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ARTS

## HARMONIC ANALYSIS OF SCRIBBIN'S PRELUDES OP.11: C MAJOR, A MINOR, E MINOR

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## Abstract

The harmonic language of Alexander Scriabin's Preludes Op. 11 offers a vivid look into the composer's early stylistic approach, marked by extended tonal frameworks and inventive choices. This study focuses on three preludes – C Major, A Minor, and E Minor – exploring Scriabin's unique harmonic structures, sequencing techniques, and influences from Chopin. Each prelude embodies different facets of Scriabin's harmonic thought, from the use of pentachords and non-tertian structures in the C Major Prelude to sequential modulation and tonal shifts in the A Minor Prelude. The E Minor Prelude showcases Scriabin's innovative textural sequencing and vertical harmonies. Through these analyses, the study aims to demonstrate the complexities and nuances of Scriabin's early harmonic language, ultimately shedding light on his contributions to late Romantic music.

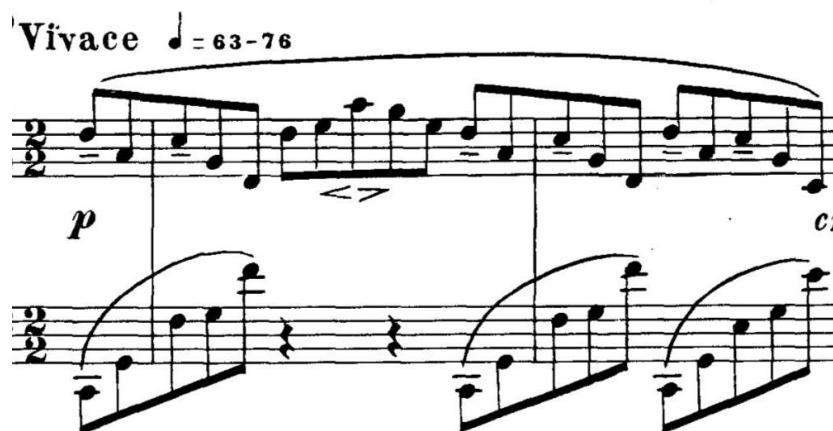
**Keywords:** Harmonic Analysis, Scriabin, Preludes Op. 11, Extended Tonal Frameworks, C Major, A Minor, E Minor, Pentachord, Non-tertian Structures, Sequential Modulation, Chromaticism, Late Romantic Music, Textural Sequencing, Vertical Harmonies, Chopin Influence, Cadential Zone, Tonal Shifts, Emotional Richness, Metrical Framework, Thematic Development.

In the early stages of Scriabin's career, harmony emerges as a defining feature of his stylistic approach. While adhering to the extended tonal framework of late Romanticism, the harmonic language in his compositions is filled with remarkable discoveries and audacious choices, often foreshadowing groundbreaking innovations to come.

Prelude No. 1 in C Major stands out as one of the most vivid depictions of "flight" in Scriabin's early oeuvre. The piece captures the composer's unique sense of inspiration while maintaining the tone of a personal, lyrical expression. In his mature and later works, the

concept of flight often serves as a transitional element between a contemplative mood and ecstatic triumph.

In Prelude No. 1 in C Major, harmony serves as a key element in the piece's figurative content, operating on multiple levels. The thematic core of the composition relies almost solely on the notes of the major pentatonic scale. Gentle dissonant harmonies arise between the voices, enriched by a wide register. Within the opening measures, a unique chordal phenomenon occurs – a non-tertian vertical structure is built over a pedal tone. This pentachord, however, should be viewed as an implied chord, serving as a suspension leading to a tonic triad.



*Pic. 1. A. Scriabin - Prelude No. 1 in C Major, Op. 11, Measures 1-2*

In a characteristic move, Scriabin employs a deliberate avoidance of strong metrical beats in the prelude, thereby shifting harmonic functions away from their traditional placement within the metrical framework. The deep bass and the first note of the melody in the

upper register land on an offbeat, while the metrical accent occurs on the third note, aligning with the first beat. As a result, the two accents neutralise each other. This technique, combined with other expressive means such as fluid tempo, transparent two-voice texture, ex-

pansive register, and the unique quintuplet figures, contributes to the ethereal lightness and a sense of weightlessness in the prelude. The form of the prelude in Op. 11 typically consists of a period with an extended second phrase, supplemented by a segment that reprises the initial phrase. The fragmentary structure that con-

cludes in the second phrase is shaped by intense harmonic development, progressing towards a dominant resolution. Notably, Scriabin employs disalteration in expanding the cadential zone, transitioning from an augmented DD43 chord to its standard form. This reveals the composition's luminous major tonality.



*Pic. 2. A. Scriabin - Prelude No. 1 in C Major, Op. 11, Measures 13-18*

Prelude No. 2 in A Minor showcases a range of features indicative of Scriabin's early harmonic thought. The sequence-based development of themes and sequences plays a significant role in shaping the composition's structure. The form is a straightforward two-part reprise with double periods. The initial four-measure thematic core is transposed to the natural dominant key of E Minor. In the reprise, it first appears in

A Minor, then shifts to D Minor, the key of the sub-dominant. This aligns with the classical tonic-subdominant-dominant-tonic (t-s-D-t) tonal structure; the quarto-fifth system is also typical for Scriabin. Notably, he employs a colourful sequential modulation in the second phrase of the first part, transitioning from A Minor to G-sharp Minor through enharmonic modulation.



*Pic. 3. A. Scriabin - Prelude No. 2 in A Minor, Op. 11, Measures 20-21*

The developmental section, constituting the first phrase of the second part, is also built on sequential development and is divided into two segments. The tonal scheme of this episode follows: E Minor - G Major - G Minor - B-flat Major. During the modulation from minor to its parallel major, the minor tonic serves as the

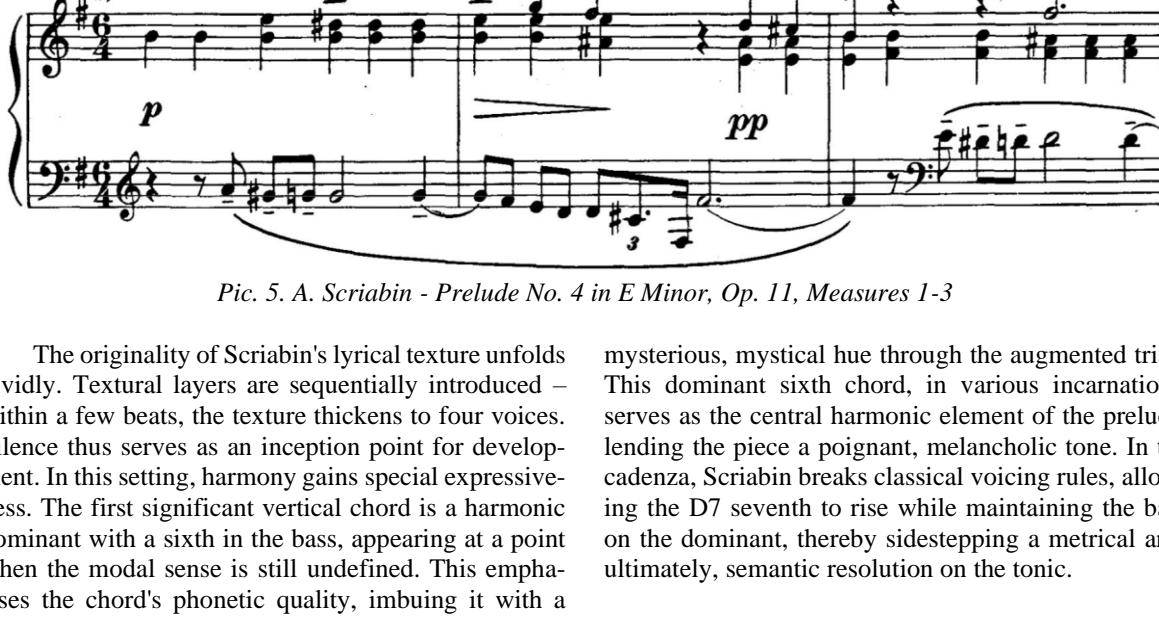
VI degree in the forthcoming key. The transition from G Major to G Minor is achieved by juxtaposition. The B-flat Major reached at the end of this section assumes the role of the Neapolitan subdominant of the primary key, naturally leading to the dominant thereafter.



Pic. 4. A. Scriabin - Prelude No. 2 in A Minor, Op. 11, Measures 57-65

The originality of Scriabin's lyrical texture unfolds vividly. Textural layers are sequentially introduced – within a few beats, the texture thickens to four voices. Silence thus serves as an inception point for development. In this setting, harmony gains special expressiveness. The first significant vertical chord is a harmonic dominant with a sixth in the bass, appearing at a point when the modal sense is still undefined. This emphasises the chord's phonetic quality, imbuing it with a mysterious, mystical hue through the augmented triad.

This dominant sixth chord, in various incarnations, serves as the central harmonic element of the prelude, lending the piece a poignant, melancholic tone. In the cadenza, Scriabin breaks classical voicing rules, allowing the D7 seventh to rise while maintaining the bass on the dominant, thereby sidestepping a metrical and, ultimately, semantic resolution on the tonic.





Pic. 6: A. Scriabin - Prelude No. 4 in E Minor, Op. 11, Measures 4-9

Much like the Prelude in A Minor, sequencing is the central principle for material development in this miniature piece. The theme initially appears in E Minor and is subsequently transposed to B Minor, the key of the natural dominant. In the second half of the phrase, dynamism is fueled by an ascending chromatic sequence, where the voice count occasionally rises to five. In such instances, the bass note precedes the entire chord, sustaining a tie from the previous weak beat. This technique subtly veils both textural and metric weightiness.

In the second phrase, the cadence undergoes significant expansion. Following two parts of the sequence, an expressive pause occurs for the first time in the prelude. The VII7 chord, resolving to A Minor – the key of the subdominant – transforms into a Neapolitan subdominant sixth chord. The D7 in the cadenza is typically voiced without the fifth; moreover, the dominant reappears twice with the sixth in the bass, mirroring the prelude's beginning. The composition's introspective and contemplative mood is underscored by the melodic prominence of the fifth in the closing section.

### Conclusion

In sum, the Preludes in C Major, A Minor, and E Minor from Scriabin's Op. 11 offer a compelling look into the composer's evolving harmonic sensibilities. These works intricately combine Romantic tonality with daring harmonic choices, serving as windows into both the historical musical landscape and the individual genius of Scriabin. The composer's penchant for complex harmonic structures—often nuanced, subtle, and layered—functions as both emotive device and structural element. From the ethereal qualities of the C Major Prelude to the poignant tensions in E Minor, Scriabin uses harmony as an expansive canvas to paint a range of human emotions and experiences. These compositions are not mere exercises in harmony; they are evocative, emotionally resonant works that manifest the limitless potentials of musical language. They bear witness to Scriabin's transformative approach to harmonic analysis, an approach that challenges, enriches, and ultimately extends the boundaries of musical understanding.

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# ECONOMIC SCIENCES

## BALANCE OF ELECTRICAL ENERGY IN ELECTRICAL NETWORKS AND COMMERCIAL LOSS ANALYSIS

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### Abstract

Electricity is an indispensable element of our daily life. When electricity is used inefficiently, technical and non-technical losses occur at the stages from power plants where energy is produced to the point of consumption. Reduction of these losses is defined as the main goal for more efficient use of existing energy systems. Since the increase in electricity tariffs due to inflation is happening all over the world, it creates conditions for the illegal consumption (theft) of electricity without accounting. For this reason, reducing the illegal consumption of electricity and compensating the financial losses of the distribution companies remains the main problem. [1] According to research, the countries of the world lose 89.3 billion annually from the theft of electricity. The US dollar is losing. The largest losses were in India (16. 2 billion US dollars), followed by Brazil (10.5 billion US dollars), Russia (5.1 billion US dollars) [2]. About 50% of the total cost of non-technical (commercial) losses of electricity in the Russian Federation (according to preliminary estimates, 30 billion kWh) is accounted for by unaccounted (unmetered, non-contractual, etc.) consumption of electricity. [2]

The rate of loss and theft in the Republic of Turkey is still higher than the rate of loss and theft in developed countries. For instance, according to the reports of Vangölü Elektrik Dağıtım A.Ş. (VEDAS), connected to the Van, Bitlis and Hakkari provinces, as of the end of 2017, the loss and theft rates were 72% in Hakkari, 53% in Van, 48.5% in Mus and Bitlis. It is shown to be 35%. [7]

These issues still remain a problem in our republic. So, despite the serious struggle against the illegal use of electricity in "Bakielektrikshebeke" OJSC, and later in "Azerishiq" OJSC, starting from 2003, according to the indicators of 2020, the number of acts pointed in this field (52,202), lost energy recovery (166.9 million kWh) continues to increase.

Losses, including commercial losses, to the extent that they can be released is the method of carrying out and applying balance sheets. It is for this reason that it is very important to conduct research, to determine the methods of accurate measurement of received and consumed energy, to study the methods of carrying out balance reports for all stages, starting from 0.4 kV networks, and to give recommendations, in order to reduce non-technical losses.

**Keywords:** energy balance, commercial losses, illegal use of electricity, smart meter.

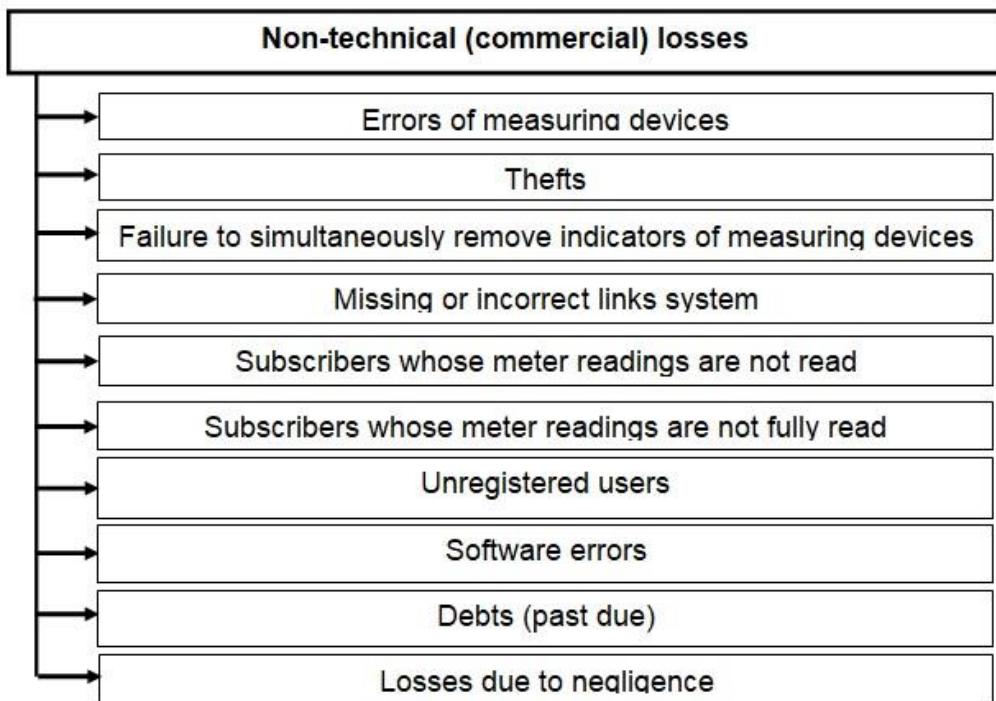
Non-technical (commercial) losses are defined as the difference between the consumed electricity and the measured electricity or billing amount. Analysis of these losses show that the ratio of non-technical losses to total distribution losses cannot be accurately estimated. Commercial losses depend on the technical condition of the networks, the social welfare of the

population of the region and the city, the organization of network management, the compliance of employees providing services to the population, etc. it varies depending on other factors.

Let's consider the structure of non-technical (commercial) losses in the table below:

Table 1

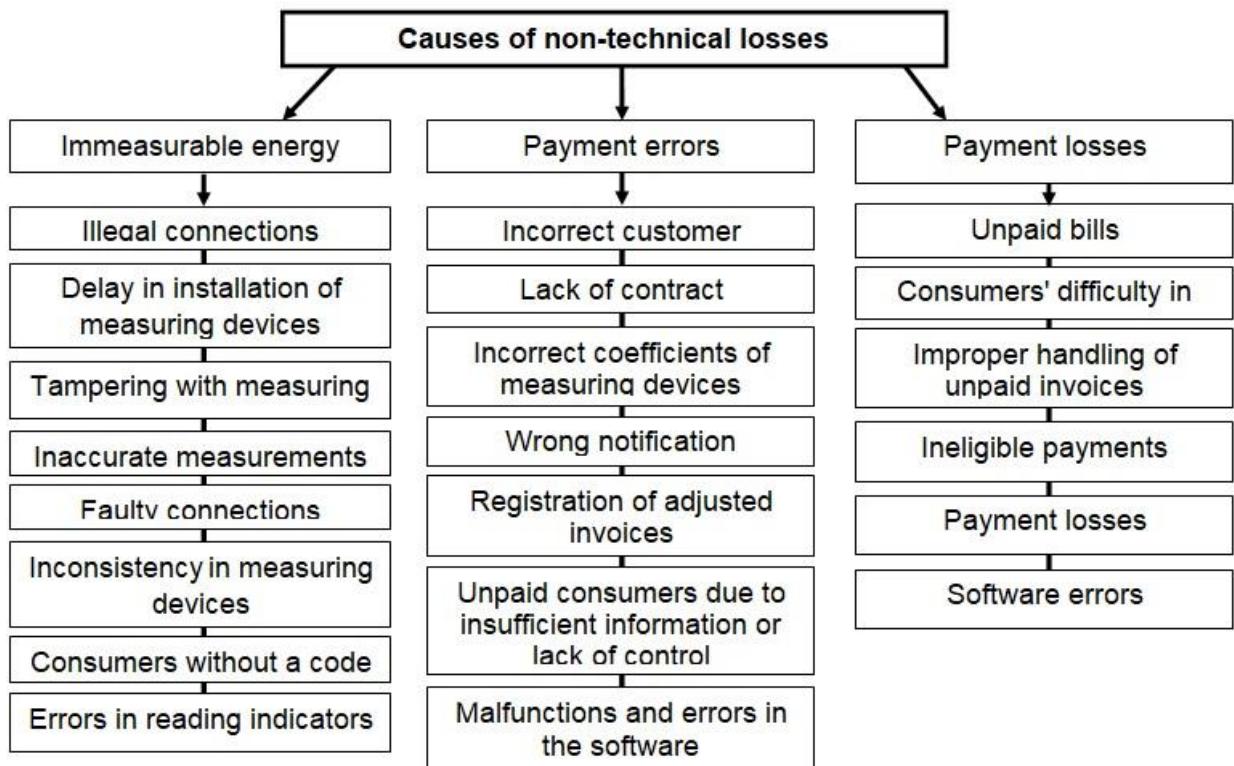
The structure of non-technical (commercial) losses



If we look at the table drawn up about the causes of non-technical losses, we will see that it mainly consists of unmetered electricity, payment errors and payment losses.

Table 2

Causes of non-technical losses



As can be seen, the commercial losses in the energy balance appear as part of the actual losses and are borne by the networks. [5]

In current literary source, commercial losses are determined by two main reasons: theft of electricity by

consumers; deficiencies in control of consumption and its payment. These losses are a complex component of total losses, mainly due to social and organizational factors. The fact that meter readings are not taken out

at the same time significantly distorts the monthly values of losses. [6]

It is appropriate to include the unpaid part of subscribers' receivables that are overdue for more than 3 years as commercial losses. Although the amount of these receivables changes every year, they are written off from the budget account after a certain time by the government's decision, but as a rule, they are not considered as commercial losses.

The level of commercial losses also depends on the organization of consumption control. Since this control is carried out by means of software in current time, the level of commercial losses of networks directly depends on the technical condition of the information base used, the service provided to it, and the perfection of the software. In the database, the following factors directly affect commercial losses:

- the absence of a specific transformer connection with the subscriber's identification code in the software;

- lack of connection of the transformer and substation with the supervising engineer;

- failure to install technical report counters at the head parts of the lines;

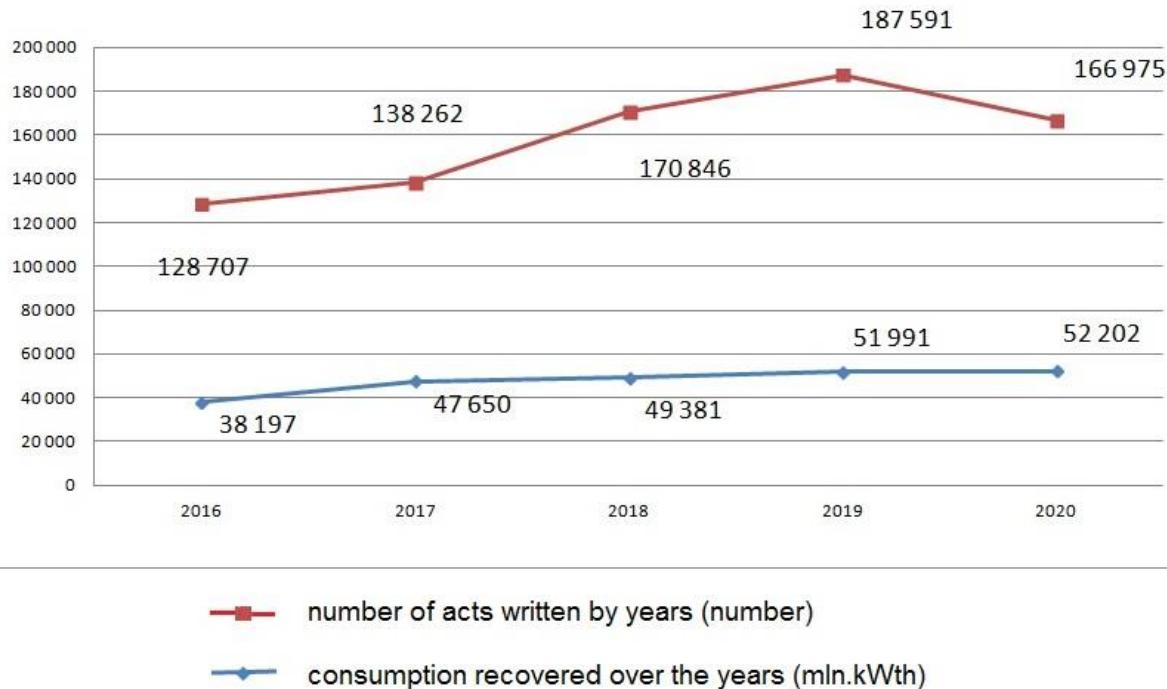
- failure to provide supervisory engineers with special devices;

- insufficient number of supervisory engineers and deficiencies in work organization.

The stolen electricity attributed to commercial losses, is formalized by the special enactment and additional payment accounts issued to subscribers, pursuant to the clause 8.17 of the "Rules for the Use of Electricity". [13]

In the last 5 years the status of the acts written on the restoration of commercial losses at "Azerishiq" OJSC (according to the EEIG) is as follows (picture 1).

**Number of written acts and recovered consumption**



*Picture 1. In 5 years the status of the acts written on the restoration of commercial losses at "Azerishiq" OJSC.*  
Table 3

In 5 years number of written acts and report of recovered consumption at "Azerishiq" OJSC.

Years	Number of written acts			Report of recovered consumption	
	Population	N/population	Total	kWth	AZN
2016	31 132	7 065	38 197	128 707 287	9 099 267
2017	40 512	7 138	47 650	138 261 899	11 841 540
2018	42 162	7 219	49 381	170 846 497	15 770 031
2019	42 457	9 534	51 991	187 591 155	16 830 039
2020	43 982	8 220	52 202	166 975 391	15 212 485

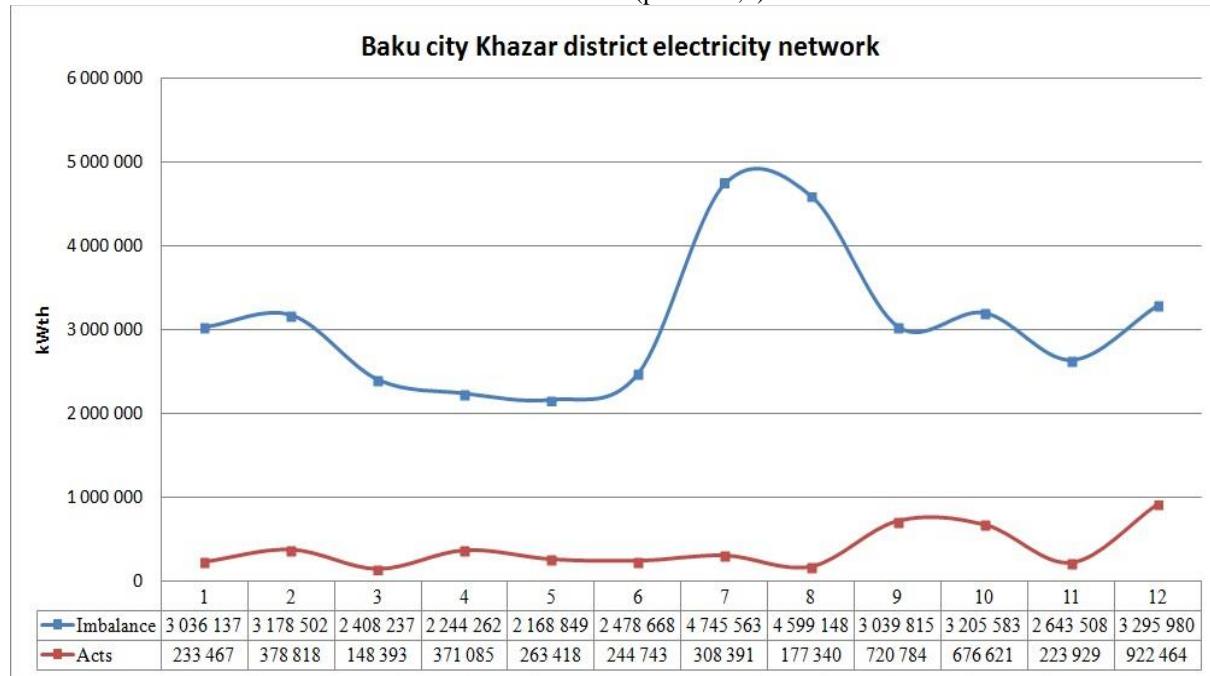
As can be seen from the table and diagram, the number of written acts and the amount of renewable consumption provided by these acts has increased by approximately 40% in the last 5 years. Although the recovery of lost (stolen) electricity is a positive thing

for the networks, it is doubtful that these acts are written to the subscribers who are fed from the lost lines. Because reports and analyzes on the location of losses in 0.4 kV lines have not been carried out in the

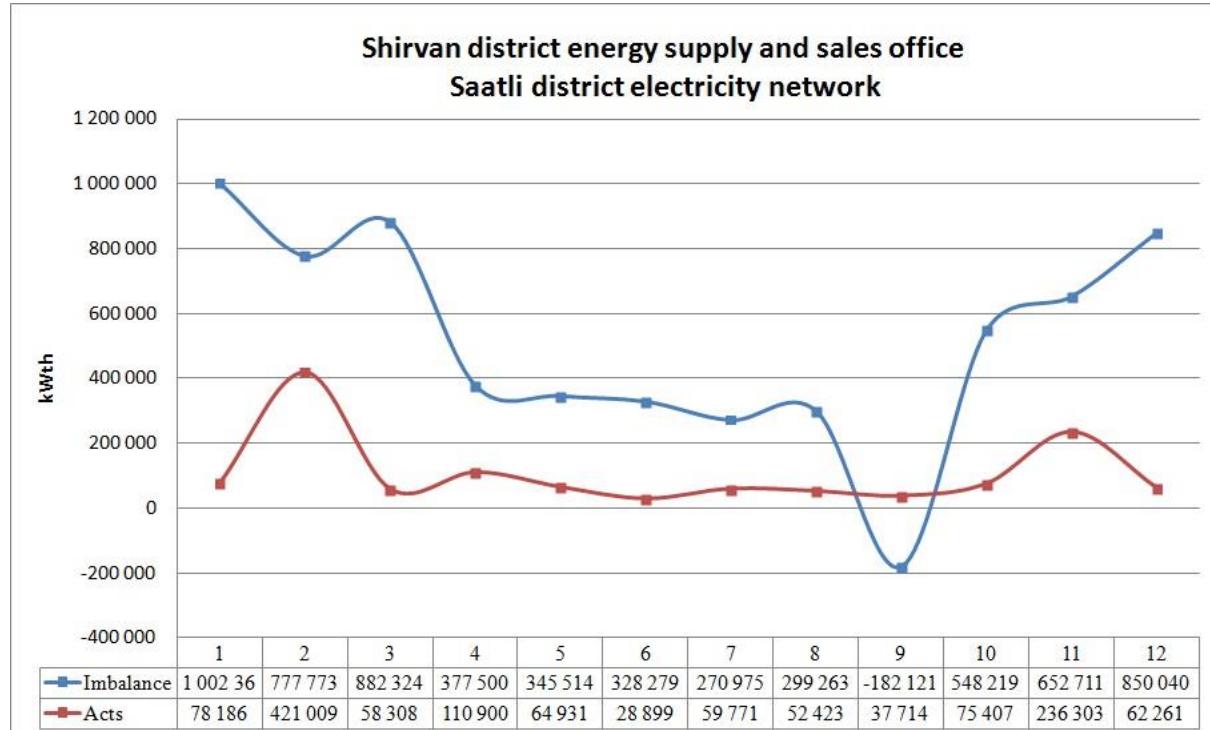
networks for a long time, such a methodology has not been developed and approved.

In the two diagrams given below, the amount of total imbalance for the months of 2021 on the Khazar

district electricity network of Baku city and the Shirvan RETSI Saatli district electricity network and the consumption (kW /hour) comparison is shown.[15] (picture 2,3).



Picture 2. The amount of total imbalance for the months of 2021 on the Khazar district electricity network



Picture 3. The amount of total imbalance for the months of 2021 on the Saatli district electricity network and the consumption.

This comparison can also be made on individual transmission lines or TM (KTM). The result confirms that when experts draw up acts according to the rules of electricity use, it is not taken into account whether or not there is a loss (imbalance) in that part of the network. Another problem is that in the relevant clauses of the "Rules for the use of electricity" when the theft of electricity by the energy supply enterprise is enacted,

"within the claim period provided for in the Civil Code of the Republic of Azerbaijan for the working hours of the consumer from the date of the last replacement of the electricity meters or the check of the connection scheme" recalculation should be carried out"[13].

This allows networks to calculate additional consumption for up to 3 years per act. Therefore, network specialists should refer to the balance sheets to

detect electricity theft, and after inspecting the lost lines or TM (KTM), they should formalize the facts of theft. At the same time, we believe that it would be more appropriate to limit the total amount of acts (kWh) during settlement, the upper limit to the amount of imbalance in that part of the network, by making additions and changes to the relevant clauses of the "Rules of Electricity Use".

In general, the occurrence of electricity theft in electric networks can be conditioned by 3 factors:

- the motive of the theft;
- availability of technical conditions;
- imperfect legal framework.

If we consider these 3 factors separately, we will see that the existence of cases of electricity theft is not at all surprising. Thus, the increase in the prices of energy resources all over the world, the increase in inflation and losses make it inevitable to increase the tariffs of utility services, including electricity. This is one of the factors that provoke people to steal electricity in foreign countries, as well as in the former Soviet republics, where energy resources used to be extremely cheap.

The imperfection of electricity measurement systems in distribution networks, the fact that low-voltage networks mainly consist of overhead transmission lines consisting of open wires, create ample conditions for illegal interference (outside lines) and illegal network connections, resulting in theft of electricity. The current technical condition of networks is also one of the factors that create fertile conditions for theft incidents. This is more typical for internal power networks, ie 0.4 kV overhead transmission lines. As the cost of energy resources increases, the reconstruction and maintenance of the technical condition of distribution networks at a modern level is a strategic task. Solving this problem is very important mainly because:

1. Increasing the power of electric networks;
2. Reduction of electricity losses during distribution, including commercial losses;
3. Ensuring uninterrupted power supply in difficult natural conditions, as well as increasing the reliability and durability of power transmission lines.

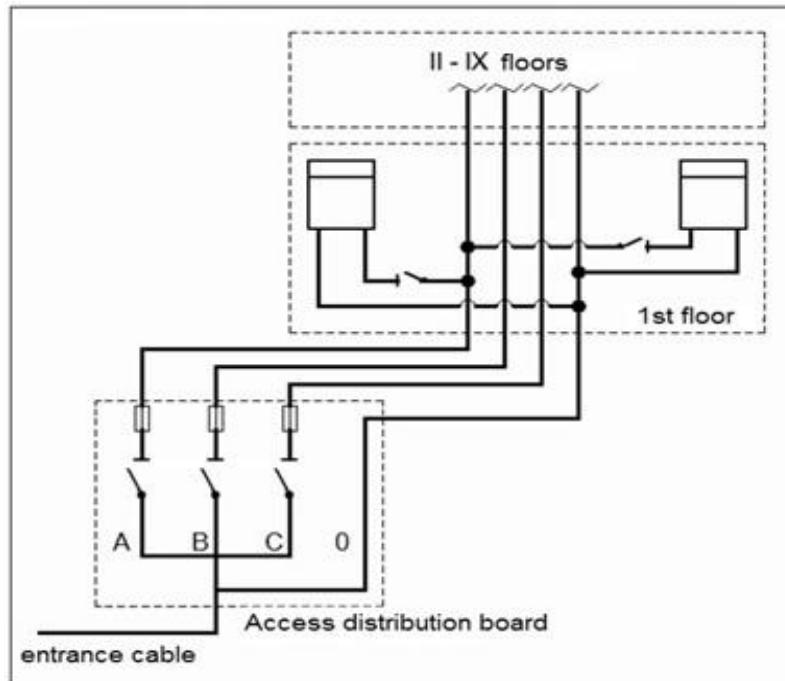
Worldwide, this problem has been solved since the 1970s with the introduction of self-supporting insulated wires (ISVs) for 0.4 kV (up to 1000V) lines. This idea was first introduced in France and later developed further in Germany. Its design is very simple: all conductors have the same cross-section, are made of the same aluminum material and have the same insulation material. These wires, that is, phase and zero aluminum insulated wires, are wrapped in a package. This four-wire system is widely used in Austria, Germany, Great Britain, Ireland, Poland, Hungary and Scandinavian countries. The system consists of four aluminum insulated conductors that equally share the same mechanical pull load. The cross-section of the wires varies between 16-150 mm<sup>2</sup>. Since the mechanical load is distributed among all four conductors, the breaking strength of the whole wire is quite high. Cross-linked XLPE polyethylene is used as insulation

material. This insulation is made of weatherproof, light-resistant, high-density thermoplastic polyethylene, making illegal intrusions impossible. At present, there are many standards of UIN cables in Europe and Russia, and they are even produced for high-voltage networks (10-35 kV) [10]. In our country, the application of UIN cables has been started since 2004 in "Bakielektrikshebeke" OJSC (at that time "Barmek Azerbaijan") as suggested by the author of this article. The proposal was supported by the Energy Institute of Scientific Research and Project Research of "Azerenergy" OJSC, and it was there that the first tests and familiarization with UIN cables were carried out. The application to the Cabinet of Ministers of the Republic of Azerbaijan about the application of LV cables in the low-voltage (0.4 kV) electric grids of Baku and Sumgayit cities was considered and, despite the pessimistic opinions of many local and foreign experts (Barmek Holding), approval was given for its application as a pilot project. The fact that the issue was controversial was the fact that the introduction of UIP cables in Russia and Turkey was not started, and the financial capacity of the project was high. However, the local specialists of "Bakielektrikshebeke" OJSC were able to break the old stereotypes. In one quarter of Yasamal district of Baku city, the application of the UIN cable was started as an experiment. After the completion of the work, the 3-month measurements and the difference in the previous (before the application) indicators fulfilled all expectations. Commercial losses were at zero level, and technical losses (technical consumption) were below the norm. The results were presented to the Cabinet of Ministers of the Republic of Azerbaijan, and it was decided to mass-introduce the cables in the entire country.

Currently, the implementation of 35 kV UIN cables in the Karabakh and East Zangezur economic regions, which have been liberated from the occupation of the Republic of Azerbaijan, is a matter of great pride.

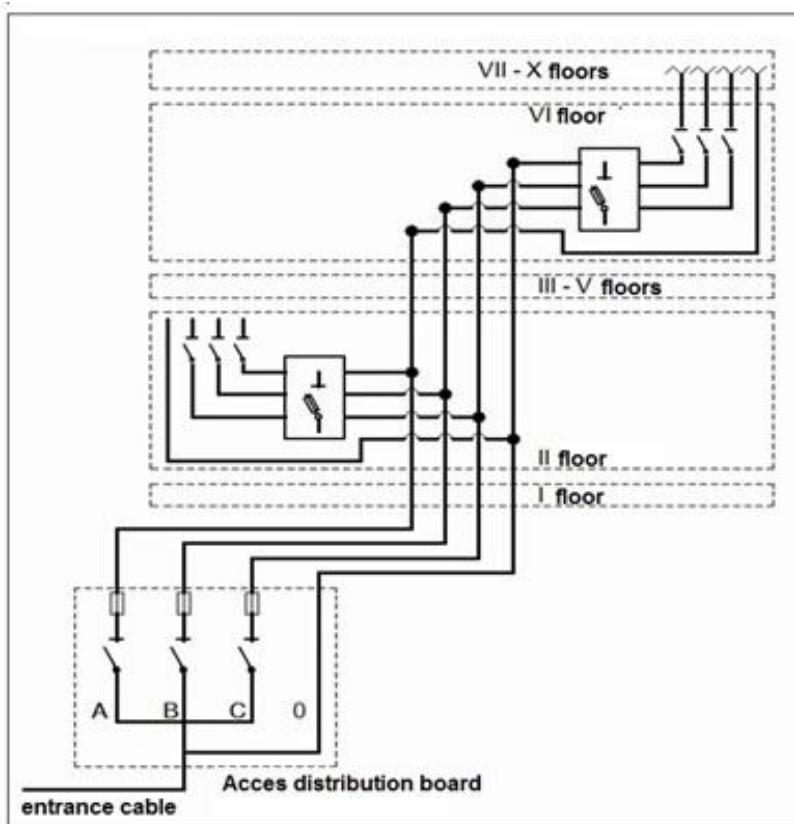
One of the most common areas of commercial losses, or rather, theft of electricity, is multi-apartment buildings. Thus, the scheme of sequential distribution of electricity to apartments from the Soviet era and even in some newly built multi-apartment buildings is very primitive and creates ample conditions for theft (picture 4).

It was in 2004 with the scheme proposed by the local experts of "Bakielektrikshebeke" OJSC (picture 5) that the internal electrical lines of more than 4,500 multi-storey (5-9) buildings of Baku were completely replaced and new copper cables were laid directly from the distribution box. Meter boards (panel) were installed on the II and VI floors. Balance sheets for multi-storey buildings were prepared, special software was developed for this purpose. It was the introduction of cables and the change of the electricity distribution scheme in multi-apartment buildings that changed the technical conditions for the occurrence of theft cases. Starting from 2005, theft cases and commercial losses in Baku began to decrease.



Picture 4.

*In multi-storey buildings the previous energy supply scheme and settlement meter of household subscribers.*



Picture 5.

*Post-reconstruction energy supply scheme and billing meters for household subscribers in multi-storey buildings.*

As for the legal issues, the situation is as follows:

Currently, the theft of natural gas, water and electricity in our Republic (by various means, it doesn't matter, outside line, tampering with the meter, etc.) is not considered theft according to the Criminal Code of the Republic of Azerbaijan and is not defined by its article 177. Legal violations in this area are regulated

by Article 189 of the Criminal Code of the Republic of Azerbaijan and Articles 279, 281, 282 of the Code of Administrative Offenses.

In our country, the electricity purchase agreement between the state electric power enterprise and the energy supply enterprise, as well as the agreements concluded between the subjects of the retail market

(networks) and electricity consumers, only regulate the relations related to the supply and payment of electricity.

Currently, there is no special criminal-legal protection of the property of distribution networks related to electricity. The Criminal Code of the Republic of Azerbaijan does not define the signs and elements of the crime related to the theft of electricity as a specific type of product and property. This situation does not allow law-enforcement agencies to effectively prevent the theft of electricity, including proving the facts of theft in courts and compensating the thieves for damages. Also, this situation does not encourage the economic use of electricity, but also makes it difficult to carry out accurate accounting and evaluation of electricity.

Due to the lack of the right to independently apply sanctions against entities that steal electricity and the absence of an approved methodology for calculating damages, distribution networks cannot fully recover the damage caused.

Regarding the international experience, in 1985, an expert group was established in Belgium to study the issues related to theft and non-payment of electricity under the study committee on economics and tariffs of the international organization UNIPEDE (International Union of Electricity Producers and Distributors) [16], which includes 11 countries. Experts from France, Italy, Great Britain, Norway, Spain, Denmark, Holland, Austria and Germany are included in this group. According to the report prepared by this group in 1998 [16], the term "electricity theft" is defined as the fact that, due to the consumer's fault, the electricity consumed by him is not fully accounted for (without a meter or when the meter is opened) or he violates the energy supply system in order to reduce his consumption measured by the meter. According to that report, only 4 countries - Italy, Great Britain, Spain, Ireland - believe that there is a problem of electricity theft. In Norway and France, electricity theft is prosecuted only under civil law, while in other countries criminal law or both apply. With the exception of the UK, Spain and Ireland, most countries have successful domestic legislation on electricity theft, which includes simplifying the punishment of those found guilty of off-meter electricity theft and non-payment of stolen electricity, including prosecution of offenders. In these countries, it is common practice in society to prosecute consumers found to have stolen electricity and to have the court order them to pay the full amount owed. Otherwise, honest consumers will have to overpay for the electricity they use to compensate for the electricity stolen by unscrupulous consumers [8].

One of the main measures implemented in order to reduce the commercial losses of electricity is the improvement of electricity metering systems. It also serves to increase the reliability of information about the structure of the electricity balance in electricity networks. A strategic way of electricity metering is the creation and implementation of a fully functional automated information and measurement system of commercial accounting of consumers in the wholesale

market and retail of electricity [10]. I should also mention that this automated software should also include accounting.

It is very important to take the following measures to get the best results from this software:

#### I. Technical measures:

- Providing normalized conditions for the use of smart meters;
- Replacement of useless and expired meters with new ones;
- Installation of additional measuring devices, including voltage and current transformers;
- Equipping consumers at all levels with smart meters;
- Placement (installation) of balance meters in terms of the implementation of tasks for the implementation of electricity distribution services;
- Protection of meters from external interference and unmeasured electricity consumption.

#### II. Organizational measures include the following:

- Evaluation of the current state of purchase accounting systems along the borders of networks;
- Creation of an automated database on electricity consumers;

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## II. Organizational measures include the following:

- Evaluation of the current state of purchase accounting systems along the borders of networks;

- Creation of an automated database on electricity consumers;

- Organization of control over connection of new subscribers, legal and natural persons to the network;

- Compliance with the dynamics of electricity consumption for months and years, calculation and analysis of electricity, actual, technical (technological) losses and imbalance in electricity networks;

- Provision of remote automated simultaneous collection of data;

- Providing the consumer with the opportunity to use a multi-tariff and differentiated menu when paying for electricity;

- Maximizing the possibilities of using advance payment functions and payment control functions;

- Provision of timely registration of events occurring in the electricity meter (light switching on, off, consumption modes, volumes, etc.);

- Ensuring the ability to control the consumption mode of electricity (restriction from a distance, shutdown, etc.)

- Organization of measurement of electricity used for production and economic needs of networks.

Thus, as can be seen from the preliminary results of research, the automation (programming) of electricity measurement systems has very important resources for reducing electricity losses.

Currently, the goal is to minimize commercial losses in front of distribution networks using modern methods, which can be achieved by taking the following measures:

- Automatically detect energy theft without involving any human power by developing an effective and efficient system;

- Develop a VEB-based mobile application to monitor all thefts, theft area and the direction of arrival to the theft area;

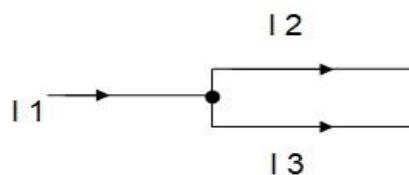
- To keep records of the total number and power of electric operators connected to the network by users in the server database and implement an online billing system;

- Develop a global WEBSITE that will facilitate analysis of thefts and provide analytics of theft incidents and probable theft area using various graphs and pictorial representations that can predict future thefts. [9]

Commercial losses are mainly caused by deliberate malfunction of meters or attempts to bypass meters by deliberate fraud, slowing down or stopping of meters, incorrect readings of meters or even illegal connection. The detection of these cases by means of modern digital information technologies and the formalization and payment of stolen consumption by means of relevant protocols (acts) is the biggest problem facing all the world's electricity networks. For this purpose, relevant studies are being conducted and software is being developed in all countries.

I consider it appropriate to apply the following method based on the law of current distribution in networks at the low voltage level after analyzing the processes related to commercial losses and theft of electricity in our country.

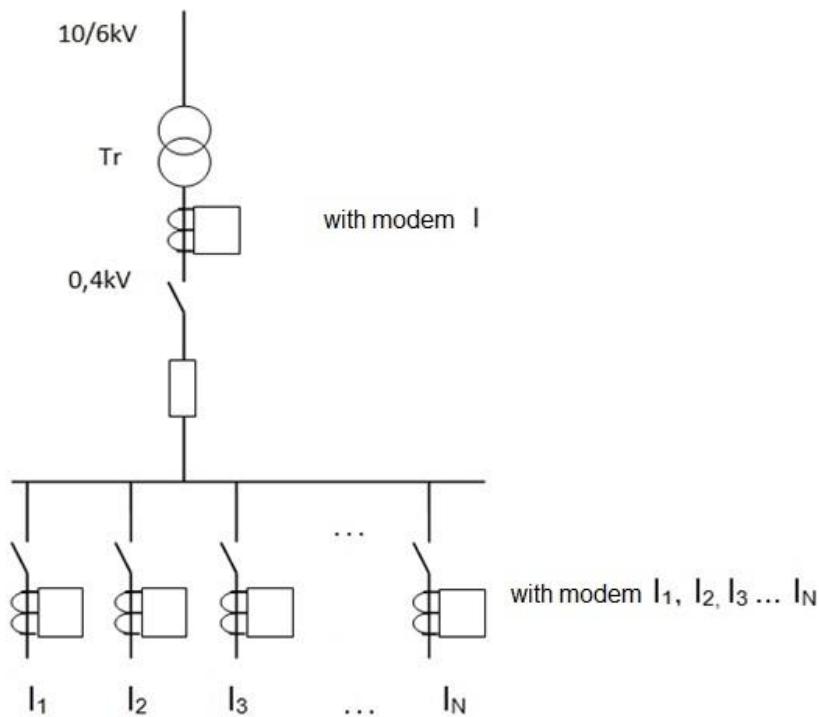
According to Kirchhoff's first law the algebraic sum of the currents at the nodal (branching) point of the electric circuit is equal to zero, in other words, the sum of the currents entering the branching point is equal to the sum of the currents leaving that point, and conventionally, the incoming currents are considered positive, and the outgoing currents are considered negative.



*Picture 6. Branching of the current from the nodal point*

If we take the current  $I_1$  directed to the nodal point as positive, and the oppositely directed currents  $I_2$  and  $I_3$  as negative, then

$$I_1 + (-I_2) + (-I_3) = I_1 - I_2 - I_3 = 0$$



$$I_1 = I_2 + I_3.$$

*Picture 7. Currents are measured by smart meters*

$$\begin{aligned} I_{b/s} &= I_1 + I_2 + I_3 + \dots + I_n \\ I_{b/m} &= I * k_{ct} \end{aligned}$$

In the picture:  $I_{b/m}$  – the current of the balance meter;

$I_1, I_2 \dots I_n$  – current of subscriber meters;

$k_{ct}$  – indicates the coefficient of the current transformer.

Considering the line loss,

$$\begin{aligned} I_{b/s} &> I \sum I_{1:N} \\ I_\Delta &= I_{b/s} - I \sum I_{1:N} \\ I_\Delta * U &= P_\Delta (\text{kw}) \end{aligned}$$

Here:  $I_\Delta$  – lost current;

$P_\Delta$  – power of electric energy;  $U$  – is voltage.

Thus, in order to detect the fact of theft, a system (measurement and comparison of current) is proposed, in which current distribution is carried out indirectly from the electric pole to the intermediate distribution box and then to individual houses, as well as to each apartment of multi-apartment buildings. The current is measured periodically in the distribution box and stored in the server database for each house using the GSM/GPRS module. At the same time, electric meters (smart) are installed for each house, which can measure the current value and send it periodically to the server database for each house or apartment using the GSM/GPRS module.

The installation (or unlocking) of the electricity meter, the user's information is entered and stored in the information database through the mobile application, including the address, geographic coordinates - latitude and longitude, as well as a photo of the user's house or area using mobile GPS. . If there is a difference between the amount of current from the distribution box and the electricity meter on the server, the fact of

theft is detected. This fact is shared with the address of the user and a photo of the house (territory) and geographic coordinates. The relevant structures of the networks register and send the fact of theft to the user by formalizing it online by means of appropriate protocols or acts. This system is similar to the way that the State Highway Patrol service, which has been successfully applied in our country, registers drivers who violate traffic rules on highways using RADAR and sends protocols online. I think that with the method I have shown above, appropriate software can be developed in our republic and successfully applied in electric networks, first as an experiment, and then on a mass scale.

This method can significantly reduce the commercial losses caused by the theft of electricity by users and, as a result, enable the profitable operation of distribution networks.

#### Conclusions

Nowdays, due to the market economics conditions, the formation of electricity balance in

distribution networks, the structure of losses, including commercial losses, analysis, study, their reduction or complete elimination has become the main factor of profitability of networks.

1. The improvement of the billing and technical accounting systems of electric energy is carried out in order to increase the reliability of information about the structure of electric energy balances in electric networks, and to reduce commercial losses of electric energy. The most productive way to do this is to make maximum use of the possibilities of digital information technologies.

2. The use of UIN cables has led to the reduction of losses, including commercial losses, in all high and low voltage networks of our country, and increased the reliability and stability of overhead transmission lines. During the design of networks of areas freed from occupation, in general, in urban planning, it is appropriate to make extensive use of UT cables and direct transmission of electricity to apartments from the distribution box, according to clause 8.17 of the "Rules for the use of electricity", the upper limit of the consumption lost (stolen) by electric networks is that TM- should be limited by the amount of loss.

3. Proposed method to prevent electricity theft by using modern information technologies Energy theft can be effectively prevented by providing online information to authorities or structures by finding out where electricity theft occurs. The proposed system will send an automatic message with its location and a description of the area to the corresponding structure as soon as the difference between the currents exceeds the limit of the current through the appropriate software.

4. The issue of accounting and settlement of unregistered electricity between subjects of the electricity industry (power plants) and consumers remains unresolved. Under these circumstances, it is necessary to develop normative-methodical documents, as well as to make changes with normative legal acts, in order to determine the amount of consumed (stolen) electricity that is not accounted for.

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UNIPEDE - International Union of Producers and Distributors of Electrical Energy

## THE EFFICIENCY OF USING A SMART PASTURE

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### **Abstract**

Meat cattle breeding remains a weak link in Kazakhstan's animal husbandry. The main conditions for breeding specialized beef cattle are the availability of pastures for which there is a shortage of labour. Also, one of the problems is using fields in the old-fashioned way, which leads to severe degradation. Therefore, to develop recommendations for the development of new technologies in meat cattle breeding and solving the problems mentioned above, researchers of the S. Seifullin KATRU introduced a "Smart" pasture of their design in the North Kazakhstan Agricultural Experimental Station LLP of the Akkayyn district, North Kazakhstan region, which opens up opportunities for reducing labour-intensive work due to the shortage of agricultural equipment, workers (shepherds), reducing the degradation of pastures and increasing the weight gain of animals.

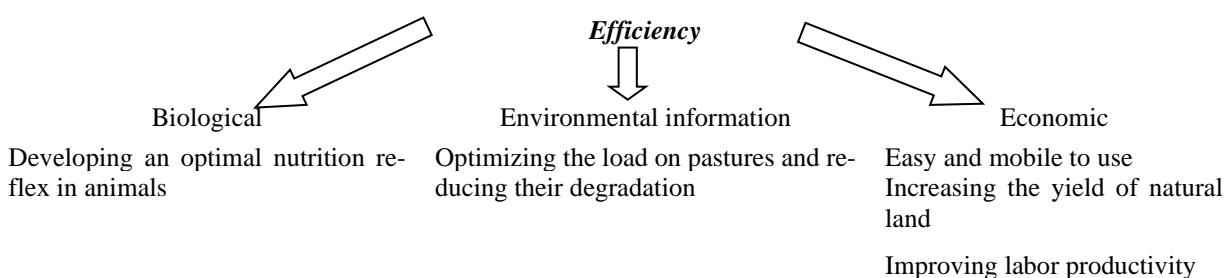
**Keywords:** pastures, economic efficiency, "Smart" pastures, pasture lands, farmers, beef cattle.

**Relevance.** There is a need for more pasture land in almost all regions of Kazakhstan. Based on the results of meetings of deputies with farmers, senators initiated and developed draft laws to resolve issues with pastures and more effective solutions to problems in this area. According to deputies, about 80% of the livestock is grazed on heavily degraded pastures within and around villages, which is about 21 million hectares. Today's estimated need for grazing livestock in a private farmstead is 50 million hectares, deficit-29 million hectares [1].

Where there are farm animals, pastures are used old-fashioned without applying scientific-based standards, rotation, coefficients of completeness of use, etc. The soil and vegetation cover is satisfactory, with no animals (non-watered pastures).

The question arises of how to change the situation in pasture areas, which are annually renewed with 23-25 million tons of feed unit feed resources. It is becoming clear that the farmers themselves, who use such land, should improve the condition of pastures along with administrative institutions of power. To do this, the land users must have the minimum knowledge that will allow them to maintain an ecological balance on the land plots used [2,3].

The way out of this situation is to improve the economic efficiency of fattening cattle by developing new production technologies, that is, using "Smart" pasture technologies, the effect of which is seen in the following scheme 1.



**Research results and discussion.** The study was conducted according to the data of "North Kazakhstan Agricultural Experimental Station" LLP in Akkayyn district, North Kazakhstan region.

From the total area of pastures of the farm, for organizing grazing by the corral (portion) method, the scientists of KATRU selected a separate section of the experimental "Smart" pasture with an area of 70 hectares, with seven corrals of an average of 10 hectares. The

pens were arranged in a petal shape with a separate single exit to the watering hole. The development was carried out according to the following concept:

1. Automatic livestock tracking;
2. Natural grazing of animals;
3. Control of drinking animals;
4. Remote control of live weight;
5. Automatic processing of animals;
6. Automatic accounting of forage capacity of pastures.

For the experiment, animals of 56 cows, three bulls and 44 calves were grazed alternately in paddocks. Sources of drinking water for livestock - a well

with a depth of 35 meters at a depth of 100 m. Here are the calculations for determining the cost, Figure 1.

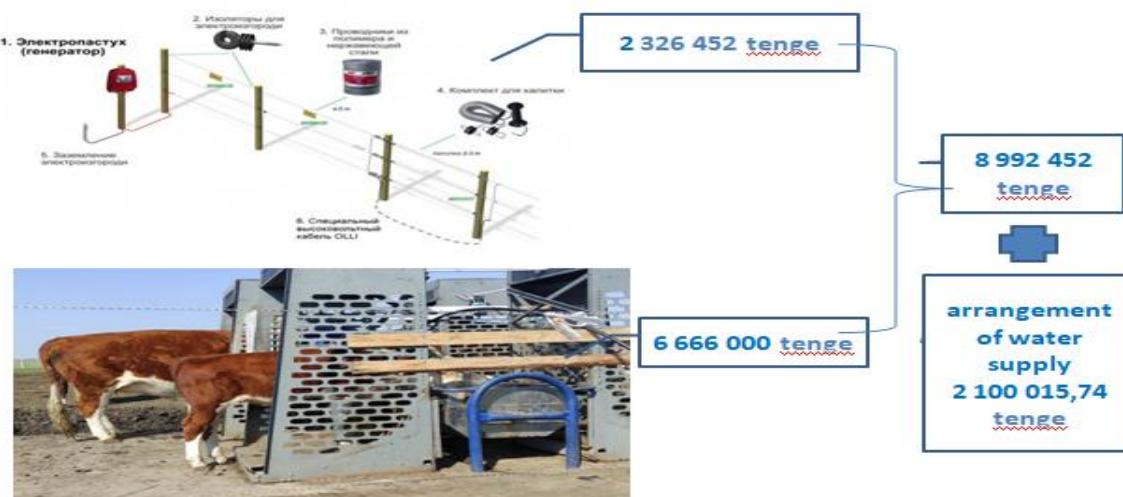


Figure 1. "Smart" pastures

Hence, the approximate cost of a smart pasture is 11,092,467. 74 tenge = (the cost of components is 8,992,452 tenge + the cost of preparation is 2,100,015. 74 tenge. It should be borne in mind that the cost may vary depending on prices and components, and the cost

does not include the cost of services of research workers. Costs per 1 ha/tenge (including the total pasture area of 70 ha) amounted to 158,463.8.

The economic feasibility of a "smart" pasture on the farm is shown in Table 1.

Table 1.

Economic efficiency of "Smart" pasture

Indicators	Technology		+.-
	Traditional	Smart pasture	
Number of employees engaged in grazing, people	4	2	-2
Average working hours, people/hour per month	1 080	540	- 540
Average monthly salary costs with deduction, thousand tenge	944,6	472,3	-472,3
Average daily weight gain, grams	720	850	+130

As you can see from the table, work is reduced to a minimum (there is no need to work all day). A worker's labour can only be used when changing the path of pasture or moving to a new one. Animals need to be watered and water updated daily, so two workers are enough since the worker will take a little time – up to an hour or a little longer, but not the whole working day. "Smart" pasture also solves the problem of a shortage of shepherds since no one wants to graze cattle in the country.

By avoiding daily grazing under the supervision of a shepherd, it is possible to recoup the costs of acquiring "Smart" pastures in a short time (by saving the wage

fund almost twice): The payback period will be  $PP=IC/CF= 2$  years.

Regardless of the area of pasture, the following advantages of "Smart" pastures can be distinguished:

The main advantage is associated with minimizing the cost of a human shepherd:

- If with traditional technology, ten or more employees were involved in sanitary work, and this whole procedure harmed the animal (the animal received stress, which led to weight loss), then with "Smart" pastures, these procedures are performed automatically and without stress for the animals. Therefore, it simplifies the implementation of preventive measures.



**Conclusion.** Low cost and fast payback. And even these costs can be reduced. A simple design of "Smart" pastures can be made independently – they make poles, buy metal mesh and wire, and use a solar station or a car battery as a power source from an economic point of view.

The easy-to-use kit is easy to reinstall when changing the boundaries of the pasture or switching to a new one from a technical point of view.

From an ecological point of view, efficiency is considered from the point of view that it becomes convenient for farmers to control the restoration of vegetation in the areas allocated for pasture. Livestock in the new place receives abundant food, and the correct distribution of fields solves the problem of measures for their degradation.

**Funding information.** This article was prepared within the framework of the project BR10865103, "Development and creation of scientifically based Smart

farms (herd horse breeding, meat cattle breeding) using various at least three digital solutions for each area of digitalization implementation for current production tasks of agribusiness entities and the formation of the necessary reference database for training employees of farms and peasant farms and transfer of digital knowledge to students studying."

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# MATHEMATICAL SCIENCES

UDC 659.1

## PLANE PROBLEM OF ELASTICITY THEORY FOR A CIRCULAR SECTOR, RADIAL SIDES OF WHICH INTERACT WITH ELASTIC STRINGER AND RIGID STAMP WITHOUT FRICTION. PART III.

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УДК 659.1

## ПЛОСКАЯ ЗАДАЧА ТЕОРИИ УПРУГОСТИ ДЛЯ КРУГОВОГО СЕКТОРА, РАДИАЛЬНЫЕ СТОРОНЫ КОТОРОГО ВЗАИМОДЕЙСТВУЮТ С УПРУГИМ СТРИНГЕРОМ И С ЖЕСТКИМ ШТАМПОМ БЕЗ ТРЕНИЯ. ЧАСТЬ III.

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### **Abstract**

With the help of the method of variables division, a plane problem of elasticity theory for the circular sector, when on the arc part of the contour radial displacement and tangential stresses are given, one radial side is in contact with the rigid stamp without friction, the other side is reinforced by elastic stringer, is solved. The characteristics of the stresses in the vicinity of the sector top and the coefficients behavior with the stress features are investigated. It is established, that the stated problem, depending on the angle opening of the sector, breaks down into separate independent problems

### **Annotation**

С помощью метода разделения переменных решена плоская задача теории упругости для кругового сектора, когда на дуговой части контура заданы радиальное перемещение и касательное напряжение, одна радиальная сторона соприкасается с жестким штампом без трения, другая сторона усиlena упругим стрингером. Исследованы сингулярности напряжений в окрестности вершины сектора и поведение коэффициентов при сингулярности напряжений. Установлено, что поставленная задача, в зависимости от угла раствора сектора, распадается на отдельные независимые задачи.

**Keywords:** elastic sector, rigid smooth stamp, elastic stringer, stress singularity, coefficients of singularities.

**Ключевые слова:** упругий сектор, жесткий штамп, упругий стрингер, особенность напряжений, коэффициенты особенности.

**Введение.** Исследование сингулярности напряжений в упругих телах с угловыми точками на контуре имеет важное теоретическое и, особенно, прикладное значение, т.к. оно тесно связано с проблемой обеспечения необходимой прочности и долговечности таких тел [1–7].

Определению характерных особенностей напряжений в окрестности вершины кругового сектора и поведение коэффициентов при особенностях напряжений, когда одна радиальная сторона соприкасается с жестким штампом без трения, вторая радиальная сторона взаимодействует с абсолютно жестким при растяжении и гибким при изгибе стрингером, а на дуговой части контура заданы хорошо известные граничные условия теории упругости, посвящены работы [8–11].

В работе [12] рассмотрено упругое равновесие кругового сектора, когда одна радиальная сторона соприкасается с жестким штампом без трения, вторая сторона усиlena упругим стрингером, а на ду-

вой части контура заданы нормальные и касательные напряжения. Установлено, что с учетом конечности энергии упругой деформации в малой окрестности вершины сектора подобные задачи следует исследовать в четырех областях изменения угла раствора кругового сектора  $\alpha$ : задача I  $(0 < \alpha \leq 2\pi)$ ; задача II  $(0 < \alpha \leq \pi/2)$ ; задача III  $(\pi/2 < \alpha \leq 3\pi/2)$ ; задача IV  $(3\pi/2 < \alpha \leq 2\pi)$ .

Показано, что задача не распадается на отдельные независимые задачи.

В работе [13] рассматривается упругое равновесие кругового сектора, когда при прочих одинаковых условиях из [12], на дуговой части контура заданы перемещения. Показано, что эта задача распадается на четыре отдельные независимые задачи.

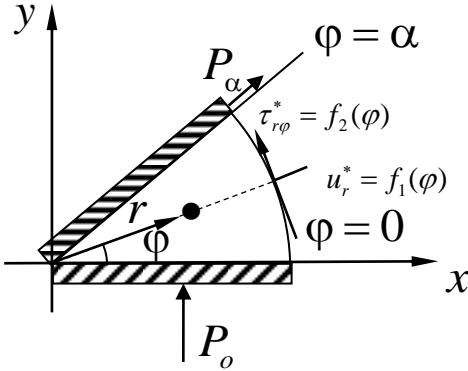
Возникает естественный вопрос: распадается ли задача об упругом равновесии кругового сектора, когда при прочих одинаковых условиях из

[12,13], на дуговой части контура заданы радиальное перемещение и касательное напряжение. Ответ на этот вопрос дает данная работа.

**Постановка и решение задачи.** Пусть упругий круговой сектор модуля упругости  $E$  и коэффициента Пуассона  $\nu$ , отнесенная, как показано на

$$\Delta \Phi^*(r, \varphi) = 0. \quad (1)$$

Границные условия данной задачи имеют вид



рисунке, к прямоугольной и полярной системам координат, находится в условиях обобщенного плоского напряженного состояния.

В полярной системе координат упругое состояние сектора определяется решением бигармонического уравнения для функции напряжения Эри

$$u_\varphi^*(r, 0) = \tau_{r\varphi}^*(r, 0) = 0, \quad (2)$$

$$u_r^*(r, \alpha) = br, \quad \sigma_\varphi^*(r, \alpha) = 0 \quad (3')$$

$$u_r^*(1, \varphi) = f_1(\varphi), \quad \tau_{r\varphi}^*(1, \varphi) = f_2(\varphi), \quad (4)$$

$$f_1(\alpha) = b, \quad f_2(0) = 0,$$

где  $f_j(\varphi)$  – функции из класса Дирихле,  $b$  – параметр, характеризующий упругость стрингера.

Границные условия (2) связаны с контактными задачами о вдавливании гладких штампов в упругое основание без трения [2], а условия (3) и (3') – с вопросами передачи нагрузок от тонкостенных элементов в виде стрингеров к упругим основаниям [14–15].

Учитывая граничные условия (3) и (3'), общее решение уравнения (1) с неоднородными граничными условиями (2) – (4) ищем в виде

$$\Phi^*(r, \varphi) = \Phi(r, \varphi) + \tilde{\Phi}(r, \varphi),$$

$$\Phi(r, \varphi) = r^{\lambda+1} [A \sin(\lambda+1)\varphi + B \cos(\lambda+1)\varphi + C \sin(\lambda-1)\varphi + D \cos(\lambda-1)\varphi], \quad (5)$$

$$\tilde{\Phi}(r, \varphi) = r^2 (G_1 + G_2 \cos 2\varphi),$$

где  $\tilde{\Phi}(r, \varphi)$  – частное решение неоднородной задачи (1), (2) – (4),  $\Phi(r, \varphi)$  – общее решение соответствующей однородной задачи;  $A, B, C, D, \lambda, G_1, G_2$  – произвольные постоянные.

Напряжения и перемещения выражаются через функции  $\Phi^*(r, \varphi)$  в виде

$$\begin{aligned} \sigma_\varphi^* &= \lambda(\lambda+1)r^{\lambda-1} [AS_\varphi^+ + BC_\varphi^+ + CS_\varphi^- + DC_\varphi^-] + 2(G_1 + G_2 \cos 2\varphi), \\ \sigma_r^* &= -r^{\lambda-1} [A\lambda^+\lambda S_\varphi^+ + B\lambda^+\lambda C_\varphi^+ + C(3-\lambda)\lambda S_\varphi^- + D(3-\lambda)\lambda C_\varphi^-] + 2(G_1 - G_2 \cos 2\varphi), \\ \tau_{r\varphi}^* &= -\lambda r^{\lambda-1} [A\lambda^+ C_\varphi^+ - B\lambda^+ S_\varphi^+ + C\lambda^- C_\varphi^- - D\lambda^- S_\varphi^-] + 2G_2 \sin 2\varphi, \end{aligned} \quad (6)$$

$$Eu_r^* = r^\lambda [-A\lambda^+ \nu^+ S_\varphi^+ - B\lambda^+ \nu^+ C_\varphi^+ + C(4-\lambda^+ \nu^+) S_\varphi^- + D(4-\lambda^+ \nu^+) C_\varphi^-] + 2r(G_1 \nu^- - G_2 \nu^+ \cos 2\varphi),$$

$$Eu_\varphi^* = r^\lambda [-A\lambda^+ \nu^+ C_\varphi^+ + B\lambda^+ \nu^+ S_\varphi^+ - C(4+\lambda^- \nu^+) C_\varphi^- + D(4+\lambda^- \nu^+) S_\varphi^-] + 2rG_2 \nu^+ \sin 2\varphi,$$

$$\text{где } \lambda^\pm = \lambda \pm 1, \quad \nu^\pm = 1 \pm \nu, \quad S_\varphi^\pm = \sin(\lambda \pm 1)\varphi, \quad C_\varphi^\pm = \cos(\lambda \pm 1)\varphi.$$

Как следует из (6), напряжения при  $0 < \operatorname{Re} \lambda < 1$  будут обладать у вершины кругового сектора сингулярностью (напряжения стремятся к бесконечности) порядка  $(1 - \operatorname{Re} \lambda)$ .

Очевидно, что параметр  $b$  в правой части граничного условия (3) не меняет порядок особенности напряжений в окрестности вершины сектора. Коэффициенты при особенностях, естественно, зависят и от этого параметра.

Из требования удовлетворения функции  $\tilde{\Phi}(r, \varphi)$  неоднородным граничным условиям (3) и (3'), для неизвестных постоянных  $G_1$  и  $G_2$  получим

$$G_1 = bE/4, \quad G_2 = -bE/4 \cos 2\alpha, \quad \alpha \neq k\pi/4 \quad (k = 1, 3, 5, 7) \quad (7)$$

В случае  $\alpha = k\pi/4$  ( $k = 1, 3, 5, 7$ ) параметр  $b = 0$ .

Удовлетворяя граничным условиям (2) – (4), для определения произвольных постоянных  $A, B, C, D$  получим однородную систему линейных уравнений

$$\begin{aligned} \lambda^+ A + \lambda^- C &= 0, \quad \lambda^+ v^+ A + (\lambda^- v^+ + 4)C = 0, \\ S_\alpha^+ A + C_\alpha^+ B + S_\alpha^- C + C_\alpha^- D &= 0, \\ -\lambda^+ v^+ S_\alpha^+ A - \lambda^+ v^+ C_\alpha^+ B + (4 - \lambda^+ v^+) S_\alpha^- C + (4 - \lambda^+ v^+) C_\alpha^- D &= 0. \end{aligned} \quad (8)$$

Следовательно, нахождение функций  $\Phi^*(r, \varphi)$  для рассматриваемой задачи приведено к определению функций  $\Phi(r, \varphi)$  для задачи, рассмотренной в работе [12,13].

*Т.е., задача упругого струнгера приведена к соответствующей задаче абсолютно жесткого при растяжении и гибкого при изгибе струнгера.*

Из системы (8) следует  $A = C = 0$  и тригонометрическое уравнение

$$\cos(\lambda + 1)\alpha \cdot \cos(\lambda - 1)\alpha = 0,$$

действительные и простые корни которого имеют следующий вид

$$\lambda_k = \alpha_0(2k+1)+1, \quad \tilde{\lambda}_n = \alpha_0(2n+1)-1, \quad \alpha_0 = \pi/2\alpha, \quad (k, n) = 0, \pm 1, \pm 2, \dots \quad (9)$$

Условие конечности энергии упругой деформации в малой окрестности вершины кругового сектора накладывает на корни (9) ограничения

$$\lambda_k > 0, \quad \tilde{\lambda}_n > 0, \quad (10)$$

которые, в зависимости от угла раствора кругового сектора  $\alpha$ , ограничивают область изменения параметров  $k$  и  $n$ :

I. при  $0 < \alpha < 2\pi$  имеем  $k = 0, 1, 2, \dots; n = 2, 3, 4, \dots$

II. при  $0 < \alpha < \pi/2$  имеем  $k = 0, 1, 2, \dots; n = 0, 1, 2, \dots$

III. при  $\pi/2 < \alpha < 3\pi/2$  имеем  $k = -1, 0, 1, \dots; n = 1, 2, 3, \dots$

IV. при  $3\pi/2 < \alpha < 2\pi$  имеем  $k = -2, -1, 0, \dots; n = 2, 3, 4, \dots$

Учитывая, что функции вида

$$\Phi_{kn}(r, \varphi) = D_k r^{\lambda_k+1} \cos(\lambda_k - 1)\varphi + B_n r^{\tilde{\lambda}_n+1} \cos(\tilde{\lambda}_n + 1)\varphi$$

удовлетворяют уравнению (1) и граничным условиям (2) и (3), функция напряжения Эри для всех четырех случаев принимает вид

$$\Phi^*(r, \varphi) = \begin{cases} a = 0 \\ a = 0 \\ a = -1 \\ a = -2 \end{cases} \sum_{k=0}^{\infty} \left[ D_k r^{\lambda_k+1} + B_k r^{\tilde{\lambda}_k+1} \right] \cos \alpha_0(2k+1)\varphi + \frac{bE}{4} r^2 \left( 1 - \frac{\cos 2\varphi}{\cos 2\alpha} \right),$$

причем, здесь и далее  $B_0 = B_1 = 0$  для задачи I;  $B_{-1} = B_0 = 0$  для задачи III;

$B_{-2} = B_{-1} = B_0 = B_1 = 0$  для задачи IV.

Компоненты напряжений, соответствующие этой функции, будут иметь вид

$$\begin{aligned} \begin{cases} \sigma_{\varphi I}^* \\ \sigma_{\varphi II}^* \\ \sigma_{\varphi III}^* \\ \sigma_{\varphi IV}^* \end{cases} &= \begin{cases} a = 0 \\ a = 0 \\ a = -1 \\ a = -2 \end{cases} \sum_{k=a}^{\infty} \left[ D_k \lambda_k (\lambda_k + 1) r^{\lambda_k-1} + B_k \tilde{\lambda}_k (\tilde{\lambda}_k + 1) r^{\lambda_k-1} \right] \cos \alpha_0(2k+1)\varphi + \\ &+ \frac{bE}{2} \left( 1 - \frac{\cos 2\varphi}{\cos 2\alpha} \right), \end{aligned} \quad (11)$$

$$\begin{cases} \tau_{r\varphi I}^* \\ \tau_{r\varphi II}^* \\ \tau_{r\varphi III}^* \\ \tau_{r\varphi IV}^* \end{cases} = \begin{cases} a=0 \\ a=0 \\ a=-1 \\ a=-2 \end{cases} \sum_{k=a}^{\infty} \left[ D_k \lambda_k (\lambda_k - 1) r^{\lambda_k - 1} + B_k \tilde{\lambda}_k (\tilde{\lambda}_k + 1) r^{\tilde{\lambda}_k - 1} \right] \sin \alpha_0 (2k+1) \varphi + \\ + \frac{bE}{2} \left( \frac{\sin 2\varphi}{\cos 2\alpha} \right), \quad (12)$$

$$\begin{cases} \sigma_{rl}^* \\ \sigma_{rII}^* \\ \sigma_{rIII}^* \\ \sigma_{rIV}^* \end{cases} = \begin{cases} a=0 \\ a=0 \\ a=-1 \\ a=-2 \end{cases} \sum_{k=a}^{\infty} \left[ D_k \lambda_k (3 - \lambda_k) r^{\lambda_k - 1} - B_k \tilde{\lambda}_k (\tilde{\lambda}_k + 1) r^{\tilde{\lambda}_k - 1} \right] \cos \alpha_0 (2k+1) \varphi + \\ + \frac{bE}{2} \left( 1 + \frac{\cos 2\varphi}{\cos 2\alpha} \right). \quad (13)$$

$$E \begin{cases} u_{rl}^* \\ u_{rII}^* \\ u_{rIII}^* \\ u_{rIV}^* \end{cases} = - \begin{cases} a=0 \\ a=0 \\ a=-1 \\ a=-2 \end{cases} \sum_{k=a}^{\infty} \left[ D_k (\lambda_k^+ v^+ - 4) r^{\lambda_k} + B_k \lambda_k^- v^+ r^{\tilde{\lambda}_k} \right] \cos \alpha_0 (2k+1) \varphi + \\ + \frac{bE}{2} \left( v^- + v^+ \frac{\cos 2\varphi}{\cos 2\alpha} \right) r, \quad (14)$$

$$E \begin{cases} u_{\varphi I}^* \\ u_{\varphi II}^* \\ u_{\varphi III}^* \\ u_{\varphi IV}^* \end{cases} = \begin{cases} a=0 \\ a=0 \\ a=-1 \\ a=-2 \end{cases} \sum_{k=a}^{\infty} \left[ D_k (\lambda_k^- v^+ + 4) r^{\lambda_k} + B_k \lambda_k^- v^+ r^{\tilde{\lambda}_k} \right] \sin \alpha_0 (2k+1) \varphi - \frac{bE}{2} v^+ \frac{\sin 2\varphi}{\cos 2\alpha} r. \quad (15)$$

Удовлетворяя граничным условиям (4) для  $D_k$  и  $B_k$  получим систему уравнений

$$\begin{cases} a=0 \\ a=0 \\ a=-1 \\ a=-2 \end{cases} \sum_{k=a}^{\infty} \left[ D_k (\lambda_k^+ v^+ - 4) + B_k \lambda_k^- v^+ \right] \cos \alpha_0 (2k+1) \varphi = -E f_1^*(\varphi), \\ \begin{cases} a=0 \\ a=0 \\ a=-1 \\ a=-2 \end{cases} \sum_{k=a}^{\infty} \left[ D_k \lambda_k (\lambda_k - 1) - B_k \tilde{\lambda}_k (\tilde{\lambda}_k + 1) \right] \sin \alpha_0 (2k+1) \varphi = f_2^*(\varphi), \quad (16)$$

$$f_1^*(\varphi) = f_1(\varphi) - \frac{bE}{2} \left( v^- + v^+ \frac{\cos 2\varphi}{\cos 2\alpha} \right) r, \quad f_2^*(\varphi) = f_2(\varphi) + \frac{bE}{2} v^+ \frac{\sin 2\varphi}{\cos 2\alpha} r.$$

Для решения подобных систем уравнений в работе [13] показано, что система функций  $\left\{ \sin \left( \frac{2n+1}{2} \vartheta \right) \right\}_{n=1}^{\infty}$  полна и ортогональна в пространстве  $L_2(0, \pi)$ . Аналогичные соотношения имеет место и для косинусов.

Тогда, умножая первое уравнение на  $\cos \alpha_0(2m+1)\varphi$ , а второе – на  $\sin \alpha_0(2m+1)\varphi$ , интегрируя по  $\varphi$  в интервале  $(0, \alpha)$ , для всех четырех случаев находим неизвестные постоянные  $D_k$  и  $B_k$ .

*Задача I.*

$$\begin{aligned} D_0 &= -\frac{2}{\alpha} \frac{E \tilde{f}_{10}^*}{\lambda_0^+ v^+ - 4} = \frac{2}{\alpha} \frac{\tilde{f}_{20}^*}{\lambda_0(\lambda_0 - 1)}, \quad D_1 = -\frac{2}{\alpha} \frac{E \tilde{f}_{11}^*}{\lambda_1^+ v^+ - 4} = \frac{2}{\alpha} \frac{\tilde{f}_{21}^*}{\lambda_1(\lambda_1 - 1)}, \\ D_k &= -\frac{1}{\alpha} \frac{E(3 - \lambda_k) \tilde{f}_{1k}^* + v^+ \tilde{f}_{2k}^*}{(v^- - 2\lambda_k^-)}, \quad B_k = \frac{1}{\alpha} \frac{E \lambda_k \lambda_k^- \tilde{f}_{1k}^* + (\lambda_k^+ v^+ - 4) \tilde{f}_{2k}^*}{\lambda_k^- (v^- - 2\lambda_k^-)}, \quad (k = 2, 3, 4, \dots), \\ \tilde{f}_{1k}^* &= \int_0^\alpha f_1^*(\varphi) \cos \alpha_0(2k+1)\varphi d\varphi, \quad \tilde{f}_{2k}^* = \int_0^\alpha f_2^*(\varphi) \sin \alpha_0(2k+1)\varphi d\varphi, \quad (k = 0, 1, 2, \dots). \end{aligned} \quad (17)$$

При этом между функциями  $f_1^*(\varphi)$  и  $f_2^*(\varphi)$  возникают соотношения

$$E\lambda_0(\lambda_0 - 1) \tilde{f}_{10}^* + (\lambda_0^+ v^+ - 4) \tilde{f}_{20}^* = 0, \quad E\lambda_1(\lambda_1 - 1) \tilde{f}_{11}^* + (\lambda_1^+ v^+ - 4) \tilde{f}_{21}^* = 0. \quad (18)$$

*Задача II.* В данном случае для  $D_k$  и  $B_k$  ( $k = 0, 1, 2, \dots$ ) получаются те же формулы.

$$\begin{aligned} \text{Задача III. } D_{-1} &= -\frac{1}{\alpha} \frac{E\lambda_0(\lambda_0 - 1) \tilde{f}_{10}^* + (\lambda_0^+ v^+ - 4) \tilde{f}_{20}^*}{(v^+ - 4)(\lambda_0 - 1)^2}, \quad D_0 = -\frac{1}{\alpha} \frac{E\lambda_{-1}(\lambda_{-1} - 1) \tilde{f}_{10}^* - (\lambda_{-1}^+ v^+ - 4) \tilde{f}_{20}^*}{(v^+ - 4)(\lambda_{-1} - 1)^2}, \\ D_k &= -\frac{1}{\alpha} \frac{E(\lambda_k - 3) \tilde{f}_{1k}^* + v^+ \tilde{f}_{2k}^*}{(v^- - 2\lambda_k^-)}, \quad B_k = \frac{1}{\alpha} \frac{E \lambda_k \lambda_k^- \tilde{f}_{1k}^* + (\lambda_k^+ v^+ - 4) \tilde{f}_{2k}^*}{\lambda_k^- (v^- - 2\lambda_k^-)}, \quad (k = 1, 2, 3, \dots). \end{aligned} \quad (19)$$

$$\begin{aligned} \text{Задача IV. } D_{-2} &= -\frac{1}{\alpha} \frac{E\lambda_1\lambda_1^- \tilde{f}_{11}^* + (\lambda_1^+ v^+ - 4) \tilde{f}_{21}^*}{9\alpha_0^2(v^+ - 4)}, \quad D_1 = -\frac{1}{\alpha} \frac{E\lambda_{-2}\lambda_{-2}^- \tilde{f}_{11}^* - (\lambda_{-2}^+ v^+ - 4) \tilde{f}_{21}^*}{9\alpha_0^2(v^+ - 4)}, \\ D_{-1} &= -\frac{1}{\alpha} \frac{E\lambda_0\lambda_0^- \tilde{f}_{10}^* + (\lambda_0^+ v^+ - 4) \tilde{f}_{20}^*}{\alpha_0^2(v^+ - 4)}, \quad D_0 = -\frac{1}{\alpha} \frac{E\lambda_{-1}\lambda_{-1}^- \tilde{f}_{10}^* - (\lambda_{-1}^+ v^+ - 4) \tilde{f}_{20}^*}{\alpha_0^2(v^+ - 4)}, \end{aligned} \quad (20)$$

$D_k$  и  $B_k$  ( $k = 2, 3, 4, \dots$ ) имеют вид (17).

Таким образом, решение данной задачи получено в виде сходящихся рядов (11) – (14), коэффициенты которых определены в явном виде.

Теперь с помощью формул (10–17) исследуем характерные особенности напряжений и коэффициентов при особенностях напряжений в окрестности вершины кругового сектора.

*Задача I.*  $0 < \alpha \leq 2\pi$ ;  $k = 0, 1, 2, \dots$ ;  $n = 2, 3, 4, \dots$ . Как следует из (11) – (13) окрестность вершины сектора ( $r \rightarrow 0$ ) находится в малонапряженном состоянии – МС [5] (напряжения стремятся к нулю), если  $\alpha < 5\pi/4$  ( $k = 2$ ). А когда  $\alpha > 5\pi/4$ , то напряжения стремятся к бесконечности (в малой окрестности вершины имеет место концентрационное состояние – КС [5]). В предельном случае  $\alpha_{np} = 5\pi/4$  напряжения в окрестности вершины сектора конечны и вообще отличны от нуля.

Порядок особенности напряжений  $1 - \tilde{\lambda}_k = 2 - \alpha_0(2k+1)$  изменяется в пределах

$$0 < 1 - \tilde{\lambda}_k \leq 3/4 \quad (k = 2), \quad 0 < 1 - \tilde{\lambda}_k \leq 1/4 \quad (k = 3),$$

а коэффициенты при таких особенностей напряжений в случае нагружения дуговой части контура сектора условиями, удовлетворяющие соотношениям (15), отличны от нуля.

При  $k = 3$  возникает второй предельный угол  $\alpha_{np} = 7\pi/4$ . Если функции  $f_1(\varphi)$  и  $f_2(\varphi)$  таковы, что коэффициент  $B_2$  становится равным нулю, основной предельный угол будет  $\alpha_{np} = 7\pi/4$ .

С учетом соотношений (18) уравнения статики для сектора удовлетворяются.

*Задача II.*  $0 < \alpha < \pi/2$ ;  $k = 0, 1, 2, \dots$ ;  $n = 0, 1, 2, \dots$ . Здесь предельный угол  $\alpha_{np} = \pi/4$ . Если  $0 < \alpha < \pi/4$ , вблизи вершины сектора имеет место МС, а при  $\pi/4 < \alpha < \pi/2$  – КС ( $k = 0$ ). Причем, в зависимости от угла  $\alpha$ , порядок особенности напряжений  $1 - \tilde{\lambda}_k = 2 - \alpha_0$  изменяется в пределах  $0 < 2 - \alpha_0 < 1$ . Коэффициенты при этой особенности в общем случае нагружения дуговой части контура

сектора отличен от нуля, так как в данной задаче отсутствуют условия (18). Когда  $\alpha \rightarrow \pi/2$ , хотя порядок особенности напряжений стремится к единице, коэффициент при этой особенности стремится к нулю. А это означает, что в решениях (11) – (13) исчезают слагаемые с "неинтегрируемыми" особенностями напряжений типа  $r^{-1+\varepsilon}$  ( $\varepsilon \rightarrow 0$  при  $\alpha \rightarrow \pi/2$ ), которые с точки зрения хрупкого разрушения материала недопустимы [1–4]. Уравнения статики для кругового сектора удовлетворяются автоматически.

**Задача III.**  $\pi/2 < \alpha < 3\pi/2$ ;  $k = -1, 0, 1, \dots$ ;  $n = 1, 2, 3, \dots$  И в этой задаче отсутствуют условия (15). Здесь имеем две предельные углы:  $\alpha_{np} = 3\pi/4$  при  $k = 1$  и  $\alpha_{np} = 5\pi/4$  при  $k = 2$ . Порядок особенности напряжений обусловлены как первыми членами формул (11) – (13), содержащими множитель  $r^{-\alpha_0}$  ( $k = -1$ ), так и соответствующими членами рядов (11) – (13) с множителями  $r^{\tilde{\lambda}_k-1}$  при  $k = 1, k = 2$ , причем

$$1/3 \leq \alpha_0 < 1 \quad (k = -1), \quad 0 < 1 - \tilde{\lambda}_k < 1 \quad (k = 1), \quad 0 < 1 - \tilde{\lambda}_k \leq 1/3 \quad (k = 2).$$

И в этом случае, когда  $\alpha \rightarrow 3\pi/2$ , порядок сингулярности напряжений стремится к единице, а коэффициенты при такой сингулярности стремятся к нулю. Уравнения статического равновесия удовлетворяются тождественно.

**Задача IV.**  $3\pi/2 < \alpha \leq 2\pi$ ;  $k = -2, -1, 0, \dots$ ;  $n = 2, 3, 4, \dots$  Здесь также отсутствуют условия (18). Предельный угол  $\alpha_{np} = 7\pi/4$ . Особенность напряжений обусловлены первыми двумя членами с множителями  $r^{-3\alpha_0}$  и  $r^{-\alpha_0}$ , причем

$$3/4 \leq 3\alpha_0 < 1 \quad (k = -2), \quad 1/4 \leq \alpha_0 \leq 1/3 \quad (k = -1)$$

и соответствующими членами рядов (11) – (13)

$$1/3 \leq 1 - \tilde{\lambda}_k \leq 3/4 \quad (k = 2), \quad 3/2\pi \leq \alpha \leq 2\pi; \quad 0 < 1 - \tilde{\lambda}_k \leq 1/4 \quad (k = 3), \quad 7/4\pi \leq \alpha \leq 2\pi.$$

Коэффициенты при таких особенностей отличны от нуля.

И здесь уравнения статического равновесия удовлетворяются без учета соотношений (18).

Следовательно, задача (1) – (4) распадается на четыре отдельные независимые задачи I, II, III, IV. Этот результат существенно отличается от той, который был получен в работе [12], где на дуговой части контура сектора были заданы внешние усилия, при тех же граничных условиях на радиальных сторонах.

По поводу параметра  $b$  отметим следующее: в работе [12] установлено, что этот параметр в задачах I – IV зависит от угла раствора сектора  $\alpha$  и от первых двух коэффициентов Фурье функции  $f_1(\varphi)$  и  $f_2(\varphi)$ . Здесь только в задаче I этот параметр имеет аналогичную зависимость, а в задачах II – IV параметр  $b$  – любое действительное число.

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# PHILOLOGICAL SCIENCES

## HISTORICITY AND FICTIONAL TRUTH IN YOHANES BOBROVSKY AND FARMAN KARIMZADEH'S CREATIVITY

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## HISTORIZITÄT UND KÜNSTLERISCHE WAHRHEIT IN DEN WERKEN VON JOHANNES BOBROVSKY UND FARMAN KARIMZADE

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### **Abstract**

In the article, the historical and fictional truth in the works of Y. Bobrovsky and F. Karimzade is studied together with facts and the writers' imagination, the analyzed heroes of the novel are presented as real historical figures, as well as the author's imagination. Just as I. Bobrovsky managed to depict the real picture of the truths about German history and German life, F. Karimzade revives Shah Ismail Khatai both through the eyes of historical sources and through artistic imagination, showing him as the founder of the Azerbaijani state, a wise statesman, and a talented poet.

### **Abstrakt**

In dem Artikel werden die Historizität und künstlerische Wahrheit in den Werken von J. Bobrovsky und F. Karimzade zusammen mit den Fakten und der Fantasie des Schriftstellers untersucht. Die Helden des analysierten Romans sind reale historische Figuren, aber auch ein Produkt der Fantasie des Autors. J. Bobrovsky schafft ein reales Bild der Wahrheit der deutschen Geschichte und des deutschen Lebens. Der aserbaidschanische Schriftsteller F. Kerimzade lässt das Leben von Schah Ismail Khatai sowohl aus historischen Quellen als auch durch künstlerische Vorstellungskraft wieder auflieben und zeigt ihn als Gründer des aserbaidschanischen Staates, als weisen Staatsmann und als talentierten Dichter.

**Keywords:** Bobrovsky, Karimzade, Historicity and Fictional Truth, Novel

**Schlüsselwörter:** Bobrovsky, Karimzadeh, Historizität und Geschichtlichkeit, Roman

Es gibt Schriftsteller in der deutschen Literatur, die über Völker schreiben, die von der Bühne der Geschichte verschwunden sind, die universelle menschliche Werte und humanistische Gedanken vermitteln und ein Gefühl des Mitgefühls widerspiegeln. Einer dieser Schriftsteller ist Johannes Bobrovsky, der in Ostdeutschland lebte und arbeitete. J. Bobrovsky, der mit der Idee lebte, dass sein ganzes Schaffen menschliche Liebe ist, alle moralischen Werte der Welt für einen Menschen gelten, wenn es keine Liebe gibt, dann gibt es keinen Menschen, lebte ein kurzes Leben und starb früh. J. Bobrovsky, der seine Arbeit mit der Poesie begann, ist im In- und Ausland als Prosaschriftsteller bekannt [8, s.39].

J. Bobrovsky ist einer der Schöpfer des historischen Romans neuen Inhalts in der deutschen Literatur. Seine Werke werden im gesamten Deutschland geschätzt, das zum Zeitpunkt des Schreibens zweigeteilt war und gelten als gelungener Schritt zur Neubesinnung nationaler Kulturtraditionen [7, s.16]. Seit den 60er Jahren des letzten Jahrhunderts

ist das Hauptkonzept von J. Bobrovskys Werk die Synthese von Tradition und Moderne, die Suche nach verschiedenen Stilen, die Verwendung der Folklore der deutschen und slawischen Völker. Im Roman „Levins Mühle“ bezieht sich der Autor auf reale Ereignisse in Deutschland und schafft es, ein reales Bild des 19. Jahrhunderts zu „schreiben“. In diesem Werk gelingt es J. Bobrovsky, den Zeitgeist, das Volksleben, den Volksalltag durch das künstlerische Wort zu vermitteln. Mit anderen Worten: In Levin's Mill gelingt es dem Autor, tiefgründige Wahrheiten über die deutsche Geschichte und das deutsche Leben ans Licht zu bringen. Mit der Beschreibung des Grenzgebiets zwischen Deutschland und Polen dringt J. Bobrovsky in die innersten Tiefen der Geschichte ein und beschreibt sie im großen Stil.

Vor dem Hintergrund der Ereignisse in einem kleinen Dorf an der deutsch-polnischen Grenze schreibt er über die „große Geschichte“ und zeigt sie mit realen Bildern. Der Autor stellt das Leben des Volkes in den Vordergrund, betont, dass die wichtigste und

bestimmende Tatsache in der deutschen Realität nicht das offizielle Deutschland, sondern das Volk sei. Mit anderen Worten: Das Konzept des Volkes im Roman wird als deutsche Realität gepriesen. Im Werk von J. Bobrovsky erwacht die Nation als majestätisches Bild zum Leben. Laut dem Autor ist die wahre "Stimme" Deutschlands das deutsche Volk. Der Wunsch des Schriftstellers, historische Wahrheiten neu zu schreiben und sie der jüngeren Generation zu vermitteln, beruhte auf der Tatsache, dass die Deutschen keine Schlussfolgerungen aus ihrer eigenen Geschichte ziehen konnten. Laut J. Bobrovsky, der die jüngste Vergangenheit des deutschen Volkes künstlerisch umgeschrieben hat, besteht der einzige richtige Weg darin, die Vergangenheit der Deutschen zu verstehen und die Zukunft durch das Prisma von heute zu betrachten. Im gesamten Werk versucht der Autor die Idee zu betonen, dass es notwendig ist, Rassismus gegenüber einer anderen Nation zu vermeiden und sich von der Idee der Überlegenheit der deutschen Rasse fernzuhalten [4, s.158].

Wie er selbst sagte, ist J. Bobrovsky ein Schriftsteller, der in der deutschen Literatur "eine lange Geschichte von Beziehungen, Unglück und Sünden zwischen den Deutschen und ihren östlichen Nachbarn" [2, s.31] definiert. Die Hauptrichtung der Arbeit des Autors sind die Themen, die sich aus den Erfahrungen des Zweiten Weltkriegs ergeben. Der Schriftsteller nahm an diesem Krieg teil, befand sich lange Zeit in Gefangenschaft und konnte später in die DDR zurückkehren. Aber auch die Stadt Tilsit in Ostpreußen, in der er geboren und aufgewachsen ist, spielte eine große Rolle in der Entwicklung von Y. Bobrovskys Schaffen. Der Autor selbst schrieb: "Ich bin am Ufer der Memel (heute auf Deutsch Neman genannt) aufgewachsen, wo Polen, Deutsche, Litauer und mit ihnen vermischt Juden Seite an Seite lebten" [2, s.23]. Der Schriftsteller verbrachte seine Kindheit am Ufer des Flusses Neman in Litauen, im Herrenhaus seines Großvaters. Antike römische Historiker nannten diese polnisch-litauischen Regionen des baltischen Sarmatiens und seiner Bewohner Sarmaten und die Ostsee Sarmatisches Meer. Es ist kein Zufall, dass J. Bobrovskys erstes Buch „Sarmatian Epoche“ heißt. Sarmatien – für Y. Bobrovsky bedeutet Erinnerung, Geschichte, Wurzeln, Vorfahren, besondere Mythologie. Dieses Land ist ein Symbol des Zusammenlebens, ein Treffpunkt für Völker, Kulturen und verschiedene Sprachen. Diese Länder sind auch der Ort, an dem die Deutschen Ritter die Kreuzzüge unternahmen, um die osteuropäischen Völker zu erobern. Religionskriege, die das Christentum verbreiteten und die vom Erdboden ausgelöschten sarmatischen Stämme haben den Autor immer zum Nachdenken gebracht. Höchstwahrscheinlich stehen deshalb in seinem Schaffen Respekt und Liebe für die zerstörten und unterdrückten Kleinvölker im Vordergrund. Eines der schönsten Werke von Y. Bobrovsky, das seine Weltanschauung zum Ausdruck bringt, ist der Roman „Levins Mühle“, der anschaulich zeigt, dass Völker Seite an Seite leben, Freunde finden und sich gegen den Feind vereinen können. Einer der Helden des Werkes ist der Anführer der Nationalisten, Großvater

Bobrovsky. Großvater kämpft gegen innere Feinde – Polen, Juden, Zigeuner, und der Klerus, das Gericht und die Polizei sind mit ihm verbündet. Diese Ereignisse finden im ersten Teil des Romans statt und der Leser lernt das kaiserliche Deutschland und die Ereignisse in seinen Territorien kennen. Der zweite Teil des Romans behandelt die Zeit Ostpreußens, die Jahre des nationalsozialistischen Deutschlands. Anhänger des Dritten Reiches „jagen“ nun nach ausländischen Feinden und bereiten sich auf die Besetzung der Ostgebiete vor.

Der Autor spricht über das deutsche Regierungssystem, das Schicksal der wenigen Völker, die von diesem System abhängig sind und in diesen Gebieten leben, und beschreibt Geschichten aus dem wirklichen Leben vor dem Hintergrund der Geschichte. Die "Oberen" tun ihr Bestes, um den Mythos vom "echten Deutschen" zum Leben zu erwecken, die "deutschen Rechte" wiederherzustellen und wollen sowohl Deutschland als auch die angrenzenden Gebiete unter vollständiger Kontrolle halten. Um ihre Wünsche zu erfüllen, bedrohen sie Menschen, erschrecken sie, töten sie und "kaufen" sie notfalls für Geld. Anhänger des Dritten Reiches hassen jeden, der kein "echter Deutscher" ist, darunter Polen, Litauer, Juden und sogar die ihnen nahestehenden Deutschen. Feindseligkeit ist für die lokale Bevölkerung, die sich den "Auserwählten" widersetzt, inakzeptabel, sie leben seit Jahrhunderten zusammen, sind Freunde, lieben sich und gründen Familien, wie ihre Vorfahren. Das vom Autor beschriebene nationale Leben ist die Solidarität und das Zusammenleben verschiedener Völker. Der Jude Levin liebt die Zigeunerin Marie und der Litauer Poshke liebt das deutsche Tutu.

Im Roman Levins Mühle wendet sich der Autor der Geschichte Deutschlands zu, schreibt historische Fakten nieder, beschreibt die Atmosphäre der damaligen Zeit in realen Bildern. Man kann jedoch sagen, dass der Autor seine Fantasie zu realen Ereignissen in der Geschichte hinzufügt, die Geschichte erhält eine künstlerischere, magischere Form als eine reale Beschreibung. Folklorehandlungen, insbesondere die Verdrängung von Märchen und Mythen, stellen den Roman in einen historischen und mythologischen Kontext. Das von J. Bobrovsky geschaffene Bild eines Deutschen polnischer Herkunft verkörpert die deutsche Macht und repräsentiert die Persönlichkeit eines „echten Deutschen“. Er macht dem Juden Levi das Leben schwer, nimmt ihm die Mühle, die für ihn und die armen Bauern der einzige Ort der Hoffnung ist, und macht seine deutsche Nationalidentität zu einer Quelle des "Handels" und nutzt sie gegen Menschen anderer Nationalitäten: "Der Großvater war ein reiner Deutscher, er hat alle seine deutschen "Verwandten" in den Prozess einbezogen. Und es kommt dazu, dass Levin alles verliert und gezwungen ist, sein Schicksal zu akzeptieren" [2, s.54]. Er nutzt seine nationale Identität überall als "echter Deutscher" aus und verhält sich gnadenlos und grausam gegenüber Juden, Polen, Zigeunern und anderen nationalen Minderheiten: "Geh, Jude, krieche zum Gericht... Wir sind Deutsche, falls du es noch nicht verstanden hast" [3, s.38].

Ein halbes Jahrhundert später zeigt der Autor in einem Gestalt eines alten Deutschen anschaulich die Ursachen und Quellen des deutschen Faschismus auf. Mit anderen Worten: Ansprüche auf absolute Dominanz über Nichtdeutsche werden als zukünftige Tragödie für das deutsche Volk angesehen. Aus diesem Grund ärgert sich der "wahre Deutsche" über die jüdische Mühle Levy.

Der alte Mann ist wie sein Vorfahre Poleske der Besitzer des Dorfes, ein deutscher Tycoon, der den bankroten Bewohnern von Neman den letzten Penny abnahm und damit reich wurde. Er hasst den Juden Levin, der den Bauern erlaubt, in seiner Mühle billigen Weizen zu mahlen. Der Hass des Großvaters auf Levin hat eher damit zu tun, dass er die Mühle billig nutzen ließ, als mit der Tatsache, dass er Jude ist. Er steigert sein Einkommen, indem er Levins Mühle zerstört, setzt einen hohen Preis für das Mahlen von Weizen fest und besticht "Obere", damit sie ihm ihr Wort geben: "Eines Morgens schien Levins Mühle nicht zu existieren". Tatsache ist, dass eine Überschwemmung kam, der alte Mann einen Damm vor der Mühle errichtete und der Damm brach. Aber es ist nicht durch Wasser zerbrochen ..." [3, s.43].

J. Bobrovsky erklärt "vierunddreißig Sätze über meinen Großvater", um die Handlung des Romans zu verdeutlichen. Schon in den ersten Zeilen erkennt der Leser, dass ein autobiografischer Roman erzählt wird; vor dem Hintergrund der Ereignisse rund um die Mühle versteht er den deutschen Staat, das Leben seiner Bewohner und die Grundlagen der zukünftigen historischen Tragödie. Die Ereignisse rund um die Mühle und die Autobiografie des alten Deutschen bilden den Handlungsstrang des Werkes. Im Roman gibt es zwei Fronten: "Polen-Katholiken" und "Deutsche-Baptisten" – auf der einen Seite Litauer, Zigeuner und der mit den Polen übereinstimmende Jude Levin, auf der anderen Seite "Obere". "Obere" sind Bürger, die das Wahlrecht haben. Wie Sie sehen, zeigt das Figurensystem des Romans den Konflikt zwischen den Deutschen und ihren östlichen Nachbarn, eine wahrheitsgetreue Darstellung der Zeit. Wenn die Gerichte, der Exekutivapparat und das Geld die Deutschen unterstützen, haben andere sich in die Macht des Volkes geflüchtet. Deshalb weiß der alte Mann, wie man mit jemandem redet und wie man jemanden daran erinnert, dass er Deutscher ist. Der alte Mann verliert nur die Möglichkeit eines Protests der armen Einwohner aus den Augen. Sie wissen, wie man gegen den "wahren Deutschen" protestiert, sie vereinen sich noch mehr. Zwar bewahrt der Autor die Realität historischer Ereignisse, die sich am Ende des 19. Jahrhunderts auf dem Land seiner Vorfahren zutrugen, aber die Charaktere des Werkes, die Ereignisse rund um die Mühle, sind ein Produkt der Fantasie des Autors. Aber darüber hinaus lässt der Schriftsteller Kaisers Deutschland wieder aufleben.

"Echte Deutsche" verstehen sich im Werk als Vertreter des offiziellen Deutschlands. Sie sind ehrgeizig in ihrem eigenen Land und sogar in den Nachbarländern. Der Autor findet die Ursachen des nationalen Konflikts heraus und präsentiert moderne

Gedanken zur Wiederherstellung der deutschen Identität.

Die künstlerische Realität von J. Bobrovsky manifestiert sich in den von ihm geschaffenen Bildern und er möchte den Mythos vom "wahren Deutschen" in den Köpfen der West- und Ostdeutschen verändern. Die Ideen von Solidarität und Einheit in J. Bobrovskys Roman "Levins Mühle" verändern die Struktur und Bedeutung des traditionellen historischen Romans. In seinem Roman vereinen sich Fiktion und Realität. Der Autor schafft eine künstlerische Nachahmung realer Ereignisse und nicht der wahren Geschichte selbst. Der Leser sieht dies in Szenen, in denen der Großvater im Schlaf mit seinen Vorfahren spricht, mit "echten Deutschen" kooperiert und seine Nationalität nutzt, um die Menschen um ihn herum in Angst und Schrecken zu versetzen.

Die Politik der "Oberen" ist begrenzt und einseitig. Grossvater und seine Anhänger beziehen sich auf die politische Elite, halten jeden, der kein Deutscher ist, in Angst: "Unser Nachname gehört unserem geliebten Kaiser, unserem Helden" oder "Bald werden wir alle Juden zeigen", "Es ist Zeit, mit euch abzurechnen" [3, s.58]. Unter dem Mythos des "echten Deutschen" werden nationalistiche Gedankengut verbreitet und interethnische Diskriminierung gefördert.

J. Bobrovsky zeigt die Entstehung des Faschismus, seine Gefahr und die Tragödie des deutschen Volkes. Der Autor wendet sich gegen die Darstellung der Geschichte des deutschen Nationalismus, vermischt mit dem Nationalsozialismus, als isoliertes Ereignis und in diesem Zusammenhang beschreibt er in seinem Werk die Ereignisse in der Realität des Alltags, zeigt die Ursachen der historischen Tragödie auf. Laut dem Autor bleibt die nationale Vergangenheit im Gedächtnis der Menschen erhalten, die Menschen können ihre Vorfahren nicht loswerden, sie führen ihr Leben fort. Das deutsche Volk hat einen Weg, seine historische Vergangenheit loszuwerden: andere Völker als das deutsche Volk zu akzeptieren und zusammen zu leben. Offenbar gerade aus diesem Grund schlägt J. Bobrovsky in seinem Roman "Lewins Mühle" vor, sich von Diskriminierung und Rassismus gegenüber anderen Völkern fernzuhalten und Vorstellungen von der Überlegenheit der Deutschen als "Auserwählte" zu vermeiden.

Die künstlerische Realität von J. Bobrovsky umfasst die jahrhundertealte Geschichte der Völker, die am Zusammenfluss von Neman und Weichsel lebten. Polen, Litauer, Deutsche, Juden und Zigeuner siedelten in diesem Gebiet, in dem alten sarmatischen Land. Der Autor entwickelt die Bewohner einer so bunten Gemeinde in lokale Streitigkeiten und Klagen, schildert das Geschehen in ihrer eigenen Sprache und ermutigt den Leser, einen Blick auf ernsthafte Konflikte zu werfen. Die Beschreibung ist so anschaulich und glaubwürdig, dass der Leser die Ereignisse, die sich vor dem Hintergrund historischer Ereignisse abspielen, manchmal als Realität wahrnimmt. Als ob das, was passiert ist, eine Widerspiegelung historischer Daten wäre. Wenn einige Episoden, die an mittelalterliche deutsche Schwanki und andere mit Humor geschriebene Genres erinnern,

werden mit folkloristischen Quellen kombiniert, wird es klar, dass es sich hierbei um Fiktion und die Fantasie des Autors handelt. Eine solche Beschreibung ist charakteristisch für den komplexen Stil und die künstlerische Beschreibung des Schriftstellers. Obwohl die Ereignisse im Roman "Levins Mühle" ein Spiegelbild der Vergangenheit sind, kann man ihn nicht im vollen Sinne als historisches Werk bezeichnen. Der Autor drückt seine Einstellung zur Geschichte aus, beschreibt die Vergangenheit aus seiner Sicht, betrachtet historische Ereignisse aus der Sicht des Autors. Er empfiehlt aber in jedem Fall, daraus Konsequenzen zu ziehen. Auch der deutsche Forscher Peter Albert stellt J. Bobrovsky als einen Schriftsteller dar, der "ein realistisches Bild von Westpreußen an der Schwelle des Jahrhunderts zeichnet und die Tragödien der Vergangenheit wieder aufleben lässt" [1, s.25].

All dies deutet darauf hin, dass der Autor neue Erfolge in der modernen deutschen Prosa erzielte, neue literarische Suchen erfolgreich durchführte und eine neue künstlerische Richtung in die historische Prosa einführte. Mit einem neuen Konzept des Romans befreite J. Bobrovsky die Deutschen von der traditionellen historischen Sichtweise und bot einen alternativen Weg anstelle von Ausdrücken über die Größe der Vergangenheit wie "Herrenrasse", "wahrer Deutscher", Allgermanismus, Kaiser Friedrich der Große, Reichskanzler Bismarck. Der Autor beschreibt die Realitäten Deutschlands im 20. Jahrhundert, die zum Ersten und Zweiten Weltkrieg führten, und schlägt vor, dass die Geschichte nicht durch Kriege, sondern durch das Leben der Völker in Erinnerung bleiben sollte. Mit anderen Worten: Geschichte wird nicht durch das Diktat von Königen und Ministern gemacht und entwickelt, sondern durch die Pracht und das Zusammenleben des menschlichen Lebens. Die von Y. Bobrovskij geschaffene Geschichte wird unter Bedingungen des gegenseitigen Vertrauens und der Zuversicht mit den Nachbarn verwirklicht.

Wie Sie sehen, J. Bobrovskys Roman basiert sich nicht auf gewöhnlichen historischen Figuren. Der Autor enthüllt und zeigt die Bedeutung der Geschichte in den Ereignissen des Alltags, im Lebensstil eines gewöhnlichen Menschen. In "Levins Mühle" treten reale historische Ereignisse in den Hintergrund, der Autor bezieht fiktive menschliche Charaktere in das Werk ein. Mit anderen Worten: Der Heldentum wird in dem Roman durch einen einfachen Menschen ersetzt. Wahre Geschichte entsteht im Gedächtnis, in Erinnerungen, im menschlichen Leben. Damit wird die Einheit von historischer und künstlerischer Realität, Realität und Fiktion verwirklicht, die das Konzept des Autors ausmacht. In solchen Romanen dienen die Weltanschauung des Autors, seine Einstellung zu Ereignissen und Kommentare im Werk einem Zweck – dem Verständnis der wahren Wahrheit über die Geschichte. Dies ist die deutsche Geschichte, die in J. Bobrovskys Roman "Levins Mühle" beschrieben wurde.

In der aserbaidschanischen Literatur – "Zwischen zwei Bränden" von Yusif Vezir Chamanzaminli, "Nebliges Täbris", "Schwert und Feder" von Mammad Said Ordubadi, "Baku-1501", "Denk an mich" von Az-

iza Jafarzade, "Apokalypse" von Isa Huseynov, "Eroberung von Fatali" von Chingiz Huseynov und andere Werke gelten als historische Romane. Obwohl diese Romane mit den Jahren der sowjetischen Literatur zusammenfielen, gaben sie den Anstoß für die Entstehung neuer Romane, die in den Jahren der Unabhängigkeit geschrieben wurden. Die Romane von Sabir Rustamhanly "Gott des Himmels", Yunus Oguz "Nadir Shah" und "Atabey Eldeniz" gelten als Beispiele dafür, die Geschichte mit den Augen der Vergangenheit und der Gegenwart zu betrachten.

Der in den 70er Jahren von Farman Kerimzade geschriebene Roman "Verschneiter Pass" war den Beginn einer neuen Etappe im Bereich des historischen Romans von Aserbaidschan. Die in den 1980er Jahren geschriebenen Romane "Khudafars Brücke" und "Die Schlacht von Chaldiran" hoben Farman Kerimzade unter seinen Zeitgenossen als historischen Romanautor hervor. In beiden Romanen ließ der Autor das Leben von Schah Ismail Khatai sowohl durch die Augen historischer Quellen als auch durch künstlerische Fantasie wieder aufleben und stellte ihn als Gründer des aserbaidschanischen Staates dar.

F. Kerimzade beschreibt die Widersprüche der Kyzylbashlar-Zeit (goldene Köpfe), des historischen Kampfes, der Kämpfe um Land und beschreibt auch künstlerisch das Bild des Dichters. So gelingt es dem Autor, gemeinsam das Bild des Herrschers von Khatai und des Dichters Khatai in der Geschichte des aserbaidschanischen Romans des 20. Jahrhunderts zu schaffen. Die Kindheit und Jugend von Khatai wird so beschrieben, dass der Leser die wahre Kindheit des Herrschers sehen kann: "Mutter und Kind gingen über den Teppich und näherten sich der Tür, und das Geräusch ihrer Füße war nicht zu hören. Ismail trug einen Kaftan aus Ganja-Stoff mit Blumen, ähnlich einem Khara. Im Kaftan waren nicht nur Blumen abgebildet, sondern zwischen den Blumenzweigen erschienen auch junge Krieger mit Pfeilen und Schwertern in den Händen. Um seine Taille trug er einen silbernen Gürtel. Die Falten seiner roten Satinhose strahlten ein rotes Licht aus, als er sich bewegte. Die Armbänder an seinen Beinen waren mit Goldfäden verziert. Er hatte einen weißen Turban auf dem Kopf" [5, s.71]. Doch gleichzeitig lässt der Autor Ismails Kampf um die Macht in echten Farben wieder aufleben. Neben den beiden Beschreibungsgegenständen beschreibt der Schriftsteller meisterhaft die historischen Bedingungen, unter denen er als Dichter und Herrscher aufwuchs und betont dabei die Geschichtlichkeit als künstlerische Wahrheit: "Schah Ismail Khatai bestieg den Thron. In Münzstätten wurden Münzen mit seinem Namen geprägt und in Moscheen wurden ihm Predigten vorgelesen" [5, s.97]. Es ist anzumerken, dass eine solche Beschreibung als neue Herangehensweise des Autors an aserbaidschanische historische Romane gewertet werden sollte.

Im Roman "Die Schlacht von Chaldyran" spricht F. Kerimzade über die gesellschaftliche Tätigkeit von Khatai. Der Autor erzählt von Ismails Kampf für ein geeintes Aserbaidschan und seinen großen Verdiensten bei der Entwicklung der aserbaidschanischen Kultur.

Im Roman "Khudafarin-Brücke", in der Fortsetzung des Romans "Die Schlacht von Chaldyran" wird Khatai als weiser Staatsmann und talentierter Dichter beschrieben. In diesem Roman repräsentiert Khatai sich selbst nicht nur als Person, sondern das gesamte aserbaidschanische Volk. Aus diesem Grund wird in der Literaturkritik der Charakter von Schah Ismail nicht als Repräsentant eines persönlichen Kampfes dargestellt, sondern als Anführer des Volkes, als Herrscher, der für das Volk kämpft.

Im Roman "Die Schlacht von Chaldyran" beschreibt F. Kerimzade den Kampf der türkischen Stämme um die Macht als Tragödie für die Türken. Im Roman schlägt er vor, Lehren aus der Vergangenheit und der Idee der Einheit der Türken zu ziehen. Er stellt die unbegründeten Streitigkeiten zwischen dem osmanischen Gericht und den Kysylbaschlar (goldene Köpfe) als historische Tragödie dar und empfindet bitteres Bedauern über diese historische Wahrheit: "Sultan Selim hat ein Auge auf Täbris geworfen. Er hatte Ambitionen in Europa, Ägypten, Arabien und den Ländern rund um das Weiße Meer. Er hatte vor, sie alle einzufangen. Im Jahr 1256 verstärkte sich in ihm die Absicht, den Thron des vom mongolischen Khan Hulaki gestürzten Kalifen wiederherzustellen und sich selbst zum Kalifen zu erklären. Aber er hatte eine Angst – Schah Ismail" [6, s.107]. Andererseits interessierte sich der Autor für den heroischen Geist des aserbaidschanischen Volkes und aus diesem Grund gelang es ihm, Themen wie nationales Denken, nationale Identität und nationale Geschichte zum Hauptinhalt beider Romane zu machen.

Gleichzeitig gelingt es dem Autor, die politische Situation der Staaten Zentralasiens im problematischen Raum des historischen Romans wiederzubeleben und so das Ausmaß der historischen Tragödie breiter darzustellen. Aus diesem Grund kann mit Bestimmtheit

festgestellt werden, dass die Romane von F. Kerimzade als eine neue Etappe im historischen Roman Aserbaidschans betrachtet werden sollten, der in den 70er und 80er Jahren entstand.

Offenbar spielten Farman Kerimzade und Johannes Bobrovsky eine besondere Rolle bei der Entstehung des neuen historischen Romans. Wenn der deutsche Schriftsteller den Romanen der 1960er Jahre in seinem Land Innovation brachte, dann gelang es F. Kerimzade mit seinen in den 1970er und 1980er Jahren geschriebenen Werken, das Genre des historischen Romans in Aserbaidschan auf ein neues Niveau zu heben.

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# POLITICAL SCIENCES

## TERRITORIAL PUBLIC SELF-GOVERNMENT IN THE SYSTEM OF LOCAL DEMOCRACY: THE PROBLEM OF CITIZENS' PARTICIPATION

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## ТЕРРИТОРИАЛЬНОЕ ОБЩЕСТВЕННОЕ САМОУПРАВЛЕНИЕ В СИСТЕМЕ ЛОКАЛЬНОЙ ДЕМОКРАТИИ: ПРОБЛЕМА УЧАСТИЯ ГРАЖДАН

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### **Abstract**

The activity of citizens determines the role of territorial public self-government as an institution of local democracy. Using the results of a sociological survey, the authors explain the reasons for the insufficiently active participation of citizens in its work. The ways of involving citizens in solving cases of local importance by increasing the political and legal status of territorial public self-government are proposed.

### **Аннотация**

Активность граждан определяет роль территориального общественного самоуправления как института локальной демократии. Используя результаты социологического опроса, авторы объясняют причины недостаточно активного участия граждан в его работе. Предложены пути привлечения граждан к решению дел местного значения путем повышения политico-правового статуса территориального общественного самоуправления.

**Keywords:** local self-government, territorial public self-government, local democracy, political participation, citizen activity.

**Ключевые слова:** местное самоуправление, территориальное общественное самоуправление, локальная демократия, политическое участие, активность граждан.

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В декабре 2021 г. в Государственную Думу РФ был внесен Проект федерального закона № 40361-8

«Об общих принципах организации местного самоуправления в единой системе публичной власти»<sup>1</sup>. Его разработчики исходят из конституционной новеллы, в соответствии с которой органы местного самоуправления входят в единую систему публичной власти. Это позволило, соответственно, включить статьи, которые, фактически, превращают органы местного самоуправления в низший уровень системы государственного управления. В связи с

<sup>1</sup> Законопроект № 40361-8 Об общих принципах организации местного самоуправления в единой системе публичной власти. URL:

<https://sozd.duma.gov.ru/bill/40361-8>

8<https://sozd.duma.gov.ru/bill/40361-8> (дата обращения 16.01. 2022).

этим, многие исследователи прогнозируют полное выхолащивание основ подлинного местного самоуправления [1,4,8,12,14].

В этих условиях особое значение приобретают иные институты локальной демократии, способные обеспечить участие граждан в решении дел местного значения. В том числе, заметную роль в системе этих институтов играет территориальное общественное самоуправление.

Правовые условия, позволяющие привлекать жителей к решению вопросов местного значения, к управлению местными делами, в том числе и через органы ТОС, были созданы еще в 2003 г. принятием Федерального закона № 131-ФЗ «Об общих принципах организации местного самоуправления в Российской Федерации»<sup>2</sup>.

За время существования института был накоплен значительный положительный опыт [5]. Отмечая возможности территориального общественного самоуправления в решении вопросов местного значения, современные авторы даже считают, что «ТОС – единственная системная форма непосредственной демократии, применяемая для решения проблем микротерритории, возникающая по волне населения территории и осуществляемая этим населением. В связи с наличием у ТОС устава, территории, собственной структуры управления (выборный орган и контрольно-ревизионный орган, председатель), бюджета и ресурсной базы можно говорить о ТОС как о квазимуниципалитете» [9]. Поэтому тем более неожиданной проблемой выступает, отмечаемая большинством авторов, недостаточно активное участие граждан в деятельности органов и мероприятий территориального общественного самоуправления [2,6, 7,10,11,13].

В качестве объяснения этого феномена исследователи чаще всего ссылаются на слабую информированность граждан о деятельности на территории их проживания ТОС [3,13].

Целью нашего исследования также являлся поиск ответа на вопрос о причинах недостаточного участия граждан в решении вопросов местного сообщества через использование института территориального общественного самоуправления. В качестве метода исследования выступал социологический опрос, проведенный в мае 2023 г. Территорией опроса выступал город Сургут в Ханты-Мансийском автономном округе. Объем выборки составил 400 респондентов. Выборка квотно-территориальная: по полу, возрасту, микрорайону проживания.

Судя по ответам наших респондентов, большинство из них вообще весьма плохо представляют себе, что такое территориальное общественное самоуправление. Треть опрошенных - 32% - заявила, что им «почти ничего неизвестно о том, что это такое». Еще почти столько же – 40,5% - ответили, что «в основном представляю, что это такое, но не очень хорошо».

Значительная доля респондентов – 69% - в ходе опроса заявила, что им неизвестно, существует ли в их микрорайоне ТОС. Примерно, лишь каждому пятому из них (20,8%) доводилось участвовать в работе ТОС через такие мероприятия как сходы, собрания, конференция жителей дома, улицы, микрорайона. Но подавляющее большинство – 77,6 процентов - в них участия никогда не принимало.

Однако мнение об изначальной пассивности населения было бы глубоко ошибочным. На самом деле, отвечая на вопрос: «Готовы ли Вы лично участвовать в работе территориального общественного самоуправления?» 17,8 % респондентов заявили о такой готовности. Более того, более половины опрошенных (в общей сложности 53,3%) однозначно заявило о своем положительном отношении к ТОС, причем большинство отметили такие важные качества, которые этот институт развивает в людях, как «чувство хозяина, повышение ответственности за качество жизни, возможность контролировать работу муниципальных служб и должностных лиц». Только 14,2% опрошенных продемонстрировали отрицательное отношение, считая, в частности, что этот институт «нужен лишь чиновникам». Еще 30,7% затруднилась с ответом.

Как объяснить возникающий парадокс: большинство респондентов считают, что территориальное общественное самоуправление в городе необходимо, высказывают готовность участия в нем, но на практике это желание не реализовывают, и за деятельность ТОС собственного микрорайона не следят?

В какой-то мере, объяснение этому дает сравнение ответов респондентов на два вопроса: о том, какие мероприятия проводит ТОС в их микрорайоне, и о том, какие направления в их деятельности респондент считал бы наиболее важными.

Это сравнение показало несовпадение того, чем реально занимается ТОС, с теми функциями, которые на самом деле ожидают от него граждане. В качестве мероприятий, проводимых территориальным общественным самоуправлением, респонденты указали такие как благоустройство дворовых территорий, организация досуга пожилых людей и подростков, проведение массовых праздников. Однако отвечая на второй вопрос - о самых важных направлениях его деятельности - они указали, впервых, на осуществление контроля со стороны ТОС за деятельностью коммунальных служб и управляющих компаний, во-вторых, – на их участие в планировании застройки микрорайонов города.

Таким образом, возможно, что именно недостаточная, с точки зрения горожанина, значимость функций выполняемых сегодня ТОС, выступает фактором, снижающим его интерес к участию в работе органов территориального общественного самоуправления.

Непростая ситуация, в которой оказался сегодня институт местного самоуправления в целом, в

<sup>2</sup> Федеральный закон от 06.10.2003 N 131-ФЗ (ред. от 20.07.2020) «Об общих принципах организации местного

самоуправления в Российской Федерации» // Собрание законодательства РФ. 06.10.2003. N 40. ст. 3822

связи с наметившейся после принятия конституционных поправок и разработки проекта нового закона, тенденцией, расцениваемой рядом авторов, как его «огосударствление», одновременно открывает для территориального общественного самоуправления определенные перспективы.

В случае постепенного превращения местного самоуправления в нижний уровень государственного управления, появится необходимость передачи ряда специфических функций местного самоуправления территориальному общественному самоуправлению. В том числе, – по привлечению к решению населения к решению дел местного значения, которые будут «уходить» из нынешних органов местного самоуправления по мере трансформации их в органы государственного управления на местах.

Однако для успешной передачи этих функций, означающее повышение статуса территориального общественного самоуправления, превращение его в «квазимуниципалитет» и эффективный инструмент локальной демократии, требуется решение ряда проблем. В первую очередь, следует точнее определить политico-правой статус органов ТОС. Возможна разработка программы поддержки ТОС на государственном уровне, включающая, например, проведение экспериментов по передаче им некоторых функций публичного управления. И, конечно, необходимо обеспечить финансирование передаваемых функций. Особенно важным повышение статуса местного самоуправления выглядит для небольших поселений, в силу фактической ликвидации в них согласно разработанному законопроекту, органов местного самоуправления.

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# TECHNICAL SCIENCES

## A METHOD OF FORMING A SET OF DIAGNOSTIC FEATURES FOR OPTIMIZING CONTROL PARAMETERS AND DIAGNOSING TECHNICAL SYSTEMS

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### **Abstract**

It is substantiated that the control of the state of technical systems is aimed at increasing the reliability of information about the real technical state. An analysis of existing methods of substantiating sets of control parameters of complex technical systems is carried out, their disadvantages and advantages are given. The purpose of the study is to develop a method that allows you to justify the number of control parameters when determining the state of technical systems. The work proposes a method (order) of forming a set of diagnostic features for optimizing control parameters and diagnosing technical systems for assessing their technical condition, which consists of three stages. The basis for the wide use of the proposed method is the hidden potential of multidimensional test signals reflecting a wide range of differences that can be deployed with respect to the generalized control parameter.

**Keywords:** diagnostics, reliability, control, method, optimization, test signal, technical condition

**Problem statement.** The functional efficiency of technical systems depends on the timely detection of possible failures. Timely detection of possible failures of technical systems depends on the quality of monitoring and diagnosing their technical condition. Thus, monitoring the condition of technical systems is aimed at increasing the reliability of information about the actual technical condition. The reliability of information about the real technical condition of the system depends on finding the control parameters (diagnostic features) within the limits of possible changes [1, 2]. At the same time, an urgent task is to determine the optimal parameters for monitoring the technical condition of systems to ensure the required level of control reliability and reduce the cost of its control, as this affects the overall operating costs of the system. A suboptimal (irrational) set of control parameters leads to high unproductive costs, reduced control reliability and the efficiency of using technical systems for their intended purpose. The optimal choice of control parameters is one of the most important and complex tasks in the theory of controlling the technical condition of systems [2].

**Literature review.** A number of methods have been developed to substantiate sets of control parameters for complex technical systems, which are conditionally divided into two groups: expert [1] – [4] and computational [5] – [9].

Expert methods are aimed at determining individual estimates of each parameter of technical systems by experts. The main disadvantage of expert methods is the subjective factor, i.e., a parameter can be assessed by different experts in a very different way. And this can lead to an erroneous conclusion about the "weight" of the control parameter for technical systems

and unreasonable exclusion from the number of controlled parameters of the parameter whose failure, if not detected in time, can lead to failure to fulfill the functional task [2, 3].

Calculation methods include those based on the assessment of various quality indicators of technical systems. Such indicators may include, for example, indicators of element reliability, maintainability, and others [5]. They are based on building a mathematical model of the system and solving the problem of optimizing the composition of control parameters, which depends on the selected optimization criterion [6, 9]. However, contradictions may arise when justifying the composition of control parameters of technical systems. For example, if the cost of controlling parameters with the available means of monitoring and diagnostics exceeds the cost of the technical system sample itself, then the control is economically unprofitable. This is due to the fact that the number of control parameters of technical systems is ambiguously related to the quality indicators of this system. To obtain an optimal solution, a method of sequential approximation is used, which consists in repeatedly solving problems of optimizing the composition of control parameters of technical systems [8].

Calculation methods for selecting control parameters for technical systems also include methods based on solving systems of inequalities that determine the relationship between the obtained and required values of the duration of technical condition monitoring, the cost of monitoring and diagnostic equipment, the frequency of monitoring, and the reliability of false and undetected failures. This group of calculation methods has a major drawback - they do

not take into account the operating parameters of monitoring and diagnostic tools used in the control of technical systems [4], [7].

**The purpose of the article** is to develop a method that allows to justify the number of control parameters when determining the technical condition of technical systems.

**Main part.** The analysis of technical systems to control their technical condition is one of the main stages of forming the initial set of diagnostic features that allow developing control and diagnostic programs.

A complex task of monitoring the state of technical systems includes the synthesis of test signals  $x_i$ , i.e., a sequence of input vectors  $X [x_1, x_2, \dots, x_i, \dots, x_m]$ , where  $m$  is the number of test effects on the technical object, to obtain the corresponding output vector  $Y(X)$  (output responses  $[y_1(x_1), \dots, y_i(x_i), \dots, y_m(x_m)]$ ). The vector  $Y(X)$  provides information about the response of the technical system to the characteristics of the control and diagnostic parameters  $m$ , which contain the diagnostic control data (control result) necessary to assess its technical condition. Technical systems are usually complex complexes (objects), so a sequence (algorithm) of diagnostic tests  $x_i$  is required to assess their condition and, as a result, determine the presence or absence of faults. Processing of this information (diagnostic control data) allows to assess the state of a technical system and detect a malfunction, i.e., to indicate the location of the malfunction with sufficient accuracy to detect it. Both tasks are solved on the basis of the initial set of diagnostic features for the technical system  $y_i(x_i)$ . In this case, when determining the optimal set of control parameters  $n$ , it is necessary first of all to establish a hierarchy of previously selected parameters  $m$  for a particular technical system. To do this, test signals are formulated – the input vector  $X$  – and a qualitative analysis of the degree of compliance of the proportions of representation of the elements of the measured parameter by such test signals is carried out. Let us consider the task of processing diagnostic testing data

to monitor the technical condition of a system. The conclusion on the assessment of the technical condition of the system based on the results of monitoring its parameters (diagnostic testing) allows us to make a certain forecast for the future development of state changes and provide recommendations for maintaining its technical condition.

The paper proposes the following method (procedure) for forming a set of diagnostic features to optimize the parameters of control and diagnostics of technical systems to assess their technical condition, consisting of three stages.

In the first stage, taking into account the mathematical model (structural diagram) of the technical system, an initial set of control parameters  $m$  is formed, which includes a set of input influences  $m$ ; reactions to them that reflect the state of the technical system under control. This stage is difficult to formalize. It is necessary to develop general recommendations for the formation of the initial set of diagnostic features that characterize the technical state of the system.

At the second stage, a diagnostic model of the technical system is selected and its characteristics are determined. A diagnostic model is understood as a method of combining (transforming, aggregating) the initial diagnostic features (variants of reactions to the input test signals) to form a generalized diagnostic indicator. There can be many such methods. We propose to use a linear diagnostic model, in which the arrangement of the initial signs is carried out by summing them with certain weights. The initial material for finding the parameters of the diagnostic model is the data of an experimental study of the use of test signals for a diagnostic test of a representative sample of technical system parameters.

It is proposed to use the results of the study by matching the results of monitoring the technical condition of the system for each monitoring parameter (Table 1).

Correspondence of the results of technical condition control to the control parameters

Set of parameters $m$	Impact on the result of technical condition control	Weight of the control parameter	Parameter dependence	Optimum parameters $n$
$x_1$	$y_1(x_1)$	0.01	$x_1(x_2)$	—
$x_2$	$y_1(x_2)$	0.1	$x_2(x_1)$	$x_2$
...	...	...	...	...
$x_i$	$y_i(x_i)$	0.2	—	$x_i$
...	...	...	...	...
$x_m$	$y_m(x_m)$	0.07	—	$x_m$

The main categories that characterize the structure of the experimental data and are used to determine the optimal parameters of the diagnostic model are the categories of similarity and difference of the rows and columns (control parameters and their results) of the experimental data table. Experimental information has a specific character, so attention should be paid to the description of this specificity and the peculiarities of applying measures of similarity and difference of

objects and features. To determine the parameters of the diagnostic model, it is proposed to use two strategies of empirical and statistical data analysis.

The first strategy is based on the criterion of informativeness of experimental data. This criterion implies that the diagnostic model can be directly determined by approximating the geometric structure, a set of objects in the space of initial features, without using information about empirical (external) influences

on the procedure for controlling technical systems. The use of numerical relations of similarity and difference of objects and features is proposed. A linear diagnostic model (linear approximation) can be built when a significant part of the initial features is highly interconnected (internal consistency) and other features cannot compete with this consistent impact on the structure of data on control parameters. If the internal consistency is due to the reflection of the required technical condition, the parameters of the linear diagnostic model (feature weights) are obtained by the principal component method. If the set of initial features includes several groups of interdependent features, then one or more groups of diagnostic parameters can be combined using factor analysis methods. In this case, useful practical results can be obtained by the method of contrasting groups, which uses the effect of increasing the internal consistency of the initial version of the linear diagnostic model.

The second strategy for determining the parameters of the diagnostic model is based on the involvement and active use of additional initial information about the quality of control as a diagnostic property of the technical system. The criteria by which the training information is formed will be considered the criteria of external informativeness or external criteria. The main components of methods that use external criteria are regression and discriminant analysis methods. It is necessary to describe the types and methods of obtaining training information, as well as provide the necessary information about the classical linear regression and discriminant analysis. It is proposed to consider various modifications of these types of analysis used in diagnostics, taking into account the specifics of experimental measurements. In the future, a piecewise linear diagnostic model will be developed, which is implemented using a typological approach.

The third stage involves standardization and testing of the proposed diagnostic model. It is necessary to develop methods for obtaining standardized diagnostic assessments and consider the main characteristics of the input diagnostic signals used to monitor the technical condition of systems and reflect the quality of the developed diagnostic tool. Automation of solving this task is associated with the use of the basics of the theory of optimization of technical system control parameters. When forming the initial set of features (the initial version of the control parameters  $m$ ), the entire set of parameters is used. To optimize the control parameters, a specific type of stimulating influences on a technical system is selected and a minimum set of reactions recorded to such influences is formed, which allows to assess the technical condition of the system. Therefore, the formation of the initial set of diagnostic features is important but difficult to formalize. To solve this problem, we offer the following suggestions.

First, it is necessary to conduct a thorough analysis of the technical system assumed as a mathematical model of the diagnostic object.

The method (procedure) of forming the initial diagnostic features to be developed must meet the following requirements:

**Sufficiency.** The set of initial signs should cover all the selected parameters that characterize the technical condition of the system;

**Cost-effectiveness.** When developing a set of features, it is necessary to avoid an excessive amount of initial information that may complicate the subsequent empirical and statistical analysis of the parameters of the diagnostic model;

**A clear structured system of features.** The features should be grouped for a uniform description of the parameters characterizing the technical condition of the system;

**Quantitative certainty of the selected features.** This certainty is required for empirical and statistical analysis. Features should be expressed in nominal, qualitative or quantitative scales.

These requirements are not exhaustive. When forming a set of diagnostic features, attention should be paid to the methods of optimizing the parameters of control and diagnosis of technical systems. In general, it can be said that the formation of the initial set of features in the design of a new algorithm for monitoring the technical condition is laborious. In fact, another approach to solving the problem of forming initial features is more common, in which such features are elements of known control algorithms. It is proposed to use individual diagnostic features in previously tested objects, to compile a new algorithm from the composition of known methods, and to use the full set of control parameters for multidimensional diagnostic methods as the initial set of features. The advantage of the first approach, where a completely new optimization algorithm is constructed, is that it takes into account the specifics of a particular diagnostic task to the maximum extent possible, which is expressed in a more targeted selection of a set of control parameters, the formulation of individual test signals and their sets. At the same time, the implementation of this approach involves considerable effort in the theoretical development of both the general concept of the mathematical model of the system and many specific details of solving the optimization problem. The second approach does not have the flexibility of the first approach, but avoids the need to solve many specific problems, since it is based on the already tested initial structure of known algorithms for determining a set of control parameters for assessing the technical condition of the system.

**Conclusions.** The basis for the widespread use of the proposed method is the hidden potential of multidimensional test signals reflecting a wide range of differences, which can be deployed with respect to a new generalized control parameter. Having determined the initial set of features, a variant of the future algorithm for optimizing control parameters is obtained. Further development of this variant is based on the experiment and analysis of its results. Presentation of information about the structure of experimental data using the matrices of relations of control features and their effects on the result of

assessing the technical condition of the system. The number of the optimal set of control parameters  $n$  and the number of diagnostic features serves as an intermediate link in the process of building diagnostic models of various types. Regardless, there are two main strategies for determining the parameters of diagnostic models.

Data informativeness exists only in relation to the type of diagnostic model used, the choice of which, in turn, is determined by technical resources and theoretical ideas about the control algorithm. In the diagnostics of complex technical systems, linear models prevail, in which the resultant indicator is presented as a weighted sum of the initial signs. The prevalence of linear models is primarily due to their greatest simplicity, clarity, and ease of solution, which allows, in particular, manual processing of control results. From a mathematical point of view, the development of diagnostics is moving away from linear models. However, they will undoubtedly always be of great practical importance due to their conciseness and good interpretability. In the future, when considering a particular method of determining the parameters of a linear diagnostic model, different terms will be used, but, as noted above, the global attribute for distinguishing these methods is the use or non-use of the criterion of external information content.

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