The use of quicklime for soil thawing in pile foundation setting

Ainur Montayeva 1, Askar Zhussupbekov 1, Sarsenbek Montayev 2, Zhankeldi Nashiraliyev 3
1 Department of Design of Buildings and Structures, L.N. Gumilyov Eurasian National University
2 Department of Construction and Building Materials, Zhangir Khan West Kazakhstan Agrarian-Technical University
3 Department of Construction and Building Materials, Satbayev University

ABSTRACT

Due to the fact that in the winter period, which in the Northern regions of the Republic of Kazakhstan lasts up to 6 months, and in the Southern regions – up to 4 months, construction companies are forced to suspend construction and installation works on the foundations. As a result, the total duration of construction of facilities increases, which leads to additional financial expenses. Therefore, new technological solutions are needed for the construction of foundations in winter, to ensure the continuity of construction and installation work. The purpose of the study is to develop a formula of chemical reagents for thawing and protection from the freezing of seasonally frozen soil in places where pile foundations are driven in winter conditions. For the study, a three-component mixture of chemical reagents of the following composition, wt.%, was selected: quick lime (CaO) – 75, calcium chloride (CaCl) – 20, sodium chloride (NaCl) – 5. The choice of the specified composition is determined by taking into account their specific chemical properties and special reactions when interacting with water and frozen soil. The active components of quick lime (CaO) are converted to Ca(OH)2 when interacting with a wet environment or water. This process is accompanied by spontaneous heat release. In the course of the study, a new composition of a chemical reagent based on quick lime was developed for local thawing and protection from the freezing of seasonally frozen clay soil in the areas of driving pile foundations. This composition has advantages in terms of reducing energy costs for thawing seasonally frozen soil, since when interacting with water, the proposed chemical reagent spontaneously releases heat \( t = 100^\circ\text{C} \) and does not cool down for a long time despite the negative ambient temperature of the air.

Keywords: Temperature, Device, Scientific and experimental work, Heat generation, construction.

Corresponding Author:
Ainur Montayeva
Department of Design of Buildings and Structures
L.N. Gumilyov Eurasian National University
010008, 2 Satpayev Str., Nur-Sultan, Republic of Kazakhstan
E-mail: montayeva6994-1@national-univesity.info

1. Introduction

The population of the Republic of Kazakhstan has increased by 4.5% since 2015 and reached more than 18 million people by 2020. The urban population has amounted to 10.4 million, and the rural population – 7.7 million. The level of urbanisation is about 57.4%. Therefore, in all cities of the Republic of Kazakhstan, multi-storey residential complexes, large business centres, as well as industrial buildings and structures are being built [1-6]. Currently, pile foundations are very often used in the construction of buildings and structures due to their high load-bearing capacity and cost-effectiveness. In the northern, eastern and western regions of the Republic of Kazakhstan, one of the most common problems is the immersion of piles in frozen soils during their seasonal freezing [7-12]. The problem is that seasonally frozen soils in an undisturbed state have high strength (Table 1).
Table 1. Strength indicators of seasonally frozen soils, most common in the Republic of Kazakhstan at a temperature of -10°C

| Type of soil    | Temporary resistance of frozen soil at a temperature of -10°C, kg/cm² |
|----------------|-----------------------------------------------------------------------|
|                | on compression stretching                                            |
| Loam           | 35-50                                                                 |
| Sandy loam     | 55-80                                                                 |
| Sand           | up to 120                                                             |

Notably, one of the important problems of immersion of piles in frozen soils is the inevitability of destruction of the head of the pile foundation, which leads to corrosion destruction of reinforcement and concrete. Analysis of pile foundation construction technologies in seasonally frozen soils allowed for the conclusion that even with a small depth of freezing, the accuracy of pile driving can be sharply reduced. At the same time, the probability of deviation of the piles from the design position is up to 10-15 cm, which is not an acceptable value. In turn, this will lead to a decrease in their load-bearing capacity [13-19]. Practical observations of the condition of piles driven into a layer of frozen soil have shown that in more than 90% of cases, the body of the piles is damaged by hammer blows. Therefore, many scientists, based on the conducted scientific and experimental studies, have come to the consensus that at a frost depth of more than 0.4 m, the soil in the places of pile driving should be thawed and protected from freezing by various methods [20-26]. However, the analysis of conventional methods of thawing seasonally frozen soils showed their high labour intensity and significant economic expenses [27-31]. Therefore, the driving of piles in winter requires additional work associated with the use of additional equipment and preliminary thawing of the soil. As a result, the labour intensity, duration, and cost of work increase [32-35]. Therefore, the main task when submerging piles in frozen soils is to avoid the destruction of the pile foundation using progressive methods of thawing the soil and protecting it from freezing.

Research in the line of foundation construction in frozen ground conditions considers many factors such as the behaviour of frozen ground and the interaction of soil with piles during lateral loading. The results show that the deformation rate inside the seasonally frozen layer usually decreases with increasing depth and distance from the ground-pile interface. A change in the deformation rate by three to four orders of magnitude can occur inside the seasonally frozen layer. Such a large variation in the strain rate can have a significant impact on the characteristics of a side-loaded pile in the frozen state, and its impact should be taken into account [35-42]. The paper [42-46] describes the environmental aspects of pile foundations, including the parameters of the geological environment, depending on the performance characteristics. The main parameters are taken into account: thermal conductivity, heat diffusivity, specific heat capacity, and soil moisture. The influence of temperature and ground water is also considered, as well as recommendations for the design and installation of pile foundations.

In the construction of monolithic pile foundations, the heat of cement hydration can cause an increase in ground temperature and a decrease in the load-bearing capacity of the pile foundation [47-54]. The observed temperature data showed that the pile foundation for buildings and structures without any cooling measures took two years to reach natural freezing. In such cases, a cold-air refrigerant system is proposed to reduce the re-freezing time [55-62]. As evidenced by the experiments in developed countries of the world, the most effective method was the thawing of soils at negative temperatures with the use of chemical reagents. The use of this method allows building facilities all year round, which significantly reduces duration of construction works. To achieve this goal, it is proposed to use the method of thawing frozen soils at negative temperatures as a basis for the construction of foundations in seasonally frozen soils of the Republic of Kazakhstan.

The purpose of the study is to develop a formula of chemical reagents for thawing and protection from the freezing of seasonally frozen soil in places where pile foundations are driven in winter conditions.

In the furtherance of this goal, it was necessary to solve the following tasks:
- to study the physical and mechanical properties of the soil in the places of driving pile foundations;
- to choose chemical reagents that provide spontaneous heat generation and prevent soil freezing;
- to conduct laboratory scientific and experimental studies on the kinetics of thawing of frozen soil, depending on the amount of chemical reagent applied and the time [63-66].
2. Material and methods

For this purpose, the soil for the construction of a residential building in Nur-Sultan (Republic of Kazakhstan) was chosen as the object of study. At the initial stage of research, scientific and experimental work was carried out to investigate the physical and mechanical properties of the soil, the results of which are presented in Table 2 [67-70].

Table 2. Physical and mechanical properties of the soil for the construction of a residential building in Nur-Sultan

| Name of the soil | Sampling depth, m | Particle density, Ps g/cm³ | Natural humidity, W % | Plasticity number, Ip | Index of liquidity, I_L | Porosity coefficient, e | Water saturation coefficient, Sr unit fraction |
|-----------------|-------------------|-----------------------------|-----------------------|----------------------|------------------------|------------------------|-----------------------------------------------|
| Loam            | 0.5               | 2.7                         | 10.4                  | 9.9                  | -0.52                  | 0.722                  | 0.34                                           |

For further study, a three-component mixture of chemical reagents was selected, which includes the following components, wt. %: quick lime (CaO) – 75, calcium chloride (CaCl) – 20, sodium chloride (NaCl) – 5. The choice of the specified composition is conditioned by taking into account their specific chemical properties and special reactions when interacting with water and frozen soil. Quick lime is the most common and affordable building material and is widely used not only in construction, but also in agriculture to improve soil fertility. Its main active components – CaO turns into Ca (OH)₂ when interacting with a wet environment or water. This process occurs with the spontaneous release of heat. The main idea of the study is to use this thermal energy for local thawing of seasonally frozen soil in the places of driving pile foundations. For the study, a standard powdered slow-quenching quick lime of the 1st grade according to GOST 9179-2018 "Building lime. Technical conditions" (EN 459-1: 2010, NEQ) [14] were used. The content of active CaO + MdO – not less than 90%.

Currently, there are several technological methods of driving piles into frozen soils. If the frost depth of the soil does not exceed 0.7 meters, then it is enough to use more powerful hammers and vibrating hammers to drive the piles. If the frost depth exceeds 0.7 meters, it is necessary to establish conditions for the immersion of piles close to summer conditions [71-77]. One of the most effective methods of foundation construction in seasonally frozen soils is the use of bored piles, which are quite well driven into the wells with the help of a jackhammer. However, before installation, a preparatory stage is necessary – drilling, and this is very difficult in conditions of frozen ground. The essence of the method is to create wells in which reinforced concrete piles are installed. At the same time, modern drilling rigs of increased capacity are required. One of the ways to solve the problem of foundation construction in winter conditions is the use of screw piles [78; 79]. The technology of the device of the screw foundation in conditions of sub-zero temperatures differs from the summer installation only by the greater labour intensity of screwing piles, the implementation of which requires the use of mechanized equipment. Figure 1 shows fragments of pile foundations in seasonally frozen soils [80-86].

![Figure 1. Fragments of the device of pile foundations in seasonally frozen soils: a – work on preliminary drilling of seasonally frozen soils in the places of pile driving; b – driving of a reinforced concrete pile into seasonally frozen soil in Nur-Sultan](image-url)
The technology of improving the construction properties of permafrost soils by thawing with chemical reagents deserves special attention [87-91]. Thawing of frozen soils at a negative temperature is carried out by injecting into their volumes concentrated aqueous solutions of salts, anhydrous liquefied and gaseous chemicals that can actively thaw ice and protect thawed soils from possible subsequent freezing. At the same time, compaction of soils combined with thawing at negative temperature is recommended by separate injection of liquefied ammonia and a solution of calcium chloride or other reagents capable of interacting with soil solutions and mineral particles to form a cementing material [92-97]. Solutions of reagents for thawing frozen, especially gravelly-sandy soils can be fed into the ground by gravity without applying external pressure. However, the injection rate is sharply reduced [98-103].

3. Results and discussion

To establish the maximum temperature of the heat released during interaction with water, laboratory tests were carried out according to the following method: quick lime in the amount of 100 g was poured into a glass chemical dish. Then, water at room temperature (t=20-22°C) in an amount of 150 g was added to the dishes with quick lime [104-108]. To measure the temperature of the generated heat, a thermometer was installed in the center of the glass dish to a depth of half the height of the quick lime filled in, as shown in Figure 2.

![Figure 2](image)

The findings showed that after the interaction of quick lime with water, a violent reaction was observed with the release of water vapour. Notably, the violent reaction did not begin immediately, but after 5-7 minutes. In parallel, the heat release temperature began to rise [109-115]. After 20 minutes, the heat release temperature has amounted to 100°C. This process is explained as follows. In the process of interaction of quick lime with water, the reaction occurs:

$$\text{CaO} + \text{H}_2\text{O} = \text{Ca(OH)}_2 + 15.5 \text{ kcal},$$

where: 1 kcal = 4.1868 × 10³ J.

In this case, the reaction proceeds rapidly, with a large release of heat – 15.5 kcal per gramme-molecule or 277 kcal per 1 kg of lime. Water, penetrating into the depth of calcareous grains, enters into chemical interaction with CaO, and the heat released in this case turns the water into a boiling state, which leads to the release of steam. It is this effect of heat release with the release of steam that is meant to be used for local thawing of seasonally frozen soil [116-121]. The additional use of calcium chloride (CaCl) and sodium chloride (NaCl) in the composition of the chemical reagent is necessary for additional intensification of the thawing process of seasonally frozen soil and the exclusion of its re-freezing. To study the effect of heat release of quick lime when interacting with water in real winter conditions, a laboratory sample of seasonally frozen soil at an ambient temperature of t = -20°C was prepared (Figure 3).
Figure 3. Fragments of preparation of a laboratory sample of seasonally frozen soil at ambient temperature $t = -20^\circ C$: a – laboratory sample of seasonally frozen soil; b – preparation of samples for experiments

The size of the laboratory sample of seasonally frozen soil – 30 cm in diameter and 20 cm in depth. At the initial stage of the study, chemical reagents were previously prepared based on the quick lime of the following composition by wt%: quick lime (CaO) – 82, calcium chloride (CaCl) – 15, sodium chloride (NaCl) – 3.0. For the purpose of carrying out experimental work, a chemical reagent based on quicklime with a thickness of 1.0 cm, 2.0 cm and 3.0 cm was filled in on the surface of a laboratory sample of seasonally frozen soil. To study the depth of thawing depending on the thickness of the backfill of the chemical reagent and on the time, experiments were conducted for each backfill separately in the open air in winter [122]. The outside air temperature was $t = -20^\circ C$. Water at room temperature ($t = +22^\circ C$) was added to the surface of the chemical reagent. After the addition of water, the time of the rapid reaction was recorded and the heat release temperature was measured in parallel using a thermometer and the depth of thawing of seasonally frozen soil by drilling. The interval between measurements was 10 minutes. (Figure 4).

Figure 4. Beginning of experimental work on thawing a laboratory sample of seasonally frozen soil using a chemical reagent based on quicklime: a – the moment of adding water; b – the moment of observing the temperature of heat release and measuring the depth of thawing
The results of the conducted experiments are presented in Figure 5.

![Figure 5](image)

**Figure 5.** The dependence of the depth of thawing of a laboratory sample of seasonally frozen soil on the time at the thickness of the backfill layer of a chemical reagent based on quicklime: a – at a layer thickness of 1.0 cm; b – at 2.0 cm; c – at 3.0 cm

As evidenced by the experimental results, when the chemical reagent backfill, thickness is 1.0 cm, there is a gradual increase in the depth of thawing of the soil, depending on the time. After a time of 5 minutes, the thawing depth was only 1.2 cm. In this case, the reaction of quick lime was not strongly manifested. However, the temperature at the thawing site tends to increase to 100°C despite the low outdoor temperature (t = -20°C). The most intense thawing is observed, starting from 40 minutes, where the thawing depth reach 9.4 cm. With an increase of thickness of the chemical reagent backfill to 2 cm, the intensive start of thawing begins as early as 20 minutes. In such case, the thawing depth reaches up to 11.6 cm. Further, the thawing process is more intense and after a time of 60 minutes, the thawing depth is 19.3 cm. The most intensive thawing of seasonally frozen soil is observed at the chemical reagent backfill of 3.0 cm. At the same time, after a time of 10 minutes, the thawing depth is already 8.2 cm [123-125]. Further, with increasing time, an intensive thawing process is observed and after a time of 50 minutes reaches a maximum mark of 20 cm. Notably, in this case of the experiment, the complete thawing of the laboratory sample of seasonally frozen soil is completed 10 minutes earlier than in the previous two conditions (Figure 6) [126].
Figure 6. Fragments of a thawed sample of seasonally frozen soil when using a chemical reagent based on quicklime: a – the process of checking the thawed laboratory seasonally frozen soil; b – the appearance of a completely thawed sample of frozen soil

4. Conclusion

1. A new composition of a chemical reagent based on quicklime was developed for local thawing and protection from freezing of seasonally frozen clay soil in the areas of driving pile foundations. The proposed chemical reagent has the following composition by wt%: quicklime (CaO) – 82, calcium chloride (CaCl) – 15, sodium chloride (NaCl) – 3.0.

2. A distinctive feature of the proposed composition of the chemical reagent is that for local thawing of seasonally frozen loam soil, the spontaneously released heat of quicklime in interaction with water is used. Under laboratory conditions, it was found that the heat generated as a result of the chemical reaction of quicklime reaches up to 100°C despite the negative temperature of the outside air (t = -20°C).

3. Under laboratory conditions, experimental studies of the thawing process of a laboratory sample of seasonally frozen clay soil were carried out using the developed composition of a chemical reagent based on quicklime. The main regularities of the change in the thawing depth depending on the backfill thickness and time at ambient temperature t = -20°C were investigated.

4. It was found that the intensity of thawing of a laboratory sample of seasonally frozen soil depends on the thickness of the backfill of a quick lime-based chemical reagent. At the same time, the most intense and relatively rapid thawing was observed at a chemical reagent backfill thickness of 3.0 cm. The developed composition of the chemical reagent based on quicklime has advantages in terms of reducing energy costs for thawing seasonally frozen soils, since when interacting with water, the proposed chemical reagent spontaneously releases heat (t = 100°C) and does not cool down for a long time despite the negative ambient temperature. And the content of CaCl and NaCl in the composition excludes the refreezing of seasonally frozen loam soil.

References

[1] Y. Zhou and J. Zhang, “A Novel Visualization Apparatus for Freezing Soils and Its Application in Freezing-Thawing Test,” Chinese Journal of Rock Mechanics and Engineering, vol. 39, no. 8, pp. 1671-1681, 2020.

[2] M. Loli, A. Tsatsis, R. Kourkoulis and I. Anastasopoulos, “A Simplified Numerical Method to Simulate the Thawing of Frozen Soil,” Proceedings of the Institution of Civil Engineers: Geotechnical Engineering, vol. 173, no. 5, pp. 408-427, 2020.

[3] V. V. Verstov, A. N. Gaido and N. A. Egorova, “Features of Immersion of Piles in Frozen Soils,” Young Scientist, vol. 20, no. 206, pp. 135-138, 2018.

[4] W. Fei, Z. J. Yang and T. Sun, “Ground Freezing Impact on Laterally Loaded Pile Foundations Considering Strain Rate Effect,” Cold Regions Science and Technology, vol. 157, pp. 53-63, 2019.

[5] M. de Moel, P. M. Bach, A. Bouazza, R. M. Singh and J. O. Sun, “Technological Advances and Applications of Geothermal Energy Pile Foundations and Their Feasibility in Australia,” Renewable and Sustainable Energy Reviews, vol. 14, no. 9, pp. 2683-2696, 2010.
[6] K. Chen, Q. - H. Yu, L. Guo and Z. Wen, “Artificial Cooling of Cast-in-Place Piles in Permafrost Regions,” China Journal of Highway and Transport, vol. 33, no. 9, pp. 104-114, 2020.

[7] Y. Shang, F. Niu, X. Wu and M. Liu, “A Novel Refrigerant System to Reduce Refreezing Time of Cast-in-Place Pile Foundation in Permafrost Regions,” Applied Thermal Engineering, vol. 128, pp. 1151-1158, 2018.

[8] A. Litvinovich, “The History of Soil Liming,” Agrophysics, vol. 2, no. 14, pp. 45-51, 2014.

[9] V. P. Yakushev, A. I. Osipov, R. M. Minnulin and S. V. Voskresensky, “On the Issue of Liming Acidic Soils in Russia,” Agrophysics, vol. 2, no. 10, pp. 18-22, 2013.

[10] A. M. Samedov and D. V. Tkach, “Strengthening Waterlogged Clayey Soils with Ground Quicklime or Burnt Magnesia,” Bulletin of the Tula State University. Earth Sciences, vol. 2, pp. 162-170, 2012.

[11] I. A. Shilnikov, “Brief Results and Tasks of Scientific Research on the Problem of Soil Liming in the Russian Federation,” in I.A. Shilnikova, N.I. Akanova (Eds.), Soil Liming Issues, Agrokonsalt, Moscow, Russian Federation, pp. 4-8, 2002.

[12] I. A. Shilnikov and L. A. Lebedeva, Soil liming, Moscow: Agropromizdat, 1987.

[13] I. V. Egorov, The Use of Ground Quicklime for Bases and Coatings from Waterlogged Clay Soils. Leningrad: Publishing house “Izdatelstvo Leningradskogo doma Nauchno-Tekhnicheskoy Propagandy”, 1962.

[14] GOST 9179-2018 “Building lime. Technical conditions” (EN 459-1:2010, NEQ), 2018, Available from: https://meganorm.ru/Data2/1/4293734/4293734276.pdf.

[15] A. A. Aldaeef and M. T. Rayhani, “Pull-out Capacity and Creep Behavior of Helical Piles in Frozen Ground,” Journal of Geotechnical and Geoenvironmental Engineering, vol. 146, no. 12, Article number: 04020140, 2020.

[16] A. E. Zakharov, “Investigation of Temperature Fields in Frozen Soils in Contact with Hardening Mortar Layers,” in Reports of the 59th Scientific Conference of Professors, Teachers, Researchers, Engineers and Postgraduate Students of the University, Saint Petersburg State University of Architecture and Civil Engineering, Saint Petersburg, Russian Federation, pp. 32-33, 2002.

[17] A. L. Nevzorov, E. V. Krieger, I. I. Sakharov, A. E. Zakharov, V. N. Paramonov and S. A. Kudryavtsev, “Assessment of Soil Deformations Associated with Freezing and Thawing,” in R. A. Mangushev, V.D. Karlov, N.G. Corvette (Eds.), Foundations and Foundations: Theory and Practice: Interuniversity Thematic Collection of Works, Saint Petersburg State University of Architecture and Civil Engineering, Saint Petersburg, Russian Federation, pp. 134-140, 2004.

[18] E. Wang, H. Jiang, Q. Fu, E. Cui and F. Xie, “Experiment on Effect of Freezing and Thawing on Physical and Mechanical Properties of Saturated Channel Foundation Soil,” Transactions of the Chinese Society for Agricultural Machinery, vol. 49, no. 3, pp. 287-294, 2018.

[19] Guidelines for the Technology of Physical and Chemical Strengthening of Freezing and Thawing Soils, 1977. Available from: https://files.stroyinf.ru/Index2/1/4293768/4293768279.htm.

[20] M. Y. Kuprikov, N. M. Kuprikov and L. N. Rabinskiy, “The Dependence of the Appearance of the Aircraft on The Conditions of the Arctic Basing,” INCAS Bulletin, vol. 11, pp. 115-123, 2019.

[21] O. V. Egorova and Y. K. Kyaw, “Solution of Inverse Non-Stationary Boundary Value Problems of Diffraction of Plane Pressure Wave on Convex Surfaces Based on Analytical Solution,” Journal of Applied Engineering Science, vol. 18, no. 4, 18(4), pp. 676-680, 2020.

[22] E. V. Akimov, D. A. Kozorez and D. M. Kruzhhkov, “Navigation Solution Concept and Its Practical Approach Development for Lunar Missions,” Russian Engineering Research, vol. 40, no. 7, pp. 605-607, 2020.

[23] E. E. Galkina and A. E. Sorokin, “Quality Management and Sustainable Economic Development,” Russian Engineering Research, vol. 40, no. 7, pp. 577-578, 2020.
[24] A. G. Getmanov and L. N. Rabinskiy, “Assessment of Durability of Coatings in Difficult Stress Conditions,” Periodico Tche Quimica, vol. 16, no. 33, pp. 490-497, 2019.

[25] V. A. Zagovorchev and O. V. Tushavina, “The Use of Jet Penetrators for Movement in the Lunar Soil,” INCAS Bulletin, vol. 11, pp. 121-130, 2019.

[26] M. Sha, O. A. Prokudin, Y. O. Solyaev and S. N. Vakhnee, “Dependence of Glare Destruction Mechanisms on the Elongation of Samples in Tests to Three-Point Flexural,” Periodico Tche Quimica, vol. 17, no. 35, pp. 549-558, 2020.

[27] A. V. Babaytsev, L. N. Rabinskiy and K. T. Aung, “Investigation of the Contact Zone of a Cylindrical Shell Located Between Two Parallel Rigid Plates with a Gap,” INCAS Bulletin, vol. 12(Special Issue), pp. 43-52, 2020.

[28] N. Fialko, R. Navrodska, M. Ulewicz, G. Gnedash, S. Alioshko and S. Shevcuk, “Environmental Aspects of Heat Recovery Systems of Boiler Plants,” E3S Web of Conferences, vol. 100, 00015, 2019.

[29] Y. Sun, M. Y. Kuprikov and E. L. Kuznetsova, “Effect of Flight Range on the Dimension of the Main Aircraft,” INCAS Bulletin, vol. 12(Special Issue), pp. 201-209, 2020.

[30] Y. Li, A. M. Arutunian, E. L. Kuznetsova and G. V. Fedotenkov, “Method for Solving Plane Unsteady Contact Problems for Rigid Stamp and Elastic Half-Space with a Cavity of Arbitrary Geometry and Location,” INCAS Bulletin, vol. 12(Special Issue), pp. 99-113, 2020.

[31] S. S. Tashpullatov, I. V. Cherunova, M. K. Rasulova, D. D. Inoganyanov, M. Yu. Umarova, A. D. Daminov, U. R. Uzakov and S. G. Jurayeva, “Development of the Calculation Method of Polymer Compound Mass to Be Applied onto the Textile Garment Pieces,” IOP Conference Series: Materials Science and Engineering, vol. 459, no. 1, 012067, 2018.

[32] V. A. Zagovorchev and O. V. Tushavina, “Selection of Temperature and Power Parameters for Multi-Modular Lunar Jet Penetrator,” INCAS Bulletin, vol. 11(Special Issue), pp. 231-241, 2019.

[33] V.V. Bodryshev, L. G. Nartova and L. N. Rabinskiy, “Digital Interpretation of Gas Dynamics Problems as A Means of Optimizing Fundamental General Engineering Education,” Asia Life Sciences, vol. 2, pp. 759-774, 2019.

[34] R. Dinzhos, N. Fialko, V. Prokopov, Y. Sherenkovskiy, N. Meranova, N. Koseva, V. Korzhik, O. Parkhomenko and N. Zhuravskaya, “Identifying the Influence of the Polymer Matrix Type on the Structure Formation of Microcomposites When They Are Filled with Copper Particles,” Eastern-European Journal of Enterprise Technologies, vol. 5, no. 6-107, pp. 49-57, 2020.

[35] S. A. Lurie, P. A. Belov, Y. O. Solyaev and E. C. Aifantis, “On One Class of Applied Gradient Models with Simplified Boundary Problems,” Materials Physics and Mechanics, vol. 32, no. 3, pp. 353-369, 2017.

[36] A. V. Babaytsev and A. A. Zotov, “Designing and Calculation of Extruded Sections of an Inhomogeneous Composition,” Russian Metallurgy (Metally), vol. 2019, no. 13, pp. 1452-1455, 2019.

[37] I. Cherunova, S. Tashpullatov and Y. Davydova, “Geometric Conditions of Mathematical Modeling of Human Heat Exchange Processes with the Environment for CAD Systems Creating Heat-Shielding Clothing,” IOP Conference Series: Materials Science and Engineering, vol. 680, no. 1, 012039, 2019.

[38] R. Navrodska, N. Fialko, G. Presich, G. Gnedash, S. Alioshko, and S. Shevcuk, “Reducing Nitrogen Oxide Emissions in Boilers at Moistening of Blowing Air in Heat Recovery Systems,” E3S Web of Conferences, vol. 100, 00055, 2019.

[39] N. M. Fialko, V. G. Prokopov, N. O. Meranova, Yu. S. Borisov, V. N. Korzhik and G. P. Sherenkovskaya, “Heat Transport Processes in Coating-Substrate Systems under Gas-Thermal Deposition,” Fizika i Khimiya Obrabotki Materialov, vol. 2, pp. 68-75, 1994.

[40] L. N. Nutfullaeva, A. F. Plekhanov, I. G. Shin, S. S. H. Tashpullatov, I. V. Cherunova, S. H. N. Nutfullaeva and E. A. Bogomolov, “Research of Conditions of Formation Package and Ensure the Safety
of the Pillows from Composite Nonwoven Fibers Materials,” Izvestiya Vysshikh Uchebnykh Zavedenii, Seriya Tekhnologiya Tekstil'noi Promyshlennosti, vol. 380, no. 2, pp. 95-101, 2019.

[41] V. V. Bodryshev, A. V. Babaytsev and L. N. Rabinskiy, “Investigation of Processes of Deformation of Plastic Materials with the Help of Digital Image Processing,” Periodico Tche Quimica, vol. 16, no. 33, pp. 865-876, 2019.

[42] E. L. Kuznetsova, G. V. Fedotenkov and E. I. Starvoitov, “Methods of Diagnostic of Pipe Mechanical Damage Using Functional Analysis, Neural Networks and Method of Finite Elements,” INCAS Bulletin, vol. 12(Special Issue), pp. 79-90, 2020.

[43] A. Zvorykin, N. Fialko, S. Juliia, S. Aleshko, N. Meranova, M. Hanzha, I. Bashkir, S. Stryzheus, A. Voitenko and I. Pioro, “CFD Study on Specifics of Flow and Heat Transfer in Vertical Bare Tubes Cooled with Water at Supercritical Pressures,” International Conference on Nuclear Engineering, Proceedings, ICONE, vol. 9, pp. 1-13, 2017.

[44] I. V. Cherunova, S. S. Tashputalov and S. V. Kurenova, “Treated Textile Electrostatic Properties Study,” Materials Science Forum, vol. 992, pp. 439-444, 2020.

[45] D. G. Blinov, V. G. Prokopov, Yu. V. Sherenkovskii, N. M. Fialko, and V. L. Yurchuk, “Effective Method for Construction of Low-Dimensional Models for Heat Transfer Process,” International Journal of Heat and Mass Transfer, vol. 47, no. 26, pp. 5823-5828, 2004.

[46] N. M. Fialko, R. O. Navrodska, S. I. Shevchuk and G. O. Gnedash, “The Environmental Reliability of Gas-Fired Boiler Units by App Lying Modern Heat-Recovery Technologies,” Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, vol. 2020, no. 2, pp. 96-100, 2020.

[47] G. A. Ganiyeva, B. R. Ryskulova and S. Sh. Tashputalov, “Ergonomic Studies of Dynamic Compliance of Parameters Within the Man-Special Clothing System for Workers of the Oil Industry,” Izvestiya Vysshikh Uchebnykh Zavedenii, Seriya Tekhnologiya Tekstil'noi Promyshlennosti, vol. 2015, no. 3, pp. 151-154, 2015.

[48] R. V. Dinzhos, E. A. Lysenkov and N. M. Fialko, “Features of Thermal Conductivity of Composites Based on Thermoplastic Polymers and Aluminum Particles,” Journal of Nano- and Electronic Physics, vol. 7, no. 3, 03022, 2015.

[49] N. M. Fialko, V. G. Prokopov, N. O. Meranova, Yu. S. Borisov, V. N. Korzhik and G. P. Sherenkovskaya, “Single Particle-Substrate Thermal Interaction During Gas-Thermal Coatings Fabrication,” Fizika i Khimiya Obrabotki Materialov, vol. 1, pp. 70-78, 1994.

[50] A. Zvorykin, S. Aleshko, N. Fialko, N. Maison, N. Meranova, A. Voitenko and I. Pioro, “Computer Simulation of Flow and Heat Transfer in Bare Tubes at Supercritical Parameters,” International Conference on Nuclear Engineering, Proceedings, ICONE, vol. 5, pp. 1-12, 2016.

[51] A. V. Babaytsev and L. N. Rabinskiy, “Design Calculation Technique for Thick-Walled Composite Constructions Operating Under High-Speed Loading,” Periodico Tche Quimica, vol. 16, no. 33, pp.480-489, 2019.

[52] R. R. Anamova, L. V. Bykov and D. A. Kozorez, “Algorithm for Designing Professional Retraining Programs Based on a Competency Approach,” Education Sciences, vol. 10, no. 8, pp. 1-9, 2020.

[53] V. A. Pogodin, L. N. Rabinskiy and S. A. Sitnikov, “3D printing of Components for the Gas-Discharge Chamber of Electric Rocket Engines,” Russian Engineering Research, vol. 39, no. 9, pp. 797-799, 2019.

[54] A. V. Babaytsev, A. A. Orekhov and L. N. Rabinskiy, “Properties and Microstructure of Alsi10mg Samples Obtained by Selective Laser Melting,” Nanoscience and Technology, vol. 11, no. 3, pp. 213-222, 2020.

[55] A. Babaytsev, V. Dobryanskii and Y. Solyaev, “Optimization of Thermal Protection Panels Subjected to Intense Heating and Mechanical Loading,” Lobachevskii Journal of Mathematics, vol. 40, no. 7, pp. 887-895, 2019.
[56] Yu. G. Evtushenko, V. I. Zubov, S. A. Lurie and Yu. O. Solyaev, “Identification of Kinetic Parameters of the Model of Interphase Layer Growth in a Fibrous Composite,” Composites: Mechanics, Computations, Applications, vol. 7, no. 3, pp. 175-187, 2016.

[57] I. Cherunova, S. Tashputatov and A. Merkulova, “Development of Automation Algorithm for Step of Designing Technology of Static Electricity Protection Clothing,” 2018 International Russian Automation Conference, RusAutoCon 2018, vol. 1, 8501821, 2018.

[58] E. L. Kuznetsova and A. V. Makarenko, “Mathematic Simulation of Energy-Efficient Power Supply Sources for Mechatronic Modules of Promising Mobile Objects,” Periodico Tche Quimica, vol. 15(Special Issue 1), pp. 330-338, 2018.

[59] V. G. Prokopov, N. M. Fialko, G. P. Sherenkovskaya, V. L. Yurchuk, Yu. S. Borisov, A. P. Murashov and V. N Korzhik, “Effect of Coating Porosity on the Process of Heat Transfer with Gas-Thermal Deposition,” Powder Metallurgy and Metal Ceramics, vol. 32, no. 2, pp. 118-121, 1993.

[60] V. N. Korzhyk, L. D. Kulak, V. E. Shevchenko, V. V. Kvasnitskiy, N. N. Kuzmenko, X. Liu, Y. X. Cai, L. Wang, H. W. Xie and L. M. Zou, “New Equipment for Production of Super Hard Spherical Tungsten Carbide and Other High-Melting Compounds Using the Method of Plasma Atomization of Rotating Billet”, Materials Science Forum, vol. 898, pp. 1485-1497, 2017.

[61] N. Kuzhel, A. Bieliatynskyi, O. Prentkovskis, I. Klymenko, S. Mikalinius, O. Kolganova, S. Kornienko and V. Shutko, “Methods for Numerical Calculation of Parameters Pertaining to the Microscopic Following-The-Leader Model of Traffic Flow: Using the Fast Spline Transformation,” Transport, vol. 28, no. 4, pp. 413-419, 2013.

[62] I. A. Kapitonov, “Development of Low-Carbon Economy as the Base of Sustainable Improvement of Energy Security,” Environment, Development and Sustainability, vol. 23, no. 3, pp. 3077-3096, 2021.

[63] F. Karadeniz, Ö. E. Aydoğan, E. A. Kazanci and E. Akdogan, “Design of a 4-DOF Grounded Exoskeletal Robot for Shoulder and Elbow Rehabilitation,” Sustainable Engineering and Innovation, vol. 2, no. 1, pp. 41-65, 2020.

[64] K. Krayushkina, O. Prentkovskis, A. Bieliatynskyi, J. Gigineishvili, A. Skrypchenko, A. Laurinavicius, K. Gopalakrishnan and J. Tretjakovas, “Perspectives on Using Basalt Fiber Filaments in the Construction and Rehabilitation of Highway Pavements and Airport Runways,” Baltic Journal of Road and Bridge Engineering, vol. 11, no. 1, pp. 77-83, 2016.

[65] V. Korzhyk, V. Khaskin, O. Voitenko, V. Sydorets and O. Dolianovskaia, “Welding Technology in Additive Manufacturing Processes of 3D Objects,” Materials Science Forum, vol. 906, pp. 121-130, 2017.

[66] I. A. Kapitonov, V. I. Voloshin and V. G. Korolev, “Energy Security of Territories as a Factor of Sustainable Development Under the Conditions of Economic Changes,” International Journal of Energy Economics and Policy, vol. 9, no. 6, pp. 210-221, 2019.

[67] Y. K. Kyaw, E. L. Kuznetsova and A. V. Makarenko, “Complex Mathematical Modelling of Mechatronic Modules of Promising Mobile Objects,” INCAS Bulletin, vol. 12(Special Issue), pp. 91-98, 2020.

[68] G. A. Ganiyeva, B. R. Ryskulova and S. S. Tashputatov, “Selection of Special Clothes Design Parameters on the Basis of Optimisation of Dynamic Conformance Parameters,” International Journal of Applied Engineering Research, vol. 10, no. 19, 10(19), pp. 40603-40606, 2015.

[69] S. Peleshenko, V. Korzhyk, O. Voitenko, V. Khaskin and V. Tkachuk, “Analysis of the Current State of Additive Welding Technologies for Manufacturing Volume Metallic Products (Review),” Eastern-European Journal of Enterprise Technologies, vol. 3, no. 1-87, pp. 42-52, 2017.

[70] B. Kovačić, R. Kamnik and A. Bieliatynskyi, “The Different Methods of Displacement Monitoring at Loading Tests of Bridges or Different Structures,” MATEC Web of Conferences, vol. 53, 01048, 2016.
[71] I. Cherunova, S. Tashpulatov and S. Kolesnik, “Automation of Deformed Fibrous Materials Thermal Characteristics Accounting Process in Garments Production,” 2018 International Russian Automation Conference, RusAutoCon 2018, 8501795, 2018.

[72] I. P. Gulyaev, A. V. Dolmatov, M. Y. Kharlamov, P. Y. Gulyaev, V. I. Jordan, I. V. Krivtsun, V. M. Korzhik and O. I. Demyanov, “Arc-Plasma Wire Spraying: An Optical Study of Process Phenomenology,” Journal of Thermal Spray Technology, vol. 24, no. 8, pp. 1566-1573, 2015.

[73] D. V. Dinzhos, E. A. Lysenkov and N. M. Fialko, “Influence of Fabrication Method and Type of the Filler on the Thermal Properties of Nanocomposites Based on Polypropylene,” Voprosy Khimii i Khimicheskoi Tekhnologii, vol. 2015, no. 5, pp. 56-62, 2015.

[74] I. A. Kapitonov, “Transformation of Social Environment in the Application of Alternative Energy Sources,” Environment, Development and Sustainability, vol. 22, no. 8, pp. 7683-7700, 2020.

[75] V. Sydorets, V. Korzhik, V. Khaskin, O. Babych and O. Bermanova, “On the Thermal and Electrical Characteristics of the Hybrid Plasma-MIG Welding Process,” Materials Science Forum, vol. 906, pp. 63-71, 2017.

[76] O. Prentkovskis, A. Beljatynskij, E. Juodvilkienė and R. Prentkovskiene, “A Study of the Deflections of Metal Road Guardrail Post,” Baltic Journal of Road and Bridge Engineering, vol. 5, no. 2, pp. 104-109, 2010.

[77] A. Zvorykina, S. Gupta, W. Peiman, I. Pioro and N. Fialko, “Current Status and Future Applications of Supercritical Pressures in Power Engineering,” International Conference on Nuclear Engineering, Proceedings, ICONE, vol. 5, no. 1, 5(1), pp. 285-300, 2012.

[78] I. A. Kapitonov, “Legal Support for Integration of Renewable Energy Sources in the Energy Law of the Countries from the International Legal Position,” Kuwait Journal of Science, vol. 46, no. 1, pp. 68-75, 2019.

[79] I. A. Kapitonov, “Peculiarities of Applying the Theory of International Business by Russian Oil and Gas Companies,” Space and Culture, India, vol. 6, no. 4, pp. 5-14, 2018.

[80] A. Z. Skorokhod, I. S. Sviridova and V. N. Korzhik, “Structural and Mechanical Properties of Polyethylene Terephthalate Coatings as Affected by Mechanical Pretreatment of Powder in the Course of Preparation,” Mekhanika Kompozitnykh Materialov, vol. 30, no. 4, pp. 455-463, 1994.

[81] N. I. Kobasko, N. M. Fialko and N. O. Meranow, “Numerical Determination of the Duration of the Nucleate-Boiling Phase in the Course of Steel-Plate Hardening. Heat Transfer,” Soviet Research, vol. 16, no. 2, pp. 130-135, 1984.

[82] G. M. Grigorenko, L. I. Adeeva, A. Y. Tunik, V. N. Korzhik, L. K. Doroshenko, Y. P. Titkov and A. A. Chaika, “Structurization of Coatings in the Plasma Arc Spraying Process Using B4C + (Cr, Fe)7C3-Cored Wires,” Powder Metallurgy and Metal Ceramics, vol. 58, no. 5-6, pp. 312-322, 2019.

[83] N. I. Dorogov, I. A. Kapitonov and N. T. Batyrova, “The Role of National Plans in Developing the Competitiveness of the State Economy,” Entrepreneurship and Sustainability Issues, vol. 8, no. 1, pp. 672-686, 2020.

[84] O. Stepanchuk, A. Bieliatynskiy, O. Polypenko and S. Stepanchuk, “Peculiarities of City Street-Road Network Modelling,” Procedia Engineering, vol. 134, pp. 276-283, 2016.

[85] S. Yu. Timkina, O. V. Stepanchuk and A. A. Bieliatynskiy, “The Design of the Length of the Route Transport Stops’ Landing Pad on Streets of the City,” IOP Conference Series: Materials Science and Engineering, vol. 708, no. 1, 012032, 2019.

[86] I. Sultangaliyeva, R. Beisenova, R. Taizitdinova, A. Abzhalelov and M. Khanturin, “The Influence of Electromagnetic Radiation of Cell Phones on the Behavior of Animals,” Veterinary World, vol. 13, no. 3, pp. 549-555, 2020.

[87] M. Yu. Kharlamov, I. V. Krivtsun and V. N. Korzhik, “Dynamic Model of the Wire Dispersion Process in Plasma-Arc Spraying,” Journal of Thermal Spray Technology, vol. 23, no. 3, pp. 420-430, 2014.
[88] I. A. Kapitonov, T. G. Filosofova and V. G. Korolev, “Development of Digital Economy in the Energy Industry-Specific Modernization,” *International Journal of Energy Economics and Policy*, vol. 9, no. 4, pp. 273-282, 2019.

[89] I. A. Kapitonov, “Development of Low-Carbon Economy as the Base of Sustainable Improvement of Energy Security,” *Environment, Development and Sustainability*, vol. 23, no. 3, pp. 3077-3096, 2021.

[90] A. Onishchenko, L. Stolyarova and A. Bieliatynskyi, “Evaluation of the Durability of Asphalt Concrete on Polymer Modified Bitumen,” *E3S Web of Conferences*, vol. 157, 06005, 2020.

[91] E. Džaferević, A. Sokol, A. A. Almiserb and S. Mohd Norzeli, “DoS and DDoS Vulnerability of IoT: A review,” *Sustainable Engineering and Innovation*, vol. 1, no. 1, pp. 43-48, 2019.

[92] M. Küçük and F. Findik, “Selected Ecological Settlements,” *Heritage and Sustainable Development*, vol. 2, no. 1, pp. 1-16, 2020.

[93] L. Akbayeva, N. Mamytova, R. Beisenova, R. Tazitudinova, A. Abzhalelov and A. Akhayeva, “Studying the Self-Cleaning Ability of Water Bodies and Watercounts of Arshalyn District of Akmola Region,” *Journal of Environmental Management and Tourism*, vol. 11, no. 5, pp. 1095-1104, 2020.

[94] S. Z. Mirzaev and U. Kaatze, “Dynamic Scaling in the Ultrasonic Attenuation Spectra of Critical Binary Mixtures,” *Chemical Physics Letters*, vol. 328, no. 3, pp. 277-282, 2000.

[95] S. Oleksandra, K. Krayushkina, T. Khymerik and B. Andrii, “Method of Increasing the Roughness of the Existing Road,” *Procedia Engineering*, vol. 165, pp. 1766-1770, 2016.

[96] A. B. Baibatsha, M. K. Kembayev, E. Z. Mamanov and T. K. Shaiyakhmet, “Remote Sensing Techniques for Identification of Mineral Deposit,” *Periodico Tche Quimica*, vol. 17, no. 36, pp. 1038-1051, 2020.

[97] D. Topchiy and A. Tokarskiy, “Designing of Structural and Functional Organizational Systems, Formed During the Re-Profiling of Industrial Facilities,” *IOP Conference Series: Materials Science and Engineering*, vol. 365, no. 6, 062005, 2018.

[98] A. Bieliatynskyi, E. Krayushkina and A. Skrypchenko, “Modern Technologies and Materials for Cement Concrete Pavement's Repair,” *Procedia Engineering*, vol. 134, pp. 344-347, 2016.

[99] R. Beisenova, S. Tulegenova, R. Tazitudinova, O. Kovalenko and G. Turlybekova, “Purification by Ketoconazole Adsorption from Sewage,” *Systematic Reviews in Pharmacy*, vol. 11, no. 6, pp. 550-554, 2020.

[100] I. A. Kapitonov, I. V. Zhukovskaya, R. R. Khusaenov and V. A. Monakhov, “Competitiveness and Competitive Advantages of Enterprises in the Energy Sector,” *International Journal of Energy Economics and Policy*, vol. 8, no. 5, pp. 300-305, 2018.

[101] A. Baibatsha, “Geotectonics and Geodynamics of Paleozoic Structures from the Perspective of Plume Tectonics: A Case of Kazakhstan,” *International Journal of GEOMATE*, vol. 17, no. 71, pp. 194-202, 2020.

[102] I. B. Labenska, G. A. Shapoval, O. S. Kruglyak, L. Omelyanchyk, O. A. Brazhko and M. P. Zavgordoniy, “Dependence of Biological Activity of N-AcyI Derivatives of 6-Alk oxy-2-Methyl-4-Mer captoquinoline on the Nature of Substituents in the Position 6 of the Heterocycle,” *Ukrain’skiy Biokhimichniy Zhurnal*, vol. 82, no. 3, pp. 49-54, 2010.

[103] D. V. Topchiy, A. S. Bolotova, A. A. Zelentsov, A. S. Vorobev and A. V. Atamanenko, “Technical Rationing of the Construction Technology of Reinforced Concrete Floor Slabs Using Non-Removable Empinitess-Liners,” *International Journal of Civil Engineering and Technology*, vol. 10, no. 2, pp. 2160-2166, 2019.

[104] G. M. Hryhorenko, L. I. Adeeva, A. Y. Tunik, M. V. Karpets, V. N. Korzyhky, M. V. Kindrachuk and O. V. Tisov, “Formation of Microstructure of Plasma-Arc Coatings Obtained Using Powder Wires with Steel Skin and B4C + (Cr, Fe)7C3 + Al Filler,” *Metallofizika i Noveishie Tekhnologii*, vol. 42, no. 9, pp. 1265-1282, 2020.
[105] Z. H. Shadova, P. A. Gurianov, S. N. Fedorova, A. V. Zemlyakova and O. V. Grishchenko, “The Structure of the Share Capital and the Interests of the Majority Shareholder,” International Journal of Economics and Financial Issues, vol. 6, no. 15, pp. 211–219, 2016.

[106] Yu. S. Borisov, V. E. Oliker, E. A. Astakhov, V. N. Korzhik and Yu. A. Kunitskii, “Structure and Properties of Gas-Thermal Coatings of Fe-B-C and Fe-Ti-B-C Alloys,” Soviet Powder Metallurgy and Metal Ceramics, vol. 26, no. 4, pp. 313-318, 1987.

[107] A. B. Baibatsha and A. Muszynski, “Geological-Geophysical Prospecting Indicators of the Arganaty District Predictive Blocks (Eastern Balkhash),” News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences, vol. 2, no. 440, pp. 31-39, 2020.

[108] S. Z. Mirzaev and U. Kaatze, “Scaling Function of Critical Binary Mixtures: Nitrobenzene-N-Hexane Data Revisited,” Chemical Physics, vol. 393, no. 1, pp. 129-134, 2012.

[109] M. Y. Kharlamov, I. V. Krivtsun, V. N. Korzhik, Y. V. Ryabovolyk and O. I. Demyanov, “Simulation of Motion, Heating, and Breakup of Molten Metal Droplets in the Plasma Jet at Plasma-Arc Spraying,” Journal of Thermal Spray Technology, vol. 24, no. 4, pp. 659-670, 2015.

[110] O. V. Chernets, V. M. Korzhik, G. S. Marynsky, S. V. Petrov and V. A. Zhovtyansky, “Electric Arc Steam Plasma Conversion of Medicine Waste and Carbon Containing Materials,” GD 2008 - 17th International Conference on Gas Discharges and Their Applications, vol. 1, pp. 465-468, 2008.

[111] A. Zh. Khastayeva, A. K. Smagulov, V. S. Zhamurova, A. T. Kozhabergenov, M. K. Kozhakhmetov and K. M. Muratbekova, “Fatty Acid Composition and Biological Value of Milk of Holstein Cows at Different Lactation Seasons,” Journal of Physics: Conference Series, vol. 1362, no. 1, 012162, 2019.

[112] A. Z. Khastayeva, V. S. Zhamurova, L. A. Mamayeva, A. T. Kozhabergenov, N. Z. Karimov and K. M. Muratbekova, “Qualitative Indicators of Milk of Simmental and Holstein Cows in Different Seasons of Lactation,” Veterinary World, vol. 14, no. 4, pp. 956-963, 2021.

[113] R. S. Zhussupov, R. A. Baizholova, I. N. Dubina and G. T. Sadykova, “Methodology for Assessing the Competitive Advantages of Agriculture in the Northern Regions of Kazakhstan,” Espacios, vol. 39, no. 16, pp. 1-10, 2018.

[114] D. Topchyi and A. Bolotova, “Systematization of Factors Affecting the Organizational Processes in the Conversion of Buildings,” IOP Conference Series: Materials Science and Engineering, vol. 753, no. 3, 032042, 2020.

[115] G. M. Grigorenko, L. I. Adeeva, A. Y. Tunik, V. N. Korzhik and M. V. Karpets, “Plasma arc Coatings Produced from Powder-Cored Wires with Steel Sheaths,” Powder Metallurgy and Metal Ceramics, vol. 59, no. 5-6, pp. 318-329, 2020.

[116] J. S. Tsertseil, V. V. Kookueva and K. V. Ordov, “Regional Competitiveness Within the Cluster's Territory: Case of the Volga Federal District's Chemical Industry,” Progress in Economics Research, vol. 37, pp. 169-184, 2017.

[117] L. Metelytsia, D. Hodyna, I. Dobrodub, I. Semenyuta, M. Zavhorodnii, V. Blagodatny, V. Kovalishyn and O. Brazhko, “Design of (Quinolin-4-Ylthio) Carboxylic Acids as New Escherichia Coli DNA Gyrase B Inhibitors: Machine Learning Studies, Molecular Docking, Synthesis and Biological Testing,” Computational Biology and Chemistry, vol. 85, 107224, 2020.

[118] M. I. Ermilova and S. V. Laptov, “Using the System-Functional Approach to Assess the Development of Housing Construction,” E3S Web of Conferences, vol. 220, 01001, 2020.

[119] A. B. Baibatsha, A. Muszynski, T. K. Shaiyakhmet and G. S. Shakirova, “3D Modeling for Estimation of Engineering-Geological Conditions of Operating Mineral Deposits,” News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences, vol. 4, no. 442, pp. 19-27, 2020.

[120] R. A. Baizholova, Y. D. Orynbasarova, A. N. Ramashova and Z. A. Abylkassimova, “Interactions Between Human Capital and Innovation,” International Journal of Economic Perspectives, vol. 11, no. 2, pp. 36-39, 2017.
[121] K. A. Alimova, R. Z. Burnashev and K. Zhуманиязов, “One Problem of Cleaning Low-Grade Raw Cotton,” *Izvestiya Vysshikh Uchebnykh Zavedenii, Seriya Tekhnologiya Tekstil'noi Promyslennosti*, vol. 2, pp. 28-30, 1999.

[122] K. Zhуманиязов, R. Z. Burnасhev, Kh. Алимова and U. M. Гулямов, “Rational Selection of the Blend in a Fibrous Web,” *Izvestiya Vysshikh Uchebnykh Zavedenii, Seriya Tekhnologiya Tekstil'noi Promyslennosti*, vol. 1, pp. 56-58, 2001.

[123] D. E. Казакова, K. Z. H. Zhуманиязов, T. A. Очкилов, D. S. Ташпулатов, A. F. Pleханов and N. A. Королева, “Influence of Different Mixture Structure on Mechanical Damage and Fiber Length on Transitions of Spinal Processes,” *Izvestiya Vysshikh Uchebnykh Zavedenii, Seriya Tekhnologiya Tekstil'noi Promyslennosti*, vol. 2019, no. 6, pp. 129-132, 2019.

[124] D. Топчи, V. Скаkalau and A. Юргайтис, “ Comprehensive Verification Construction Compliance Control as the Developer's Project Risk Reduction Tool,” *International Journal of Civil Engineering and Technology*, vol. 9, no. 1, pp. 985-993, 2018.

[125] D. V. Топчы, “Formation of Organizational and Technological Systems for Renovation of Production Facilities Located on the Territory of Megacities,” *International Journal of Civil Engineering and Technology*, vol. 9, no. 8, pp. 1452-1457, 2018.

[126] V. Климина, A. Юргайтис and D. Топчы, “Unified Classification of Defects Detected by the Technical Examination,” *E3S Web of Conferences*, vol. 110, 01086, 2019.