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The beautiful thing about learning is nobody can take it away from you—B. B. King

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TABLE OF CONTENTS

ISSN: 2613-5817; E-ISSN: 2613-5825
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SATATE PROGRAM FOR THE DEVELOPMENT OF THE REGIONS IN THE REPUBLIC OF AZERBAIJAN: WESTERN REGIONS OF THE COUNTRY SHAMKIR, TOVUZ, GADABEY AND GAZAKH BASED ON THE MATERIALS

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ABSTRACT

The Republic of Azerbaijan, the largest country in the Caucasus, left the Soviet Union in 1991 and entered a new path of development after becoming independent. It is true that some social and political events sometimes hindered these activities in one way or another, but they could not stop the development. The neighboring Republic of Armenia against Azerbaijan Although groundless land claims, the occupation of our lands, and the presence of 1 million refugees and internally displaced persons have created a number of problems in the country, socio-economic measures that have taken the right direction are bearing fruit. Adoption of the Constitutional Act "On State Independence of the Republic of Azerbaijan" on October 18, 1991 laid the foundation for a new stage in the history of our republic. In the process of the collapse of the USSR, relations between the production enterprises of the former USSR and Azerbaijan were broken. New production and service structures were created in the republic. Systematic measures were started in the direction of accelerating the development of the economy and the non-oil sector, deepening agrarian reforms, increasing the employment of the population, creating modern enterprises and opening new workplaces. After the death of Heydar Aliyev, this strategy is successfully continued by President Ilham Aliyev.
For this purpose, according to the order dated February 11, 2004, the "State Program for Socio-Economic Development of the Regions of the Republic of Azerbaijan in 2004-2008" was approved. After the decree was signed, important work was done in the country: new schools were built, old buildings were repaired, new roads were built, and new jobs were opened in the regions. After the first State Program was successfully implemented, on April 14, 2009, the second "State Program of Socio-Economic Development of the Regions of the Republic of Azerbaijan in 2009-2013" was approved. The tasks of this program were also successfully completed.
The funds obtained from the sale of "Black Gold" were directed to the restoration and development of infrastructure, which is an important condition for the socio-economic development of the regions.
6-8 billion manats have been invested in the implementation of the planned projects of the First State Program (2004-2008).
Investments for the implementation of the planned projects of the Second State Program (2009-2013) have reached 19.8 billion manats. Thus, 26.6 billion manats have been allocated for the development of regions within the framework of two programs.
During the implementation of the State Programs I and II of the socio-economic development of the regions, the President of Azerbaijan signed 240 decrees that provide for the acceleration of the socio-economic development of the cities and regions included in the economic regions. In the

last 12 years, 64,000 institutions, including 41 Olympic Sports Centers, 30 Youth Centers, 2,900 schools, and 560 medical institutions, were built and repaired. 84 settlements were built for 210 thousand forced migrants. 10,000 km of roads were built, 340 bridges and tunnels were built. The construction of 6 airports and 23 power stations has been completed. The main goal of the reforms, construction installation works, and infrastructure changes was to improve the living conditions of the citizens and raise the standard of living of the people of the country.
Keywords: State Program, socio-economic, regions, workplaces, production areas, infrastructure.

Introduction

Adoption of the Constitutional Act "On State Independence of the Republic of Azerbaijan" on October 18, 1991 laid the foundation for a new stage in the history of our republic. The existing Soviet system was abolished with the protest of the majority of the people, and a republic was declared for the third time in the history of Azerbaijan. Thus, the first republic in Azerbaijan, the first republic of the East, the Azerbaijan Democratic Republic, existed from May 28, 1918 to April 28, 1920. This first republic, founded by our democratic grandfathers, fell due to the intervention of the Soviets. On April 28, 1920, the Azerbaijan Soviet Republic was established, which is considered the second republic.

On October 18, 1991, our independence was restored and the third free and independent Republic of Azerbaijan was declared.

After that, a number of important steps were taken for the socio-economic and cultural development of the country.

Until the First World War, Azerbaijan directly exported various types of agricultural goods and raw materials for industry to foreign countries. Azerbaijan oil, fish, black caviar, silk, licorice, etc. was famous all over the world.

In later times, Azerbaijan's direct contact with the countries of the world was limited. The Azerbaijan Soviet Republic could communicate with foreign countries only through Russia.

During the Soviet period, the economy in Azerbaijan was not governed by the principle of democratic centralism, as was claimed at that time, but by the principle of socialist legality. Therefore, the economy was developing in a one-sided direction. As a result, Azerbaijan has been a region exporting cheap raw materials for many years. There were very few production and labor intensive areas. Thus, in the republic with a low standard of living, the service sector was far behind. There was a crowd of unemployed and partially unemployed. In the process of the collapse of the USSR, relations between the production enterprises of the former USSR and Azerbaijan were broken, and new production and service structures were created. However, this process continued blindly under military conditions.

The need to transform and modernize the economy in Azerbaijan is felt significantly. The processing and economic exploitation of oil, gas, iron ore, mercury and other natural resources should serve the interests of the people. For this, it was necessary to improve the existing areas of the economy that meet the requirements of the market economy.

After national leader Heydar Aliyev came to power on June 15, 1993, the country's development strategy in this direction was launched. The signing of the "Contract of the Century" on September 20, 1994 gave a strong impetus to attracting foreign investments to the country. In order to achieve a balanced development of the national economy, the revenues obtained were directed to the development of the non-oil sector.

H. Aliyev turned Azerbaijan into the most influential state of the Caucasus region with a strong economy and army, and a full-fledged member of the European family. As a result of his tireless and titanic activity, political-ideological, socio-cultural and economic mechanisms were developed for the transformation of Azerbaijan into a strong sovereign state, and the concept of state building was developed.

In this regard, one of the main goals of the economic policy of the state was to accelerate the development of the regions. The material and technical base left over from the Soviet era is outdated and resources are exhausted. The economy was almost completely destroyed. Thus, systematic measures have been started in the direction of effective use of natural and economic potential of the regions, labor resources, acceleration of the development of the economy and the non-oil sector, deepening of agrarian reforms, increasing the employment of the population, creation of modern enterprises and opening of new jobs.

Main part and methodology

After the death of Heydar Aliyev, this strategy is successfully continued by President Ilham Aliyev.

For this purpose, according to the order dated February 11, 2004, the "State Program for the socio-economic development of the regions of the Republic of Azerbaijan in 2004-2008" was approved [3, p.17].

After the decree was signed, important work was done in the country: new schools were built, old buildings were repaired, new roads were built, and new jobs were opened in the regions.

After the first State Program was successfully implemented, on April 14, 2009, the second "State Program of Socio-Economic Development of the Regions of the Republic of Azerbaijan in 2009-2013" was approved. [4, p. 23.]. The tasks of this program were also successfully completed.

The funds obtained from the sale of "black gold" were directed to the restoration and development of infrastructure, which is an important condition for the socio-economic development of the regions.

6-8 billion manats have been invested in the implementation of the planned projects of the First State Program (2004-2008).

The investment for the implementation of the planned projects of the Second State Program (2009-2013) has reached 19.8 billion manats [3, p.17]. Thus, within the framework of two programs, 26.6 billion manats were allocated for the development of regions.

During the implementation of the State Programs I and II of the socio-economic development of the regions, the President of Azerbaijan signed 240 decrees that provide for the acceleration of the socio-economic development of the cities and regions included in the economic regions. In the last 12 years, 64,000 institutions, including 41 Olympic Sports Centers, 30 Youth Centers, 2,900 schools, and 560 medical institutions, were built and repaired. 84 settlements were built for 210 thousand forced migrants. 10,000 km of roads were built, 340 bridges and tunnels were built. The construction of 6 airports and 23 power stations has been completed [4, p.5]. In 2014, within the framework of the III State Program, President Ilham Aliyev made 23 visits to the regions, where he participated in the opening ceremonies of more than 120 different infrastructure facilities and new enterprises. He got acquainted with the activities of existing enterprises and held meetings with the public. 72 decrees were signed by the head of state to solve a number of issues, and 270 million manats were allocated. This is an example of the head of the country paying special attention to the development of regions.

The socio-economic development policy of the regions has led to the improvement of the macroeconomic indicators of the country. Gross domestic product (GDP) increased by 3.2 times, per capita growth by 2.8 times, and in the non-oil sector by 2.6 times. Average annual economic growth was 12.9%. Strategic currency reserves 31 times, foreign trade turnover 6.6 times,
export - 9.3 times, import - 4.1 times, state budget revenues - 16 times, average monthly salary - 5.5 times, pensions - 9.6 times, population savings - 27 times [3, p.35] .

As a result of the implementation of the I and II state programs on the development of regions, 1 million 461 thousand jobs were created, of which 70 percent fell to the regions [3, p. 37].

Within the framework of these programs, necessary measures were taken to improve the living conditions of the population, including the families of martyrs and the disabled, and rehabilitation centers for the disabled were established.

Even during the crisis period of the world economy, there was some progress in the non-oil sector of the Azerbaijani industry. With the help of highly innovative technologies, favorable conditions have been created for the development of the competitiveness of industrial production. In order to increase the employment of the population by using modern technologies, a number of industrial enterprises such as Sumgayit Technology Park, Sumgayit Chemical Industrial Park, Balakhani Industrial Park, High Technologies Park, and Zeyam Technology Park were established in the Zeyam settlement of Shamkir region.

The State Program of socio-economic development of the regions of the Republic of Azerbaijan was successfully implemented in the western regions of the country. Within the framework of this program, several million manat projects were implemented in **Shamkir,** Tovuz, Gadabey and Gazakh regions.

Within the framework of the State Program in 2004 and 2009-2013, a large amount of work was carried out in Shamkir district. Shamkir district is geographically located in the north-west of the country. According to the decree of the President of the Republic of Azerbaijan on the new division of economic districts on July 7, 2021, district 7 Gzakh -Tovuz is part of the economic district. The area of the district is 1,657 square meters. According to the data of 2019, the population of Km is 219,500 people. [18.] The region was one of the ancient settlements. During the recent archaeological excavations on the banks of the Kur River, settlements and an ancient city were discovered from the Early Bronze Age.

The name of the center of the region, the city of Shamkir, is taken from the name of the Shamkir fortress, which existed in the 5th-6th centuries. In 1924, Jahangir Zeynaloglu, who published the work "Comprehensive History of Azerbaijan" in Istanbul, named the place as "Shams" Gunesh, "kur", that is, the home of those who worship the Sun. [5, p, 97.]

Shamkir is an early medieval city. The ancient fortress walls of the city still remain on the banks of the Kur River. The area was occupied by the Arabs in the 6th century and by the Turkish Seljuks in the 11th century. The city flourished in the 11th-12th centuries. The city was occupied by the Mongols in the 13th century. Shamkir district was established at the beginning of the 16th century. In 1803, Shamkir was occupied by Russian troops. In 1817 The tsarist government places a group of German colonists in Shamkir. [18]

In 1930, Shamkir district was created with the city of Shamkir as its center. The name of the district was called Shamkhor until February 7, 1991. On February 7, 1991, the ancient name of the city was restored.

After a short historical excursion, let's look at the real facts about the work done in the region within the framework of the State Program for Economic Development of Regions. From this point of view, it is planned to develop the areas of production and processing of agricultural products, increase the level of textile industry and fishing. At the same time, within the framework of the I State Program, development of construction materials production, construction of water lines to Shamkir city and villages is planned. Şiştepe, construction of a centralized sewage line, a 240-bed hospital, a secondary school in the village. Residential buildings were built for disabled people and families of martyrs in Dallar-Jirdakhan villages [12, p.6].

Within the framework of the State Program, a Sports and Health Center, four secondary schools, and a new type hospital in the settlement of Gasim Ismayilov were built and put into use at the expense of the Heydar Aliyev Foundation. Dozens of secondary schools, including city school No. 1, have been fundamentally renovated.

In the Zayam settlement, they seriously engaged in the restoration of the work of the "Zayamkendmash" plant, which existed in the Soviet years, and restored the plant under the name of the Zayam Technology Park, which means providing employment to hundreds of people.

Agrotechnical service areas have been established in the agricultural areas of the region. A new type of shopping center has been commissioned in Zayam settlement.

Opening of various healthcare, educational and commercial facilities means opening of new jobs. Thus, in 2004-2005, as a result of putting workshops, commercial and household facilities into use, 360 permanent, 640 seasonal, and 330 temporary jobs were opened in Shamkir region in 2005.

The largest project implemented within the framework of the State Program I was the strengthening and increasing the capacity of the 380 megawatt Shamkir HPP and Yenikend HPP, which were founded in 1975 and 1979. At present, this hydropower plant provides a large part of the energy demand of the republic. [14,p,1]

In 2008-2013, a lot of work was done to achieve socio-economic and cultural development in the

Tovuz region, which is another large western region of the country. Tovuz region, which is an ancient Turkish homeland, was one of the settlements where ancient people lived. Sabir Turks of Hun origin lived here in the 3rd century AD. It is likely that the name of the city of Tovuz came from them. [1, p. 182.]

The modern city of Tovuz is located near the railway line built along the edge of the ancient Taust fortress. Until the 60s of the 19th century, the local population called and wrote the name of the fortress as Tavus. In the Soviet era, this name was distorted into "Tovuz".

The region known in history as Shamshedil, Shamsheddin, and Tavus was created by the Soviets in 1930 as a regional administrative territorial unit under the name of Tovuz. Currently, the area of the region is 194,000 square kilometers and the population is 170,400. There are two cities (Tovuz and Govlar) and 102 villages in the region. [19] The district is one of the largest economic districts of the country. A number of measures have been taken to achieve the social, economic and cultural development of the district and to improve the welfare of the population.

Thus, the President of the Republic Ilham Aliyev has signed orders on different dates on the acceleration of socio-economic development of Tovuz region (14.10.2005), improvement of gas supply of the region (04.07.2008), reconstruction of Tovuz region.

Big Kishlaq-Garalar highway (07.10.2009), - economic development of Tovuz region (07.06.2013), about additional measures to improve socio-economic development of Tovuz region (05.01.2012) and reconstruction of the highway. Tovuz-Khunanlar-Karakhanli-Duz Cirdakhan asphalt construction of the road (20.08.2014) and other orders signed millions of manat expenditures from the State budget for the improvement of this region of the country. For this purpose, millions of manats have been allocated from the President's reserve fund. As a result of this, a lot of work has been done in Tovuz region, both in agriculture and agrarian field, and new opportunities have been opened. The implemented economic reforms have given a dynamic character to the socio-economic development of the region. Reconstruction, construction, improvement works are being carried out not only in the district center, but also in villages and settlements. In agricultural fields such as potato growing, grape growing, and tobacco growing, new production facilities are put into use, entrepreneurship is developing, and cultivated areas are expanding. Preference is given to domestic production that replaces imports. [7, p 3]

A modern milk processing plant was commissioned in the village of Bozalganli. In order to preserve the products produced here, three hundred ton refrigerating chambers have been put into use in the village of Ashagi Gushchu.

Based on the President's decree of October 14, 2005, the construction of the Tovuzchay reservoir was started in 2006. The length of the reservoir is 2.6 km, and the total water capacity is 20 million cubic meters. [13.p.3] On February 16, 2016, the President of the Republic Ilham Aliyev participated in the opening ceremony of the Tovuzchay reservoir.

Later, 15 subartesian wells were dug and put into operation in 2014 to meet the population's economic and household water needs.

In recent years, 18 new schools have been built and 10 schools have been renovated in Tovuz district. Taking into account the ancient history of Tovuz region, on April 18, 2012, President Ilham Aliyev signed a decree on the establishment of Goytepe Archaeological Park. Based on this decree, the expedition of the Institute of Archeology and Ethnography of the National Academy of Sciences together with French experts conducted observations in the Goytepe settlement and based on the analysis of the materials, they determined that the Goytepe settlement belongs to the VI-IV millennia BC. [7,p,3.]

Within the framework of the projects, thousands of kilometers of roads were built and put into use in Tovuz region.

Socio-economic development of the regions of the Republic of Azerbaijan State programs are successfully implemented in other western regions of the republic, including **Gadabay r**egion. The territory of Gadabey district, which is part of Gazakh-Tovuz economic district, is 1230 sq km, and its population is 100,400 people. Gadabay, a high mountain region, was the area inhabited by ancient Turkic tribes. Thus, there are geographical names derived from the words "Ket" and "bey" in Turkestan (Central Asia). Already in the 13th century, the Albanian historian Mikhtar Gosh mentioned the name of the area as "Kettabey" in his Albanian chronicle. [15, p, 256.] The meaning of the word is "big brave boy". From the territory of the district, which is the place where ancient people lived, B.C. A large number of material culture samples and settlements belonging to the Khojaly-Gedebek archaeological culture covering the 14th and 9th centuries have been discovered. The natural resources in the Gadabay area with such a rich history attracted foreign capitalists as early as the 19th century. The German Siemens brothers bought the copper ore plant created by local entrepreneurs in 1855-1856 and put it into operation in 1865. After the Galakand-Gadabay railway was launched in 1879. In 1883, the Galakand Miseritme plant was built. The Galakand-Gadabey railway was the first railway in Transcaucasia with a length of 28 km. Millions have been invested in the region's economy even in our modern times. A gold processing plant and a mineral water plant were built in Gadabey, and important

infrastructure projects were implemented. A new bus station, chess school, house of lovers were built. During 2004-2008, new jobs for 2700 people were opened in Gadabay district.[16]
The central district hospital and cultural center have been overhauled, and educational and other socially oriented facilities have been put into use. New highways were built, bridges were built, a number of construction works were carried out in the area of beautification of the region. During this period, roads from the center of Gadabay to a number of villages were paved with asphalt. The construction of the Garikend-Miskinli-Chalbur highway has started, [8,p,4]
By the Decree of President Ilham Aliyev dated May 31, 2014, additional funds were allocated for the continuation of road construction. In order to continue economic measures in the region, the President of the Republic signed a decree on the allocation of 2 (two) million manats from the Reserve Fund of the President on September 20, 2013. More than sea level blue gas lines were laid to hundreds of houses in the village of Shynikh located at a height. [2, p, 4] Due to the location of Gadabay in the heart of the mountains and the wonderful nature, rich in healing natural springs, the development of tourism was encouraged and recreation centers were opened here.
Important infrastructure works were also carried out in Gazakh region within the framework of the State Program of the economic development of the regions of the President of the Republic of Azerbaijan [11, p, 4.]

Gazakh region is the western gate of the country and has an ancient history. Babadarvish of the Bronze Age, Neolithic-Bronze Age remains of Goytepa and Damchili spring in the region prove that the area is one of the ancient human settlements.
Regarding the etymology of the Kazakh ethnonym, there are different versions. We believe that the most correct of them is the version related to the name of a Turkish tribe. As it is known, the word "Kazakh" in the ancient Turkish language means "free", "separated people", "runaway soldiers". Famous orientalist scientists V. Velyaminov-Zernov, V. Bartold, A. Yudin also supported the explanation we put forward above [17].
In different periods of history, the territory of the current Gazakh region was included in the study of various administrative territorial divisions according to its time. The Kazakh sultanate was established in the middle of the 15th century. The Kazakh sultanate was subordinate to the Karabakh Beylarbey. At the beginning of the 18th century, during the Ottoman occupation, Gazakh was declared a Sanjak and divided into 4 districts. It is recorded on page 63 of the 1046-page notebook "Details of Tbilisi Province" which is currently kept in the Presidential Archives in Istanbul and was compiled in 1828 during the period of Turkish rule, that the Kazakh sanjagliy consisted of 205 villages, 10 winter camps and was inhabited by 5 nomadic tribes [6, p. 12].
In 1801, the Kazakh sultanate was annexed by Russia as part of Eastern Georgia. This was the beginning of the occupation of Azerbaijan by Russia. In 1819, the sultanate was abolished and turned into a district. On December 9, 1867, the Yelizavetbol governorate was created and Gazakh became a district within it. The territory of the Kazakh district, which was given to Armenia during the Soviet period, included the Dilijan valley, the areas up to Goycha lake - Ijevan, Karagoyunlu district - Noembryan, Chambarak - There was also Krosnoselsk. In 1929, the Kazakh accident was canceled. On August 8, 1930, Gazakh district administrative territorial unit was established [6, p.14].
On the basis of the State Program, state investments have been allocated to the development of agricultural fields, as well as construction and social fields in Gazkh region. In the years 2004-1013, dozens of new facilities were built in the region. a bridge with a length of 114 meters and a

width of 14 meters was opened [9, p.5]. This bridge was built in 1898 to connect two parts of Gazakh region, but it has not been repaired until now. During these years, the opening of the Olympic Sports Complex in the region on May 30, 2007, the Treatment-Diagnostic Center on September 24, 2008, the Kazakh State Art Gallery, and the Shamkir-Kazakh highway on November 1, 2006, after major repairs, were also held with the participation of President Ilham Aliyev. In several villages of Gazakh region, production areas (cement processing plant in the village of Dash Salahli) - new workplaces and other socially oriented facilities to provide employment to the population, were built at the level of modern requirements, production and processing enterprises were opened, new roads were built and large-scale repair and preventive works were carried out, improvement works were done [10, p. 5].

Conclusion

The President of the Republic of Azerbaijan, Mr. Ilham Aliyev, signed the first Decree on the approval of the State Program for Social Economic Development of Regions on February 11, 2004-2008. With this, not only the capital Baku and large cities, but also the social- A number of projects were prepared and implemented for economic and cultural development. Infrastructural projects were implemented based on the principle of prosperous cities and prosperous villages. New jobs were created and production areas were opened to improve the living standards of the population.

After the implementation of State Programs, I (2004-2008) and II (2009-2013) in the western region of the country, the state of well-being of the population of the region has improved significantly, infrastructure projects have increased the beauty of the western region.

Thus, the successful implementation of the first two State Programs for the development of regions, President Ilham Aliyev signed the third decree "On the State Program" on February 27, 2014 [3, p.98].

The main goal of the program was further development of the non-oil sector in the country, diversification of the economy, continuation of measures aimed at rapid development of regions, improvement of infrastructure and social services.

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ESTABLISHMENT AND ACTIVITY OF IREVAN TEACHERS' SEMINARY

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ABSTRACT

The article is based on the establishment of the Irevan Teachers' Seminary and its history. It is informed that the school established in October 1880 in the city of Irevan.
The main aim in the article is explore establishment history of the school and its achtivity. This educational institution, which operated for a total of 37 years, was closed on 6 August, 1918 at the same time as Irevan gymnasium and Uluhanli school. Irevan Teachers' Seminary played an important role in the development of the educational environment in Azerbaijan, fulfilling its historical mission and creating a new stage.
So, on 14 January, 1832, Azerbaijani children began to study together with children of different nationalities in the first emergency school opened in Irevan. Additionally, the Irevan emergency school opened in 1832 became a gymnasium in 1869 and a 5-class gymnasium on 31 March, 1881.
Due to the original regulations of the teachers' seminary, Orthodox boys over the age of 16 could be admitted to the such educational institutions. In 1875, the Instruction on the Teaching Clergy allowed Muslims to study in theological schools alongside the Orthodox. On 20 October of 1880, the Russian State Council adopted the decision "On the organization of teachers' seminars in Kutaisi and Irevan governorates." According to this decision, 28,350 rubles were allocated from the state treasury to Irevan Seminary. Irevan Teachers' Seminary started working on 8 November, 1881 in the current building of the Irevan National Economic Institute with 42 students and 9 teachers. The first director of the seminary school was an educator Jacob Stepanovich Sushevsky.
The study of the history of the Teachers' School founded 141 years ago. Conferences, round tables and a series of events will continue in this regard. The legacy of this great source of information, which made great contributions to the development of our national education and opened bright pages in our educational history, will continue to shine hundreds of years later.
Result: The Irevan Teachers' Seminary, which has been operating for 37 years, has played an important role in the development of the educational environment in Azerbaijan, including fulfilling its historical mission and creating a new stage.
Application importance: this material can be used in HEIs and can be useful for historians and to whom interested in history.
Keywords: teachers’ seminary, Irevan, education, Azerbaijan

Introduction

History of Irevan Teachers' Seminary: Until the 70s of the 19th century, there was no school teaching secular subjects in the entire Caucasus, or any educational institution training pedagogical personnel to teach these subjects. As in Azerbaijan, until the opening of secular schools, only mollakhanas and madrasahs functioned as educational institutions, apart from mosques. Madrasahs and mollakhanas, which have been operating for centuries, have not been able to ensure the cultural progress of our people and have slowed down the development process. Thus, the political processes in the South Caucasus at the beginning of the 19th century caused new trends in school and education, as in all fields. Madrasahs and mollakhanas, which are now functioning as educational institutions, have gradually shrunk and had to be replaced by secular schools [2].

After the South Caucasus was occupied by Russia, including the Azerbaijani khanates, every sphere of life began to come under Russian control. In 1829, at the beginning of August, the Ministry of Education of Russia adopted the decision "On the state of Transcaucasia schools". The establishment of emergency schools and the management of the general education system were reflected here. In the 70s of the 19th century, in these schools, which were opened in various areas of the South Caucasus, educational institutions that taught children the basics of science in a new way began to be seriously organized. Dozens of progressive Azerbaijani intellectuals joined this enlightenment movement, which started in the South Caucasus, and started fighting for the participation of young people in education.

Thus, on January 14, 1832, Azerbaijani children began to study together with children of different nationalities in the first emergency school opened in Irevan. In addition, the Irevan emergency school opened in 1832 became a gymnasium in 1869, and a 5-class gymnasium on March 31, 1881. On November 8, 1881, the Irevan Teachers' Seminary, an educational institution, was opened in Irevan. Apart from representatives of many nationalities, Azerbaijanis also studied here. It can be noted that the establishment of the Irevan Teacher's School and Gymnasium had an important impact on the spread of enlightenment in the South Caucasus. Tatar language (Azerbaijani language) was taught in the seminar by Akhund Mammad Bagir Ghazizade. He was born in Irevan in 1853 and graduated from Irevan gymnasium. Having high knowledge, Ahund Mammad Baghir also headed the Azerbaijani branch of Ghazizade theological school. In 1911, he was one of the authors of the "Mother Language" textbook published in Tbilisi with a group of colleagues working in Irevan Teachers' Seminary. According to the conducted research, Akhund Mammad Bagir Ghazizadeh, who is the head of the Azerbaijan branch of the theological school, played a great role in conducting Sharia classes at a high level, improving the teaching conditions and engaging our young people more.

The creation of a new school system in the territory of Irevan coincided with the 1930s. The first charter of Transcaucasia schools was adopted in order to keep the local population obedient, to implement Christianization and Russification policies, and to strengthen the tsarist administration. According to this charter, 20 emergency schools were to be opened in the South Caucasus. In 1832, the first secular school, a two-room emergency school, was established in Yerevan. In 1839, the emergency school was transformed into a three-class emergency school, and in 1869 into a four-class progymnasium, and in 1881 into a gymnasium. About 600 Azerbaijanis graduated from the gymnasium. A major part of the pedagogical activities of Firidun Bey Kocharli, a prominent Azerbaijani educator, was related to the gymnasium. The emergence of new-style mother tongue schools in the city of Irevan also coincides with this period. In 1882, Mashadi Molla Ismayil Haji Kazimov from Tabriz, as well as Mirza Hasan Rushdiya and Mirza Kazim Ashkarzade came to Irevan in 1883 and opened new method schools [4]. Over the years, the opening of emergency and primary village schools in Iravan governorate created a necessary need for public teachers. At that time, state teachers for primary schools were trained in theological schools and teachers' institutes.

According to the original regulations of the teachers' seminary, Orthodox boys over the age of 16 could be admitted to such educational institutions. In 1875, the Instruction on the Teaching Clergy allowed Muslims to study in theological schools alongside the Orthodox. On October 20, 1880, the Russian State Council adopted the decision "On the organization of teachers' seminars in Kutaisi and Yerevan governorates." According to this decision, 28,350 rubles were allocated from the state treasury to Irevan Seminary. Irevan Teachers' Seminary started working on November 8, 1881 in the current building of the Irevan National Economic Institute with 42 students and 9 teachers. The first director of the seminary school was Jacob Stepanovich Sushevsky, an educator. Here, education was managed by the primary school under the preparatory class for 3 years. Pupils spent their pedagogical experience in this school. The dormitory operated. Along with Azerbaijanis, children of Armenian, Russian, Georgian and other nationalities were educated here. The charter of this institution is the same as the Gori Teachers' Seminar. Like other seminaries, Irevan Teacher's Seminary consisted of 4 classrooms. Preparatory group and first-year student admissions were announced every year. Students were not allowed to enroll in classes II and III directly. Those admitted to the first course had to take exams in Russian language, theology, geometry, arithmetic, history, geography, and biology. In the 1883/1884 academic years, the number of weekly lessons in the preparatory group is 36 hours, in the first year 38 hours, in the second year 39 hours, and in the fourth year 40 hours. In the following years, the number of students and teachers increased. According to information up to December 1882, 54 students studied there [1].

In the academic years of 1882-1883, 61 students, 13 of whom were Azerbaijanis, studied in the primary school within the madrasa. In 1889-1900, the number of students reached 82 people. The director of the model school was V. A. Mukhin, A. Suvorov and the first Azerbaijani teacher Mashadi Baghir Kasimzade at different times. Azerbaijani children in lower preparatory classes: 5 hours on Russian language, 5 hours on mathematics, 4 hours on theology, 2 hours on history, 2 hours on geography, 2 hours on physics, 2 hours on natural sciences, 2 hours on song, 2 hours of poetry lessons, 2 hours of painting, 2 hours of calligraphy lessons, total 30 hours per week. Azerbaijani children can work with Christian children after learning the Russian language, history, geography and Russian traditions. Children who did not speak Russian were taken to the lower preparatory class. It was not mandatory for Azerbaijani students to be admitted to lower preparatory classes and to study at the seminary for 5 years. When completing the lessons, the preparation levels of the students were taken into account. Students who knew Russian and had a certain level of preparation were admitted to secondary school or first grade. The seminars lasted 4 hours in the 2nd grade, and 8 hours in the 3rd grade in the elementary school.

Akhund Mammadbaghir Gazizade was the first Azerbaijani teacher who taught at the Irevan Teachers' Seminary, an outstanding scientist, pedagogue. Since the opening of the seminary, he taught theology and the Azerbaijani language, and in the years 1897-1917, he taught only theology. Since 1892, Mirza Rahim Khalilov taught Azerbaijani language at the theology school. Khalilov graduated from this theological school in 1881 and was hired for this position on the advice of his teacher Akhund Mammadbaghir Gazizadeh. Educator Akhund Mammadbaghir Gazizadeh had important services in the preparation of those teachers for Azerbaijani schools in the theological school. He spent all his knowledge and skills on training teachers. In various times in Azerbaijan, they gave seminars to Mammadbaghir Gazizadeh, Mirza Mammadvali Gamarli, Akhund Mammadbaghir Kazimzadeh, Rashid bey Shahtakhtinsky, Jafar bey Jafarbeyov, Hamid bey Shahtakhtinsky, Akhund Mammadbaghir Taghizadeh, Mammad Akhundov, Mirza Jabbar Muhammad [8].

Tuition fee was paid in this seminary as in other seminaries. A certain part of the students were financied by state. Those admitted paid 210 manats in the first academic year, and 180 manats in the following years. According to the information of 1907, only 20 of the 70 students studying here were educated at their own expense. According to the information given in the 1913 issue of the "Caucasian Calendar", only 46 of the 128 students studying at the theological faculty are Russian, 30 are Azerbaijanis, 37 are Armenians, 6 are Georgians, and 9 are representatives of other nationalities.

Main part and methodology

The development of the Irevan Teachers Seminary. The first graduation of the Irevan Teachers Seminar in history dates back to 1884. 5 Azerbaijanis graduated from the seminary that year. The tenth edition of the seminar took place in 1893, the twentieth in 1903, and the thirtieth in 1913. At the end of the 19th century, many provincial school teachers and principals working in the territory of the South Caucasus obtained the right to teach in that theological school by taking an external exam in different years. By the decision of the Faculty of Theology Pedagogical Council, in 1895, Mammad bey Gaziyev, Jalil Mirzayev, Taghi bey Safiyev, and in 1902, Jabbar Mammadov, Ibadullah bey Mughanlinski, Shamdan Mahmudbeyov and others were given the title of village teacher. The initiator and organizer of this noble work was former educator Akhund Mammadbagir Gazizadeh. Graduates were required to work in rural schools by appointment. It is clear from the document issued to Mehdi Kazymov, who graduated from the Faculty of Theology in 1910, that he had to work for 6 years, otherwise he had to pay 520 rubles to the treasury.

Ahmed bey Gaziyev, Ali Eshref Gaziyev, Hasan bey Akhund Molla, son of Khalil bey Gaziyev, Faramez Mahmudbeyov, Yusif bey Gaziyev (Gazizadeh), Mahmudbeyov son of Mammad bey Ali bey, Hasan Nasirbeyov, Khalil Mammadaliyev, Jafarbey Jafarbeyov, Saleh Meshadi Teymur, his son Agha Bey Firudinbeyov, Abbas Gadimov, Ali Sultanov, Abbas Allahverdi Gadimov, Mir Hashim Bey Vazirov, Farrukh Aghakisibeyov, Ali Jalilzade, Shikhali Bey Firudinbeyov, Mirza Baghir Aliyev, Ibrahim Shahtakhtli, Jabbar Mahammadzade, Vahid Musabey Bey, Rahid Musabey Bey Shafibeyov, Najaf Bey. Vazirov, Ibadulla bey Mughanlinski, Hashim bey Vazirov, Mirza Abbas Mahammadzadeh, Huseynali bey Rustambayov, Vahid Musabeyov, Hashim bey Narimanbey, Sahmil bey Narimanbey, Taghi bey Safiyev, and others, Sahmil bey Naribey and others were distinguished. Ibrahim Safi, one of the famous artists of Turkey, also graduated from the same theological school.

The seminar was chaired at different times by Ivan Andreyevich Pasyutevich, Jacob Stepanovich Sushevsky, Valentin Vasilyevich Dubromin and Mikhail Alekseyevich Miropiev [7].

Irevan Teachers' Seminary has become not only an educational institution, but also a center of science and culture of the city. In 1881-1914, 63 Azerbaijanis graduated from Iravan Teachers' Seminary.

In 1915, the Irevan Teacher's Seminary was transferred to Sardaraba (present Armavir) and this seminary operated there until 1918. At that time, B.B. Dobromin was in charge of the seminar. 3 theology teachers, 9 branch teachers and 1 doctor served in the seminar. Mirza Jabbar Mammadov taught the subject of Azerbaijani language, and Akhund Mammadbaghir Ghazizadeh taught the subject of Sharia (religious subject). Thoses two subjects were conducted by them. In 1918, the

Madrasah ceased its activity as a result of the ethnic cleansing carried out by the Armenians against the Azeris, some teachers and students were brutally murdered, and the survivors left their homes and took refuge in Azerbaijan and Turkey. The first Armenian state (Ararat) was established on the basis of the Iravan governorate, which was established with the direct support of Tsarist Russia as a result of the assistance of the Russian Soviet Federative Socialist Republic in the territory of the former Azerbaijan. Azeris, the former inhabitants of these lands, became one of the few peoples in their homeland. In 1924, thanks to the national will and insistence of Bala Efendiyev, the head of the minority department of the Central Committee of the Communist Party of Armenia, Mehdi Kazimov, the head of the "Minorities" bureau of the People's Education Commissariat, Huseynov, the editor-in-chief of Mustafa Zangi newspaper and other intellectuals, the Irevan Teachers' Seminary successor Irevan Turkish Pedagogical College was opened on October 15. The goal was to prepare primary school teachers for the schools where Azerbaijanis study. However, the environment of the Turkish Pedagogy Technikum District, where the traditions of the Irevan Teachers' Seminary played an important role in the formation and development of the eternal cultural and educational society, faced great difficulties from the very beginning. Due to mass deportation of Azerbaijanis from the current territory of Armenia, he moved to Khan region. The ground was prepared for mass deportation [5].

Research shows that Jalil Mammadguluzadeh visited Irevan in June 1906, met prominent Azeri intellectuals, teachers and students at the theological school, and exchanged wide views about the "Molla Nasreddin" magazine. The teachers and students of the Azerbaijani branch of the Yerevan Teachers' Seminary had a great role in the creation of the "Molla Nasreddin" magazine in Yerevan. "Zanbur", "Igdam", "Tuti", "Babayi-Amir", "Translator", "Mazali", "Irshad", "Shalala", "Suvagat", "Kaspi", "Kashkul" etc. Azerbaijani students and intellectuals played an important role in its spread in Irevan.

It is possible to note that in 1904, the Irevan Teachers Seminary Rashid bey Shahtakhtinski, and in 1907, and Hamid bey Shahtakhtinski teached the Azerbaijani language (Tatar). After graduating from the Irevan Teachers Seminary in June 1899, Hamid bey, the Iranian Russian-Tatar school was appointed by Azerbaijani language at the Irevan Russian-Tatar school in early September 1899. On 27 October, 1901, due to the decree (number 14622) of the head of the Caucasus Enlightenment department, Hamid bey was appointed as the Tatar language (Azerbaijani language) teacher of Irevan Teacher Seminary. At the end of the late October, due to the decision (19273) of Caucasus Education Department, Hamid Bey resigned his post as the Tatar language (Azerbaijani language) teacher in the Irevan Teacher Seminary.

Mirza Jabbar Mammadzadeh was appointed as an Azerbaijani language (Tatar language) teacher after Hamid bey’s release from the seminary in 1907. He had worked in the seminary untill 19 January of 1913. Students from Baku, Nakhchivan, Daghistan and other cities studied in the seminary. Alumnis were given a certificate on teacher of village primary school.

Ali Ashref Gaziyev, Ahmad bey Gaziyev, Hasan bey Akhund Molla, Yusif Bey Akhund, Khalil Mahmudbeyov, Hasan Nasirbayov, Saleh Mahmadaliyev, Hasan Nasirbayov, Mir Hashim Bey Vazirov, Abbas Allahverdi Gadirov, Farrukh Aghakishibeyov, Ali Sultanov, Mirza Baghir Aliyev, Ali Jalilzadeh, Jafarbeyov, Ibrahim Shahtakrakhti and others have graduated from the seminar of Irevan. Until 1910, 30 Azerbaijani teachers graduated from school. The total number of Azerbaijanis studying in 1915 was 22 [4].

Educational system of Irevan Teachers' Seminary
In the seminar, Azerbaijani language, Russian language, geography, sports, mathematics, etc. music was also taught. In 1885, a total of 69 people, including Azerbaijanis, received music education under the guidance of N. Kasradze, who worked as a music teacher in the madrasa.
Graduates of the Yerevan Teachers' Seminary played a major role in the development of national education in the South Caucasus. They actively participated in the opening of new schools in the regions where Azerbaijanis live, including the participation of Azerbaijani children in education. These supporters of education made great sacrifices for this national renaissance mostly in Yerevan, Nakhchivan and different regions of Azerbaijan. Ibadullah Bey Mughanlinski, Mammad Akhundov, Jafar Karimov, Mammad Vali Gamarlinski and others spent not only their efforts and skills, but also their lives and financial resources for the cultural progress of our people in Irevan. Jafarbay Jafarbayov was also in Irevan and he managed to open a private school and managed the hostel that opened by him. In 1897, Jafar bey graduated from the preparatory class of the Irevan gymnasium, and in 1901 he graduated from the Irevan Teachers' Seminary. Asghar Akhundov, who graduated from the Irevan Teacher Training School in 1911, manages to open a third-grade 1-class boarding school here. In 1903-1917, Shamdin Bey Mahmudbeyov, who graduated from the Faculty of Theology, studied at Uluhanli village school, Shikhali Bey Firudinbeyov at Gamarli village school, Yusif Babayev at Dvin-Aysor village school, Mirza Jabbar Mammadov at Goymesjidullah village school. In 1903-1917, he was the head of the village school of Darachichek. Ilya bey Mahmudbeyov, Ahmed Hashimov in Chobankara village, Jalil Mammad oglu Mirzayev, Shikhali bey Firudinbeyov, Hasanbey Akhund Molla Khalil bey oglu Gaziyev, Mirza Muhammad Akhundov in Gamarli, Mammad bey, Mammad bey in Yerevan, Akhund Mammad Bagir in Gazizade, Big Ved in Lut, Jafar Karimov Sharurda and Faramez bey Mahmudbeyov taught. These teachers working in Irevan and the regions have done very important work for the sake of national progress. In addition, Taghi bey Safiyev, who graduated from Irevan Teachers' Seminary in 1895, also worked as a teacher in Nehram village of Nakhchivan for a long time. During this period, his booklet "Nehram Village" was published. Hasan Safarli was one of the graduates of Irevan Teachers' Seminary. Hasan Safarli, a good Russian language and mathematics expert, also taught at the "Rushdiya" school operating in Nakhchivan from 1917 to the middle of 1919. In 1919, H. Safarli worked as the director of an orphanage in Nakhchivan. In 1965, he received the honorary title of "Honory Teacher".
Huseynali bey Rustambayev, an alumni of the Faculty of Theology, did great educational work in Lahij and Jalil Babayev at the Basgal village school of Ismayilli district of Azerbaijan. It can be noted that the author of the one-act play "Unwilling Marriage" staged in Irevan on April 4, 1890, was Abbas Rizayev, a student of the Irevan Seminary. As a result of research, it was found that 63 Azerbaijanis graduated from Iravan Teachers' Seminary in 1881-1914, and 22 in 1915.
Hasan Bey Gaziyev was one of the leading graduates of the Irevan Teachers' Seminary. He was born in 1879 in Irevan. After graduating from the Irevan Teachers' Seminary in 1896, he taught Russian at the Ulukhanli school, and until 1918 he taught Russian at various national schools in Irevan. Hasan Bey was also a member of the religious community of Muslims in Iravan province. He settled in Nakhchivan during the massacres of Armenian bandits in 1918 and he taught Russian in various schools. Our respected teacher Hasan Bey Gaziyev dedicated a large part of his life to the development of our national education. He was buried in Nakhchivan in 1950 [8].
Ali Azim Ibrahimov occupies an important place among the graduates of the Irevan Teachers' Seminary. He was born in Aghdam in 1894 and worked here for a long time in the field of public

education. After graduating from theological school in 1914, A. Ibrahimov joined the revolutionary movement and became one of its activists. In 1914-1916, he worked as a teacher in the village of Big Vedi. At the beginning of 1916, he settled in Aghdam province and taught Russian there.

Ibrahim Safi, one of the famous artists of Turkey, also graduated from the Irevan Teachers' Seminary. After the Second World War, he settled in Turkey and lived there until the end of his life. In general, the graduates of the Azerbaijan section of the Irevan Teacher's Seminary and Gymnasium in the "Red Tabor" created by Abbasgulu bey Shadlinski made great contributions to the education of the people of West Azerbaijan and the fight against Armenian chauvinists. It is also known from the research that most of those who were oppressed in 1937 were graduates of Irevan Teacher's Seminary and Irevan Gymnasium, as well as secular schools there.

During the mass massacres committed Armenians against Azerbaijanis in 1918, the centers of education and culture, which paved the way for the national renaissance mentioned above, ceased their activities. Some of the Azerbaijani teachers, students and intellectuals working in these cultural and educational institutions were brutally murdered during these events, and some had to leave history and their homeland to avoid being brutally murdered.

At the end of November 1920, with the establishment of the Soviet power in Armenia, the attitude to the problem of school and education changed in this area as well as in other republics. On December 6, 1920, the Armenian Revolutionary Committee signed a decree on the transfer of all schools to the state and education in the mother tongue. In the middle of December 1921, by the order of the Armenian People's Commissariat of Education, old-style schools were canceled and new-style Soviet schools were started to be organized. According to the decree of ExMK dated April 23, 1921 regarding the organization of new type of schools, it was stated that Azerbaijanis living in the republic could study in their mother tongue.

Thus, one-year, two-year and private schools were abolished, the first steps were taken towards the organization of Azerbaijani schools in a new context. New type of schools were organized and started to operate. After the establishment of new-type schools, the expansion of the network of educational centers in our mother tongue in Irevan and in all regions inhabited by Azerbaijanis led to a rapid increase in the number of students studying there [6].

Influence of the Irevan Teachers' Seminary to Azerbaijani schools

One of the main reasons for the rapid increase in the number of Azerbaijani students is the part of our compatriots who left their homeland in 1918 to escape the cruelest killing methods as a result of the persecution of Armenian bandits. After the establishment of Soviet governer in Armenia in 1920, they returned to their homeland.

The expansion and management of the network of educational centers in our national language and the rapid increase in the number of students studying there have increased the need for pedagogical staff.

At the first congress of EK(b)P held on January 30, 1922, the idea of creating an educational center that prepares teaching staff for national schools was brought up by Azerbaijani intellectuals, but their demands were not taken into account.

However, the issue of solving the problem of teacher shortage in Azerbaijani schools remains on the agenda. At the Second Congress of the CP of Armenia held at the end of March 1923, the issue of training of teaching staff for Azerbaijani schools was brought up again, but it has not yet been resolved. At the congress, the commissioner of public education of Armenia and chauvinist circles A. Mravyan considered it more appropriate to invite academic staff from Azerbaijan in order to provide teaching staff to schools in the country. Chauvinist circles of Armenia used various means to prevent the preparation of local personnel for schools in Azerbaijan. Here, the most traitor goals of the Armenian bandits, who entered the Bolshevik veil, were to hinder the education, cultural development and future prospects of Azerbaijanis at any cost. In the middle of 1923, in order to provide Azerbaijani schools with pedagogical personnel, lecturers of various specialties were invited from Azerbaijan and sent to Irevan and the regions where Azerbaijanis live to perform pedagogical activities. The real Armenian character created unbearable conditions for teachers teaching in schools in Azerbaijan, so they had to leave Armenia because they could not bear the financial and moral difficulties [3].

Summer training course for two months was held in Irevan in November 1923 as a result of the efforts of Mehdi Kazimov, the head of the Department of Minorities established under the Ministry of Education and Culture in 1922. The need for teaching staff in Azerbaijani schools. More than 60 teachers were trained in Azerbaijani schools in this preparatory course. In addition, preparatory courses were held in Uluhanlı, Vedi, Basharkechar, Zangezur, Agbaba and various regions where Azerbaijanis live. Many pedagogues have gained qualifications by studying in such courses. These preparatory courses, held at the end of 1923, prepared 143 teachers, 6 of whom were women, by 1926. Bala Efendiyev, Mehdi Kazimov, Mustafa Huseynov and others, prominent representatives of Azerbaijan's socio-political, literary and cultural environment in Yerevan, played a role in organizing these courses.

Based on the approval of the Azerbaijan People's Commissariat of Education, 16 people from Irevan were sent to Baku in 1923, and 38 people were sent to many higher educational institutions for pedagogical training in order to partially eliminate the problem of teacher shortage. After graduating from the Azerbaijan Higher Pedagogical Institute, our young people like Tajira Baghirova and Zahra Abbasova returned to Yerevan and contributed to the development of education.

Despite all this, these measures could not meet the needs of teaching staff. In addition, the chauvinist circles of Armenia did not want to open an independent educational institution training teachers for the schools of Azerbaijan in the territory, they wanted to open an Azerbaijani department under the Armenian Pedagogical Technical College. Bala Efendiyev, head of the Minorities Department of the EC(b)PMK, Mehdi Kazimov, head of the "Minorities" office of the EC(b)PMK, Mustafa Huseynov, the editor-in-chief of the "Zengi" newspaper, and other zealous Azerbaijani intellectuals insisted, with serious efforts, political and national the will. The Yerevan Turkish Pedagogical Technical College, considered the successor of the Irevan Teacher's School, was opened on October 15, 1924 in front of Armenian chauvinist circles [4].

Thus, with the opening of the Iravan Turkish Pedagogical Technical College, the first step was taken in the field of organization of work in the direction of satisfying the need for pedagogical personnel in the schools of Azerbaijan. If we look at the first period of activity of the technical school, Mehdi Kazimov's Russian language teacher and director, Bala Efendiyev's community teacher, Asgar Asgarzade's mother tongue teacher, Jamil Aliyev's nature teacher, and Karim Maharramov work as technical assistant.

In 1925, this educational institution was named Iravan Turkish Pedagogical Technical College after Nariman Narimanov.

The research shows that the problems in all Azerbaijani schools in Irevan are also present in this technical school. This educational institution, which operated in the building of the Armenian

Pedagogical Technical College, consisted of a narrow classroom and two bedrooms for 30 students. It is known that in order for any educational institution to function harmoniously and normally, it must provide an independent structure, create a material and technical base, and have favorable conditions for the educational process. The newly created Iravan Turkish Pedagogical Technical College works in completely unbearable and unfavorable conditions, textbooks and teaching aids, lecture cabins, laboratories, educational programs, dormitory, canteen, etc. The lack of equipment definiely hindered the normal functioning of this educational institution.

The Armenian authorities, dressed in the "Bolshevik" skin, did not make any effort to eliminate the problems and shortcomings that existed not only in the technical school, but also in Azerbaijani schools. The discriminatory and biased policy of the Armenian chauvinists against the Azerbaijanis in every field has also manifested itself in the field of education. In the pedagogical technical school, books, training programs, teaching aids, etc. whereas the Armenian People's Commissariat of Education did not want to meet that demand, while there was a great need for its provisions. According to the decision of the Armenian People's Commissioner of Education, Ashot Hovanesyan in the middle of December 1920, education should be in the mother language, schools should be functioned under the state, and new Soviet-type schools should be created free of charge. In 1925, 25 students were enrolled in that preparation course, and after graduation in 1926, they began teaching according to their branch.

While the Dashnak government of Soviet Armenia provided the Armenian Pedagogical Technical College with a separate building and showed great care and attention, the Turkish Pedagogical Technical College was deprived of these cares. If that discriminatory policy showed that the "Soviet government" in Armenia had its own characteristics, on the other hand, it was manifested by the fact that the Armenian communists acted according to completely different principles in words and deeds. Because, unlike other republics, there were two sides of party life, national politics and social environment in Armenia: the first - visible, the second - invisible. The visible side was the "implementation of the ideas of Bolshevism", "proletarian internationalism", and the invisible side was the anti-Turkish and chauvinist policies carried out secretly by the official leadership of Armenia.

As mentioned, one of the insidious goals of the Armenian chauvinists, who tried to prevent the development of our national education in every possible way, was to lay the foundation for the end of the Turkish pedagogical technical school in the future.

However, despite all these difficulties and serious obstacles, strengthening the newly created technical school, revitalizing its activities, creating a teacher-student union, organizing education, etc. were the most important issues facing our hard-working intellectuals. These intellectuals include B. Efendiyev, director of the "Minorities Department", M. Kazimov, director of the technical school, M. Huseynov, editor-in-chief of "Zengi" newspaper, and others.

If we look at the first period of the activity of the technical school, the organization of the pedagogical team, teaching, etc. some progress has been made in these areas. In a short time, intellectuals such as Asgar Asgarzade, Ismayil Babayev, Ashraf Bayramov, Muhammad Azimzade, Miryusif Mirbabayev, Bulbul Kazimova began to gather around this educational center [5]. It should be noted that the world-renowned academician and scientist Yusif Mammadaliyev started his career in this technical school. During the years 1926-27, he taught biology and chemistry at the educational institution. At that time, an important pedagogue, Latif Huseynzade, was teaching at the technical school for a while.

It should be noted that the Turkish Pedagogical Technical College played a great role not only as an educational institution, but also in the development and formation of Azerbaijani literature, culture and art in Yerevan.

Mass genocide of Azerbaijanis committed by Armenians in 1918-20 led to the decline of Irevan's literary and cultural environment. One of the prominent representatives of the literary and cultural circle was destroyed, and some of them went to Turkey, Iran, Central Asia, Azerbaijan and other countries to avoid being mercilessly killed. With that, since there are no intellectuals of the older generation left in Irevan, the relations between the predecessors and the followers have been completely broken. Undoubtedly, all of these could not affect the creative potential of the Irevan literary school.

After the revolution, the students and teachers of the Turkish Pedagogical Technical College provided exceptional services in the revival, development and formation of the eternal cultural environment of Azerbaijan in Irevan. Thus, the teaching and student staff of the technical school had a great role in promoting and promoting the newspaper "Zengi" (1924), which was the only printing house in Irevan in the Azerbaijani language, and in increasing its circulation. the introduction of the new Turkish alphabet and the eradication of illiteracy. Active supporters and reporters of "Zengi" newspaper were teachers and students of this educational institution. Mehdi Bashirov, Taghi Jamalov, Rustam Taghiyev, Telman Nazarli, Nariman Fakhri, Gasim Aliyev, Yunis Taghiyev, Abbas Tahir, Aligulu Salimov, Abulfat Rahimov, Abilfat Ibrahim, Musa Gafarov, Adil Akhundov, Shamoyev Hatamov, Nurali Gurbanov, Nazar Pashayev, etc. They were the most active reporters in "Zengi" newspaper.

In the revival and expansion of this educational institution, the Azerbaijani branch, which was organized under the Society of Proletarian Writers of Armenia in 1927, rendered a great service.

The first graduation of the technical school became in June of 1929. In 1926, 20 of the 32 students (18 boys and 2 girls), were able to graduate from the technical school. Due to the information given by the sources, it is understood that 3 of the students died of a serious and infectious disease while studying, and 9 had to leave the technical school, interrupting their studies for various reasons.

Among the first alumni are Amir Abasguluyev, Adil Akhundov, Nariman Aliyev, Pasha Makinski, Abulfat Ibrahim, Imangulu Karimov, Nariman Fakhri, Rubaba Baghirbeyova, Nasir Aliyev, Musa Gafarov, Abulfat Rahimov, Taghi Bagirov, Nazar Pashayev, Mirza Bashirov.

Professors such as Nariman Aliyev, Zarifa Budagova, Budaq Budaqov, Yusif Yusifov, Farhad Farhadov, Nazəar Pashayev, Suleyman Mammadov, Ali Farajov, Gurban Bayramov, Abbas Ismayilov, Jafar Jafarov, Hamid Aliyev, Khadim Maharramov, Gasim Mustafayev, Sabir Safarov, Hamid Efendiyev, Abbas Tahir, Nariman Kazimov, Jabbar Guliyev, Zahra Aliyeva, Nariman Yusifov, Kovsar Tarverdiyeva, Gasham Aslanov, Habib Hasanov , Tapdig Amiraslanov, Mammadali Maharramov, Jumayil Mardanov, honored teacher Shafiga Maharramova and others were graduated from this school [9].

Despite all this, the introduction of general compulsory education in 1930 was an impetus for the rapid growth of the number of both schools and all students studying there. Thus, in the academic year of 1922-23, there were 36 Azerbaijani schools operating in Western Azerbaijan, 62 in 1924, 112 in 1929-1930, and a total of 245 in 1931. 45 of them were discovered in Iravan region. The management of these schools and the provision of teaching staff were among the most important issues of the day. Because the pedagogical technical school, which graduates 20-30 people per year, could not fully meet the demand for teachers of our national schools. Due to the lack of teachers, many schools in the regions had to rely on those studying in two-month and three-month preparatory courses. Due to the lack of teaching staff, the students of the pedagogical technical school worked alternately as teachers in the 1st grade Turkish schools operating in Irevan, in the village house and in the women's club. Even graduates of the 9-year Turkish school inIrevan were sent to work as teachers in order to partially eliminate the need for teaching staff in Azerbaijani schools.

However, despite all of these, despite the great demand for teaching staff in Azerbaijani schools, hundreds of Azerbaijani teachers and students are called as "bey (mister)", "khan", "mulkadar" (landlord), "gölkomak", "kulek (wind)", "khurafatchi (superstition)". They were stigmatized (marked) and expelled from educational institutions. The students of the Technical College Faramaz Kazimbayov, Mikayil Aliyev, Alakbar Hasanzadeh, Khalil Afendiyev, Tarifa Ismikhanova, Farhad Asgarov, Muhammad Rzayev, Ali Khalilov, Akbar Jabbar Haji Hasanoghlu, Maharram Khalilov, Anvar Gaziyev, Gadimali Valiyev called for an investigation. Azerbaijani intellectuals were undergone not only to oppression, but also to physical terror.

Thus, despite all the difficulties and obstacles it faced in the context of Armenian chauvinism, the Turkish Pedagogical Technical College has strengthened its position in the education system with its achievements. This technical school has achieved great success at the secondary school level in the South Caucasus. In 1934, the Iravan Turkish Pedagogical College took first place in the All-Union technical school competition and received a cash prize of 7,000 manats.

In 1934, coryphaeus such as Muzaffar Nasirli, Nasib Efendiyev, Nazar Pashayev, Abbas Azeri, Zahra Abbasova, Tajira Bagirova, Kerem Abbasov, Mammad Hasanov taught at the pedagogical technical school. The presence of highly trained teachers in the technical school led to an increase in the quality of teaching. In 1935, a delegation consisting of Mammad Said Ordubadi, Mehdi Huseyn, Mikayil Mushfig and others met with the teachers and students of the Pedagogical Technical College during their visit to Irevan.

In general, important prominent intellectuals of Azerbaijan - Ali Nazim, Jalil Mammadguluzade, Yusif Vazir Chamanzaminli, Mir Jalal, Samad Vurgun, Sabit Rahman, Abulhasan, Mikayil Rafili, Nigar Rafibeyli, Suleyman Rustam, Vali Huluflu and others were guests of this educational center. Irevan Azerbaijan Pedagogical School has trained 1,370 secondary-educated pedagogical personnel from the days of its establishment to the middle of 1947.

If you follow the activities of the pedagogical school, it becomes clear that this educational institution was headed by Bahlul Yusifov, Mehdi Kazimov, Asgar Jafarov, Habib Mahammadzade and Mammad Hasanov, Eyyub Babayev, Raziya Ismayilova, Sadig Heydarzade, Zarri. Thanks to the selfless work of the teachers of the school Gurbanova, Tavakkul Karimov, Habib Akbarov, Huseyn Aliyev, Jafar Alakbarov, Shura Farhadova, Sura Babayeva, Raziya Abdullayeva and others, the high level of education of the students was achieved [8].

The Iravan Turkish Pedagogical School, which operated until 1949, played a great role not only as an educational institution, but also in the formation, development and preservation of our culture, literature, and art in Western Azerbaijan. As a result of the insidious policy of the Armenian bandits under the guise of Bolsheviks, this educational institution, which has passed a great and glorious history and is one of the most glorious pages of our educational history, was subjected to mass deportations and handed over to the people. In 1949, the Khanlar region of Azerbaijan operated here until 1972.

President Ilham Aliyev visited various regions in connection with the 125th anniversary of the establishment of the Irevan Azerbaijan Drama Theater on 30 August of 2006 and the 125th anniversary of the Uluhanli school of Irevan district on 29 December. On December 29, 2021, he signed an Order on the celebration of the 140th anniversary of the Irevan Teachers' Seminary [10]. This seminary will encourage the further study, research and promotion of a glorious page in the history of education. His opinions about Irevan, Zangezur, Goycha and other ancient places of our homeland are irrefutable. Special facts announced by him about our historical place names, "No Ararat - Zangibasar", "Not Gegarkunik but Goycha", "Not Yeraskh but Arazdeyan", "Not Vardenis but Basarkecher", "Not Tavush but Dilijan", "Not Syunik but Zangezur", "Not Lori but Dag Borchali", "Not Vayochdzor but Derelayaz" once again confirm the undeniable and irrefutable facts. We must never forget our history, national and moral values.

Conclusion

Irevan, the ancient land of Azerbaijan, which is one of the glorious pages of our educational history, the study of the history of the Teachers' School founded 141 years ago, conferences, round tables and a series of events will continue to be held in this regard. The legacy of this great source of information, which made great contributions to the development of our national education and opened bright pages in our educational history, will continue to shine hundreds of years later. Irevan Teachers' Seminary, which has been operating for 37 years, has played an important role in the development of the educational environment in Azerbaijan, including fulfilling its historical mission and creating a new stage.

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IMPACT OF INVESTMENT ON THE FORMATION OF HUMAN CAPITAL

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ABSTRACT

The article considers one of the important provisions of the theory of human capital, since it makes up a large part of the welfare of society. In modern conditions, the effectiveness of the development of the state's economy largely depends on human capital, which is the most important component of modern productive capital, which is represented by a rich stock of knowledge inherent in man and creative potential. It is noted that investment is the most important prerequisite for the production of human capital and has a number of features that distinguish them from other types of investment. Based on the analysis, a structure was compiled, and a formula was proposed for evaluating the effectiveness of investments in human capital.
Keywords: human capital, investment, formation, education, conditions, structure, information, accumulation.

Introduction

According to the World Bank, investment in human capital gives a return of 5-6 times more than material production, that only 15-16% of economic growth is due to physical capital, about 20% to natural capital, and 65% is mainly due to human and social capital. It was also noted here that our business has now begun to understand more and more that investments in human development are the most profitable. People are the main strategic resource of social and economic development. Therefore, it is necessary to consider human capital as the most important independent value, and not as auxiliary means for increasing profits and profitability. So far, despite the fact that it is constantly declared both here and abroad that the concept of sustainable development of human potential is replacing theories of economic growth, practically nothing has changed in essence.

One of the important provisions of the theory of human capital is that its increase is among the main causes of economic development, since human capital makes up a large part of the welfare of society. In modern conditions, the effectiveness of the development of the state's economy largely depends on how much money it invests in human capital, which is the most important component of modern productive capital, which is represented by a rich stock of knowledge characteristic of a person, developed abilities, determined by intellectual and creative potential. The main factor in the existence, development and increase in the value of human capital is investment. Investment in human capital refers to any measure taken to increase productivity. All types of costs that can be assessed in monetary or other form and which are expedient, and also contribute to the growth in the future of earnings (income) of a person, are considered as investments in human capital.

K. Macconnell and S. Brew give the following definition - “Investment in human capital is any action that improves the skills and abilities, and thereby the productivity of workers. Expenditures that increase one's productivity can be seen as an investment, because current expenditures, or

costs, are carried out with the expectation that these costs will be compensated many times over by an increased income stream in the future. They distinguish three types of investment in human capital:
- expenditures on education, including general and special, formal and non-formal, on-the-job training;
- health care costs, consisting of the costs of disease prevention, medical care, dietary nutrition, improvement of living conditions;
- mobility costs, which move workers from places of relatively low productivity to places of relatively high productivity [1].

J. Kendrick's approach to the classification of investments in human capital is distinctive. He divided all types of investments into the following categories: material, embodied in people; material, not embodied in people; immaterial, embodied in people. He divides investments in human capital into tangible and intangible ones. The former include all the costs necessary for the physical formation and development of a person (mainly the costs of giving birth and raising children). To the second - the accumulated costs of general education and special training, part of the accumulated costs of health care and the movement of labor. A feature of intangible investments is that, despite their "intangible" nature, these costs, multiplying the knowledge and experience of people, contribute to the growth of the productivity of capital embodied in people [4].

Features of investment in human capital

Investment is the most important prerequisite for the production of human capital, but not yet its production itself, which is carried out in the process of activity, where the owner of this capital is either an object, or a subject, or the result of an impact. Human capital is created both in the public sector of the economy through the market mechanism, and in the personal one in the sense that the costs of labor and efforts for self-development and self-improvement play a decisive role in this process. But these costs are then inevitably included in social costs in the entire reproductive process, because the accumulated stock of knowledge, skills and other productive qualities of a person can be realized and can be evaluated only in society through the vigorous activity of their owner. Investments in human capital have a number of features that distinguish them from other types of investments.

1. The return on investment in human capital directly depends on the life span of its carrier (on the length of the working period). The earlier investments are made in a person, the faster they begin to give returns. But you need to keep in mind that higher quality and longer-term investments bring a higher and longer-term effect.
2. Human capital is not only subject to physical and moral wear and tear, but also capable of accumulating and multiplying. Depreciation of human capital is determined, firstly, by the degree of natural depreciation (aging) of the human body and its inherent psychophysiological functions, and secondly, by the degree of moral (economic) depreciation due to obsolescence of knowledge or changes in the value of the education received. The accumulation of human capital is carried out in the process of periodic retraining of an employee and the accumulation of production experience. If this process is carried out continuously, then as human capital is used, its qualitative and quantitative (quality, volume, value) characteristics improve and increase.
3. As human capital accumulates, its profitability rises to a certain limit, limited by the upper limit of active labor activity (active working age), and then sharply decreases.

4. In the formation of human capital, there is a "mutual multiplier effect". Its essence lies in the fact that in the process of learning, the characteristics and abilities of not only the student, but also the one who teaches improve and increase, which subsequently leads to an increase in the earnings of both the first and second.
5. Not all investments in a person can be recognized as investments in human capital, but only those that are socially expedient and economically necessary. For example, the costs associated with criminal activity are not investments in human capital, since they are socially inappropriate and harmful to society.
6. The nature and types of investments in people are determined by historical, national, cultural characteristics and traditions. Thus, the level of education and the choice of profession by children largely depend on family traditions and the level of education of their parents.
7. Compared to investments in various other forms of capital, investments in human capital are the most beneficial both from the point of view of the individual and from the point of view of the whole society [2,6].

In the conditions of an innovative economy, when scientific knowledge and information are the basis for the production of competitive products, investments in the development of human capital are of paramount importance. It should be borne in mind that with proper management, the maximum amount of return on investment in human capital is almost three times the return on investment in technology. A study of the dependence of labor productivity on education showed that with a ten percent increase in the level of education, productivity increases by 8.6%. With the same increase in share capital, productivity increases by 3-4%.

The reproduction of human capital requires significant costs and various types of resources both from the side of the individual and from the side of society (state institutions, private firms, families, etc.). Emphasizing the similarity of such costs with investments of other types of capital, economists refer to them as investments in human capital. The sources of investment in human capital are the costs of employers, state budget expenditures, and individual expenditures of citizens.

Investing in human capital implies for the employee - increasing the level of income, job satisfaction, improving working conditions, increasing self-esteem, improving the quality of life. For the employer, this is an increase in labor productivity, a reduction in the loss of working time and an increase in production efficiency, which ultimately contributes to an increase in the competitiveness of the company. For the state, this is an increase in the well-being of citizens, an increase in gross income, and an increase in the economic activity of citizens [3].

Making investments is a very important process in the reproduction of human capital, in which it acts either as an object, or as a subject, or as the result of an impact. Thus, investments only create the basis for the production of human capital in the system of education, healthcare, advanced training, economic motivation, geographic mobility, etc. Their content is not just an investment, but also a real, conscious and purposeful activity of the investor. At the same time, an important role in the creation of human capital is played by the costs of labor and efforts for self-development and self-improvement. The costs incurred are inevitably included in the social costs in the entire reproduction process [5,7].

The structure of investments in human capital: includes the following types of investments (Figure 1):

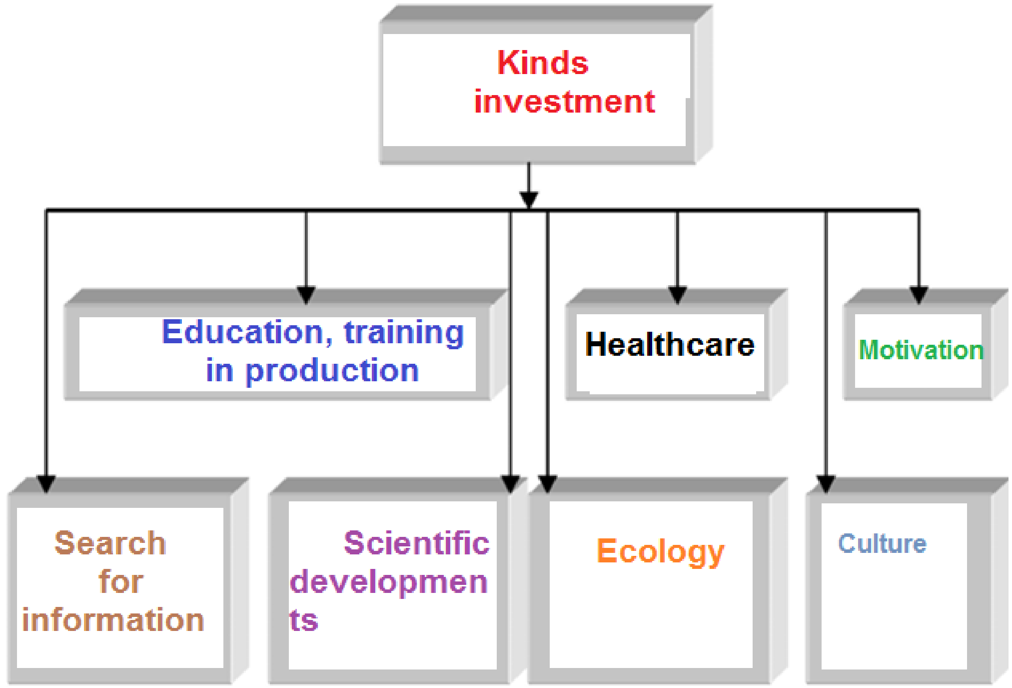

Figure 1. Types of investment in human capital

As can be seen from the figure, education and training at work increase the level of human knowledge, and, consequently, increase the volume and quality of human capital. Investments in education are usually divided into formal and informal according to their content. Formal investments are getting secondary, specialized and higher education, as well as getting a second education, vocational training at work, various courses, training in a magistracy, graduate school, doctoral studies, etc. Informal ones are self-education of an individual; this type includes reading developing literature, improving in various forms of art.

With an increase in the level of education, the efficiency of the worker's work is increased either by increasing labor productivity, or by obtaining knowledge that makes the worker capable of carrying out such work activities, the results of which are of great value.

The accumulation of human capital implies not so much an increase in the volume of knowledge as the development of skills in applying this knowledge, awareness of one's importance and one's place in society, and the ability to adapt to changing conditions in one's favor.

In developed countries, vocational training is of particular importance, serving as a mechanism by which a person who comes to an enterprise can become better acquainted with his work, learn more about the enterprise in production and retraining courses that provide employees with the opportunity to acquire knowledge in new promising areas within the framework of existing specialty [6].

During training, a person is often deprived of the opportunity to receive a normal income, limited in free time, the employee agrees to a reduction in income for the duration of vocational training. These lost earnings are called lost opportunities and amount to significant amounts. Studying is seen as a distraction of the labor force from the sphere of economic activity.

Of all types of investments, along with education, the most important are investments in human health, since health protection really prolongs a person's life, and, consequently, the time of functioning of human capital.

Research results show that human health depends on health care by only 8-10%, environmental conditions by another 20%, genetic factors determine another 20%, and human health by 50% depends on the lifestyle of the person himself (rational daily regimen). , the use of various methods for the fastest recovery and stimulation of working capacity, the hygiene of rational nutrition, getting rid of bad habits and excess weight, the formation of a beautiful figure), the prevention and elimination of stress, the use of various sets of physical exercises, traditional and unusual hardening methods, various types of massage, etc.

The main factors of degradation of human capital that have a direct impact on the health of the population include: deterioration in the health of the population, self-destructive behavior (alcoholism, smoking, drug addiction), a reduction in the consumption of medical services due to an increase in the number of paid services and a decrease in the quality of free medical care, deterioration of social conditions life.

Along with the ability to work (health and qualifications), the structure of the human capital of any employee also implies the presence of a desire to work. In this regard, as a component of investment in human capital, it is necessary to consider the costs associated with employee motivation to improve the quality of their work. The results of foreign studies indicate an increase in the importance of internal incentives (the possibility of self-realization, satisfaction with the work in which the employee is engaged, a sense of one's own success, etc.) in comparison with external ones, especially for highly qualified personnel.

The search for information contributes to the movement of labor to areas and industries where labor is better paid, i.e. where the price of human capital services is higher.

Today, it is important to include expenditures on fundamental scientific developments as investments in human capital. In the process of development of science, not only intellectual innovations are created, on the basis of which new production technologies and ways of consumption are then formed, but also the transformation of people themselves as economic entities, which act as carriers of new abilities and needs. In the information society, science turns into a kind of generator of "human capital" [8].

Culture (including religious culture) leaves its mark on the process of reproduction of human capital, affecting primarily its psychological component. In culture, the experience of generations is concentrated, knowledge, skills, abilities are preserved and do not disappear with the death of a particular person, built-in regulators of relations between people and structures for the application of labor efforts are formed and developed. The cultural level of citizens largely determines the economic achievements of society, its socio-political, ideological, educational, spiritual and moral structure.

The main problem that modern enterprises have to face is the assessment of the effectiveness of investments in human capital. There are various approaches to its solution.

So Fitzenz J., conducting research, as the simplest calculation of the return on investment in human capital, divided income by the number of employees. It was the first indicator to appear in the Human Resources Effectiveness Report in 1985. He also proposed a return on investment in human capital. Return on investment in human capital is determined by the formula:

$$K_{oi} = \frac{Re - (Ex - \lfloor P + Be \rfloor)}{P + Be}, \quad (1)$$

where Koi is the payback ratio of investments in human capital.,Re-re venue.,Ex – expenses.,P-pay.,Be -benefits.

One of the indicators of the economic efficiency of human capital is the level of intellectuality of production. After the procedure for determining the costs of education and the benefits from its receipt, the benefits are compared with the costs, reduced to one point in time by discounting. The difference between the discounted benefits and costs gives the net present value of acquiring education, which is calculated using the formula:

$$NPV = \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} - \sum_{t=1}^{n} \frac{C_t}{(1+i)^t}, \quad (2)$$

where NPV - net present value; Bt - income from education at time t; Ct - training costs at time t; n - is the number of time periods; i - rate of interest.

Here it is necessary to take into account the fact that the value of the present value of lifetime earnings depends very much on the chosen discount factor (norm). The selection of the desired discount rate is a rather laborious process.

There are various methods for calculating the rate of return on education. The most commonly used method is to calculate the corresponding net benefits for each time period from 0 to n, and then select a discount rate at which the total discounted net benefits become zero. This rate of discount is called the internal rate of return. Another method for estimating the rate of return is based on the analysis of statistical relationships between the level of an employee's earnings and his level of education.

G. Psacharopoulos provides data on the dynamics of social return on investment in education in terms of per capita incomes of countries. In most of the poorest developing countries with low per capita income, the social return of primary education is 23%, secondary 15%, and tertiary 11%. In the most developed countries of the world with a high level of income (OECD), the social return of primary education is 14%, secondary - 10%, higher - 8%. It should be noted that when developing state policy in the field of education, a number of government structures in these countries are beginning to use explicit or estimated discount rates that are below 8% when evaluating projects in the field of public education.

Studies that compared academic, or general, and technical, or vocational, secondary education showed that, on average, the return of the first 16%, and the second - 11%. And here the decisive factor is the cost: vocational training is more expensive than general academic education.

From the point of view of T. G. Myasoedova, when investing in human capital, it is necessary to take into account that each of the components of human capital is of a probabilistic nature and depends on many factors. Some components of human capital can be considered as independent quantities, and some - as conditionally dependent. For example, the presence of good or bad natural abilities does not change the likelihood of good or bad health, the presence of certain knowledge, good or bad motivation for continuous development or productive work. The presence of professional knowledge may increase the likelihood of a high motivation to work, but (in the absence of a high general culture) may not have any effect on it.

Investments in human capital and knowledge capital bring economic and non-economic benefits to the individual, organization, and society. Economic benefits are expressed in the form of wage increases, labor productivity or economic growth, while non-economic benefits are expressed in increased social cohesion, reduced crime, improved health and quality of life, and improved environment. Investments in intellectual capital and knowledge capital contribute to the growth of social capital, which is manifested in increased trust, development and observance of moral and legal norms, as well as understanding and respect for different cultural traditions.

Many world leaders of the modern economy have already realized the importance and balance of investments in human capital, their benefits for their own growth and prosperity. The world-famous DuPont company has proclaimed four key strategic directions for development:

• 1. investment in their employees.

• 2. wide presence of the company in the business and industrial circles of the countries where the company's production facilities are located.

• 3. large-scale research and development in various areas of the company's activities.

• 4. Commitment to high ethical standards, labor protection, safety, environmental protection.

The French company Unilever believes that one of the most effective ways to support sustainable development is socially conscious and responsible business conduct, health care and investment in the development of its employees, and environmental protection.

Thus, the leading firms of all countries make the main bet on human capital, considering it the basis of technological, managerial, and financial innovations generated by human creative abilities.

The result

Investment-being and sustainable development of any nation depends on human capital, therefore, a well-thought-out and consistent policy in the field of human resource development and balanced investment in human capital is needed, both at the level of an individual company and at the state level as a whole.

2. Cultural and moral capital is also an important indicator of the quality of human capital. A high production culture of human resources is also necessary in the development of a modern economy, like qualifications and intelligence. Business ethics and a professional code of honor create an optimal moral and psychological climate in the team, increase the level of labor productivity and income of enterprises.

3. In order to increase the rate of growth in the level of employment and real money income of the population of Azerbaijan, special attention should be paid to the sphere of education and training of qualified labor force, when at the present stage this sphere is in a crisis state. The resolution of these problems, as well as the increase in the availability of education for talented young people from low-income families, the increase in the level of education of the population as a whole, is impossible without the following fundamental measures:

- increasing wages for employees of educational institutions, which will increase the prestige of the teaching profession and the level of teaching disciplines in educational institutions.

- availability of education for all social strata of the population, benefits for the most capable youth, on which the future of Russian science depends.

- it is necessary to provide young people with conditions for obtaining education, without being distracted by earnings in the learning process, which significantly reduces the quality of the acquired material, it is necessary to introduce benefits for students who have shown success in learning at least up to the subsistence level.

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RESEARCH AND EVALUATION OF DETERMINING FACTORS OF SUSTAINABLE DEVELOPMENT OF INDUSTRIAL ENTERPRISES

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ABSTRACT

The article considers the sustainable development of enterprises as the most important factor in the functioning of an organization in the modern world. It is noted that the effectiveness of the formation of sustainable development lies not only in the positive dynamics of indicators and compliance with certain standards, but in the adaptation of an enterprise to changes in the economy of the world and the state.

The factors that determine the sustainable development of industrial enterprises, the indicative definition of innovative activity in the regulatory economic literature in strategic and tactical terms, foreign and domestic experience in the framework of the concept of sustainable development of industrial enterprises have been studied and evaluated. The goals of conducting innovative processes at enterprises, the factors influencing the increase in innovative potential and the efficiency of enterprises are analyzed. Here, indicators are established that characterize the main provisions of the balanced scorecard system, the system of interaction between environments that ensure sustainable development, and the classification models of the principles of sustainable development of an enterprise.

Keywords: sustainable development, scientific and industrial interaction, innovations, socio-economic development, strategy, concept, factor, analysis, environment.

Introduction

The concept of sustainable development is defined as a set of measures aimed at meeting current human needs while preserving the environment and resources, that is, without compromising the ability of future generations to meet their own needs. Quite often, this concept is used with an emphasis on environmental aspects, but it is also based on other components. Since 2002, the term has evolved to include social justice and poverty alleviation as key principles of sustainable development. The realization of sustainable development is currently described as being possible when three main components are in balance: economic growth, social responsibility and environmental balance.

Sustainable enterprise development from a strategic perspective is now highlighted as a priority in the United Nations vision papers "The Future We Want" (2012), "2030 Agenda for Sustainable Development" and "Paris Climate Agreement" (2015) . One of its goals for 2030 is to build sustainable infrastructure, promote inclusive and sustainable industrialization, and spur innovation. In turn, innovative development is inextricably linked with the creation and registration of objects of intellectual activity, which act as a target indicator of the level of development of science and technology. Such objects are a kind of link between theoretical research and their commercial implementation. At the same time, the emphasis in managing the competitiveness of countries is shifting to the smart specialization of individual regions [1]. Such a concentration of resources and abilities of each individual industrial entity at a certain stage of creating the value of the final product or service, part of the business process, determines the increasing role of interaction between them as macro units, as well as individual business units at the meso level. The sale of products or services, in particular innovative ones, becomes not only inefficient, but practically impossible without the participation of other business entities. This determines the relevance and significance of the issues of choosing partners for interaction, its forms, tools and methods of implementation. Cooperative networking and integration are also emphasized as a strategic priority for the sustainable development of socio-economic systems.

The innovative development of the economy should remain the main direction of the economic policy of the state and administrative bodies, including enterprises. In many programs adopted by Azerbaijan, it is mentioned the need to choose an innovative economic development path of the country's economy and to prepare and implement serious measures in this direction. In the modern global economic system, there is no alternative to the innovative development path at the scale of the world and national economy.

In order to achieve the development of the country's economy, to become a competitive state, it is necessary to achieve innovative development in the fields of production and services.

In order for the innovation process to take place, it is necessary to involve various resources in the production activity. These resources mainly consist of the expenses incurred in connection with the adoption of the production of newly designed or improved types of products, their application to production and ensuring their mass production. Although these resources are directed to different directions of innovative activity in our country, there are large discrepancies between the predicted and obtained results.

Innovations realize socio-economic functions in the activities of enterprises. Innovation as an economic category performs two important functions. These functions include reproduction and stimulation functions. According to the reproduction function of innovation, it acts as an important source of financing to maintain the stability of the broad reproduction process. The financial resources formed from the application of innovations or sales to external enterprises act as the main source of profit formation for the investor, the entrepreneur who applies the innovation.

There are different approaches to sustainability, but they all boil down to two aspects: the existence of sustainability potential and ensuring the effective use of this potential. The sustainability potential, which can ensure the restoration of a stable state, is created on the basis of modern innovative production. Therefore, many researchers consider sustainability potential and innovation potential to be the same. However, to create this potential, the enterprise needs a significant amount of financial and other resources. These costs are enough to disrupt the stability of the enterprise. In addition, a certain period of time is required for the introduction of innovation, but during this period, sustainability may be disturbed.

Therefore, in the analysis of innovative development and sustainability, it is important to consider all its characteristics and their interrelationships.

Research and evaluation of the factors that determine the sustainable development of industrial enterprises: In conventional economic literature, innovation activity as a category is defined mainly by two groups of indicators that define it in strategic and tactical terms.

Strategic plan indicators include:

- the quality of the innovative strategy of competition;
- level of mobilization of innovation potential;

- the level of involved capital investment, investment investment;
- the method used in innovative changes, the level of "culture";
- the importance of the level of activity realized.

The tactical plan indicators consist of the following:

- the appropriateness of the enterprise's response to the nature of the strategic competitive situation;
- speed of innovation changes.

Each of these indicators is defined by a number of parameters. But all certain uncertainty is characteristic of these indicators, and their treatment is also ambiguous. In order for industrial enterprises to have a stable operation, it is necessary to support the stability of its structure, as well as the stability of all its elements [2].

One of the main reasons for the disruption of the stability of the enterprise's activity is the uncertainty of the external environment, and the following are factors of the external environment in connection with it [3]:

- economic-political;
- socio-political;
- loan capital market;
- sales market;
- enterprise-competitors;
- purchase market of raw materials and materials;
- condition of supporting areas;
- labor market;
- scientific and technical progress;
- new technology market;
- environmental requirements;
- other factors.

Analogous factors were considered in the joint scientific articles of A.A. Majajikhov and E.R. Miskhojev entitled "Dynamic normative model of diagnostics of economic stability of industrial enterprises"[4]. The article presents their model for the external and internal environment of the enterprise. The temporal dynamics of the system is characterized by its transition from an equilibrium state to an unbalanced state, its spatial dynamics is realized by the violation of structural stability. At this time, the balance and stability of the complex dynamic system are interrelated from the system technical and synergistic point of view.

The goal of carrying out innovation processes is, of course, to increase the innovation potential and efficiency of industrial enterprises.

In order to increase the efficiency of the activity and achieve sustainable development, it is necessary to control the processes in this field, study and analyze the experience of other enterprises and draw conclusions.

It should be taken into account that if enterprises are to feel and see changes in the external environment in advance, sometimes to stimulate it, strategic management aimed at creating a future competitive advantage is carried out. In practice, there are those who value such innovations as preventive innovations.

In accordance with the strategic goals of industrial enterprises, new types of products and services are constantly developed and applied. According to data from economic literature and scientific sources, an average increase of up to 10% in the number of new products and services leads to an increase in the growth rate of gross profit by 25%. There are certain important factors for the formation of strategic goals of sustainable development of industrial enterprises, which act as an integral element in the formation of strategic goals. Formulation of strategic goals of sustainable development of industrial enterprises includes the following main issues: - improvement of financial flow management; - creating, in other words, creating new sources of financing for extensive reproduction; - increasing the technology and efficiency of special production; - orienting production to the active introduction of goods and services in domestic and foreign markets; - connection of the whole production-technological ring, not only individual enterprises, to the circulation of goods with the foreign market.

In general, sustainable development of industrial enterprises is possible with an innovative approach and a proper management mechanism. The concept of "control mechanism" is widely used in economic research.

According to M.I. Kruglov, the concept of "management mechanism" includes management goals: - quantitative analog of goals - management criteria; - management factors – factors of the management object affected by the interest of achieving the set goals and their relationships; - methods of influencing the given factors of management; - management resources – material and financial resources, social and organizational potential, using them, the chosen method of management is realized and achievement of the set goal is ensured. The management mechanism for each management object is formed from the above-mentioned elements [5]. According to him, the management mechanism consists of complex complex criteria, which combines a number of local mechanisms. These local mechanisms include:

- economic mechanisms;
- motivation mechanisms;
- organizational mechanisms;
- legal mechanisms;
- political mechanisms.

In forming the resilience management mechanism, it is necessary to take into account the presence of both positive and negative counter-relationships in this mechanism. Positive feedback allows the development of the system, while negative feedback does not allow the system to lose stability.

Each of the mentioned relationships have negative effects for development. Resilience pushed to its limit by negative feedback halts every developmental process.

The change in the stability state creates a dynamic cycle in the development of a complex system at each specific time, which characterizes this process.

Harmonic balance formed on the basis of positive and negative feedback forms dynamic stability, which allows the system to maintain its integrity and system characteristics on the one hand, and provides opportunities for development on the other hand.

Numerous quantitative and qualitative evaluation indicators are used in domestic and foreign economic practice.

Let's analyze some of these methods. The main difference in the methodology of evaluating the performance indicators of the enterprise is the arrangement of users into separate categories and the principle of direction.

In the 20s of the last century, more progressive enterprises began to use a system of interrelated indicators for the preparation of financial and economic reports.

A more well-known example of such a system is the Du Pont model. At that time, the reporting system had a precisely monitored interaction between the tasks of the enterprise and the indicators characterizing these tasks.
The direction of development according to one or another strategy is determined by the enterprise itself. In this case, the goal is the main driving force that motivates the enterprise for progressive development. The set of goals set is very hierarchical in nature and arranged according to the degree of importance.
Such a purposeful approach to the system of indicators is ultimately recognized as one-sided, but it occupies an important place in economic theory, because it complements other evaluation methods [6].
Most of the modern system of the main indicators of economic activity is based on a targeted approach. The difference lies in the methods used by the enterprise to achieve the set goals. In order to implement strategic management by the enterprise, a strategy realization mechanism is needed, which allows monitoring the results of production activities and the changes that occur.
Today, the most developed and widespread model is the "balanced GPS system" model [7].
As an example, let's analyze the "balanced GPS system" model. The original name of this theory is "Balanced Scorecard". This model was first published in 1992 by authors David Norton and Robert Kaplan in their Harvard Business Review article, The Balanced Scorecard – Measures That Drive Performance.
The system of balanced indicators optimally characterizes various aspects of the enterprise's activity, such as finance, marketing, production, etc. are complex measures that allow to manage the enterprise at a strategic level based on indicators based on quantitative and qualitative measurement of its work.
The main provisions of the system of balanced indicators can be characterized as follows:
1. In addition to financial indicators, there are also non-financial indicators.
2. The system of balanced indicators allows to turn the strategy into a set of interrelated indicators.
3. Indicators are balanced in four main directions:
- financial system;
- interaction with clients, relationship;
- internal business environment;
- formation of personnel capital.
4. The system evaluates the efficiency of the enterprise's activity both in the past and also in the future. For this purpose, indicators in the system are distinguished as lagging and leading.
5. There is a "cause-and-effect" relationship between indicators in the system, which is reflected in the "strategic map" of the enterprise.
6. For each division, its own strategic indicators are worked out.
7. The system consists of a limited set of indicators [8].
It should be noted that the system of balanced indicators allows to coordinate the strategic goals of the enterprise with the formation of a strategic map.
The presented and investigated system is widespread in economic practice and has been used in the United States, France, Germany, and India in various industry-related enterprises and in various forms of ownership, which proves its universality [9].
According to the opinion of experienced experts, Kaplan's "balanced indicator system" model is more acceptable among the above-mentioned models in the conditions of dead economic relations

in the country. Thus, this model allows to evaluate the activity of the enterprise on the basis of a much richer set of indicators.

The advantage of this model is that it has a complete description of its structure and practical use. This, in turn, fully characterizes the efficiency of the department and the enterprise as a whole.

The system of balanced indicators allows to connect the strategic goals of the enterprise with a set of interrelated indicators formed at different levels of management. This model is used in the economy of many countries of the world, in the fields of economy.

Today, the system of balanced indicators is used more often in foreign companies, which allows for a detailed study of the efficiency of the enterprise's activity.

The universality of the system of balanced indicators allows it to be used in various areas of the economy and social sphere, including even in power management, banking structures, insurance, telecommunications, energy, food and light industry, automotive industry and other similar areas. This system is still relevant in many countries of the world.

The widespread use of Kaplan and Norton's system of balanced indicators, a number of signs reflecting its superiority create a solid basis for the formulation of the evaluation methodology of sustainable development indicators of an economic object. In this regard, we use the Kaplan and Norton methodology during the research in the preparation of the system of important factors and the level of sustainable development. These stages can be described as follows:

1. Detailing the strategic perspective of the enterprise's activity.
2. Creation of a strategic map, more precisely, the interconnection of the goals of the strategy with "cause-effect" relationships.
3. Determining more important evaluated indicators and finding their target quantities.
4. Formation of the tool base - in other words, development of strategic processes and processes.

The conducted analyzes show that the studied model has a special potential for application in the country's economy. Thus, the system of balanced indicators is widely used in various field enterprises, it has a precise structure, and there is no need for adaptation for its application to the country's economy.

Unlike the previously mentioned models, the system of balanced indicators has a different feature, this system has been revised over the years, its defects have been eliminated and it has been adapted to the economy. Taking such factors into account, certain conclusions were reached:

1. Based on the conducted analysis, it was determined that the model that is effective for the country's economy is a system of balanced indicators.
2. The essence of the enterprise's system of balanced indicators is the need to evaluate its strategy in several perspectives, as well as to specify strategic goals and assess the level of their achievement.
3. The historical formation of the "Balanced Indicators System" model has undergone numerous revisions and changes, as we mentioned above.

Nevertheless, the essence of the system of balanced indicators has been preserved, especially the reconciliation of qualitative and quantitative indicators, which are one of the main factors-indicators that constitute the superiority of this system. The correct establishment of "cause-effect" relationships between the elements of the system allows the enterprise to rise to its optimal level of balanced development.

4. The main stages of determining the level of "sustainable development" based on the "balanced indicator system" of the enterprise are as follows:

- detailing the strategic perspective of the enterprise's activity;

- creating a strategic map;
- determination of more important evaluation indicators;
- formation of the evaluation tool base.

Assessment of the level of sustainable development is the most effective tool for managing the sustainable development of industrial enterprises, it creates a comprehensive picture of its situation. In order to more accurately analyze the current state of the industrial enterprise, it is considered necessary to evaluate its sustainable development and, at the same time, to prepare the future tactics of the enterprise.

It is necessary to evaluate the efficiency of the operation of the farm system and carry out meaningful and comprehensive indicators.

Directions for increasing the sustainability of industrial enterprises: Economic-mathematical models should be used to increase the stability of the activity of industrial enterprises, the processes occurring in the production system should be viewed comprehensively, and the self-regulation mechanism should be used.

At the modern stage of development of science and the world economy, there are a number of different mechanisms for the stability of development and management of enterprise activity, including in the conditions of innovative development.

Russian scientist A.B. Baranov has given a lot of space to these issues in his works. In his work, A.B. Baranov offers methods and tools for ensuring sustainable innovative development of industrial enterprises [10].

Formation of the economic mechanism in the innovative-investment process in the conditions of sustainable development of the enterprise was carried out by V.M. Bezdenezhnykh analyzed the modern problems of innovation, the problem of enterprise restructuring taking into account financial stability [11]. A.A. Jarov, as mentioned in the abstract of his dissertation work, suggests adding innovative activity to the basis of the sustainable development mechanism of the . The author expanded this concept and completed it with the concepts of "innovative efforts" and "innovative results".

Such an expression of this concept allows to expand the set of tools for evaluating real innovation processes in the enterprise and to identify pseudo-innovation projects in the future.

Evaluation of the level of innovative development of enterprises is possible by carrying out differentiation based on the use of the system of criteria proposed according to A.A. Jarov's methodology. At this time, such differentiation of enterprises is carried out step by step, that is, it is an iterative process [12].

A. V. Sargayev is also one of the scientists distinguished by his individual approach to innovation. Thus, considering innovation as a factor of economic stability for industrial enterprises, he specified economic categories such as "innovation", "innovative policy", "innovative climate" in his works [13].

However, concepts such as "innovative policy" and "innovative climate" are presented in a somewhat abstract and unspecified manner. So, in the analysis of innovation processes, specific innovation projects should be analyzed taking into account the resources and results.

E.A. Lyasovska's dissertation devoted to the management of the innovative development of enterprises in the abstract presented by the concept of risk sustainability, based on it, an attempt was made to manage the implementation of the innovation strategy in the conditions of an unstable and uncertain external environment .

In order to manage the stability of the enterprise in the implementation of the innovation strategy, it is proposed to use the complex of deviations and extremes of economic indicators taking into account the cyclic nature of innovation processes as input variables [14].
Thus, T.V. Kolosova, like other researchers, did not pay special attention not only to the necessity of gathering and forming the innovation potential, but also to the issues of its effective realization in the analysis of the impact of the innovation potential. Every innovative technology should be applied, every innovative equipment should be used, the intellectual property of the enterprise should bring profit, etc.
The mentioned studies confirm that innovative development has a positive effect on the sustainability of the enterprise. However, many enterprises are wary of innovative development, fearing the loss of sustainability, and in many cases abandon it. In this regard, one of the most important issues facing researchers, perhaps the most important, is to find and propose such a mechanism for managing innovative development, so that the applied newly formed innovative development program does not endanger the stability of industrial enterprises, but instead paves the way for innovative sustainable development. Thus, the important task of sustainable development is manifested in fulfilling the wishes and aspirations of mankind. For sustainable development, it is necessary to meet the more important needs of a wide segment of the population, and it is also important to provide equal conditions for the improvement of the personal life of the population in realizing their own opportunities.
At the present time, the category of "sustainable development" is being dealt with by a wide section of the society.
Modern economic scientists believe that the concept of sustainable development is related to the transformation of the socio-economic structure of the world and the continuous development of individual economic subjects. More precisely, the direction of sustainable development is related to global processes and it can be described as follows (Figure 1).

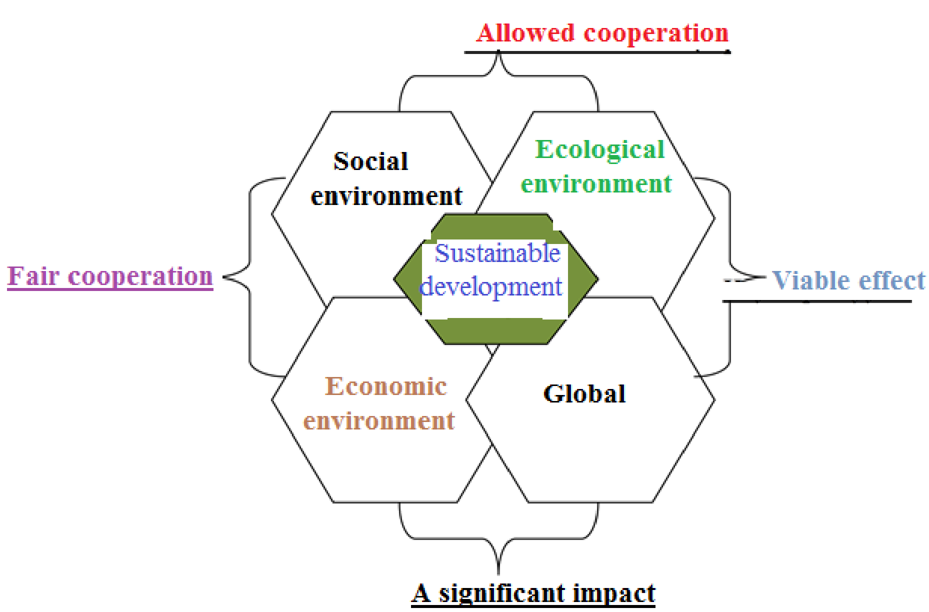

Figure 1. A system of interaction of environments that ensures sustainable development

As can be seen from the picture, stronger and more active effects of global processes have begun to be observed in recent years, when any socio-economic change in individual countries has a significant impact on the sustainable development of another state and the world economic structure. [15].

Many scientists associate sustainable development with the concept of sustainable economic development of an enterprise. At the same time, the Russian scientist J.N. Kaziyeva in her works connects the sustainable development of enterprises with obtaining a stable income from sales.

Taking into account the above, the classification of the principles of sustainable development of the enterprise can be described as Figure 2.

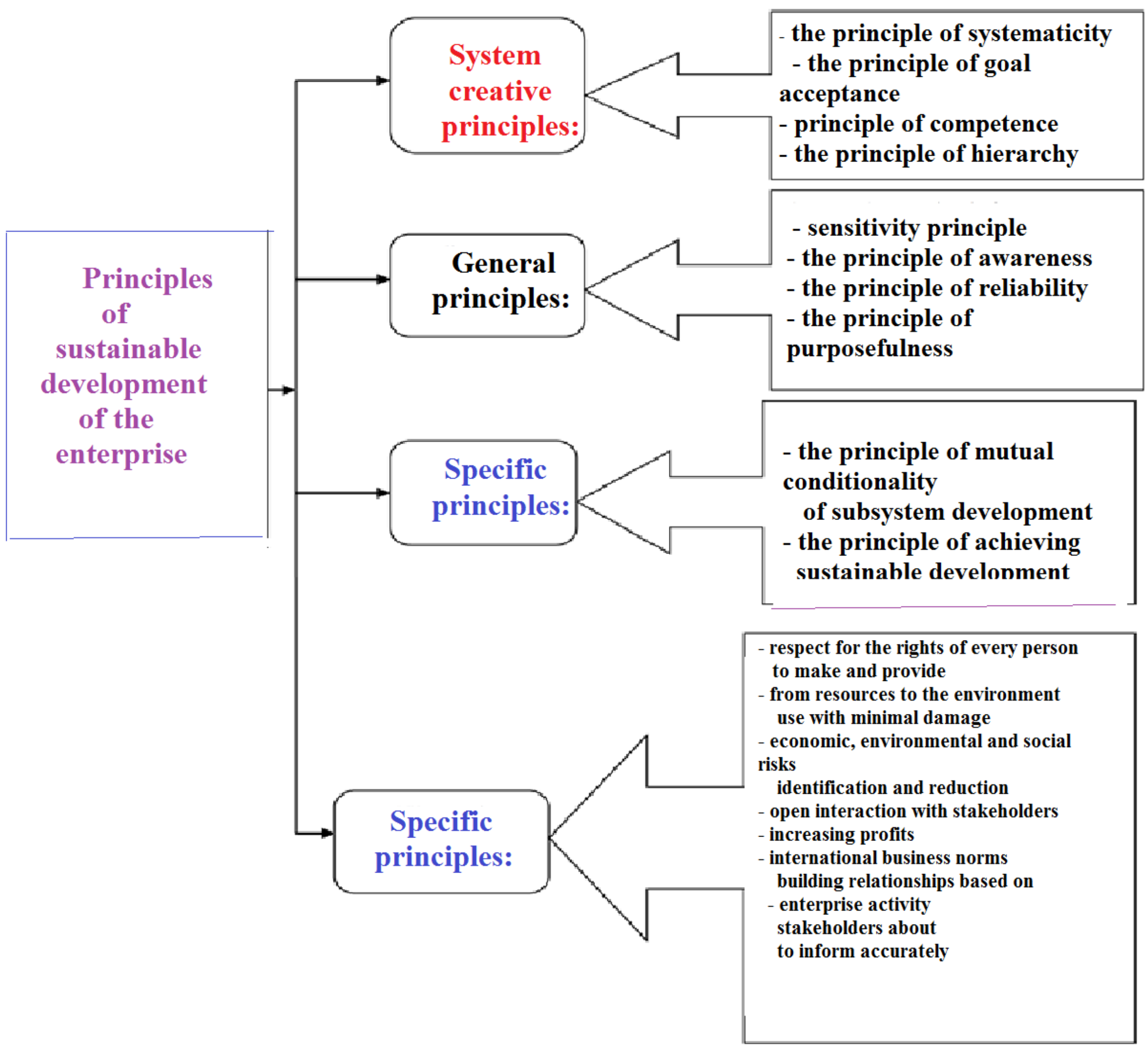

Figure 2. Classification of principles of sustainable development of the enterprise.

Successful sustainable development of the country is closely related to increasing the level of industrial production. Industry plays a special role in the innovative development of technology, which determines the economic and social development of each country, and in the conduct of scientific research, experimental and design works.

Economic sustainability is a complex economic concept that determines the status of an enterprise as a higher system (field or regional) element.

An efficient operating enterprise creates a certain development mechanism of the system, which allows the level of self-organization of this system to rise and expands the scope of its economic sustainability.

An analysis of the experience of creating a sustainable Chinese economy shows that the number of university professors and articles turned out to be insignificant for the level of gross regional product, while there is a very strong correlation with data on patents [20]. Intellectual property itself has always been an integral part of the overall economic, social and cultural development around the world, but new challenges further emphasize how globally interconnected the systems of generation, increment and dissemination of knowledge, as well as their protection have become [39]. The system-forming role of intellectual property as the main productive force in the region, which forms new technological structures and value chains, is noted in the work of domestic scientists [16].

An analysis of the work of foreign scientists in this field has shown the existence of several interpretations of this concept, focusing on its various aspects. It is possible to single out a systematic approach to the consideration of socio-economic ecosystems, the cross-cutting nature of the interaction of science, industrial technologies and the state in the implementation of innovative processes, the need to balance the interests of all subjects, the importance of scientific and educational components. The interconnection and cooperation of subjects located on a single territory is noted as one of the important components of such development in the context of regional and production restrictions. At the same time, much attention is paid to the factors of financial support for processes, infrastructure opportunities (including the development of information and switching equipment and tools), and the scientific and educational component.

It should be noted that the strengthening of the role of intellectual property in the sustainable development of subjects, as well as its significant backbone importance for regional social and production systems in the interaction of these subjects at the present stage. The use of intellectual property tools contributes to the creation of an effective knowledge network, which contributes not only to their accumulation, but also to the active dissemination of knowledge.

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Considering the above, in the course of the study, conceptual approaches were developed to improve the intellectual support of Azerbaijani industrial enterprises, including the main areas:

- organizational and economic mechanism for the introduction of digital technologies.
- model of neo-industrial complex of industry.
- a system of high-tech equipment for production.

The strategic goal of the digitalization of the economy should be the qualitative growth of its competitiveness and the emergence of a leading position in certain segments of high-tech goods and services in the world market, the growth of welfare and the improvement of the quality of life of citizens through the digital transformation of all aspects of human activity. The flagship of this development should be the organizational and economic mechanism for the introduction of digital technologies, which form the technological core of the industry.

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ANALYSIS OF THE CONDITION OF METROLOGICAL SUPPORT IN THE FIELD OF NANOTECHNOLOGY

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ABSTRACT

In the modern world, the most important task for the development of the nano industry is the formation of the infrastructure of the nano industry corresponding to its modern level in economically developed countries. One of the indicators of such infrastructure is the level of its metrological support.
This article analyzes the use of a modern instrumental base of high-precision measuring devices in nanotechnology, including the use of metrologically ensured in operation measuring instruments. The modern fundamentals of the technical support of nanometrology are outlined, and special attention is paid to the main metrological operations - verification and calibration. The issues of instability, accuracy, and uncertainty of nano measurements are described.
Analysis and monitoring of measurement needs and measurement capabilities for the purpose of metrological support of nanoproducts are very relevant at the present time.
Keywords: nanometrology, accuracy, metrological assurance, traceability, measuring instruments.

Introduction

One of the most important areas covered by nanotechnology is nanometrology, which includes fundamental research, the development of methods and means for measuring quantities and parameters that characterize the properties of nanoobjects, nanomaterials, nanostructures, and nanosystems and nanodevices synthesized on their basis. In this case, the errors (uncertainties) of measurements should be within the limits that ensure the proper operation of nanosystems and nanodevices. The world scientific and technical community believes that without the proactive development of nanometrology, any innovations in all areas of nanotechnology are impossible.
An urgent task of today's nanometrology is the development of metrological support for measurements and control of the properties of nanoparticles and nanoobjects. The problem here is the unknown level of toxicological hazard of nanoparticles, to determine which, first of all, it is necessary to have methods and means of obtaining reliable quantitative information about the properties of nanoparticles.
The International Organization for Standardization (ISO) has formed the technical committee ISO/TC 229 Nanotechnologies, the first meeting of which was held in London in November 2005. The scope of this committee covers issues related to the standardization of various areas and areas of nanotechnology, in particular research, measurement, and control of the properties of materials and processes in the range of nanoscales (100 nm and less) in one, two and three dimensions, where new properties depending on the size of the nano object begin to appear and new processes occur that are promising for the development and application of nanostructures.

All countries that have adopted programs for the creation and development of the nano industry at the government level are aware of the need for advanced development of metrology, standardization, and certification in this area.
Scientific-research works carried out by scientists working in the Republic of Azerbaijan in the field of nanotechnology correspond to the works of leading countries in terms of their scientific level. At the Azerbaijan National Academy of Sciences, Azerbaijan State Oil and Industry University, Baku State University, and Azerbaijan State Medical University, scientific research works on different fields of nanotechnology, and applied works are being carried out at the laboratory level.
Large-scale development of nanotechnology is impossible without appropriate metrological support. Metrological assurance of the uniformity of measurements in nanotechnologies is associated with the creation of standards of physical quantities, reference installations, the development of methods for verification (calibration) of measuring instruments used in nanotechnologies, the development and certification of methods, the measurement of physical and chemical parameters and properties of nanotechnology objects.
Quality nanotechnology products can be produced with as much precision as they can be measured. Therefore, any nanotechnology element of the nano industry requires comprehensive metrological support to provide information on the production of nanotechnology objects and their performance, measurement, control, and research results with given accuracy and reliability.
At a time when nanotechnology is developing at a great speed, it is important to conduct new scientific research in this field.

Main Part

Metrological assurance of the uniformity of measurements in nanotechnologies is associated with the creation of standards of physical quantities, reference installations, the development of methods for verification (calibration) of measuring instruments used in nanotechnologies, the development and certification of methods, the measurement of physical and chemical parameters and properties of nanotechnology objects. In accordance with the law of the Republic of Azerbaijan “On ensuring the uniformity of measurements” dated 06/13/2013 [1], the principles of metrological assurance should be of a leading nature and used in any technological processes and scientific research without exception, which also applies to nanotechnologies.
Implementing the nanoscale in the nanometer and surrounding regions is the primary goal of nanometrology.
This necessitates the following actions:
1. Based on the metrology of linear measurements, the first job of nanometrology is to guarantee the uniformity of measurements of the geometric parameters of a nanoobject.
2. The positioning of the measuring device's probe to the target spot with reference accuracy is required for measurements of a nanotechnology object's mechanical, electrical, magnetic, optical, and many other parameters and qualities.
The "Concept for the Development of Work in the Field of Nanotechnologies for the Period Up to 2010" and "Program for Coordination of Work in the Field of Nanotechnologies and Nanomaterials in Russia" are the primary texts on nanotechnology in Russia.
The need for advanced development of measurement information in the market of modern technologies is constantly emphasized in the annual reports of the US National Institute of Standards and Technology (NIST). According to NIST, “Innovation in measurement and

metrology will often be a factor in a successful technological breakthrough in almost all areas of the economy. In the first quarter of the 21st century, special hopes are associated with nanotechnologies" [2].

The most important element of the metrological support of measuring instruments used in the nanoindustry are reference measures and standard samples of the properties and composition of nanostructured materials. For each type of measurement, the design of reference measures and standard samples of various nanostructured materials is developed, which should reproduce the required physical parameter with a given accuracy and high stability. The issues of ensuring the uniformity of measurements are no less important when measuring the physicochemical parameters and properties of nanoobjects, such as mechanical, optical, electrical, magnetic, acoustic, etc. All these problems require reference to a standard that reproduces the unit of a given physical quantity. Ensuring the uniformity of measurements in nanotechnologies is based on a number of factors and requirements: firstly, these are standards of physical quantities and reference settings, as well as standard samples of composition, structure, and properties to ensure the transfer of the size of units of physical quantities in the nano range; secondly, these are certified or standardized methods for measuring the physicochemical parameters and properties of nanotechnology objects, as well as methods of calibration (verification) of the measuring instruments used in nanotechnologies; thirdly, this is the metrological support of the technological processes themselves for the production of materials, structures, objects, and other products of nanotechnology; fourthly, accurate, reliable and traceable measurements are the basis for ensuring the successful and safe development of nanotechnologies, as well as the evidence base for evaluating and confirming the conformity of nano industry products. A block diagram of the traceability of measurements in nanometrology of linear dimensions is shown in fig.1 [3].

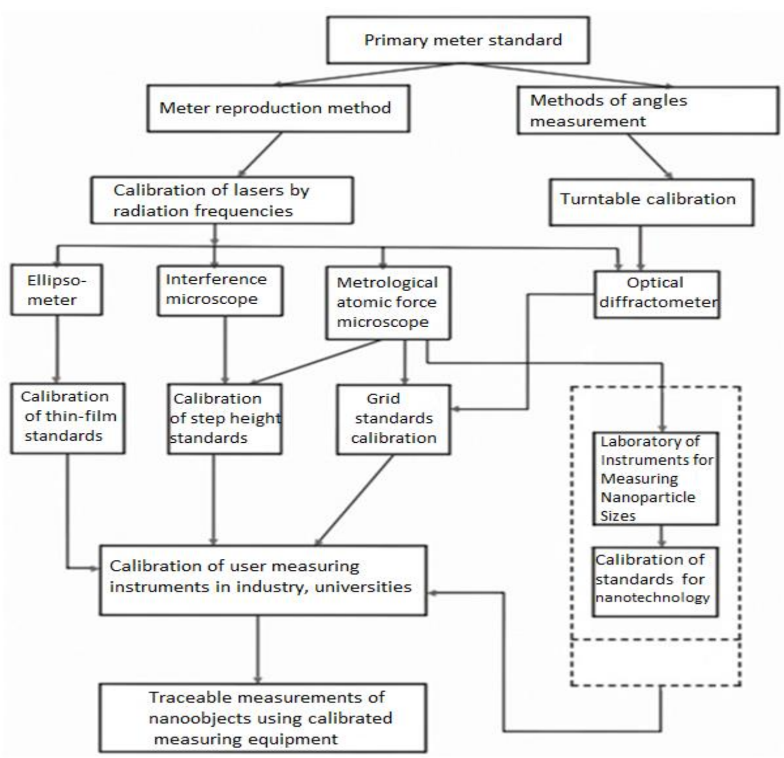

Figure 1: Structural diagram of the traceability of measurements of nanometrology of linear dimensions

Methods for studying and measuring the properties of nanoobjects - transmission and scanning electron microscopy, scanning probe microscopy, ion field microscopy, photoemission and optical spectrometry and optical diffractometry, etc. - SI measurements are required for the corresponding samples of composition, structure, properties with known dimensional abilities. Detection measurement in the nanometer dimension involves the use of high-resolution scanning electron and scanning probe microscopy techniques in laser interferometry evaluation and diffraction detection while maintaining an absolute reference to the meter reference standard.
Ensuring the uniformity of measurements of physical and chemical parameters and properties of the object of measurement requires linking the corresponding measuring instrument to a standard that reproduces a unit of a given physical quantity, and in nanotechnologies, in most cases, also a mandatory link to the basic standard of a unit of length (Fig. 2) [4].

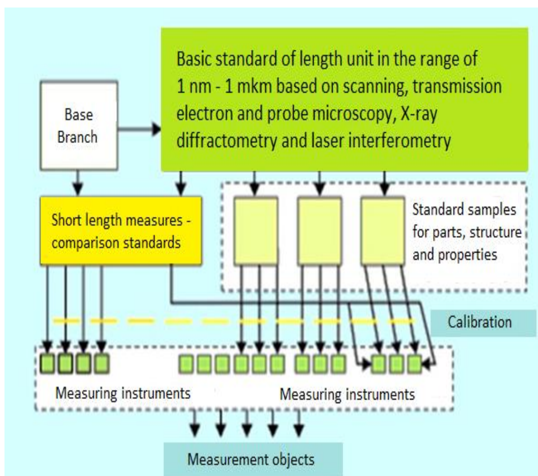

Figure 2: Scheme of metrological and standardization support of nanotechnology

For practical nanometrology, it is important to develop standards for the methods of measuring the parameters of nanoobjects and nano processes, verification procedures and the development of calibration measures that allow for the calibration of measuring equipment used in nanotechnologies, as well as the development and testing of software for calibration in nanometrology. Calibration standards are important elements of all measuring nanotechnologies. Foreign manufacturers of measuring equipment used in the nano industry provide the equipment with their own calibration samples. Therefore, the results obtained in the same environment using the same measurement technologies after calibrating the equipment with different calibration samples may differ. For this reason, EU nanometers have taken the initiative to group many of the available calibration samples and conduct studies to characterize them.
The concept of precision in the nano industry is interpreted very broadly. This is the accuracy of the measuring instrument itself (SI), and the accuracy of the measurement result, and the accuracy of the relative positioning of the object and the scanning (or measuring) tool. Positioning accuracy in nanotechnology is determined by the fact that the production of nanoproducts is always

associated with precision positioning (nano positioning). Nano positioning is the installation of the object under study (or probe) to the required position in a given coordinate system. In this case, the absolute errors in determining the coordinates do not exceed one nanometer. No less than the accuracy of movements, the accuracy of the geometric shape of the tools is important. More precise tools allow, in turn, to increase the accuracy of measurements and production. Nanotechnology often requires sharp and finely shaped instruments.

Accurate measurements of intermolecular forces, linear dimensions of nanostructures and molecules, and their mechanical properties are the basis for theoretical understanding, development of computer simulation systems and design of nano systems. Research into the precision processing of nanostructures, precision positioning and spatial metrology is aimed at developing the technologies needed to produce standards with atomic precision and a given structure.

The calculation of the uncertainty of nano measurements does not differ from the general procedure for calculating the uncertainty.

The most important step in solving the problems of metrological support of linear measurements in the nanometer range was the creation of real size carriers - measures with a programmable surface nano relief, which ensure the calibration of measuring instruments with the highest accuracy. It is precisely such three-dimensional measures of small length, or comparison standards, that are material carriers of size that make it possible to carry out complex calibration and control of the main parameters of scanning electron and scanning probe microscopes. Measures allow one image of it in a scanning electron microscope, which is very important for the control of technological processes, to calibrate the microscope. In addition, if it is necessary to confirm the correctness of measurements, it is possible to control the parameters of the scanning electron microscope directly in the process of measuring the dimensions of the object under study, which is an additional guarantee of high-quality measurements. The measure makes it easy to automate linear measurements and create automated measuring systems based on scanning electron microscopes.

Similarly, according to the given parameters of the measure, calibration, and control of such characteristics of atomic force microscopes as the division value and the linearity of the scales in all three coordinates, the orthogonality of the scanning systems, the radius of the probe tip, the adjustment of the parameters and the exit of the microscope to the operating mode are carried out. Scanning electron and scanning probe microscopes can only be considered as measuring instruments when their parameters are appropriately certified, calibrated and controlled, and the latter directly in the measurement process.

Conclusions

Measurement and control of certain parameters of technological processes in the field of nanotechnology and the use of nanodevices, as well as the characteristics of materials with special physical, chemical and biological properties created as a result of the industrial application of nanotechnology, in many cases is carried out within the framework of traditional metrology. However, the new characteristics and capabilities of nano industry products and the properties of materials created as a result of the use of nanotechnologies impose special requirements on the measuring instruments used and their metrological support. These measuring instruments should have new functionality, extended measurement ranges and increased accuracy. First of all, this refers to the accuracy, measurement ranges and functionality of primary standards and necessitates their directed improvement.

Solving the problems of metrological support nanotechnologies is not limited to the improvement of standards, it is required to modernize the existing and create more modern verification equipment that meets the new tasks, as well as the development of regulatory documents for the methods and means of verification of measurements used in the nano industry and other areas of nanotechnology, for methods of performing measurements in connection with the development of nanotechnology. It is very important to identify the sources that affect the accuracy of measurements in the nano industry.

The development of science, the practical use of the results of scientific work in the field of nanotechnology requires a systematic improvement of legislation, the emergence of institutions to control the possible negative consequences of the knowledge being implemented, which, on the one hand, will help strengthen the economic potential of the Russian state, and on the other hand, will ensure security and protection individual rights, environmental protection.

The idea of nanometrology's development offers an integrated method for addressing the issue of metrological assistance for the businesses in the nanotechnological network of the nano industry. Because a number of interconnected tasks in the following key areas of science, technology, organization, and methodology must be resolved:

• development of a standardization system in accordance with international standards and providing all necessary requirements for nanotechnologies, nanomaterials, and nano industry products;

• development of a national system for ensuring the uniformity of measurements up to the level of the leading countries of the world and the corresponding efficient functioning of the infrastructure of the nano industry;

• development of a distributed system of metrological centers for collective use, formed on the foundation of metrological centers for collective use, created on the foundation of metrological research institutes and organizations, as well as the chief scientific organization and the chief organizations of industries in the main areas of the nano industry.

There is a comparative analysis of facilities in nanometrology:

Due to the lack of mechanical contact between the sample and the instrument and the use of low energy tunneling electrons, STMs can analyze the surface of a material without causing any damage. They also have resolution at the atomic level:

• creating a true three-dimensional representation of the surface topography; and • working in both air and vacuum.

STM can only be used on conductive objects, though.

AFM has a lot of benefits, including special, inherent STM, with parameters similar to SEM in terms of sensitivity and locality:

• carrying out measurements under atmospheric conditions; • the non-destructive nature of impact on the sample; • the possibility of determining the characteristics of materials, structures, and devices by electrophysical parameters. Dielectric materials, for example, cannot be studied by the SEM method without resolution loss due to "charging" of the sample surface.

AFM also enables you to obtain a genuine three-dimensional surface topography, in contrast to SEM, which only provides a pseudo-three-dimensional image of the sample surface. The use of a conductive metal layer, which frequently causes the surface to bend noticeably, is not necessary when utilizing AFM on non-conductive surfaces. Since most AFM modes can be used in air or even liquid, SEMs cannot operate correctly in either.

This brings up the prospect of researching living cells and biomacromolecules. AFM can theoretically offer a better resolution than SEM. For instance, AFM can deliver true atomic resolution in an ultrahigh vacuum. Similar in resolution to a scanning tunneling microscope and a transmission electron microscope is ultrahigh vacuum AFM. Resolution in SPM not constrained by diffraction, but solely by volume size interactions between the probe and the material, i.e. several picometers.

The smaller scanning field size of AFM when compared to SEM is a drawback. The SEM can scan a surface area of a few millimeters in the lateral plane with a few millimeters of vertical height difference. The biggest height difference in an AFM measurement is a few microns, while the largest scanning fields are, at most, 150 150 m.

AFM's primary technical challenges include developing a needle that is truly sharpened to atomic dimensions, providing mechanical stability at a level better than 0.1 (including thermal and vibration stability), developing a detector capable of reliably detecting such small movement, obtaining a sweep with a step-in fractions of an angstroms, and ensuring a smooth approach of the needle to the surface.

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INVESTIGATION OF STABILITY LOSSES OF THE PACKER WITH A GIRDLE-CYLINDRICAL-CONICAL CONSTRUCTION

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ABSTRACT

In the paper stability losses of the packer with a girdle construction have been investigated by taking into account compactness mechanism. Expanding and constricting cases of conical surface of the packer with a girdle construction have been studied, stability problem of the packer has been solved via numerical estimation by using finite differences method. With this purpose, continuity condition of the deformation has been written for packer construction (cylindrical and conical surface of the packer) and added to stability losses condition. In the first approach the solution has been carried out in boundary and junction nodes of the packer (where cylindrical and conical surfaces combine), however, in the second approach by finite differences method. During packing process stability losses limit has been studied for the first time for a girdle construction.
Keywords: packing, well packing, cylindrical-conical construction packing, mode of deformation, critical pressure in packing.

Introduction

Let's study packing mechanism [4, 5, 1] by regulating stability losses with the participation of friction forces of packers placed between the tube attached to the pump receiver and operating pipeline in order to regulate dynamic level in the well being operated by rod well pumping unit. It has been accepted that, the packer lapping proposed increases the efficiency of the work in using the packer without tap (lapping replacing the anchor for creating packer stop). Thus, being in contact with operating pipeline thanks to friction force, its packing lapping switches to packing mode (without the help of tap lapping). Because, the construction of the packer newly created consists of two parts (whole) with cylindrical and conical surface.

Materials and methods

Let's consider the problem of stability losses during the work of the packer with ΔP girdle (cylindrical-conical surface) by external pressure distributed equally.

The packer with cylindrical-conical construction is generally considered to have different thicknesses, and being connected with cylindrical- conical parts between them. This can also be called a packer with girdle construction.

Objectives of the problem

The following two cases of the connection are possible:

- with its small diamteric edge conical part is connected to the cylindrical part (Figure 1) (expanding of conical part)

Initial data: Let's note the following markings:

ℓ_{cyl} - the length forming the cylindrical part of the packer;

h_{cyl} - the thickness of cylindrical part wall of the packer;

a_{cyl} - the radius of the middle surface of cylindrical part of the packer;

E_{cyl} - elasticity module of packer material of cylindrical part;

μ_{cyl} - Puasson coefficient of packer material of cylindrical part;

$D_k = \frac{E_{cyl} h_k^3}{12(1-\mu_{cyl}^2)}$ - cylindrical hardness of the cylindrical part;

ℓ_0 - the distance measured along the generatrix from top surface of the cone to the edge of small diameter;

h_k - the thickness of conical part wall of the packer;

α - the angle between the cone generatrix and its base;

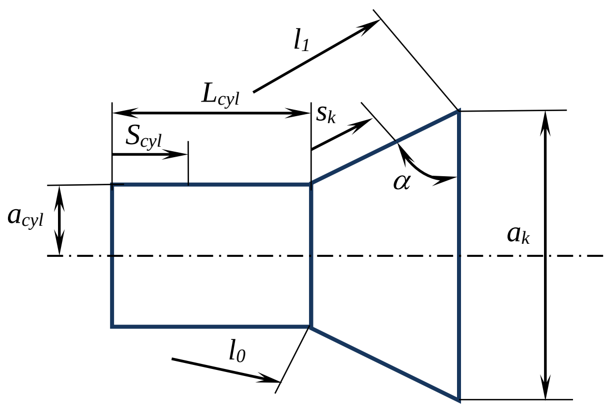

Figure 1. Expanding direction parameters of conical surface of the packer with girdle construction.

E_k - elasticity module of packer material of conical part; ($E_{cyl} = E_k$);

$D_k = \frac{E_k h_\kappa^3}{12(1-\mu_\kappa^2)}$ - cylindrical hardness of the packer conical part.

Differential equation, solving stability problem of sylindrical part due to $\Delta P = q$ external pressure impact, can be written as follows within conditions

$$\frac{h_{cyl}}{a_{cyl}} < \left(\frac{\ell_{cyl}}{a_{cyl}}\right)^2 < \frac{a_{cyl}}{h_{cyl}} :$$

$$\frac{d^{u}\psi_{cyl}}{dx_{cyl}^4} k^4 \cdot \psi_{cyl} = 0 \qquad (1)$$

here $\psi_{cyl}(x)$ is deformation – flexion function of the packer and is connected with $W_{cyl}(S)$ flexion as follows:

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$$W_{cyl} = \psi_{cyl} \cos n_{cyl} \theta \tag{2}$$

where $x_{cyl} = \dfrac{s_{cyl}}{a_{cyl}}$ is a measureless coordinate;

n_{cyl} - is the number of the waves occured in circular direction during stability losses;

θ - is the angle coordinate formed by the middle surface;

$K^4 = P_{cyl}^3 (\nu_{cyl} - P_{cyl})$; $P_{cyl} = \varepsilon_{cyl} n_{cyl}^2$ and $\nu_{cyl} = \dfrac{qa_{cyl}}{E_{cyl} \cdot h_{cyl} \cdot \varepsilon_{cyl}^3}$ - are measureless parameters;

$\varepsilon_{cyl} = \sqrt[4]{\dfrac{\mathrm{h}_{cyl}^2}{12(1-\mu_{cyl}^2)\alpha_{cyl}^2}}$ - are measureless parameters of the packer.

1. If α isn't equal to zero or $\pi/2$, then the system of differential equations, solving the stability problem in accordance with [4] work for conical part of the packer, can be replaced by a single equation.

$$\frac{d^2}{dx_k^2}\left(x_k^3 \frac{d^2\psi_k}{dx_k^2}\right) + \left(\frac{P_k^4}{x_k^2} - P_k^2 \nu_k\right)\psi_k = 0 \tag{3}$$

where $\psi_k(x)$ is flexion funciton and is connected with $W_k(S)$ flexion by the following relation.

$$W_k = \psi_k tg\alpha \cos n_k \theta \tag{4}$$

where $x_k = \dfrac{S_k}{\ell_1}$ - is a measureless coordinate;

$n_к$ - is the number of the waves occured in circular direction during stability losses;

$P_k = \varepsilon_k \dfrac{n_k^2}{\cos^2 \alpha}$ and $\nu_k = \dfrac{q\ell_1}{E_k h_k}\left(\dfrac{ctg\alpha}{\varepsilon_k}\right)^3$ are measureless parameters;

$\varepsilon_k = \sqrt[4]{\dfrac{\mathrm{h}_k^2 ctg^2 \alpha}{12(1-\mu_{sil}^2)\ell_1^2}}$ - is a measureless parameter of the packer construction.

After transformations, (1) and (3) equations can be as follows:

$$\frac{1}{P_{cyl}} \cdot \frac{d^4\varphi_{cyl}}{dx_{cyl}^4} + P_{cyl}\psi_{cyl} = \nu_{cyl}\psi_{cyl} \tag{5}$$

$$\frac{x_k^3}{P_k^3} \cdot \frac{d^4\psi_k}{dx_{cyl}^4} + \frac{6x_k^2}{P_k^2} \cdot \frac{d^3\psi_k}{dx_k^3} + \frac{6x_k}{P_k^2} \times \tag{6}$$
$$\times \frac{d^2\psi_k}{dx_k^2} + \frac{P_k}{x_k^3} \cdot \psi_k = \nu_k \psi_k$$

Thus, the same pressure q impacts on the construction formed by cylindrical and conical surfaces of the packer, then ν_{cyl} parameter can be indicated by ν_k, that is the following equation is obtained:

$$\nu_{cyl} = \nu_k \frac{E_k h_k a_{cyl}}{E_{cyl} h_{cyl} \ell_1} \left(\frac{\varepsilon_k}{\varepsilon_{cyl}} tg\alpha \right)^3 \qquad (7)$$

The approximate differential equations (5) and (6) do not allow for precise formation of elements attachment conditions (cylindrical and conical parts) of the packer with girdle construction.
Let's carry out only the following four of the eight attachment conditions.
1) Equality of W displacement projections perpendicularly to the rotation axis of a girdle construction of the packer to displacement projections U alonggeneratrix of cylinder and cone, as they are very small,W can not be taken into account;
2) the equality of rotational angles υ forming cylinders and cones,
3) equality of the spindle angles M_1;
4) equality of sliding forces T_{12};
During the connection of conical part with its large diameter edge to the cylindrical part (Figure 2) (cone limitation), the positive direction of the coordinates is presented in Figure 2.
Positive directions of W displacement, rotational angle υ, bending moment M_1, and sliding force T_{12} is presented in Figure 3.

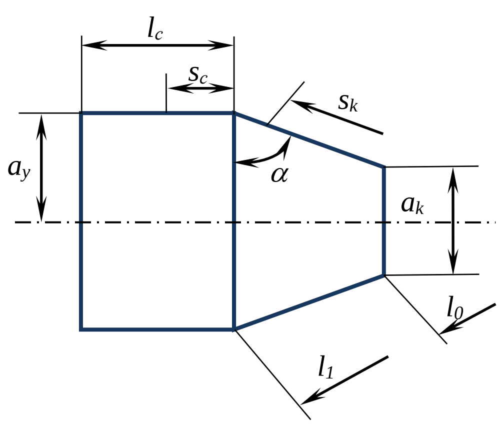


Figure 2. Direction of coordinates in the constricting of the conical surface of the packer with a girdle construction

If $S_{cyl} = \ell_{cyl}$ and $S_k = \ell_0$ are available, for "open to outside" girdle construction, the followings can be taken:

$$\begin{cases} W_{cyl}^{(\ell_{cyl})} = W_k^{(\ell_0)} \cdot \sin\alpha; \; \upsilon_{cyl}^{(\ell cyl)} = \upsilon_k^{(\ell_0)} \\ M_{1cyl}^{(\ell_{cyl})} = M_{1k}^{(\ell_0)}; \; T_{12cyl}^{(\ell_{cyl})} = T_{12k}^{(\ell_0)} \end{cases} \qquad (8)$$

• when $S_k = 0$ and $S_k = \ell_1$ are available, then for the "constricting" girdle construction of the packer the following equation can be taken

$$\left. \begin{matrix} W_{cyl}^{(0)} = W_k^{(\ell_1)} \cdot \sin\alpha; & \upsilon_{cyl}^{(0)} = \upsilon_k^{(\ell_1)} \\ M_{1cyl}^{(0)} = M_k^{(\ell_1)}; & T_{2cyl}^{(0)} = T_{12}^{(\ell_1)} \end{matrix} \right\} \qquad (9)$$

the following equation can be written for M_{1cyl}, M_{1k} bending moments and T_{12cyl}, T_{12k} sliding forces:

$$\begin{aligned} M_{1cyl} &= -\frac{D_{cyl}}{d_{cyl}^2}\left(\frac{d^2\psi_{cyl}}{dx_{cyl}^2} - \mu_{cyl} n_{|cyl}^2 \psi_{cyl}\right)\cos n_{cyl}\theta; \\ T_{12cyl} &= -\frac{E_{cyl} h_{cyl}}{a_{cyl} n_{cyl}^3} \cdot \frac{d^3\psi_{cyl}}{dx_{cyl}^3} \cdot \sin n_{cyl}\theta; \\ M_{1k} &= -\frac{D_k tg\alpha}{\ell_1^2} \cdot \left(\frac{d^2\psi_k}{dx_k^2} + \frac{2}{x_k} - \frac{\mu_k n_k^2}{x_k^2 \cos^2\alpha} \cdot \psi_k\right) \\ T_{12k} &= -\frac{E_k h_k}{\ell_1 n_k^3} \cdot x_k^2 tg^2\alpha \cdot \cos^3\alpha \times \\ &\times \left(\frac{d^3\psi_k}{dx_k^3} + \frac{2}{x_k} \cdot \frac{d^2\psi_k}{dx_k^2}\right)\sin n_k\theta \end{aligned} \qquad (10)$$

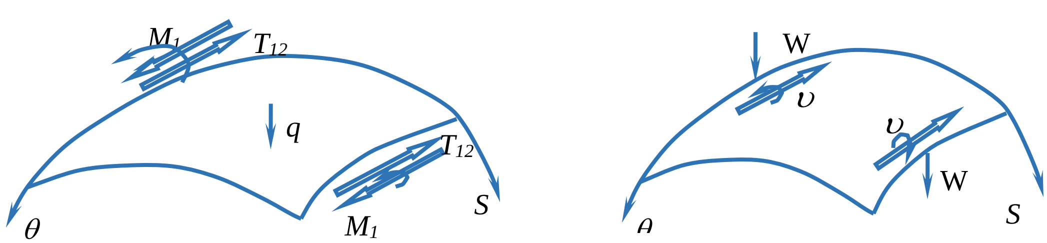
The following equaiton should be carried out during stability lossesin the merging part of the cylindrical and conical parts of the packer with girdle construction in accordance with the conditions of the deformation unfiling and internal force factors.

$$n_{cyl} = n_k = n$$

On the base of this attachment condition, (8) and (9) can be written as follows:

$$\begin{cases} \psi_{cyl}^{(r)} = \psi_k^{(s)} \cdot \sin\alpha tg\alpha; \dfrac{d\psi_{cyl}^{(r)}}{dx_{cyl}} = x_s \dfrac{d\psi_k^{(s)}}{dx_k} \cdot \sin\alpha; \\ \dfrac{d\psi_{cyl}^{(r)}}{dx_{cyl}^2} = \dfrac{D_k}{D_{cyl}} \cdot x_s^2 \left[\dfrac{d\psi_k^{(s)}}{dx_k^2} + \dfrac{\mu_k}{x_s} \cdot \dfrac{d\psi_k^{(s)}}{dx_k}\right] \cdot \sin\alpha\cos\alpha + \\ + \left(\mu_{cyl} - \mu_k \cdot \dfrac{D_k}{D_{cyl}}\right) n^2 \varphi_k^{(s)} tg\alpha \\ \dfrac{d^3\psi_{cyl}^{(r)}}{dx_{cyl}^3} = \dfrac{E_k h_k}{E_{cyl} h_{cyl}} \cdot x_s^3 \left(\dfrac{d^3\psi_k^{(s)}}{dx_k^3} + \dfrac{2}{x_s} \cdot \dfrac{d^2\psi_k^{(s)}}{dx_k^2}\right) tg_\alpha^2 \cos^4\alpha \end{cases} ; \qquad (11)$$

where $\psi_{cyl}^{(r)}$ and $\psi_k^{(s)}$ are flexion funciton of their derviatives for merging junction of cylindrical-conical parts of the packer.



a) b)

Figure 3. Positive directions: a - bending moment M_1 and sliding force T_{12} vectors; b – W displacement and υ rotation angle vectors $\upsilon \leftarrow \vartheta$

The solution of the tasks

Thus, since the solution of differential equation (6) is indefinable in a closed case, let's solve the stability problem of the packer with girdle constructionby numerical evaluation using the finite difference method [6].

Let's divide the length forming cylindrical area of the packer with girdle construction into m_{cyl} equal parts and the length forming the conical area to m_k equal parts.

Then, the step for cylindrical area will be $t_{sil} = \dfrac{\ell_{sil}}{a_{sil} m_{sil}}$, however, for conical area it will be $t_k = \dfrac{1 - x_0}{m_k}$, where $x_0 = \dfrac{\ell_0}{\ell_1}$.

Let's indicate the derivatives in the boundary zones (lapping) and at the junction of the girdle construction of the packer with the first convergence expressions forfinite values, and for all intermediate nodes with second convergence expressions [3]

Then attachment condition(11) will be as follows:

$$
\begin{aligned}
&\psi_{cyl}^{(r)} = \psi_k^{(s)} e_1;\\
&\psi_{cyl}^{(r+1)} - \psi_{cyl}^{(r-1)} = \psi_k^{(s+1)} e_2 - \psi_k^{(s-1)};\\
&\psi_{cyl}^{(r+1)} - 2\psi_{cyl}^{(r)} + \psi_{cyl}^{(r-1)} = \psi_k^{(s+1)} e_3 - \psi_k^{(s)} \cdot e_1 + \psi_k^{(s-1)} e_5;\\
&\psi_{cyl}^{(r+2)} - 2\psi_{cyl}^{(r+1)} + 2\psi_{cyl}^{(r-1)} - \psi_{cyl}^{(r-2)} = \psi_k^{(s+2)} e_6 - \psi_k^{(s+1)} \times\\
&\times e_7 - \psi_k^{(s)} e_8 + \psi_k^{(s-1)} \cdot e_9 - \psi_k^{(s-2)} e_{10}
\end{aligned}
\tag{12}
$$

where, $e_1 = \sin\alpha tg\alpha$; $e_2 = z_s t_{cyl} \sin\alpha$;

$$e_3 = \frac{D_k}{D_{cyl}} \cdot z_s \left(z_s + \frac{\mu_k}{2} \right) t_{cyl}^2 \sin\alpha \cdot \cos\alpha;\ e_4 = \left[\frac{D_k}{D_{cyl}} \left(2z_s^2 + \mu_k n_1^2 \right) - \mu_{cyl} n_1^2 \right] t_{cyl}^2 \sin\alpha \cdot \cos\alpha;$$

$$e_5 = \frac{D_k}{D_{cyl}} \cdot z_s \left(z_s - \frac{\mu_k}{2} \right) t_{cyl}^2 \sin\alpha \cdot \cos\alpha;\ ;$$

$$e_6 = \frac{E_k h_k}{E_{cyl} h_{cyl}} \cdot z_s^3 t_{cyl}^3 \sin^2\alpha \cdot \cos^2\alpha$$

$$e_7 = 2\frac{E_k h_k}{E_{cyl} h_{cyl}} \left(1 - \frac{2}{z_s} \right) z_s^3 t_{cyl}^3 \sin^2\alpha \cdot \cos\alpha;\ ;$$

$$e_8 = 2\frac{E_k h_k}{E_{cyl} h_{cyl}} \cdot z_s^2 t_{cyl}^3 \sin^2\alpha \cdot \cos^2\alpha$$

$$e_9 = 2\frac{E_k h_k}{E_{cyl} h_{cyl}} \left(1 + \frac{2}{z_s} \right) z_s^3 t_{cyl}^3 \sin^2\alpha \cdot \cos^2\alpha;$$

$$z_s = \frac{x_s}{t_k}; \qquad n_1 = \frac{n}{\cos\alpha}$$

Replacing (5) and (6) differential equations with finite-difference equations for the junction of the boundary zones and packer (cylindrical and conical spaces) yields the following result:

$$\begin{aligned}
&A\psi_{cyl}^{(i+2)} - 4A\psi_{cyl}^{(i+1)} + \left[6 + (P_{cyl}t_{cyl})^4\right]A\psi_{cyl}^{(i)} - \\
&- 4A\psi_{cyl}^{(i-1)} + A\psi_{cyl}^{(i-2)} = \nu_k\psi_{cyl}^{(i)}; \qquad (13)\\
&B_j\left(1+\frac{3}{z_j}\right)\psi_k^{(j+2)} - 2B_j\left(2+\frac{3}{z_j}-\frac{3}{z_j^2}\right)\psi_k^{(j+2)} + \\
&+ B_i\left(6+\frac{12}{z_j}+\frac{P_k^4}{x_j^2 z_j^4}\right)\psi_k^{(j)} - 2B_i\left(2-\frac{3}{z_j}\right)\psi_k^{(j-1)} + \\
&+ B_i\left(1-\frac{3}{z_j}\right)\psi_k^{(j-2)} = \nu_k\psi_k^{(j)}
\end{aligned}$$

where

$$A = \frac{E_{sil}h_{sil}\ell_1}{E_\kappa h_\kappa \alpha_{sil}t_{sil}}\left(\frac{\varepsilon_{sil}ctg\alpha}{\varepsilon_\kappa P_{sil}t_{sil}}\right)^3; \qquad B_j = \frac{z_j^3}{P_k^3 t_k}$$

i - is the boundary zone index of the cylindrical part of the packer with girdle construction and obtains 0 and m_{cyl} values;

j - is the boundary zone index of the conical part of the packer with girdle construction, obtains 0 and m_k values;

Finite-difference equations for the intermediate zones of the packer with girdle construction will be as follows:

$$\begin{aligned}
&-\frac{A_k}{6}\psi_{cyl}^{(i+3)} + 2A\psi_{cyl}^{(i+2)} - 6A\psi_k^{(i+1)} + \left[9 + (P_{cyl}t_{cyl})^4\right]\times \\
&\times A\psi_{cyl}^{(i)} - 6A\psi_{cyl}^{(i-1)} + 2A\psi_{cyl}^{(i-2)} - \frac{A}{6}\psi_{cyl}^{(i-3)} = \nu_k\psi_{cyl}^{(i)} \\
&B_j\left(\frac{1}{15z^2}-\frac{3}{4z_j}-\frac{1}{6}\right)\psi_k^{(j+3)} + 2B_j\left(1+\frac{3}{z_j}-\frac{9}{10z_j^2}\right)\times \\
&\times\psi_k^{(j+2)} + B_j\left(\frac{9}{z_j^2}-\frac{39}{z_j}-6\right)\psi_k^{(j+1)} + B_i\left(9-\frac{16}{z_j^2}+\frac{P_k^4}{x_k^2 z_j^4}\right)\times \\
&\times\psi_k^{(j)} + B_j\left(\frac{9}{z_j^2}+\frac{39}{z_j}-6\right)\cdot\psi_k^{(j-1)} + 2B_j\times \\
&\times\left(1-\frac{3}{z_j}-\frac{9}{10z_j^2}\right)\psi_k^{(j-2)} + B_j\left(\frac{1}{15z_j^2}+\frac{3}{4z_j}-\frac{1}{6}\right)\times \\
&\times\psi_k^{(j-3)} = \nu_k\psi_k^{(j)} \qquad (14)
\end{aligned}$$

In (14) equations i index can obtain whole numerical values from 1 to $m_{cyl} = 1$ however, j index can obtaion the values from 1 to $m_k - 1$

The following finite differences equation for the amplitude values of bending moments and sliding forces in boundary zones are written as follows:

$$M_{icyl}^{(i)} = -\frac{D_{cyl}}{a_{cyl}^2 t_{cyl}^2}\left[\psi_{cyl}^{(i+1)} - (2+\mu_{cyl} n^2 t_{cyl}^2)\psi_{cyl}^{(i)} + \psi_{cyl}^{(i-1)}\right];$$

$$T_{12cyl}^{(i)} = -\frac{E_{cyl} t_{cyl}}{2a_{cyl} n^2 t_y^3}\left[\psi_{cyl}^{(i+2)} - 2\psi_{cyl}^{(i+1)} + 2\psi_k^{(i-1)} - \psi_{cyl}^{(i-1)}\right];$$

$$M_{1k}^{(j)} = -\frac{D_k tg\alpha}{\ell_1^2 t_k^2}\times$$

$$\times\left[\left(1+\frac{\mu_k}{2z_j}\right)\psi_k^{(i+1)} - \left(2+\frac{\mu_k n_i^2}{z_j^2}\right)\psi_k^{(j)} + \left(1-\frac{\mu_k}{2z_j}\right)\psi_k^{(j-1)}\right];$$

$$T_{12k}^{(j)} = -\frac{E_k h_k}{2\ell_1 t_k}\cdot z_j^2 \cdot \frac{tg^2\alpha}{n_i^3}\times$$

$$\times\left[\psi_k^{(j+2)} - 2\left(1-\frac{2}{z_j}\right)\psi_k^{(j+1)} - \frac{8}{z_j}\psi_k^{(j)} + 2\left(1+\frac{2}{z_j}\right)\psi_k^{(j-1)} - \psi_k^{(i-2)}\right] \quad (15)$$

For "spreading" case of the packer construction, the following equation is obtained from finite difference equation (12) condition of the junction zone of the cylindrical part of the packer with a girdle construction:

$$\psi_{cyl}^{(m_{cyl})} = e_1\psi_k^{(0)}$$

$$\begin{aligned}
&\psi_{cyl}^{(m_{cyl})} = e_1\psi_k^{(0)};\\
&\psi_{cyl}^{(m_{cyl}+1)} = f_{11}\psi_{cyl}^{(m_{cyl}-2)} + f_{12}\psi_{cyl}^{(m_{cyl}-1)} + f_{13}\psi_k^{(0)} +\\
&+ f_{14}\psi_k^{(1)} + f_{15}\psi_k^{(2)};\\
&\psi_{cyl}^{(m_{cyl}+2)} = f_{21}\psi_{cyl}^{(m_{cyl}-2)} + f_{22}\psi_{cyl}^{(m_{cyl}-1)} + f_{23}\psi_k^{(0)} +\\
&+ f_{24}\psi_k^{(1)} + f_{24}\psi_k^{(2)};\\
&\psi_{cyl}^{(-2)} = f_{31}\psi_{cyl}^{(m_{cyl}-2)} + f_{32}\psi_{cyl}^{(m_{cyl}-1)} + f_{33}\psi_k^{(0)} +\\
&+ f_{34}\psi_k^{(1)} + f_{35}\psi_k^{(2)};\\
&\psi_k^{(-1)} = f_{41}\psi_{cyl}^{(m_{cyl}-2)} + f_{42}\psi_{cyl}^{(m_{cyl}-1)} + f_{43}\psi_k^{(0)} +\\
&+ f_{44}\psi_k^{(1)} + f_{45}\psi_k^{(2)}
\end{aligned} \quad (16)$$

where, $f_{11} = f_{12} = \frac{e_5 - e_2}{e_2 + e_5}$; $f_{13} = e_2\frac{2e_1 - e_4}{e_2 + e_5}$; $f_{14} = e_2\frac{e_3 + e_5}{e_2 + e_5}$; $f_{15} = 0$;

$$f_{21} = -1;\quad f_{22} = \frac{8e_5}{e_2 + e_5};\quad f_{23} = 4e_2\frac{2e_1 - e_4}{e_2 + e_5} - e_1\left[6 + (P_s t_s)^4\right] + \nu_\kappa \frac{e_1}{A};$$

$$f_{33} = \left\{\frac{e_4 - 2e_1}{e_2 + e_5}(e_9 + 2e_2) - e_8 + \left[6 + (P_s t_s)^4 - \frac{\nu_k}{A}\right]e_1\right\};\quad f_{34} = \frac{1}{e_6}\left(e_9\frac{e_2 - e_3}{e_2 + e_5} - 2e_2\frac{e_3 + e_5}{e_2 + e_5} - e_7\right);$$

$$f_{35} = 1;\quad f_{41} = 0;\quad f_{42} = \frac{2}{e_2 + e_5};\quad f_{43} = \frac{e_4 - 2e_1}{e_2 + e_5};\quad f_{44} = \frac{e_2 - e_3}{e_2 + e_5};\quad f_{45} = 0$$

In "constricting radial direction" of the packer with a girdle construction:

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ISSN: 2613-5817; E-ISSN: 2613-5825
VOLUME 23 ISSUE 02 2023

$$
\begin{aligned}
&\psi_{cyl}^{(o)} = e_1 \psi_k^{(m_k)};\\
&\psi_{cyl}^{(-1)} = \delta_{11}\psi_{cyl}^{(2)} + \delta_{12}\psi_{cyl}^{(1)} + \delta_{13}\psi_k^{(m_k)} + \delta_{14}\psi_k^{(m_k-1)} +\\
&+\delta_{15}\psi_k^{(m_k-2)};\\
&\psi_{cyl}^{(-2)} = \delta_{21}\psi_{cyl}^{(2)} + \delta_{22}\psi_{cyl}^{(1)} + \delta_{23}\psi_k^{(m_k)} + \delta_{24}\psi_k^{(m_k-1)} +\\
&+\delta_{25}\psi_k^{(m_k-2)};\\
&\psi_k^{(m_k+2)} + \delta_{31}\psi_{cyl}^{(2)} + \delta_{32}\psi_{cyl}^{(1)} + \delta_{33}\psi_k^{(m_k)} + \delta_{34}\psi_k^{(m_k-1)} +\\
&+\delta_{35}\psi_k^{(m_k-2)};\\
&\psi_k^{(m_k+1)} = \delta_{41}\psi_{cyl}^{(2)} + \delta_{42}\psi_{cyl}^{(1)} + \delta_{43}\psi_k^{(m_k)} + \delta_{44}\psi_k^{(m_k-1)} +\\
&+\delta_{45}\psi_k^{(m_k-2)}
\end{aligned}
\tag{17}
$$

where $\delta_{11} = 0$; $\delta_{12} = \dfrac{e_3 - e_2}{e_2 + e_3}$;

$$\delta_{13} = e_2 \frac{2e_1 - e_4}{e_2 + e_3};\ \delta_{14} = e_2 \frac{e_3 + e_5}{e_2 + e_3};\ \delta_{15} = 0;$$

$$\delta_{21} = -1;\ \delta_{22} = \frac{8e_3}{e_2 + e_3};\ f_{23} = 4e_2 \frac{2e_1 - e_4}{e_2 + e_3} - e_1\left[6 + (P_{cyl}t_{cyl})^4\right] + \nu_k \frac{e_1}{A};$$

$$\delta_{24} = 4e_2 \frac{e_3 + e_5}{e_2 + e_3};\ \delta_{25} = 0;\ \delta_{31} = \frac{2}{e_6};\ \delta_{32} = \frac{2}{e_6} \cdot \frac{e_7 - 2(e_2 + 2e_3)}{e_2 + e_5};$$

$$\delta_{33} = \frac{1}{e_6}\left\{\frac{e_4 - 2e_1}{e_2 + e_3}(2e_2 + e_7) + e_8 + \left[6 + (P_{cyl}t_{cyl})^4 - \frac{\nu_k}{A}\right]e_1\right\};\ \delta_{34} = \frac{1}{e_6}\left(e_7 \frac{e_2 - e_5}{e_2 + e_3} - 2e_2 \frac{e_3 + e_5}{e_2 + e_3} - e_9\right);\quad \delta_{35} = 1;$$

$$\delta_{41} = 0;\ \delta_{42} = e_2 \frac{2}{e_2 + e_3};$$

$$\delta_{43} = \frac{e_4 - 2e_1}{e_2 - e_3};\quad \delta_{44} = \frac{e_2 - e_5}{e_2 + e_3};\quad \delta_{45} = 0$$

The value of the displacement function being outside the boundary of the packer is defined by the equaiton of boundary conditions.

Commonly, they can be presented as follows:

- for cylindircal part of the packer with a girdle construction

$$
\begin{aligned}
&y^{(-2)} = g_{11}y^{(0)} + g_{12}y^{(1)} + g_{13}y^{(2)};\\
&y^{(-1)} = g_{21}y^{(0)} + g_{22}y^{(1)} + g_{23}y^{(2)}
\end{aligned}
\tag{18}
$$

- for conical part of the packer with a girdle construction

$$
\begin{aligned}
&y^{(p+1)} = g_{31}y^{(p-2)} + g_{32}y^{(p-1)} + g_{33}y^{(p)};\\
&y^{(p+2)} = g_{41}y^{(p-2)} + g_{42}y^{(p-1)} + g_{43}y^{(p)}
\end{aligned}
\tag{19}
$$

where y is flexion function value in cylindrical and conical parts of the packer with a girdle construction.

Finite difference equations have been used to remove the unknowns, belonging to the zones outside the boundary of the packer with a girdle construction, from the equations, so that, it is necessary to delete the row $m_{cyl}+1$ and column $m_{cyl}+3$ from matrix A.

As a result, we obtain matrix "A". Matrix "A" consists of the row $m_{cyl}+m_k+1$ and column $m_{cyl}+m_k+9$, i.e., it is a rectangle.

Let's create matrix "G" with boundary conditions, taking into account specific boundary conditions in the girdle (junction) part of the packer with a girdle construction.
If we multiplymatrix "A"bymatrix "G" (with boundary conditions), we will have the square matrix "R" consisting of row $m_{cyl}+m_k+1$ and $m_{cyl}+m_k+1$ column and the coefficients of unknown bending functions in the nodes of the packer with a girdle construction.
Thus, stability problem of the packer with a girdle construction in the effect q of the same external pressure and given boundary conditions is brought to the solution of the following matrix equation.

$$(R-\nu_k E)/y=0 \qquad (20)$$

Let's consider the boundary conditions where the lower part of the cone is free,the top of the cylinderpractically loggedto:
Let's form the boundary conditions as follows
- in logged case of the top of the cylinder

$$W(g)=\upsilon(g)=0$$

- in free case of the bottom of the cone

$$W(g)=M_1(g)=0$$

where "g" is a boundary zone index.
- the part of the packer with a girdle construction "spreading in radial direction" has been logged completely: $g_{11}=0$; $g_{12}=8$; $g_{13}=1$; $g_{21}=0$; $g_{22}=1$; $g_{23}=0$; $g_{31}=0$; $g_{32}=1$; $g_{33}=0$;

$$g_{41}=\frac{3-Z_{m_k}}{3+Z_{m_k}};\ g_{42}=4\frac{2Z_{m_k}^2-3}{Z_{m_k}(3+Z_{m_k})};\ g_{43}=0 \qquad (21)$$

The bottom edge of cylindrical part has been logged, however, conical edge is free:

$$g_{11}=0;\quad g_{12}=8;\quad g_{13}=-1;\quad g_{21}=0;\quad g_{22}=1;\quad g_{23}=0;\quad g_{31}=0;$$

$$g_{32}=-\frac{2Z_{m_k}-\mu_k}{2Z_{m_k}+\mu_k};\quad g_{33}=0;\quad g_{41}=\frac{3-Z_{m_k}}{3+Z_{m_k}};\quad g_{42}=-4\frac{6Z_{m_k}^2}{Z_{m_k}(3+Z_{m_k})};\quad g_{43}=0$$

(22)

Both edges of the packer with a girdle construction are free:

$$g_{11}=0;g_{12}=0;g_{13}=-1;g_{21}=0;g_{22}=-1;g_{23}=0;\quad g_{31}=0;\quad g_{32}=-\frac{2Z_{m_k}-\mu_k}{2Z_{m_k}+\mu_k};\quad g_{33}=0;$$

$$g_{41}=\frac{3-Z_{m_k}}{3+Z_{m_k}};\ g_{42}=-4\frac{6Z_{m_k}^2-\mu_k(3-2Z_{m_k}^2)}{Z_{m_k}(2Z_{m_k}+\mu_k)(3+Z_{m_k})};\ g_{43}=0 \qquad (23)$$

"Constricting" part of the packer with a girdle construction:
- for the logged case of the edges

$$g_{11}=0;\ g_{12}=8;\ g_{13}=-1;\ g_{21}=0;\ g_{22}=1;g_{23}=0;\ g_{31}=0;\ g_{32}=-4\frac{2Z_0+\mu_k}{2Z_0-\mu_k)};\ g_{33}=0;g_{41}=\frac{3+Z_0}{3+Z_0};$$

$$g_{42}=-\frac{6Z_0^2+\mu_k(3-2Z_0^2)}{Z_0(2Z_0-\mu_k)(3-Z_0)};$$

$$g_{43}=0 \tag{24}$$

The edge of cylindrical part is free, however, conical part edge has been logged:

$$g_{11}=0;\ g_{12}=8;\ g_{13}=-1;\ g_{21}=0;\ g_{22}=1;\ g_{23}=0;\ g_{31}=0;\ g_{32}=1;\ g_{33}=0;\ g_{41}=\frac{3+Z_0}{3-Z_0};$$

$$g_{42}=-4\frac{6Z_0^2-3}{Z_0(3-Z_0)};\ g_{43}=0 \tag{25}$$

Both edges of the packer with a girdle construction have been logged:

$$g_{11}=0;\ g_{12}=0;\ g_{13}=-1;\ g_{21}=0;\ g_{22}=-1;\ g_{23}=0;\ g_{31}=0;g_{32}=-\frac{2Z_0+\mu_k}{2Z_0-\mu_k};\ g_{33}=0;\ g_{41}=\frac{3+Z_0}{3-Z_0};$$

$$g_{42}=-4\frac{6Z_0^2+\mu_k(3+2Z_0^2)}{Z_0(2Z_0-\mu_k)(3-Z_0)};$$

$$g_{43}=0 \tag{26}$$

Results and discussion

Stability problem of the packer with a girdle construction can be solved when the smallest special value ν_k of "n" wave number, "R" matrix and according to this ν_k value, special vector y is determined. Special vector y and "n" wave number characterize the form of the packer with a girdle construction during its stability losses, according special vector ν_k, the following equation is used:

$$q_{cr}=\nu_k\frac{E_k h_k}{\ell_1}(\varepsilon_k tg\alpha)^3 \tag{27}$$

As "n" wave number (20) isn't determined directly by matrix equation solution, values of critic pressure and ν_k parameter are determined. By determining "n" values and (20) solving matrix equation, a number of values of ν_k parameter is found. Among the values of $\nu_k(n)$ the smallest value of ν_k providing the following equality is chosen.

$$\nu_k(n-1)>\nu_k(n)<\nu_k(n+1)$$

Iteration method of opposite matrix has been used for solving (20) matrix equation [2].
Iteration process finishes in case the following inequality is ensured.

$$\left|\frac{\nu_k^{(m+1)}-\nu_k^{(m)}}{\nu_k^{(m+1)}}\right|\le 10^{-3}.$$

For estimating precision of the solution on the following equation:

$$\delta=\sqrt{\frac{\sum_{i=1}^{N}(S_i-\nu_k\gamma_i)^2}{N-1}}.$$

Middle quadratic error of "R" matrix equation is calculated, where $S_i=\sum_{i=1}^{N} r_{ij}\gamma_j$, N is the number of matrix.

Initial calculations showed that, increasing division number of cylindrical and conical parts into lengths of generatrix from 10 to 20 specifies the solution 1%.

Based on this $m_{cyl} = m_k = 10$ has been accepted for the solution of the problem.

For the calculation, the packer the greatest and smallest radius and distance of which remain unchanged between the boundaries, has been selected. As changed value α angle has been taken. At this time as a rule, the lengths of generatrix of cylindrical and conical parts were changed (Figure 4 and 5).

The calculation of "the logged part" of the packer with a girdle construction is carried according to measurements and characters of the given packer material.

$a_{cyl} = 50mm$; $a_k = 76mm$; $L = 140mm$; $E_{cyl} = E_k = 6MPa$; $\mu_{cyl} = \mu_k = 0{,}48$.

In "constricting" case of the packer with a girdle construction:

$a_{cyl} = 50mm$; $a_k = 28mm$; $L = 140mm$; $E_{cyl} = E_k = 6MPa$; $\mu_{cyl} = \mu_k = 0{,}48$

Table 1 presents the results of the comparison of various values of the packer with a girdle construction with experiment values.

As it is seen from the table, contact critic pressure of the packer is less $\approx 0{,}7\, q_{cal}$ than $q_{cr}^{\exp}$ calculation pressure [7].

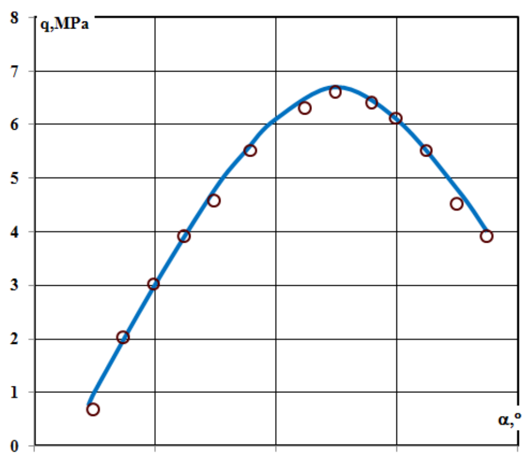

Figure 4. The dependence of q_{cr} pressure on α angle for various conditions and wall thickness of "expanding" elements of the packer with a girdle construction.

$W_{cyl} = W_k = 0$; $v_{cyl} = v_k = 0$; $h_{cyl} = 95mm$; $h_k = 65mm$.

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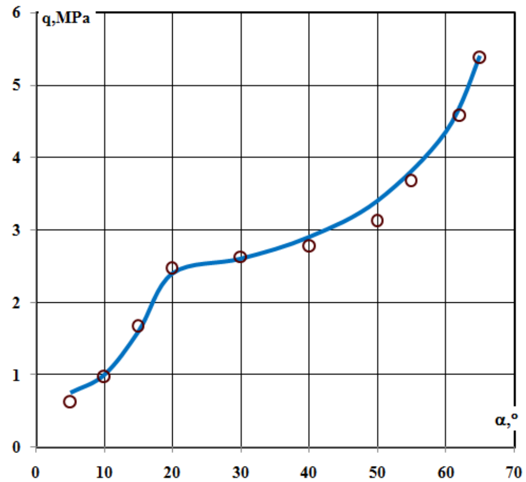

Figure 5. The dependence of q_{cr} pressure on α angle for various conditions and wall thickness of "constricting" elements of the packer with a girdle construction.
$W_{cyl} = W_k = 0$; $\nu_{cyl} = \nu_k = 0$; $h_{cyl} = 95mm$; $h_k = 65mm$

Table 1
Results of the comparison of various values of the packer with a girdle construction with experiment values

α°	ℓ_c, mm	ℓ_k, mm	q_{cal}, MPa	q_{cr}^{exp}, MPa	$\frac{q_{cr}^{exp}}{q_{cal}}$	The type of the packer during placement process
30	342	116	2,53	1,7	0,67	Constricting packer
60	227	200	3,75	2,5	0,68	
60	227	200	4,75	3,3	0,69	Expanding packer

Conclusion

Initial calculations show that, increasing division number of cylindrical and conical parts into lengths of generatrix from 10 to 20 specifies the solution with 1% error.
By theoretical experiments it has been grounded that, the value obtained from calculations should be multiplied ≈0,7 coefficient for determining q_{cr}^{exp} critic pressure of the packer with a girdle construction (cylindrical-conical surface), which will take into preparation technology of packer construction.

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A DEVICE WITH A MICROCONTROLLER THAT KEEPS THE TEMPERATURE STABLE DURING THE PRODUCTION OF PLASTIC PIPES

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ABSTRACT

The quality of plastic pipes is negatively affected by many destabilizing factors, which include improper operation of the traction mechanism, vacuum forming, cleanliness of the forming head, dependence on the screw, etc. All these destabilizing factors affect the quality of the product. But an important destabilizing factor among these reasons, of course, is the temperature of the molten raw material and its stability over the entire production cycle. Due to the inaccurate setting of the temperature of the raw material and its change during the production process, the raw material can be more or less liquid or viscous, which directly affects the quality of the pipe. Due to the temperature error, it is difficult to accurately determine the wall thickness of a plastic pipe. When the pipe is stretched to the required thickness, intramolecular deformations of the pipes may occur, which can have a deplorable effect on the operation of the pipes in the future. Therefore, all pipe manufacturers pay special attention to temperature control. The article analyzes the process of thermal stability of raw materials, proposes a scheme for accurately setting and maintaining a stable temperature based on microprocessor technology, and a full-scale verification of the work done. Experiments have shown the correctness of theoretical studies.
Keywords: Proportional-integral-derivative controller, temperature control, control program, automatic control device, heating element, differential, temperature error, deformation, exploitation, melt raw materials, a heating element.

Introduction

Recently, polyethylene pipes have found wide application in various fields of science, technology and production. The reason for this is high technical characteristics, ease of use and affordable price. They have certain advantages over metal pipes: durability, ease of installation and installation, corrosion resistance and hygiene. However, polyethylene pipes have a number of disadvantages compared to metal pipes. One of these disadvantages is the lack of strength. The strength of polyethylene pipes is influenced by the accuracy of formation of the pipe wall thickness, which is currently insufficient due to the action of various destabilizing factors [1,2,3,4].

Due to the fact that the existing control systems for extrusion lines for the production of polyethylene pipes do not allow achieving a certain accuracy in the formation of pipes of a given thickness, some measures have been developed to improve the accuracy of forming pipes of a given thickness.

The aim of our achievements is to increase the rate of melting of the raw material and its high achievement of the set temperature. Due to the large inertia of the thermocouple itself, the system proposed by us strictly determines the moment of turning on and off the heating element, taking into account the inertia of the thermocouple, the rate of temperature rise and temperature by 1°C.

Therefore, it covers the most accurate shutdown of the heating element in order to accurately reach the ambient temperature, in comparison with other manufacturers of thermostats.

Problems of temperature control systems

As we know in the world, many companies pay utmost attention to temperature control issues. Technology proportional-integral-derivative (PID) temperature control controller has a special place in this issue.

This can sometimes be difficult for personnel to do, or pre-set coefficients do not meet temperature control requirements.

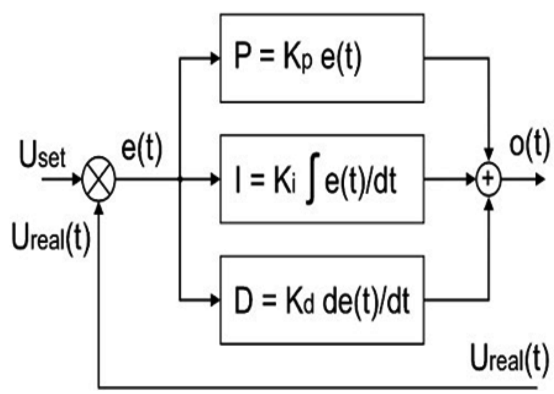
The PID controller is an automatic control device with feedback. The control signal is formed according to the proportional-integral- differential law, that is, the effect is the sum of three components of the difference between the input signal and the feedback signal:

Proportional.

Integral.

Differential (derivative).

The block diagram of the device and the formulas of each component are shown in the Figure 1.



C diagram of the device and formulas of the three components of the difference between the input signal and the feedback signal

PID controllers are continuous devices, they are most widely used in automatic control systems. Such devices have significant speed, respond to error trends, and are resistant to noise.

Setting up the PID controller comes down to selecting the values of 3 coefficients so that the device maintains the specified parameter at a certain level.

Consider setting up a PID temperature controller (Figure 2). Let's say its current value is 10 °C, and the required value should be 25 °C.

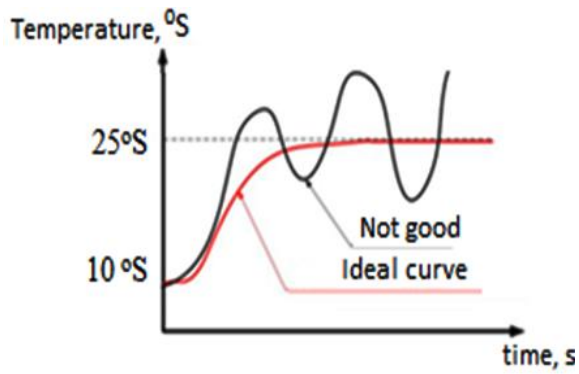


Figure 2: Setting the PID temperature controller.

Setting the PID temperature controller.

The graph shows 2 different transients that occur as the temperature increases. The diverging curve, shown in black, illustrates the operation of an untuned regulator. The controlled value does not accept the set value, the function "runs out".
The red color indicates the “ideal curve”, the characteristic is quite steep, which indicates a short response time, the value quickly reaches the value of 25 ° C and is held at this level.
Setting the proportional gain (Figure 3).
To select the optimal proportional component, the integral and differential coefficients are set to zero. Then set the temperature value, different from the current one.
Then, at regular intervals, the resulting transition values are entered into the table and a graph is built.

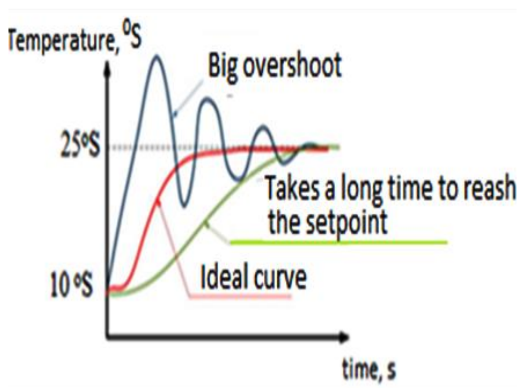


Figure 3: PID controller tuning.

Setting the PID temperature controller
The graph shows 2 different transients that occur as the temperature increases. The diverging curve, shown in black, illustrates the operation of an untuned regulator. The controlled value does not accept the set value, the function "runs out".
The red color indicates the “ideal curve”, the characteristic is quite steep, which indicates a short response time, the value quickly reaches the value of 25 ° C and is held at this level.
Setting the proportional gain (Figure 3).

To select the optimal proportional component, the integral and differential coefficients are set to zero. Then set the temperature value, different from the current one.
Then, at regular intervals, the resulting transition values are entered into the table and a graph is built.

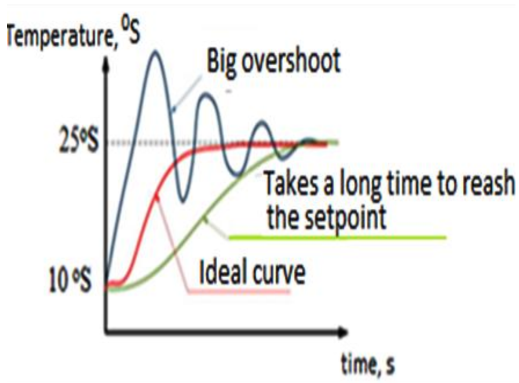


Figure 3: PID controller tuning.

Setting up the PID controller.
With a high overshoot, as in the curve shown in blue, the proportional component is reduced, while the desired temperature is slowly reached, the coefficient is increased. The task is to bring the graph closer to the "ideal curve" depicted in red.
Derivative gain setting (Figure 4).
After debugging the proportional component, adjust the differential coefficient. It is necessary to achieve the absence of overshoot, which is displayed in the form of temperature jumps above the set value. To do this, the differential component is smoothly increased.
If there are jumps in the range below the upper specified value of the controlled parameter, the differential component is reduced. At the same time, there is also the task of bringing the actual graph closer to the "ideal curve".

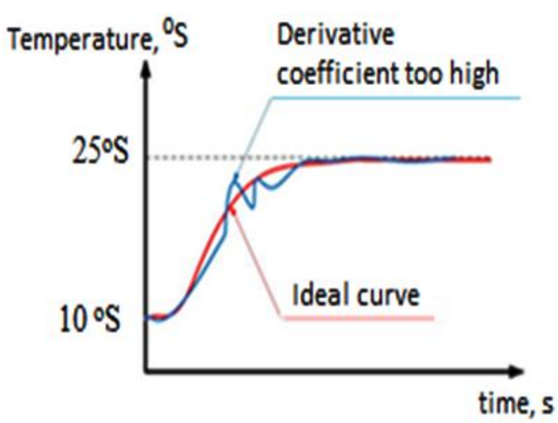


Figure 4: Setting the PID derivative gain.

Setting the integral gain (Figure 5).

After debugging the proportional and differential components, it is possible to obtain a curve that is very close to ideal. However, the temperature does not reach the set value and is maintained at a lower value.

FigFF

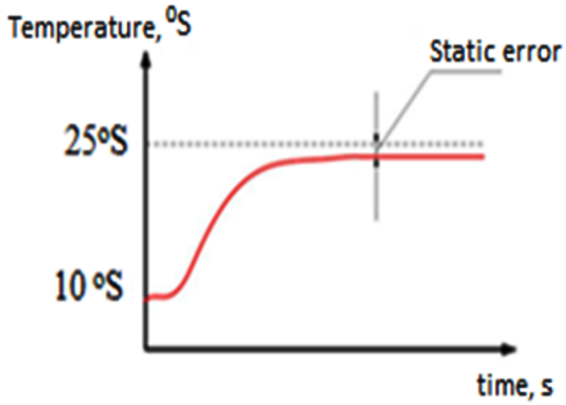


Figure 5. Setting the PID integral gain

This discrepancy is called a static error. To exclude it, adjust the integral component. The coefficient is smoothly increased until the static error disappears. When jumps in the values of the value of the controlled parameter are detected, the integral component is also smoothly reduced.

PID Control Problems

In practice, it is rarely possible to achieve settings close to ideal. Any system is subject to disturbances from the outside, which makes it impossible to achieve the "ideal curve". Usually limited to a setting that satisfies the conditions of the process.

The next problem with PID control is that when replacing the heating element, the power of the heating element must be taken into account, otherwise the PID control accuracy loses its meaning. High or low mains voltage will also introduce distortions into temperature control. In this regard, we offer a completely different approach to the management of temperature control.

Temperature control principle

The meaning of our temperature control system is to calculate the time for a change in temperature by 1 °C and adjust the switching off or on of the heating element for the entire time period of the melt of the raw material, i.e.

temperature control will be carried out all the time while the process of melting raw materials is in progress. In addition, the true calculation data will be stored after the raw material has been heated to 100 °C. Generally, all materials used in plastic pipe production melt above 100°C. There are of course exceptions, which we will neglect for now! Let us give an example for complete clarity of the picture of temperature control.

Suppose we have to heat the raw material by 190° C in one zone.

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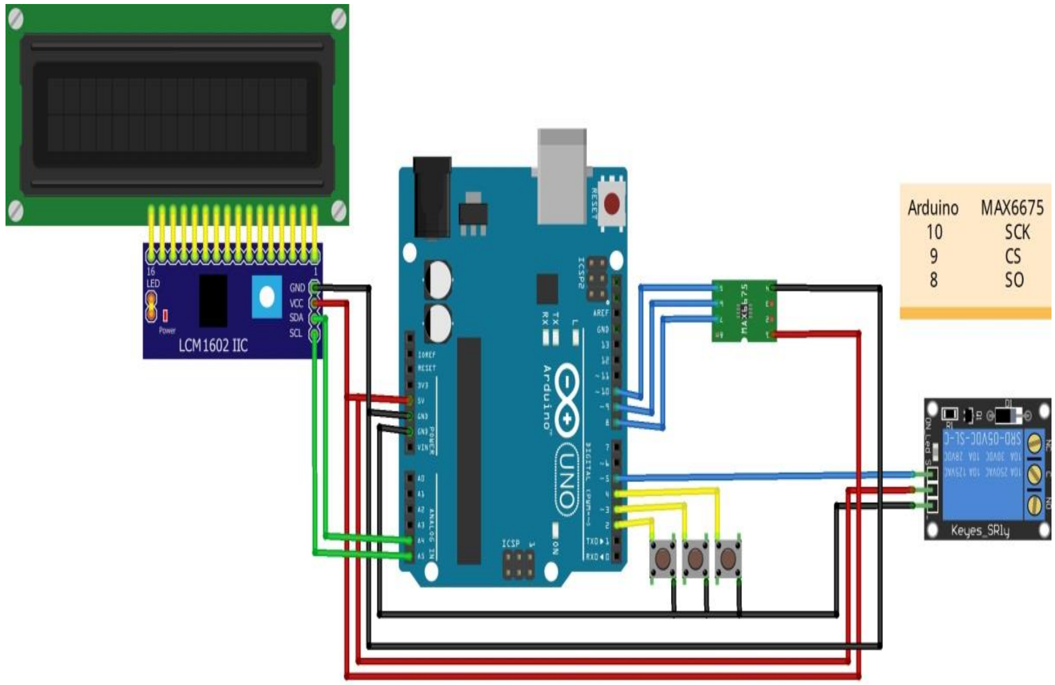

Figure 6. Temperature control system on microcontroller.

We turn on the heating. The system waits until the temperature reaches 100°C and then records the time it takes for the temperature to rise by 1°C. (Since the heating of raw materials to 100 ° C has its own characteristics, such as the beginning of the inertia of heating. The cold cylinder will take a long time to gain temperature at the beginning of turning on the heating and the temperature will not change for a long time, although power will be applied to the heating element). Having made 3 measurements of the increase at 1° C the system calculates the average of 3 measurements. This time will be stored in the memory cell. Next, the rate of temperature increase from time is calculated by measuring 3 more measurements throughout the entire heating cycle.

The data is stored in a memory cell. After entering data according to the formula $T_{off.} = T_{set} - V_{av}$, (where T_{off} is the temperature of turning off the heating element, T_{set} is the set, and $V_{av.}$ is the average rate of temperature rise in 1 sec.), the temperature of turning off the heating element is calculated for a smooth approach to the set temperature of 190°C. Naturally,

after turning off the heating element, the raw material cools down. And for this process, the cooling temperature per 1 °C in time and the cooling rate are calculated to turn on the heating element when it cools down from the set temperature. The entire heating and cooling data collection cycle occurs throughout the entire process. As a result, if the mains voltage rises or falls, the system will respond to changes. Also, if the heating element is replaced, this will also not affect the quality of temperature control.

The circuit was assembled on Arduino and shown in the figure. The circuit uses a thermocouple type “K” (fig.6).

Temperature control results:

With this method of temperature control, results were achieved that exceeded the heating of raw materials to a given temperature much faster than manufacturers (ENDA ET-4420) temperature controllers, as well as a more accurate approximation to the set temperature. The results are entered in the table 1.

Table 1. Temperature control results

Trial	Croplast Time to reach 190 °C min.	Enda control ET -4420 Time to reach 190 °C min .	Croplast Preset temperature accuracy 190°C	Enda control ET -4420 Preset temperature accuracy 190°C
1	42	44	190.3	194.2
2	42.2	46	190.1	193.0
3	42.1	44	190.5	193.6
4	42.1	45	190.3	192.8
5	42.1	45	190.2	193.4
6	42.3	44	190.2	193.7
7	42.1	46	190.2	192.4
8	42.1	45	190.1	192.6
9	42.1	46	190.4	193.3

Analysis of the obtained experimental results showed that thanks to the proposed microcontroller system for stable temperature control, the accuracy of temperature setting (0.4^0C) increases in a lower time (0.3 min.) compared to the existing method (1.8^0C in 2 min.). Thus, experimental studies have confirmed the proposed theoretical calculations.

Conclusion

Full-scale experiments of the constructed microcontroller system showed that it performs its function quite effectively. The experimental data obtained are in good agreement with the theoretical proposals. For the entire cycle of experimental heating and cooling of raw materials, not a single failure occurred. And also there was not a single case of personnel intervention in these systems. The microcontroller temperature control system itself controlled the temperatures within the specified ranges with the specified accuracy. It should be noted that the proposed microcontroller temperature control system is achieved programmatically by entering a program code into the controller.

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ACQUISITION AND ANALYSIS OF DIGITAL CONTROL DIAGNOSTIC MODELS

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ABSTRACT

Technical control and technical diagnostics of vehicles is a set of interrelated methods, technological processes, standards and tools that allow you to establish the serviceable or faulty condition of the entire vehicle as an object, its units, assembly units and systems. Diagnostic tasks arose as a logical continuation and development of control tasks. However, the diagnostic procedure differs from the control procedure, although both control and diagnostics have the same goal - to determine in which of the pre-established set of states the object or system under study is located. Technical control, including automated, is engaged in the establishment of the state of the object as a whole using certain methods and means (for example, operable or failure, serviceable or faulty), while the object itself is considered as a whole. At the same time, the control result does not provide for the establishment of a specific cause that caused the real state of an object or system, the issuance of recommendations for changing this state, or forecasting the state of an object for a given period of time.
Keywords: Technical control, diagnostics, interrelated methods

Introduction

The economic situation that has developed in the energy sector in recent years makes it necessary to take measures aimed at increasing the service life of various equipment. The adoption of efficient techniques for instrumental control and technical diagnostics will go a long way toward resolving the issue of evaluating the technical state of electrical equipment in electrical networks. [2].

Technical diagnostics (from the Greek "recognition") is an apparatus of measures that allows you to study and establish signs of a malfunction (operability) of equipment, establish methods and means by which a conclusion (diagnosis) is given about the presence (absence) malfunction (defect). In other words, technical diagnostics makes it possible to assess the state of the object under study. The primary goal of such diagnostics is to identify and examine the internal causes of equipment failure. External factors are visibly identified [3].

According to GOST 20911-89, technical diagnostics is defined as "a field of knowledge covering the theory, methods and means for determining the technical condition of objects." The object, the state of which is determined, is called the object of diagnosing (OD), and the process of studying OD is called diagnosing. Technical diagnostics' major objective is, first of all, the recognition of the state of a technical system in conditions of limited information, and as a result, an increase in reliability and an assessment of the residual life of the system (equipment). It is characterized by two interpenetrating and interrelated areas: the theory of recognition and the theory of controllability. Recognition theory studies recognition algorithms in relation to diagnostic problems, which can usually be considered as classification problems.

Application (selection) of the type of technical diagnostics is determined by the following conditions:

1) the purpose of the controlled object (field of use, operating conditions, etc.);

2) the sophisticatedness of the controlled item (the complexity of the design, the number of controlled parameters, etc.);

3) economic feasibility;

4) the degree of danger of the development of an emergency situation and the consequences of the failure of the controlled object.

The condition of the framework is portrayed by a bunch of boundaries (includes) that characterize it; while diagnosing a framework, they are called demonstrative boundaries. While picking demonstrative boundaries, need is given to those that meet the prerequisites for the unwavering quality and overt repetitiveness of data about the specialized condition of the framework in genuine working circumstances. By and by, a few indicative boundaries are normally utilized at the same time. Indicative boundaries can be the boundaries of working cycles (power, voltage, current, and so forth), going with processes (vibration, commotion, temperature, and so on) and mathematical qualities (freedom, kickback, beat, and so on.).

Thus, for instance, the quantity of estimated demonstrative boundaries of force transformers and shunt reactors can reach 38, oil circuit breakers - 29, SF6 circuit breakers - 25, flood silencers and arresters - 10, disconnectors (with a drive) - 14, oil-filled estimating transformers and coupling capacitors - 9 [5]. Thus, analytic boundaries ought to have the accompanying properties: 1) responsiveness; 2) expansiveness of progress; 3) uniqueness; 4) steadiness; 5) instruction; 6) recurrence of enrollment; 7) accessibility and accommodation of estimation.

The responsiveness of a symptomatic boundary is the level of progress in a demonstrative boundary when a practical boundary is fluctuated, for example the bigger the worth of this worth, the more delicate the symptomatic boundary is to an adjustment of the practical boundary.

As each value of the functional parameter corresponds to a single value of the diagnostic parameter, and each value of the diagnostic parameter to a single value of the functional parameter, the diagnostic parameter's uniqueness is determined by its monotonically increasing or decreasing dependence on the functional parameter in the range from the initial to the limiting change in the functional parameter. Stability sets the possible deviation of a diagnostic parameter from its average value during repeated measurements under constant conditions.

Latitude of change is the range of change of the diagnostic parameter, corresponding to the given value of change of the functional parameter; thus, the greater the range of change of the diagnostic parameter, the higher its information content.

Informativeness is a property of a diagnostic parameter, which, in case of insufficiency or redundancy, can reduce the effectiveness of the diagnostic process itself (diagnosis reliability).

The frequency of registration of a diagnostic parameter is determined based on the requirements of technical operation and manufacturer's instructions, and depends on the rate of possible formation and development of a defect.

The availability and convenience of measuring a diagnostic parameter directly depend on the design of the object being diagnosed and the diagnostic tool (instrument).

In various literature, you can find different classifications of diagnostic parameters, in our case, for the diagnostics of electrical equipment, we will adhere to the types of diagnostic parameters presented in the source [6].

Diagnostic parameters are divided into three types:

1. Parameters of the information view, representing the object characteristic;
2. Parameters representing the current technical characteristics of the elements (nodes) of the object;
3. Parameters that are derivatives of several parameters.

The diagnostic parameters of the information view include: 1. Object type;

2. Commissioning time and operation period;
3. Repair work carried out at the facility;
4. Technical characteristics of the object obtained during testing at the factory and / or during commissioning.

Diagnostic parameters representing the current technical characteristics of the elements (nodes) of the object are most often the parameters of working (sometimes accompanying) processes.

Diagnostic parameters that are derivatives of several parameters include, first of all, such as:

1. Maximum temperature of the hottest point of the transformer at any load;
2. Dynamic characteristics or their derivatives.

In many ways, the choice of diagnostic parameters depends on each specific type of equipment and the diagnostic method used for this equipment. [9].

Concept and results of diagnostics

Modern diagnostics of electrical equipment (by purpose) can be conditionally divided into three main areas:

1. Parametric diagnostics;
2. Troubleshooting;
3. Preventive diagnostics.

Parametric diagnostics is the control of normalized parameters equipment lines, detection and identification of their dangerous changes. It is used for emergency protection and equipment control, and diagnostic information is contained in the aggregate of deviations of these parameters from the nominal values.

Fault diagnostics is the determination of the type and size of a defect after the fact of the occurrence of a fault has been registered. Such diagnostics is a part of maintenance or repair of equipment and is performed based on the results of monitoring its parameters.

Preventive diagnostics is the detection of all potentially dangerous defects at an early stage of development, monitoring their development and, on this basis, a long-term forecast of the state of equipment [7].

Modern diagnostic systems include all three areas of technical diagnostics in order to form the most complete and reliable assessment of the equipment condition.

Thus, the diagnostic results include:

1. The third determination of the equipment's condition (an evaluation of the equipment's condition);
2. Identification of the type of defect, its scale, location, causes of occurrence, which serves as the basis for making a decision on the subsequent operation of the equipment (putting it out for repair,

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additional examination, continuation of operation, etc.) or on the complete replacement of equipment ;
3. Forecast on the timing of subsequent operation - an assessment of the residual life of electrical equipment.
Therefore, it can be concluded that in order to prevent the formation of defects (or detect them in the early stages of formation) and maintain the operational reliability of equipment, it is necessary to apply equipment control in the form of a diagnostic system.
According to the general classification, all methods for diagnosing electrical equipment can be divided into two groups, also called control methods: methods of non-destructive and destructive testing. Non-destructive testing methods (NDT) are methods for testing materials (products) that do not require the destruction of samples of the material (product). Accordingly, destructive testing methods are methods for testing materials (products) that require the destruction of samples of a material (product).
All MNCs, in turn, are also divided into methods, but already depending on the principle of operation (the physical phenomena on which they are based). Below are the main MNCs, according to GOST 18353–79, most commonly used for electrical equipment:
1) magnetic,
2) electric,
3) eddy current,
4) radio wave,
5) thermal,
6) optical,
7) radiation,
8) acoustic,
9) penetrating substances (capillary and leak detection).
Within each type, methods are also classified according to additional signs.Let us give each method of LSM clear definitions used in the regulatory documents. Magnetic control methods, according to GOST 24450–80, are based on the registration of stray magnetic fields arising above defects, or on the determination of the magnetic properties of controlled products.
The article analyzes the effects of electromagnetic signals of the atmosphere in real conditions of aerospace observations, considers the problems of mathematical modeling of the main characteristics of the Earth's atmosphere for Atmospheric correction of remote sensing data and their adequacy in different time intervals on Con-Cretaceous areas.
In order to verify the adequacy of the mathematical model for assessing the influence of meteorological factors on the relay scattering of electromagnetic waves in the atmosphere, the calculated values of the molecular scattering coefficient were compared with the data for the 0.2-0.4 mm range given in the relevant literature sources, and the adequacy of the model was confirmed based on
In order to study the detailed model possibilities, two variants of computational experiments were carried out, graphs of dependence of relay scattering coefficients on changes in air temperature were established using different values of the air temperature. The graphs show that the influence of air temperature on the relay coefficient is linear, and as the temperature increases, the coefficient increases.

Defects in electrical equipment

Assessment of the technical condition of electrical equipment is the most important element of all the main aspects of the operation of power plants and substations [8]. One of its main tasks is to identify the fact of serviceability or malfunction of equipment.

It is customary to consider equipment serviceable, the condition of which meets all the requirements established by regulatory documents, otherwise it is faulty.

The transition of the product from a good state to a faulty one occurs due to defects. The word defect is used to refer to each individual nonconformity of the equipment.

Defects in equipment can occur at different points in its life cycle: during manufacture, installation, adjustment, operation, testing, repair, and have different consequences [9].

There are many types of defects, or rather their varieties, in electrical equipment. Since acquaintance with the types of diagnostics of electrical equipment in the manual will begin with thermal imaging diagnostics, we will use the gradation of the state of defects (equipment), which is more often applicable in IR control. There are usually four main categories or degrees of defect development:

1. Normal condition of the equipment (no defects);
2. A defect in the initial stage of development (the presence of such a defect does not have a clear effect on the operation of the equipment);
3. A highly developed defect (the presence of such a defect limits the possibility of operating the equipment or reduces its life span);
4. A defect in the emergency stage of development (the presence of such a defect makes the operation of the equipment impossible or unacceptable).

As a result of the identification of such defects, depending on the degree of their development, the following possible solutions (measures) are taken to eliminate them:

1. Replace the equipment, its part or element;
2. Repair the equipment or its element (after that, conduct an additional examination to assess the quality of the repair performed); 3. Leave in operation, but reduce the time between periodic ski surveys (increased control);
4. Carry out other additional tests.

Conclusions

In the conclusion, The main purpose of technical diagnostics is, first of all, the recognition of the state of a technical system in conditions of limited information, and as a result, an increase in reliability and an assessment of the residual life of the system (equipment). It is characterized by two interpenetrating and interrelated areas: the theory of recognition and the theory of controllability. Recognition theory studies recognition algorithms in relation to diagnostic problems, which can usually be considered as classification problems.

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VOLUME 23 ISSUE 02 2023

INTELLIGENT CONTROL SYSTEM FOR SAFE TRAFFIC OF VEHICLES AND OTHER MOVING OBJECTS

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ABSTRACT

Intellectualization of production and processes is one of the applications of information technology and it is always of interest to develop and apply new methods. The creation and use of an intelligent transport system is considered one of the most important tasks in the field of automation. The article review is devoted to the development and operation of an intelligent control system for the safe movement of vehicles and other moving objects.
The basic principles of ensuring road safety are given, the works, standards for the creation and development of transport systems are investigated, the architecture of an intelligent transport system is determined. A simplified top-level logical architecture of an intelligent transport system is presented, which includes task groups, as well as links between them and with external objects. And the physical model includes the functions of the logical architecture, classes, subsystems of processes and placement of places for the implementation of these functions. Classes include: passengers, centers, vehicles, equipment, and telecommunications facilities. The subsystems of the intelligent transport system and the tasks they cover are listed. An intelligent transport system as an integrator of modes of transport can improve the efficiency and safety of transport systems.
Keywords: Intelligent transport system, security, architecture, standardization, simplified, information, new method.

Introduction

The main principles of ensuring road safety (RTS) are:
- the priority of life and health of citizens participating in road traffic over the economic results of economic activity;
- the priority of the responsibility of the state for ensuring road safety over the responsibility of citizens participating in road traffic;
- observance of the interests of citizens, society and the state in ensuring road safety;
- program-targeted approach to road safety activities.

Accidents in road transport is a problem facing most countries in the world.
About a quarter of all accidents occur due to violations of traffic rules (TR) by pedestrians, more than half of the total number of traffic accidents (TA) with injured pedestrians is registered through the fault of pedestrians themselves.
Currently, the process of defining specific functions and powers of various executive authorities is ongoing, and a procedure for coordination in the field of improving the safety of road users is being developed.

The scale of road traffic is constantly increasing all over the world. One of the most important problems is the congestion of the road networks. To date, the world has accumulated significant experience in implementing measures aimed at solving this problem.

These activities are divided into a number of main groups:
- measures aimed at increasing the maximum capacity of road networks (RN);
- measures aimed at improving the efficiency of using the existing RN;
- measures aimed at regulating the volume and structure of transport demand.

Based on the above, various organizations are currently working on the creation of a number of systems (called intelligent transport systems (ITS)). However, a single strategic concept for their creation and development within the framework of a single information environment of the transport complex [1] has not yet been developed. Moreover, the definition of the concept of "intelligent transport system" itself has not been formulated and therefore it is not interpreted in the same way [2].

Intelligent transportation systems can be defined as systems that use a combination of computer technology, communication technology, positioning and automation to improve the safety, control and efficiency of ground transportation systems [3]. These systems are designed to solve problems associated with traffic accidents and the safety of moving objects. For mobile vehicles, communication systems are very important to enable the exchange of several types of information between such control systems and users.

Intelligent transport system is a system that integrates modern information, communication and telematics technologies, control technologies and is designed for automated search and adoption for implementation of the most effective scenarios for managing the region's transport system, a specific vehicle or group of vehicles in order to ensure a given population mobility, maximize indicators use of the road network, increase the safety and efficiency of the transport process, comfort for drivers and transport users [4].

Problem set up. To determine ITS architecture studying the works, standards on creation and development of transport systems.

Solution. The ITS architecture defines the main structure, on the basis of which various design approaches can be developed for its development, as well as the functions of collecting, storing, processing, transmitting information, and others.

The ITS architecture provides a common structure for the development of ITS. It is neither system design nor design principles. Its function is to define a basic structure from which various design approaches can be developed, each designed to meet the specific needs of the user while maintaining the benefits of a common architecture mentioned above. The architecture defines the functions (for example, traffic information collection or route request) that must be performed to provide a particular service to the user, the physical objects or subsystems in which these functions are implemented (for example, roadside or vehicle), interfaces/information flows between physical subsystems and communication requirements for information flow (for ex., wired or wireless). In addition, it establishes and defines the requirements for the standards necessary to support national and regional cooperation, as well as the product standards necessary to ensure the development of a mass production economy.

The ITS architecture provides a framework that links transport and telecommunication systems to enable the development and efficient implementation of a wide range of ITS services for the user. A variety of communication options are available to the system designer. The flexibility to choose between different features gives those implementing them the ability to select a particular technology to suit local, regional or national needs. The architecture defines and evaluates the

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VOLUME 23 ISSUE 02 2023

capabilities of the communication technologies proposed for implementation, but it does not select or recommend "winning" systems or technologies. One of the underlying guiding philosophies in the development of the ITS architecture was the expansion of the use of existing and deployment of transport and communications infrastructures. This reduces the risk and cost of deployment and increases market acceptance, penetration and rapid deployment.
The transport policy of the European Union until 2050 is based on the integrated strategy developed and adopted by the European Commission (the White Book document), which indicates the main tasks for this period in the field of transport development [5]. Its primary comprehensive goals are to increase mobility, remove obstacles in key industries, stimulate economic growth, employment, and ensure the quality of everyday life.

The safety of vehicles and other moving objects can be defined as a set of measures aimed at ensuring the safety of all road users.
In the United States, National Architecture of ITS carries out all work on the creation and development of ITS.
The simplified top-level logical architecture of the US ITS includes groups of tasks, as well as links between them and with external objects [5].
The physical model includes the functions of the logical architecture, classes, process subsystems, and the placement of places to implement these functions. Classes include: passengers, centers, vehicles, equipment, and telecommunications facilities.
The goals of US ITS can be grouped into the following six target groups:
1. Increase the operational efficiency and capacity of the transport system.
2. Increase personal mobility, convenience and comfort of the transport system.
3. Improve the security of the national transport system.
4. Reduce energy consumption and environmental damage.
5. Increase the present and future productivity of individuals, organizations and the economy as a whole.
6. Create an environment in which ITS development and deployment can flourish.
The European framework architecture of ITS (Figure: 1), has significant differences from the US ITS [6]. The European Architecture (also known as the "FRAME Architecture") has a standardization requirement document [7].

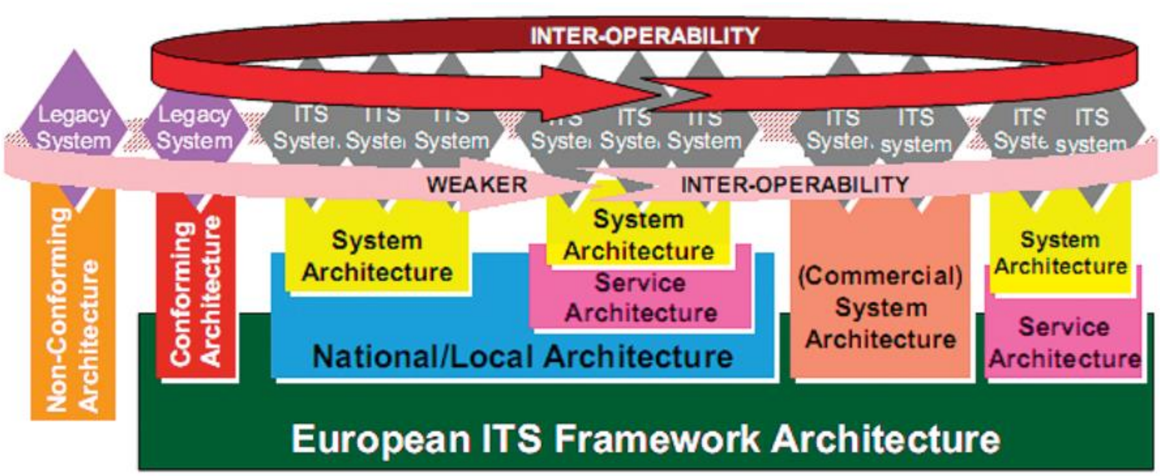

Figure: 1 Relationship between the components of the European ITS architecture

The following world standardization systems have the greatest influence in the field of technical regulation of ITS:
- ISO - International Organization for Standardization, where the scope of ITS is regulated by Technical Committee 204 (Technical Committee 204 - Intelligent Transport Systems);
- CEN - European Committee for Standardization, where the scope of ITS is regulated by Technical Committee 278 (Technical Committee 278 - Road Transport and Traffic Telematics);
- ITS Standards of Japan - Japanese standardization system.

The working groups created in these organizations specialize in the following areas:
- Architecture;
- Systems for the return of stolen vehicles;
- Public transport;
- Parking management;
- Public close communication;
- Human/machine interface;
- Automatic identification of vehicles;
- Broadband communication/protocols and interfaces;
- Freight transport and mobile stock control systems.

The main standardization organizations for the intelligent transport system in Europe are:
- CEN, European Standards Committee;
- CENELEC, European Committee for Electrotechnical Standardization;
- ETSI, European Telecommunications Standards Institute.

The E-FRAME architecture now covers the following areas of ITS:
- electronic collection of payments;
- notification and response of an emergency in the vehicle and on the road;
- traffic management;
- management of public transport; - systems in the vehicle;
- assistance to passengers and road users;
- support for the right to apply;
- cargo and cargo transportation management;
- support for cooperative systems;
- multimodal interfaces.

The E-FRAME architecture includes the following cooperative systems:
- COOPERS (CO-OPerative SystEms for Intelligent Road Safety);
- CVIS (Cooperative Vehicle-Infrastructure Systems);
- SAFESPOT.

The COOPERS system focuses on the development of innovative telematics applications for road infrastructure with the long-term goal of "Cooperative traffic management" between vehicle and infrastructure [8].

The aim of the project is to improve road safety on the road section.

Figure 2 shows European countries, regions and cities where the specified architecture is used or is supposed to be used, as well as countries where other architectures are used [10].

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Figure: 2 Using the FRAME architecture

The International Standards Organization of the Intelligent Transport System (ISO) has "Intelligent transport systems" (Intelligent transport systems).
All three major ITS standardization centers listed above use their own system architecture. These centers carry out work on the mutual harmonization of standards, but its possibilities are limited.
At the world level, standardization is mainly carried out by the International Organization for Standardization ISO (International Standard Organization), and at the European level - by the European Committee for Standardization CEN (Committee European de Normalization) [10, 11].
And yet, there is a global Japanese standardization system: ITS Standards of Japan.
So, ITS can be divided into 4 groups of subsystems:
1. Traveler subsystems.
2. Central subsystems.
3. Subsystems on roadsides.
4. Subsystems in transport.
Traveler subsystems provide access to personal information. It also provides remote travel support.
Central subsystems cover:
- traffic management;
- emergency management;
- radiation control;
- management of commercial transportation;

- planning;
- transit management;
- provider of information services;
- managing the collection of fees;
- management of freight traffic and vehicle fleet.

Roadside subsystems are for highway, parking, toll collection, commercial traffic surveillance.
And, finally, the following types are assigned to subsystems in transport:

- personal transport;
- transit transport;
- commercial transport;
- technical assistance vehicle.

Conclusions

Intelligent transport systems are considered as part of the solution to current and future transport problems. They are increasingly recognized by the international community as a tool for achieving efficient, safe and sustainable mobility that improves the quality of life. ITS as an integrator of modes of transport can improve the efficiency and safety of transport systems, ensure their sustainable development.

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PROBABILISTIC-PHYSICAL MODEL OF GAN:SI RADIATION RECOMBINATION SPECTRA LONG-TERM EVOLUTION DUE TO MICROWAVE RADIATION, WEAK MAGNETIC FIELD AND ELECTRON RADIATION TREATMENTS

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ABSTRACT

The influence of microwave radiation (MR) (2.45 GHz), weak magnetic field (WMF) (60 mT) and electron radiation (ER) (4 MeV) treatments on processes of defects reorganization in near-surface layers of GaN:Si have been studied. Long-term processes of photoluminescence spectra transformations after MR, WMF and ER treatments have been modeled. Our approximation assumes that evolution processes in the defect subsystem of a crystal are random events, and distribution of the random value – the time before a random event – is a subject to the Weibull-Gnedenko law. Qualitative and quantitative agreements between experimental data and theoretical models of long-term observed changes caused by noted treatments have been obtained. According to the proposed approach, the same mechanism could be applied for explanation long-term reorganizations after noted treatments semiconductor material. Moreover, this approach enables to explain non-monotonous behavior of photoluminescence spectra after MF, WMF and ER treatments and could be applied to prediction the consequences of noted actions.
Keywords: Microwave radiation, weak magnetic field, electron radiation, photoluminescence, gallium nitride.

Introduction

Phenomena associated with thermal interaction of MR with semiconductor materials are usually observed at microwave-induced effects. However, this approach cannot explain observed transformations of the semiconductor defect structure in some cases [1, 2]. That is why in [1, 3] as noted that in addition to microwave heating it was necessary to consider non-thermal microwave radiation factors. In addition to this even at the low powers of MR, noticeable changes in the structural parameters of crystals have also been observed without thermal heating of samples. At the same time WMF induced modification of solids at th e energy of three orders of magnitude smaller than the thermal energy of electrons at room temperature is of interest and promising [4-8]. Despite numerous investigations

in these fields and some proposed explanations, the problem of WMF and MR interactions with practically important III-V semiconductors remains open [7, 8].
In this work, possible mechanisms of defect structure transformation at the non-thermal action of MR and WMF on the material have been analyzed using gallium nitride and gallium arsenide semiconductor compounds as examples. Moreover, we propose one general resonance-related mechanism for noted active actions.

Experimental
Objects of our study were the structures of epitaxial GaN doped with Si, thickness ~2.2 μm, was obtained using MOCVD- method on sapphire substrate. The charge carrier concentration was close to $8 \cdot 10^{17}$ cm^{-3}. We studied steady-state photoluminescence (PL) at room temperature in the 350–650 nm wavelength range using a Perkin-Elmer LS55 PL luminescence spectrometer, with an error below 0.5 nm, at the excitation light wavelength of 315 nm and emittance of 5 μW/cm^2.
Since absorption coefficient of structures under investigation in studied spectral region is ~10^5-10^6 cm^{-1}, we shall analyze surface layer with thickness <100 nm.
The PL spectra of the samples were measured for the extended period after microwave treatment (up to 90 days). Microwave treatment of the samples was carried out at the frequency 2.45 GHz and power 7.5 W/cm^2. The duration of exposure was 60 s. The total exposure time was accumulated with 5-s periods of microwave irradiation and 3-min pauses between these periods. The temperature of our samples was measured using a thermocouple. WMF treatment was carried out at room temperature with a weak pulsed magnetic field with the parameters: B = 60 mT, f = 10 Hz, τ = 1.2 ms for 10 min.
Third group of samples have been irradiated by a pulsed beam of electrons with energy of 4 MeV, generated by a linear electron accelerator "Electronics". Pulse duration and pulse tracking period were t=4.3 μs and t=5 ms, respectively. The beam current density (average value per second) was j=0.5 μA/cm^2. Samples have been irradiated to obtain equivalent dose 10^7 rad.
The specimens receiving no MR, WMF and ER treatments were used as the reference ones. All measurements were repeated after the treatment to reveal the time dependent.

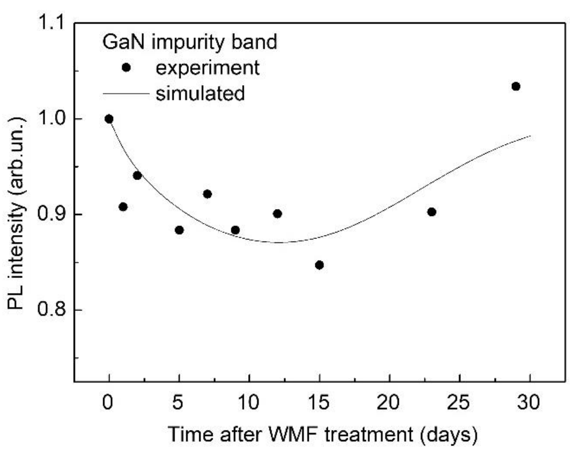
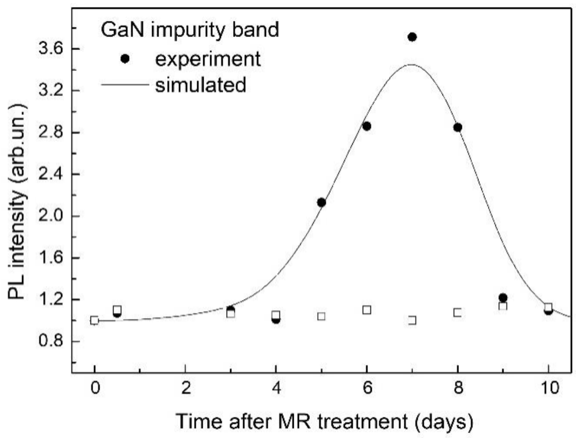


Figure 3: The variation of the normalized PL intensity of impurity bands of GaN:Si as a function of time after WMF treatment (dots – experiment, line – averaging, empty squares for control sample)



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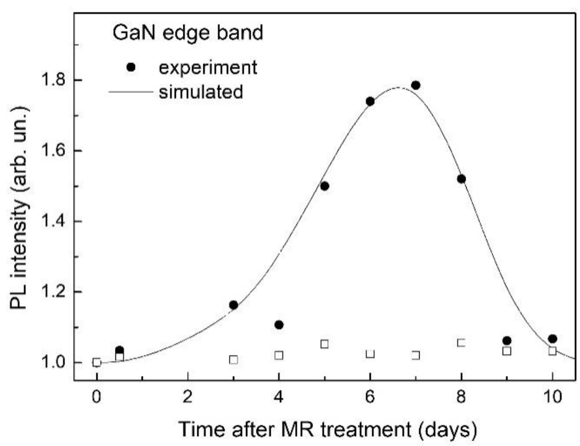

Figure 3: The variation of the normalized PL intensity of impurity bands of GaN:Si as a function of time after WMF treatment (dots – experiment, line – averaging, empty squares for control sample)

Results and discussion

The initial PL spectrum of GaN-structure consists of two bands peaking at about 3.42 and 2.34 eV. The first peak is attributed to near-edge emission. The second one is assigned to the complex with VGa cooperation [9] and apparently is not trivial. Moreover, according to [9] radiative transitions take place not from donor (D) to VGa as it is often interpreted, but from a distant donor or from the conduction band to the VGa+D complex. Changes in the PL band intensities after the MR treatment were non-monotonous for GaN-based structures (Fig. 1, 2). First, the band intensity increases, but later it decreases to the initial values or close to them. The obtained results testify about the change of impurity-defect composition of near-surface layer in GaN crystals due to the influence of MR.

The intensities of the PL bands of studied structures after WMF treatment generally decrease, but over some relaxation period they return to a previous value or close to it. The observed long-time non-monotonic changes in the intensities of PL bands after MF treatment are similar to that, observed at MR treatment. This fact can testify about general physical transformation in near-surface layer, which formed PL signal.

To describe observed features let's assume that the physical processes are caused by random events, and the corresponding random variables – the times before the events – obey the distribution Weibull-Gnedenko [10].

We introduce the following random events: a random event – movement of a defect (dislocations, gallium vacancies) from the near-surface region to the surface (boundary) and a random event – movement of a defect to the near-surface area from the epitaxial layer (source) bordering with the near-surface area and commensurate with the sizes of the latter. Once again, we emphasize that the near-surface area means the thickness of the layer, in which the electron-hole pairs generate, when this layer is exposed to light of PL excitation. Then, the random variable is time to a random event. Accordingly, *F1(t)* is the function of time distribution before movement of the defect from the near-surface area to the boundary (the probability of movement from the near-surface area to the boundary); *F2(t)* is the function of time distribution before movement of the defect to the near-surface area from the source (the probability of movement to the near-surface area from the source). Let's consider a new random event – the absence of a defect in the near-surface area. This event is complex and consists of random event – the movement defect from the near-surface area to the boundary – and a random event – the absence of the movement of a defect to the near-surface area from the source. Let us assume that these events are independent. Then the probability of this complex event is the product of the probabilities of the events constituting:

$$P_{1-2} = F_1(t)[1 - F_2(t)], \quad (1)$$

where

$$F_1 = 1 - exp\left(-\left(\frac{t}{\tau_1}\right)^{m_1}\right), \quad (2)$$

and

$$F_2 = 1 - exp\left(-\left(\frac{t}{\tau_2}\right)^{m_2}\right), \quad (3)$$

where τ1 and τ2 are the time constants of random events; m1 and m2 – form factors of the time distribution function before corresponding random event. Accordantly time dependence of PL intensity could be fitted by expression

$$I(t) = I_{in} \pm I_0\left\{\left[1 - exp\left(-\left(\frac{t}{\tau_1}\right)^{m_1}\right)\right] exp\left(-\left(\frac{t}{\tau_2}\right)^{m_2}\right)\right\} \quad (4)$$

where Iin is the initial value of the PL band intensity, I0 – proportionality factor [11, 12].

The results of approximation of changes in the PL intensity for impurity bands in GaN:Si epitaxial structure by the least squares method with expression(4),areshownonFig.1-3.Onecannote a good agreement between the experimental and theoretical results.

Table 1. Estimated diffusion coefficients.

Treatment	Effective diffusion coefficient
MR	$(1.6\text{-}1.7)\cdot 10^{-14}$ cm^2/s
WMF	$(1.2\text{-}1.3)\cdot 10^{-14}$ cm^2/s
ER	$(0.8\text{-}1.9)\cdot 10^{-14}$ cm^2/s

We estimated the parameters that characterize transformation of the defect structure. If the movement of defects has diffusive character, in accordance with [10]

$$D_{diff} = \frac{d^2}{\tau_1}, \qquad (4)$$

where D_{diff} is the effective diffusion coefficient, and d – thickness of the layer in which the electron-hole pairs are generated under exposure to light of photoluminescence excitation. In our experiments, for the latter d is of the order 10^{-7} ...10^{-6} m. Effective diffusion coefficients data are collected in Table 1.

One can conclude two main features. The first one is the present of general long-term model of PL spectra transformation, which can be applied when long term processes take place after treatments (MR, WMF or ER). And the second one is in similar effective diffusion factors, which have been obtained at estimation by using expression (4). The last features could testify about the same (or with similar configuration) defects, which react on external treatments.

Resonant-related mechanism

We propose, that under resonance conditions (the coincidence of eigenfrequencies of the dislocation segment vibrations and electrical component of MR), multiple dislocation loops occur. A released loop by the source creates mechanical tensions at the location of the source. These tensions block further generation of dislocation loops, when their certain "critical" value is reached. The considered mechanism of dislocation multiplication influences both internal stresses of the crystal and curvature of the lattice. Their changes relax with time due to increasing the size of dislocation loops and/or their ordering. Along with the multiplication of dislocations caused by microwave radiation treatment, their movement can take place, when an energetic barrier is absent. The initial quasi-equilibrium state of the crystal changes in the elastic field of moving dislocation. The concentrations of point defects and impurities, level and sign of internal tensions change too. New state of the material is non-equilibrium, and crystal relaxes to the initial one or close to it for some time interval.

If we place the III-V semiconductor crystal in a uniform constant magnetic field, electrons, which have scalar effective mass, starting to move along helical paths, i.e. screw lines, with the axis which coincide with the magnetic field direction. The angular speed of rotation of an electron is called a cyclotron (Larmor) frequency. Since the rotation of electron occurs with acceleration which has constant magnitude and directed perpendicular to the velocity, it is a source of radiation of electromagnetic waves at a certain frequency. So, we have previous case with MR treatment.

If we consider components of impurity complexes, responsible for the observed emission, as ions, the equation of the motion of ions is given by the harmonic oscillator with the ion-plasma frequency:

$$\omega = \left(\frac{e^2 N}{\varepsilon \varepsilon_0 \mu}\right)^{\frac{1}{2}} \qquad (5)$$

where μ is the reduced mass of the ion pair, N – concentration of impurity. If the frequency of the electromagnetic wave coincides with the plasma frequency of impurity ions, one can observe a resonance phenomenon accompanied by a significant increase in the amplitude of oscillations of ions and further destruction of impurity complexes.

In case of dislocation, as shown in [3], anchored at the ends have their own (basic) frequency of vibration ωd equal to

$$\omega_d = \left(\frac{\pi^2 G}{L^2 \rho}\right)^{\frac{1}{2}} \qquad (6)$$

where G is the shear modulus, ρ – bulk density of material, L – dislocation length. When the dislocation is electrically charged and fixed by two stoppers at the ends, the frequency of the electromagnetic radiation is equal to the frequency of intrinsic oscillations of dislocation ω, and then under the influence of the electric component of an electromagnetic wave, the phenomenon of resonance is observed. At the resonant frequency, the amplitude and energy of oscillations sharply increase at low damping. As soon as the energy of oscillations exceeds the binding energy of the dislocation with stoppers, the dislocation detaches and becomes able to move. However, this effect is characterized by strong selectivity of lengths of detached dislocations to the frequency of microwave radiation.

Our calculation resonance frequency for the epitaxial structures under investigation with the concentration of a doped impurity NSi=8·1017 cm-3 gives ν = 2.1 GHz. The obtained value ofthe ion-plasma frequency is sufficiently close, but, nevertheless, differs from the radiation frequency of microwave generator νem=2.45 GHz.

Thus, the evolution of the defect subsystem in III-V semiconductor structures under the action of MR and WMF is caused by the resonance effects of the microwave radiation with wide range of frequencies. In case of magnetic field this radiation induced in the semiconductor crystals by free electrons, which moved by circular trajectories in magnetic field. The observed features of long-term changes of PL intensities of the observed bands are well described by physical-statistical model of behavior defects. Moreover, it was found that MR and WMF treatments could be use dalong with thetraditional methods of modification of III-V semiconductors near-surface layer, but in non-trivial and cost-effective way. Long-term processes of defect reorganization in GaN due to the 4 MeVelectron irradiation were detected. The radiation “memory effect” in wurtzite GaN was detected by PL measurements as well as “magnetic memory effects” was observed in [5,13-16] at magnetic field treatment. Proposed approach of long-term processes modeling could be applied to estimate diffusion factors of migrating defects which appeared after external treatments.

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FIBER OPTIC SENSORS

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ABSTRACT

In addition to the benefits, recent developments and cost reductions have sparked interest in fiber optical sensing. In order fiber optic sensors must be made, researchers integrated optoelectronic devices with fiber optic telecommunications' byproducts. In the past few decades, numerous studies using various research methods and fiber optic sensors have been carried out. The most popular sensor types for fiber optics are those based on intensity, phase, and wavelength. An overview of optic sensors and their uses is provided in this paper.
Keywords: Fiber optics, smart systems, interferometry, microbending, and fiber Bragg gratings (FBGs)

Introduction

The development of the laser in the 1960s sparked a surge in interest in optical data transmission systems. Researchers were inspired to investigate fiber optics possibilities for data communications, sensing, and other uses by the advent of the laser. Compared to microwave and other electrical technologies, laser systems could convey far more data. The unhindered passage of the laser beam through the air was the focus of the first laser experiment. Researchers also performed tests by passing laser beams through various waveguide designs. The preferred medium for light transmission was soon glass fibers. Initially, optical fibers couldn't completely replace coaxial cables because of their significant losses. Early fibers couldn't be used because of losses of around 1000 dB/km.

In 1969, various scientists came to the conclusion that the signal loss in optical fibers was caused by imperfections in the fiber material. It was able to create low-loss optical fibers by eliminating these contaminants. Corning Glass Works produced multimode fiber in 1970 with losses under 20 dB/km. The same manufacturer created a high silica-core multimode optical fiber in 1972 with a 4 dB/km loss.

The telecommunications sector has undergone tremendous transformation as a result of recent developments in fiber optic technology. The capacity of optical fibers to transmit gigabits of data at the speed of light expanded their research potential. Similar new product sectors emerged as a result of concurrent advances and cost reductions in optoelectronic components. The last revolution was the result of designers fusing optoelectronic technology with fiber optic telecommunication by products to produce fiber optic sensors. It was soon found that one could perceive changes in phase, intensity, and wavelength from external perturbations on the fiber itself when material loss nearly vanished and the sensitivity for detection of the losses increased. Fiber optic sensing was created as a result.

Concurrent with these developments, fiber optic sensor technology has been a significant user of optoelectronic and fiber optic communication industry technologies. These industries frequently use components that were originally created for fiber sensor applications. In turn, the creation and ensuing mass manufacture of components to service these businesses has frequently been the

driving force behind fiber optic sensor technology. Fiber optic sensors are more capable of displacing conventional sensors as component costs have declined and quality has improved.
Following are some of the many benefits that fiber optic sensors have over traditional electronic sensors for detecting environmental changes:

- Due to their tiny size and cylindrical design, they are simple to integrate into a broad variety of structures, including those made of composite materials, with minimal interference.
- Non-conductivity of electric current.
- Immune to radio frequency and electromagnetic interference.
- Lightweight.
- Robust, more resistant to harsh environments.
- High sensitivity.
- Using multiplexing to create sensor networks.
- Remote sensing capability.

In order to monitor a variety of environmental characteristics, including location, vibration, strain, temperature, humidity, viscosity, chemicals, pressure, current, electric field, and a number of other environmental elements, fiber optic sensors have been employed extensively.
Fiber Optic Basics
The core, cladding, and coating or buffer are the three components that make up an optical fiber. Figure 1 depicts the fundamental structure. Typically formed of glass, the core is a cylindrical rod of a dielectric substance. Light primarily travels down the fiber's core.

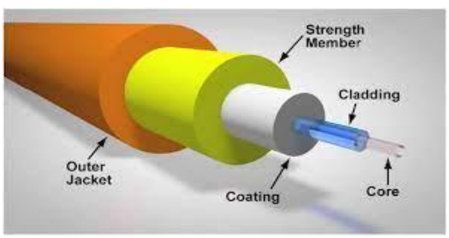

Figure 1. Fundamental design of an optical fiber

An index of refraction-containing dielectric substance serves as the cladding layer's material. The cladding material has a lower index of refraction than the core material. Typically, either glass or plastic is used for the cladding. The cladding performs tasks include reducing the amount of light that escapes the core into the surrounding air, reducing scattering loss at the core's surface, shielding the fiber from impurities on the surface, and boosting mechanical strength.
An optical fiber is shielded from physical harm by a layer of material known as a coating or buffer. A sort of plastic is the substance that buffers are made of. The buffer's elastic nature shields against abrasions.
A dielectric substance having an index of refraction is used to create the cladding layer. The cladding material's index of refraction is lower than that of the core material (see Figure 2). Typically, glass or plastic is used for the cladding. The cladding performs tasks such reducing light loss from the core into the surrounding air, reducing scattering loss at the core's surface, shielding the fiber from absorbing surface impurities, and boosting mechanical strength. A layer

of substance called a coating or buffer is used to shield an optical fiber from physical harm. A particular kind of plastic is utilized to make buffers. Because it is stretchy, the buffer guards against abrasions.

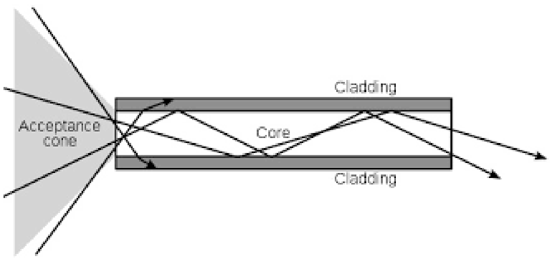

Figure 2. In an optical system, total internal reflection

Principles of Fiber Optic Sensors

The general design of an optical fiber sensor system is shown in Figure 3. It has a sensor or modulator element, an optical detector, processing circuitry, and an optical source that turn the measurement into an optical signal (such as a laser, LED, laser diode, etc).

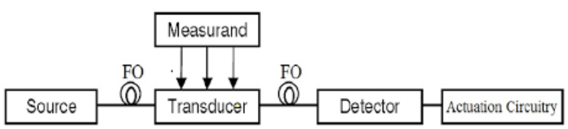

Figure 3. Basic components of optical sensor

System

Three groups can be used to categorize fiber optic sensors: the application, the working principle, and the location of the sensor. Depending on where it detects, a fiber optic sensor can be classified as intrinsic or extrinsic. An external optical device, where the sensing takes place, is only transported light to and from via a fiber optic extrinsic sensor (Figure 4). In these cases, the fiber just acts as a delivery system for light to the location of the sensing.

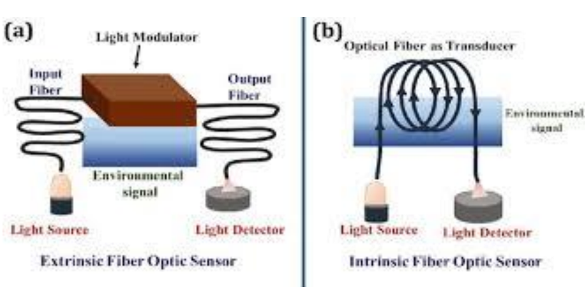

Figure 4. Types of fiber optic sensors that are intrinsic and extrinsic.

However, one or more of the fiber's physical properties change in an intrinsic fiber optic sensor (see Figure 4). As a result of perturbations, the fiber changes several properties of the light within of it.
Fiber optic sensors can be categorized as an intensity, phase, frequency, or polarization sensor depending on how modulation and demodulation work. Due to disturbances from outside sources, all of these factors are potentially changeable. Thus, By identifying these characteristics and their changes, the external disturbances can be observed.
Depending on its use, a fiber optic sensor can be categorized as follows:
• Physical sensors: These are devices that measure things like temperature and stress.
• Chemical sensors: Used for spectroscopic research, gas analysis, pH measurement, etc.
• Biomedical sensors: These devices are used in biomedical applications to assess things like blood flow and glucose levels.

Fiber optic sensor types

4.1. Intensity-Based Fiber Optic Sensors

Fiber optic sensors that measure intensity rely on some signal loss. They are created by converting the measurement's force into a force that bends the fiber and weakens the signal using an equipment. The signal can also be weakened by a target's absorption or scattering. Since More lighting is needed for the intensity-based sensor, multimode large core fibers are typically used The optical intensity transmitted by an optical fiber may fluctuate as a result of a number of measurand-induced effects, such as microbending loss, attenuation, and evanescent fields. Benefits of these sensors include their simplicity of use, low cost, ability to multiplex, and ability to perform as real distributed sensors. The drawbacks are as follows: In the absence of a reference system, relative measurements and variations in the intensity of the light source may lead to inaccurate readings.
The microbend sensor is one of the intensity-based sensors. It is predicated on the hypothesis that mechanical periodic micro bends could lead to a coupling of the guided modes' energy to their radiation modes, which would then attenuate the transmitted light. Figure 5 illustrates how the sensor is made up of two grooved plates with an optical fiber running through them.

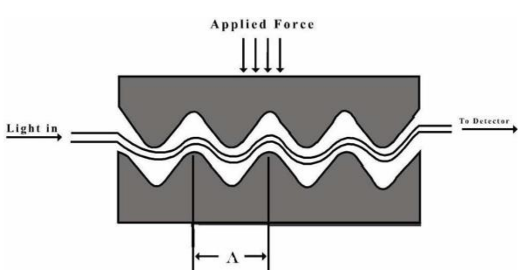

Figure 5. Intrinsic fiber optic sensor.

4.2. Wavelength Modulated Fiber Optic Sensors

Sensors with wavelength modulation employ variations in light's wavelength to make a detection. Wavelength-modulated sensors include the Bragg grating sensor, black body sensors, and fluorescence sensors. Fluorescent-based fiber sensors are widely used in medical applications, chemical sensing, and physical parameter measurements such as temperature, viscosity, and humidity. There are numerous configurations for these sensors; Figure 6 shows two of the more common ones. Light goes down the fiber to a fluorescent material probe for the end tip sensor. The resulting fluorescent signal is then recorded on the same cable and returned to an output demodulator.

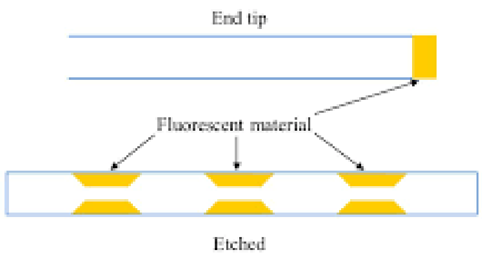

Figure 6. Fiber optic sensor probe that is fluorescent

Figure 7's representation of a blackbody sensor illustrates one of the most basic wavelength-based sensors. An optical fiber is finished with a blackbody cavity. The hollow begins to glow and function as a light source as the temperature increases. The contour of the blackbody curve is then determined using detectors and narrow band filters. This kind of sensor has been successfully marketed and used to measure temperature under strong RF fields to within a few degrees centigrade.

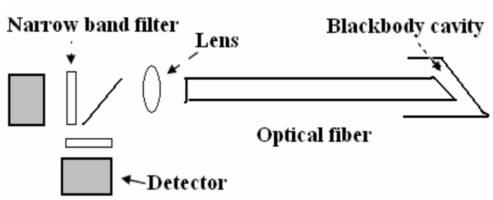

Figure 7. Blackbody fiber optic sensor

The Bragg grating sensor is the most used wavelength-based sensor. By creating regular changes in the index of refraction in the core of a single mode optical fiber, fiber Bragg gratings (FBGs) are created. Exposing the fiber core to a strong UV interference pattern causes this periodic shift in index of refraction to occur. The resulting refractive index fluctuation creates an interference pattern that functions as a grating.

4.3 Polarization-Modulated Fiber Optic Sensors

The direction of the electric field component of the light field determines the polarization state of the light field. The light field can be polarized in three different ways: linear, elliptical, and circular. The electric field's direction always remains in the same direction during the propagation of light for the linear polarization condition. The direction of the electric field shifts during the propagation of light for the elliptical polarization condition. Elliptical polarized light is so named because the electric field vector's end has thiss hape.

Stress or strain causes a fiber's refractive index to alter. Due to the induced pH difference between the various polarization directions. The photoelastic effect is the name of this phenomenon. Additionally, the term "induced refractive index" refers to the refractive index of a fiber that has undergone a specific stress or strain. The induced refractive index varies with the direction of applied stress or strain. Induced phase difference between various polarization directions results as a result. In other words, the optical fiber behaves as a linear retarder when subjected to an external perturbation like stress or strain. Therefore, changes in the output polarization state can be used to detect the external disruption.
The optical configuration for the fiber optic sensor based on polarization is created by polarizing the light coming from a light source using a polarizer, which could be a piece of fiber that maintains polarization. A length of bi-refrigent fiber that preserves polarization is used to launch the polarized light at a 45° angle to the chosen axes. This fiber segment serves as a sensor fiber. In reaction to an external perturbation like stress or strain, the phase difference between two polarization states shifts. Following that, the output polarization state is altered in line with the perturbation. As a result, by looking at the output polarization state at the fiber's exit end, the external disruption can be identified.
Conclusions
An overview of fiber optic sensors and their applications has been provided. Among the major sensor categories studied were microbending sensors, evanescent wave sensors, FBGs, optical fiber interferometers, and polarization modulated fiber optic sensors.

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MATHEMATICAL MODELLING OF THE PROCESS OF QUALITY CONTROL OF CONSTRUCTION PRODUCTS

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ABSTRACT

The study's abstract summarizes the findings of years of research in the area of quality management of industrial production and construction production, which were based on mathematical modeling techniques, process, and outcomes of implementing the developed program of monitoring and quality control in the enterprise's production process. The objective of this work is to show to the scientific community the useful outcomes of mathematical modeling in software applications. Quality control and safety represent increasingly important concerns for project managers. Defects or failures in constructed facilities can result in very large costs. Even with minor defects, re-construction may be required and facility operations impaired. Increased costs and delays are the result. In the worst case, failures may cause personal injuries or fatalities. Accidents during the construction process can similarly result in personal injuries and large costs. Indirect costs of insurance, inspection and regulation are increasing rapidly due to these increased direct costs. Good project managers try to ensure that the job is done right the first time and that no major accidents occur on the project. The research focused on describing applicable mathematical models, viewpoints, and practical outcomes of their use in the applied sector to evaluate quality control. This mathematical model was applied by the authors. The outcomes of using this approach are presented in the article. By utilizing mathematical modeling techniques, the authors created an experimental software management and quality assessment system. The authors continue their study in this area to enhance prognostic and diagnostic processes based on mathematical modeling methodologies for diagnostic systems and quality management systems.. The independent quality control, which was based on some traditional inspection techniques and used mathematical modeling techniques, revealed a negligible partial discrepancy in the results of the estimation, proving both the efficacy of the product and the suitability of the mathematical modeling concept.
Keywords: Quality control, mathematical modeling, construction quality.

Introduction

The suggestion that there should be established some approaches of objective quality control to be systematized as a full management comes from the systematization of the quality control of construction products. It should be clear that this specific stage can only be completed if the system contains algorithms for determining estimating indicators and algorithms, management, and the outcomes of production process analysis. Since the quality of production immediately affects realization, modernization, and production costs, including those unjustifiable losses resulting from optimizing the production cycle and output in light of the needed standards, genuine quality management now means financial management. This article presents the findings of the authors' extensive research in the area of quality management of construction production, which was based on a number of mathematical techniques for process modeling and the outcomes of implementing the quality management system they had created in the production process.

The historical context

In Russia and beyond the border, quality management has been extensively researched over the past 300 years; nonetheless, there are still a number of issues that have not been resolved. Every new era calls for new techniques and plans since there is a need to go to a higher degree of technology and more sophisticated modes of production and management. Since the initial conceptual models proposed by Adam Smith [1, 142-145] and Karl Marx [2, 76-78], who assumed that prognostic analysis and management by means of objective models, from mathematically justified ones to those of automatic control, could be possible, a significant amount of ground has been covered. L. B. Zelentsov's works,

"Optimization model of quality management system in construction," A. L. Zelentsov and K. N. Ostrovsky Organizational Mechanism of Management of Quality in Construction in Self-Regulation, A. L. Zelentsov, 3 V. V. Kostuchenko, [4] D. O. Kudinov, "Informative Provision of Construction Systems Management," [5], M. Assyra, V. Pogorelov, and V. Kostuchenko Controlling Investment Strategy and Innovation in Underground Construction [6]. Control the panel construction's quality, according to S. L. Avir Quality Management in Building Trust, L. I. Pokrass, p. "Reliability of designs of operational buildings," by A. G. Roitman, 8 The use of mathematical techniques to apply a scientific and methodological approach to the idea of quality management is demonstrated in [9].

The conceptual monographs "Methods of mathematical modeling" and "Mathematical modeling of complex subsystems" by Y. F. Blinov, V. Ivantsov, and P. V. Serb provide significant support for the practical use of mathematical modeling [10, 11]. I.V. Chervjakov's "Mathematical model of quality control based on the theory of interval estimation" and "Competence and output quality control" have both made major contributions.

Reliability theory and quality control mathematical techniques To develop techniques of estimating and product quality control using mathematical modeling, see "Methods of Quality Management" [12–14].

Studies have always placed a strong emphasis on control and quality management, and new publications on challenging topics related to this multifaceted issue are constantly being released. The following scientists ought to be mentioned here: Investments in an Unstable Economic System by O.A. Pobegailov O.V. Kliuchnikova and O.A. Pobegaylov, "Rationalization of Strategic Management Principles as a Tool to Improve a Construction Company Services," Terra Economicus Scholar V. 2-2, No. 10, 2012, pp. 35–38 [15], [16.]

Diagnostic algorithms and mathematical models for quality estimation

The most important issue to be resolved through quality control in building production is the development of a quick and mathematically verified method for estimating and revealing the flaws of building production. The algorithms for identifying technical, technological, and remedial faults are strongly related to the methods of mathematical modeling for estimating production quality and, consequently, the management of production [11].

Production demonstrates a specific random number generator and concrete quality sign values in terms of mathematics. A batch is a collection of values, or quality indicators, that are typically

obtained sequentially and under identical circumstances (homogeneous raw materials, consistent technological operating procedures, the same equipment maintained in good working order, etc.). A batch serves as a sample of the infinite set produced by production under the aforementioned conditions. Following a set of regulations, the batch, which is the subject of business, legal, and judicial relations between the supplier and the customer, transforms into a stand-alone carrier of quality, expressed quantitatively in the form of a group indicator (more often as a share of inappropriate units of production in batches or numbers of discrepancies per hundred units of production) Consequently, the group quality indicator is the a broad indication that considers the quality of each individual product in the batch as a whole [12]. The mathematical components of the quality assurance model are obtained directly from a depiction of
a technical process as a generator of random integers, or quality indicators. The outcomes of quality control provide information about the characteristics of the product as well as the characteristics of the production process, including its management techniques. When production is completely under control, is being studied, and is resistant to rules and outside influence, acceptance control of production becomes less important [14].

With the boundary values of the expected value of quality indicators at a known dispersion and bilateral limits, mathematical approaches enable the definition of the level of discrepancies in the batch or in the technical process, divided up into stages. The degree of discrepancies in the batch of construction products or a series of technological procedures can therefore be communicated between the interval and dot estimations of the group quality indicator.

The models of distribution of quality indicators and the model of the quality assurance process, both of which are discussed within the context of the general theory of decision-making under uncertainty, should be clearly distinguished from one another. The results of selective control under the defined plans, based on the statistical models of distribution of quality indicators, should be utilized to arrive at some fair conclusions on the quality of production and efficiency of the general management of the supplier [14,15]. The reliability of the control results then decreases where the modeling representations about the distributions of indicators are simplified, for example, as a result of replacing the hypergeometrical distribution with a more straightforward - binomic or Puasson one, according to the strict mathematical form, which allows for some corresponding estimations.

In light of this, one should unquestionably and unambiguously define the level of trust for an interval estimation of the population mean, compatible with the risks of the final or intermediate consumer at controlling the supplier as well as the risks of the supplier at controlling the consumer [12,19], based on the principle of domination of the general theory of decision-making under uncertainty.

The acceptance factor remains the same as in the case of a known dispersion, and the sample volume of estimated production increases by 1 K times, it was demonstrated using the asymptomatic normal property of unknown dispersion, as well as in systems based on dot estimation at unilateral restriction of an indicator of quality.

For cases with the bilateral restriction of indicators of quality, the authors offer a
method of constructing an area of unconditional trust for the joint distribution of the population mean and a dispersion in the form of an initial ellipse of the dispersion, the semiaxes of which in t^* λb co-ordinates only depend on sample volume n and trust factor γ.

So, here we are

$$\frac{t^2}{a_{el}^2} + \frac{(\lambda_b - 1)^2}{b^2{}_{el}} \quad (1)$$

are ellipse semi-axes

The semi-axes of a real ellipse of dispersion are linearly connected to semi-axes of well-accepted

$$a_x = x + a_{el} * \frac{s}{\sqrt{n}} \text{ and } b_x = b_{el} * s^2, \quad (2)$$

where X and s^2 – are selective average and dispersion respectively.

This specific technique for creating a private space is independent of the distribution style because it is carried out using the principles of maximum credibility and regularity. Additionally, in order to find the efficiency values (interval borders) of the effectiveness function, which depend on the population mean and a dispersion, one needs search along the boundary of a genuine ellipse of dispersion [14].

We have provided a method of multiple parameter quality assurance based on structural methods of reliability and the well-known theorem of integrity of a chain of consistently connected elements. This method enables estimation of the top confidential border of the level of discrepancies of a complex product based on the outcomes of independent control of the elements of the object or process under study. The top confidential border of the level of discrepancies of the ready-made object, according to the authors, only depends on the degree of trust and the minimal volume of sampling from the individual plans of control of each parameter and should be calculated using the renowned Kloper-Pirson formula [14, 20].

1) Multiple-parameter control is useful for evaluating the degree of discrepancy of a complex product or process based on the outcomes of controlling their constituent aspects

2) multiple-parameter control is essentially not a "filter - divider"of the production into fit and unfit; this type of control is expedient for being applied for estimating the level of discrepancies of a complex product or process judging by the results of controlling their constituent elements;

3) settlement value of the level of discrepancies in this method does not depend on the quantity or complexity of those individual parameters that define the quality of the "compound" product.

4) When controlling using this method, the decision-making rule has been reduced to the "fit - unfit" alternative which allows to avoid extra assumptions and also controlling the type of distribution of some individual resulting quality indicators.

Therefore, using the interval estimation theory along with the principles of decision-making under this idea, it is possible to:

1) to increase the accuracy and usefulness of the results of building production quality assurance in regard to both the final products and the technological processes involved.

2) to make the selection or computation of the parameters of the target plan of control and the actual operation of control simpler than with standard monitoring systems.

3) to ensure that the TQM general ideology's control procedures adhere to several ISO 9000 regulations.

4) Using these results to gauge the general management of the business, interpret the control results as the outcomes of quality measurements.

Acknowledgements

Experience using experimental work in practice.

Using the above-described mathematical modeling techniques, the authors have created an experimental piece of software to aid in quality control and estimate.
A certain quantity of data on the quality management of building production has been collected and systematized thanks to this application for assessing the actual operations of the building businesses LLC RP Stroymekhanizatsiya -, LLC Palmira, JSO Assembler, and JSO Sigma.
Table 1 displays some key findings from the author's research. in higher education.
ΔXн - standard tolerance, n - sampling size. - average index. - standard deviations of parameters. Ks - conformity to norm factor. Kd - absence-of-defects. KT - parameter of technological process accuracy. Sd - criticality defect parameter. In the denominator, the values of longonormal distributions with parameters are shown.
Therefore, the parameters governing the thickness of mortar seams, reinforcing, and some geometrical facets of masonry work exhibit the highest variances. According to the criticality parameter's value, the defects in brick durability, horizontal seam laying, and reinforcing should be considered critical flaws, while other variations should be considered less severe.
Given their significance, important flaws must be quantitatively analyzed to identify the root causes of these deviations, particularly flaws in the horizontal seams and concrete fabric. Table 1 displays the findings from tracking the average for all objects' group quality attributes.

Table 1. Results of system quality assurance of building production.

Quality parameter group	K_s	K_d	K_t
indicators of Material	0.69	0.62	0.48
indicators of Geometrical	0.81	0.70	1.16
Indicators of bonding elements	0.72	0.61	0.12
Indicators of of seams	0.61	0.52	0.58
Non-critical geometrical indicators	0.82	0.77	0.96

Given their significance, important flaws must be quantitatively analyzed to identify the root causes of these deviations, particularly flaws in the horizontal seams and concrete fabric. Table 2 displays the findings from tracking the average for all objects' group quality attributes.

Table 2. Values of group parameters of quality

Controllable, Departures from the parameters	$\Delta X_н$ ($X_н$)	n	Kc, *Sc*	K_d	K_t	C_d	$\bar{X}\mu$	σ
Stone (brick) endurance, МПа	-	87	2.32	3.34	0.82	0.80	0.63	40
Mortar toughness at seams, МПа	-	125	5.75	5.04	0.93	0.89	0.51	30
Concretized material, mm	±5	303	-1.28	10.21	0.66	0.55	0.44	20
Concrete fabric spacing, rows	-	225	1.80	1.89	0.36	0.24	0.33	90
Horizontal seam thickness, mm	-2 +3	380	3.41	5.48	0.62	0.47	0.44	48
Wall element thickness, mm	±15	326	5.85	8.80	0.88	0.84	1.38	10
Wall axial deviation, mm	±10	292	-0.28	5.63	0.95	0.88	2.12	20
Wall vertical deviation, mm	10	300	6.83/	6.03/	0.83/	0.7/	0.32/	20

			1.5	0.9	0.8	0.8	0.9	
Deviation of marks of support, mm	-10	446	-2.10	6.23	0.65	0.53	1.09	5
Opening size, mm	+15	304	7.97	10.76	0.76	0.63	0.90	5

Conclusions

The independent quality control, based on some conventional methods of inspection and employing mathematical modeling techniques, has revealed a negligible partial discrepancy in the results of estimation, demonstrating both the effectiveness of the product and the suitability of the mathematical modeling idea. The goal of the authors' ongoing research in this area is to improve diagnostic and quality control systems by basing them on mathematical models of prognostic and diagnostic processes.

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INTELLECTUAL TECHNOLOGIES IN THE MANAGEMENT OF OIL FIELDS

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ABSTRACT

The goal of this effort is to create new strategies and enhance the control over oil-producing wells and an oilfield using artificial intelligence techniques. The advancement of knowledge necessitates the implementation of intelligent technologies with the objective of creating a unified scientific and technological oilfield space. Methods for optimizing operation modes for complex technological systems; expert knowledge-based decision-support systems; unified requirements for intelligent system interfaces and modules, as well as means to represent and store knowledge, including distributed knowledge base architectures; and mathematical and software support are among these.

Advanced intelligent technologies and tools built on them may be used to modify goal-attainment procedures. The key characteristics of the applicable artificial intelligence tools that are necessary for implementation at all levels are detailed, along with a suggested three-tiered system of intelligent oil field control that assures optimization of oil output and the operation of equipment. The idea and the suggestions provided in the study can serve as a springboard for more investigation and the construction of actual intelligent wells and intelligent oilfields.

Keywords: intelligent oilfield, oil, production, artificial intelligence

Introduction

For making coordinated operational choices at a high level, several events that must be correctly handled occur every minute in large-scale, multi-well oilfields. The accuracy of these choices is influenced, among other things, by the information's relevancy and how quickly it is processed. Full automation of all key technical processes is necessary for the economically efficient production of oil in an intelligent oilfield (IO). As part of the automation, so-called "intelligent wells" are used (IWs). The occurrences listed below might be seen as indications of interest in the development and introduction of IOs: The 2012 edition of INMESTOR, an international conference on science and technology, is titled "Intelligent Oilfield: World Experience and Modern Technolo- gies" (May 10–11, 2012)

According to V.V. Kulchitsky's talk to the attendees of the round-table debate on smart wells, IWs have the following distinguishing characteristics.

(1) the ability to coordinate acceptable behavior and maintain a direct connection to the outside world through information communication channels.

(2) openness brought on by self-adjustment, self-organization, and self-learning.

(3) the capability of an IW to anticipate changes in the external environment and in its own behavior.

(4) the presence of intelligent control systems to make up for inaccurate knowledge about an object model; and

(5) the capacity to continue operating autonomously when links are disrupted or when higher levels in the hierarchy of IWs lose control over controlling actions. [5]
The following characteristics, in our view, should be included to the list:
(6) a system for monitoring, controlling, and diagnosing well and equipment functioning.
(7) sophisticated visualization tools (including cognitive ones) to aid decision making.
(8) the presence of a well (oilfield) mathematical model produced in conjunction with the controlling model of a valve or a downhole pump, simulation tools.
(9) a high degree of autonomy, the capacity to maintain or accomplish objective states (e.g., maximum flow, maximum efficiency, and maximum oil-recovery factor) in the presence of external factors that disrupt or prevent these states from being attained.
Without losing generality, we may investigate the employment of artificial intelligence technology in data processing, forecasting, and optimization of the production and management of valve motors and pumps inside a single well. A scientifically valid idea of artificial-intelligence approaches in both the administration of individual wells and fields does not yet exist, as evidenced by an examination of world-class scientific articles [4, 6-21]. This may be explained by a disconnect from the most recent advances in the idea of developing intelligent dynamic-control systems, as well as a lack of connection between the creators of such systems and top scientists in the field of artificial intelligence (Fig. 1).

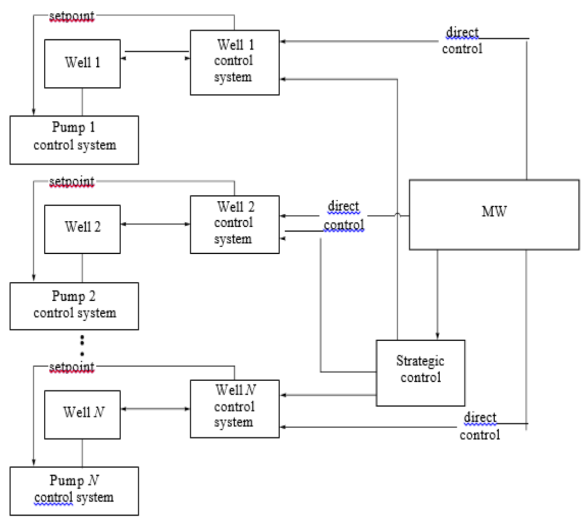

Figure 1. The plan for smart oilfield control.

Domestic expert-system technologies, intelligent information-processing techniques based on neural networks and genetic algorithms, Bayesian networks, software tools for building intelligent application systems, and accumulated and formalized expert knowledge in the field of automatic control of downhole pumps and motors [22- 26] are recommended as the foundation for well automation. It is recommended to transition from the notion of "discreet time" control to "continuous" monitoring, diagnostics, and control of well equipment using high-performance computer resources for data processing. We should move on from the notion of local process optimization within the framework of an intelligent well to the challenge of developing an intelligent oilfield within the framework of networked control, which allows for global optimization utilizing data from various processes. The system might be built on pump station management workstations (MWs) that operate as essential sections of a data-processing network used to manage an oilfield.

The intellectual component of the oilfield

The dynamic component of an intelligent oilfield inside the unified scientific-technological area is accomplished utilizing software tools for knowledge capture, storage, and analysis. The component can take advantage of intelligent-agent technologies, neural networks, genetic algorithms, pattern analysis, and other recent artificial intelligence advancements. The intelligent component should include data collecting, data analysis, a database, and a knowledge base. The modules of the intelligent component should be adaptive and capable of optimizing their functions; trainable and capable of adopting additional information and accumulating useful knowledge to accomplish tasks within the framework of a module's functions more accurately; communicative and capable of inter-action with other modules and thus, if necessary, able to perform actions outside the scope of its own functions during operation.

Figure 1 depicts the overall layout of an intelligent oilfield control system. The scheme contains the following major modules:

(1) a real-time monitoring system of elements and processes.

(2) a system for the simulation, recognition, and analysis of the global current situation that assists the works supervisor in emergency situations (ES) and normal operation.

(3) a real-time system to forecast the development of emergencies in time and their distribution across the interacting sub-systems.

(4) a real-time scheduler to adjust the working plan during emergencies; solution optimization using.

(5) an interface to inform operators about possible ways to stabilize the technological process.

(6) a real-time solver to output recommendations to operational staff about ways to prevent inappropriate influences on the object: (recommendations on counteracting emergency situations; issuing opinions on the possibility (appropriateness) of specific control actions in the given current situation);

(7) a subsystem that displays the current situation.

(8) user interfaces.

Russian methods to the intelligent dynamic control issue are currently being explored. Closure rules, computational functions, transition rules, control rules, sub-goals, and control zones are all part of the control technique. Control rules choose a control strategy from a set of admissible methods based on the current aim. In reality, the rules are specified by and identical to the system of intelligent control orders at this point.

Controlled objects have a number of key characteristics connected to the fact that their state parameters are specified by various types of variables, such as quantitative, Boolean, or linguistic variables. At the same time, there is no comprehensive a priori description of the states. The behavioral rules for such systems either lack a full analytic explanation or cannot be defined analytically at all. The states, on the other hand, can be characterized using a collection of expert or empirical knowledge. The state vector of the controlled item is computed using current data. The permissible alternative strategies for resolving a problem are presented, taking into account the issue's priori information.

Three sorts of techniques are used to infer an efficient choice. The rule-based system is the first type. Every specific vector that characterizes the current state of a situation corresponds to an efficient technique to address the problem for this mechanism. These methods are implemented as "if... then... otherwise..." rules, with an expert-assisted simulation ensuring the rules' completeness and consistency. The second type of mechanism is based on multi-criteria selection algorithms. The list of possible resolutions and the set of result assessment criteria for each resolution are defined in this scenario. The third category includes procedures for presenting a successful precedent that is relevant to the current situation. The most relevant technique in such instances is to utilize a knowledge matrix and a situation description vector with linguistic variables as coordinates.

The system's computational mechanism consists of a collection of rules, a database, and a technique for selecting rules. The execution of the rules entails the execution of related closure processes, targeting, control method selection, and transition. [27, 28] outline the procedure of implementing intelligent control.

The organization of automated workstations

The current condition of oilfield development is raising the bar for automated workstations used to administer geological and technological services, resulting in the expansion of functional capabilities in terms of intelligent information processing. This promotes the saturation of a company's units with high-performance computer hardware and innovative software. Connection to the worldwide information network, as well as the information-processing system and measurement system, are all given special consideration.

The automated workstation's hardware must guarantee the efficient implementation of all software functions. As a hardware platform, a multiprocessor computer system in the form of a cluster with GPU accelerators can be employed. The problem of outfitting wells with sensors and monitoring systems that collect technological data directly on oilfields is critical. The acquired data is processed and evaluated to enable techno-ecological choices about various parts of the production cycle. Further advancements in these technologies will allow for real-time remote access to information concerning well procedures. This will allow you to choose the best operation mode for the well pad and everyone well based on a production model. We suggest using the framework of the intelligent component of modular automated workstations [21]. This approach's tools have been utilized to design a variety of applicable systems [13, 14].

Specification of the scientific and technical challenges that require solution: suggestion.

The following scientific and technological difficulties must be addressed as part of the process of developing an intelligent oilfield (Figure 2).

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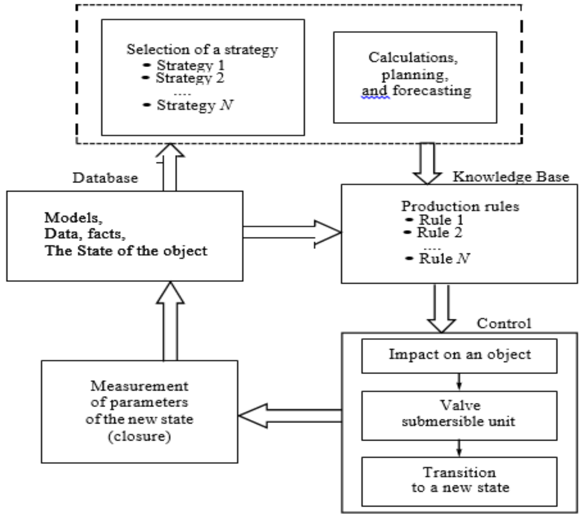

Figure 2. Intelligent analysis and control schematic diagram

The Development of Control Strategiesand a Goal-Setting Module

Allow the "trajectory" of a dynamic item (a pump station) to be specified as a succession of estimated phase states as it approaches the preset flow. We suggest using a rule-based dynamic system to introduce control techniques relevant to the intended global goals. Among the strategies are:

a point-wise moving strategy; the strategy is acceptable, for example, to control and stabilize downhole pump operation (a preset rotation frequency);

a strategy for achieving the maximum (or minimum) value of a target criterion (efficiency, pressure, etc.);

the strategy is acceptable to control the operation of separate pumping stations in general based on a known model of the environment (or well);

The following acts are included in the goal-setting method as they apply to pump station operation:

(1) turning on the facility (the Work operation mode);

(2) turning off and disabling the facility from turning on (operation modes: On hold, Emergency, and Blocked) due to a malfunction or departure of the controlled parameters.

(3) adjusting and maintaining the rotation frequency of the electric motor.

(4) forecasting the state of the environment and generating a plan of controlling actions.

(5) maintaining maximum efficiency.

(6) maintaining the maximum well flow (or a preset pump suction pressure); (7) selecting an operation mode for a well pad and each well based on the production model.

(8) transition to the system of selection and switching rules.

(9) transition to the system of switching rules.

The development of the rules system for intelligent control.

The suggested basic architecture for intelligent management of a pump station as a complex dynamic object (Fig. 2) is comprised of two intelligent control circuits: one (internal) regulates the rotation (stabilization) of a downhole pump's valve motor (and its reverse operation). The second (external) circuit controls the general pump station in line with the control strategy and the state of the media in which the pump is submerged. The goal-setting block is critical because it establishes the global station control goals and solves the strategic challenge of selecting the control mode.

For a certain number of steps, the planning block estimates the flow of event and model state parameters. For the model to function, an integrated database including telemetry data, relevant facts, and current model-state parameters is required. Frames, rules, and semantic webs that facilitate the representation of an item, its properties, structure, and behavior processes are used for knowledge representation.

In our example, the knowledge base comprises production rules that define the conditions that trigger the creation of certain pumping station controlling signals in line with existing goals and the defined plan. The control block modifies the mechanism that controls the levers. As a result, the system enters a new state. In a dynamic environment, the functioning of an intelligent system necessitates a prompt response to changes in environment parameters and takes into consideration the occurrence of transitory processes between states. This limits both the time required to complete the analysis and the time required to measure present parameters in order to refresh the database on deadline (closure) [11, 12].

The following functions are carried out during the execution of a continuous control mechanism:
(1) external queries and setting goals, criteria, and control strategies.
(2) queries to a knowledge base and the corresponding database.
(3) retrieving current parameters from the knowledge base and database.
(4) a request to generate the plan (sequence of control selection rules);
(5) plan generation (calculating goal functions, forecasting, and planning).
(6) plan development: gathering calculated and experimental data, comparing the current global situation to the calculated one, executing a query to search for the relevant rules and regulations (applicable rules are rules with preconditions that correspond to the present state);
(7) comparing the current global situation to the calculated one.
(8) transferring the selected production rule to the system for execution.
(9) synchronizing the system's internal clock cycles to real time; and
(10) measuring (closing) and storing the current state parameters in the database.

The algorithm is always running in order to achieve and maintain the global objective state. The control technique is based on the application of rules, which are the primary way of synthesizing and representing plans while they are in operation.

Development of a calculation and forecast module for key indicators.

The module computes the following:
(1) pump efficiency, considering viscosity, free gas, and operating mode.
(2) pump head relating to water at the ideal operating mode.
(3) pump and submersible motor horsepower; and
(4) interpolation using a parametric cubic spline (Fig. 3).

Splines enable the development of software and the modeling of complicated surfaces using an uniform methodology. It is feasible to store geometric data in digital format with arbitrary accuracy by using splines, such as Hermite splines. This is utilized in data-transmission and data-recovery systems and simplifies hardware solutions significantly.

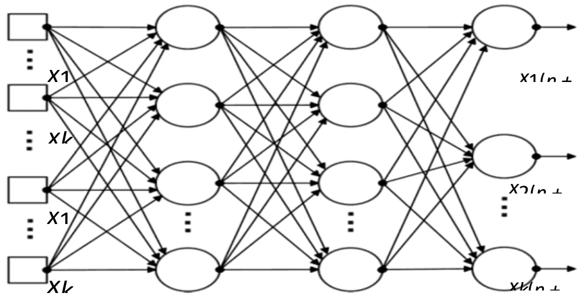

Figure 3. The architecture of the forecasting neural network

The development of the mathematical simulation block for the valve motor control

We suggest using the hierarchical methodology presented in [29] to mimic the motor control and stabilization system. These solutions enable one to meet the criteria on the valve motor control system: positioning sensor adjustment and self-calibration, programmed control, and transmission disturbance correction. As a result, the positioning dynamics and rotation-speed stability increase. The created techniques for parameter adjustment and identification make it easier to employ the control block's extra functions.

The usage of a proportional-integral-differential controller as a digital rotation frequency controller raises the difficulty of determining the best controller settings. We suggest employing one of AI's methodologies, namely gradient descent and genetic algorithms, to change the proportional-integral-differential controller that digitally regulates the frequency of the downhole motor. As an integrated estimate of the transitory process, the sum of a sequence of fuzzy membership functions can be used. The suggested approach is distinguished by the utilization of interdependency between the parameters of the proportional-integral-differential controller and ratio-based estimations of the quality of the transient process in the closed control loop. This method is supported by the fact that an experienced engineer may precisely select the controller settings based on his own experience and expertise [30].

Development of the forecasting block

Using a direct-propagation artificial neural network (ANN) with a sigmoidal activation function, this block predictions the state of technical subsystems. The first layer's inputs are kn in number and correspond to k vectors of goal coordinates (in the k-dimensional space covered by the window of width n). The number of neurons in the first and second layers is determined via experimentation. The third layer includes k neurons, the output of which is utilized to anticipate the following point's coordinate (forecast). The ANN training approach is as follows. Let us use a sliding window to scan the available time series. We attempt to retrieve the (n + 1) th values by covering n values of the series with a sliding window (Fig. 3). The acquired prediction point is appended at the conclusion of the available sequence of points for a long-term forecast.

Development of the monitoring and diagnostics block

Monitoring and diagnostics refer to the process of identifying deviations and looking for system flaws that may be described as a task of recognition (classification) of a condition based on measurement and intelligent data analysis. The continuous monitoring of sensor failures is also based on data correlation analysis. We suggest using a probabilistic neural network (PNN) to identify abnormal conditions.

The probabilistic network is trained to assess the probability density function, and its output is regarded as the predicted model value at the given location in the input space. The probabilistic network does not require traditional training since all network parameters are established directly from the training data. In the last layer, the output with the highest probability density is chosen to reduce error. If there are enough training cases, this strategy can produce a decent estimate to the real probability.

An alternate option might be a fully linked two-layer forward propagation neural network (two-layer perceptron). To configure the network, the well-known Widrow- Hoff learning rule is utilized. It is also feasible to create a discriminant function using the group data handling approach (GMDH). Using sample observations, the GMDH may be used to recover the dependence between input and output variables. It will be utilized in this situation to classify input vectors.

Conclusions

The developing area of knowledge entails the introduction of intelligent technologies with the goal of building a unified scientific and technological oilfield space. These include: methods for optimizing operation modes for complex technological systems; expert knowledge-based decision-support systems; unified requirements for intelligent system interfaces and modules, and means to represent and store knowledge, including distributed knowledge base architectures; and mathematical and software support.

Advanced intelligent technologies and tools built on them may be used to modify goal-attainment procedures, identify the global condition, diagnose errors, and alter technical processes to produce the most efficient conclusion for an oil field. Implementing an integrated system for real-time monitoring, analysis, and control of production might assist to eliminate existing technological shortcomings, boost productivity, and extend the life cycle of an oil field.

As a result, we can state that the work of introducing intelligent systems within the context of developing a unified scientific and technological oil-field environment is relevant; its execution is a strategically vital scientific and technological problem. The ideas given in this study can serve as a starting point for future research in the subject of intelligent oilfield construction.

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SEA LEVEL MEASUREMENT USING SATELLITES

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ABSTRACT

Sea level measurement represents a huge interest and importance globally in the world being one of the most discussed and relevant topics in scientific society. It is also related to one of the most important global problems in the modern time as global warming and water levels dramatically increasing in the world ocean. However, accurate measurement and analysis of the sea levels can prevent global catastrophe and assist humanity to understand the nature of planet Earth and how it reacts to global processes flowing in every continent, all over the world. There are two main causes of sea level rise, and both are heat related. Glaciers and ice sheets are large masses of ice that lie on land. As our planet is getting warmer, this ice rapidly melts and flows into the open oceans. The more water in the oceans, the higher the sea level. Secondly, water expands when heated. Thus, warm water takes up more space in our oceans, raising sea levels. Together, these two things have raised the sea level by about six to nine inches (about fifteen to twenty-two centimeters) since 1900s. This is a big problem for millions of people living in settlements close to the coast. Unfortunately, you can't just drop a long line in the ocean to raise sea levels. Sea level varies from place to place of poisoning. This is due to differences in geography, gravity, temperature, ocean currents and tides. Oceans cover about 70 percent of the globe. So, to find out if the sea level is rising all over the planet, you have to restore the rulers in millions of different places.
Keywords: Global warming, sea level measurement, satellites, space observers, planet's surface.

Introduction

Level of the research on the subject: During this paper it will be discussed the effectiveness of sea level measurement using satellites, different methods of investigation, advantages and drawbacks, the history of successful attempt of measuring the surface of the planet using satellites and experience received from it.

Relevance: Satellites method consist of it its efficiency and high accuracy in the process. As an example, Sentinel-6 will be at an altitude of about 800 miles and will use radar to measure and calculate the surface of the ocean. An instrument on the satellite sends a radar wave to Earth. The radar reflects off the surface of the ocean and returns to the satellite. By measuring how long it took the radar to descend and return, and by considering the humidity of the atmosphere, which slows down the radar, scientists can determine how far the ocean surface is from the satellite.

Otherwise, the satellite can inform scientists on base in Earth how high the oceans are and how that height calibrates over segment of time.

One of the advantages of such a project is its high precision in measurement as it is use a high-demand program being tested calibrated and performed in various of platforms to prove itself as an efficient technology for meteo – objectives. The other advantage is also related to its high-demand modern technology. It is about the ability to perform the results with miniscule probability of failure, or an error occurs during the session. Moreover, it is possible to mention its multi-functionality due to big variations of sub methods. And to finalize satellite sea level measurement provides high safety index for the personnel (technicians), because most of the processes occurs remotely from the stations on the planet while the measurement process itself being calculated from the satellite, as a result it represents as the most reliable way to measure sea/ocean levels without physical contact and opens perspective of researching the same values on other planets except Earth.

General information about satellite water measurement

Since the end of 1990, s satellites have become useful in not only observing missions and photography but as a rise of different projects which potentially are very beneficial for almost every sphere of development. Being aware of world water level alteration is exceptionally important in such a sphere as Environment, engineering and construction, energy, renewables sources, maritime, government.

In 2006, NASA first started to collect massive data from satellites using photos recorders and different technologies including laser beams to observe how water level changes in seas and oceans. The technology of putting laser beam inside of a liquid was not a novelty by that time, however integrating this idea in to the satellites projects was something extraordinary and courageous. NASA collected necessary data in 2010 and discovered a huge advantage of satellites measuring abilities. The fact it is much easier to measure water surface and depth from above and significantly more accurate to collect results using laser rays. In the process of time satellites were developing as the technology and algorithms utilized for calculating the difference of water loss and income annually. Since 2012 scanning satellites include programmable logical units which working processes are automated and oriented to observe and collect data from different parts of a planet in one year and compare the data with a previous session. Modern Satellites are now able to determine precisely the depth of even small water pools such as little lakes less than 100 square meters; hence it gives an opportunity to measure water level in internal water sources.

Factors impact on sea level measurement.

There are lots of factors which have a significant or huge effect on the annual water loss and water stream (income). Here are the most important of them below in a smart art (Figure1).

As it is possible to see all the facts below are chained insomuch as almost all of them related to human extremely intensive activation on a planet last 2 centuries.

Climate change refers us to global warming and glaciers melting in poles, which critically augments the level of all oceans especially Pacific and Atlantic. Surely, it leads to some harmful consequences such as Temperature changing in some regions, tsunamis, ecological catastrophes, economic difficulties, general nature misbalance due to flora and fauna changes.

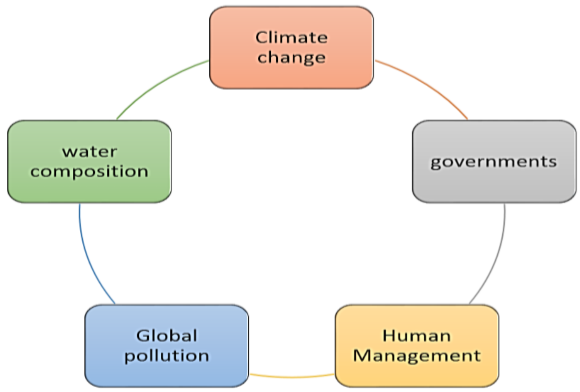

Figure 1. Main factors

Water composition is a bound form of the previous factor. As glaciers melt water, composition precipitously improves. Salt concentration is an exceptional variable in ocean flora and fauna in other words local live forms may reach to extinction.
Global pollution also has an effect on global water amounts and its quality. Annually millions of tons are being ejected to open seas and oceans, which contributes and accelerates the water quality and amount decrease (Figure 2). Besides that, it is also one the reasons of global warming.
Human management and governmental programs of seas drying ups are two facts strictly representing the role of humanity on water arrangement and manipulation. According to statistics from NASA 57% of world drinking water sources comes to share of human controlled variabilities.

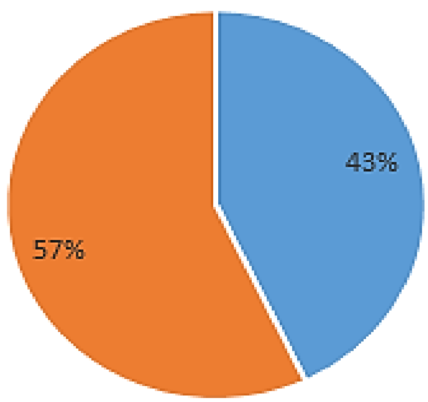

Figure 2. Human efforts percentage

Satellite measurement working principle.
The upper part of the atmosphere is the agreed boundary between the Earth's atmosphere and open space. Satellites reach this space, making global communications easier and photographing the planet, calculating changes in ice height and changes in earth mass. While satellite technology is highly advanced, the long-standing problem is how to accurately determine the water depth for

every shallow water off the coastline, according to scientists from Xiamen University and the University of Massachusetts Boston.

The problem is not the type or amount of data collected, but how to convert it into an accurate estimate of how shallow coastal waters are. To solve this problem, they created a machine learning algorithm that uses data from two Earth observing satellites to determine and inspect the water level of optically shallow water.

Measurement of bottom depth, named bathymetry, has traditionally been done with sonar, but as satellite technology has improved, more and more measurements have been taken with satellite LIDAR.

While these techniques and systems corresponds highly accurate measurements of bottom depth, they are expensive, time required, and strictly oriented to areas that can be reached by ships (for sonar) or satellite LIDAR lines that cannot be acquired from space to generate a high-resolution bathymetric map," said first author Wendian Lai, from Xiamen University. The algorithm is able to accurately mark optically shallow water and optically deep water in 95% of cases.

For the first several test sessions the new algorithm was able to prove itself in a tropical area where the water is clear most of the time, however new upgrades of this technology give a good opportunity to utilize satellites laser beam in intensively composed waters.

These algorithms analyze the light frequency of images from different parts of the satellite's spectral range and adapts with existing reference structures, such as validated results from similar sources elsewhere, and database of different types of seafloors reflect light. According to Doctor Marcello Passaro from Technical University of Munich, the concrete working principle is very simple. Satellite emits a powerful laser beam reaching the surface of the water, hence when observers exactly know the trajectory of satellite's orbit it's velocity and angle, it is possible to determine the level of water itself by recording the time till the laser will be reflected back from the water surface. Usually, it is enough to make hundreds of measurements to calculate the exact value of the level, however, here are some cases when it is not enough or includes some extra complications of variables.

1. The presence of seaweed or other water plants and corals. In general, acceptable mass of such plants are not significant during measurements, however in some areas especially in huge coral reefs, large accumulations of sea plants may play a barrier role, being an obstacle for pulses produced from satellites. It can totter the results being incorrect or inexact. Certain types of seaweed are even able to reflect or absorb some amount of radiation.

2. Extremely large gatherings of waste products in the oceans and seas because of ecological incompetence. Different variations of wastes in an open ocean can be a trouble for satellites to carry out all necessary tasks on sea level measurement.

Weather condition. Unfavorable meteo-circumstances is always a complication for satellites to suggest measurements. Such weather conditions as storms hurricanes tornados and etcetera. Another technology of measuring water in natural pools is based on floats practical integration. Floats are middle –sized inflatable objects floating on liquid, made predominantly from solid synthetic plastic or polyvinyl chloride. The main purpose of these floats is concentrated on continuous reporting satellites about sea level condition and its change. Traditionally they are used from several decades to hundreds of floats depending on the area of scrutiny and investigation. Floats transmits signals to satellites creating a certain channel of communication or in other words a chain between satellites and the floats. The process comprises satellite emitting a pulse reaching a float and directed back, apropos this process occurs extremely fast and repeats

millions of times to record changes and calculate results being studied later in command center by scientist observers.
The main advantages of these technology is its ability to provide higher accuracy and more reliability, Float-method exactness related to continuous repetition of tests and measures which proves it's high-demand. However, there is an insignificant probability of failure during this reoccurrence. It is also important to consider that it is appreciably harder to control and administrate this kind of system. Unlike satellites, which have a concrete strict orbit and trajectory, floats are passive and do not support any technology that could help to manipulate or control remotely. Therefore, it is hard to hold it within area limits. Besides, due to harsh weather conditions it can sail away to distant shores. Despite the presence of GPS trackers fitted into, when floats are located too far from the necessary area, the genuine results might have a lack of calibration.
Usually, a standard measurement session consists of 8-15 months of scrutiny. NASA Launches a group of satellites to take into control of a big area. Jason-3 and Sentinel-2 are flagships of scientific studies and discoveries. In this project, the main proposal is about upgrading the measuring unit of a satellite by increasing the area of measurement using large lamp-formed orbit with integrated technology block. This technology block includes several pulse emitters and receivers. Here is the algorithm of actions below necessary to implement.
Technology block composed of several emitting and receiving units will send out pulses to different directions. Signals will touch the water surfaces in different parts of the studying area and lead back to satellite. There in technology block will take place all calculations and measurements. The same process occurs in neighboring satellites in one area.
Advantages of this upgrade:
1. Considering significantly wider area of measurement to receive information from huge lakes seas and oceans.
2. Utilizes less resources because of using one technology block instead of thousands iterative sessions
3. Beneficial from financial point of view
4. More efficient as it is taking larger area of study
5. Higher reliability
Disadvantages aspects:
1. Harder to implement as it is a complicated technology
2. Requires more energy.
It is also important to mention that mentioned upgrade is able to reduce average period of study and analysis for scientists during observation, which plays an exceptional role when global warming causes many climatic incidents and expeditious water level augmentation.
Jason-3 and Sentinel-2 satellites from NASA are suitable to implement this method as these satellites are well adapted to various tasks and missions.

Conclusions
This paper includes information about sea level measurement, causes of its increase and potential consequences related to global warming and human impact on it. Considering all the above, it was presented several methods and technologies of sea level measurement using satellites. Satellites are representatives of the new generation in measurement solutions in many spheres including the topic of this paper and it proves its effectiveness. Using floats as a component of sea level

measuring project is an auxiliary support to gain exact results and aiding to understand how seas and oceans change in a better way. Upgrade of this technology by using a wider technology block including several emitting and receiving units is a justification of efficiency of pool gauging and accurate square determination. To juxtapose all mentioned before, satellite sea level measurement is the most efficient and reliable manner of measuring all types of natural water pools includes little lakes and seas or oceans.

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BIOMEDICAL SMART HOME SYSTEMS

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ABSTRACT

Biomedical engineering is a system that includes the design, manufacture and operation of various systems, devices and methods used in the diagnosis and treatment of problems that may occur in human health. In recent years, as in the whole world, some important innovations in this field apply in the research conducted in Azerbaijan. Over the past 30 years, biomedical engineering has been established as an independent field of science and engineering. Currently, biological medicine is not limited to the field of medicine, it has continued to develop as a potential field, making an important contribution to the dentistry, veterinary medicine, rehabilitation, physical education, and sports fields. The types of biomedical devices available in stationary health care institutions are expressed in hundreds, and the number is expressed in thousands. From implant to stethoscope, from complex imaging medical devices such as MRI (magnetic resonance imaging) and X-rays devices to patient beds, many products that could be considered simpler have been designed by engineers. In modern hospitals, sophisticated engineering devices are used by doctors to treat patients. Biomedical smart home system or health-based smart homes are designed for patients who feel the need to return home after an average time from a hospital or healthcare facility, or who need to receive care at home. The article presents information about innovations in the mentioned field.
Keywords: Bioengineering, biomedical equipment, biomedical sensor, smart home

Introduction

Currently, with the development of wireless communication technologies, there are advances in the direction of creating smart environments with wireless devices that facilitate the monitoring of patients, the elderly, and the disabled in automation systems. Many reliable and real-time applications were developed by integrating wireless biological and environmental sensors, remote intelligent monitoring systems, healthcare applications, and patient monitoring systems. Smart systems that combine technology and services continue to work toward the needs of society. In this work, the medical applications of smart home systems, which play an important role in patient follow-up, are investigated, and the development of types of biomedical sensors is planned.

Method and materials

Home technologies are the adaptation of control systems used in many fields of industry to everyday life, and automation is the application of these technologies to personal needs and desires [1].

A smart home is the integration of technology and services over a home network for a better quality of life [2]. Today, smart home technology ensures the safety of homes and the environment, and in addition is a system that performs to heating and cooling facilities, automatic control of garage and garden doors, control of children's playgrounds and rooms from your office, automatic feeding of pets, and ease of mobility of the elderly, patient information is entered into the same network. [1]. Programs have been developed for continuous monitoring of biological data and daily activities important for human health in home automation systems for patient monitoring [4,5]. Smart systems include sensors, actuators, and biomedical monitors are installed in homes. Networked devices connect to a remote-control center via the Internet for data collection and processing. The technologies used in smart homes, which are the most comprehensive example of automation applications, can be listed as follows: Fuzzy logic, Telemetry, X-10 Technology, RF Systems, Bluetooth Technology, IEEE 802.11b, Infrared and ZigBee Technology. In addition, cell phone-controlled microcontroller remote control systems can be adapted to smart homes [7].

Information technology provides the collection, processing, and transmission of data and information using Web technologies and artificial intelligence, which is a powerful tool for data processing and decision-making under information uncertainty. Naturally, the use of built-in artificial intelligence in devices and equipment makes it possible to increase the level of their automation and operating efficiency at times.

Solution of the problem

Health homes are developing rapidly every day in all countries. A similar program called TERVA provides consistent communication over a smart system and regularly monitors all patient vitals [8]. Health-based smart homes are designed for patients who feel the need to return home after an average time from a hospital or healthcare facility, or who need to receive care at home. Especially in chronic patients, the field of treatment can be selected according to specific symptoms or the general condition of the patient. The purpose of this application is to integrate health directly into smart home information systems. In the creation of a patient information system, sensors are placed in each room and the patient is monitored while doing daily tasks at home. Hourly samples are taken in the program to detect faint changes. Based on a large number of measurements, it can estimate the average value in the face of an abnormal situation. The provision of biomedical health support, both at home and in hospitals, is of great importance to patients. In this regard, there are smart home applications that are developed by combining many technologies such as communication, micro-materials, low-energy design, and flexible sensors, and ensure the safety and comfort of patients. Smart clothes and smart sensors made with non-invasive sensors that have 90% contact with the body surface create effective solutions for health monitoring in ambulances or home automation systems. Even sensors for wearable devices or smart homes are a potential definitive solution.

All these systems can provide environmental safety and comfort with the contribution of home health services to public health and disease prevention [6]. After location, movement, and physiological data of patients an early intervention by families can be performed. Room sensor, breathing sensor, heart monitoring sensor, motion sensor and camera can be used for inpatient. In an unusual situation, family members can be notified through an alert system. It includes all the places that are used daily, such as the kitchen (Figure 1). In addition to this, special rooms can be designed with high-tech computers available for patient use and sports equipment that will contribute to the patient's health and happiness when required.

Various vital data received by sensors in the system are transmitted to the home center system based on priority measurement results in real-time. Applications can be used effectively by incorporating this system into smart home technologies, known as smart metering and smart

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clothes. Figure 1 shows the use of wireless sensor networks in a structure using a local area network. In an elderly health monitoring application, the Controller Area Network is connected to environmental and physiological sensors. In smart home systems, many communication networks are used under the name of Body Area Network, and Personal Area Network, which are included in Wireless Sensor Networks. From medicine to industry, from entertainment and retail to defense, to emergency management, our daily lives are rapidly changing and evolving thanks to the widespread adoption of ZigBee-based wireless sensor network technologies that provide bidirectional communication and control. detectors that are not used frequently but may need to be used remotely [2].

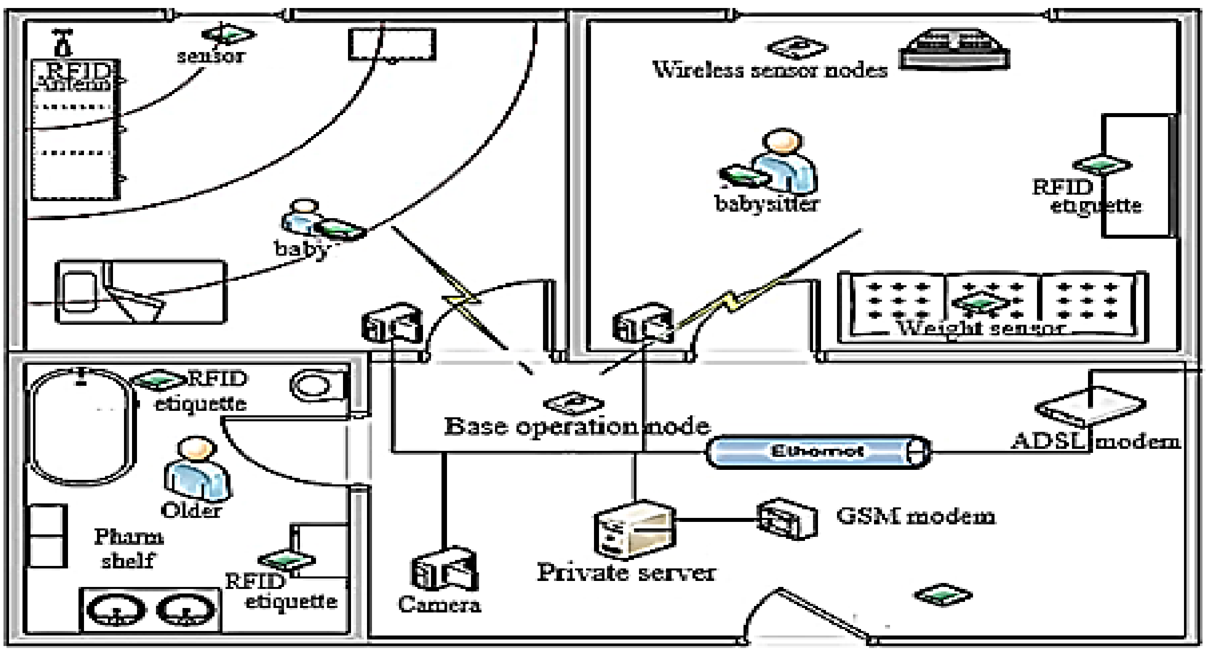

Figure 1. Biomedical smart home system

ZigBee Wireless Sensor Networks provides reliable, cost-effective, low-energy, wireless network-enabled devices in the home that meet global standards and can be controlled via a monitor. The purpose of ZigBee protocol is to provide a wireless network protocol to devices or point.
Obviously, in all the above cases, one of the stages in the development of bioengineering is the automation of production, or the very functioning of the developed devices, high-tech systems and complexes, and robotic systems for biomedical purposes. Based on this, this problem must be considered in combination with all components of bioengineering, especially artificial intelligence tools.
Artificial intelligence tools are especially effective in the development of diagnostic devices and systems, which are determined by the structure and logic of the functioning of the software itself, the underlying principles and methods of data processing, and the output of results. Among artificial intelligence algorithms, neural networks and genetic algorithms are used for this purpose, capable of developing an existing database through machine learning, adding new data and new rules for processing information and inference.

Another direction in the development of bioengineering is the development of algorithms for processing and analyzing biomedical signals and data that are pre-processed at the hardware level (filtered, averaged, etc.) using modern digital signal processors that provide digital signal processing. The final, extended processing in order to analyze the results obtained and substantiate the conclusions can also be eventually carried out using artificial intelligence algorithms.

The emergence of microprocessors and microcontrollers and PLC programmable logic controllers open up new opportunities for the development of biomedical devices, supercomputers with high performance and memory make it possible to increase the level of computerization of medical procedures themselves, ensuring prompt processing of information and issuing the necessary recommendations. In addition to this, there is the possibility of modeling processes for a more complete study of them.

Being a promising area of science and industrial production in the 21st century, bioengineering is developing in cooperation with chemistry, biology, physics, and mathematics and rapidly developing information technologies. The above directions of development of bioengineering are innovative and require huge investments to attract forces and resources in order to solve many interrelated tasks.

It should be noted that the developed products, devices, and equipment) of bioengineering must comply with international standards for devices, equipment, and products.

There are many applications where physiological and biological data of patients are detected, known as biomedical sensors. Flexible, wearable, intelligent non-invasive sensors can be integrated into patient-specific systems to provide the best possible healthcare. The most flexible sensors in smart systems are designed for public health, personal health, and disease prevention. These sensors are of great importance in the comfortable movement of patients. The concept of a smart home has emerged as a multi-sensor-based structure. These sensors have been used to measure the activity of people who are alone at home, detect them walking on the carpet, place them in places such as chairs, beds, toilets, doors and take measurements and intervene early in situations that may occur. Adding biomedical sensors to this system has made it easier to monitor patients at home. New sensors manufactured using surface-mount technology can be easily added to electronic systems as a printed circuit board (PCB). These integrated circuits support smart home automation systems such as microprocessors and digital signal processing (DSP) core technologies.

In addition, other studies have used sensors attached to the wrist over a glove, such as a non-invasive glucose sensor and a respiratory flow sensor (Figure 2).

Wearable systems can be developed in applications such as the VTAMN-France project, WEALTHY-Europe project, and LifeStyle-America project, and patients can be monitored easily and more accurately with many sensors.

It is a sensor that can connect the heart rate sensor to our Arduino board (Figure 2).

Figure 2: Wrist band

The body of the sensor contains its infrared LED and receiver. The sensor has 3 terminals: the positive pole of the power supply (Vcc), the negative pole, and the signal pin. The sensor generates a signal equal to the number of pulses. The operating voltage of the sensor is 5 volts.
The pulse sensor can be worn on the wrists of users in their daily life at home and of any weight. It is designed in such a way that it does not create or hinder mobility. The process that begins with the detection and interpretation of the signal received from the pulse begins with the conversion of the signal into a number. If the measured value is between 40 and 60, the user is in sleep mode. A sleep mode signal is sent to the smart home. When the heart rate drops below 40, the user's life is in danger. In this case, an emergency signal is sent to the smart home system and the emergency mode is activated.
Bioengineering is a field of science and technology that aims to improve human health based on developments in the field of biology and medicine and engineering.
The structure of the relationship between the indicated areas of science and modern technologies is shown in Figure 3. An analysis of the stages and prospects of bioengineering allows us to speak about the following main directions of its further development. As can be seen from Fig. 1, the main areas of science are biology, medicine, mathematics, physics, chemistry, and the branches of engineering are applied mathematics, applied physics, applied chemistry, information technology, artificial intelligence, additive manufacturing, nanotechnology, and industrial automation.
Thus, the further development of health smart homes is related to the development and application:
- of artificial intelligence algorithms to improve the intelligence of instruments and equipment.
- of further automation of the processes of collecting, transmitting, and processing information to increase efficiency and speed.
- adequate mathematical models for additive manufacturing using 3D printers to improve the quality of the resulting products.
- of the new composite materials using nanotechnologies to improve the quality indicators of manufactured products.
- of completely new highly sensitive sensors and sensors of biological parameters to obtain more reliable, and in some cases new data on the processes under study.
- of interfacing devices to reduce information loss and increase efficiency.

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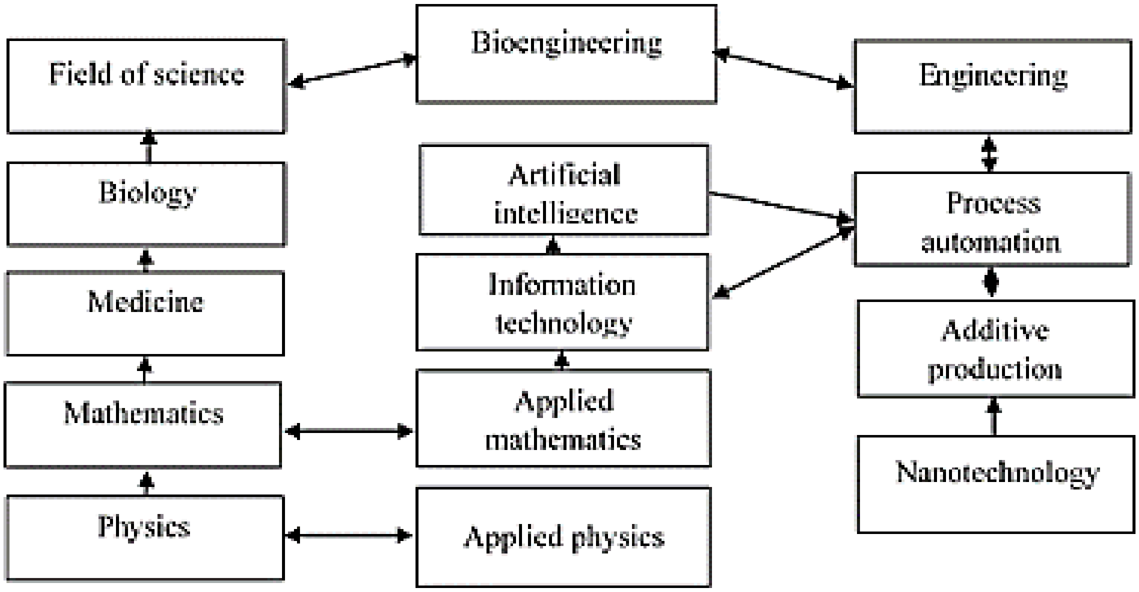

Figure 3. Structure of components and perspective of bioengineering

Further development of bioengineering is associated with the development of nanotechnology, the development of new materials and highly sensitive sensors for various parameters, and the further introduction of improved programs for processing measurement results, in particular, artificial intelligence, which allows not only to increase the reliability of measurements but also to obtain new data for solving new problems and highly acceptable decisions to continue treatment or to develop smart devices and equipment. In this aspect, it is necessary to note the use of additive manufacturing for the creation of various prostheses and implants, artificial organs for the human body, which in turn contributes to the development of transplantation for the replacement of damaged and incapacitated human organs by surgery, with the appropriate choice of suitable biomaterials for the production or growing of the required organ.

Examples include artificial joints, pacemakers, magnetic resonance imaging, renal dialysis, ventilators, and cardiopulmonary bypass.

It is necessary to note that the use of artificial intelligence algorithms for analyzing the symptoms of various diseases, methods, and means of their treatment makes it possible to develop software for diagnosing diseases by signs, case histories, images of computed and magnetic resonance imaging.

Additive manufacturing is one of the names for the production of non-serial products using 3D printers [2]. This production technology is successfully used in bioengineering. However, the problems of constructing an adequate 3D model for the created organ or body part, and the choice of conditions for their maintenance during production and storage are the main directions in the development of bioengineering.

For prosthetics of some parts of the body, materials of a different quality level are required. According to many scientists and engineers, such materials are nanomaterials, which, as studies show [3], which, in combination with other materials, make it possible to create composite materials with new characteristics. In other words, one of the areas of development of bioengineering is nanotechnology for the production of various materials.

Obviously, in all the above cases, one of the stages in the development of bioengineering is the automation of production, or the very functioning of the developed devices, high-tech systems and complexes, and robotic systems for biomedical purposes. Based on this, this problem must be considered in combination with all components of bioengineering, especially artificial intelligence tools.

Conclusions

Along with the development of science and technology, the opportunities provided by technology have shown their importance in improving the standard of living as well as protecting the quality of life. In every period of human life, research is conducted to improve the health status of people against various diseases. Being able to continuously monitor patients' data in an environment equipped with smart technologies in a hygienic environment outside the hospital has provided great comfort. Smart homes are designed for patients in automation systems that are used without human intervention. The information is evaluated according to the condition of the disease and will help patients move comfortably and continue their daily activities. Systems have been developed to inform users about the warning system in case of a sudden change in the situation. Technologies used in smart home programs developed in the biomedical field were investigated during the given research. It was discovered that the technologies used in all smart home systems to make life easier and provide security could easily be used in a system that could be created in the medical field. Many sensors to monitor health data in smart home applications were developed. All measurements on patients under hospital supervision and long-term follow-ups in smart homes can be performed without the need for a caregiver. During the research, it became known that there are special sensors produced for different diseases. A program has been developed that determines the location of objects from the camera that records during the day. These applications are thought to contribute to new areas of research. According to the condition of the diseases, special sensors can be designed and incorporated into smart home automation systems.

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DETERMINING THE AMOUNT OF OXYGEN IN THE BLOOD BY A NONINVASIVE METHOD

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ABSTRACT

Photoplethysmogram is used in medicine to monitor several diseases in a basic and convenient way. The object of research is a pulse oximeter - a device that measures the concentration of noninvasive hemoglobin in the blood and pulse ratios, based on the recording of a photoplethysmogram from a tool placed on the fingertip. This method is used in anesthesiology, resuscitation departments and operating rooms, is widely used in pulmonology departments, therapy and cardiology. In addition, the pulse oximeter goes beyond medicine and is used successfully in sports, games, professional fields, and so on.
In the ultimate qualification work, existing methods of heart rate determination (pulse), based upon the method of photoplethysmography, which formed the basis for the development, was considered. This non-invasive method, formed on studying the absorption of light passing through the tissue site with pulsating blood, is simple and convenient. It is intended to operate this device, available to a wide range of users, both in monitoring vital signs and early diagnosis of diseases, and in self-monitoring and training.
Keywords: Pulse oximetry, heart rate, non-invasive

Introduction

Every year, many mortalities are caused by diseases of the cardiovascular system. Moreover, half of these are related to sudden cardiac death, more than 80% of which begin with cardiac arrhythmias. Sudden cardiac death survival rate less than 1%. Cardiovascular diseases can be asymptomatic, and often people may be at risk and may not be aware of the presence of violations.
Pulse oximetry may be used to see if there is enough oxygen in the blood. This information is required in many cases. It may be used:

- During or after surgery or procedures that use sedation.
- To see how well lung medicines are working.
- To check a person's ability to handle increased activity levels.
- To see if a ventilator is needed to help with breathing, or to see how well it works.

To check a person has moments when breathing stops during sleep (sleep apnea)
For a lot of people, pulse oximeters are accurate enough to safely monitor oxygen levels. However, there is a 2% margin of error due to the simple nature of the device. There are also external factors that can affect a pulse oximeter's accuracy. We have already discussed how smoking may create inaccurately high readings. Nail polish is also known to interfere with the device, as it can reflect too much light back into the device. People with darker skin tones may have difficulty getting accurate readings for similar reasons.

In the article, the pulse oximeter, which is widely used in the field of medical diagnostics, especially in recent times, is a device that measures the degree of oxygen impregnate in the blood. The two-beam densitometer procedure was used to decide the saturation. To determine the value of saturation, the values of light absorption were determined for two selected the wavelengths (660 nm and 940 nm). These values were normalized, and saturation was calculated as the ratio of absorption in the red region of light to absorption in the infrared region.

There are six basic types of pulse oximeters:

- The tip of the finger.
- Handheld device;
- Counter top;
- Connecting by phone;
- Wearable (e.g., watches).

Reasons to use a pulse oximeter could be:

- Assess the effectiveness of lung medication or beathing medicine.
- Evaluate if someone needs help breathing (with a supplemental oxygen supply), especially if they are short of breath;
- Assess the success of the ventilator or supplemental oxygen afford.
- Display O_2 saturation level before and after an abscission with sedation.
- Display O_2 saturation levels previous, during activity, and after exercise therapy, especially for respiratory patients.

When considering the pulse oximeter method, the following concepts and designations are used:

Hemoglobin, Hb - a red pigment containing iron in the blood of vertebrates and some invertebrates, including humans. Due to its chemical composition, it is a complex protein. It is the main component of erythrocytes; it is a respiratory enzyme and ensures the respiratory function of blood.

HbO_2 - oxyhemoglobin - hemoglobin in which four oxygen molecules (O_2) are included in each molecule. It has a different absorption spectrum of light radiation.

DHb deoxyhemoglobin - deoxygenated hemoglobin. This is a decrease in hemoglobin.

is also called.

SpO_2 - arterial oxygen saturation measured with Photoplethysmography.

SaO_2 - oxygen saturation of arterial blood.

The level of oxygen in the blood

Blood quantity is a calculation of how much oxygen the red blood carries. Your body closely regulates the oxygen level of your blood. Maintaining an accurate balance of oxygenated blood is critical to your health. Additionally, children and adults do not need to display blood oxygen levels. In fact, many doctors won't check it until it shows signs of a problem, such as emphysematous or discomfort in the chest [1].

Nevertheless, people who has chronic diseases monitor the oxygen levels in their blood. It includes heart disease, asthma, and COPD (chronic obstructive pulmonary disease). In such a situation, lifeblood O2 monitoring can help define if medicaments are working or on condition that adjustments are needed [2]. Blood oxygen level can be moderated by two unalike tests:

1. Arterial blood gas;
2. Pulse oximeter.

Arterial blood gas - an ABG (arterial blood gas) test is a just blood experiment. That measures the oxygen of your blood. That can also detect the number of other gases in the blood, as well as the pH amount which calculates acid\base. The arterial blood gas is highly accurate, but nonetheless invasive. To gain an arterial blood gas measurement, our doctor is going to draw blood from an artery rather than a vein. Arteries have a palpable pulse, dissimilar veins. In addition, blood taken from arteries is shown with oxygen. It is used because the artery in our wrist is more easily felt than the others in our body. The wrist is a hypersensitive area, and it is more uncomfortable to draw blood there than a vein near which located near the elbow. Veins are also shallower than arteries, which causes discomfort [3].

Low blood oxygen levels can cause abnormal circulation and lead to symptoms such as:

- lack of breath;
- headaches;
- anxiety\restlessness;
- lightheadedness and vertigo-dizziness;
- hyperventilation;
- acute myocardial infarction;
- high blood pressure;
- lack of coordination;
- visual disorders;
- sense of euphoria;
- rapid heartbeat.

A pulse oximeter is a non-invasive device that approximates the oxygen content in your blood. These do this by sending infrared light to the capillaries in your finger, ear, or toe. It then measures how much light is give back from the gases. That test has a 2 percent probability of error. This means the reading could be 2 percent lower or higher than normal person's actual blood oxygen amount. This test can be a little less accurate, but it is easier for doctors to perform. That's why doctors trust it for speed reading. There are some reasons that cause the pulse oximeter to read lower than normal, for example, frozen limits or dark nail enamel. If person's reading seems abnormally low, doctors can remove any polish from nails before using a device [4]. Since the pulse oximeter is non-invasive, you can use this device yourself. You should buy pulse oximeter devices online or at plenty of stores that carry health-related brands. Before using the home device, advise your doctor hence people accept how to interpret the results [5].

The measurement of the oxygen in blood is called oxygen saturation level. In medical phonography, you can hear that called a PaO_2 when using a blood gas, an oxygen (O_2), oxygen saturation (SpO_2) when using a photoplethysmography. These table 1 will help us understand what our result might mean [6]:

Table 1. Blood oxygen saturation

Oxygen saturation (SpO_2) %	Observation
96% or more	Normal readings
95 %	Acceptable
93-94%	Seek advice

92% or less	Need urgent medical advice

Normally, when you're good, you have a percentage of oxygen saturation (SpO_2) near or greater than 95%. When saturation goes down below 90% and you have cough and fever, it's a sufficiently big problem [7].

Though the photoplethysmography test is much easier, quicker, and less painful than the ABG test, that is not so right. Several facts may hamper with the results including:

- dirty fingers;
- bright lights;
- darker skin tones;
- nail polish;
- poor circulation to the extremities.

Pulse oximeter sensor and basic principles

Components Required to build Arduino based pulse oximeter circuit.

- Arduino Nano;
- 2 pcs – 4.7k resistor for I2C pull-up;
- MAX30100 Sensor;
- OLED Display SSD1306 based 128x32 Resolution;
- 5V adequate power supply unit with the rated current of at least 300mA.

In the electronics OLED displays are very widespread. Since all pulse oximeter devices available in the electronics use OLED display, we can use OLED display. In this work, we are going to use 1.3 Inch I2C based OLED display It has 128x64 resolution with SSD1306 chip.

There are many pulse-oximeter sensors previously works, we also made an Iot-based heart rate where obtainable in the store for pharmaceutical grounds, and in one of the data is sent from a device to the storage. Now, here in this project, we will do the selfsame thing however variously with a different mindset. We will make the project using a MAX30100 sensor and an OLED display that will display the output in the same manner as a proper Pulse-Oximeter sensor display (Figure 1).

It's a very easy schematic. The pin A5 and A4 of the Arduino Nano are attached with pulse oximeter sensor (brand is 30100) and OLED Display with the SDA and SCL pins. SDA and SCL are not using a pull-down resistor just using pull-up resistor of 4.7k value.

The pulse detector module is used to test a people's heart rate by detecting changes in infrared light shining through a fingertip. Key features of the pulse detector module [8]:

Infrared (IR) transmitter;

Infrared receiver;

3.3 or 5V operation.

We can see circuit diagram in Figure 2 below, it's just an infrared led that lights a photodiode. There are also two resistors to protect the led and read the small signal of the sensor.

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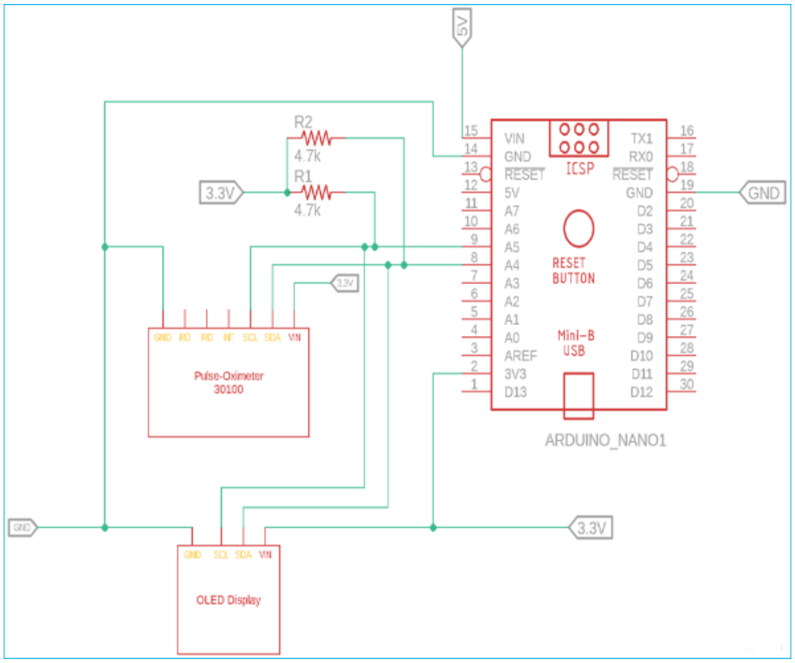
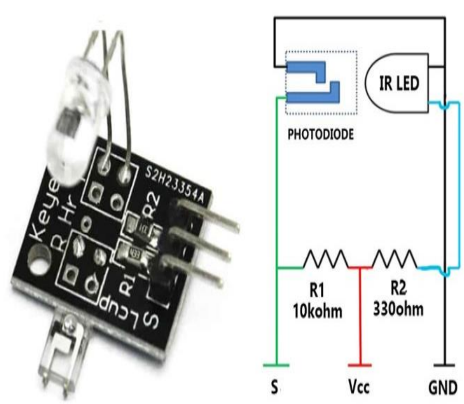


Figure 1. Schematic of the Oximeter Circuit



The finger is placed between the sensor and the photodiode. While the heart is making a beat, the blood is pushed in veins and the light immersion changes. The light emitted by the infrared led is relatively suck up by the skin, the nail, and some parts of your finger, but it's not unchanging because that changes as the blood flowing through your vein’s changes [9]. We may measure the current produced by a photodiode brighten by infrared light reaching it. Our blood absorbs light differently as the wavelength of light changes. The red light (600nm) is absorbed better by the blood that contains more oxygen, so we can compare the measures made with infrared led (950 nm) with the ones made with red led and find the percentage of oxygen in our blood [10]. This merit is called SpO_2% (capillary oxygen saturation). The level of oxygen saturation (SpO_2) is the ratio of oxygenated hemoglobin to complete Hb (hemoglobin) and is a parameter's function called R [11]:

$$R=\frac{RED_{max}-RED_{min}}{IR_{max}-IR_{min}}, \quad (1)$$

where, RED_{max} and RED_{min}; IR_{max} and IR_{min} are max and min merits of RED led and IR led [12].

Photoplethysmogram is elicited from two physical principles [13,14]:

The presence of a vibrate signal generated by arterial blood, which is relatively independent of steady (non-pulsatile) arterial blood, veins and capillary blood, another tissues;

The fact that oxyhemoglobin (O_2Hb) and reduced hemoglobin (Hb) have unalike immersion spectra.

Oximeters currently available use two light-emitting diodes (LEDs) this emits light at the red (660 nm) and the infrared (940 nm) wavelengths. These wavelengths are used because O2Hb and Hb have unalike immersion spectra at these specific wavelengths [15,16].

A photoplethysmogram works on the principle that the light 's immersion in oxygenated hemoglobin (HbO_2) and deoxygenated hemoglobin (Hb) differs remarkably at specific wavelengths of light. [17,18].

Main photoplethysmogram is made up two LED and a one photodiode (PD) in a meditative or spread configuration (see Figure 3) [19,20].

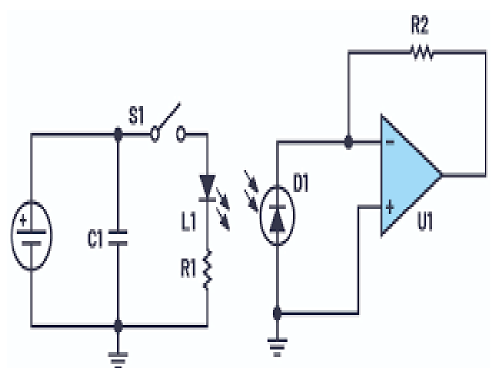


Figure 3. Basic pulse oximeter circuit

Conclusions

In the article, the functional, principled schemes of pulse oximetry, which allow non-invasive measurement of pulse and the amount of oxyhemoglobin in arterial blood based on the principle of photoplethysmography, were investigated. The method of photplethys-mography and its application have been investigated. Preliminary data on pulse oximetry, which allows for non-invasive measurement of pulse and arterial blood oxyhemoglobin based on the principle of photoplethysmography, moreover the principal scheme of the device was examined.

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THE GROWING IMPORTANCE AND RELEVANCE OF GAS FILTERS IN THE MODERN GAS INDUSTRY

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ABSTRACT

Natural gas is a mixture of various hydrocarbon gases. It can be found both alone and mixed with crude oil in oil fields, it is considered the most widely used fuel in industry, it is used in a wide range of industries such as glass, plastic, fertilizer, and steel. In addition, natural gas is the main fuel for household heating systems almost all over the world. Because it burns more ecologically, is safer and does not pollute the environment, it is substantially ahead of other fuels (such as coal and diesel) worldwide. However, we must note that natural gas can contain many liquid and solid contaminants. For the processes to be effective in the whole process, it must be cleaned effectively starting from the initial stage.
Keywords: Natural gas, gas filters, natural gas contamination.

Introduction

Natural gas can go through several purification technologies to get from the raw state to a state suitable for reaching the consumer, including:

- Strainers. Simplex and duplex strainers can be considered the first step for cleaning pipelines where gases are transported. It is mainly made of steel and cleans large contaminants (up to 100 microns). Suitable for continuous and repeated application.
- Separators. They are used to separate large liquid contaminants (hydrocarbon oils, paraffin, gels, etc.) from the gas pipeline stream [1]. Separators are made in such a way that when the gas is transported through several devices (inertial separators, finned packages, mesh pads), the small waste droplets fall in it and are combined into large droplets, then removed.
- Coalescer filter. We can consider this as the final stage of gas purification. Even after large and solid particles are cleaned through a basket filter and liquid drops are cleaned with the help of separators, the gas content is not as clean as it should be. In this case, filters come to the rescue. In our time, filters are made that can clean solid and liquid particles of 1 micron size or less with up to 99.9% accuracy.

Filters installed in gas lines are used not only in industrial enterprises, gas distribution stations, greenhouses, and boiler houses to prevent problems caused by the contamination of gas. It is also very important for most research work on gases. A researcher may think that he is working with a pure gas, but it is useful to make sure that it is purified to protect the process from unexpected developments and consequences. This situation is also important for the gas consumer who uses gas in industrial enterprises and greenhouses and buys gas consumption measuring equipment at his own expense at certain intervals. By pre-installing the filter, we filter the gas before it enters the consumption meter, clean it of sand and corrosion debris, and unwanted liquids.
These types of expenses mainly include:

- financial loss caused by production delay that may occur during the removal and installation (or temporary replacement) of the damaged instrument.
- The cost of repairing and replacing the meter or repairable parts of the meter if they are sent for inspection after being damaged.
- Financial costs for providing a new one if the device becomes completely unusable as a result of the inspection.
- Maintenance and calibration costs, etc

Examples of the most common contaminants in the gas stream include water vapor, sulfur-based compounds, oil droplets, silicates (sand), hydrocarbons, oil droplets, and paraffin [2].

High-quality gas cleaning reduces the wear process of sealing surfaces and allows to delay the period of major repairs of these devices. Reduces wear and increases accuracy of gas flow meters, which are particularly sensitive to erosion.

Effect of gas contamination on gas flow meters

Due to their design, measuring devices and gas meters can be sensitive to the effects of gas contamination during the flow. In this regard, gas flow meters work with two different sensor principles:

1. Those who use the "Bypass" principle
2. Those using the "CTA" principle (Constant Temperature Anemometry).

The first type of flowmeter is more sensitive to gas pollution. Only a part of the gas passing through them passes through the Bypass-sensor part. The rest passes through the flow element, which has flow-enhancing discs inside. This part is more easily damaged by dirt.

The second type of flow measuring devices are made not by the Bypass principle, but by the Constant Temperature Anemometry principle. Devices of this type have a stable straight flow channel and are less sensitive to moisture and pollution.

When installing gas meters, it is important to install gas filters before them for the following reasons:

- Contamination of the gas passing through the pipes during movement with high pressure and even the smallest unnecessary particles in the gas can have a negative effect on the flow meter, its working process and most importantly, its service life.
-Especially the gas used in industrial facilities can be more polluted during the flow due to various reasons.
- Oil leakage from gas compressors, even in small amounts, can have a negative impact on the work process [3].

Gas filters, their main elements and working mechanisms.

The main element of gas filters is a cartridge made of synthetic cartridge. This detail cleans it effectively during a large gas flow. Gas filters can differ according to the material of which the cartridge is made, its construction (linear or angular), the method of making the body (casting or welding), the direction of movement of the gas passing through it (direct or rotating). It is not enough to buy a filter once to keep the measuring equipment working well.

More specifically, its cartridge must be constantly monitored and replaced or cleaned at appropriate intervals. The correct selection of filters and their qualified operation is one of the most important steps that ensure the reliable and safe operation of the gas supply system [4].

Basic types of gas filters and their features of use

When making gas filters, it is important to choose a filter material that will not chemically affect the gas it emits, will provide the required degree of purification, and will not fail during periodic cleaning of the filter. working conditions [5] .

In terms of filter material, the most common commercially are mesh filters that use metal meshes, while others are fringe filters that use kapron threads impregnated with viscose oil.

Although mesh filters are selected for cleaning intensity, blockages in the mesh during gas flow reduce its throughput. In fringe filters, in-flow shaking, and periodic cleaning reduce gas filtering capacity. To achieve the expected gas purification process in the filter, it is more appropriate to limit the given gas flow rate to a predetermined limit and to keep the pressure within the permissible limit. For example, the pressure difference should not exceed 5000 Pa for mesh filters, and 10000 Pa for fringe filters. Before the process or during filter cleaning, this difference should be 2000-2500 Pa for grids and 4000-5000 Pa for fringe filters.

Filters are designed in such a way that they have connectors for connecting some additional devices.

Basic elements and working principle of the mesh filters.

The working mechanism of mesh filter can be studied with the help of ФС type filter example (Figure 1). Here, a single-layer, cylindrical metal mesh is used as a filter element. This cylinder itself is soldered to the cylindrical frame. Inside the 1 corpus there are 2 net cassettes and 3 a clip of finely woven netting. The clip is attached to the walls of the case by means of 4 plugs. From the inlet pipe, the gas enters the clamp (cage), where it gradually begins to pour particles of solid waste. The gas passing through the filter is directed to the main device (meter) through the outlet pipe. To clean the filter with the fasteners closed, the plug that holds it in place is opened, the clip and mesh are removed and washed thoroughly. A differential pressure gauge is usually connected through 5 shtusets to measure the pressure difference across the filter. The nets of this type of filter can be made of various metals or their alloys, including plastic.

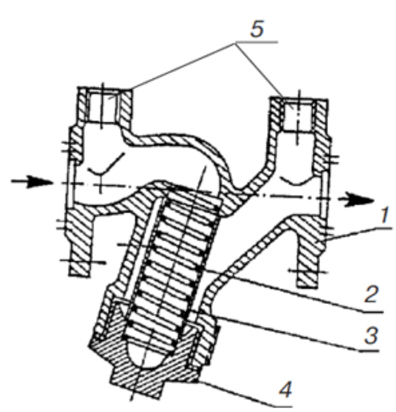

Figure 1. Structural scheme of the ФС type mesh filter

Basic elements and working principle of the fringe filters.

To analyze the working principle of the fringe filter, let's take a look at the ΦΓ type model (Figure 2).

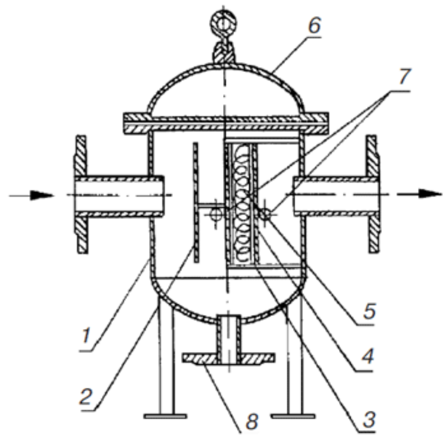

Figure 2. Structural scheme of FQ type fringe filter.

3 cassettes are placed in 1 corpus. In front of it, there are 2 steel plates with the function of a protective layer to prevent the cassette from being damaged by large and solid particles. The outer parts of the cassette are fastened with wire mesh.

Corner parts of the cassette are fixed with wire mesh. The space between them is filled with visceral fat-impregnated nylon threads or horsehair. When the gas flow passes through this gap, it is cleaned of small and solid particles. (4) A perforated sheet with holes is placed behind the cassette. This plate performs a protective function when the pressure exceeds the permissible limit. The corpus is covered from above with (6) lid through bolts. The function of shutters is the same as that of mesh filters.

When cleaning the fringe filter, the cover is opened, the corpus is removed, and 8 faucets are opened. The filter is shaken to remove solids and usually cleaned by washing with benzoyl.

Conclusions

Even choosing the right filtration method and suitable filters, considering all the process and details during the gas flow, sometimes does not guarantee the effectiveness of the process. Due to regular maintenance and monitoring, situations such as reduced flow rate, clogging, unplanned interruptions in the work process can be avoided and lead to long uninterrupted operation. It should also be considered that the industrial processes in which the gas flow occurs may change over time. This means changes in important factors such as flow rate, compressed gas condition and pressure. Therefore, the filtration system in enterprises must be designed according to the changing requirements that affect the process.

Although gas filtration is an area that requires constant attention and expert support, both technically and theoretically, it is strongly based on engineering ideas. Technical and theoretical results in this field are already being electronicized and research is being done for the best results in application. In this part of the gas industry, the demand for improving the metrological level of measurements and increasing the measurement accuracy is always relevant. The process has gone beyond being just intra-enterprise or intra-city/intra-country to become global.

In 2022, as a result of difficult and hard processes taking place in the countries of the world, gas import and consumption of countries entered the next stage. There have been significant quantitative changes in the import and supply of gas for the countries. This year, there is a record increase in gas imports for Azerbaijan. In 8 months of this year alone, our country exported 7.3 billion cubic meters of gas to Europe, 5.4 billion cubic meters to Turkey, and 1.7 billion cubic meters to Georgia. This means an increase of 23% compared to the year. This import, which brought a profit of 10 billion 317 million 686 thousand dollars in 8 months, is expected to take a larger scale by the end of the year thanks to new agreements.
Reducing gas pollution in processing plants and transportation has the potential to improve product quality, reduce operating costs and downtime. This, in turn, means that the process is carried out properly - according to international standards and norms. By consistently producing quality gas, the consumer also gains a competitive advantage and protects its reputation.

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RISK MANAGEMENT IN THE CONDITIONS OF GLOBALIZATION ON THEEXAMPLE MACHINE-BUILDING INDUSTRY OF AZERBAIJAN

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ABSTRACT

One of the key processes in the development of the world economy of the 21st century is progressive globalization, i.e. a qualitatively new stage in the development of the internationalization of economic life.
The article examines the modern ways of development of the machine-building industry of Azerbaijan in global conditions, as well as the importance of risk management, their assessment and monitoring of the development of machine-building enterprises to increase competitiveness in order to achieve a synergistic effect through integration, increase its efficiency in the development of machine-building enterprises. In turn, all this will allow them to master the latest technologies, increase the return on capital and their competitiveness in global markets.
The purpose of the study of this work is to consider the main aspects of the implementation of the concept of risk management by developing ways to increase the effectiveness of risk management in relation to the integration policy of enterprises in the machine-building complex.
All areas of economic activity are subject to risk, and risk management improves predictability and certainty, which gives a sense of confidence in certain situations.
Keywords: Globalization, engineering industry, economics, risk management.

Mechanical engineering is one of the key industries in Azerbaijan. It is believed that the state of this industry primarily determines the technological level of development of the country. It has been established that the profit received from this industry contributes to the development of the entire industry of the developed countries of the world and their technical re-equipment.
The machine-building industry of Azerbaijan covers energy, electrical engineering, radio electronics, instrument making, machine tool building, transport, agriculture, and other machine-building areas that interact with each other.
Mechanical engineering ranks first among industrial sectors in terms of the value of products and the number of employees.
Until recently, engineering in Azerbaijan specialized in the field of oil engineering. This area produces ¼ of the total output produced in this area. One of the largest enterprises in the field of oil engineering is the Glavneftkhimmash Association. This enterprise exports manufactured products to 40 countries [7].
Stationary platforms manufactured at the Baku Deep Sea Foundation Plant, located in the village of Sahil, allow drilling a well at a depth of up to 200-300 m from the surface of the Caspian Sea. Machine-building plant named after Sattarkhan, Keshli machine-building plant, Binagadi clay and steel plants are also large enterprises related to the oil engineering of Azerbaijan.

After the commissioning of the Steel Plant in Baku, Azerbaijan suspended the purchase of cast steel from abroad [3, p.166].

In recent years, in addition to oil engineering, newer branches of engineering have been developed in Azerbaijan. These include the branches of electrical engineering, instrumentation, and radio electronics.

2020 was a difficult year for the economy of the Republic of Azerbaijan due to the negative consequences of the coronavirus pandemic, global economic processes and war. Nevertheless, the choice of the right path of Azerbaijan's economic policy and the resistance of the general economic system have once again confirmed themselves.

Azerbaijan has been trying for a long time to expand its capabilities in the field of mechanical engineering and improve the advanced technologies used. We have good prerequisites for creating machine-building clusters in the liberated regions. In modern conditions, there is a leap in the development of mechanical engineering in the country, and this can be confirmed by the high demand from Russia, Iran, Turkmenistan, and Kazakhstan.

In 2020, there were products of this industry (cars, machinery, and equipment, etc.) in Azerbaijan for about 352.2 million manats.

If we compare it with 2019, then it is in the production of machinery and equipment that the dynamics increased by about 36%, and the production of other vehicles by about 46.8% [4].

Currently, there is no single, generally accepted definition of the concept of globalization. Thus, the American economist J. Dunning under globalization means the interconnection of individuals and various institutions within the world space, carried out for personal or institutional interests, economic, cultural or political purposes.

M. Castells, professor of sociology at the University of California, USA, defined globalization as a “new capitalist economy”, and singled out information, knowledge, and information technologies, which are the main sources of growth and competitiveness, as its distinctive features. This new economy is organized predominantly through a network structure of management, production, and distribution, and not through individual firms, as before, and is global.

Globalization is a multifaceted process that covers the most diverse aspects of social life. In this regard, globalization can be characterized as the degree of internationalization of economic life, in which the free movement of goods and the main factor of production is realized. The multi-stage process of globalization consists in strengthening the interdependence and mutual influence of various spheres and processes within the global space, transforming the world economy into a single market for goods, services, capital, labor, knowledge, and technologies, and forming a single network of information and investment flows [8].

The globalization of the economy and its impact on the country became especially relevant after the direct negotiations that Baku launched in 2004 regarding Azerbaijan's accession to the World Trade Organization (WTO), even though Azerbaijan applied for WTO accession in 1997, and the status has been an observer at the WTO since 1997.

The current situation in the economy of Azerbaijan, as well as the initiatives that the Azerbaijani government is now putting forward to develop the real non-oil sector, are connected, first of all, with the supply of domestic domestic, in particular, consumer market with products. That is why, today, the issue of the country's accession to the WTO should be treated with caution. In this direction, the government adheres to the correct position. After all, the country, joining this organization, will face a rather difficult competitive environment. And this will lead to a significant complication of competition for Azerbaijani producers [5].

Globalization is beneficial, first, to the most developed countries. This is due to the peculiarities of historical and economic development. The country embarked on the path of transition from a command economy to a market economy not so long ago. The process of Azerbaijan's transition to a new stage of economic development should take place "from below", i.e. at the micro level, through the entry of national companies into the international market.

Azerbaijan has recently implemented a number of reforms, including the adoption of 12 strategic road maps for economic development, changes in trade regulation, and improved trade and logistics infrastructure.

The “Strategic Roadmap of the National Economy and Main Sectors of the Economy”, adopted in 2016 in Azerbaijan, lists all important sectors of the economy that require special attention and state assistance. These include the prospects for the national economy of Azerbaijan, the development of the oil and gas industry (including chemical products), the production and processing of agricultural products, the production of consumer goods in the country at the level of small and medium-sized enterprises, the development of heavy industry and engineering, the development of a specialized tourism industry, etc.

In the context of globalization, Azerbaijan is implementing a targeted policy aimed at creating the competitive advantages of national economic systems based on the effective use of all types of intellectual resources and high technologies. The data of the Central Statistical Bureau of Azerbaijan indicate that the industry has over two thousand business entities and about 18 thousand individual entrepreneurs who are engaged in industrial activities [2].

Globalization, being an objective trend in the development of human civilization, opens up additional opportunities and promises considerable benefits to individual countries. Thanks to this objective process, savings on production costs are achieved, the allocation of resources on a global scale is optimized, the assortment is expanded and the quality of goods in national markets is increased, and the achievements of science, technology and culture become widely available [1].

As for any industry in the economy, the machine-building industry in Azerbaijan is subject to several risks.

The sustainability of the development of sectors of the country's economy is affected by the completeness and correctness of considering risks in assessing and forecasting the results of the economic activities of such enterprises.

Risk management comes down to leveling their impact on the project, and ideally, completely removing the potential problem from the project.

The four risk management strategies most described in the project management literature are avoid, transfer, accept, and mitigate.

Risk avoidance. This strategy consists of eliminating the impact of the risk on the project by changing the nature of the project or the project management plan. Some of the risks that arise early in the project, such as the lack of a clear definition of the customer's requirements, can be avoided by spending extra time and effort to identify them. However, an avoidance strategy cannot eliminate risk.

Transfer of risk. The transfer strategy also eliminates the threat of risk by transferring negative consequences with responsibility for response to a third party. The transfer of risk is usually accompanied by the payment of a risk premium to the party that assumes the risk and

responsibility for its management. The risk itself is not eliminated. The conditions for transferring responsibility for certain risks to a third party may be specified in the contract. For IT projects, a third party may be a consulting company that is responsible for risk management.
Risk acceptance. Strategy means the team's decision not to shy away from risk. In passive acceptance, the team does nothing about the risk and, if it occurs, develops a way to bypass it or correct the consequences. In active acceptance, an action plan is developed before a risk can occur and is called a contingency plan.
Risk reduction. A strategy involves an effort to reduce the likelihood and/or consequences of a risk to acceptable limits. The mitigation strategy uses the inclusion in the project plan of additional work that will be performed regardless of the risk, such as additional testing of the functionality of the information system, development of a system prototype, additional involvement of experienced employees [9].
Identify as many early hazards as possible, prioritize each one, and start mitigating those risks while the project remains relatively flexible.
A good risk assessment is not an afterthought and should be done well in advance, often, and throughout every phase of the device development cycle. Instead of using only one risk assessment tool, you need to combine the tools at your disposal into a powerful and effective risk mitigation methodology to identify and mitigate more issues early in the cycle. Regular risk assessment using multiple tools throughout the product lifecycle will improve product safety, reduce time to market, and help eliminate costly recalls.
In modern conditions, the problem of the survival of companies, the preservation and provision of their further development has become particularly relevant. The crisis has engulfed not only individual enterprises, but entire industries. The most affected is the automotive industry. The bankruptcy of Chrysler and the problems of Opel are clear examples. In this regard, there has been a sharp increase in interest in solutions that can increase the survival of business entities in extreme economic conditions.
The crisis highlighted the key problem - the imperfection of risk management in all aspects: conceptual, methodological, managerial, technological, organizational. For example, 47% of companies in the engineering industry in the world do not have risk management systems, which indicates a lack of attention of their owners and management to maintaining business, as well as a tendency to short-term business strategies and paternalistic sentiments.
Until recently, the Azerbaijani engineering industry has benefited more from globalization, as it needs free markets. But as protectionism grew, entrepreneurs from Azerbaijan began to lose their shares in many countries. Tariffs, import licenses, technical regulations, and measures to encourage exports from other countries all have a detrimental effect on companies.
Due to trade restrictions, Azerbaijani machine builders are losing market shares around the world.
Experts state that global protectionism is on the rise. Azerbaijan's engineering industry, with its export quota, is very much dependent on the availability of free markets, and there are fewer and fewer of them.
At the same time, countries use not only classical restrictive measures, such as duties, import licenses and technical regulations. It is also common practice to stimulate exports, when certain states are granted tax breaks or non-refundable financial assistance. This gives them huge advantages over competitors from Azerbaijan. What is happening has affected Azerbaijani machine builders, who have previously benefited the most from globalization, in all important export markets, that is, in

China, USA, Russia and even in EU countries. They have to compete with products whose export sales are stimulated. Most of the restrictions are introduced by developing countries, as they want to strengthen their own industry.

Today, there are risks of ousting heavy equipment manufacturers from the Azerbaijani market, which entails the danger of the complete disappearance of the domestic oil engineering industry and the emergence of a total dependence of the mining and processing industries on the supply of foreign equipment [6].

In the event of a decrease in competitiveness or the disappearance of oil engineering products from the market, the level of monopoly on the part of foreign suppliers in the market will increase sharply, which will certainly cause an increase in the price of acquiring and servicing fixed assets in the primary industries by tens of percent. All this will cause a heavy blow to the productivity of the primary industries, that is, to the foreign trade balance, to budget revenues, in fact, to the country's economy.

It is possible to reduce the risks associated with the business processes of manufacturing products, increase the stability of these business processes, maintain and promote the image of organizations, eliminate real and prevent potential threats in a timely and consistent manner by integrating automated production management systems and accounting reporting with a risk management system based on process-oriented approach, including taking into account the requirements of continuity of production. As expected, this will reduce unplanned losses in the production of products in the engineering industry, as well as improve the quality and efficiency of business process management.

Thus, the world economy, including the Azerbaijani one, is in for a rather long difficult period. It is necessary to go through it with the least losses and be ready to develop effectively after the end of the crisis. This, no doubt, requires risk management and the ability to do so in difficult conditions.

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$$f(x) = a_0 + \sum_{n=1}^{\infty} \left(a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right) \quad (1)$$

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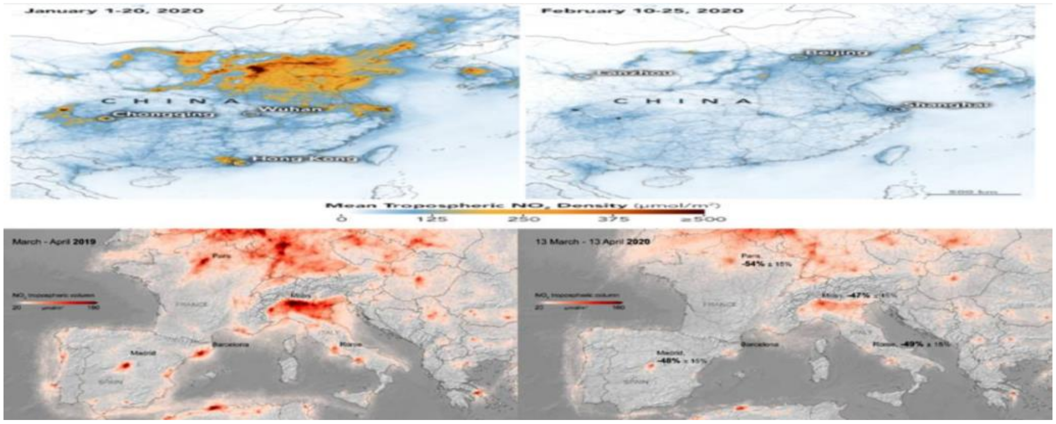

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6. M. Ahmad, "Importance of Modeling and Simulation of Materials in Research", J. Mod. Sim. Mater., vol. 1, no. 1, pp. 1-2, Jan. 2018. DOI: https://doi.org/10.21467/jmsm.1.1.1-2

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