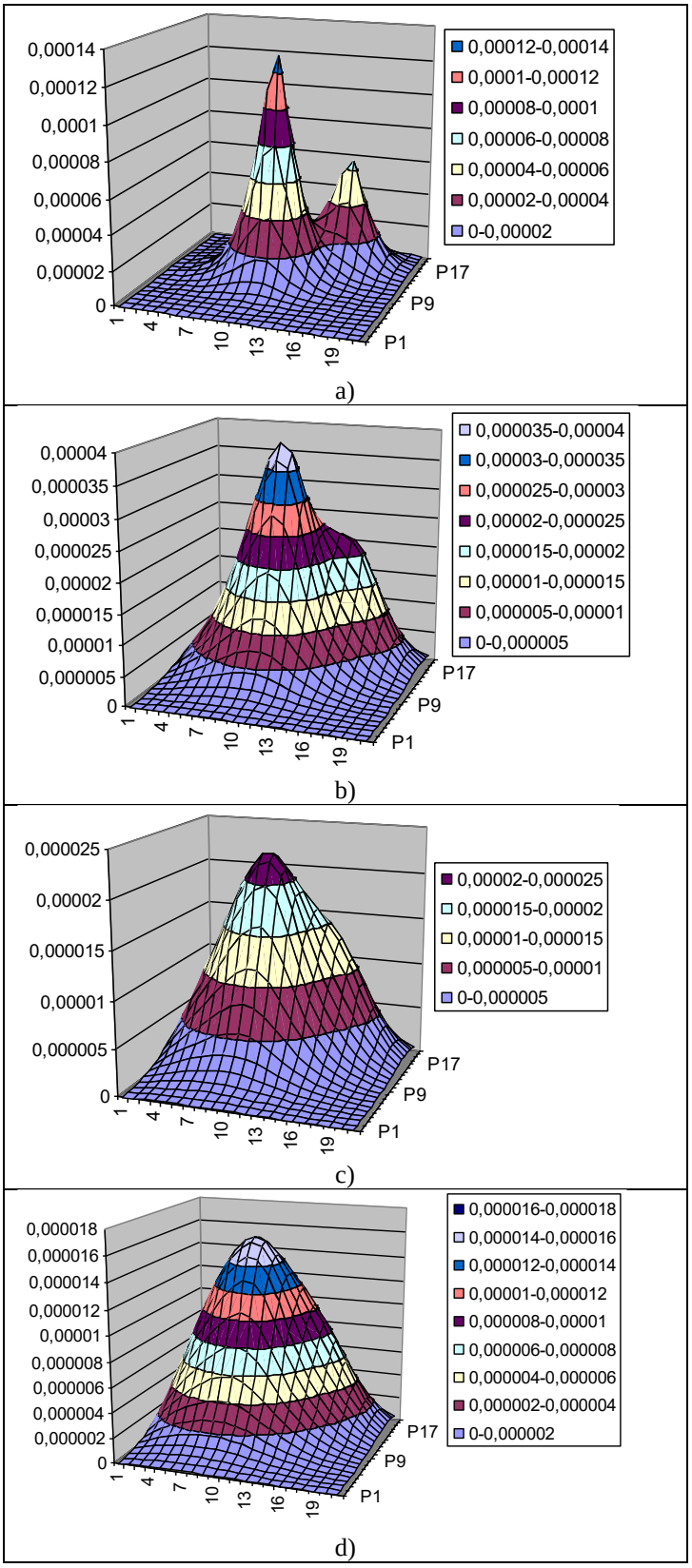
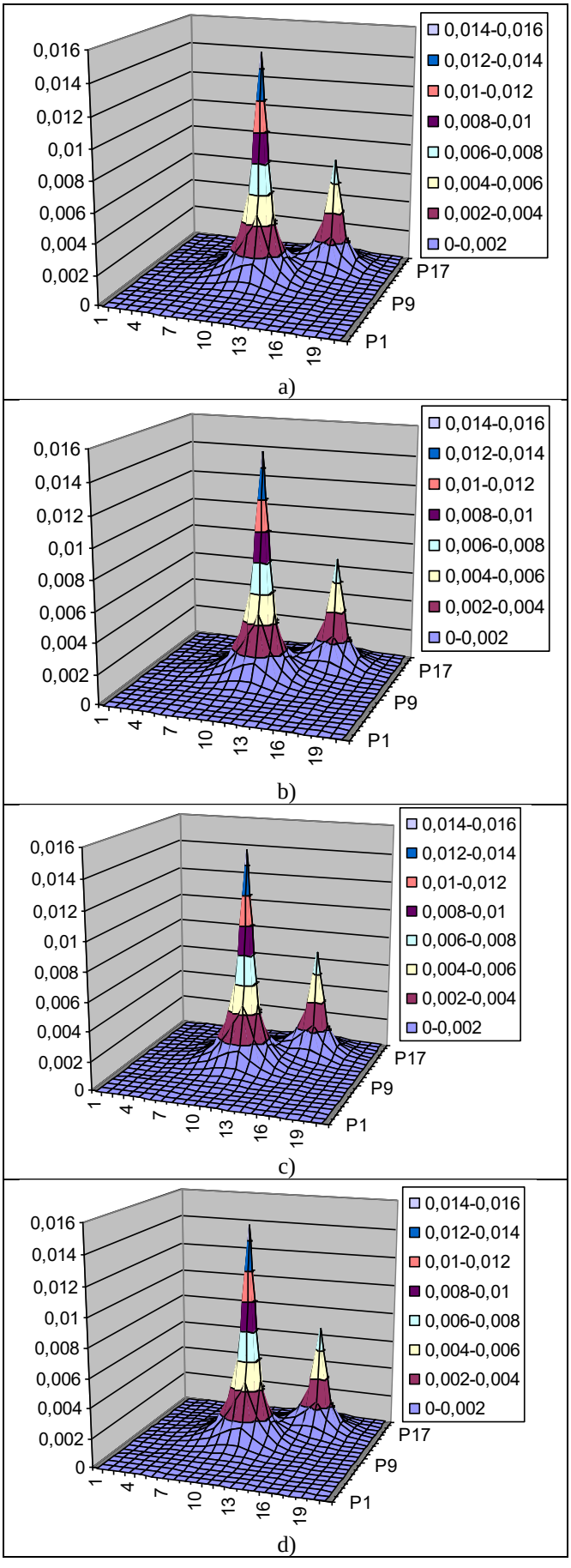


Fig.5. Change in the concentration of harmful substances in the third layer of the atmosphere (H = 300m) at wind speed: *a) u = 1 m/s.; b) u = 3 m/s; c) u = 4 m/s; d) u = 5 m/s.*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1
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7
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13
16
19
P1
P9
P17
0,014-0,016
0,012-0,014
0,01-0,012
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0,006-0,008
0,004-0,006
0,002-0,004
0-0,002
a)
b)
c)
d)

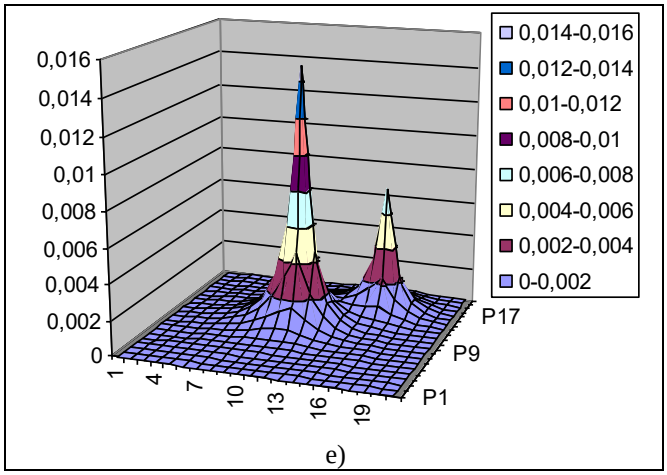
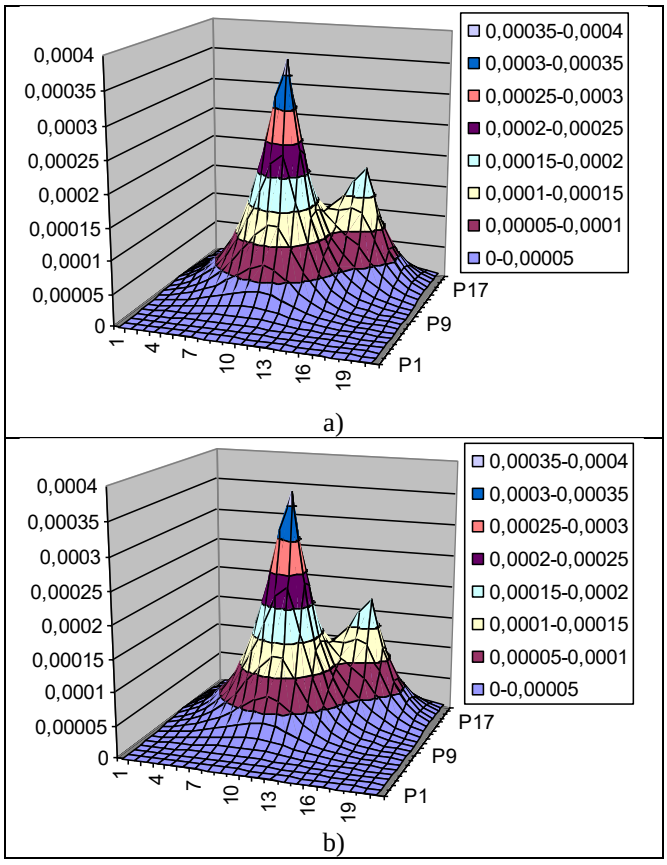


Fig.6. Change in the concentration of harmful substances in the first layer of the atmosphere (H=100m) at the initial particle settling velocity: *a) w g = 0.00015 m/s; b) w g = 0.0003 m/s; c) w g \u003d 0.0006 m / s .; d) w g = 0.0009 m/s; e) w g = 0.009 m/s.*

Another parameter that significantly affects the change in the concentration of harmful substances in the atmosphere, on the earth's surface is the rate of deposition of harmful particles (Fig. 6-8). As it was established by the computational experiments carried out on a computer, the vertical transfer of harmful substances into the atmosphere depends: firstly, on the initial rate of particle settling; secondly, on the vertical speed of the air mass of the atmosphere; in thirds of the physico-mechanical properties of particles (radius of particles; cross-sectional area of particles) and properties of the atmosphere (ρ atmospheric density); fourthly from the acceleration of gravity.



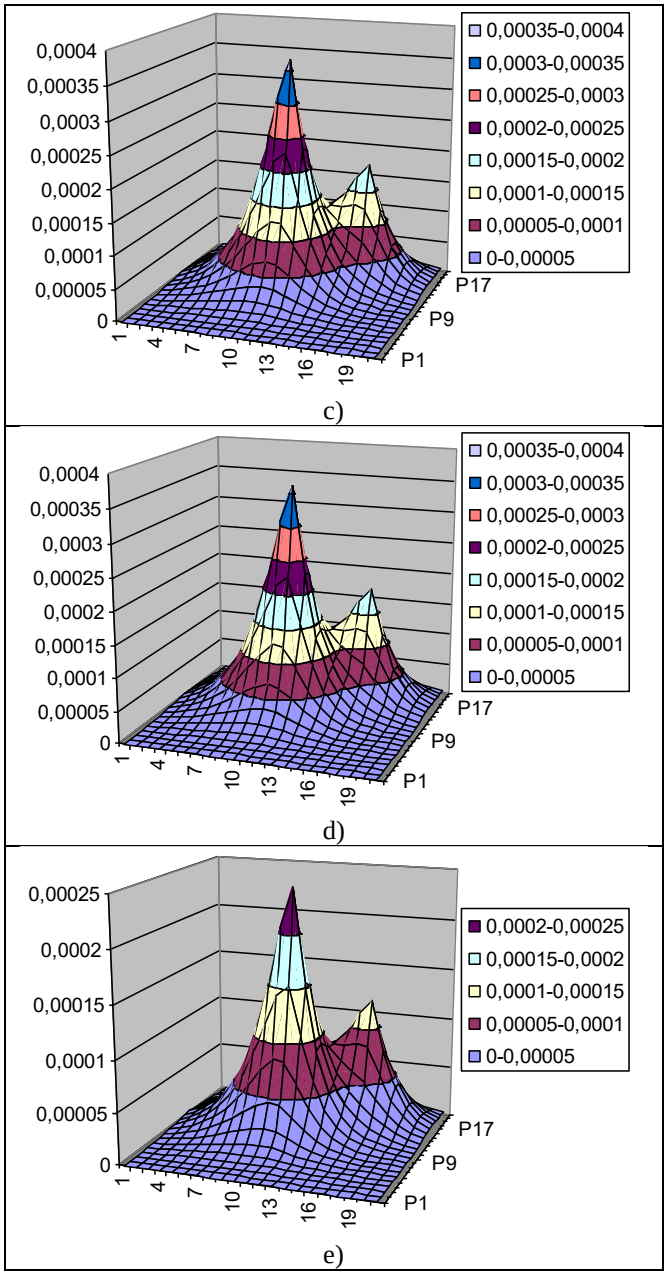
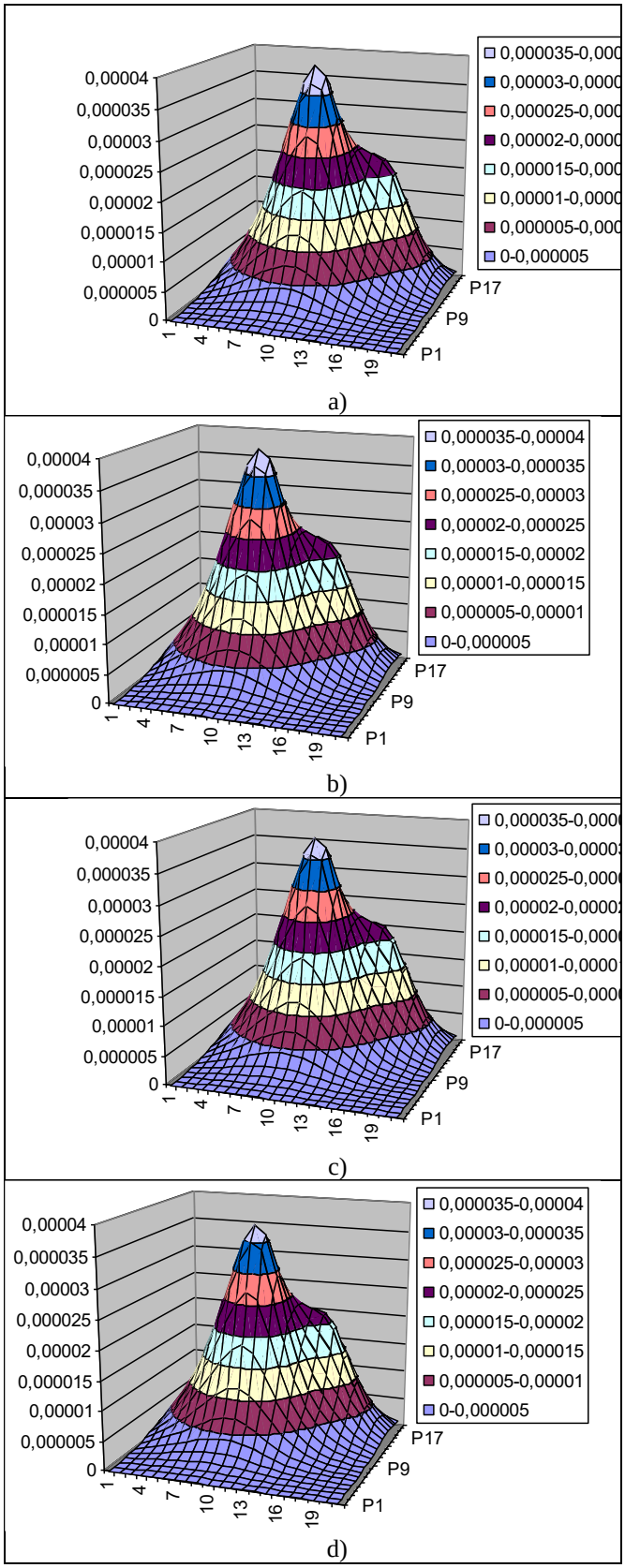


Fig.7. Change in the concentration of harmful substances in the second layer of the atmosphere (H=200m) at the initial particle settling velocity: ***a) w g = 0.00015 m/s; b) w g = 0.0003 m/s; c) w g \u003d 0.0006 m / s .; d) w g = 0.0009 m/s; e) w g = 0.009 m/s.***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0,00003-0,0000
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a)
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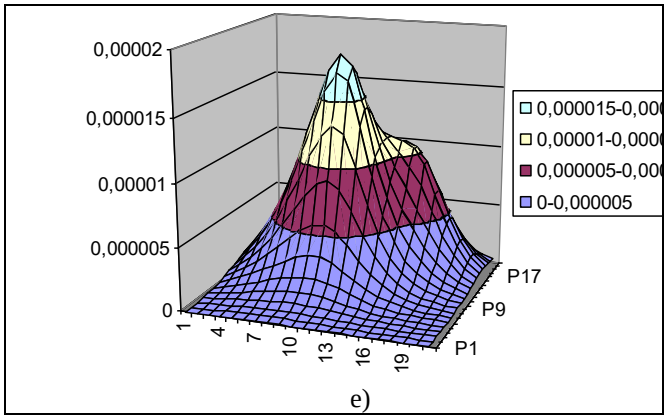
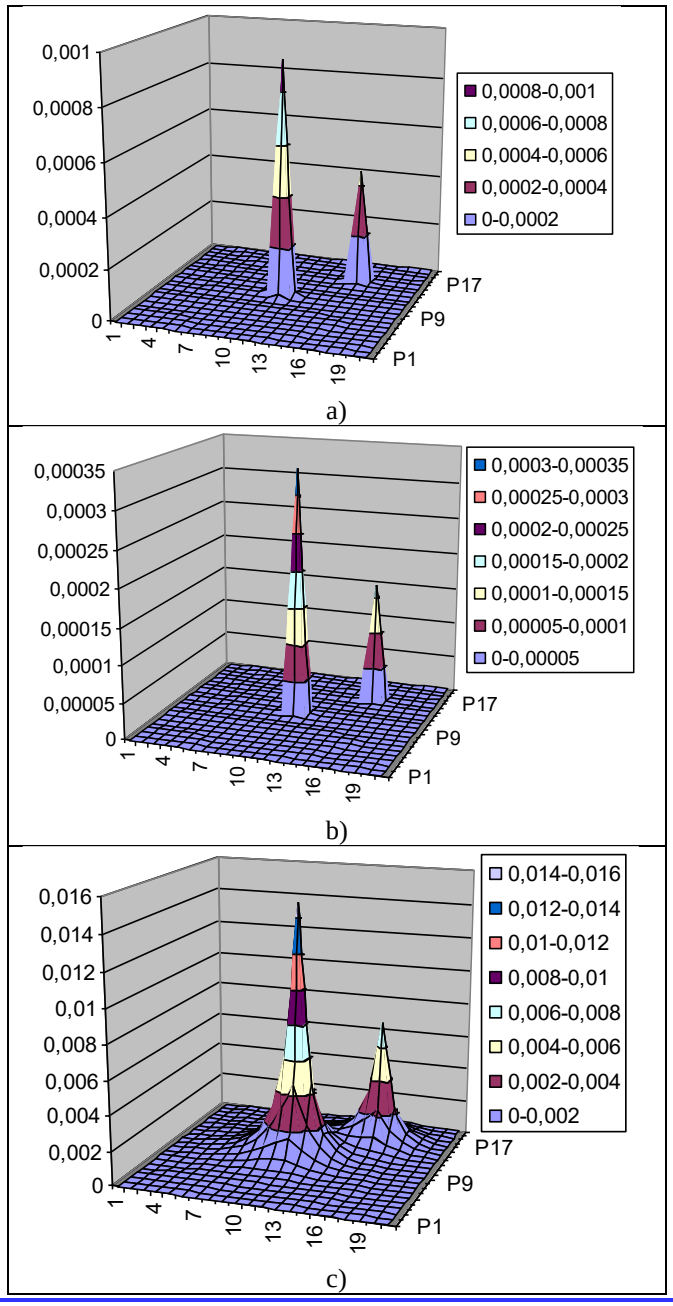
0,000005-0,00001
0-0,000005
b)
c)
d)



e)

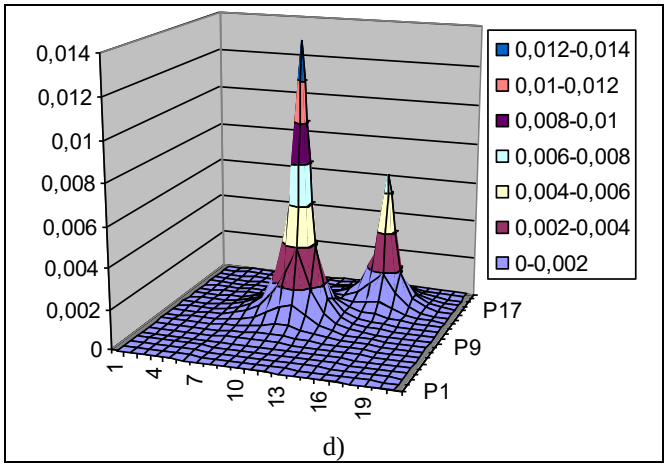
Fig.8. Change in the concentration of harmful substances in the third layer of the atmosphere (H=300m) at the initial particle settling velocity: *a)* $w_g = 0.00015$ *m/s;*
b)* $w_g = 0.0003$ *m/s; c)* w_g *\u003d 0.0006 m / s .; d)* $w_g = 0.0009$ *m/s; e)* $w_g = 0.009$ *m/s.



a)

b)

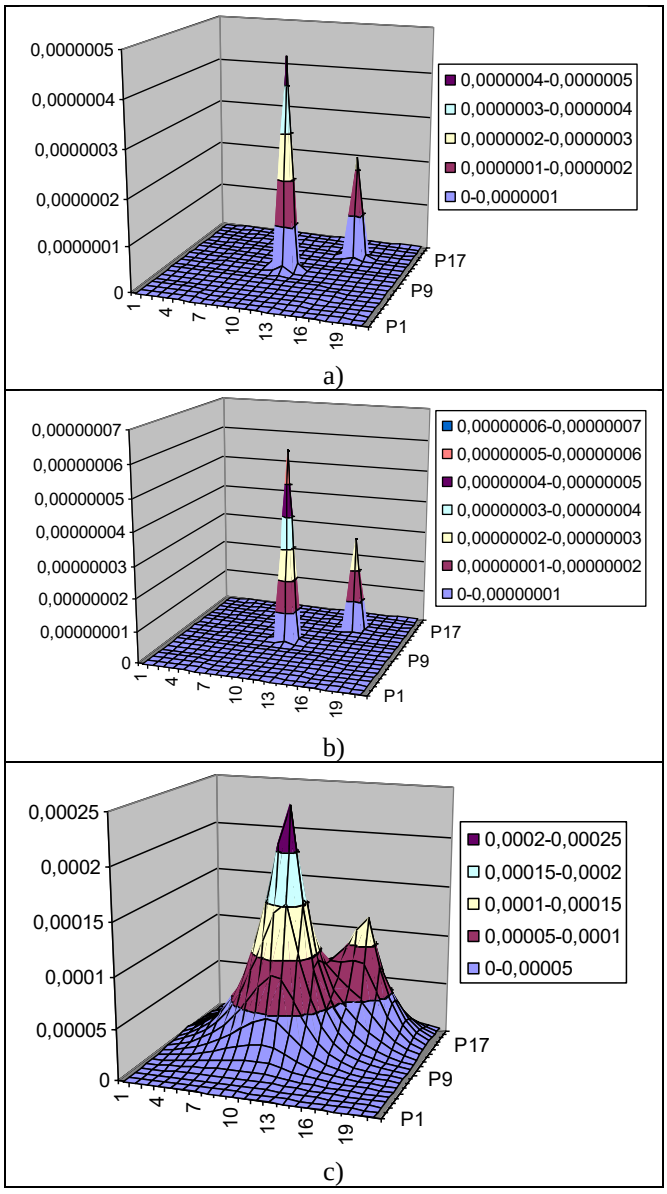
c)



d)

Fig.9. Change in the concentration of harmful substances in the first layer of the atmosphere (H=100m) for different absorption coefficient values

a) σ = 10%; b) σ = 20%; c) σ = 30%; d) σ = 40%.



a)

b)

c)

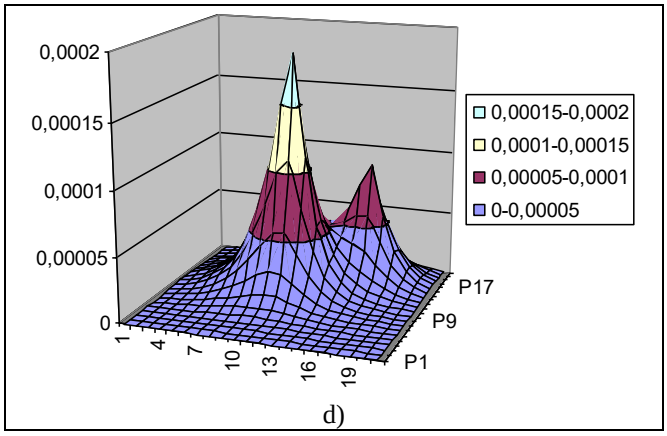
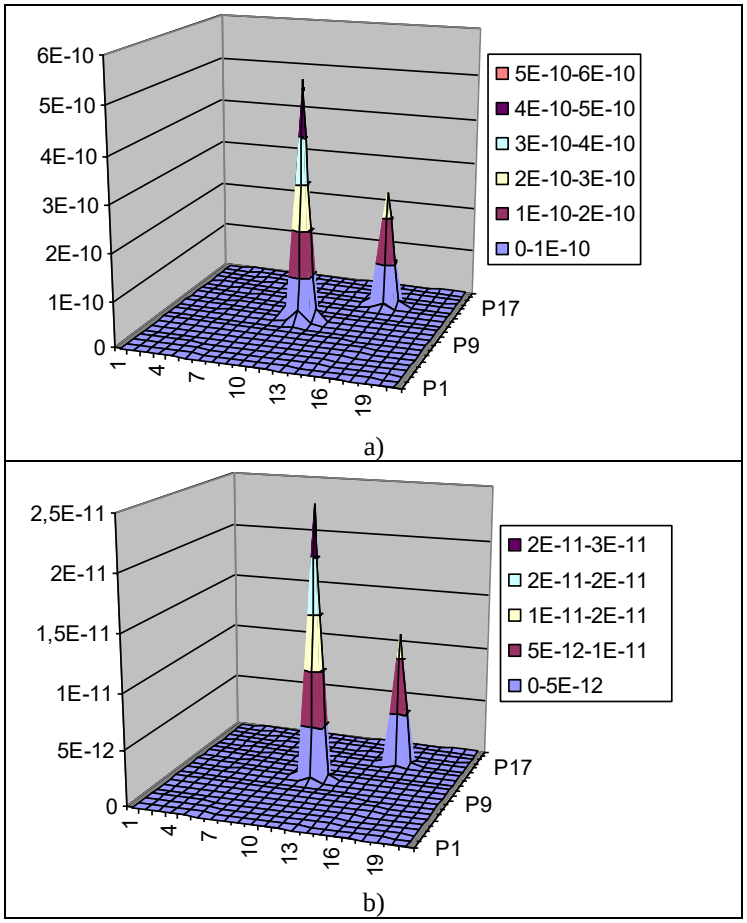


Fig.10. Changes in the concentration of harmful substances in the second layer of the atmosphere (H=200m) for different values of the absorption coefficient *a) σ = 10%; b) σ = 20%; c) σ = 30%; d) σ = 40%.*

Numerical calculations on a computer were carried out at different values of the particle absorption coefficient (Fig. 9-11). Computational experiment established that 10 to 18 percent of aerosol particles are absorbed in the atmosphere. The growth of the absorption of harmful substances in the atmosphere depends on the humid state of the air mass of the atmosphere. The change in the absorption coefficient of direct images depends on the temperature and humidity of the atmosphere [16].



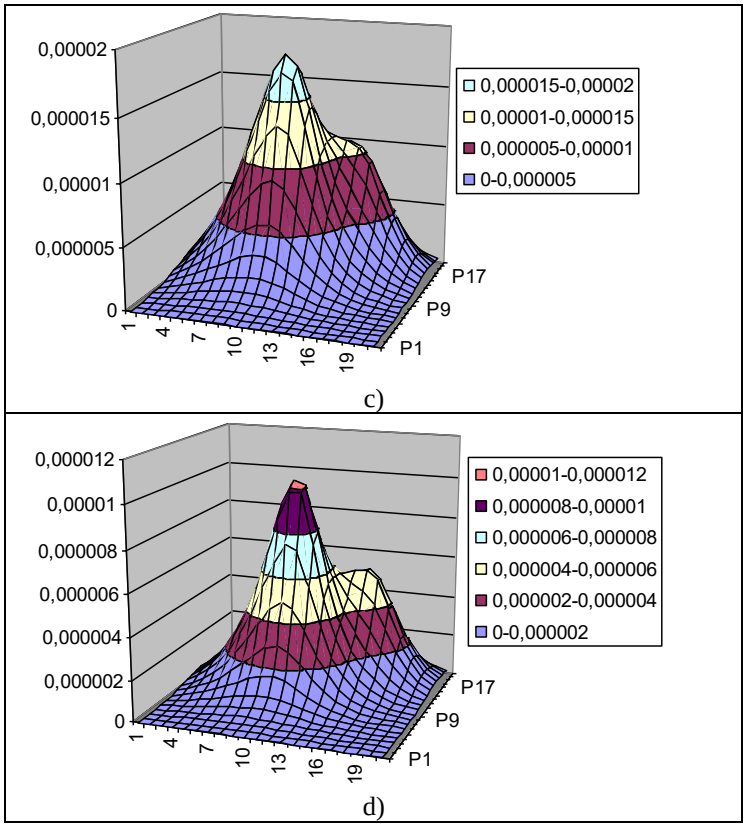
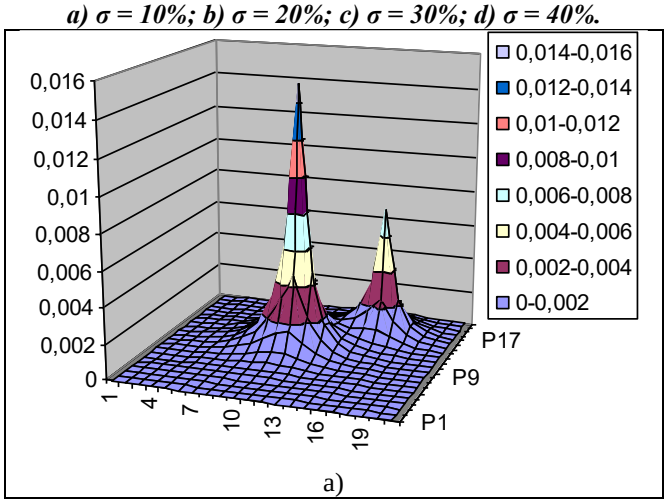


Fig.11. Change in the concentration of harmful substances in the third layer of the atmosphere (H=300m) for different values of the absorption coefficient

a) σ = 10%; b) σ = 20%; c) σ = 30%; d) σ = 40%.



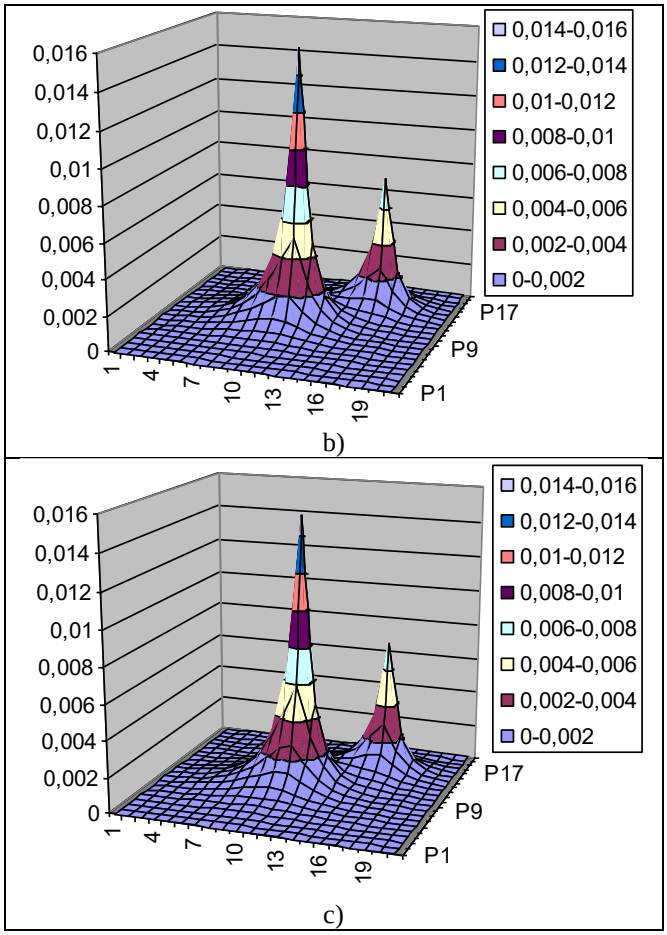
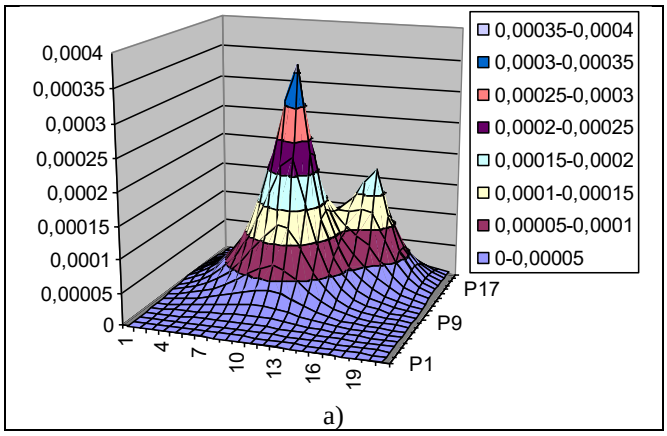


Fig.12. Change in the concentration of harmful substances in the first layer of the atmosphere (H=100m) for different values of the wind speed direction

a) α\u003d 45 ^{0}; b) α= 85 ^{0}; c)) α= 120 ^{0}

Another parameter that significantly affects the horizontal transfer and diffusion of harmful substances in the atmosphere is the direction of the horizontal wind speed (Fig. 12-14). As can be seen from the calculations carried out on a computer, the direction of the wind strongly affects the process of transport of harmful substances in the atmosphere when H changes from 300 to 300 м. (Fig. 14).



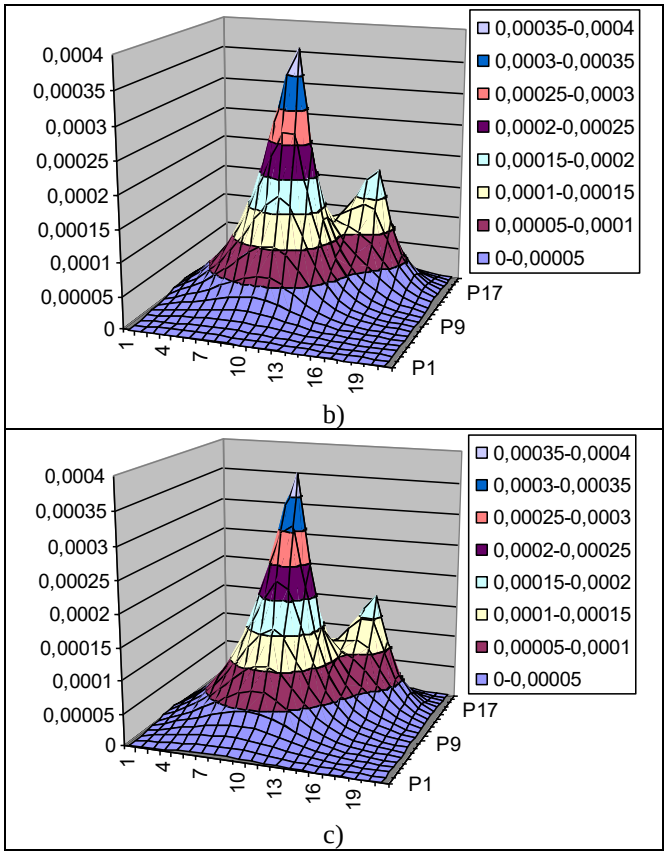
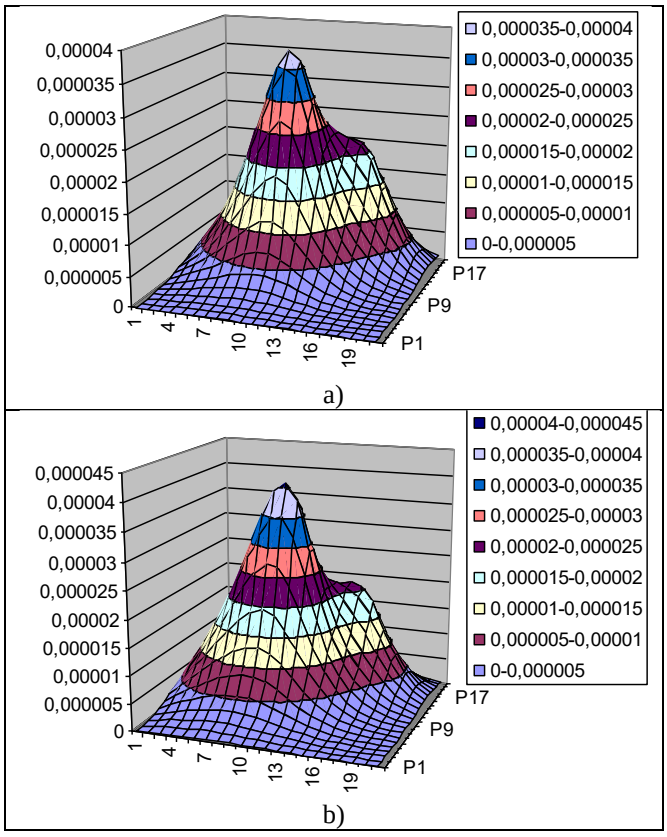


Fig.13. Change in the concentration of harmful substances in the second layer of the atmosphere (H=200m) for different values of the wind speed direction

a) α\u003d 45 ^{0}; b) α= 85 ^{0}; c) α= 120 ^{0}



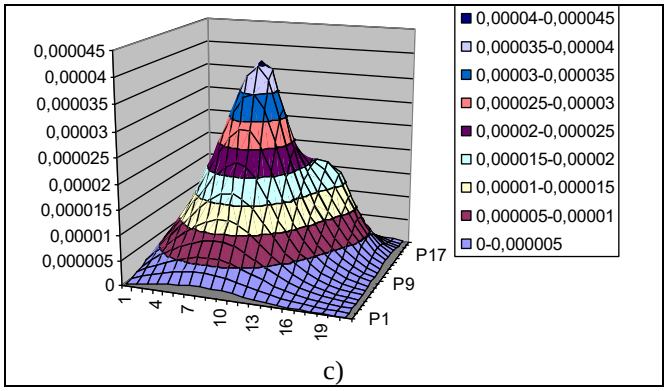


Fig.14. Change in the concentration of harmful substances in the third layer of the atmosphere (H=300m) for different values of the wind speed direction

a) α \u003d 45 ^{0} ; b) α = 85 ^{0} ; c) α = 120 ^{0}

Conclusion

Numerical calculations have established that the change in the concentration of aerosols in the atmosphere depends significantly on the absorption coefficient of particles in the atmosphere. This parameter varies depending on the degree of humidity of the air mass of the atmosphere, time of year and day. At the same time, the maximum absorption of harmful aerosol particles in the atmosphere is typical for the morning and evening hours of the day.

Computational experiment established that 10 to 18 percent of aerosol particles are absorbed in the atmosphere. The growth of the absorption of harmful substances in the atmosphere depends on the humid state of the air mass of the atmosphere.

The numerical calculations carried out on a computer showed that the distribution of aerosol particles in the atmosphere along the vertical depends: firstly, on the initial rate of particle settling; secondly, on the vertical speed of the air mass of the atmosphere; in thirds of the physico-mechanical properties of particles (radius of particles; cross-sectional area of particles) and properties of the atmosphere (ρ atmospheric density); fourthly from the acceleration of gravity.

An analysis of numerical calculations showed that the area of distribution of harmful substances in the surface layer of the atmosphere expands with an increase in the speed of the air mass of the atmosphere. This can be especially observed at H=200- 300 м.

The numerical experiments carried out for different wind directions and speeds have shown that these parameters directly affect the change in the concentration of aerosol emissions in the atmosphere. It was also established that with an increase in the power of aerosol generators, the area of \u200b\u200bthe area where the concentration exceeds the permissible sanitary norm increases. With unstable wind stratification, the area of distribution of harmful substances has a sawtooth character, it maximizes over time and over a short period of time.

The calculated data showed that elevations - hills or mountain ranges located on an open landscape - play a significant role in changing the speed and direction of winds. Above the hills, the wind speed is higher compared to the surrounding flat area. Since the high pressure area actually expands some distance to the hill, the wind changes its direction before reaching it. If the air mass meets a steep hill with an uneven surface, then the wind speed increases sharply, which leads to an increase in the turbulence coefficient. The wind speed increases with an increase in the atmospheric pressure drop, and the air flow speed decreases near the ground due to friction due to the roughness of the underlying surface;

Computational experiments have established that when harmful fine particles propagate in the atmosphere, taking into account the coefficient of interaction with the underlying surface plays a special role.

When specifying different heights of the source of pollution, it was found that with emissions from high sources, the maximum concentrations of pollution are recorded at dangerous wind speeds (in the range from 3 to 6 m/s, depending on the speed of the outflow of gases from the mouth of the exhaust pipes). Dangerous wind speed, combined with unstable stratification and intensive transport of impurities, leads to a maximum increase in the concentration of harmful substances in the surface layer of the atmosphere. In such cases, the main role in the dispersion of harmful substances in the atmosphere is played by horizontal flows.

To conduct a comprehensive study of the process of spreading harmful substances into the environment, taking into account the mutual transformation of aerosol particles in the atmosphere due to changes in weather and climate factors, a mathematical model was developed that more adequately describes the object of study.

A differential equation is obtained for calculating the settling rate of fine and aerosol

particles propagating in the boundary layer of the atmosphere, where the mass and radius of aerosol particles, atmospheric density, and air resistance force are taken into account.

For the numerical solution of the problem, an efficient algorithm based on the "method of lines" has been developed, which allows reducing the multidimensional problem described by a partial differential equation to the integration of an ordinary equation.

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SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 06.06.2022 **http://T-Science.org**

Issue **Article**

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PROPERTY OF YARN TREATED WITH MODIFIED STARCH

Abstract: *This article presents the results of a study of the physical and mechanical properties of yarn based on modified starch.*

Key words: *starch, sizing, sodium carboxymethyl starch, Hydrolyzed polyacrylonitrile, polymer composition, viscosity, adhesion, rheology.*

Language: *English*

Citation: Nazarov, S. I., Norov, I. I., & Sultonova, S. F. (2022). Property of yarn treated with modified starch. *ISJ Theoretical & Applied Science, 06 (110),* 89-92.

Soi: http://s-o-i.org/1.1/TAS-06-110-12 ***Doi***: https://dx.doi.org/10.15863/TAS.2022.06.110.12

Scopus ASCC: *1500.*

Introduction

The viscosity of sizing agents is one of their main indicators, which should be within the optimal value, as a result of which a protective film is formed on the surface of the yarn, which gives the yarn strength and elasticity[1-3]. The results of changing the viscosity of the solution at various concentrations are shown in table 1.

The study of the dependence of the viscosity of the composition containing 5-7% starch, 0.4-0.7% HPAN and 0.03-0.06% Na-CMS showed that all the studied solutions have the required viscosity. In this case, changing the concentration of Na-CMS from 0.03% to 0.06% significantly affects the structural and mechanical properties of starch-based compositions[4-6].

Table 1. Change in the viscosity of the solution depending on the content of modified starch (T=298K, cottonseed oil 0,03 %).

Rice starch, %	HPAN,%	Change in solution viscosity at different concentrations (%) Na-CMS, (Pa.s)			
		0,03	0,04	0,05	0,06
	0,4	1,10	1,17	1,26	1,40

5	0,5 0,6 0,7	1,19 1,36 1,75	1,28 1,51 1,93	1,44 1,65 2,25	1,70 2,05 2,61
6	0,4 0,5 0,6 0,7	1,21 1,34 1,55 1,78	1,33 1,50 1,68 2,13	1,44 1,72 1,93 2,41	1,62 1,95 2,20 2,71
7	0,4 0,5 0,6 0,7	1,32 1,44 1,71 2,01	1,41 1,64 1,82 2,23	1,55 1,91 2,13 2,64	1,72 2,11 2,35 2,89

The sizing process affects the breaking of the yarn under force, i.e. the strength of the sized yarn increases compared to conventional yarn. Thus, in the course of the study, differences were revealed between the rupture of sized and non-sized yarns under the action of force. The results obtained are presented in table 2.

The results show that not only the amount of starch and HPAN, but also, to a certain extent, the amount of Na-CMS depends on the breakage of the sized yarn.

For example, the yarn breaking under force is 391 cN in the presence of 6% -starch, HPAN-0.5% and 0.04% Na-CMS, with an increase in the concentration of starch to 7% and Na-CMS to 0.05% force breakage increases to 398 cN. Thus, the study of the dependence of the physicochemical and physico-mechanical properties of sized yarn on the chemical nature and concentration of the components satisfies the requirements for adhesive and film-forming components of modified starch with HPAN and Na-CMS. According to the work performed, it can be concluded that the composition with good rheological and physical and mechanical properties of the yarn consists of the following components: 6% rice starch, 0.5% HPAN and 0.04% Na-CMS.

As can be seen from Table 3, the physical and mechanical properties of modified starch yarn meet all the requirements for the weaving process.

Table 2. Physical and mechanical characteristics of sized yarn with modified starch (cottonseed oil 0,03 %)

Composition of modified starch ,%			pH	Force break, P,cN	Elongation, E, %	Gluing, K,%
Starch	HPAN	Na-CMS				
5	0,4 0,5 0,6	0,03 0,03 0,03	7,2 7,0 6,9	347 380 395	20,63 22,68 23,85	3,01 3,52 4,28
6	0,4 0,5 0,6	0,04 0,04 0,04	7,3 7,0 6,8	375 391 414	22,68 23,93 24,15	4,49 4,77 5,61
7	0,4 0,5 0,6	0,05 0,05 0,05	7,7 7,3 6,8	387 398 416	23,21 25,28 26,40	4,91 5,94 7,09

Table 3. Comparative physical and mechanical characteristics of yarn according to the composition of the sizing component

Technological indicators	Size types		
	Corn starch	Rice starch	Modified starch
Sizing viscosity, Pa.s: In the Chanda sizing bath	1,40 1,15	1,20 1,05	1,50 1,20
Breakage , %	0,38	0,50	0,35
Average strength,N: Softly sized	262 383	250 373,7	267 393
Medium elongation, %	2,80	3,00	2,65

The breakage of yarn sized on a loom is lower than the breakage of yarn sized by other types of starch, with this in mind, it is recommended to introduce the development into production[7-9].

The treatment of yarn with the proposed compositions increases their technological characteristics, i.e. allows you to reduce the number of breaks on the loom by 8-12%.

The decrease in yarn breakage during sizing is due to the high permeability of the modified starch solution and the formation of a strong smooth film[10]. Due to these properties, the solution is easily absorbed by the yarn, gives the yarn strength and elasticity after drying and protects them from mechanical damage.

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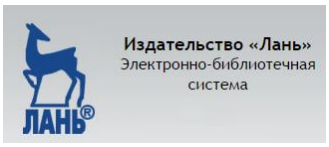

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«Theoretical & Applied Science» (USA, Sweden, KZ)
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