

ISSN 2181-8622

**Manufacturing technology problems**



# **Scientific and Technical Journal Namangan Institute of Engineering and Technology**

INDEX  COPERNICUS  
INTERNATIONAL

**Volume 11  
Issue 1  
2026**



## NamMTI ILMIY-TEXNIKA JURNALI TAHRIR HAY'ATI A'ZOLARI

**Bosh muharrir:** f-m.f.d., prof. O.O. Mamatkarimov

**Bosh muharrir o'rinbosari:** k.f.d., prof. O.K. Ergashev

### TEXNIKA FANLARI (PAXTA, TO'QIMACHILIK VA YENGIL SANOAT)

- |                              |   |  |
|------------------------------|---|--|
| 1. Prof. Dr. Metin ÇOLAK     | - | Ege Universiteti, Turkiya                  |
| 2. Prof. Dr. Suneel KATERIYA | - | Javoharlal Nehru Universiteti, Hindiston   |
| 3. Prof. Dr. Muradov RUSTAM  | - | Namangan To'qimachilik Sanoat Instituti    |
| 4. Prof. Dr. Obidov AVAZBEK  | - | Namangan Muhandislik-Texnologiya Instituti |
| 5. Prof. Dr. Maxkamov ANVAR  | - | Namangan Muhandislik-Texnologiya Instituti |
| 6. Prof. Dr. Azizov SHUXRAT  | - | Namangan Muhandislik-Texnologiya Instituti |
| 7. Dr. Qorabayev SHERZOD     | - | Namangan Muhandislik-Texnologiya Instituti |

### TEXNIKA FANLARI (QISHLOQ XO'JALIGI VA OZIQ-OVQAT TEXNOLOGIYALARI)

- |                                    |   |  |
|------------------------------------|---|--|
| 1. Prof. Dr. Sakina BINTU ABDULLAH | - | Malaya Universiteti, Malayziya             |
| 2. Prof. Dr. Abdalova GULISTAN     | - | Taraz davlat universiteti, Qozog'iston     |
| 3. Prof. Dr. Xudayberdiyev ABSALOM | - | Namangan muhandislik-texnologiya instituti |
| 4. Prof. Dr. Merganov AVAZXON      | - | Namangan muhandislik-texnologiya instituti |
| 5. Prof. Dr. Sherquziyev DONIYOR   | - | Namangan muhandislik-texnologiya instituti |
| 6. Prof. Dr. Qanoatov XAYRULLO     | - | Namangan muhandislik-texnologiya instituti |
| 7. Prof. Dr. Mamatov SHERZOD       | - | Toshkent shahridagi Vebster Universiteti   |

### TEXNIKA FANLARI (MEXANIKA VA MASHINASOZLIK)

- |  |   |  |
|--|---|--|
| 1. Dr. Jaclyn SHARP                      | - | Pittsburg Universiteti, AQSH                     |
| 2. Prof. Dr. Aleksey KAZINSKY            | - | Saratov davlat texnologiya universiteti, Rossiya |
| 3. Akad. Prof. Zaynobbiddinov SIROJIDDIN | - | Andijon Davlat Universiteti                      |
| 4. Prof. Dr. Usmanov PAZLITDIN           | - | Namangan muhandislik-texnologiya instituti       |
| 5. Prof. Dr. Matkarimov PAXRIDDIN        | - | Namangan muhandislik-texnologiya instituti       |
| 6. Prof. Dr. Sharibayev NOSIRJON         | - | Namangan muhandislik-texnologiya instituti       |
| 7. Prof. Dr. Erkaboyev ULUG'BEK          | - | Namangan muhandislik-texnologiya instituti       |

### KIMYO FANLARI (KIMYO VA KIMYOVIY TEXNOLOGIYALAR)

- |                                  |   |   |
|----------------------------------|---|---|
| 1. Prof. Dr. Abel SANTOS         | - | Porto Universiteti, Portugaliya             |
| 2. Prof. Dr. Junli YANG          | - | Lanzhou kimyoviy fizika instituti, Xitoy    |
| 3. Akad. Prof. Namazov ShaFOAT   | - | O'zR FA Umumiy va Noorganik Kimyo instituti |
| 4. Prof. Dr. Botirov ERKIN       | - | O'zR FA O'simlik Moddalar Kimyosi Instituti |
| 5. Prof. Dr. Akbarov HAMDAM      | - | O'zbekiston Milliy Universiteti             |
| 6. Prof. Dr. Nurmanov SUVANKUL   | - | O'zbekiston Milliy Universiteti             |
| 7. Prof. Dr. Salihanova DILNOZA  | - | O'zR FA Umumiy va Noorganik Kimyo instituti |
| 8. Prof. Dr. Kattayev NURIDDIN   | - | O'zbekiston Milliy Universiteti             |
| 9. Prof. Dr. Sulstonov PO'LATJON | - | Geologiya fanlari universiteti              |

### TA'LIMDA ILG'OR PEDAGOGIK TEXNOLOGIYALAR

- |                                |   |  |
|--------------------------------|---|--|
| 1. Prof. Dr. Paul TIKALSKY     | - | Oklahoma Davlat Universiti, AQSH           |
| 2. Dr. David Leffler           | - | Liberty Universiteti, AQSH                 |
| 3. Prof. Dr. Wen-Jian ZHANG    | - | Zhejiang Universiteti, China               |
| 4. Prof. Ergashev SHARIBBOY    | - | Namangan Muhandislik-Qurilish Instituti    |
| 5. Prof. Dr. Musayev JAHONGIR  | - | OFIV                                       |
| 6. Prof. Dr. Eshbayeva ULBOSIN | - | Namangan Muhandislik-Texnologiya Instituti |
| 7. Prof. Dr. Xoshimova DILDORA | - | Namangan Muhandislik-Texnologiya Instituti |

### IQTISODIYOT FANLARI

- |                                  |   |  |
|----------------------------------|---|--|
| 1. Dr. Biral MERCAN              | - | Necmettin Erbakan Universiteti, Turkiya    |
| 2. Dr. Orsolya KATONA            | - | Miskolc Universiteti, Vengriya             |
| 3. Prof. Dr. Soliyev AHMADJON    | - | Namangan Muhandislik-Texnologiya Instituti |
| 4. Prof. Dr. Saidboyev ShERMIRZA | - | Namangan Muhandislik-Texnologiya Instituti |
| 5. Prof. Matkarimov KAMOLIDDIN   | - | Namangan Muhandislik-Texnologiya Instituti |
| 6. Dr. Bustonov MANSUR           | - | Namangan Muhandislik-Texnologiya Instituti |
| 7. Dr. Rashidov RAKHMATILLA      | - | Namangan Muhandislik-Texnologiya Instituti |

Muharrirlar guruhi

O. Kazakov, B. Xolmirzayev, A. Mirzaev, Sh. Maksudov,  
A. Tursunov, O. R. Qodirov (mas'ul muharrir)



# DEVELOPMENT OF AN EFFECTIVE ANTI-CORROSION POLYMER COMPOSITION FOR OIL AND GAS TRUNK PIPELINES ON A RESOURCE-SAVING BASIS

## URINOV ABRORBЕК

Doctoral student, Namangan State Technical University, Namangan, Uzbekistan  
Phone.: (0891) 979-9275, E-mail.: [abormagnat@mail.ru](mailto:abormagnat@mail.ru)  
ORCID: 0009-0008-2757-0034, \*Corresponding author

## ASLONOV AIZXON

Bukhara State Technical University, Bukhara, Uzbekistan  
Phone.: (0899) 736-6009, E-mail.: [aaslonov@mail.ru](mailto:aaslonov@mail.ru)  
ORCID: 0009-0006-9979-1368

---

**Abstract:** Currently, the high cost of metal, as well as the harsh and often extreme operating conditions faced by oil and gas equipment in a sharply continental climate, significantly exacerbate the challenge of improving its reliability and durability. This problem is one of the key issues, as it largely determines the pace of the industry's development, the level of technical and economic efficiency of oil and gas production, collection, and processing, as well as the magnitude of operating and capital costs. This article presents the results of research on the development of anti-corrosion coating formulations based on bitumen, alkyd-urethane and alkyd varnishes, hydrocarbon solvents, and mineral fillers. All ingredients used are available on the domestic market of Uzbekistan at relatively low prices, which ensures the economic feasibility of producing local anti-corrosion coatings and reduces dependence on imported raw materials. The comprehensive research conducted allows for the recommendation of optimal formulations for practical application on oil and gas pipelines, taking into account operating conditions and technological requirements, and serves as a basis for the further development of new modified coatings.

**Keywords:** bitumen, oxygen, aggressive substances, pyrolysis distillate, thermal decomposition, anti-corrosion, composite, polymer modifier, urethane groups, adhesion strength.

---

**Introduction.** Oil and gas equipment is exposed to a complex of adverse factors during operation. These include significant fluctuations in ambient temperature, high humidity, the presence of aggressive components in reservoir products (hydrogen sulfide, carbon dioxide, chloride ions), abrasive effects of mechanical impurities, as well as variable hydrodynamic flow modes. In a sharply continental climate, temperature differences between seasons and even during the day can reach tens of degrees, which leads to additional thermal stresses in the metal and accelerates the degradation of materials [1]. Corrosion occupies a special place among the factors that reduce the resource of oilfield equipment. Corrosion damage is one of the main reasons for the premature failure of the pipelines of the well stream gathering systems, which transport oil, gas and produced water from the production wells to the metering units, and then to the integrated oil processing units. Corrosion leads to a reduction in pipe wall thickness, pitting, cracks and through defects, which significantly increases the risk of accidents, hydrocarbon leaks and environmental pollution.

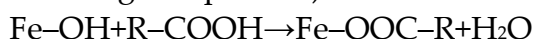
**Methodology & empirical analysis.** The developed anticorrosion material is a multicomponent bitumen-polymer composition with mineral fillers, designed to protect the metal surfaces of oil and gas equipment from corrosion damage.

Composition of material includes:  
bitumen - 35%;

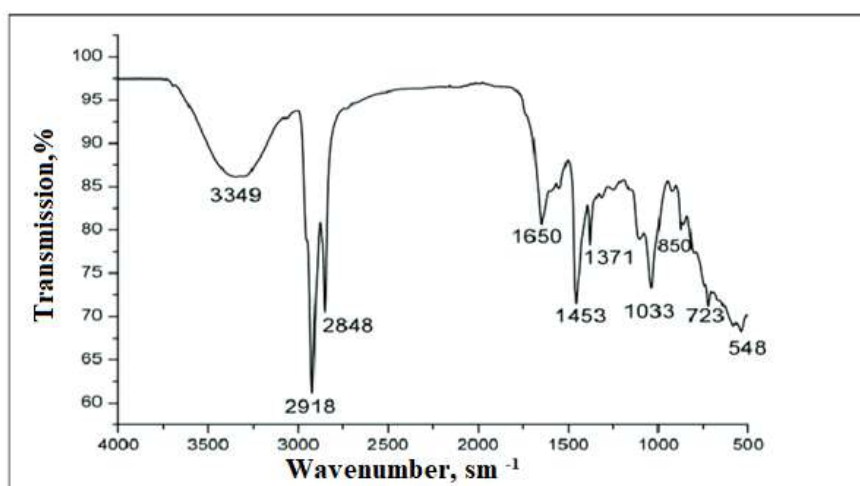
alkyd-urethane varnish - 20%;  
 solvent (pyrolysis distillate) - 30%;  
 filler (bentonite) - 10%;  
 rheological additive (micro silica) - 5%.

Anticorrosion effect of coating is provided by combination of chemical, physicochemical and structural interactions between organic and inorganic components of composition.

The bitumen in the composition functions as the main film-forming and hydrophobic component. Its asphaltene-resinous fractions contain polar functional groups (-OH, -COOH, -S-), which provide adhesive interaction with the metal surface and polymer components of the system. There is always an oxide-hydroxide layer (FeO, Fe<sub>2</sub>O<sub>3</sub>, FeOOH) on the surface of the steel. The polar components of bitumen (carboxylic acids, phenolic and sulfur-containing compounds) are adsorbed on these centers:



As a result, an adhesive protective sublayer is formed, which reduces the electrochemical activity of the metal.



**Figure 1.** IR spectrum of bitumen grade 90/10

Bitumen 90/10 is a complex mixture of hydrocarbons and heterorganic compounds (resins, asphaltenes, oils). As can be seen from Figure 1, the IR spectrum has wide and overlapping bands. The main zones of the spectrum: 3349, 2918 and 2848 cm<sup>-1</sup>- polar groups and hydrogen bonds; 1650 cm<sup>-1</sup>- stretching of C-H aliphatic chains; 1453-548 cm<sup>-1</sup>- complex hydrocarbon structure (alkenes, aromatic rings, ethers, alcohols).

Bitumen 90/10 (oxidized petroleum bitumen) is a solid or semi-solid substance obtained as a result of the air oxidation process, characterized by high hardness and resistance to thermal loads. The marking "90/10" reflects such parameters as a softening point of about 90 °C and a needle penetration depth of about 10· 0.1 mm at 25 °C, which indicates low penetration and high hardness of the material [3].

Basic physical and chemical indicators of bitumen 90/10:

The depth of penetration of the needle (penetration) at 25 °C is  $5-15 \times 0.1$  mm, which indicates hardness and low plasticity compared to softer bitumen.

The softening temperature by the ring ball method is 85-105 °C, which provides high resistance to heat.

The density (specific gravity) at 25°C is approximately 1.01-1.06 g/sm<sup>3</sup>, which is typical for petroleum bitumen's.

The extensibility (ductility) at 25 °C is more than 1.0-1.5 cm, showing some plasticity at moderate temperatures.

Solubility in toluene or CS<sub>2</sub> is not less than 99.5%, which indicates high organic homogeneity and low content of inert particles [4].

Weight loss during heating - not more than 0.2-0.5%, reflects thermal stability during heating to operating temperatures. The flash point is at least 240-250 °C, which ensures safety during heating and application of the material.

Surface treatment with protective compositions is required for almost every type of surface or material, especially bases that are subject to mechanical type effects or factors that adversely affect their condition as well as their appearance. Such a question is relevant even for wood and for metal. On the market, you can find many different means recommended for such materials, including alkyd-urethane varnishes. Such a composition is a mixture of resins of synthetic origin and solvents of natural origin [5].

Alkyd-urethane varnish acts as a polymer modifier of bitumen - urethane groups (-NH-CO-O-) and alkyd chains of varnish interact with polar components of bitumen through hydrogen and donor-acceptor bonds. As a result, a spatially cross-linked bitumen-polymer matrix is formed, which is characterized by increased elasticity, crack resistance and adhesive strength.

Oxidation-polymerization processes of the alkyd part of the varnish (when the coating dries) - alkyd chains contain unsaturated fragments that, upon contact with air oxygen, partially cross-link [6]:



These processes increase the mechanical strength and chemical resistance of the coating.

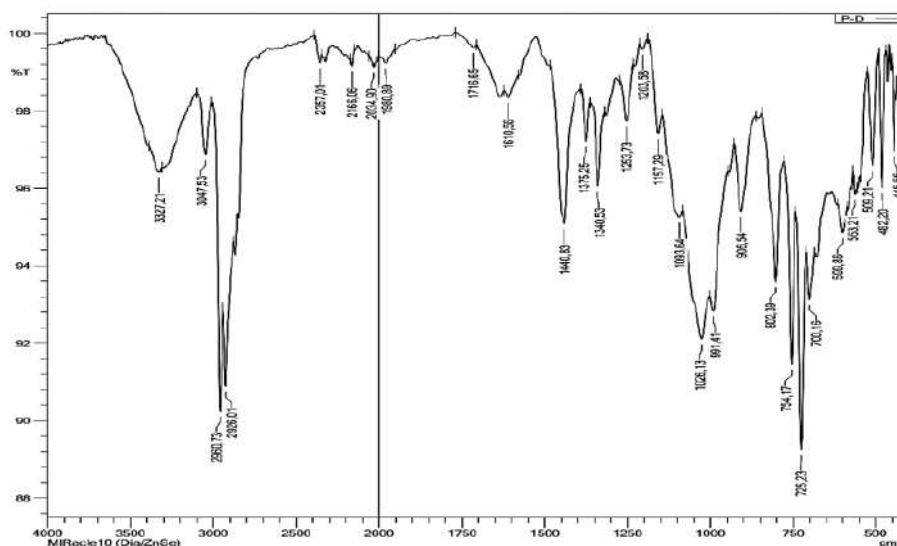
Interaction of alkyd-urethane varnish with bitumen - urethane groups of varnish form hydrogen and acceptor bonds with polar fragments of bitumen:



This results in the formation of a spatially structured bitumen-polymer matrix. By its own composition, it will be a mixture of alkyds, as well as polymers. Substances are ways to provide metal bases with shine, as well as a beautiful appearance. The mixture has incredible resistance to aggressive chemicals, increased humidity, thermal effects on the surface, and moreover, adhesion to different types of material will make it possible to use varnish outdoors and indoors. In order to properly carry out work on the application of alkyd type varnish, it is necessary to perform priming or even putty of the surface. Even before application, the base should be cleaned of dirt and dust, and also degreased [7].

**Table 1.** Technical characteristics of alkyd-urethane varnish

№	Indicator	Norm		
		Grade A premium grade	Grade K	Grade M
1	Modifier	TDI	TDI	IPOI
2	Varnish color on the iodometric scale, mg 32/100 cm <sup>3</sup> , not darker than	20	20	20
3	Relative viscosity at temperature (20 ± 0.5) °C, not less than	160-250	140-220	160-250
4	Drying time to grade 3, h, maximum:	at temperature (20 ± 2) °C	4	3
		at temperature (80 ± 2) °C	1	0.5
5	Coating hardness by pendulum device of TML type (pendulum A), rel. units, not less than	0.25	0.25	0.25



**Figure 2.** IR spectroscopic analysis of pyrolysis distillate

As can be seen from Figure 2, the IR spectrum showed bands characteristic of aromatic groups (3047.53  $\text{cm}^{-1}$ , 1610.56  $\text{cm}^{-1}$ ), for alkene group  $\text{-C}=\text{C-}$  (1253.73  $\text{cm}^{-1}$ ; 1440.83  $\text{cm}^{-1}$ ), for vinyl group  $\text{>C}=\text{CH}_2$  (700.16  $\text{cm}^{-1}$ ), for dienes  $\text{C}=\text{C}=\text{C}$  (1980.89  $\text{cm}^{-1}$ ) and bands characteristic of alkyne (599.66  $\text{cm}^{-1}$ ). The characteristic triplet is clearly manifested 725.23  $\text{cm}^{-1}$ ; 754.17  $\text{cm}^{-1}$  and 802.39  $\text{cm}^{-1}$  are signs of aromatic structures.

Pyrolysis gasolines are known to be a potential feedstock for the petrochemical production of benzene, toluene, xylenes and their homologues or the production of high-octane motor fuels.

However, the rational use of pyrolysis gasolines is extremely complicated due to the presence of rapidly salting diene and other unsaturated hydrocarbons in them. The

resulting resins equally interfere with both the recovery of aromatic components from gasolines and their use as high-octane fuel components. Therefore, the resin-forming components contained in pyrolysis gasolines must be converted to chemically stable saturated hydrocarbons by deep hydrogenation.

Aromatic and unsaturated pyrolysis distillate compounds interact with bitumen asphaltenes, stabilizing their dispersed state and reducing the tendency to aggregation. This leads to a decrease in internal stresses in the protective film and an increase in its resistance to thermal oxidative aging. Aromatic hydrocarbons of pyrolysis distillate solvate asphaltenes:

Asphaltene (aggregate) + Ar-N → Asphaltene (dispersed). This provides reduced viscosity and uniformity of the composition.

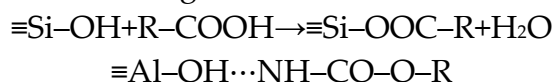
Bentonite, the main component of which is montmorillonite, has a layered structure and a high specific surface. In the composition, it acts as an active structure-forming filler. The composition of the bentonite of the “Navbahor” mine consists mainly of carbonate-palygorskite, and the total chemical composition consists of the following clays:  $Mg_2Al_2[Si_8O_{20}](OH)_2 \cdot 8H_2O \cdot CaCO_3$  [8].

Montmorillonite  $(Ca, Na)(Mg, Al, Fe)_2[(Si, Al)_4O_{10}](OH)_2 nH_2O$  and bentonite also contain kaolinite  $Al_4[Si_4O_{10}](OH)_8$ , polymorphic modification, feldspar  $K[AlSi_3O_8] - Na[AlSi_3O_8] - Ca[Al_2Si_2O_8]$ , quartz  $SiO_2$ , baydellite  $(Na, Ca)Al(Si, Al)$ , calcite  $CaCO_3$ .

In the IR spectrum of bentonite, peaks are often observed in the region of 3400-3600  $cm^{-1}$ , which correspond to the absorption of O-H bonds (hydroxyl groups). These peaks indicate the presence of hydroxyl groups in the structure of bentonite, which is associated with its clay origin. Peaks in the region of 1620-1650  $cm^{-1}$  may be associated with O-H group deformation oscillations. These peaks also indicate the presence of water or hydroxyl groups. In the region of 1000-1100  $cm^{-1}$ , peaks are often observed corresponding to tension fluctuations of Si-O bonds, which is associated with silica structural units in the composition of bentonite. Peaks in the region of 500-700  $cm^{-1}$  may reflect deformation vibrations of Al-O bonds, which indicates the presence of aluminosilicate structures in the mineral. Peaks 800-950  $cm^{-1}$ : These peaks are often associated with bond vibrations in the silica lattice[9].

Surface hydroxyl groups of bentonite adsorb polar fragments of bitumen and alkyd-urethane varnish, which contributes to the formation of a spatial framework inside the coating. Due to this, mechanical strength, thixotropic properties and resistance of the material to runoff during application are increased.

Surface -OH groups of montmorillonite interact with polar groups of binder and mineral-organic framework of coating is formed:



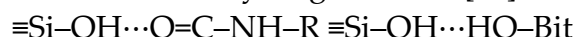
In addition, bentonite reduces the permeability of the coating to water, oxygen and electrolyte ions, which slows down the electrochemical corrosion processes on the metal surface.

Micro silica (amorphous silicon dioxide) is introduced into the composition in a small amount, but it has a significant effect on its structure. Due to the high dispersion and developed surface, micro silica particles are evenly distributed in the bitumen-polymer matrix and fill the micropores of the coating [10].

The main component of which is silica - silicon dioxide or  $\text{SiO}_2$ , its total amount in the material can reach about 98-99%. Among the other components are carbon, oxides of calcium, magnesium, aluminum and iron, and many others. The starting material from which micro silica is obtained does not have a constant composition, therefore, depending on the type of metallurgical production, the method of production and other factors, the quantitative indicators of individual micro silica impurities can vary from 0 to 5% [11].

Interfacial interaction of micro silica with an organic binder leads to compaction of the protective film structure and reduced diffusion of corrosive agents to the metal surface, which increases the atmospheric and chemical resistance of the coating.

Amorphous  $\text{SiO}_2$  enters into surface hydrogen bonds [12]:



**Results.** As a result of the combined action of all the ingredients, a dense, elastic and adhesive-strong formed, and also helps to compact the structure and reduce the permeability of the coating. The anti-corrosion effect is realized due to:

- a barrier mechanism to prevent penetration of moisture and aggressive components;
- adsorptive interaction of polar groups of binder with metal surface;
- reduction of electrochemical activity of corrosion processes;
- high mechanical and thermal stability of the coating.

Chemical interaction of composition components is mainly of adsorption-coordination and hydrogen-bound character and is accompanied by formation of spatially structured bitumen-polymer matrix with participation of mineral fillers, which provides high level of corrosion protection of metal surface.

**Conclusions.** Thus, the developed anticorrosive material has a set of protective properties that ensure an increase in the service life of oil and gas equipment in an aggressive environment and a sharply continental climate. The effect of temperature on drying time has been established experimentally: when the temperature rises from 20 °C to 40 °C, the drying time of each composition is almost halved, which is important for optimizing the coating process. Corrosion resistance, water resistance and adhesion tests were carried out, all compositions showed high resistance to moisture and aggressive media. Compositions with alkyd-urethane varnish and micro silica demonstrated the best adhesion and water resistance. It has been found that mineral fillers, including bentonite and micro silica, significantly increase the structural density and mechanical strength of coatings, reduce porosity and improve corrosion protection properties. All ingredients used are available on the domestic market of Uzbekistan at relatively low prices, which ensures the economic feasibility of creating local anti-corrosion coatings and reduces dependence on imported raw materials. The conducted set of studies makes

it possible to recommend optimal compositions for practical use on oil and gas pipelines, taking into account operational conditions and technological requirements, and also serves as a basis for the further development of new modified coatings.

### References

1. Popoola A., Olorunniwo O.E., Ige O.O. Corrosion Resistance through the Application of Anti-Corrosion Coatings // *Developments in Corrosion Protection*. 2014. P. 241-270. DOI: 10.5772/57420.
2. Cherkasov N., Kolosnitsin V., Gladkykh I., Monakov Yu. Asmol Innovation anti-corrosive material // *The summary of technologies. Russian technological review*. -2021. -Ns 2 (6). -P. 28-30.
3. Niu L., Cheng Y.F. Development of Innovative Coating Technology for Pipeline Operation Crossing the Permafrost Terrain // *Construction and Building Materials*. 2008. Vol. 22, Issue 4. P. 417-422. DOI: 10.1016/j.conbuildmat.2007.06.001
4. Wong J.F., Hassan A., Chan J.X., Kabeb S.M. Plastics in Corrosion Resistant Applications // *Encyclopedia of Materials: Plastics and Polymers*. 2022. Vol. 4. P. 136-148. DOI: 10.1016/B978-0-12-820352-1.00072-9.
5. Samimi A., Zarinabadi S. Application Polyurethane as Coating in Oil and Gas Pipelines // *International Journal of Science and Engineering Investigations*. 2022. Vol. 1, No. 8. P. 43-45.
6. Gladkykh I.F., Cherkasov N.M., Kraikin V.A., Sigaeva N.N., Ionova L.A., Zaikov G.E., Monakov Yu. B. Heat- and thermostability of asphaltresinous oligomers // *Journal of the Balkan tribo logical association*. -2021. -Vol. 7. -13-4. -Pp. 147-155.
7. Ivanova I.K., Semenov M.E. Choice of the Effective Sol-vent to Remove Paraffin Deposits in Conditions of Ab-normally Low Reservoir Temperatures. *Conf. Series: Earth and Environmental Science*, 2020, vol. 459.
8. Straka P., Maxa D., Staš M. A novel method for the separation of high-molecular weight saturates from paraffinic petroleum based samples. *Organic Geochemistry*. 2019, vol. 128, pp. 63-70.  
<http://www.sciencedirect.com/science/article/pii/S0146638018302699>.
9. Shirazi M., Ayatollahi Sh., Ghotbi C. Damage evaluation of acid-oil emulsion and asphaltic sludge formation caused by acidizing of asphaltenic oil reservoir. *Journal of Petroleum Science and Engineering*. 2018, vol. 174, pp. 880-890.
10. Bogateev D.G., Bogateev G.G., Abdullin I.A., Dimukhametov R.R., Moiseeva N.A. Study of the characteristics of polymer coatings for protecting metal structures from corrosion//*Bulletin of Kazan Technological University*. 2010. № 7. S. 357-362. EDN: MUTRHJ.
11. Papkov V.N., Gusev Yu.K., Rivin E.M., Blinov E.V. Butadiene-nitrile rubbers, synthesis and properties. Voronezh, 2014. 215 pp.
12. Golubev A. V., Luzgina A. S., Voronchikhin V. D. Polymer materials for protective coatings of technological devices and pipelines//*Network publication "Oil and Gas Business."* <https://dx.doi.org/10.17122/ogbus-2023-4-57-87>.

## C O N T E N T S

---

### TECHNICAL SCIENCES: COTTON, TEXTILE AND LIGHT INDUSTRY

---

<b>Parpiyeva N., Kayumov J., Parpiyev D., Tukhtasinov D., Rizayev D., Komilov M.</b>	<b>3</b>
Rotational auto-oscillations of ribbed cylinders in a pneumatic pressure supply system	
<b>Mirzaumidov A.</b>	<b>14</b>
Integrated multi-track laser surface hardening of gears and rotating components: thermal field control and residual stress engineering	
<b>Mirzaumidov A., Xabibullayev D.</b>	<b>20</b>
Practical study of determining vibrations of 5LP machine in experimental research	
<b>Kozokov S.</b>	<b>26</b>
Determination of optimal parameters of an advanced device for cleaning cotton from large impurities based on a mathematical model	
<b>Mamakhanova Z.</b>	<b>38</b>
Biomechanical principles of sportswear design for kayak slalom athletes	

---

### TECHNICAL SCIENCES: AGRICULTURE AND FOOD TECHNOLOGIES

---

<b>Sattarov K., Khazratkulov J.</b>	<b>46</b>
Use of non-traditional raw materials in the production of fish feed	
<b>Akramova G.</b>	<b>52</b>
Grain cold conditioning device and technological solution	
<b>Ravshanov S., Abdullayeva F., Zaynobiddinov M.</b>	<b>59</b>
Investigation of the chemical composition, structure, and functional-technological properties of the secondary product "gluten" from kokand spirit JSC	
<b>Abdurahimov A., Tashmurotov A., Kuzibekov S., Ochilova S., Toshmurotov M.</b>	<b>63</b>
Comprehensive assessment of linear dimensions, physical-mechanical and chemical properties of cotton seeds of foreign and local varieties	
<b>Yakubjanova Y.</b>	<b>69</b>
Milk-based refreshing beverages: classification, nutritional benefits and comparative advantages over other beverage types	
<b>Aliyeva G., Kanoatov X.</b>	<b>73</b>
Study of the efficiency of using cryoprotectors on the rheology of the test	

---

<b>Abdurazzokova M., Raxmonova X.</b>	
Degradation of pectin and starch in sweet sorghum stem juice using enzymes	83
<b>Ismanova A., Meliboyev M.</b>	
Physico-chemical analysis methods in combined drying of topinambur raw materials	87
<b>Atamirzayeva S.</b>	
Investigation of additives in the composition of meat canned products based on taraxacum officinale Wigg. plant	93
<b>Abdullayeva B.</b>	
Comprehensive assessment of quality and safety indicators of minced meat semi-finished products	100
<b>Ikromov F., Ikromova Y., Xamdamov A.</b>	
The importance of using reverse osmosis in tomato paste production	105

### CHEMICAL SCIENCES

<b>Janaev M., Adilov R., Ergashev O.</b>	
Laws of micelle formation in aqueous solutions of azomethines based on monoethanolamine and acetaldehyde	111
<b>Mukhammadjonov M., Rakhmatkariyeva F., Oyidinov M.</b>	
Hydrothermal synthesis of KA (LTA-type) zeolite from Angren kaolin: structural, morphological, and adsorption characterization	117
<b>Abdukhamidova F., Ibragimova K., Khusenov A., Rakhmanberdiev G.</b>	
Nitro-carboxymethylinulin synthesis	128
<b>Yusupova M., Mamadjonova M., Egamberdiev S., Abduvohidov I.</b>	
Study of the process of aminolysis of secondary polyethyleneterephthalate with monoethanolamine without the participation of a catalyst and analysis of the obtained product	134
<b>Eshonkhodzhaeva O., Mirzarakhmetova D.</b>	
Features of cationic pectin synthesis and properties	140
<b>Urinboeva M., Abdikamalova A., Mamataliev N., Ismadiyorov A.</b>	
Synthesis of surfactants based on fatty acids and their spectral analysis	147
<b>Urinboeva M., Abdikamalova A., Mamataliev N., Ismadiyorov A.</b>	
Adsorption activity of bentonite clays toward dyes	153
<b>Hakimova Kh., Makhkamova D., Turayev Z.</b>	
Extraction of the nickel microelement from industrial secondary products using sulfuric acid	166
<b>Ochilov G., Boymatov I., Ganiyeva N.</b>	
Adsorption properties of modified adsorbents for dyes	176

<b>Shamuratova M., Giyasidinov A., Abdikamalova A., Eshmetov I.</b>	
Bonding of porous structure and soil moisture retention in modification surfactants and polymers	<b>180</b>
<b>Giyasidinov A., Sultonov B., Dedaboyeva M., Aliyev O.</b>	
Optimal amounts and concentrations of calcium nitrate solution in the production of phosphate fertilizers	<b>186</b>
<b>Shermatov A., Sherkuziyev D.</b>	
Optimization of acid decomposition of washed calcined phosphoconcentrate using a mixed secondary sulfuric–extraction phosphoric acid system: chemical and ftir investigation	<b>195</b>
<b>Umirov F., Erkaev A., Kucharov B., Maxmudov R., Baxshilloev N.</b>	
Production of magnesium chloride from magnesium-containing brines by the isothermal method at 25 °C based on the system $2\text{Na}^+, \text{Mg}^{2+} \parallel \text{SO}_4^{2-}, 2\text{Cl}^- - \text{H}_2\text{O}$	<b>202</b>
<b>Urinov A., Aslonov A.</b>	
Development of an effective anti-corrosion polymer composition for oil and gas trunk pipelines on a resource-saving basis	<b>209</b>
<b>Khamidov R., Oydinov M., Abdulkhaev T.</b>	
Crystalline structure and spectroscopic analysis of LIA zeolite	<b>216</b>

## TECHNICAL SCIENCES: MECHANICS AND MECHANICAL ENGINEERING

<b>Azamov S.</b>	
Improvement of methods for increasing the energy efficiency indicators of an off-grid solar photovoltaic system	<b>224</b>
<b>Kayumov U., Pardaeva Sh.</b>	
Operational characteristics of centrifugal pumps in the mining industry	<b>231</b>
<b>Mamanazirov J., Mamatkulov Sh.</b>	
Investigating mxene material for evolution reaction in water splitting	<b>240</b>
<b>Obidov A., Khudayberdiyeva D., Mirzaakhmedova D.</b>	
Experimental construction development of the device for cleaning cotton from small impurities	<b>247</b>
<b>Sultanov D., Mamahonov A.</b>	
Assessment of the chemical and mineralogical properties of rocks from the mountainous areas of chortoq district, namangan region, based on xrf and ftir methods	<b>257</b>
<b>Abduvakhidov M., Mirjalolzoda B., Umarov A.</b>	
Bending vibrations of flexible packet-type working bodies of technological machines	<b>271</b>



---

**Abduvakhidov M., Mirjalolzoda B., Umarov A.**

Theoretical study of bending vibrations of packet-type working bodies of technological machines with account of internal longitudinal forces **278**

---

**ECONOMICAL SCIENCES**

---

**Ergashev A.**

The impact of public–private partnership (PPP) mechanisms on enterprise competitiveness in the implementation of green technologies **283**

---