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Contact address

Journal of Baku Engineering University
AZ0102, Khirdalan city, Hasan Aliyev str. 120, Absheron, Baku, Azerbaijan

Tel: *00 994 12 - 349 99 66/78* ***Fax:*** *00 994 12 349-99-90/91*

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METROLOGICAL SUPPORT FOR THE INFORMATION-MEASUREMENT SYSTEM OF ELECTRIC ENERGY ACCOUNTING

NAMIG GANJAYEV

Azerbaijan State Oil and Industry University,
Baku city, Azerbaijan

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ABSTRACT

The primary features of the government tools used to measure electric energy include the errors that arise during electricity accounting, which is essential for the development of the national economy within an information-sharing system. Issues related to reducing these errors and the associated losses are also addressed. The study analyzes the main characteristics of the measurement devices employed for electric energy accounting. It explores the causes and origins of errors in the measurement channel when developing an information-measurement system. Based on the analysis results, the sources of errors in measurement channels are identified according to the structural schemes of information-measurement systems utilizing various measuring devices (such as voltmeters, ammeters, electric energy meters, and voltage and current transformers). It has been demonstrated that errors in the measurement channel arise not only from the design and operating principles of the measuring instruments and signal processing devices but also due to distortions caused by harmonics in the voltage and current within the electrical network, as well as specific interferences. The primary sources of measurement errors in determining electric energy are mainly related to inaccuracies in measuring voltage, current, and phase shift, along with errors induced by temperature effects on the elements and devices used for these measurements. Although temperature errors may not be immediately apparent, they can contribute to various types of inaccuracies. In this context, the importance of implementing temperature compensation or correction schemes has been emphasized once again.

1. Introduction

In our country, the production of electricity is constantly being increased in order to accelerate the development and reconstruction processes in the liberated territories. In this case, improving the accuracy of energy measurement and the integrity of its accounting during the production and consumption of electricity is one of the main issues [1]. The measurement of the consumed electric energy taking into account a large number of parameters is carried out using multi-functional automated accounting systems. In recent years, information-measuring systems (IMS) for electric energy accounting, as well as telemetering systems that allow accurate measurement of active, reactive and total power, phase voltages and currents in three- and four-wire three-phase networks, have become widespread.

Functional possibilities of existing electricity meters are wide. These include: multi-tariffing, accounting of direct and reverse electric energy flows, integration of active and reactive counters into one device, data transfer for information-metering and centralized energy accounting systems, ease of data collection and storage in a given time interval, as well as the current of the monitored network, includes capabilities such as measuring voltage, power, power factor, frequency characteristics, and constructing load graphs and tables. If the electricity measuring devices are multifunctional for sufficiently remote points, if the measuring points (points) are compactly located on the territory, it is more appropriate to transfer some complex functions of the electric energy meters to the information-measuring system of electric energy accounting.

2. Electricity modeling based on AC power and its cost

During the development of market relations in electric energy, more and more attention is paid to the reduction of commercial losses, which often exceed technical losses in many energy systems. Currently, up to 30-50% of commercial losses are determined by electricity metering errors and imperfect automated systems for electricity control and accounting [5].

Errors of measuring devices lead to inaccurate accounting of electricity produced by power plants and supplied to consumers. Therefore, this part of electrical energy loss can be called measurement losses (errors). Measurement losses are determined by the final error in each measurement channel, which in turn is characterized by total errors with random and systematic components [2].

Electricity is measured indirectly. The most common procedure for obtaining indirect measurement results is implemented in multichannel information measurement systems. In general, the required result is calculated as a function of the results of direct measurement of many variables - the parameters of a complex object, obtained by means of various measurement channels of the IMS.

The IMS for monitoring and accounting of electric energy should have unique features: installation of electric meters and measuring transformers produced by various manufacturers at the place of operation, distribution on the site and on the territory, and as a result, the presence of long communication lines between its multi-channel components, the possibility of installation during operation, constructive to the measuring objects connection, complete provision of computing equipment, etc. In addition, for monitoring and accounting of electric energy, most of the IMS should be included in more complex structures [4, 8].

In this case, the energy measurement is the result of an indirect measurement and is a function of a directly measured quantity (voltage, current, phase shift, and time). This situation arises not only in IMS, but also when using a digital device (digital electricity meter) with a processor or controller (microprocessor) or when manually processing the results of direct measurements of a quantity.

As you know, alternating current electric power and its price, electric energy is determined as follows:

$$P = UI\cos\varphi \quad \text{və} \quad W = PT = UIT\cos\varphi, \qquad (1)$$

where P is electric power; U – applied voltage; I – intensity of the current flowing from the load (operator); φ – phase shift between voltage and current; W – electric power; T is the

period of connection of the load to the network (food source). Here, the main quantity, electric energy *W*, is determined based on the results of direct measurements of other quantities *u*, *i*, *φ*.

The metrological structural scheme of indirect measurements for cases where the results of direct measurements, which are input data for computer programs, are calculated by means of a computer, is shown in Figure 1.

The metrological structure-scheme presented in Figure 1 uses fixed quantities as initial data and direct measurement results of variable quantities. Here, the measurement error of the time period *T* is not taken into account. At this time, the value of the indirectly measured electric energy *W* is related to the functional dependence of the voltage - *u*, current *i* and the phase shift between voltage and current - *φ*, which must be measured directly, and $W = U \cdot I \cdot T \cdot \cos\varphi$. Real calculations are indirect measurement results

$$W^* = U^* I^* T \cos\varphi^* \qquad (2)$$

this price will give

$$\Delta W = W^* - W = (u^* i^* \cos\varphi^* - ui\cos\varphi) \cdot T \qquad (3)$$

contains absolute error.

Were

$$u^* = u + \Delta u;\ i^* = i + \Delta i;\ \varphi^* = \varphi + \Delta\varphi \qquad (4)$$

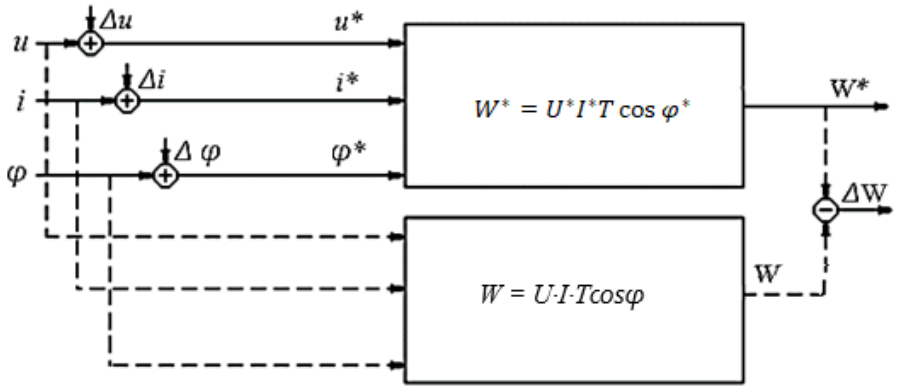

Fig. 1 Metrological structure of indirect measurements performed in the IMS

are the results of direct measurement of their quantities.

Errors in the results of indirect measurements are caused by the following reasons:

- approximate implementation of continuous functions and operations such as integration and differentiation in digital computers;
- Δu of direct measurement results, which creates hereditary errors in the results of indirect measurements; Δi and $\Delta\varphi$ errors;
- errors during calculations due to rounding, stopping iteration processes and other reasons.

In accordance with the theory of errors [6], to evaluate the accuracy of indirect measurements, the separation of the signal into the Taylor series is used without taking into account the second and higher order limits. In this case, the absolute value of the total error is determined as follows:

$$\Delta = \sum_{i=1}^{m} \left|\frac{df}{dx_i}\right| \Delta_i, \qquad (5)$$

where m is the number of arguments; f – measurement function; x_i – the specified value of the i-th argument; Δi are the limits of the absolute error of the i-th argument.

At this time, the cumulative relative errors δ_{OK} of the measurement channels are deter-mined as follows:

for a four-wire connection scheme

$$\delta_{OK} = \frac{1{,}96}{\sqrt{3}} \sqrt{\delta_s^2 + \sum_{i=1}^{3}\left(\frac{1}{3}\delta_{xi}\right)^2 + \sum_{j=1}^{l}\delta_j^2 + \sum_{i=1}^{3}\left(\frac{1}{3}\delta_{CTi}\right)^2 + \sum_{i=1}^{3}\left(\frac{1}{3}\delta_{GTi}\right)^2 +}$$

$$+ \sum_{i=1}^{3}\left(\frac{1}{3}100 \cdot \theta_{CTi} tg\varphi\right)^2 + \sum_{i=1}^{3}\left(\frac{1}{3}100 \cdot \theta_{GTi} tg\varphi\right)^2 \qquad (6)$$

- for a three-wire connection scheme

$$\delta_{OK} = \frac{1{,}96}{\sqrt{3}} \sqrt{\delta_s^2 + \sum_{i=1}^{2}\left(\frac{1}{2}\delta_{xi}\right)^2 + \sum_{j=1}^{l}\delta_j^2 + (\delta_{CT} + \delta_{GT})^2\left(\frac{1}{6}tg^2\varphi + \frac{1}{2}\right) + \left(100 \cdot (\theta_{CT} + \theta_{GT})\right)^2} \cdot$$

$$\cdot \left(\left(\frac{1}{2}tg^2\varphi + \frac{1}{6}\right)\right). \qquad (7)$$

where δ_S is the limit of the main relative error of the electricity meter (S), %; δ_{CT} – current error of current transformer (CT), %; δ_{GT} – voltage error of voltage transformer (GT), %; θ_{CT} and θ_{GT} – angular errors of current and voltage transformers, in radians; δ_{xi} and δ_{sez} – permissible voltage losses in the lines and additional errors of the meter; %; i – phase number; j – number of additional error of the meter; l is the number of additional errors of the counter.

3. Development of the structure of errors in IMS with transformer input circuit

In a four-wire circuit, the total error is less when measuring electricity with the same measuring devices. The schemes corresponding to the noted errors and measurement method for one measurement channel will be as follows (Figure 2 and Figure 3).

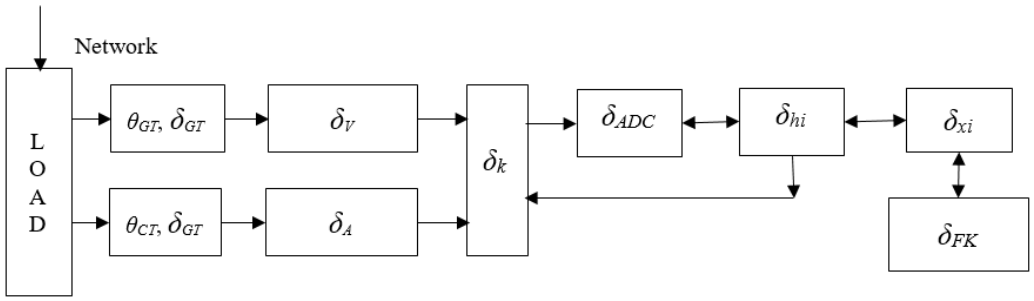

Fig. 2 Structure of errors in IMS with transformer input circuit: δ_V – voltmeter error; δ_A – ammeter error; δ_k – the error introduced by the switch; δ_{ADC} – analog-digital converter error; δ_{hi} – the error of the calculation-control device; δ_{KS} is the computer (server) error. The origin of the last error is an algorithmic error, related to rounding and iteration operations

The temperature errors on the blocks, modules, elements and devices shown in the structural schemes are inconspicuously included in the errors related to those components and manifest themselves when the temperature changes sufficiently. It is determined by the error caused by the effect of temperature on the devices - due to the heat generated by the environment and during the operation of the device. The temperature error is not obvious, it can be included in various types of errors. In this regard, it is appropriate to use a temperature compensation or temperature correction scheme or schemes.

In Figure 3, δ_{GS} is the voltage sensor error; δ_{CS} is the current sensor error. When measuring time-varying quantities u, i by means of multi-channel IMS, the aperture error, which is a component of the error in the results of direct measurements, can increase significantly. This is due to the fact that the measurement channels of the IMS are sequentially polled by the control controller, and the polling time is the sum of the measurement time in each channel, the time of the execution of the exchange protocol and the time due to the speed of the reconciliation interface devices.

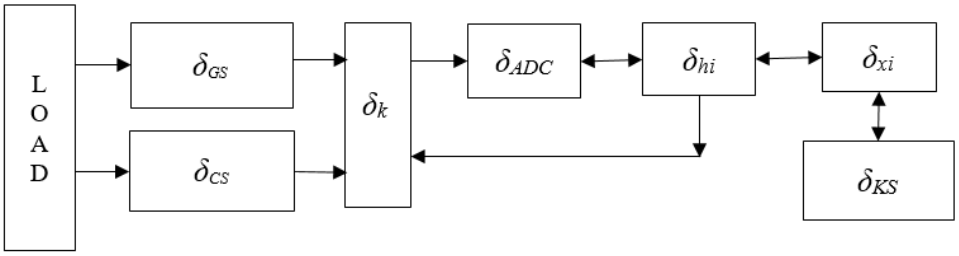

Fig. 3 The structure of errors in the IMS with a sensor input circuit

Therefore, the actual measurement moments performed by such channels differ. At the same time, each result of indirect measurement is attributed to a certain moment of time, as a rule, the moment of application to the first channel [7]. In multi-channel measurements, the difference in the actual measurement moments of the quantities included in the calculation formulas is large and can cause significant aperture errors in the indirect measurement results.

Thus, the expression for the error of the result of indirect measurements when measuring the time-varying quantities u, i and φ by means of a multi-channel IMS will be as follows:

$$\Delta W(t_i) = u^*(t_i + \Delta t_1) \cdot i^*(t_i + \Delta t_2) \cdot \cos\varphi^*(t_i + \Delta t_3) \cdot T - u(t_i + \Delta t_1) \cdot i(t_i + \Delta t_2) \cdot \cdot \cos\varphi(t_i + \Delta t_3) \cdot T, \quad (8)$$

where, Δt_1, Δt_2, Δt_3 are the time delay (shift) errors due to time recording of measurements on measurement channels.

These errors increase as the number of IMS channels increases (since transmitters are polled sequentially). A radical tool to reduce reading dating errors in multichannel measurement systems is a multichannel sampling and storage device (SSD). The SSD is connected before the switch. In normal operation, the output signal repeats the input signal and works in tracking mode. At the start of the channel request, a signal from the computer enters through the interface and switches the SSD to the mode of simultaneous storage of all signals at the output of the system channels. The switcher polls the channels and in turn sends the instantaneous values of the output signals at the same instant of time alternately to the input of the ADC and then to the computer's memory for recording or processing. The transition time of SSD from tracking mode

to storage mode is tens of nanoseconds, and the dispersion of this time is even smaller. Therefore, the error of the switch (multiplexer) will be negligible. Thus, the effect of time-shifting errors is almost completely eliminated.

The structure of errors for the IMS using a modern type digital electricity meter will include the modern electricity meter, communication lines and computer-introduced errors and will be presented as shown in Figure 4. In Figure 4, δ_{MESn} is the error of a modern electricity meter (n = 1,N).

The common error in such a structured IMS is the error introduced by the switch; error of the calculation-management device (controller); it is possible to download by reducing the algorithmic error of the computer (server).

Additional errors in the proposed schemes will be determined both by the presence of harmonics in the network and by the errors caused by the influence of temperature on the measuring devices. In addition, the transmission of information through power lines will cause a certain change in the structure of the named errors, which is also related to the generation of harmonics in the power network [9].

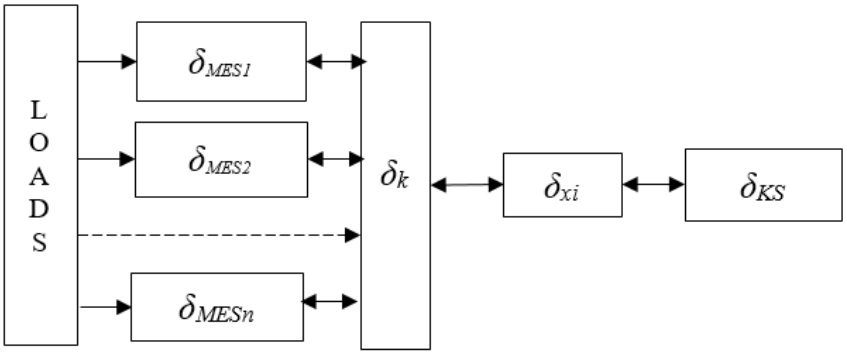

Fig. 4 The structure of errors in the modern electricity meter IMS

4. Conclusion

As a result of the analysis of the sources of errors in the measurement channel, it was shown that the occurrence of those errors is caused by the working principle and construction of the measuring devices, the conversion of information from analog to digital form and vice versa, and additional errors in the measurement of electric energy are determined by the presence of harmonics in the network and the errors caused by the influence of temperature on the measuring devices. is being

The temperature error caused by the effect of temperature on the devices - due to the heat generated by the environment and during the operation of the device is not obvious, it can be included in the composition of various types of errors. To reduce this error, it is advisable to use a temperature compensation or temperature correction scheme or schemes.

Due to the fact that it is not possible to perform measurements in multi-channel IOS in parallel, in direct measurements, the moments of the measurement are shifted, which eventually leads to the appearance of additional errors.

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STUDY OF OPTIMAL PARAMETERS OF SMALL HYDROELECTRIC PLANTS USING POLYETHYLENE PIPES

JALALADDIN VALIYEV

Baku Engineering University, Baku /Azerbaijan

cavaliyev@beu.edu.az

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permissible parameters.

ABSTRACT

The issues of determining the optimal value of its consumption when using pressurized polyethylene pipes (PE 100) and determining the allowable value of static pressure for PE 100 (1.0 MPa) were considered in the article. For this purpose, during the use of PE 100 (1.0 MPa) brand polyethylene pipes with an outer diameter of 800 mm, the value of the appropriate consumption (Q) for determining their main parameters and the maximum value of the hydraulic pressure (Pmax) generated inside the pipe, which ensures the reliable operation of the pipes, were determined in accordance with the norms.

The investigation of the considered issue was considered in the examples of "Gusar-1" small HPP on the Gusar tributary channel and "Balakan-1" small HPP on the Balakan river.

If we take into account that the main parameters that determine the power of the hydroelectric station are consumption (Q) and pressure (Hg), then the power of the hydro unit:

$$N = 9{,}81 \cdot Q \cdot H_g \cdot \eta \qquad (1)$$

where: η - is the useful work coefficient of the hydro unit.

Pressurized polyethylene pipes (PE) - should ensure the minimization of pressure losses when supplying water to hydroturbines and maintaining the internal hydraulic pressure created in PE pipes during the entire period of operation of small HPPs.

Therefore, when using PE 100 (1.0 MPa) brand polyethylene pipes with an outer diameter of 800 mm, the value of consumption (Q) corresponding to the minimal pressure loss that can be released for the application of their main parameters and the maximum value of the available hydraulic pressure available inside the pipe that ensures reliable and safe operation of the pipes (Pmax) should be determined according to the norms [2, 3, 4, 6, 9].

1. Determining the optimal cost of PE pipes consumption

The total pressure loss during the movement of water in pressurized pipes consists of hydraulic losses along the length of the pipe and local hydraulic losses. Local losses occur when

water passes through nets, drawers, bends, places where the diameter of the pipe changes, and do not exceed 10-15% of the hydraulic losses along the length of the pipes.

Hydraulic losses along the length of the pipes are proportional to their length (L), water consumption or average velocity, internal diameter of the pipe, roughness of the walls and in which hydraulic mode they work. The Darcy-Weisbach formula that connects all these features is defined by the following expression:

$$h_e = \lambda \frac{L \cdot \upsilon^2}{d \cdot 2g} \tag{2}$$

where λ - is the coefficient of hydraulic resistance of the pipe material.

When the speed of water is υ>1,2 m/sec., the value of coefficient λ of PE pipes depends on the inner diameter of the walls and the Re number, and it works in the "hydraulic smooth pipes" zone, which does not depend on the roughness. The coefficient of hydraulic resistance for polyethylene pipes with an inner diameter of 700 mm is determined from the tables in the survey book and is λ= 0.0095 [2,6,7,8].

For the work of pipes, the form of replacing speed with consumption in formula (2) is more convenient ($Q=\upsilon \cdot \omega=\upsilon \cdot \pi \cdot d^2/4$). Since the pressure loss (h_e) is proportional to the length (L) of the pipe, it is possible to calculate the pressure loss for different pipe lengths by defining the loss per unit length by the dimensionless quantity $i_e = \frac{he}{L}$, i.e. $h_e=i_e \cdot L$. The formula (2) for the unit pressure loss for a pipe with an inner diameter of 700 mm can be reduced to:

$$i_e = \frac{h_e}{L} = 0.0095 \frac{16 \cdot Q^2}{\pi^2 \cdot d^5 \cdot 2g} = 0.0047 Q^2 \tag{3}$$

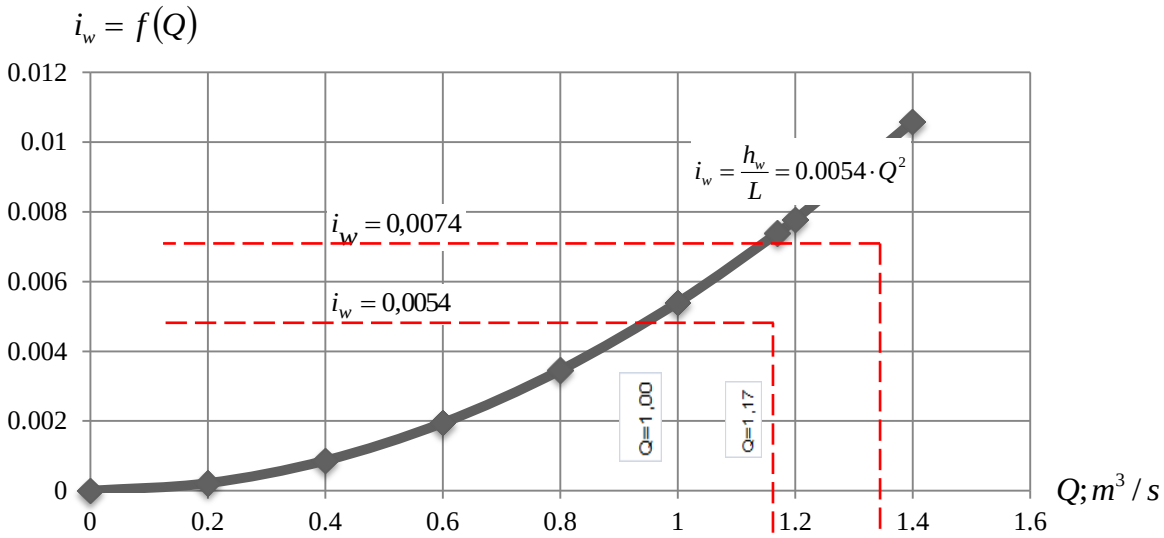
If we take into account the local losses, which cannot exceed 15% of the longitudinal losses, then

full hydraulic losses for 1 p. m. of PE 100 brand pipe can be determined as:

$$i_w = 0{,}0054 \cdot Q^2 \tag{4}$$

In order to simplify the calculations, a graph of the dependence of the unit losses on the consumption was established for the PE 100 pipe with an outer diameter of 800 mm (Fig. 1).

Fig. 1 Graph of pressure unit losses i_w=f (Q)



2. Allowable value of static pressure for PE 100 (1.0 MPa). Determination

They take the internal design pressure equal to the greatest pressure that can occur in the pipe during operation. In pressurized pipes, a phenomenon of hydraulic shock occurs, which can increase the internal pressure several times. With the help of various constructive measures (extinguisher, waste water discharge, etc.), it is not possible to eliminate it completely, it can only be significantly reduced. It is recommended to limit the maximum relative pressure increase Z=⌾H/Ho during hydraulic shock at the end of the polyethylene pipe to the following values [4]:

$H_o \leq 40$ m when	Z=0,7÷0,5
H_o=40÷100 m when	Z=0,5÷0,3
$H_o \geq 100$ m when	Z=0,3÷0,25

Taking this into account, the internal pressure of the pipe

$$P=H_o \cdot (1+Z) \quad (5)$$

will be.

For pressurized PEB whose internal limit pressure is equal to the P^0_{limit}, it can be used if the following condition is met [1, 2, 3, 4, 5]:

$$P \leq k_y \cdot k_d \cdot \gamma_n \cdot P^0_{limit} \quad (6)$$

where: P^o_{limit} – limit pressure of PE 100 (1.0 MPa) brand pipe Pohaddi=1.0 MPa = 10 atm. = 100 m; ky is a coefficient that takes into account the working conditions of PEB, ky =0.96; Kd is a coefficient that takes into account the decrease in the strength properties of PEB during the operation process due to the change in water temperature; kd = 0.80 (for t = 30^0 C); γ_n – reliability coefficient taking into account the class of devices, γ_n =0.98 (class III); ky; kd The values of γ_n coefficients [1, 2, 3, 4, 5, 6] are generally accepted.

If we substitute these values in the formula, we get:

$$P \le 0,96 \cdot 0,80 \cdot 0,98 \cdot 100 = 76,0 \text{ m} \quad (7)$$

$$\text{or } H_o(1+Z) \le 76,0 \text{ m}$$

When using PEBs of PE 100 (1.0 MPa) brand, the maximum value of static pressure (Ho) will be as follows:

H_o^{max} = 53,0...54,0 m

Let's show the results of the calculations with examples:

1. "Gusar-1" small HPP on the Gusar tributary channel (Fig.2)

The main parameters given are:

H_o=40,53 m; Q=1,17m^3/s; L=577 m

Determining the possibility of using PE 100 (1.0 MPa) branded pipes with an outer diameter of 800 mm as pressure pipes.

We determine the total hydraulic losses of the pressure:

According to the value of consumption Q from Fig. 1, we determine the unit losses of pressure for PEB.

i_w=0,0074

$h_w=i_w \cdot L$=0,0074·577=4,26 m

We define the existing raid: $H_g=H_o - h_w$=36,27 m

For the turbine, Hg=36.44 m is assumed, which corresponds to the pressure available when using PE 100 (1.0 MPa) polyethylene pipe.

We determine the value of the hydraulic pressure (Pmax) that can be released in the pipe by the formula (6).

For pressure Ho=40.53 m, z=0.4 is taken.

P_{max} =40,53(1+0,4)=56,75 m

P_{max}<76,0 m because the conditions are followed.

PE 100 (1,0 MPa) branded polyethylene pipe can be used.

Fig.2 "Gusar-1" small HPP on the Gusar tributary channel

2. "Balaken-1" small hydropower station on the Balaken river (Fig.3)

The main parameters given are:

Ho=63,4 m; Q=1,0 m^3/s; L=1960 m

Let's determine the total hydraulic losses:

First, we determine the unit losses of pressure corresponding to consumption Q=1.0 m^3/s from Fig.1

i_w=0,0054 later $h_w=i_w \cdot L=0,0054 \cdot 1960=10,58$ m we define.

We define the existing raid: $H_g=H_o-h_w=63,4-10,58=52,8$ m

In the design, the design head for the turbine is assumed to be 60.0 m. When using PE 100 pipe, the losses make up more than 17% of the static pressure.

We determine the allowable value of the hydraulic pressure in the pipe (Pmax) by the formula (6).H_o=63,4 m when, z=0,5 is accepted

P_{max} =63,4 (1+0,5)=95,1 m

P_{max}>76,0 m

Acceptance of PE 100 (1.0 MPa) brand pipes due to violation of pipe strength condition is not considered appropriate, therefore, a pressed steel pipe with a diameter of 1500 mm was adopted in the project.

Fig.3 "Balaken-1" small hydropower station on the Balaken river

CONCLUSION

1. Pressurized polyethylene pipes must ensure the minimization of pressure losses when supplying water to hydroturbines and maintaining the internal hydraulic pressure generated in PE pipes during the entire operation of small HPP.
2. In order to simplify the calculations in order to determine the optimal value of pipe consumption, a dependence graph of unit losses on consumption was established for a PE 100 pipe with an outer diameter of 800 mm.
3. As a result of our investigations, when using PE 100 (1.0 MPa) branded pipes with an outer diameter of 800 mm, it was determined that the maximum value of the static pressure is H_o^{max} = 53.0...54.0 m.
4. The investigation of the considered issue was considered in the examples of "Gusar-1" small HPP on the Gusar tributary channel and "Balakan-1" small HPP on the Balakan river. It was determined that PE 100 (1.0 MPa) brand polyethylene pipe can be used in "Gusar-1" small HPP. In "Balakén-1" small HPP, due to the violation of the strength condition of the pipe, it is not considered appropriate to accept PE 100 (1.0 MPa) pipes, therefore, a pressed steel pipe with a diameter of 1500 mm was adopted in the pro

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RESEARCH OF THE DENSITY OF THERMAL WATERS OF THE KHACHMAZ DISTRICT OF THE REPUBLIC OF AZERBAIJAN

MAHIR BASHIROV [1], NOFAL NABİYEV [2], AYTAN NAMAZOVA [3]

[1] Baku Engineering University, Department of "Mechanical Engineering"

mbashirov@beu.edu.az

[2] Baku Engineering University Department of "Logistics and Transport Technology"

nnabiyev@beu.edu.az

[3] Technical Humanitarian High School

aytan_bashirova@yahoo.com

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ABSTRACT

During the measurement of (p, ρ, T) dependences, in order to obtain high-accuracy values of density by means of graphical extrapolation at atmospheric pressure in each case of equilibrium, efforts were made to create the lowest possible values of pressure, the obtained values were compared with the values of density measured on the DMA 5000M device. The experimental values of the density of the "4th section " thermal water of Khachmaz district of Azerbaijan at different pressures and temperatures were measured. First, in order to check the measurement accuracy of the experimental device, the results obtained for water and toluene were compared with the information given in various literature. The obtained experimental results are shown in the table and expressed by the equation of state.

1. Introduction:

Currently, extensive measures are being taken both within the Republic and internationally to reduce the amount of carbon dioxide emitted into the atmosphere. Great work is being done in this direction in Azerbaijan (including at the Department of Mechanical Engineering of Baku Engineering University). In accordance with the "State Program on the Use of Alternative and Renewable Energy Sources in the Republic of Azerbaijan" approved by the decree of the President of the Republic of Azerbaijan dated October 21, 2004, the Ministry of Industry and Energy of the Program the implementation coordinator has been determined (Decree of the President of the Republic of Azerbaijan, 10 november 2009). In the State Program, the main directions for the implementation of measures related to the use of the potential of wind energy, as well as solar energy, the hydropower of geothermal waters, mountain rivers and water channels, as well as the energy of biomass, as the most efficient energy sources for our Republic, have been defined.

In addition to the regional fracture in the zone of thermal water distribution, there is also a zone of tectonically disturbed rocks with a branched system of sharply falling (descending) cracks covering the entire Mesozoic layer. The velocity of water is higher in the main drainage

channels, i.e., where the transfer of water heat to the surrounding rocks is the least, thus the water has the maximum temperature, and in the zones with many cracks. This is confirmed by the outputs of geothermal sources in the erosion depressions of the intersection of the main water collection zones (Namazov, 2017; Ibragimova I.Sh., Babaev, 2000; Tagiyev et al., 2001; Babayev, Ibrahimova, 2004).

The hydrogeological parameters of the discharge zone of thermal waters directly depend on the degree of cracking and the character of the hydrous rocks. The abundance and abundance of gryphons in natural outcrops indicates a well-developed rift.

Geothermal energy resources of the studied region (Khachmaz district) are particularly valuable. Thus, the colorful chemical composition, high healing properties, favorable geographical position of the area create a good basis for their treatment purposes and wide application in various fields of the national economy (Namazov, 2017; Bashirov et al., 2013).

2.Research objective

The analysis of the chemical composition of thermal water of Khachmaz district "4th section" was measured in atomic emission spectrometer with IRIS Intrepid II Optical Emission Cheomotograph inductively coupled plasma (Bashirov et al., 2013; Nabiev, 2011). The results show that the majority of chemical elements are sodium (Na). Na constitutes approximately 72.41 ÷ 90.12% of all chemical substances in the thermal water of the Khachmaz district of Azerbaijan. In the tables 1-2 shown below, the geographical coordinates of the thermal water of the "4th section" station located in Khachmaz district of Azerbaijan, the temperature at the time of exit from the source and the amount of minerals in the chemical composition are given (Bashirov et al., 2013; Nabiev, 2011).

Geographical coordinates of Khachmaz district "4th section" thermal water and its temperature at the moment of exit from the source

Table 1

Name of source	Geographical coordinates	Temperature at exit
4th section	North 41⁰36′17″ East 48⁰41′54″	T = 317,15 K

Chemical composition of thermal water of "4th division" of Khachmaz region of Azerbaijan

Table 2

The name of Thermal water	Name of the mineral	Amount of the mineral, ml/lt
4th section	Al1670	<0,01
	As1890	<0,01
	B2089	1.87
	Ba2304	0.11
	Ca3181	158.0
	Cd2288	<0.01
	Co2286	<0.01
	Cr2055	<0.01
	Cu3247	<0.01
	Fe2599	0.02
	Hg1849	<0.02
	K7664	18.30
	Li6707	0.16

	Mg2790	28.20
	Mn2939	0.11
	Mo2045	0.02
	Na8183	832
	Ni2316	<0.01
	P2136	<0.01
	Pb2203	<0.01
	S1820	37.40
	Sb2175	<0.02
	Se1960	<0.02
	Si2124	3.09
	Sr4077	9.28
	Ti3349	<0.01
	Tl1908	<0,05
	V2924	<0.01
	Zn2062	<0.01
	Total:	**1088.56**

Taking into account the fact that the vibrating tube densimeter device needs to be calibrated with at least two substances for the study of the density of liquids after checking the device's performance, for this purpose, water, toluene are used as the main calibrator. standard) were selected as substances. The results obtained for water and toluene were compared with the information given in the literature (Wagner, Pruss, 2002; Lemmon, Span, 2006). As a result of the comparison, the difference between the obtained values for the density of water and toluene and the information in the literature shows that the estimated errors of the measurements in the device are very small. Obtaining results with a small error and close to each other shows the high accuracy of the created experimental device (Nabiev, 2011; Bashirov et al., 2009).

3.Discussion of the research work and its results:

After the verification experiments on the properties of water and toluene (p,ϱ,T) were carried out, the density of the thermal water of Khachmaz district "4th section" of Azerbaijan was measured at high pressure and different temperatures in the experimental facility that works with the vibrating tube densimeter method. . During the measurement of (p,ϱ,T) dependences, in each case of equilibrium, an effort was made to create the lowest possible values of the pressure in order to obtain high-precision values of the density by means of graphic extrapolation in the atmospheric pressure, and the obtained values are the DMA of the density It was compared with the values measured in the 5000M device. The values obtained by different methods agree well within ± 0.02% (Bashirov, et al., 2013; Nabiev, 2011; Bashirov et al., 2009). Researches for thermal water of Khachmaz district "4th division" were conducted at temperatures T=(278.15÷373.15) K and pressures up to p=40 MPa. Experimental indicators obtained on (p,ϱ,T) dependencies are given in table 3.

Experimental values of the density of the "4th section " thermal water of Khachmaz district of Azerbaijan at different pressures and temperatures

Table 3

p / MPa	ρ / kq/m^3	T / K	p / MPa	ρ / kq/m^3	T / K
0.201	1007.44	278.15	0.214	991.53	328.15
5.006	1009.65	278.15	5.006	993.57	328.17
10.006	1011.92	278.16	10.301	995.81	328.16
15.214	1014.26	278.14	15.921	998.17	328.15
20.004	1016.39	278.15	20.152	999.93	328.14
25.301	1018.72	278.16	25.008	1001.94	328.15
29.986	1020.76	278.15	30.102	1004.03	328.13
35.114	1022.97	278.13	35.026	1006.03	328.15
39.997	1025.04	278.15	39.996	1008.03	328.15
0.690	1006.06	288.16	0.302	983.52	343.15
5.061	1007.95	288.11	5.014	985.64	343.17
10.162	1009.96	288.10	10.006	987.85	343.15
15.166	1011.85	288.13	15.308	990.14	343.16
19.942	1014.07	288.11	20.410	992.30	343.15
24.996	1016.13	288.13	25.008	994.21	343.16
30.010	1018.40	288.11	29.998	996.23	343.16
34.744	1020.45	288.13	35.047	982.30	343.15
40.002	1022.67	288.13	39.995	1000.14	343.15
0.798	1002.95	298.19	0.304	974.18	358.15
5.132	1004.77	298.19	5.008	976.40	358.14
9.979	1006.82	298.19	10.009	978.69	358.16
14.879	1009.03	298.14	15.308	981.04	358.15
20.098	1011.23	298.13	20.008	983.07	358.15
25.123	1013.33	298.13	25.021	985.18	358.16
30.022	1015.38	298.12	29.987	987.20	358.17
34.932	1017.28	298.13	35.030	989.19	358.15
39.846	1019.24	298.14	39.994	991.08	358.15
0.385	997.61	313.07	1.393	963.97	373.08
5.158	999.87	313.08	5.416	965.99	373.08
10.079	1002.12	313.08	10.407	968.36	373.08
15.112	1004.32	313.08	15.587	970.77	373.09
19.962	1006.44	313.06	0.420	972.95	373.09
25.287	1008.74	313.06	25.274	974.97	373.09
29.992	1010.62	313.07	30.049	977.01	373.09
35.037	1012.69	313.06	35.201	978.99	373.09
40.130	1014.69	313.08	39.745	980.72	373.10

The obtained experimental results are expressed by the following equation of state:

$$p = A\rho^2 + B\rho^8 + C\rho^{12} \qquad (1)$$

Here, coefficients A(T), B(T) and C(T) depend on temperature in polynomial form:

$$A(T) = \sum_{i=1}^{3} a_i T^i,\ B(T) = \sum_{i=0}^{2} b_i T^i,\ C(T) = \sum_{i=0}^{2} c_i T^i \qquad (2)$$

Values of coefficients a, b and c in equation (2) are given in table 6.

Table 4

$a_1 = -1.2533813$	$b_0 = 736.75489731$	$c_0 = -488.2859137$
$a_2 = -0.339952 \cdot 10^{-2}$	$b_1 = -3.43166265$	$c_1 = 3.2130145$
$a_3 = 0.96906297 \cdot 10^{-5}$	$b_2 = 0.87206243 \cdot 10^{-2}$	$c_2 = 0.61334197 \cdot 10^{-2}$

The equation (1) allows us to express the experimental values of the dependence (p, ϱ, T) ofhermal water with an error of 0.007%, taking into account the values of the coefficients A (T), B (T) and C (T).

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DOUGH USED IN THE NATIONAL CUISINE OF AZERBAIJAN STUDY OF RHEOLOGICAL PROPERTIES OF SEMI-TREATMENT

AKHMED MELIKOV

Azerbaijan State Agrarian University

axmed_melikov@mail.ru

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ABSTRACT

The article examines some rheological properties of a semi-finished dough product, including the property of elastic recovery of the dough and density changes depending on pressure, in order to determine the technological and design parameters of the rollout during the formation of the dough.
The change in the elastic-reducing properties of the dumpling dough at different design parameters of the rolling machine and at different dough humidity (W = 45-50%) and the change in dough density depending on pressure were experimentally studied.
The study's purpose is to ensure the high quality of the semi-finished study's purpose is to ensure the high quality of the semi-finished product by conducting the moulding process in an optimal mode.

INTRODUCTION

The result of the analytical study shows that lavash, juha, noodles, hangel, dushbara, etc. are typical for our national cuisine. in its preparation, semi-finished dough of various thicknesses is used. Depending on the purpose, the thickness of the mentioned test semi-finished products may be in the range of 0.5-1.5 mm. In most products, the dough is formed by rolling out semi-finished products. The coefficient of elastic recovery of the mechanically acting dough mass is one of the main parameters required in the report of dough forming machines. In this regard, the coefficient of elastic recovery of the dough varies depending on the humidity of the dough, its temperature, the duration of mechanical action, the number of repeated rolls and the distance between the shafts [1,3,4,6].

The purpose of the study

The purpose of the study is to ensure the high quality of the semi-finished product by carrying out the machine molding process of semi-finished dough products used in our national cuisine in an optimal mode.

The method of experiments.

For an experimental study of the elastic recovery properties of the dough, a dough rolling device consisting of two rolling shafts was used (fig. 1). The device provides the possibility of adjusting the gap between the shafts within 0.5...20 mm. The rotation speed of the spreading

shafts was 100...120 rpm. The thickness of the test sample at the initial stage and after molding is recorded by measuring with a micrometer. The experiment was carried out on semi-finished products of dushbara and hangal dough (dough humidity 45-50%)..

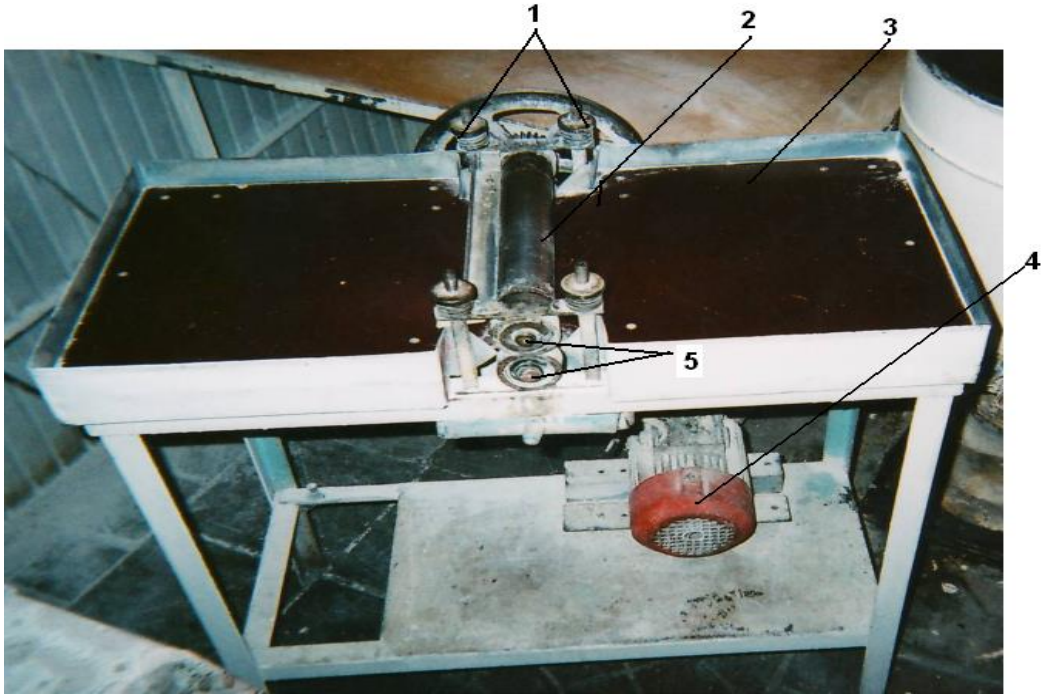

Figure 2.6. Experimental setup for kneading dough.

1 – regulators, 2 – shafts, 3 – table, 4 – electric motor;

The coefficient of elastic recovery of the test is calculated using the following expression [8]:

$$\varepsilon_b = \frac{\delta_x}{a}, \quad (1)$$

Where

δ_x- the thickness of the test tape after rolling, m;

a- distance between shafts, m.

A device consisting of a cylinder, a piston, and a table for placing cargo was used to study the change in the density of the test semi-finished product depending on the pressure. During the experiment, 50 g of dashboard dough was used. To determine the height change of the text placed inside the cylinder, a pointer that is in rigid contact with the piston shaft inside the cylinder, and a measuring ruler is attached to the device body. A magnifying glass attached to the instrument body is used to determine the offset relative to the ruler.

The density of the test is determined by the following expression[10].:

$$\rho = \frac{m}{V}, kq/m^3 \quad (2)$$

Where

m - the mass of the dough, kq;

V- the volume of dough in the cylinder,m^3.

The volume of dough in the cylinder is determined by the following expression [2].

$V = \frac{\pi d^2}{4} h,$ (3)

Where

d- diametr of cylinder,m;

h- height of the part of the cylinder filled with dough,m^3.

Analysis of the research results

The results obtained show that the moisture content of the dough, the distance between the shafts and the number of repeated rolls affect the elastic recovery coefficient of the dough (table 1). The analysis of the study shows that as the moisture content of the dough increases, the elastic recovery coefficient also begins to increase. When the value of the shaft spacing is $a = 2{,}0 \cdot 10^{-3}$ m, with a dough humidity of W = 45%, the elastic recovery coefficient ε_b= 1,65, with a dough humidity of 47%, $a = 1{,}70$, and a dough humidity of 50% increases and becomes $\varepsilon_b = 1{,}75$ (rolling was repeated once). As the distance between the shafts increases, the coefficient of elastic recovery decreases. So, with the distance between the shafts $a = 1 \cdot 10^{-3}$ elastic recovery coefficient ε_b=2,30, $a = 2 \cdot 10^{-3}$ m elastic recovery coefficient ε_b=1,65, and at the distance between the shafts $a = 3 \cdot 10^{-3}$.The coefficient of elastic recovery is equal to ε_b=1,5. With an increase in the number of repeated rolls, the coefficient of elastic recovery in the dough begins to decrease. The distance between the shafts a =3$\cdot 10^{-3}$ m, test humidity W =45%, elastic recovery ε_b=1,5 with a single unfolding of the test mass, when it spreads for the second time, ε_b=1,43, and when it spreads for the third time, ε_b=1,33.

Table 1

The results of experimental studies conducted depending on the thickness of the dough $\delta_x(m)$, the coefficient of elastic recovery ε_b, its humidity W (%), the distance between the spreading shafts a(m) and the number of rolls (n)

W,%	$a \cdot 10^3, m$	The amount of rolled dough, n					
		1		2		3	
		$\delta_x \cdot 10^3, m$	ε_b	$\delta_x \cdot 10^3, m$	ε_b	$\delta_x \cdot 10^3, m$	ε_b
45	1,0	2,3	2,30	2,2	2,20	2,0	2,00
	1,5	2,8	1,86	2,6	1,73	2,5	1,66
	2,0	3,3	1,65	3,2	1,60	3,1	1,55
	2,5	3,9	1,56	3,8	1,52	3,6	1,44
	3,0	4,7	1,50	4,4	1,43	4,1	1,33
47	1,0	2,4	2,40	2,3	2,30	2,1	2,10
	1,5	3,0	2,00	2,8	1,88	2,5	1,67
	2,0	3,4	1,70	3,3	1,65	3,2	1,60
	2,5	4,0	1,60	3,8	1,52	3,5	1,40
	3,0	4,7	1,56	4,4	1,47	4.1	1,37
50	1,0	2,5	2,50	2,3	2,30	2,1	2,10
	1,5	3,3	2,20	3,2	2,10	3,0	2,00
	2,0	3,5	1,75	3,4	1,70	3,3	1,65
	2,5	4,3	1,70	4,2	1,68	4,0	1,60
	3,0	4,9	1,60	13,2	1,50	13,0	1,40

Thus, it can be concluded that by re-rolling the dough several times, it is possible to reduce the coefficient of elastic recovery and thereby obtain a semi-finished dough of the required thickness. During the technological process, the mass of the dough subjected to mechanical processing changes its density depending on the pressure. In the process of forming national

flour products, when designing technological equipment, it is necessary to take into account the change in dough density depending on mechanical pressure. Thus, the density of the dough affects the quality of the finished product and productivity [7,8,9,10].

The change in the density of the dough depending on the pressure is shown in table 2. As can be seen from the table, with increasing pressure, the density of the dough begins to increase. This is due to the fact that as a result of the influence of microbiological processes during processing, porosity is created in the dough, and as the pressure force increases, the dough gradually begins to shrink. After the pressure value $P = 245{,}5$ kPa, the density of the dough remains unchanged. A similar situation occurs with different values of dough humidity.

Table 2

Changing the density of the dough depending on the pressure (test storage time t=10 min., temperature $T = 20^0\ C$

№	Preassure P,kPa	Density of dough $\rho, kq/m^3$	
		W=45%	W=50%
1	30,60	1112,4	1113,5
2	60,47	1115,7	1116,8
3	90,30	1125,5	1127,9
4	130,20	1137,6	1138,7
5	169,93	1143,5	1143,6
6	200,74	1160,3	1160,3
7	245,50	1160,9	1160,8

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ANALYSIS OF THE DEMAND ON MOVEMENT OF THE POPULATION BY PUBLIC TRANSPORT AND TAXI VEHICLES IN THE MINGACHEVIR CITY

ALLAZ ALİYEV [1, 2]

[1]Azerbaijan Technical University[1]

allaz.aliyev@aztu.edu.az

[2] Mingachevir State University[2]

allaz.aliyev@mdu.edu.az

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ABSTRACT

The article is dedicated to the demand on public transport and taxis in the Mingachevir city, which belongs to the class of medium cities of our country. A survey was conducted to analyze the current situation in the field of transportation and transport in Mingachevir city and to identify problems. The survey covered different age groups (under 18, 18-25, 26-35, 36-45, 46-55, 56-65, over 65), different professions and different zones in the Mingachevir city. As a result of the conducted survey, the opinions of the population on these issues were studied, the existing problems in this field were revealed and solutions were proposed. Also, visual monitoring of buses and taxis was carried out and deficiencies were revealed. As a result of the conducted scientific-research works, it was determined that buses in general use are more accessible than taxis.

INTRODUCTION

The Urban Mobility Plan concept (UMP) was first used in the European Union (EU) between 2009 and 2013. It emerged as a result of the inability of traditional transport planning practices to offer solutions to the mobility problems that arised in modern cities.

This approach was taken as a basis during the preparation of the action plan of the cities of Azerbaijan, including the Mingachevir city. The SMP is a strategic plan designed to meet mobility-related demand to improve the quality of life of people living in and around cities and to provide better service levels to commercial establishments located there. This plan is implemented on the basis of existing planning practices, taking into account the principles of monitoring and evaluation.

The Mingachevir city is the fourth largest city of Azerbaijan in terms of population. It received city status on November 11, 1948. On February 4, 1954, the republic became a subordinate city. It is located on the banks of the Kura River. Mingachevir city is bordered by Yevlakh district on the east, south and west, and Mingachevir Reservoir on the north [1].

The territory of Mingachevir city is 130 km², the local population is 105,671 people, the internally displaced are 20,740 people. According to the 2018 census, 50.5% of the population are men and 49.5% are women [1].

The implementation of the mobility project in the Mingachevir city, the improvement of the transport provision of the population in residential areas serves to increase the labor productivity of the population and the quality of life.

Within the framework of the mobility project in the Mingachevir city, during the monitoring of bus routes, there were cases that caused a decrease in the quality of service to the population.

The low quality of public transport services causes a rapid increase in the number of private cars in our country. As a result, traffic jams increase and dangerous situations on the roads are accompanied by more traffic accidents.

At the same time, there are more cases of environmental pollution with emission gases, other car waste and noise [2].

METHODOLOGY

In order to determine the level of transport services provided to the population, surveys and monitoring were conducted in 16 cities of our country under the organization of "Logistics and Transport Institute" operating under the Azerbaijan Technical University. One of those cities is Mingachevir. Tablets and mobile phones were used to conduct the survey, and live observation was used to conduct the monitoring. Surveys and monitoring were carried out by undergraduate and graduate students of Azerbaijan Technical University. The survey was conducted among 424 respondents and 50 questions were included in the questionnaires. A certain part of the survey questions is devoted to the study of population displacements in the Mingachevir city. By using the survey method, the opinions of the population regarding the transport service in Mingachevir city were obtained and the emerging problems were identified. Corresponding improvements have been proposed to solve the problems.

ANALYSIS OF POPULATION MOVEMENTS

The share of use of common means of transport (buses) used by the respondents who took part in the survey for the Mingachevir city during the month is shown in the following pictures (Figures 1-3).

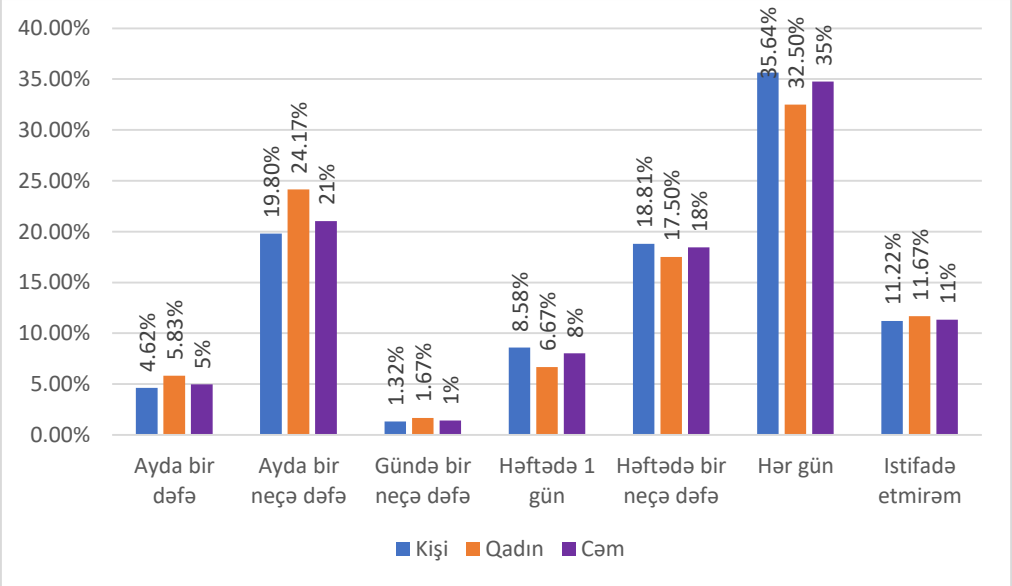

Figure 1. Frequency of using the bus during the month of the respondents participating in the survey

As it can be seen from Figure 1, 18.81% and 17.50% of male and female respondents participated in the survey, respectively, several times a week, 19.80% and 24.17% several times a month, 35.64% and 32.5% every day, 4.62% and 5.83% once a month, 8.58% and 6.67% 1 day a week, 1.32% and 1.67% use the bus several times a day. 11.22% and 11.67% of male and female respondents, respectively, said that they did not use the bus during the month.

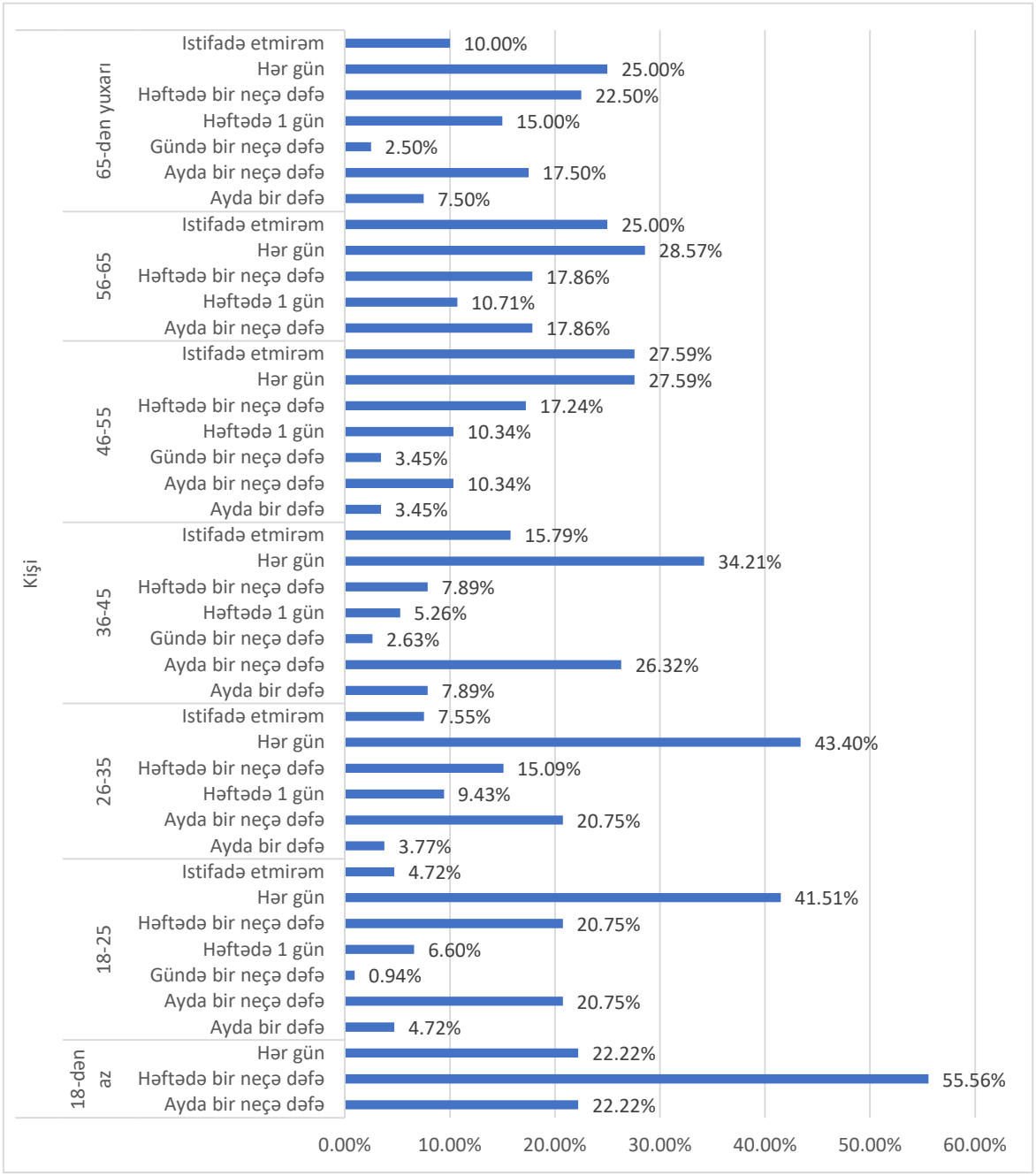

Figure 2. Frequency of bus use by male respondents

As it can be seen from Figure 2, 55.56% of male respondents in the age group less than 18 several times a week, 20.75% in the age group 18-25 several times a week, 43.40% in the age group 26-35- every day, 7.89% of the 36-45 age group once a month, 10.34% of the 46-55 age group several times a month, and 17.86% of the 56-65 age group several times a month, 65 over 25.00% reported that they used the bus every day.

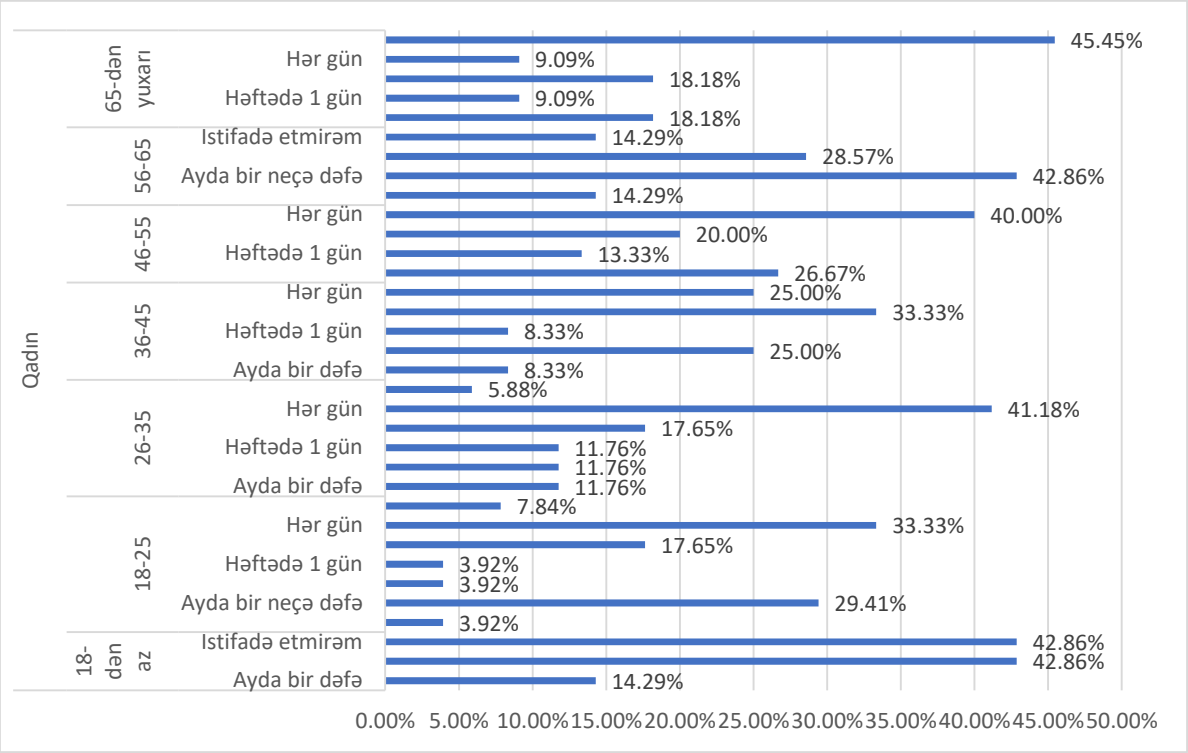

Figure 3. Frequency of using the bus by female respondents

As it can be seen from Figure 3, 42.86% of female respondents under the age group of 18 do it every day, 17.65% of the 18-25 age group do it several times a week, and 11.76% of the 26-35 age group do it once a week. day, 33.33% of the 36-45 age group used the bus several times a week, 20.0% of the 46-55 age group several times a week, 42.86% of the 56-65 age group used the bus several times a month, 45.45% of the age group over 65 said that they did not use the bus.

The frequency of the respondents' use of taxis during the month is given in the following pictures (Figures 4-6).

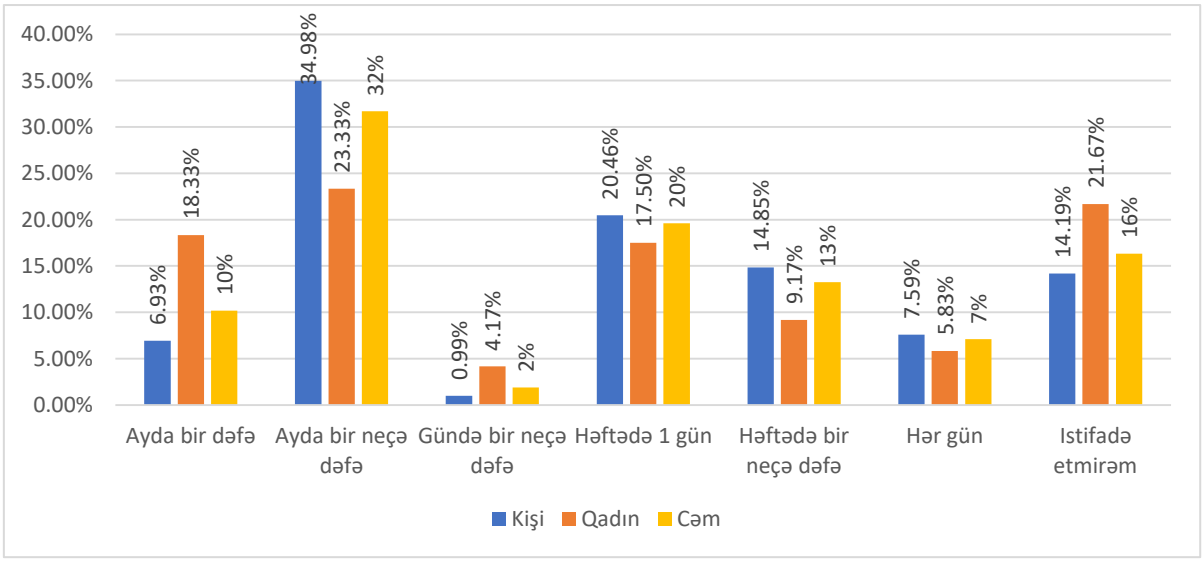

Figure 4. The frequency of using a taxi during the month of the respondents who took part in the survey

As it can be seen from Figure 4, 34.89% and 28.33% of male and female respondents participated in the survey several times a month, 6.93% and 18.33% once a month, and 14.85% and 9.17% several times a week. , 7.85% and 5.83% reported that they used a taxi every day, 20.46% and 17.5% once a week, and 0.99% and 4.17% reported that they used a taxi several times a day. 14.19% of male respondents and 21.67% of female respondents said that they do not use taxis.

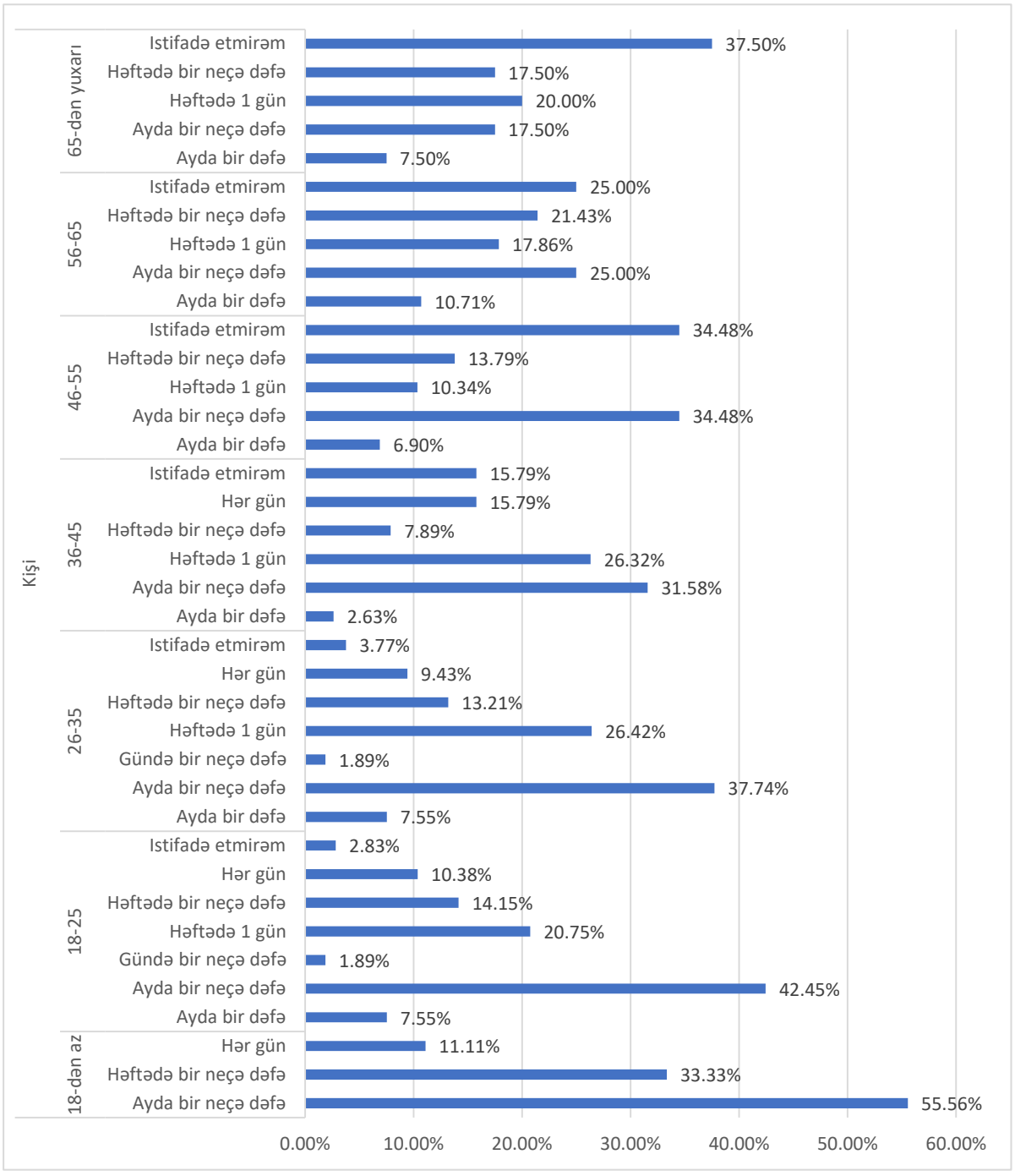

Figure 4. Frequency of taxi use by male respondents

As it can be seen from the picture, 55.56% of the under 18 age group several times a month, 42.45% of the 18-25 age group several times a month, and 37.74% of the 26-35 age group several times a month. , 2.63% for the 36-45 age group once a month, 34.48% and 25.00% for the 46-55

and 56-65 age groups several times a month, respectively, and 7.5% for the over 65 age group They reported that they used a taxi once a month.

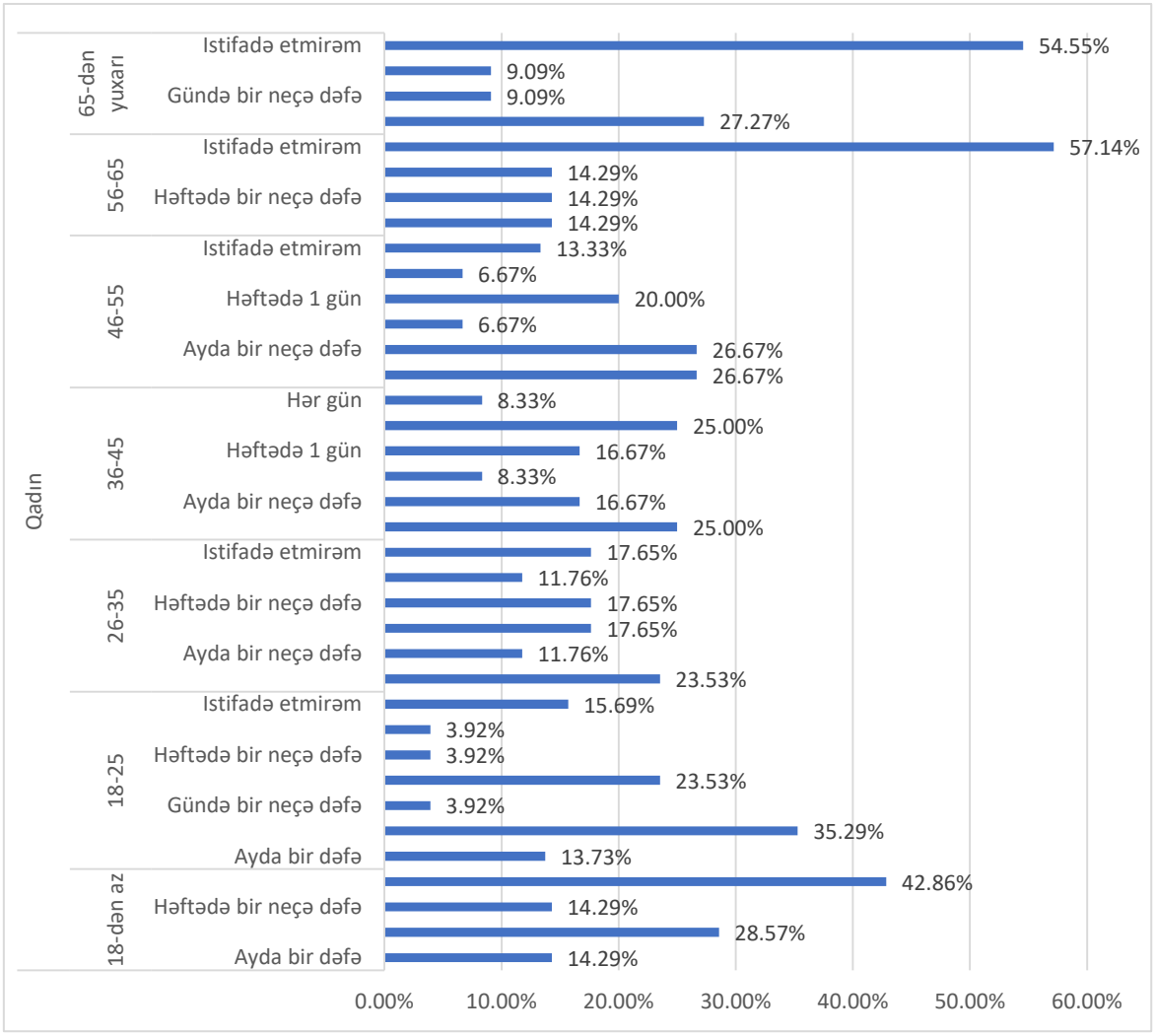

Figure 6. Frequency of taxi use by female respondents

As it can be seen from the figure, 42.86%, 15.69%, 17.65%, 0%, 13.33%, 14.29% and 54.55% of the female respondents in all age groups stated that they did not use a taxi.

Thus, it is clear from the results of the conducted research that buses in general use are more accessible than taxis. However, the fact that both the bus fleet and the taxi fleet are too old does not fully satisfy the residents of Mingachevir city. Therefore, the tendency of the majority of city residents to use private passenger cars can lead to an unnecessary increase in the city car park. An excessive increase in the car park usually causes traffic problems.

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FLOODS IN THE TERRITORY OF THE REPUBLIC OF AZERBAIJAN AND COUNTER MEASURES AGAINST THEM

A.SH. MAMMADOV, A.A. BAYRAMOV, E.B. JAVADZADE, G.H. HUSEYNOV

"HYDROLOG" Limited Liability Company, AZ1102, Baku city, Tbilisi Ave.

*e-mail:*ahmad.m@hidrolog.az

S.A.Velieva associate professor (Azerbaijan University of Architecture and Construction)

e-mail:velieva-sevda@mail.ru

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ABSTRACT

The article is devoted to mudflow activities that caused destruction on the territory of the Republic of Azerbaijan, the socio-economic problems they caused and their elimination. It also provides extensive information on the causes of floods and their hydraulic regime, devices used in global practice for managing flood waters, and sound recommendations for taking measures to reduce the damage caused by floods to the country's economy. Mudflow floods are caused by high steepness of river slopes, accumulation of large amounts of erosive material in river basins, heavy downpours and prolonged rains, intensive melting of snow cover accumulated in river basins due to a sharp increase in air temperature, and human economic activity . The mountainous and foothill regions of Azerbaijan, especially the southern slopes of the Greater Caucasus, are considered one of the regions with the largest number of mudflows in the world.

If earlier in our country mudflows occurred every 5-10 years, in recent years, under the influence of climate change and socio-economic development, the intensity, frequency and duration of floods have been observed (even on some rivers they repeat every year, and sometimes several times a year).

Introduction. Flood (an Arabic word for strong river currents) is a stony-muddy stream that suddenly appears in the bed of mountain rivers as a result of intense rains.Floods easily move stones weighing 100 tons by creating a flow with a speed of 3 m/s, and sometimes 10-15 m/s. Sometimes the amount of dependent materials he brings with him is several million. The sound, roar and roar of the approaching floods can be heard from a distance of a hundred meters or even several kilometers. The average height of flood waters reaches 3-5 meters, and rarely 8-10 meters.The main reason for the occurrence of floods is the physical-geographical conditions of the area, including the orographic-geomorphological structure - climate, soil, vegetation and hydrometeorological processes. A short-term (sometimes within a few hours) destructive muddy-stone flow of mountain rivers is called a flood. Intense torrential rains, rapid melting of glaciers and seasonal snow cover wash debris from the slopes and fill it into the river bed (channel) /1/.In most cases, floods occur 2-3 hours after heavy rains or after intensive melting of snow cover accumulated in river basins. The flood flow in the river lasts from several minutes to several hours. 80-90 percent of floods in Azerbaijan are caused by rainwater.The volume of

debris materials in flood flows is from 20-25% to 70-80% of the mass of the flow. Therefore, in a short period of time, a large amount of waste material is transported to the delivery cones of rivers through floods. The high flow of a flood increases its destructive power, which distinguishes it from ordinary floods. It is necessary to distinguish flood and flood flows.

Floods is the phase of the hydrological regime that occurs in rivers depending on the physical-geographical and climatic conditions of the river basin. Floods occur throughout the year mainly in spring and autumn seasons. Compared to floods, the amount of discharge in flood flows does not exceed 2-5% of the total flow. Flood flows in rivers are considered an expected event, and the times of its observation are informed by the population in advance. Since floods occur unexpectedly, in an instant, it is impossible to predict them in advance. The main cause of floods in dry valleys is sudden heavy downpours. The water runoff from the rains creates a rapid flow in the valleys with large slopes, which is collected in the river causes its materials to be washed and transported to the lower parts. The resulting rapid and destructive flow causes serious damage to communication lines and agricultural fields located along the road in a short period of time. The main mass of the flood is made up of large-sized sediments accumulated on the steep mountain slopes. These sediments are washed to the surface as a result of erosion on the mountain slopes and fall into the river valleys after being washed by small spurs. As a result of the tectonic processes occurring in the mountainous areas, rock splitting and the formation of small pieces of stone also occur. The formation of floods in rivers is closely related to landscape zones. In the Gobustan zone of the republic, sometimes muddy floods occur after heavy rains. Such floods are observed in Jeyrankechmez, Sumgayitchay, Takhtakorpu, Atachay and Gilgilchay basins /2, 3, 4/.

At the edges of the riverbeds, the detrital material from the erosion of the steep slopes is washed away by the currents when the floods pass through the river valley, causing the floods to take a more powerful form. Such cases are often found in Kishchay, Shinchay, Demiraparanchay, Girdimanchay and Valvalechay basins. Floodplains are mainly located in the highlands of the Big, Small Caucasus and Zangezur ranges. Debris materials collected at the foot of steep slopes and in the subsoil of river beds are also considered potential flood sources /3,4/. Currently, the alpine and subalpine meadow landscape has become an area of rapid erosion due to irregular use as summer pastures. Such areas can be found in the Hekari, Tartar, Ordubad, Girdiman, Pirsaat, Kish and Shin river basins. Flood flows are divided into 3 parts according to their composition /1,8/:

- Watery and stony floods;

- *Watery Muddy floods;*

- *Rocky-muddy floods*

According to the hydraulic structure of the flow, floods are divided into 2 places: Turbulent and laminar floods;

Turbulent floods. This flood is characterized by heavy flow and irregular movement of flow elements and intensive mixing of flow layers. Solids make up about 30-40% of the entrained materials in turbulent flows. These floods are weaker than other floods due to their destructive power.

Laminar or structured floods. Structurally in these floodsthe flow moves in parallel layers. Laminar or structural floods are stony-muddy, gravel-muddy or muddy. These floods are characterized by a large amount of silt in the flow, moving mainly in a straight direction and with itselfteabrings out a large amount of materials to its bed.Such floods are found mainly in Girdiman, Shin and Kish rivers. Such floods cause great destruction.Combating laminar or structural floods requires the construction of large-scale hydrotechnical facilities.

Floods are observed in almost all mountainous and foothill areas of the Republic of Azerbaijan.Out of 1700 rivers in the republic, 170 are considered to be flooded rivers. 67 of these rivers are considered more dangerous. 16 of the dangerous rivers (Balakenchay, Katekhchay, Talachay, Mukakhchay, Kapychay, Kurmukchay, Dashagylchay, Kishchay, Shinchay, Alijanchay, Turyunchay, Tikanilichay, Agchay, Bumchay, Demiraparanchay, Hamzalichay), 4 (Goychay, Girdimanchay, Agsuchay, Pirsaat)) are in mountainous Shirvan, 12 (Gusarchay, Guruchay, Gudyalchay, Agchay, Karachay, Chagachugchay, Valvelachay, Shabranchay, Devechichay, Gilgilchay, Atachay, Tughchay) are located in Guba-Khachmaz. 12 of the rivers with a high risk of flooding belong to the Nakhchivan Autonomous Republic, 6 to Ganja-Kazakh, 4 to Lachin-Kalbajar, 6 to Upper Karabakh, 5 to Lankaran-Astara region, and 2 to Absheron. Flooded rivers located in the territory of Azerbaijan have been a constant object of research. On the Kish River, where devastating floods are often observed, extensive research work has been carried out and embankment devices have been built. From 1772 to 1916, destructive floods passed through the Kish River 10 times, from 1926 to the present time, 43 times. Due to the economic damage they cause, floods are ahead of other natural disasters /6,7,9/.

Due to the effect of global climate change in the world, more intensive rains have been observed in the territory of the Republic in recent years. In 2022-24, more floods began to be observed in the territory of the republic. As a result of the floods that occurred in April-June 2024, up to 120 bridges located in the territory of the Republic were seriously damaged. Strong depth deformations occurred around the supports of the bridges. Bridges and other communications that suffered the most damage are mainly located on rivers in the Guba-Khachmaz zone. One of the main reasons is the removal of large amounts of sand and gravel from the channels of these rivers. Figures 1 and 2 show that the guard rail of the "Baku-Khachmaz" road bridge located on the Valvala River and the "Shollar-Baku" water pipeline crossing the river were washed away by the flood waters and fell into an accident.

Figure 1. Opening of guard rail of "Baku-Khachmaz" road bridge by washing.

Figure 2. Opening by washing the "Shollar-Baku" aqueduct crossing from the Velvele river

As can be seen from the photos, a very strong depth deformation is taking place in the river channel, and the river channel has created a 15-20 m wide deep gorge in the washed soil. The main stone-gravel alluvial soils that formed the channel were excavated and the river channel began to re-form on structurally weaker soil. In the newly formed river channels, depth deformations started to occur faster than the effect of floods. The area of the bringing cone of Mukhakhchay, which brings floods, is 310 km2, Balakenchay 255 km2, Kurmukchay 220 km2, Kish river 210 km2, and Shin river 185 km2. Hundreds of thousands of hectares of agricultural land in the catchment area of these rivers have become unusable by being covered with stones, gravel and clay brought by the flood. Many areas in Balakan, Zagatala, Gakh, Sheki, Oguz, Gabala, Ismayilli regions have been eroded by floods. S.Q.Rustamov summarized the

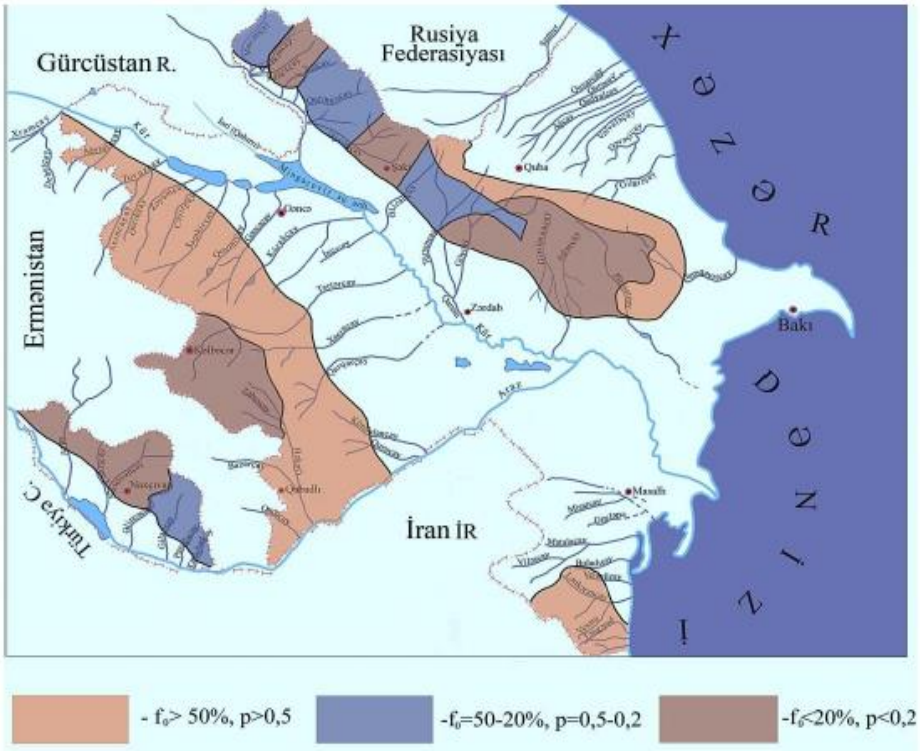
information about rivers that bring floods flowing from the southern slope of the Great Caucasus Mountains (table 1). As it can be seen, up to 40-50% of the catchment areas of Kish, Dashağıl and Girdiman rivers are floodplains /4/.

Table 1. Information about rivers that bring floods

Rivers	The average slope of the river until it brings the cone	The catchment area of the river until it reaches the cone, km2	Area of flood prone areas, km2	The ratio of the area of flood-prone areas to the total area in %
Mazymchay	0.128	117	20	17.1
Balakenchay	0.108	178	22	18.7
Katekhchay	0.118	334	51	15.3
Talachay	0.106	153	46	30.1
Mukhachay	0.088	287	92	32.1
Gurmukhchay	0.091	289	105	35.4
Gashkachay	0.113	66	10	15.2
Gumchay	0.056	108	7	6.5
Shinchai	0.092	223	91	41.0
Kishchay	0.117	165	75	45.5
Kunqutchay	0.103	166	46	27.7
Dashagilchay	0.092	259	106	40.9
Alijanchay	0.116	340	56	16.5
Turyanchay	0.081	898	280	31.2
Goychay	0.046	687	215	31.3
Girdimanchay	0.065	451	232	51.5
Agsuchay	0.071	321	96	30.0

In recent years, as a result of the expansion of settlement in the mountainous and foothill areas of the republic, anthropogenic effects on the environment have become stronger. Anthropogenic effects in all cases lead to the destruction of forest cover located in the catchment areas of rivers. The measures taken to mitigate the negative impact of anthropogenic factors in the water catchment parts of the rivers have not yet yielded significant results and the erosion areas are expanding rapidly.

Intermittent flow of floods through the channels of mountain rivers - in a wave-like hydraulic mode - causes their destructive power to be great. Depending on the physical and mechanical properties of the rocks that make up the river valleys, the river channel has a wide and narrow canyon-like cross-section. Sometimes the narrow parts of the channel are blocked by large pieces of rock and stone, creating traffic jams. A large amount of fetching material is collected behind these plugs from small floods. In cases of strong floods in the river, these plugs are broken and debris collected there is spread over a wider area of the channel with great speed. The large number of narrow areas along river valleys leads to an increase in the number of traffic jams and the creation of more destructive flood flows. The rivers of the Big, Little Caucasus and Zangezur ranges are characterized by the alternation of narrow and wide cross-sectional channels. The flood map on the territory of Azerbaijan is given in figure 3 /10/.



Georgia, Russian Federation, Armenia, Turkey, Iran I.R., Caspian Sea

Figure 3. Flood map of the territory of Azerbaijan

Flood control measures: More than 1.5 million people live in the valleys of flooded rivers in the territory of Azerbaijan. More than 200 settlements of 18 districts of the republic are located in flood-prone areas. According to statistics, 300 km of railways, more than 1000 km of highways, hundreds of bridges and other communications are located in flooded areas. In the world the measures to combat handworms are mainly carried out in two directions: active and passive methods. Active control measures are aimed at preventing natural and anthropogenic factors that cause floods. These control measures are carried out by carrying out phytomeliorative works in mountain-meadow and forest zones, as is the case all over the world. Among these measures, it is important to protect the forest zone in the catchment basin and to completely ban cattle grazing in the forests. Determining the norms of animal grazing in alpine-subalpine meadows, where the main floodplains are formed and used as summer pastures, is one of the important issues. In the world experience and very little active control measures in Azerbaijan show that the restoration of the forest-forest-shrub ecosystem has a greater effect in high-altitude and medium-altitude areas subject to intense erosion. These fighting measures should be carried out on a larger scale at the state level.

Passive methods include engineering facilities built in riverbeds where floods pass, embankments for the protection of settlements and economic facilities in the flow cones of rivers, flood catcher-level-raising partitions built along the length of the channel (walls with a height of 2-3 m and barriers with holes and meshes that are higher). and include clauses that leave the relatively dry part while keeping the flow of the flood /1, 8/. The general classification of this type of devices is given in table 2.

Table 2. Devices used in the engineering protection of areas against floods

Possible actions and type of device	Purpose of the device and conditions of application
Flood-catcher devices	
Concrete, reinforced concrete and stone dams:	Keeping the flood flows in the upper bay and letting the relatively smooth flow in the lower bay by taking the mains
Dams with irrigation	
Porous-mesh dams	
Deaf soil-stone embankments	
2. Flood release devices	
Channels	Ensuring discharge of flood flows through or bypassing the area
Flood gutters	
Bridges that release floods	
3. Directing flood waters	
Flow diverting dams	
Spurs	
4. Regulatory devices	
Adjustment teeth in the form of a cascade	Actions related to retention of flood waters in the catchment area or weakening of the power of the flow
Retaining walls	
Drainage facilities	
Creation of terraces on slopes	
Forestry measures	
5. Flood prevention devices	
Flood control dams	
Water throwing near reservoir dams	
6. Organization - technical works	
Monitoring and warning service	Forecasts on the occurrence of flood flows

In order to partially extinguish the energy of the flow and deposit large-sized stones in the channel in the streams that bring floods, thresholds of concrete elements are built along the length of the channel. These calming-regulatory thresholds should be designed to release 2% of the flood flows generated in the valley. The material and height of the device -H, spacing -L are calculated based on the fractional composition of the probable flow of the flood (Figure 4).

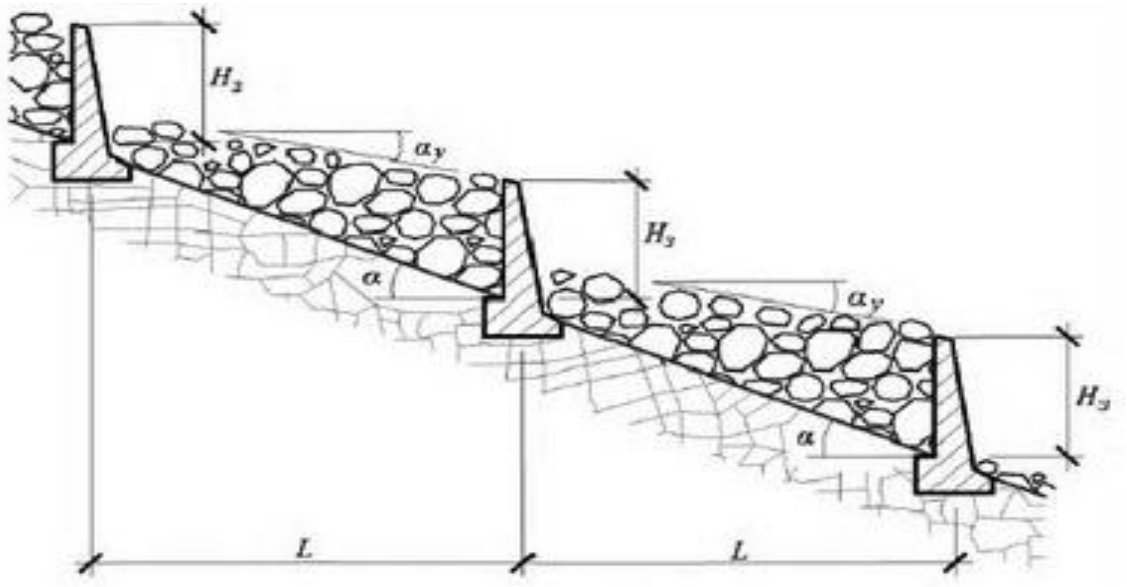


Figure 4. Placement of regulatory thresholds along the length of the duct

In some cases, it is necessary to release the flood flows over roads and railways, water channels. For this purpose, bridge-type tributary devices are built on these devices. Floodwaters are diverted through troughs made of concrete or steel sheets placed on special supports (Fig. 5 a). In order to protect the roads built along the channels of the rivers from the influence of flood waters, spurs (spurs) are placed along the bank of the channel, directing a stream at a certain distance (Fig. 5 b).

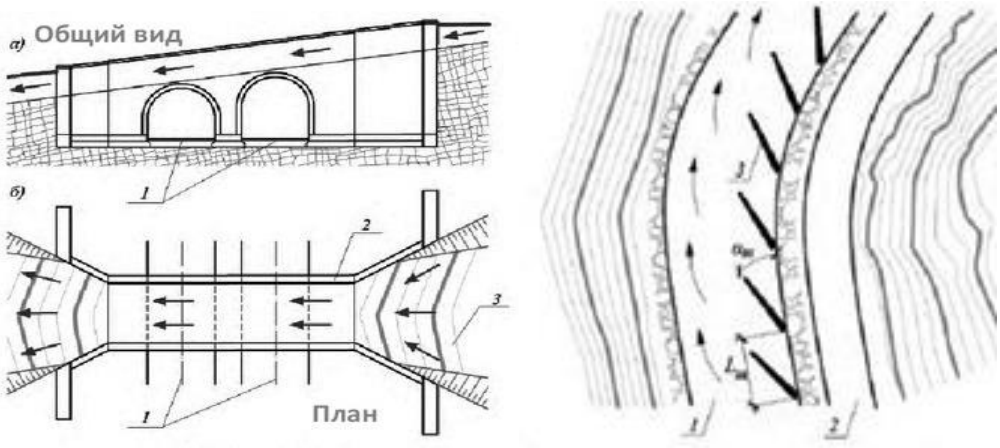


Figure 5. Flood release device

a) The device that releases the flood over the road and channel; 1-motorway, 2-flood discharge device, 3- torrent channel.

b) Flood directing device; 1-flood channel, 2-protected highway, 3-rivers.

Concrete channels designed under special conditions are used to safely carry floodwaters through cities and villages. The hydraulic capacity of these troughs should be calculated to safely release the maximum floodwater. Sometimes there is a need to build different-purpose facilities in the river channel (electric poles, various-purpose supports, etc.). for the protection of this type of facilities from flood waters, walls are used that cut off the flood flow and direct the debris to the outside (picture 6).

Artificial concrete chanel

flood, protected object

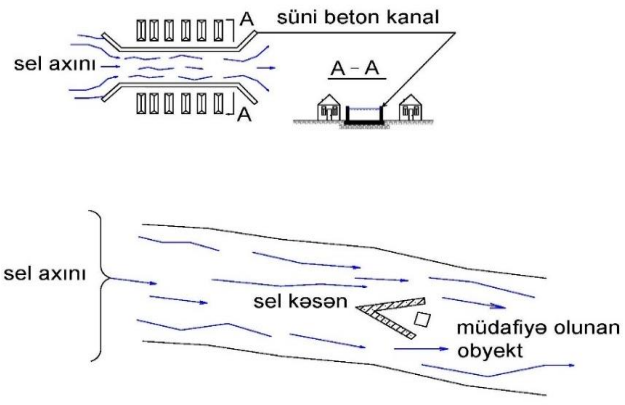


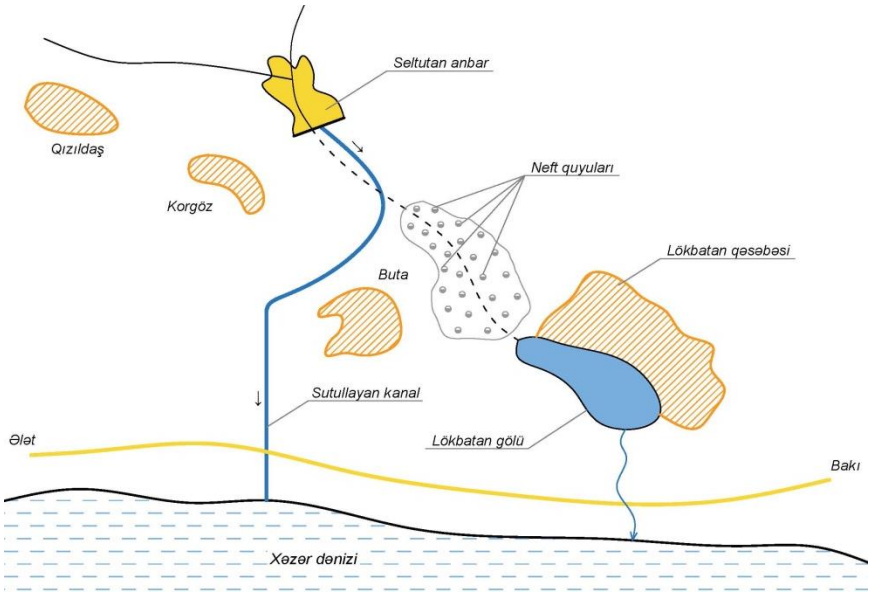
Figure 6. Floodwater management within the city and around facilities

It should be noted that until now in the Republic of Azerbaijan, flood control measures in river basins have been mainly carried out by passive methods. In the territory of the Republic, the protection of settlements, roads, agricultural fields and other infrastructures from flood waters is carried out mainly by strengthening the banks of rivers and directing flood waters. In the rivers where more floods occur in the territory of the republic action plan and corresponding projects of combat measures have been prepared. In the rivers, embankment and sewerage works are carried out, concrete, stone-concrete and gabion dams are built. At present, there are 22 kilometers of stone-concrete dams in the upper parts of mountain and foothill rivers, and 23 kilometers of protection dams made of prefabricated reinforced concrete elements in the middle parts. Experience shows that the amount of funds spent to eliminate the consequences of floods and floods is more than to prevent them in advance. is many times more than the funds needed for the measures to be taken. Flood prevention projects include protection of residential areas, industrial facilities, engineering and technical communications and agricultural fields from the harmful effects of floods in Balaken, Zagatala, Gakh, Sheki, Oguz, Gabala, Ismayilli, Goychay, Agsu, Gusar regions and the most dangerous parts of the rivers passing through the territory of Nakhchivan AR. construction of concrete dams with a total length of up to 95.0 km is planned.In recent years, reinforced concrete retaining walls with a length of 4.5 km and a height of 4-6 m were built along the right bank of the Demiraparan river in order to protect newly created recreation centers and other facilities from flood waters in Gabala. In order to protect the city of Sheki from flood waters, a 2.5 km long coastal protection embankment was built along the left bank of the Kish River /9/.

In the territory of Azerbaijan, some settlements are located at the exits of dry valleys with a large catchment area. During heavy downpours, short-term but large mud floods are observed in Buderas, which causes serious consequences. An example of such flood events is the floods that occurred in 1957 in Kendelenchay, Gargabazarchay, Cherakenchay, Jabrayilchay and Chakhmagchay, which caused great destruction. On October 18 and 27, 1957, the torrential rains that fell on Chakmag and Jabrayil rivers caused a strong flood. The flood that occurred in the valley of the tributary of the Chakhmag river, the Guruagac branch, damaged up to 30 houses in the village of Hovuslu, and some yards and roads were covered with stones and mud 1.5-2.0 m high. On October 27, the flood that passed through the Jabrayil River caused more damage, the floodwaters came out of the river channel and spread to the main central street of the city and destroyed the cocoon receiving station. After a short flood, the yards of the houses on the main street of the city and around the Chinar river were filled with mud and 1.0-1.5 m diameter stones. After the flood that passed through the river valley, grass and tree branches were left hanging on telephone and electric wires with a height of 3-3.5 m. The river channel with a width of 20.0 m and a depth of 3.0 m was filled with silt during 2-3 hours. The flood in Kondalanchay lasted for 5 hours, and at that time the maximum water consumption was 220.0 m3/sec, which did not pass through the silting device of the water reservoir built in the course of the river (up to this time, the maximum flood consumption in the river was 15.0 m3/sec) and as a result, the right bank of the dam was washed away by the flood. destroyed. The flood from the Çerakan river, which is mainly a dry river valley, caused serious destruction in the city of Fuzuli. The floodwaters came out of the Cheraken river and flooded the courtyards of private houses and public buildings located in the city. In October, a short-term flood occurred from the Gargabazar river located in the territory of Fuzuli region, and the village area was seriously damaged. This river was flooded twice with a break of 3 hours, and after the flood, a layer of sand and gravel 3 m high was formed in the river valley /5, 7/.

In general, more floods and floodings were observed in the territory of Azerbaijan in the 1950s. Sumgait and Jeyrankechmez rivers, located on the Absheron peninsula, experienced floods in 1952, 1953, 1958 and 1963, which seriously damaged some infrastructure facilities and oil fields /2/. The floods that occurred in 1952-53 caused serious damage to the oil fields and the railway located around Lokbatan settlement. The floodwaters coming from the direction of Korgoz and Gizildash caused the level of Lokbatan lake to rise sharply and surrounding houses were flooded. Taking into account the situation, a project was developed and construction works were carried out, which envisages the capture and regulation of the flood waters of the stream flowing in the direction of Lokbatan and bypassing this area and transferring it to the Caspian Sea. According to the project, in the east of Korgoz settlement, the front of the stream was cut with a 20.0 m high earthen embankment, and a reservoir with a total volume of up to 4.2 million cubic meters was created for the regulation of flood waters. In order to direct the flood waters collected in the reservoir to the Khakhar Sea, a 7.8 km long, maximum water consumption of 12.0 m3/s channel was built. By bypassing the direction of Lokbatan, this channel allowed flood waters to flow from the western part of Buta settlement to the sea. Unfortunately, during the heavy rains in this area on April 23, 1966, the flood dam was washed away and collapsed /6, 7/.

During heavy rains, it is likely that more than 60.0 m3/sec of flood flow is observed in the creek entering the reservoir (393.0 m3/sec of flood flow was observed in the Jeyrankechmez River during this rain) /2/. There is an urgent need to rebuild this system taking into account the current climate change. If the rains that occurred in 1966 are repeated, there is a possibility that a part of Lokbatan settlement, Bina trade center and many strategically important infrastructures will be flooded. At present, the 5.2 km section of the water throwing channel of this hydrotechnical facility system is partially operational and is used for the purpose of diverting rainwater generated in the direction of Buta settlement (Fig. 7).



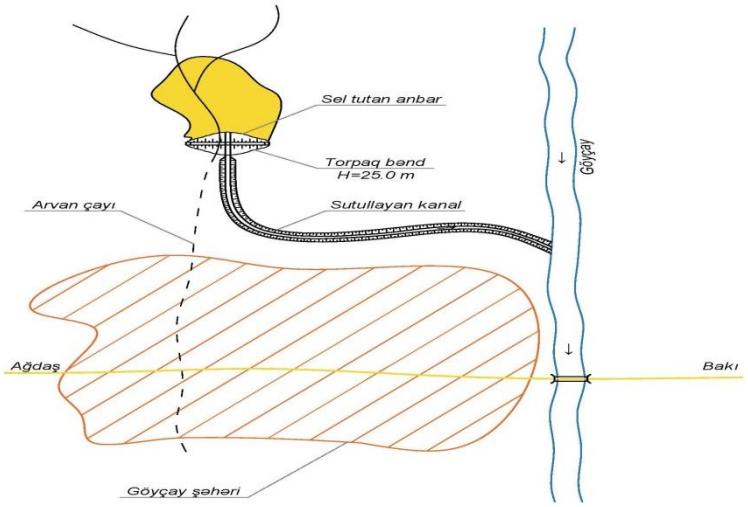
Kizildash, Korgoz, Alat, Buta, Flood catchment reservoir, oil wells, Lokbatan settlement, water catchment canal, Lokbatan lake, Baku.

Figure 7. Plan of the facilities built to protect Lokbatan settlement and oil fields from flood waters

The same catastrophic natural event occurred during the flood in the Arvan river passing west of Goychay city. The length of 12.0 km, the catchment area is mostly bare mountains, the

river Arvan river is currently located in the western part of Goychay city. At one time, the course of this river passed beyond the western boundary of the city. The city expanded rapidly to the west, and now the course of the river remains within the city. In this river, which has a catchment area of up to 2100 hectares, mud floods are observed during heavy rains. The last flood that caused greater destruction occurred on the Arvan River on April 25, 1973. As a result of the flood, the basements and courtyards of up to 200 houses located in the western part of the city were filled with mud 0.5-1.0 m high. The flood has completely paralyzed the traffic on the main streets of the city. Equipment and people from neighboring regions have come to help clean the mud accumulated on the streets. In order to prevent the situation from happening again, a special reservoir of flood catchment was built in the course of the Arvan river. In the upper part of the city, in the narrow part of the river channel, a system of hydrotechnical devices was built and put into use in 1977, which allows to catch and regulate the flood waters and partially throw them into the channel of the Blue River. An earth dam with a height of 25.0 m and a length of 230 m was built in the course of the river, and a 2.0 km long, concrete-lined channel with a maximum water consumption of 30.0 m3/sec was built to allow the flood waters to flow into the course of the Goychay River.

The total volume of the created flood catchment reservoir was 3.8 million cubic meters. In the body of this dam, a tower intake device with open windows (3x3 m in size) was built, which takes water from 4 different levels and transfers it to the canal. The flood waters entering the reservoir are partially regulated in this reservoir, and after a part of the silt settles, it is pumped into the course of the Goychay River through the siltation channel. The Seltutan reservoir created in this way ensured the complete protection of the city of Goychay from flood waters. 45-50 m3/sec of flood water in the Arvan River first enters this reservoir, and from here it is discharged into the Goychay River with a consumption of 15-20 m3/sec. It should be noted that in 2021, during our inspection of this flood catchment storage, it was found that the two windows of the subaqueous tower located below were covered with silt deposits. This flood catchment reservoir on the Arvan river is the only magnificent facility of this type in working condition in the territory of Azerbaijan (photo 8).



Arvan river, Agdash, Goychay city, flood catchment reservoir, earth embankment, flood catchment canal, Goychay city, Baku.

Figure 8. Facilities built to protect the city of Goychay from flood waters

Flood control measures in world practice: Serious engineering facilities are being built to protect large cities and strategically important industrial areas from the effects of destructive floods. These facilities were built primarily for the purpose of disrupting the structure of flood waters along the river channels and reducing its strength. In the territories of Turkey, Kazakhstan and Georgia, devices that destroy the flow structure of the flood, mainly concrete, stone-concrete and steel structures, are widely used in the course of mountain rivers. Barriers made of metal construction are used to reduce the speed of the flood and mainly to keep pieces of stones /6, 8, 11/. Barriers of this type are built in several characteristic places in the channel, and periodically the sediments collected in their upper reaches are excavated and used as construction material (Figure 9).

Figure 9. A flood catcher made of steel elements

In small streams, barriers made of metal mesh are used to reduce the speed of the flood and mainly to retain the pieces of rock. Metal nets in this type of barriers are connected with cables to supports built on the shore. In the channel with unstable banks, this type of devices are attached to concrete partition walls (photo 10).

Figure 10. A flood catchment device made of steel mesh

Depending on the local conditions and the nature of the flood, thresholds that turn off the power are built in the channel. These thresholds are made of concrete or masonry, depending on the speed of the flood. Thresholds are built 3-5 m high, depending on local conditions. Behind these thresholds, flood deposits collapse and the bottom slope of the channel decreases, which allows for a sharp decrease in the flow and the destructive power of the flood (Figure 11).

Figure 11. Sequential threshold flood dampers along the channel

Depending on the strength of the flood and local conditions, combined flood arresters are also widely used. In these installations, both the concrete dam and the steel construction flood catchment installations support each other by placing them at a certain distance. Holes of a special size are installed in the body of the concrete dam to release water (photo 12).

Figure 12. Combined flood catchment devices

In world practice, the practice of using large reservoirs is also used to manage floods with greater destructive power. The most dangerous floods in the world are in Austria (Alps), United States of America (California), Peru (Cordillera-Blanca mountains), Japan (Kobe port), Ukraine (Carpathians and Crimea), Turkmenistan (Ashgabad city), Uzbekistan (Fergana valley). and is observed in the territories of Kazakhstan (Zeylik Alatau). Many devastating floods occurred in these areas in the 18th and 20th centuries, which in many cases caused great loss of life. In order to fight against floods in Austria, more than 4400 km of embankments, 5540 levees and dams, and 700 hectares of upland forest were planted in 90 years (1884-1973). One of the cities most affected by floods is the city of Los Angeles in the United States. The city is located 80 km along the ocean coast at the foot of the 3000 m high San Gabriel Mountains. After the devastating flood in 1914, projects were developed to protect the city from flood waters. Construction works based on these projects were completed in 1970. During this period, 20 flood control dams, 105 flood catchment dams and 1033 km of channels of various sizes were built. These protective structures, which were built, mainly protected the city during the great floods that occurred in 1969. During this flood, a total of 12.4 million cubic meters of water was collected in the reservoirs. The Japanese city of Kobe is located at the foot of the Rocci Mountains in the south of Hongsyo

Island. This mountain system is made up of rapidly washed mountain rocks. The city is located around the cones of numerous rivers flowing through this rock. During the 1938 flood disaster, 616 people died in this city and the city suffered a lot of damage. In 1968, a project was implemented to protect the city from flood waters. According to this project, up to several million cubic meters of soil located in the mountains, prone to being washed away by floods, was cut and used for the expansion of the port /8, 11/.

Floodwaters in Ukraine are observed mainly in the rivers flowing from the Carpathian Mountains and the Crimean Peninsula. In both areas, numerous flood-regulating thresholds with a height of 3-5 m have been built. Rivers that bring floods in the territory of Uzbekistan are mainly located in the Fergana valley. In order to fight against floods, the construction of mainly small-volume flood catchment reservoirs has been given ample space. During the flood, the partially rinsed water collected in these reservoirs is used for irrigation. In the territory of Turkmenistan, the most floods occur in the Kopetdag range. The city of Ashgabat is most vulnerable to floods. From the direction of the Iranian border, 11 floods are directed towards the city of Ashgabat. In 2018-19, floodwaters entering from these valleys caused serious damage to the city. Taking this into account, a flood catchment channel was built at the end of these flooded valleys, and in several places, flood reservoirs were created with a volume that could be filled with silt for a period of 25 years.

The most floods in the territory of Kazakhstan are observed in the Zaylik Alatau region, which has been a constant source of danger for the city of Almaty. In 1887, 1910, 1921, 1956, 1963 and 1973, catastrophic floods occurred that seriously damaged the city of Almaty. The most dangerous of these floods occurred on July 8-9, 1921 in the Big and Small Almatinka rivers. During this flood, a total of 7-10 million cubic meters of stones and mud entered the city area from these rivers, a part of the city was destroyed in a short time, and 500 people died. One of the most destructive floods occurred on Sunday, July 7, 1963, and during 3-4 hours, up to 6-7 million cubic meters of stones and mud entered the city from these streams. The flood destroyed Lake Issyk in the highlands and tragically killed up to 150 tourists who were vacationing there. This flood showed a serious threat to the city of Almaty and the reliable engineer was the basis for the implementation of measures. In order to protect the city of Almaty from flood waters, the government of Kazakhstan has decided to build a 110 m high stone-soil dam (the volume of the dam is 3.0 million cubic meters) in the Medeo area of the Little Almatinka River (at an altitude of 1750 m above sea level) and create a large-scale flood storage reservoir.

The construction of this blast dam was started in 1964, and the reservoir was put into operation in 1972. Thus, after two directed explosions, a dam with a width of 500 m from the bottom, a width of 100 m from the top and a height of 85 m was created in the river valley. The upper and lower slopes of the soil mass poured into the river valley were relatively leveled and the height of the dam was increased to 107 m. By building this dam, a reservoir with a total volume of 6.2 million cubic meters was created. The severe flood that occurred on July 15, 1973 was the most difficult test for the Medeo reservoir. During this flood, up to 5.3 million cubic meters of stone and mud flowed from the Little Almatinka River. Since the newly built dam completely blocked the flood, the water level in the reservoir began to rise rapidly, and there was a danger of the water overflowing the dam and washing it away /8, 11/.

Large seepage flows from several directions were observed from the body of the dam. Considering the situation, hundreds of pumps were installed in the upper side of the dam and

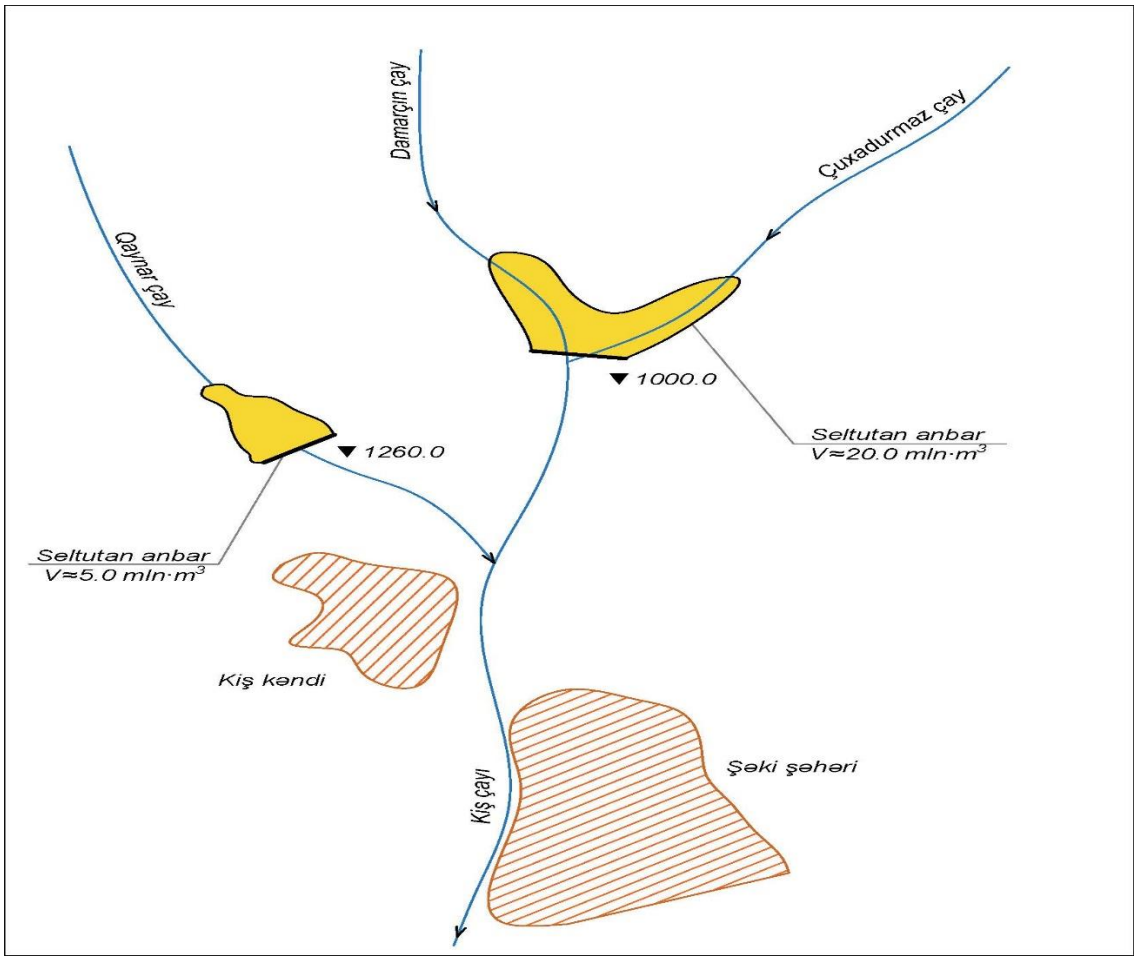
the water level was relatively lowered. After this catastrophic flood, the height of the dam was increased to 150 m, and the volume of the reservoir was 12.6 million cubic meters. The width of the dam is 20 m from the top, 800 m from the bottom, and the volume of soil and rock is 8.5 million cubic meters. This reservoir is one of the largest structures of this type in the world. A multi-window automatic water release device with a maximum consumption of 30.0 m3/sec has been built in the body of the dam, which can regulate the flood waters and release them to the lower bay. There are 35 water-releasing windows from the reservoir in three directions, allowing water to be taken at different levels and released into the lower bay. The alluvial sediments collected in the upper basin of the strategically important Medeo reservoir are used as construction material. A cable car was built around this warehouse and the area has become a favorite travel destination for tourists. The water collected in the reservoir is used in the water supply of the city of Almaty. For this purpose, a complex of water purification devices was built in the lower bay of the dam.

Necessary works against floods in the territory of the Republic: Destructive floods are often observed in the territory of the Republic of Azerbaijan. Floods wash the beds and banks of rivers, destroy obstacles, settlements, bridges, etc. It causes human casualties. Shin (1510), Kish (1901, 1982), Kurmuk (1921), Dashağıl (1656), Demiraparan (1963), Girdiman (1976), Pirsaat (1974), Mazım (1956), Kondalan, etc. floods with a great destructive force occurred in the rivers.

The conducted studies show that the area of floodplains in the river basins located on the southern slope of the Great Caucasus has increased by 15-20% on average compared to the data of 1961-1990. This increase is mainly observed in Shin, Kish, Demiraparan and Girdiman rivers. It was determined that floods cause great damage due to the lack of or very weak anti-flood devices in the river basins. For example, the flood that occurred in the Bum river in July 2015 (as a result, some houses in the village of Gamarvan were buried under a mass of mud), in the Kish river in July 2016 (as a result, the bridge connecting the village of Kish with the city of Sheki completely collapsed, the surrounding recreation centers under a thick layer of mud), in September 2016 in the Demiraparan river (as a result, several recreation centers in the city of Gabala were covered by a mass of mud), in June 2018 in the Goychay river flood (as a result of the flood, the district center of Galachiq and surrounding villages and the bridge connecting the city of Goychay with surrounding villages collapsed), the floods that occurred in Dashkasan and Gadabey in 2023, and in Goranboy and Zagatala in 2024 can be mentioned.If the flow cones of all flooded rivers and eroded land areas in Azerbaijan increase at this rate and serious measures against floods are not taken, 100-120 thousand ha of the most productive land areas of the republic may become unusable within the next 30-50 years /6, 7, 9 /.

There is a serious need to take substantial measures against floods in the Kish and Shin rivers, which bring the most floods and damage farms in the republic. The construction of dams of special construction to catch the floods in the channels of these rivers is considered to be the right option from the economic and ecological point of view. By building an earthen dam with a height of 50.0 m on the Gaynar tributary of the Kish river in the upper part of the Kish village, at the level of 1260 m in the river course, it is possible to create a reservoir with a volume of about 5 million cubic meters and regulate the river's flood flows, and use its water resources more efficiently. The silt reservoir to be built will allow to regulate the flow of the river and to use it as construction material. By placing a stone-sand quarry on the upper side of the flood catchment unit, it is possible to exclude and effectively use the river deposits that periodically settle there.

Seltutan reservoirs of the same type should be built at the junction of the Chukhadurmaz and Damarchin branches of the Kish river, at the level of 1000.0 m. Preliminary calculations show that it is possible to create a flood catchment reservoir with a volume of up to 20 million cubic meters by building a dam with a height of 65 m at the confluence of the rivers. It should be noted that the average price of the annual flow of the Kish River is about 100 million cubic meters. In these reservoirs designed to regulate flood waters, devices that can ensure that a part of it bypasses the dam and releases it into the lower bay when the floods come should also be provided. The location plan of the flood catchment reservoirs, which are planned to be built in the Kish river channel, is given in Figure 13.



Kish village, flood catchment reservoir, Gaymalchay, Kish river, Sheki city, Darmarchin river, Chukadurmaz river, flood catchment reservoir,Sheki city

Figure 13. Location plan of flood catchment reservoirs, which are planned to be built on the Kish River

As we mentioned above, the Shin river located in this zone is also a river that brings a lot of floods. Several large villages of Sheki district are located in the catchment area of this river. The transport cone is crossed by the republic's strategically important Sheki-Kakh highway and the Baku-Balakan railway. Floods in the river cause serious damage to communication lines and agricultural fields located in the area every year. According to the section of the river near the village of Shin, the water catchment area is 119 km2, and it brings about 120 thousand cubic meters during the year. Preliminary calculations show that it is possible to create a flood catchment reservoir with a volume of up to 30 million cubic meters by building a dam with a

height of 75 m in the course of the river, at an absolute level of 1100 m. In this reservoir, which is intended to regulate flood waters, when floods come, special facilities should also be provided to release a part of it in transit, bypassing the dam, into the lower bay. The location plan of the flood catchment reservoirs, which are planned to be built in the course of the Shin river, is given in figure 14.

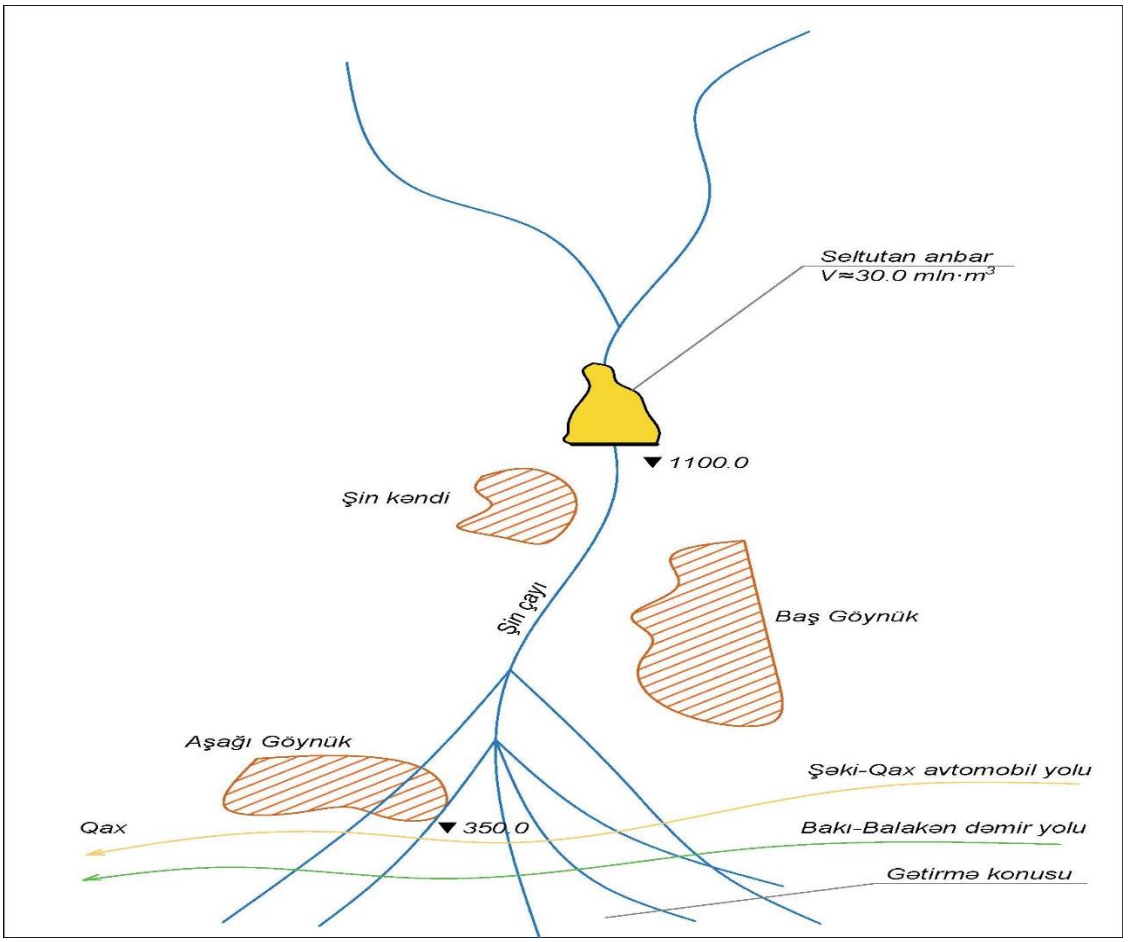


Figure 14. The location plan of the flood catchment reservoirs, which are planned to be built in the course of the Shin River

About 250-300 thousand cubic meters of sand-gravel material will be deposited in these flood catchment reservoirs to be built. By placing stone-sand processing quarries in the upper reaches of the flood catchment reservoirs, construction sites of the republic can be continuously supplied with construction material (sand, gravel, stone, clay). The sand-gravel material to be used here can be delivered cheaply and quickly to any construction site of the country by using the Baku-Balakan railway, which is located very close to the area.

There is a need to implement the following urgent measures against floods in the territory of the Republic:

- When designing settlements and other infrastructures, hydrological data related to destructive floods in the area should be extensively investigated;
- In cases where settlements are built along dry valleys and in the areas where they come out to the plain, not to interfere with the channels created by large floods that have historically passed through this area;

- During the design of residential areas built along river valleys, the level of flow resulting from the maximum floods that may occur must be taken into account and the construction of protective walls;
- In order to ensure the safety of the population living in the existing settlements, the creation of systems that detect the danger of flooding in advance along the river valleys;
- Preparation of special evacuation plans to quickly and safely remove the population from flood-prone areas;
- Reducing the volume of floods by carrying out forest and forest-shrub ecosystem restoration works in the highlands and mid-mountain areas that are subject to erosion in the catchment area of rivers;
- Determining animal grazing norms in alpine-subalpine meadows where the main floodplains are formed and used as summer pastures;
- Creation of special water reservoirs in the upper parts of these valleys in order to protect settlements built in the course of dry valleys from floods;
- Construction of canals diverting flood waters around flood-prone settlements, if the relief allows;
- By creating stone-sand quarries in the channels of larger rivers that bring floods (Kish, Shin, Girdiman, Tala, Gurmukh, etc.), deepening of their channels and preventing the spread of flood waters around;
- Cascading control devices should be built along the channels of small rivers where intense floods are observed.

Main results

1. **Taking into account the effects of global climate change, the hydrological regimes of flood-prone rivers located on the territory of the republic and the maximum possible water consumption should be determined.**
2. **Hydrological information about floods that may occur in dry valleys where large settlements are located should be clarified and appropriate engineering measures should be taken for the safety of the population.**
3. **Appropriate engineering measures should be taken to protect Lokbatan (Sadarak and Bina shopping centers), Buta, Sahil settlements and industrial facilities from flood waters in Garadagh district of Baku city.**
4. **It is considered appropriate to create large-scale silt reservoirs in the channels of rivers Kish, Shin, Girdiman, Tala, Gurmukh, etc.**
5. **In order to use in construction works, stone-sand quarries should be created in the channels of Kish, Shin, Girdiman, Tala and Gurmukh rivers, dredging of their channels and partial control of flood waters should be carried out.**

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STATIC ANALYSIS OF RECTANGULAR PLATES

N. S. RZAYEV, A. H. QULİYEV, V. F. GAHRAMANOV
Baku Engineering University, Hasan Aliyev str., 120, Baku, AZ0102, Azerbaijan
nzayev@beu.edu.az

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ABSTRACT

In the article, a static analysis of plates made of AISI 1020 steel with different cross-sectional dimensions was performed. The cross-sectional dimensions of the plates are 300x150x15 and 400x200x15 mm, respectively. 3D solid models of the plates were drawn in the Solidworks program. A static analysis of the plates was performed using the Solidworks simulation application. The plates were rigidly fixed on both sides (Fixed Geometry fastening type was selected), and a load of 100,000 N was applied along the surface. A fine mesh of 2.46 mm and 0.43 mm was selected for the plates. As a result of the static analysis, the values of Von-Mises stress, strain, deformation and safety factor distributed along the surface of the plates were obtained. The obtained results were analyzed. The plates showed a difference of 6% in stress, 43% in deflection, 2% in strain, and 44% in safety factor.

5. Introduction

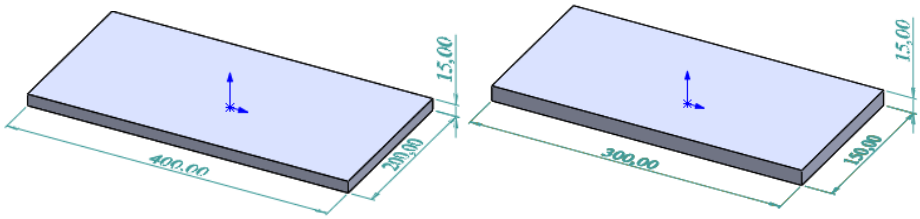
Plates are considered to be metal construction parts whose thickness is very small compared to other dimensions. Plates are widely used in various types of engineering structures. Some examples are parts in vehicles (cars, airplanes, helicopters, armored vehicles, buses, railway vehicles, etc.), rocket and missile systems, modern bridges, dam and canal covers. In addition, plates are even parts used in very high-tech space and aviation industries.

Plates can be analyzed by the equations of elasticity theory. The exact solution of the differential equations of some plates can be obtained only under certain boundary and loading conditions. With the development of computer technology, numerical solution methods have become widespread. There are methods such as finite difference, boundary element and finite elements for solving plate problems. Among the numerical solution methods, the finite element method is used more than other methods. Examples of analytical methods include the Navier and Levy methods [1-3].

The static analysis of an isotropic rectangular plate is given in [4]. Here, the optimal values of the plate thickness are obtained for various boundary conditions and load values. E. Reissner developed a plate theory that takes into account the deformations caused by shear forces [5]. The problems of rectangular plates simply supported on two opposite sides and free on the other side were solved by Levy [2- 11].

The purpose of plate theory is to calculate static and dynamic parameters such as stress, deformation and vibration in a plate under no load or under load. Thus, it is possible to obtain

the static load-bearing properties of a plate. Reducing the weight of the structural parts used and increasing the operational efficiency are important problems facing engineers. For this purpose, accurate engineering reports are of great importance. In the presented article, a static analysis of plates with different cross-sectional dimensions was carried out using the finite element method using Solidworks simulation (Figure 1).



N1 N2

Fig. 1 Plates with different cross-sectional dimensions.

According to the applied load value, the Von-Mises stress, total deflection and deformation, distributed values of stress, deflection and deformation along the x, y, z axes, and safety factor were obtained. The results of the static analysis are presented in the form of tables and graphs.

2. Materials and methods

2.1. Design of boards and selection of materials

The dimensions of the boards used in the article are as follows:

Plates 1 (N1): Length L=400mm; width b=200mm; thickness d=15mm.

Plates 2 (N2): Length L=300mm; width b=150mm; thickness d=15mm.

The boards were drawn using the design application Solidworks. For this, a 2D drawing of the boards was first drawn, then converted into a 3D solid model (Figure 2).

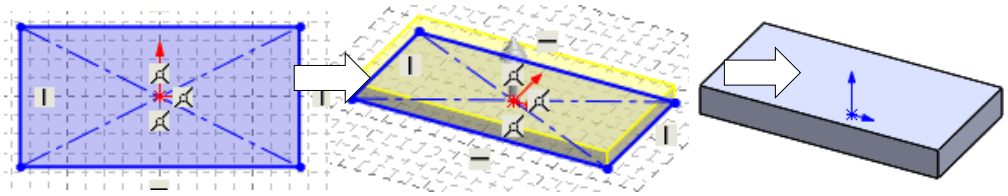


Fig. 2 Steps for drawing a 3D solid model of a plate.

It is assumed that the plates are made of AISI 1020 steel (St20 according to GOST). AISI 1020 steel has the following mechanical properties:

Modulus of elasticity: 200000N/mm2;

Poisson's ratio: 0.29;

Modulus of elasticity in shear: 77000N/mm2;

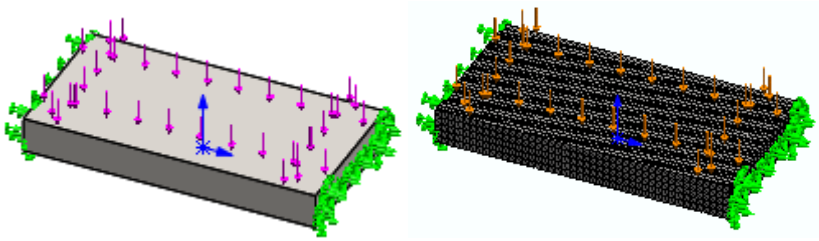
Density: 7900kg/m3;

Strength limit: 420.507N/mm2;

Yield limit: 351.571N/mm2.

2.2. Static analysis of the plate

In this paper, the simulation application in Solidworks was used to analyze the bending behavior of the plates under static load. Both sides of the plates were fixed ("Fixed Geometry"). A force of 100000N was applied to the other top surface. Isotropic AISI 1020 steel material was selected from the model library as the material. Mesh is one of the main elements of the simulation process in finite element analysis (FEA). Mesh plays an important role in the engineering simulation process. Creating a high-quality mesh is one of the most important factors to be considered to ensure the accuracy of the simulation. A fine-grained mesh was selected. The mesh parameters are 2.86mm and 0.143mm (Figure 3).

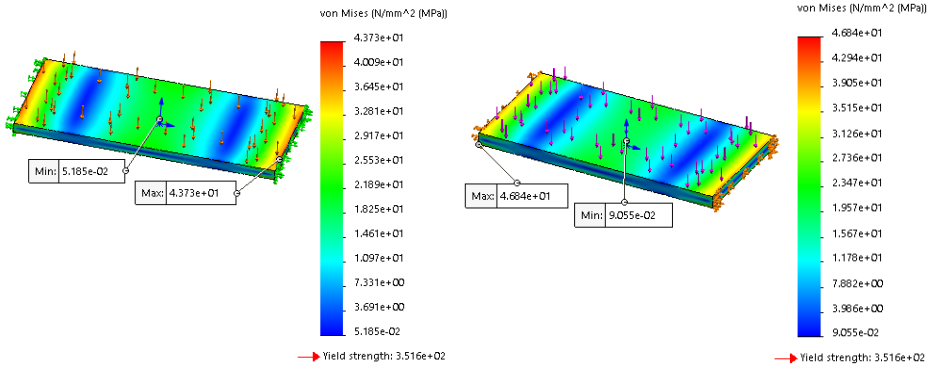


a) b)

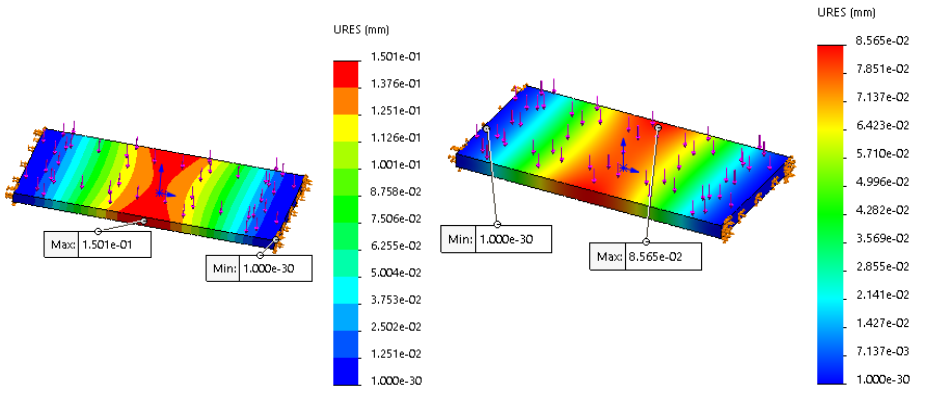
Fig. 3 Static analysis of a plate using the finite element method.

a) boundary conditions, b) application of the mesh property.

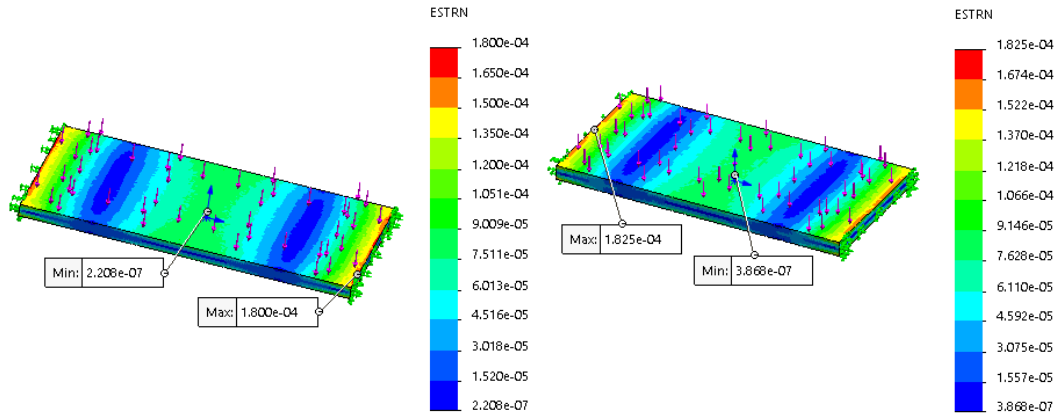
In the analysis, the maximum Von-Mises, normal stresses, maximum deflection and relative deformation safety factors were obtained. The values of the mentioned parameters distributed over the plate model are given in Figure 4.



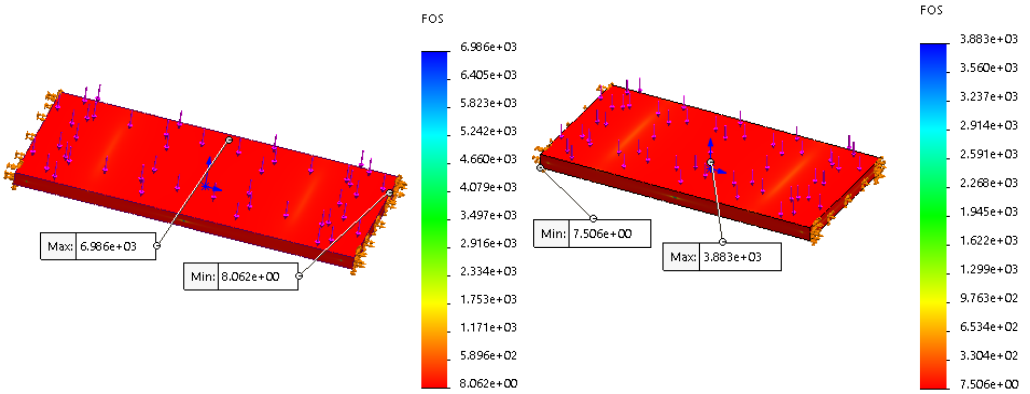
N1 N2 a)



N1 N2 b)



N1 N2 c)



N1 N2 d)

Fig. 4 Values obtained as a result of static analysis: a) Distributed values of von Mises stress; b) Distributed values of yield; c) Distributed values of deformation; d) Distributed values of safety factor.

3. Static analysis results

The values obtained as a result of static loading of two different plates are given in Table 1 and Figure 4. It is a theory that states that failure will occur as a result of triaxial stress. It was developed by Richard Von-Mises. The Von-Mises stress is calculated by the following expression:

$$\sigma_{von-Mises} = \sqrt{\frac{1}{2}\left[\left(\sigma_x - \sigma_y\right)^2 + \left(\sigma_x - \sigma_z\right)^2 + \left(\sigma_y - \sigma_z\right)^2\right] + 3\left(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2\right)} \quad (1)$$

Here σ_x, σ_y və σ_z – are the normal stresses along the corresponding axes, and τ_{xy}, τ_{yz} və τ_{zx} – are the tangential stresses.

The maximum and minimum Von-Mises stresses in the plates subjected to bending were observed in sample 1. These values were 43,73N/mm² and 0,05 N/mm², respectively. In plate N2, they ranged from 46.84N/mm² to 0.09 N/mm². Sample 2 had the maximum stress value. The difference between the stress values in plates N1 and N2 was 6%.

In plate N1, the stress values along the x axis were 56.18N/mm² and 9,29 N/mm², along the y axis were 22,95N/mm² and 3,79N/mm², and along the z axis were 22,95N/mm² and 3,79 N/mm².

The stress values along the x-axis in plate N2 were 60.19N/mm² and 0.132N/mm², along the y-axis 25,28N/mm² and 0,05N/mm², and along the z-axis 25,28N/mm² and 4,26 N/mm². The maximum stress difference between plates N1 and N2 was 7% along the x-axis and 9% along the y and z axes.

Table 1. Values of von Mises stress and normal stress obtained along the corresponding axes (x, y, z).

Won mises stress, N/mm²		Normal stress, N/mm²					
		X-axis		Y-axis		Z-axis	
№1	№2	№1	№2	№1	№2	№1	№2
43,73	46,84	56,18	60,19	22,95	25,28	22,95	25,28
40,09	42,94	46,80	51,61	19,12	21,08	19,12	21,08
36,45	39,05	37,42	41,31	15,29	16,87	15,29	16,87
32,81	35,15	28,05	31,02	11,46	12,67	11,46	12,67
29,17	31,26	18,67	20,72	7,62	8,46	7,62	84,64
25,53	27,36	9,29	10,43	3,79	4,26	3,79	4,26
21,89	23,47	-0,08	0,132	-0,03	0,05	-0,035	0,05
18,25	19,57	-9,45	-10,16	-3,86	-4,15	-3,86	-4,15
14,61	15,67	-18,84	-20,46	-7,69	-8,35	-7,69	-8,35
10,97	11,78	-28,21	-30,75	-11,52	-12,56	-11,52	-12,56
7,331	7,88	-37,59	-41,05	-15,35	-16,77	-15,35	-16,77
3,691	3,98	-46,97	-51,34	-19,18	-20,97	-19,18	-20,97
0,05	0,09	-56,34	-61,64	-23,01	-25,18	-23,01	-25,18

The values of the wear along the surface of the N1 and N2 plates are given in Table 2 and Figure 2b. The total wear value varied between 0.15mm and 1x10-30 on the N1 plate. On the N2 plate, it was between 0.085mm and 1x10-30. As can be seen, the wear value on the N1 and N2 plates was 43% higher than that on the N2 plate.

The maximum values of the deflection in plate N1 were 0,0085mm on the x axis, 0,0001mm on the y axis, and 0,0020mm on the z axis. In plate N2, they were 0,0064mm, 0,00008mm, and 0,0015mm, respectively. The maximum deflection difference was observed on the x axis. This difference was 0,0021mm.

The values of the distribution of the relative deformation values along the surface of the plates are given in Figure 5c. The total deformation values were in the range of 1,8x10-4 and 0,0022x10-4 for plate N1, and 1,82x10-4 and 0,0038x10-4 for plate N2. The total deformation difference between the plates is 2%. In plate N1, the maximum deformation was 2,17x10-4 along the x axis, 8,3x10-5 along the y axis, and 5,23x10-5 along the z axis. In plate N2, it was 2,18x10-4, 8,20x10-5, and 4,66x10-5, respectively. The deformation difference between the plates was 10% along the z axis.

The distribution of the safety factor values is given in Figure 3d. The safety factor is calculated as the ratio of the ultimate stress to the applied working stress for brittle materials.

$$n = \frac{\sigma_h}{\sigma} \quad (2)$$

Here $n -$ is the safety factor, $\sigma_h -$ is the ultimate stress, and $\sigma -$ is the applied stress.

For plastic materials, it is calculated as the ratio of the yield strength to the applied stress.

Table 2. Values of total deflection and deflection along the corresponding axes (x, y, z).

Total deflection, mm		Deflection, mm					
		X axis		Y axis		Z axis	
№1	№2	№1	№2	№1	№2	№1	№2
0,15	0,085	0,0085	0,0064	0,0001	0,00008	0,0020	0,0015
0,14	0,078	0,0071	0,0053	-0,0124	-0,0070	0,0017	0,0013
0,12	0,071	0,0056	0,0042	-0,0249	-0,0142	0,0013	0,0010
0,11	0,064	0,0042	0,0032	-0,0374	-0,0215	0,0010	0,0008
0,10	0,057	0,0028	0,0021	-0,0499	-0,0285	0,0007	0,0005
0,087	0,050	0,0014	0,0010	-0,0624	-0,0356	0,0003	0,0003
0,075	0,042	$1,6x10^{-7}$	$1,22x10^{-7}$	-0,0750	-0,0427	$3,4x10^{-7}$	$-8,85x10^{-8}$
0,062	0,035	-0,0014	-0,0010	-0,0875	-0,0450	-0,0003	-0,0003
0,050	0,028	-0,0028	-0,0021	-0,1000	-0,0570	-0,0007	-0,0005
0,037	0,021	-0,0042	-0,0031	-0,1126	-0,0641	-0,0010	-0,0008
0,025	0,014	-0,0056	-0,0042	-0,1251	-0,0713	-0,0013	-0,0010
0,125	0,007	-0,0071	-0,0053	-0,1376	-0,0780	-0,0017	-0,0013
$1x10^{-30}$	$1x10^{-30}$	-0,0085	-0,0063	-0,1501	-0,0856	-0,0020	-0,0015

Təhlükəsizlik əmsalının qiyməti konstruksiya hissələrinin istismar vəziyyətinə görə dəyişir. Bu əmsal konstrukiya hissələrinin normal şəraitdə lazım olduğundan daha möhkəm, dayanıqlı olması üçün nəzərdə tutulub. Bu, onların fövqəladə hallar, əlavə yüklər, həddən artıq istifadə və ya köhnəlmə nəticəsində yaranan deqradasiya kimi ekstremal şəraitdə belə işləməyə davam etmə ehtimalını artırır. Cari istifadə üçün əlavə təhlükəsizliyi təmin etməklə konstruksiya hissələrinin funksionallığını qoruyur. Əmlakın, işçilərin və maşınların zədələnməsinin qarşısını alır. Məmuldan istifadə zamanı baş verə biləcək gözlənilməz risklərdən müdafiəni təmin edir. Məmulun sıradan çıxma ehtimalını azaldır. Təhlükəzilik əmsalı nə qədər çox olarsa məmul və ya konstruksiya hissəsi bi o qədər təhlükəsiz hesab olunur. N1 lövhəsi üçün təhlükəzislik əmsalının qiyməti 6986 və 8, N2 lövhəsi üçün isə 3883 və 7,5 aralığında dəyişir. Tətbiq olunan qüvvəyə görə təhlükəszlik əmsalları arasında 44% fərq var.

4. Conclusions and Discussions

The ranges of stress, deflection, strain and safety factor values were determined for two plates with different cross-sectional dimensions. For both plates, the maximum value of Von-Mises stress was obtained at the attachment surfaces of the plates, and the minimum values were obtained at the center point.

As the area of the plates increased, a decrease in stresses was observed. A 6% increase in stress was observed for a change in the area of 525000mm2.

The maximum value of deflection was observed at the center of both plates. The deflection value decreased equally from the center of the plates to the edges. The deflection value decreased proportionally with the decrease in the area of the plate. The deflection value decreased by 43%, corresponding to a 44% decrease in the area.

The maximum values of deformation were obtained at points close to the attachment surfaces of the plates, and the minimum values were obtained at the center. An equal distribution of deformation was observed in the tension and compression regions.

The maximum value of the safety factor was at the center of the plates, and the minimum value was at the attachment points. The value of the safety factor decreased with increasing area. Thus, for a 44% increase in area, the safety factor decreased by 44%.

The results obtained in the article can be used in the stability reports of plates used in various fields.

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MINIMIZING ENERGY CONSUMPTION WHEN TURNING ON AND STOPPING THE MAIN EXECUTIVE MECHANISM OF THE CPM

A.H. GULIYEV[1], B.H.ALIYEV[2], Y.A. ABDULAZIMOVA[3]

[1] Baku Engineering University, "Mechanical Engineering" department, Baku, Azerbaijan
asquliyev@beu.edu.az
[2] Baku Engineering University, "Mechanical Engineering" department, Baku, Azerbaijan,
baeliyev@ beu.edu.az
[3] Baku Engineering University, "Mechanical Engineering" department, Baku, Azerbaijan,
yabdulazimova@beu.edu.az

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ABSTRACT

The issues of minimizing energy consumption for turning on and off the main executive mechanism are considered. Analytical dependencies are obtained for calculating the optimality criteria depending on the drive parameters. This study explores methods to minimize energy consumption during the start-up and stopping phases of the main executive mechanism of a Continuous Processing Machine (CPM). These phases often involve significant power surges, contributing to energy inefficiencies and operational costs. The research investigates energy-efficient control algorithms, optimized motor drive systems, and dynamic scheduling techniques to enhance performance while reducing energy usage. A combination of theoretical modeling, simulations, and experimental validation demonstrates the effectiveness of the proposed approaches. The findings provide actionable insights for improving the energy efficiency of CPM systems, supporting sustainable manufacturing practices, and reducing operational expenses without compromising productivity or system reliability.

Introduction. The efficiency of the CPM (forging and pressing machine) as a whole and its individual units is possible with the optimal choice of its parameters, ensuring the highest technical and economic indicators of its operation.

One of the criteria for the optimality of the CPM is the minimization of energy consumption for turning on and off the GIM. The energy consumption for switching on and stopping the CPM with a planetary drive is determined by the formula:

$$A = I_a \omega_{an}^2 (j_n + j_0), \qquad (1)$$

where Ja - is the moment of inertia of the driving parts of the drive, reduced to the central (sun) gear of the gearbox;

ωан - is the nominal angular velocity of the central gear;

jп, jO - are, respectively, the relative moments of inertia of the driven parts of the drive when switching on and stopping

$$J_n = \frac{J_b}{J_a p^2},\ J_O = \frac{J_h}{J_a(1+p^2)} \qquad (1.1)$$

Jb - is the moment of inertia of the outer gear of the gearbox;

Jh - is the moment of inertia of the carrier, intermediate gear and CPM parts.

Substituting the values of the relative moments of inertia jп and jO, after simple transformations, the formula can be represented as,

$$A = \varpi_N^2 i_O^2 \left[\frac{J_v}{p^2} + \frac{J_h}{(1+p^2)}\right] \qquad (2)$$

where ωн - is the nominal angular velocity of the main shaft of the CPM.

The moments of inertia Jb and Jh- generally depend on the drive circuit (planetary gear type, presence of intermediate gear transmission), the transmitted load, the design of the drive components and the breakdown of the overall gear ratio iO, i.e. the parameters p and iZ.

Research methodology. It is practically impossible to obtain precise functional dependencies for determining the moments of inertia Jb and Jh due to the diversity and design complexity of the drive components. For comparative calculations, an approximate analysis method is used, according to which the moments of inertia Jb and Jh are defined as the moments of inertia of several main drive components (drive elements), represented as simple geometric figures. The design coefficients take into account the correspondence between the actual and calculated moments of inertia and the influence of other drive components, the moments of inertia of which are approximately taken as multiples of the moments of inertia of the drive elements. The moment of inertia Jb of a planetary gear drive is defined as the moment of inertia of a solid ring replacing a gear wheel with internal engagement. The inner diameter db and the width bb of the ring are taken to be equal to the initial diameter and the width of the gear ring, and the outer diameter of the wheel Db is a multiple of the diameter db, i.e. Db=dbβ, where β is the proportionality coefficient.

Expressing the width bb of the gear ring through the diameter db and the relative width of the ring ψb, the moment of inertia Jb is determined by the formula

$$J_b = \frac{\pi l}{32} k_b b_b \left(D_b^4 - d_b^4\right) \frac{\pi l}{32} k_b \psi_b k_b d_b^5 \qquad (3)$$

were

The diameter db is determined by the condition of the contact strength of the working surfaces of the teeth

$$d_b = \ d_b = p \sqrt[3]{\frac{2M_{sm}}{pi_Z(p-1)\psi_b n_\varpi [K_0]_R}} \qquad (4)$$

Substituting the values db into formula (3) and denoting

$$E_b = \frac{\pi\gamma}{32} k_b \psi_b k_b \beta \sqrt[3]{\frac{2}{\psi_b n_\varpi}}$$

we obtain a dependence for determining the moment of inertia Jb in the form

$$J_b = E_{b \sqrt[3]{\left(\frac{M_{sm}}{[K_0]_R}\right)^5}} \left(p \sqrt[3]{\frac{1}{pi_Z(p-1)}}\right) \qquad (5)$$

The moment of inertia Jh is the sum of the moments of inertia of the carrier and the reduced moment of inertia of the intermediate gear

$$J_h = J_{hR} + J_{hZ}$$

If the carrier is represented as a solid cylinder with dimensions Dh and dh multiples of the dimensions of the gear engagement of the wheel b, i.e., Dh = kddb, bh = kbbb the moment of inertia JhR can be determined by the formula

$$J_{hR} = \frac{\pi\gamma}{32} k_h b_h D_h = \frac{\pi\gamma}{32} k_h k_\beta k_d^4 \psi_d d_b^5 \quad (6)$$

where kd, kb are proportionality coefficients.

Substituting the value of db according to formula (4) and designating

$$E_{hR} = \frac{\pi\gamma}{32} k_h k_d^4 \psi_b \left(\sqrt[3]{\frac{2}{\psi_b n_\varpi}} \right)^5$$

formula (6) we represent as

$$J_{hR} = E_{\{hR} \sqrt[3]{\left(\frac{M_{sm}}{[K_0]_R}\right)^5} \left(p \sqrt[3]{\frac{1}{p i_Z^{(p-1)}}} \right)^5 \quad (7)$$

The moment of inertia JhZ is defined as the moment of inertia of the gear wheels of the intermediate gear reduced to the driven shaft of the planetary gear reducer, represented in the form of solid disks with dimensions equal to the dimensions of the toothed rims of the corresponding wheels and parts of the GIM. For a single-stage gear transmission with the same width of the toothed rims of the pinion and wheel, the moment of inertia JhZ is determined by the formula

$$J_{hZ} = \frac{\pi\gamma K_G}{32} b_1 (k_1 d_1^4 + k_2 d_2^4 i_Z^{-2}) = \frac{\pi\gamma K_G}{32} \psi_2 i_Z d_1^5 (k_1 + k_2 i_Z^2) \quad (8)$$

The coefficient KG takes into account the magnitude of the moment of inertia of the GIM parts in the total moment of the driven masses. Its average value is 1.2-1.4.

The diameter of the gear d1 is usually limited by the contact strength of the working surfaces of the teeth, therefore, using the corresponding dependencies, formula (8) can be represented as

$$J_{hZ} = E_{hZ} b \sqrt[3]{\left(\left(\frac{M_{sm}}{[K_0 1]_R}\right)^5\right)} \left(\sqrt[3]{i_Z + 1}\right)^5 (k_1 + k_2 i_Z^2) i_Z^{-4} \quad (9)$$

Were

$$E_{hZ} = \frac{\pi\gamma}{32} \psi^2 \left(\sqrt[3]{\frac{2}{\psi^2}} \right)^5$$

If the gear engagements of the planetary gearbox and the intermediate gear are made of equal strength (i.e., assume that $[K_0]_R = [K_0]_Z$), which ensures both the lowest total weight of the drive and its lowest inertia, the energy consumption for switching on and stopping can be determined by the formula

$$A = \varpi_N^2 i_O^2 (1+p)^n \varpi_H^2 \left(\frac{M_{sm}}{[K_0]_R}\right)^5 \left[+\frac{E_{hZ}}{(1+p)^2}\left(\sqrt[3]{i_Z+1}\right)^5 (k_1 + k_2 i_Z^2) i_Z^2 i_Z^2\right) \qquad (10)$$

The value $\varpi_H^2 \left(\sqrt[3]{\frac{M_{sm}}{[K_0]_R}}\right)^5$ does not depend on the drive parameters and is constant for each CPM. Therefore, the ratio

$$R_A = \frac{A}{\varpi_H^2}\left(\sqrt[3]{\frac{[K_0]_R}{M_{sm}}}\right)^5 \qquad (11)$$

(11) represents the dependence of the relative energy consumption for switching on and stopping the GIM on the drive parameters and is taken as the second criterion for the optimality of the RA parameters.

Discussion of results. The design coefficients of the gear wheels and the proportionality coefficients are taken equal to:

kb = 1. 3..2.4; kh = 1. 08..1.85; k1 = 1. 4..2.5; k2=0. 27..0.42; β=1. 1..1.17; kd=0. 7..0.82. For relatively narrow gear wheels (ψb≤0.15), smaller values of the coefficients kd, β and larger values of the coefficients kb, k1 k2 are adopted.

Fig. 1, a) shows the dependence of the RA criterion on the parameters p and iZ, and Fig. 1, b) on the parameter p for a certain general gear ratio p and iO. The graphs in Fig. 1, a) show the degree of influence of each of the parameters p and iZ on the value of energy consumption A. From Fig. 1, b it is clear that for each gear ratio iO there is a unique combination p and iZ at which the value of RA will be the smallest. The optimal values of the parameter p are found as the coordinate of the intersection point of the RA curve for the corresponding value of iO with the line SA, which is the line of minimum values of the RA criterion.

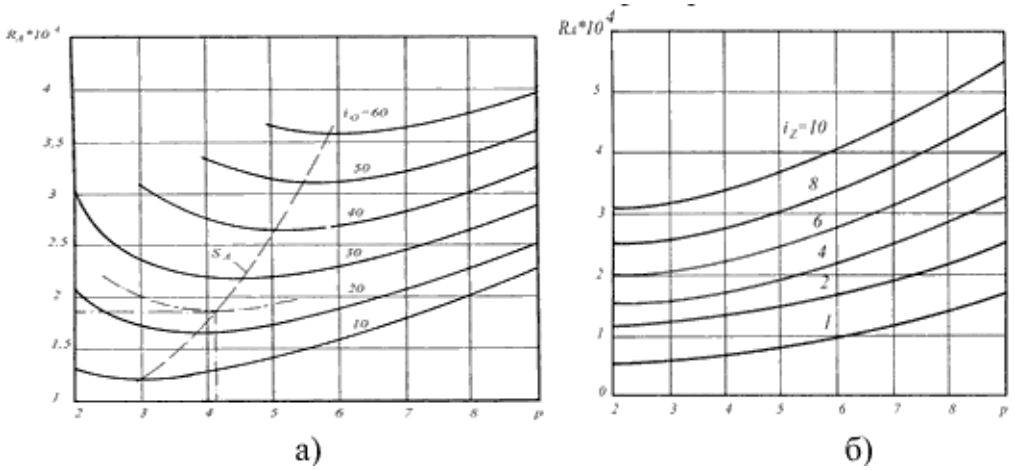

Fig. 1. Dependence of the RA criterion on the drive gear ratios

According to Fig. 1, b), it is also possible to estimate the degree of overestimation of energy consumption compared to the minimum value with non-optimal drive parameters. For example, with

iO = 25, the lowest energy consumption will be at p = 4.12 and iZ = 4.88 (shown in Fig. 2 by a dash-dotted line). If we take p = 3 and iZ = 6.25, the energy consumption will be overestimated by 1.06 times.

Conclusion

1. Thus, analytical dependencies for calculating the optimality criteria depending on the drive parameters were obtained.
2. This study has demonstrated effective strategies to minimize energy consumption during the start-up and stopping phases of the main executive mechanism of a Continuous Processing Machine (CPM). By implementing optimized control algorithms, energy-efficient drive systems, and operational protocols, significant energy savings can be achieved without compromising performance.
3. The experimental and simulation results confirm the potential of these approaches to enhance efficiency and sustainability. These findings contribute to reducing the environmental footprint of CPM systems and provide practical insights for industries seeking to optimize energy use, lower operational costs, and promote environmentally responsible manufacturing practices. Future work could explore real-time adaptive systems for further improvements.

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INSTRUCTIONS FOR AUTHORS

1. "The Baku Engineering University Mechanical and Industrial engineering" accepts original unpublished articles and reviews in the research field of the author.
2. Articles are accepted in English.
3. File format should be compatible with **Microsoft Word** and must be sent to the electronic mail (**journal@beu.edu.az**) of the Journal. The submitted article should follow the following format:

- Article title, author's name and surname
- The name of workplace
- Mail address
- Abstract and key words

4. The title of the article should be in each of the three languages of the abstract and should be centred on the page and in bold capitals before each summary.
5. **The abstract** should be written in **9 point** type size, between **100** and **150** words. The abstract should be written in the language of the text and in two more languages given above. The abstracts of the article written in each of the three languages should correspond to one another. The keywords should be written in two more languages besides the language of the article and should be at least three words.
6. .**UDC** and **PACS** index should be used in the article.
7. The article must consist of the followings:

- Introduction
- Research method and research
- Discussion of research method and its results
- In case the reference is in Russian it must be given in the Latin alphabet with the original language shown in brackets.

8. **Figures, pictures, graphics and tables** must be of publishing quality and inside the text. Figures, pictures and graphics should be captioned underneath, tables should be captioned above.
9. **References** should be given in square brackets in the text and listed according to the order inside the text at the end of the article. In order to cite the same reference twice or more, the appropriate pages should be given while keeping the numerical order. For example: [7, p.15].

Information about each of the given references should be full, clear and accurate. The bibliographic description of the reference should be cited according to its type (monograph, textbook, scientific research paper and etc.) While citing to scientific research articles, materials of symposiums, conferences and other popular scientific events, the name of the article, lecture or paper should be given.

Samples:

a) ***Article:*** Demukhamedova S.D., Aliyeva İ.N., Godjayev N.M.. *Spatial and electronic structure af monomerrik and dimeric conapeetes of carnosine üith zinc,* Journal of structural Chemistry, Vol.51, No.5, p.824-832, 2010

b) ***Book:*** Christie ohn Geankoplis. *Transport Processes and Separation Process Principles.* Fourth Edition, Prentice Hall, p.386-398, 2002

c) ***Conference paper:*** Sadychov F.S., Aydın C., Ahmedov A.İ.. Appligation of Information – Commu-nication Technologies in Science and education. II International Conference."*Higher Twist Effects In Photon- Proton Collisions", Bakı, 01-03 Noyabr, 2007, ss 384-391*

References should be in 9-point type size.

10. The margins sizes of the page: - Top 2.8 cm. bottom 2.8 cm. left 2.5 cm, right 2.5 cm. The article main text should be written in Palatino Linotype 11 point type size single-spaced. Paragraph spacing should be 6 point.
11. The maximum number of pages for an article should not exceed 15 pages
12. The decision to publish a given article is made through the following procedures:

- The article is sent to at least to experts.
- The article is sent back to the author to make amendments upon the recommendations of referees.
- After author makes amendments upon the recommendations of referees the article can be sent for the publication by the Editorial Board of the journal.

YAZI VƏ NƏŞR QAYDALARI

1. "Journal of Baku Engineering University- Mexanika və sənaye mühəndisliyi" - əvvəllər nəşr olunmamış orijinal əsərləri və müəllifin tədqiqat sahəsi üzrə yazılmış icmal məqalələri qəbul edir.
2. Məqalələr İngilis dilində qəbul edilir.
3. Yazılar **Microsoft Word** yazı proqramında, (**journal@beu.edu.az**) ünvanına göndərilməlidir. Göndərilən məqalələrdə aşağıdakılara nəzərə alınmalıdır:

- Məqalənin başlığı, müəllifin adı, soyadı,
- İş yeri,
- Elektron ünvanı,
- Xülasə və açar sözlər.

4. **Məqalədə başlıq hər xülasədən əvvəl** ortada, qara və böyük hərflə xülasələrin yazıldığı hər üç dildə olmalıdır.
5. **Xülasə** 100-150 söz aralığında olmaqla, 9 punto yazı tipi böyüklüyündə, məqalənin yazıldığı dildə və bundan əlavə yuxarıda göstərilən iki dildə olmalıdır. Məqalənin hər üç dildə yazılmış xülasəsi bir-birinin eyni olmalıdır. Açar sözlər uyğun xülasələrin sonunda onun yazıldığı dildə verilməklə ən azı üç sözdən ibarət olmalıdır.
6. Məqalədə UOT və PACS kodları göstərilməlidir.
7. Məqalə aşağıdakılardan ibarət olmalıdır:

- Giriş,
- Tədqiqat metodu
- Tədqiqat işinin müzakirəsi və onun nəticələri,
- İstinad ədəbiyyatı rus dilində olduğu halda orjinal dili mötərzə içərisində göstərməklə yalnız Latın əlifbası ilə verilməlidir.

8. **Şəkil**, **rəsm**, **grafik** və **cədvəllər** çapda düzgün, aydın çıxacaq vəziyyətdə və mətn içərisində olmalıdır. Şəkil, rəsm və grafiklərin yazıları onların altında yazılmalıdır. Cədvəllərdə başlıq cədvəlin üstündə yazılmalıdır.
9. **Mənbələr** mətn içərisində kvadrat mötərizə daxilində göstərilməklə məqalənin sonunda mətn daxilindəki sıra ilə düzülməlidir. Eyni mənbəyə iki və daha cox istinad edildikdə əvvəlki sıra sayı saxlanmaqla müvafiq səhifələr göstərilməlidir. Məsələn: [7,səh.15].

Ədəbiyyat siyahısında verilən hər bir istinad haqqında məlumat tam və dəqiq olmalıdır. İstinad olunan mənbənin biblioqrafik təsviri onun növündən (monoqrafiya, dərslik, elmi məqalə və s.) asılı olaraq verilməlidir. Elmi məqalələrə, simpozium, konfrans, və digər nüfuzlu elmi tədbirlərin materiallarına və ya tezislərinə istinad edərkən məqalənin, məruzənin və ya tezisin adı göstərilməlidir.

Nümunələr:

a) ***Məqalə:*** Demukhamedova S.D., Aliyeva İ.N., Godjayev N.M.. *Spatial and electronic structure af monomeric and dimeric complexes of carnosine with zinc,* Journal of structural Chemistry, Vol.51, No.5, p.824-832, 2010

b) ***Kitab:*** Christie ohn Geankoplis. *Transport Processes and Separation Process Principles*. Fourth Edition, Prentice Hall, 2002

c) ***Konfrans:*** Sadychov F.S., Aydın C., Ahmedov A.İ.. Appligation of Information-Communication Technologies in Science and education. II International Conference. "*Higher Twist Effects In Photon- Proton Collisions", Bakı, 01-03 Noyabr, 2007, ss 384-391*

Mənbələr 9 punto yazı tipi böyüklüyündə olmalıdır.

10. **Səhifə ölçüləri:** üstdən 2.8 sm, altdan 2.8 sm, soldan 2.5 sm və sağdan 2.5 sm olmalıdır. Mətn 11 punto yazı tipi böyüklüyündə, **Palatino Linotype** yazı tipi ilə və tək simvol aralığında yazılmalıdır. Paraqraflar arasında 6 punto yazı tipi aralığında məsafə olmalıdır.
11. Orijinal tədqiqat əsərlərinin tam mətni bir qayda olaraq 15 səhifədən artıq olmamalıdır.
12. Məqalənin nəşrə təqdimi aşağıdakı qaydada aparılır:

- Hər məqallə ən azı iki ekspertə göndərilir.
- Ekspertlərin tövsiyələrini nəzərə almaq üçün məqalə müəllifə göndərilir.
- Məqalə, ekspertlərin tənqidi qeydləri müəllif tərəfindən nəzərə alındıqdan sonra Jurnalın Redaksiya Heyəti tərəfindən çapa təqdim oluna bilər.

YAZIM KURALLARI

1. "Journal of Baku Engineering University- Makine ve endüstri mühendisliği" önceler yayımlanmamış orijinal çalışmaları ve yazarın kendi araştırma alanın-da yazılmış derleme makaleleri kabul etmektedir.
2. Makaleler İngilizce kabul edilir.
3. Makaleler Microsoft Word yazı programında, (**journal@beu.edu.az**) adresine gönderilmelidir. Gönderilen makalelerde şunlar dikkate alınmalıdır:

- Makalenin başlığı, yazarın adı, soyadı,
- İş yeri,
- E-posta adresi,
- Özet ve anahtar kelimeler.

4. **Özet** 100-150 kelime arasında olup 9 font büyüklüğünde, makalenin yazıldığı dilde ve yukarıda belirtilen iki dilde olmalıdır. Makalenin her üç dilde yazılmış özeti birbirinin aynı olmalıdır. Anahtar kelimeler uygun özetin sonunda onun yazıldığı dilde verilmekle en az üç sözcükten oluşmalıdır.
5. Makalede UOT ve PACS tipli kodlar gösterilmelidir.
6. Makale şunlardan oluşmalıdır:

- Giriş,
- Araştırma yöntemi
- Araştırma
- Tartışma ve sonuçlar,
- İstinat Edebiyatı Rusça olduğu halde orjinal dili parantez içerisinde göstermekle yalnız Latin alfabesi ile verilmelidir.

7. **Şekil, Resim, Grafik** ve **Tablolar** baskıda düzgün çıkacak nitelikte ve metin içerisinde olmalıdır. Şekil, Resim ve grafiklerin yazıları onların alt kısımda yer almalıdır. Tablolarda ise başlık, tablonun üst kısmında bulunmalıdır.
8. **Kullanılan kaynaklar**, metin dâhilinde köşeli parantez içerisinde numaralandırılmalı, aynı sırayla metin sonunda gösterilmelidir. Aynı kaynaklara tekrar başvurulduğunda sıra muhafaza edilmelidir. Örneğin: [7,seh.15].

Referans verilen her bir kaynağın künyesi tam ve kesin olmalıdır. Referans gösterilen kaynağın türü de eserin türüne (monografi, derslik, ilmî makale vs.) uygun olarak verilmelidir. İlmi makalelere, sempozyum, ve konferanslara müracaat ederken makalenin, bildirinin veya bildiri özetlerinin adı da gösterilmelidir.

Örnekler:

a) ***Makale:*** Demukhamedova S.D., Aliyeva İ.N., Godjayev N.M.. *Spatial and Electronic Structure of Monomerik and Dimeric Conapeetes of Carnosine Üith Zinc,* Journal of Structural Chemistry, Vol.51, No.5, p.824-832, 2010

b) ***Kitap:*** Christie ohn Geankoplis. *Transport Processes and Separation Process Principles*. Fourth Edition, Prentice Hall, p.386-398, 2002

c) ***Kongre:*** Sadychov F.S., Aydın C., Ahmedov A.İ. Appligation of Information-Communication Technologies in Science and education. II International Conference. "*Higher Twist Effects In Photon- Proton Collisions", Bakı, 01-03 Noyabr, 2007, ss 384-391*

Kaynakların büyüklüğü 9 punto olmalıdır.

9. **Sayfa ölçüleri**; üst: 2.8 cm, alt: 2.8 cm, sol: 2.5 cm, sağ: 2.5 cm şeklinde olmalıdır. Metin 11 punto büyüklükte **Palatino Linotype** fontu ile ve tek aralıkta yazılmalıdır. Paragraflar arasında 6 puntoluk yazı mesafesinde olmalıdır.
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2. Статьи принимаются на английском языке.
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5. **Аннотация**, написанная на языке представленной статьи, должна содержать 100-150 слов, набранных шрифтом 9 punto. Кроме того, представляются аннотации на двух других выше указанных языках, перевод которых соответствует содержанию оригинала. Ключевые слова должны быть представлены после каждой аннотации на его языке и содержать не менее 3-х слов.
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Например:

a) ***Статья:*** Demukhamedova S.D., Aliyeva I.N., Godjayev N.M. *Spatial and electronic structure of monomeric and dimeric complexes of carnosine with zinc,* Journal of Structural Chemistry, Vol.51, No.5, p.824-832, 2010

b) ***Книга:*** Christie on Geankoplis. *Transport Processes and Separation Process Principles.* Fourth Edition, Prentice Hall, 2002

c) ***Конференция:*** Sadychov F.S, Fydin C,Ahmedov A.I. Appligation of Information-Communication Nechnologies in Science and education. II International Conference. *"Higher Twist Effects In Photon-Proton Collision",* Bakı,01-03 Noyabr, 2007, ss.384-391

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