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BIOLOGICAL SCIENCES

PHYSICAL AND HYDRO-PHYSICAL PROPERTIES OF IRRIGATED SOILS OF THE LOWER AMUDARYA RIVER

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ABSTRACT

The article provides information on the physical properties of irrigated meadow-alluvial and barren-meadow soils of Chimboy and Shumanay districts: soil bulk density, specific gravity, soil porosity, and water physical properties. The specific gravity is 2.58-2.68 g/cm3 in the upper layers and 2.69-2.75 g/cm3 in the lower layers. Cross-sections were excavated in key areas and it was found that the bulk density of the soil by layer was 1.31-1.38 g/cm3, slightly denser in the lower layers and fluctuated between 1.39-1.45 g/cm3. The specific gravity fluctuated between 2.58-2.68 g/cm3 in the upper layers, while the lower layers were 2.69-2.75 g/cm3.The moisture content of newly irrigated meadow-alluvial soils in the studied areas is 1.26-9.22%. In the Kamishariq massif of Chimboy district, the moisture content at wilting is 2.03-7.47%, while in the Bozatou massif this indicator is 1.89-10.69%.

Keywords: general physical properties of meadow-alluvial and takyr-like-meadow soils, specific gravity, bulk density and porosity, maximum hygroscopic moisture content and compaction moisture content.

Introduction: Factors that cause the degradation of agricultural lands in the world are soil erosion, salinization, as well as the depletion of humus and nutrients, pollution with toxic substances and compaction. Since such negative processes constantly occur in the soils of our republic, especially in irrigated soils, they are considered one of the important economic problems of the development of agriculture in our country, and the effective use and protection of land resources by preventing soil degradation and eliminating its consequences has become one of the urgent issues.The fertility of irrigated soils depends on several factors, one of the most important of which is the physical properties of the soil. The physical properties of soils affect the processes of soil formation and the growth and development of plants.

Research object and methods: The object of research is the old and newly irrigated meadow-alluvial and takyr-like meadow soils, widespread in the Chimboy and Shumanay districts on the right and left banks of the Lower Amu Darya.

The research was carried out using generally accepted genetic-geographical, profile-geochemical methods for soils [1]. Soil bulk density was determined using a cylinder V-100 cm3, soil specific gravity was determined using a pycnometer; soil porosity was determined by calculation.

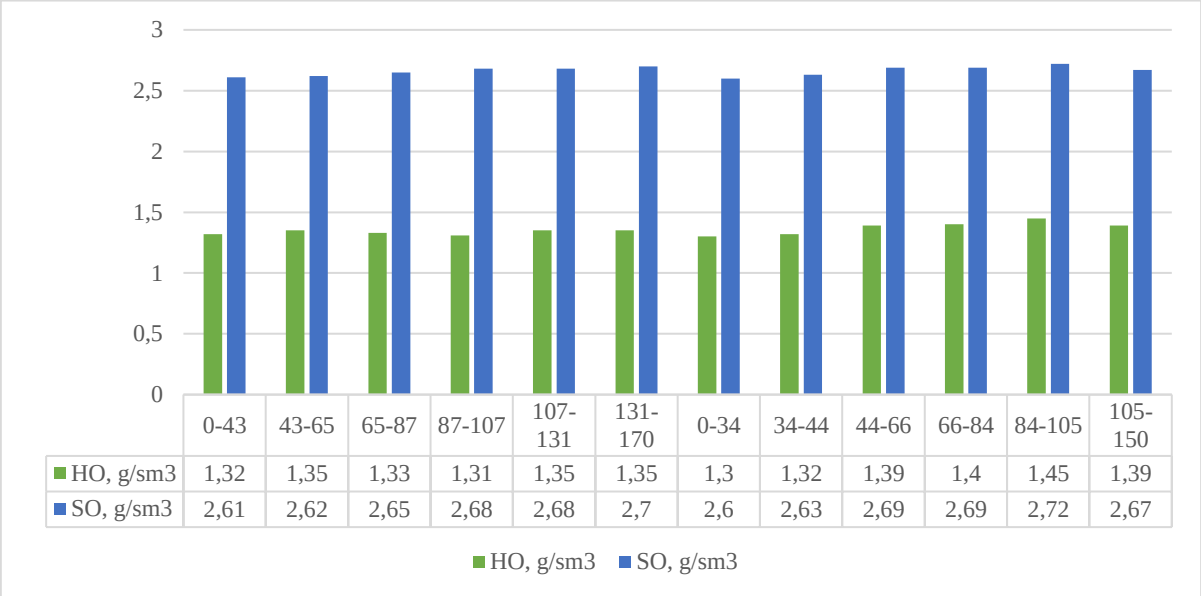
The maximum hygroscopicity and wilting moisture of soil layers were determined using the Nikolaev method.

Analysis of literature on the topic: L. Tursunov noted that for irrigated heavy and medium loamy serozem-pasture, meadow, and takyr-like soils formed on loess, alluvial-proluvial, and alluvial deposits common in the serozem and desert regions, the optimal density is 1.2-1.4 g/cm3 and the critical density is 1.5-1.6 g/cm3. In the plowed layer of light loamy soils, the optimal density is 1.34-1.43 g/cm3.[4,5]. Total porosity is closely related to the mechanical composition of the soil and is the largest (50-54%) in sandy, sandy loam and light sandy soils and similar layers. The total porosity of soils is 38-40% in soils with a density of 1.5-1.6 g/cm3, which is considered unsatisfactory.[2,3]. In previously irrigated meadow soils, due to repeated introduction of heavy agricultural machinery into the fields in a state of physical immaturity of the soil and non-compliance with the irrigation regime, soil layers were compacted above the acceptable density (1.55-1.60 g/cm3), and it was found that as the mechanical composition became heavier, the density of the soils also became somewhat higher. In old irrigated meadow soils, the total porosity was 47-51% in the upper layers. In the lower layers, it decreased sharply and was observed in the range of 38-45%, which is considered unsatisfactory.[6]. Various land reclamation measures are used to reduce soil salinity and increase its fertility. These measures are aimed at improving the physical, chemical and biological properties of the soil, which ensure good plant growth and development [7, 8]. Scientifically based recommendations have been developed for cleaning the soil from salinity and restoring its fertility. These recommendations include the implementation of land reclamation measures, taking into account the physical, chemical and biological properties of the soil [9].The amount of humus in the soil, the presence of water-soluble salts, the presence of dead water reserves, and the presence of fine particles increase the moisture capacity of the soil, while increasing its density reduces the moisture capacity reserve [10].

Results and their analysis:

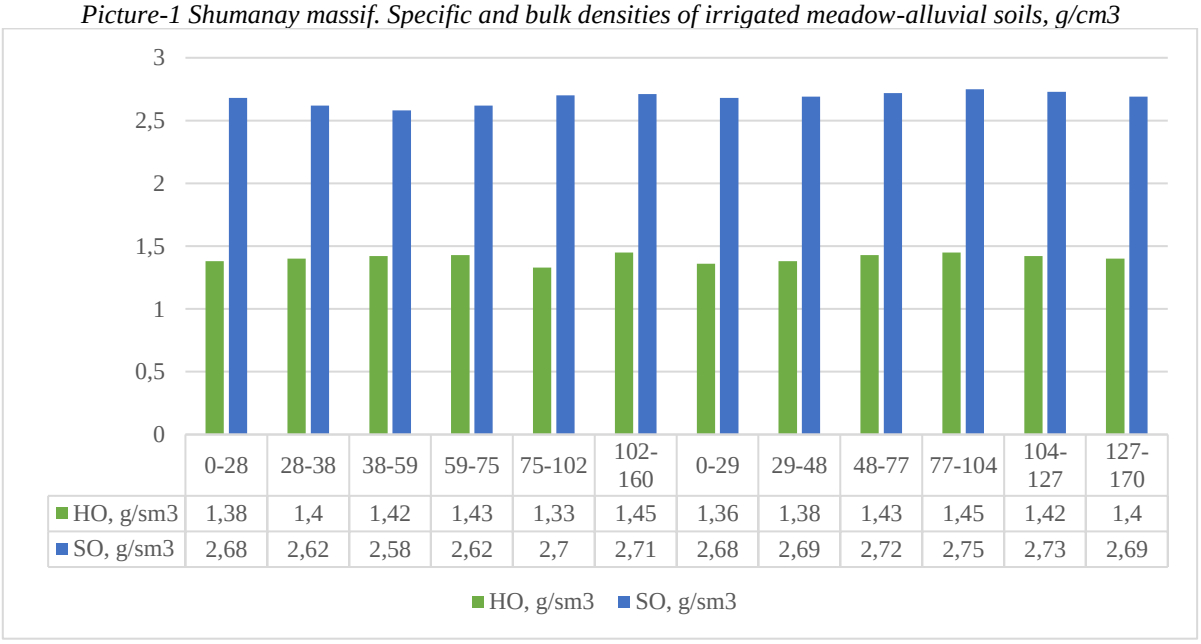
The general physical properties of the meadow-alluvial and takyr-like meadow soils of the Shumanay (Shumanay and Begjap) and Chimboy (Bozatau and

Qamishariq) districts, which are considered one of the objects of the study, were determined. According to the results obtained, the following analysis can be made. It was found that the specific gravity of the soils of the studied area was in the range of 2.60-2.65 g/cm3 in the upper layers, and fluctuated around 2.67-2.72 g/cm3 in the lower layers as the soil section deepened (pic 1).The reason for the high specific gravity in the lower layers is due to the amount of minerals in the soil. The higher the level (specific gravity), the more mineralized the soil is. It was found that the optimal value of the bulk density for normal growth of most plants is 1.2-1.3 g / cm3. In these sections, the total porosity was found to be in the range of 46.7-51.1%. It is reported in the literature that the optimal porosity for a number of agricultural crops is about 50%, and if this indicator is less than 40%, it is found that the penetration of their own roots into the soil layers is impeded.



	0-43	43-65	65-87	87-107	107-131	131-170	0-34	34-44	44-66	66-84	84-105	105-150
HO, g/sm3	1,32	1,35	1,33	1,31	1,35	1,35	1,3	1,32	1,39	1,4	1,45	1,39
SO, g/sm3	2,61	2,62	2,65	2,68	2,68	2,7	2,6	2,63	2,69	2,69	2,72	2,67

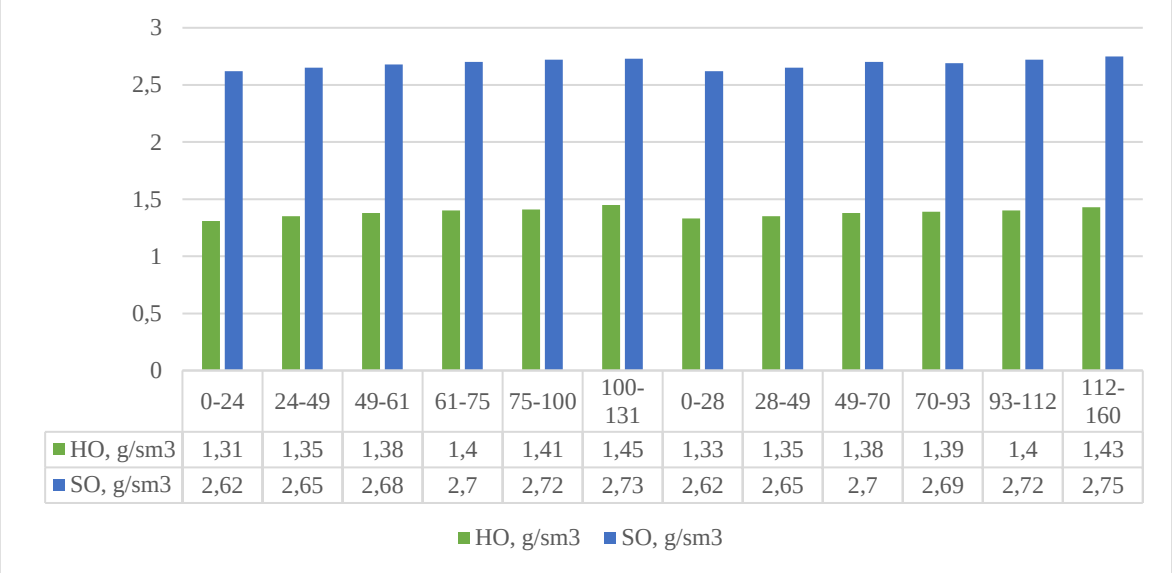
Picture-1 Shumanay massif. Specific and bulk densities of irrigated meadow-alluvial soils, g/cm3



	0-28	28-38	38-59	59-75	75-102	102-160	0-29	29-48	48-77	77-104	104-127	127-170
HO, g/sm3	1,38	1,4	1,42	1,43	1,33	1,45	1,36	1,38	1,43	1,45	1,42	1,4
SO, g/sm3	2,68	2,62	2,58	2,62	2,7	2,71	2,68	2,69	2,72	2,75	2,73	2,69

Picture-2. Chimboy district, Kamishariq massif. Specific and bulk densities of irrigated meadow-alluvial soils, g/cm3

According to the results of the analysis of sections 6 and 3 in the meadow-alluvial soils from the Qamisharyk massif to the Olin, the specific gravity in the upper layers fluctuated within 2.58-2.68 g/cm3, while the lower layers were 2.69-2.75 g/cm3. The specific gravity (maximum hygroscopic) depends on the composition and ratio of mineral and organic substances that make it up. The total porosity was also determined in these sections, which was 45.0-50.7%. (pic 2).



	0-24	24-49	49-61	61-75	75-100	100-131	0-28	28-49	49-70	70-93	93-112	112-160
HO, g/sm3	1,31	1,35	1,38	1,4	1,41	1,45	1,33	1,35	1,38	1,39	1,4	1,43
SO, g/sm3	2,62	2,65	2,68	2,7	2,72	2,73	2,62	2,65	2,7	2,69	2,72	2,75

Picture-3. Chimboy district, Bozatau massif. Specific and bulk densities of irrigated takyr-like meadow soils, g/cm3

According to data obtained from the soils of the Bozatav massif, it was determined that the specific gravity of sections 4 and 2 in the takyr-like meadow soils was in the range of 2.62-2.68 g/cm3 in the upper layers and oscillated around 2.70-2.75 g/cm3 in the lower layers. The volume density in these sections was slightly denser in the lower layers than 1.31-1.38 g/cm3 and oscillated in the range of 1.39-1.45 g/cm3. (pic 3).

In order to increase the fertility of the lands of the right and left banks of the Lower Amu Darya, create their optimal land reclamation conditions, irrigation volumes and regimes, it is necessary to conduct a thorough study of the water-physical properties of the lands.

The maximum hygroscopic moisture content (maximum hygroscopic) of soils depends on their mechanical composition, absorption capacity and mineralogical composition, the amount and composition of organic matter, water-soluble salts in them, and the density of soils. As a result of the data obtained during the research, it was found that the maximum hygroscopic moisture content varies along the soil cross-section. The reason for this is the mechanical composition and chemical properties of soils, the most important of which are the amount of clay and salt. In meadow-alluvial soils distributed on the left bank of the Lower Amu Darya (Shumanay massif, Shumanay district), the content of MG was found to be in the range of 1.68-6.15%. In the Begjap massif, it was found to fluctuate around 1.28-4.60%. In meadow-alluvial soils distributed on the right bank of the Lower Amu Darya, the maximum hygroscopic content was found to fluctuate between 1.36-4.98%, and in barren meadow soils, it fluctuated between 1.26-7.13%.

In the Begjap massif, it was found to fluctuate around 1.28-4.60%. In meadow-alluvial soils distributed on the right bank of the Lower Amu Darya, the maximum hygroscopic content was found to fluctuate between 1.36-4.98%, and in barren meadow soils, it fluctuated between 1.26-7.13%.

Table.

Maximum hygroscopic and storage moisture of meadow-alluvial and takyr-like meadow soils distributed on the right and left banks of the Lower Amu Darya.

Sample №	Cross-sectional depth, cm	MG %	SN %	Sample №	Cross-sectional depth, cm	MG %	SN %
Newly irrigated meadow-alluvial soils				Old irrigated meadow-alluvial soils			
Shumanay district Shumanay massif 5	0-43	3,82	5,73	Chimboy district Qamishariq massif 3	0-29	2,71	4,06
	43-65	3,05	4,57		29-48	2,36	3,54
	65-87	1,68	2,52		48-77	1,63	2,45
	87-107	3,98	5,97		77-104	3,46	5,19
	107-131	6,15	9,22		104-127	4,05	6,07
	131-170	5,24	7,86		127-170	2,13	3,19
Newly irrigated meadow-alluvial soils				Old irrigated takyr-like-meadow soils			
Shumanay district Shumanay massif 1	0-34	2,08	3,13	Chimboy district Bozatou massif 2	0-28	6,60	9,90
	34-44	1,70	2,55		28-49	5,99	8,98
	44-66	2,13	3,19		49-70	3,57	5,36
	66-84	2,03	3,04		70-93	3,75	5,62
	84-105	2,92	4,38		93-112	3,34	5,01
	105-150	2,69	4,03		112-160	2,35	3,52
Newly irrigated meadow-alluvial soils				Old irrigated meadow-alluvial soils			
Shumanay district Shumanay massif 6	0-27	3,13	4,37	Chimboy district Qamishariq massif 6	0-28	3,35	5,02
	27-52	3,35	3,33		28-38	2,57	3,85
	52-76	3,07	2,62		38-59	3,72	5,57
	76-101	3,64	2,44		59-75	3,48	5,23
	101-125	2,03	1,51		75-102	2,17	3,25
	125-160	2,59	1,26		102-160	1,36	2,03
Newly irrigated meadow-alluvial soils				Old irrigated meadow-alluvial soils			
Shumanay district Begjap massif 5	0-30	2,95	4,43	Chimboy district Qamishariq massif-5	0-24	3,18	4,77
	30-49	1,47	2,20		24-41	3,72	5,58
	49-108	1,41	2,11		41-62	4,52	6,78
	108-141	1,45	2,18		62-101	4,98	7,47
	141-163	1,89	2,83		101-153	3,02	4,53
Newly irrigated meadow-alluvial soils				Old irrigated takyr-like-meadow soils			
Shumanay district Begjap massif 2	0-35	4,60	6,90	Chimboy district Bozatou massif 4	0-24	7,13	10,69
	35-54	1,88	2,81		24-49	4,37	6,55
	54-81	1,28	1,91		49-61	3,33	4,99
	81-115	1,46	2,20		61-75	2,62	3,93
	115-141	1,93	2,89		75-100	2,44	3,66
	141-191	1,43	2,15		100-131	1,51	2,26
					131-200	1,26	1,89

Studying the wilting moisture content of plants is necessary to determine the lower limit of moisture required by plants, to set the active moisture limits, and to prevent the moisture content in the soil from reaching (wilting moisture). Plants suffer from moisture deficiency when the limit is exceeded, therefore, efforts should be made to avoid lowering the moisture content in the soil from. In the newly irrigated meadow-alluvial soils of the studied areas (Shumanay and Begjap massifs of the Shumanay district), the moisture content of the soil is 1.26-9.22%. In the Kamishariq massif of the Chimboy district, the moisture content of the soil is 2.03-7.47%, and in the Bozatou massif this indicator is 1.89-10.69%. The high moisture content of the soil in the barren meadow soils is explained as follows. Such soils have a large number of clay particles, retain more moisture, and have low plant uptake, which is mainly characteristic of saline soils. According to the data on the relationship between plant wilting moisture and soil density, soil density makes it difficult for plants to absorb moisture. The change in wilting moisture indicators in the upper layers is due to the uneven mechanical composition, density, and salt content (table).

Conclusion: The general physical properties of meadow-alluvial and takyr-like meadow soils distributed on the right and left banks of the Lower Amu Darya were determined, and the general porosity was observed to be satisfactory and unsatisfactory in the sections where it was determined. The bulk density was found to be medium in the arable layers and strongly concentrated in the sub-arable layers. According to the relative density, it was found to be medium and high in

the arable and sub-arable layers. In old irrigated meadow-alluvial soils, the soil porosity was found to be somewhat lower than in the newly irrigated areas. As a comment, we can say that this, in turn, is explained by the state of soil culture, the duration of the irrigation period, and the agro-ameliorative conditions used. It has been observed that the general physical properties of irrigated soils on the right and left banks of the Lower Amu Darya have changed under the influence of degradation processes, which affects soil fertility and agronomic properties.

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ECONOMIC SCIENCES

RISK ASSESSMENT AND BUSINESS CONTINUITY PLANNING IN DRILLING OPERATIONS

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ABSTRACT

Risk assessment and business continuity planning are critical components of effective drilling operations, ensuring safety, operational efficiency, and resilience in the face of uncertainties. This paper explores the systematic processes of identifying, analyzing, and mitigating risks associated with drilling activities, including technical, environmental, financial, and operational challenges. By integrating risk assessment frameworks, such as Failure Mode and Effect Analysis (FMEA) and Bow-Tie Analysis, companies can proactively address potential hazards and minimize disruptions. Furthermore, the study highlights the importance of business continuity planning (BCP) in drilling operations to maintain functionality during unforeseen events, such as equipment failures, natural disasters, and geopolitical disruptions. The role of technological advancements, data-driven decision-making, and real-time monitoring systems in enhancing risk management and BCP strategies is emphasized. Through case studies of successful implementations in offshore and onshore drilling, the research underscores how integrated risk assessment and business continuity frameworks improve operational sustainability and reduce financial and environmental impacts. Ultimately, adopting comprehensive risk management practices ensures drilling operations are resilient, adaptable, and capable of sustaining long-term performance in a volatile industry.

Keywords: mitigation, risk assessment, drilling operations, implementations.

Introduction

Drilling operations, whether onshore or offshore, are inherently complex and fraught with risks. The high stakes involved—ranging from environmental hazards to financial liabilities—make effective risk assessment a cornerstone of successful drilling projects. Risk assessment in drilling operations involves the systematic identification, evaluation, and prioritization of risks to prevent accidents, minimize operational disruptions, and safeguard investments. It is a proactive process aimed at enhancing safety, reducing environmental impacts, and ensuring compliance with industry regulations. In an industry where minor oversights can lead to catastrophic outcomes—such as oil spills, equipment failures, or loss of life—rigorous risk assessment is non-negotiable. The importance of risk assessment lies in its ability to anticipate challenges and implement measures that mitigate potential hazards. For instance, the infamous Deepwater Horizon disaster in 2010 underscored the devastating consequences of inadequate risk management, resulting in massive environmental damage and financial losses for BP [1, p.512]. Such events highlight the critical role of risk assessment in preventing disasters and fostering operational resilience.

Common Risks in Drilling Operations

Drilling operations face a myriad of risks, broadly categorized into technical, environmental, financial, and operational domains.

Technical Risks arise from equipment malfunctions, well control issues, and blowouts. For example, poorly maintained rigs or substandard materials can lead to catastrophic failures. These risks are exacerbated in ultra-deepwater drilling, where extreme pressures and temperatures challenge the integrity of equipment.

Environmental risks include oil spills, gas leaks, and ecosystem disruption. These risks not only endanger local habitats but also attract regulatory scrutiny and public backlash. Offshore drilling poses a heightened environmental threat, with incidents like the Exxon Valdez oil spill serving as grim reminders of the consequences.

Financial Risks. Drilling projects are capital-intensive, with substantial upfront investments in infrastructure, technology, and manpower. Financial risks stem from fluctuating oil prices, cost overruns, and delays. Additionally, non-compliance with safety or environmental standards can result in hefty fines and reputational damage.

Operational risks encompass workforce safety, supply chain disruptions, and logistical challenges. Drilling involves hazardous working conditions, with potential accidents such as slips, trips, and falls. Moreover, geopolitical instability in resource-rich regions can disrupt operations and escalate costs [3, p.49].

Risk Assessment Frameworks and Methodologies

Effective risk management in drilling relies on robust assessment frameworks and methodologies, such as FMEA and Bow-Tie Analysis.

Failure Mode and Effect Analysis (FMEA) is a structured approach for identifying potential failure modes in equipment or processes and analyzing their effects on operations. In drilling, FMEA can be applied to critical components like blowout preventers (BOPs) to ensure they function reliably under adverse conditions. The methodology helps prioritize risks based on their likelihood and severity, enabling targeted mitigation strategies.

Bow-Tie Analysis is a visual risk assessment tool that links potential hazards to preventive and mitigative controls. In drilling, this framework helps illustrate the pathways leading to blowouts or oil spills and identifies barriers to prevent such events. Its intuitive design makes it an effective communication tool for stakeholders at all levels.

Quantitative Risk Assessment (QRA) combines statistical modeling with historical data to estimate the likelihood and impact of risks. This approach is particularly useful for evaluating high-stakes scenarios, such as well blowouts or offshore platform failures.

HAZOP (Hazard and Operability) Studies involves systematic brainstorming sessions with multidisciplinary teams to identify potential hazards in drilling operations. It is a proactive method to anticipate risks during the planning and design stages [7, p.136].

Role of Real-Time Monitoring and Predictive Analytics

Modern drilling operations increasingly leverage technology to enhance risk assessment and management. Real-time monitoring systems and predictive analytics have transformed the way risks are identified and mitigated.

Real-time monitoring systems track key parameters, such as pressure, temperature, and flow rates, during drilling. Sensors placed on rigs and wells provide continuous data streams, enabling operators to detect anomalies and take immediate corrective actions. For instance, early detection of pressure buildups can prevent blowouts, ensuring the safety of personnel and equipment [4, p.108].

Predictive analytics uses machine learning algorithms to analyze historical data and forecast potential risks. By identifying patterns and trends, these tools enable proactive decision-making. For example, predictive models can estimate the likelihood of equipment failures, allowing operators to schedule maintenance before issues escalate.

Advanced drilling operations often feature integrated operations centers where experts monitor multiple rigs remotely. These centers combine real-time data with predictive analytics to provide a holistic view of risks, enabling swift and informed responses.

Digital twin technology creates virtual replicas of drilling assets, simulating various scenarios to predict potential risks. This innovation allows operators to test mitigation strategies in a risk-free environment, enhancing preparedness and resilience.

Risk assessment is an indispensable aspect of drilling operations, offering a structured approach to anticipate and mitigate hazards. By addressing technical, environmental, financial, and operational risks, companies can safeguard their investments, protect the environment, and ensure the safety of their workforce. Frameworks like FMEA, Bow-Tie Analysis, and HAZOP provide systematic methodologies for evaluating risks, while technological advancements such as real-time monitoring and predictive analytics further enhance decision-making capabilities. As the industry evolves, integrating these tools with a strong safety culture will be crucial for sustainable and resilient drilling operations. By prioritizing comprehensive risk assessment, the drilling sector can minimize disruptions, meet regulatory standards, and maintain public trust, paving the way for a safer and more sustainable future.

Business Continuity Planning (BCP) for Drilling Operations

Drilling operations are vital to the global energy supply chain, yet they are also highly susceptible to disruptions ranging from equipment failures to natural disasters and geopolitical instability. Business Continuity Planning (BCP) serves as a critical framework to ensure that these operations remain functional even during unforeseen events. BCP is a systematic approach aimed at ensuring that essential business functions continue during and after a disruption. In the drilling industry, where downtime can result in millions of dollars in losses per day, BCP is indispensable for maintaining operational integrity, safeguarding assets, and minimizing environmental impacts. The significance of BCP lies in its ability to address uncertainties inherent in drilling, such as equipment malfunctions, adverse weather conditions, and geopolitical tensions. Effective BCP not only mitigates financial losses but also enhances an organization's resilience, reputation, and compliance with regulatory requirements [2, p.131]. Moreover, BCP aligns with industry goals of sustainable and safe operations by integrating risk management and emergency preparedness into a cohesive plan.

A robust BCP for drilling operations must account for the unique risks and challenges of the industry. Key components include emergency response, resource allocation, and communication strategies.

Emergency Response

Emergency response planning is at the heart of any BCP. This involves developing protocols to manage critical incidents such as well blowouts, oil spills, or crew injuries. For instance, offshore platforms often conduct regular emergency drills, simulating evacuation scenarios to ensure preparedness. A comprehensive emergency response plan includes clearly defined roles, rapid response teams, and access to medical and logistical support.

Resource Allocation

Efficient resource allocation ensures that critical supplies, equipment, and personnel are available during a crisis. This includes maintaining spare parts for drilling rigs, securing backup power supplies, and pre-positioning emergency equipment in strategic locations. For example, redundancy in vital systems, such as blowout preventers, minimizes downtime and enhances operational reliability.

Communication Strategies

Effective communication is crucial for coordinating efforts during disruptions. A drilling-specific BCP should include protocols for real-time communication between onshore and offshore teams, as well as with external stakeholders such as regulators and suppliers. Advances in satellite communication and digital platforms have significantly improved the ability to relay critical information during emergencies [5, p.243].

Strategies for Ensuring Operational Continuity

Drilling operations require tailored strategies to address diverse disruptions, including equipment failures, natural disasters, and geopolitical challenges.

- **Mitigating Equipment Failures:** Equipment reliability is essential for uninterrupted drilling. Predictive maintenance, powered by IoT sensors and data analytics, enables operators to identify potential equip-

ment failures before they occur. For instance, monitoring the performance of rotary drill bits and mud pumps can prevent costly downtime.

- **Responding to Natural Disasters:** Natural disasters, such as hurricanes and earthquakes, pose significant threats to drilling operations. Offshore platforms in hurricane-prone regions often implement hurricane preparedness plans, which include shutting down operations, securing equipment, and evacuating personnel. Similarly, onshore operations in seismic zones design infrastructure to withstand earthquakes, ensuring safety and continuity.
- **Addressing Geopolitical Challenges:** Geopolitical instability in resource-rich regions can disrupt supply chains and threaten personnel safety. Companies often diversify their supply chains and maintain strong relationships with local governments to mitigate these risks. Additionally, deploying mobile rigs and modular drilling units allows for flexible relocation in response to political unrest.
- **Leveraging Technology**: Digital tools play a pivotal role in ensuring operational continuity. Remote monitoring systems, digital twins, and advanced simulation technologies allow operators to manage operations from centralized locations, even during disruptions. For example, integrated operations centers enable real-time decision-making by consolidating data from multiple rigs.

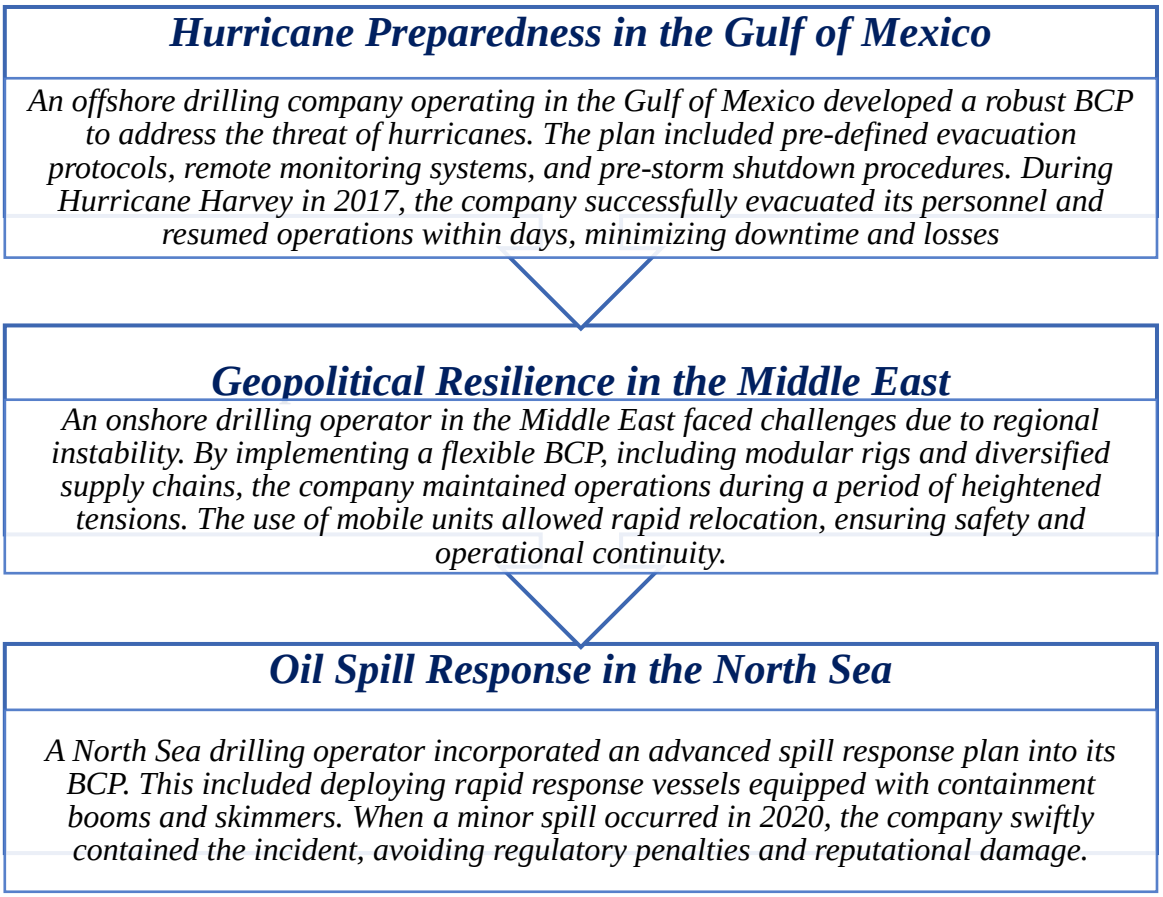

Figure 1. Successful BCP Implementations
Source: Smith, R., Jones, P., & Baker, L. (2018). Hurricane Resilience in Offshore Drilling Operations. Journal of Disaster Preparedness, 29(4), 345-367

Conclusion

Business Continuity Planning is a fundamental aspect of drilling operations, enabling companies to navigate disruptions with minimal impact on safety, productivity, and the environment. By integrating emergency response, resource allocation, and communication strategies, BCP ensures operational resilience and aligns with industry best practices. Through strategies such as predictive maintenance, disaster preparedness, and technological advancements, drilling operators can mitigate risks and adapt to a dynamic operating environment. The case studies highlighted demonstrate the effectiveness of robust BCP frameworks in managing diverse challenges, from natural disasters to geopolitical instability.

As the drilling industry continues to evolve, investing in comprehensive BCP frameworks will remain essential for sustaining operations and meeting the demands of a volatile energy landscape. By fostering a culture of preparedness and leveraging innovative technologies, companies can enhance their resilience, safeguard assets, and contribute to sustainable energy development.

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MEDICAL SCIENCES

POSSIBILITIES OF DEVELOPING MYELODYSPLASTIC SYNDROME

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ABSTRACT

A rare clinical case report is provided regarding an 83-year-old man who was admitted to the Hematology Department of the First University Clinic of Tbilisi State Medical University (Georgia) in 2021. The patient was scheduled for surgical treatment due to cataract. The patient did not have any symptoms of Fanconi anemia until the age of 80. The preoperative complete blood count revealed leukopenia, neutropenia: leukocyte - 2.6 x 10'9/l; neutrophil - 22%., General condition satisfactory, constitutional type - normosthenic. He does not tolerate alcohol and does not use tobacco. He had no genetic history. There are no developmental defects. This case suggests that myelodysplastic syndrome is multisymptomatic and therefore, determining the underlying causes is crucial. Fanconi anemia, as known, is homozygous, while this case, which has been confirmed as heterozygous, supports the idea that it may transform into myelodysplasia over time. This gives us grounds to conclude that it is advisable to conduct a thorough examination of all cytopenic patients, including from a molecular-genetic perspective.

Keywords: Fanconi Anemia, Myelodysplastic Syndrome, Bone Marrow Report.

Fanconi anemia is a rare genetic disease, also known as Fanconi congenital panmyelopathy. It often occurs in consanguineous marriages. It is transmitted in an autosomal recessive manner. It is characterized by impaired hematopoiesis, developmental defects, and the formation of malignant tumors. It is manifested by pallor, weakness, frequent bleeding, and bruising under the skin. In general, a special system of enzymes in cells, under the influence of chemical and physical reagents or during the biosynthesis process, restores the broken DNA molecule. In Fanconi anemia, a genetic defect in a cluster of proteins responsible for DNA repair leads to increased chromosome fragility. As a result, bone marrow dysfunction develops. In particular, neoplasia and aplastic anemia (1). Oncological diseases are often represented by acute myeloid leukemia, when the accumulation of altered white blood cells is provoked. This leads to inhibition of the growth of erythrocytes, platelets, and normal leukocytes. Accordingly, in aplastic anemia, the maturation and growth of all three types of blood cells is sharply reduced as a result of bone marrow dysplasia.

Fanconi anemia can be caused by mutations in at least 15 genes. The proteins produced by these genes are involved in a cellular process known as the FA pathway. The FA pathway is involved in DNA replication. The FA pathway sends certain proteins to the site of damage, which causes DNA to be repaired so that DNA replication can continue (2).

The FA pathway is particularly sensitive to certain types of DNA damage known as interstrand cross-links (ICLs). ICLs occur when two building blocks of DNA (nucleotides) on opposite strands of DNA are abnormally attached or linked together, stopping the process of DNA replication. ICLs can be caused by a build-up of toxic substances in the body or by treatment with certain cancer drugs (3).

Eight proteins associated with Fanconi anemia group together to form a complex known as the FA core complex. The FA core complex activates two proteins called FANCD2 and FANCI. Activation of these two proteins brings DNA repair proteins to the ICL region so that the cross-link can be removed and DNA replication can continue.

80-90 percent of Fanconi anemia cases are caused by mutations in one of three genes, FANCA, FANCC, and FANCG. These genes provide instructions for making the components of the FA core complex. Mutations in many genes associated with the FA core complex cause the complex to malfunction and disrupt the entire FA pathway. As a result, DNA damage is not repaired effectively, and over time, ICLs accumulate. ICLs stop DNA replication.

Ultimately, they lead to pathological cell death due to the inability to make new DNA molecules or to uncontrolled cell growth due to the lack of DNA repair processes. Cells that divide rapidly, such as bone marrow cells and developing fetal cells, are particularly affected. The death of these cells leads to the reduction in blood cells and the physical abnormalities characteristic of Fanconi anemia. When the accumulation of errors in DNA causes uncontrolled cell growth, acute myeloid leukemia or other cancers can develop (3).

Fanconi anemia is most often inherited in an autosomal recessive pattern, meaning that both copies of the gene in each cell have mutations. The parents of an individual with an autosomal recessive condition carry one copy of the mutated gene, but they usually do not show symptoms of the condition.

The condition is very rarely inherited in an X-linked recessive pattern. The gene for X-linked recessive Fanconi anemia is located on the X chromosome, one of the two sex chromosomes. In males (who have only one X chromosome), one altered copy of the gene

in each cell is sufficient to cause the condition. In females (who have two X chromosomes), one altered copy of the gene in each cell is sufficient to cause the condition. In females, the mutation must occur in both copies of the gene to cause the disorder. Because women are less likely to have two altered copies of this gene, males are more likely to suffer from X-linked recessive disorders than females. A characteristic of X-linked inheritance is that fathers cannot pass on X-linked traits to their sons.

People with Fanconi anemia experience fatigue due to low red blood cell counts (anemia), frequent infections due to low white blood cell counts (neutropenia), and clotting problems due to low platelet counts (thrombocytopenia); and physical developmental defects. For example:

Uneven skin color, unusually light skin (hypopigmentation or café-au-lait spots), flat spots that are darker than the surrounding skin, malformed thumbs or forearms, and other skeletal problems, and short stature. Other developmental defects of the kidneys or urinary tract; gastrointestinal disorders; heart defects; eye abnormalities, such as small or abnormally shaped eyes; and malformed ears and hearing loss. People with this condition may also have genital abnormalities or reproductive system abnormalities (4).

As a result, most affected men and about half of affected women are unable to father biological children. Additional signs and symptoms may include abnormalities of the brain and spinal cord (central nervous system), including an increase in fluid in the center of the brain (hydrocephalus), or an unusually small head size (microcephaly.)

Life expectancy in Fanconi anemia depends on the severity of bone marrow dysfunction. Sometimes patients live without treatment to about 40 years, although more often they die in early childhood from severe anemia and oncological diseases. In modern conditions, it is possible to increase life expectancy with timely allogeneic bone marrow transplantation.

An 83-year-old man applied to the Hematology Department of the First University Clinic of Tbilisi (Georgia) State Medical University in 2021. The patient was planning surgical treatment for cataracts. The patient did not have any symptoms of Fanconi anemia until the age of 80.

The preoperative general blood test revealed leukopenia, neutropenia: leukocyte - 2.6 x 10’9/l; neutrophil - 22 %., general condition satisfactory, constitutional type - normosthenic. Does not tolerate alcohol and does not use tobacco. Has no genetic history. No developmental defects are noted.

In 2022, the patient repeatedly applied to the hematology department, in addition to leukopenia, macrocytic anemia was observed in the general blood test. Treatment was carried out with vitamin B 12. However, leukopenia and neutropenia remained. In order to verify the cause, a trepanobiopsy of the femur was performed and a morphological study of the material was performed: the bone tissue is well represented in the trepanation and no significant changes were seen in it, the overall structure of the bone marrow is preserved, the cellular composition is polymorphic. All three branches are well represented. Against such a basic background, single hypocellular areas are noted, where the amount of adipose tissue is increased. Due to the absence of clinically significant changes, it was decided to observe the dynamics.

During a routine check-up in 2024, the patient's blood showed changes, which led to repeated thorough studies. Namely: Bone Marrow Report, Haematological Malignancy Gene Panel Report (both studies were conducted at Peter MacCallum Cancer Centre Victoria Australia), FISH cytogenetic study, flow cytometry, Comprehensive Immune and Cytopenia Panel Plus.

Bone Marrow Peport, Conclusion: The aspirate demonstrates trilineage dysplasia and a myelodysplastic neoplasm is favored (MDS-Low blasts with MLD). Correlation with clinical features, either ancillary tests (hematinic, heavy metals), and molecular/cytogenetic studies are required for diagnostic confirmation and integration (Peter MacCallum Cancer Centre Victoria Australia).

Fish cytogenetic study. Conclusion: The research findings did not confirm the presence of trisomy or monosomy of chromosomes 7 and 8, nor deletions Del(5q); 17p13 del. (TP53); Del(7q); Del(20q) in the evaluated interphase cells.

Flow cytometry, Conclusion: No changes-Comprehensive Immune and Cytopenia Panel Plus: Sequence and Del/Dup (CNV) analysis using the blueprint genetics (BpG) Comprehensive Immune and Cytopenia Panel did not detect any known disease-causing or rare variants that could explain the patient’s phenotype as described to the laboratory at the time of interpretation. Summary of Results: Negative for explaining the patient’s phenotype. The patient is heterozygous for FANCCD2 c.757C>T, p (Arg253), which is likely pathogenic. (Blueprint Genetics Oy, Finland).

Based on the in-depth studies conducted, it is conceivable that the cause of the patient's leukopenia and neutropenia may be related to the development of myelodysplastic disease. This case suggests that myelodysplastic syndrome is multisymptomatic, and therefore, determining the underlying causes is crucial. Fanconi anemia, as known, is homozygous, while this case, which has been confirmed as heterozygous, supports the idea that it may transform into myelodysplasia over time. This gives us grounds to conclude that it is advisable to conduct a thorough examination of all cytopenic patients, including from a molecular-genetic perspective.

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TUBERCULOSIS

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ABSTRACT

Tuberculosis (TB) is an infectious disease primarily caused by Mycobacterium tuberculosis, which most often affects the lungs (pulmonary TB) but can also target other parts of the body such as the lymph nodes, bones, kidneys, and brain. TB spreads through the air when a person with active pulmonary TB coughs, sneezes, or talks. It remains a leading global health concern, despite significant advances in treatment and prevention.

TB manifests in two forms: latent TB, where the bacteria remain dormant without causing symptoms and cannot spread, and active TB, which leads to symptoms such as persistent cough, chest pain, weight loss, and coughing up blood. Risk factors for TB include close contact with infected individuals, weakened immunity (such as in people with HIV/AIDS), malnutrition, and living in areas with high TB prevalence.

Treatment for TB typically involves a combination of antibiotics taken over a 6-month period. However, multidrug-resistant TB (MDR-TB), which does not respond to the most common first-line treatments (isoniazid and rifampin), poses significant challenges to global TB control efforts. Drug-resistant forms of TB, including extensively drug-resistant TB (XDR-TB), require more complex and prolonged treatment regimens.

In India, TB remains one of the leading causes of morbidity and mortality, with a large burden attributed to both the general population and those co-infected with HIV. The National Tuberculosis Elimination Program (NTEP) aims to reduce TB incidence and achieve elimination by 2025, focusing on improved diagnostics, treatment adherence, and prevention strategies.

For more in-depth information, the World Health Organization and India's National TB Control Program offer resources and reports on TB statistics and strategies.

Keywords: Tuberculosis, Pulmonary TB, Latent TB, Active TB, Multidrug-resistant TB, Revised National Tuberculosis Control Program, BCG Vaccine, India TB Report 2024, Public-Private Partnership, Epidemiology, Tuberculosis prevalence.

Aim: Epidemiological studies of tuberculosis in India to quantify the burden of the disease, understand risk factors such as comorbidities and malnutrition, and monitor drug resistance trends to assess the effectiveness of existing programs.

Tuberculosis in India

Tuberculosis (TB) has had a profound and long-lasting impact on India, shaping both public health policy and the country's social and economic landscapes. Here's an overview of TB's historical significance in India:

Early History and Colonial Era

TB, historically known as "consumption," was a major cause of death in India during the colonial era. The British colonial administration first acknowledged the significance of TB in India in the late 19th and early 20th centuries. During this period, TB was considered a major public health challenge due to its widespread nature, with social conditions like overcrowding, malnutrition, and poor sanitation exacerbating the spread of the disease.

In the early 1900s, efforts to control TB were focused on isolating patients in sanatoriums, and the disease was often viewed as a social stigma. However, India lacked the infrastructure and medical knowledge necessary to effectively combat TB during this time.

Post-Independence (1947-1980s)

After India gained independence in 1947, TB continued to be a significant health problem. The newly established government recognized the need for comprehensive TB control programs, leading to the launch of India's first National Tuberculosis Program (NTP) in 1962. However, the program faced numerous challenges, including inadequate infrastructure, lack of awareness, and limited resources.

The widespread prevalence of TB persisted in the 1970s and 1980s, contributing to high mortality rates, especially in rural areas. The country's healthcare system, despite efforts to treat TB, was under-resourced and struggled to manage the increasing caseload.

Emergence of Drug-Resistant TB (1990s-Present)

In the 1990s, India faced a growing crisis of multidrug-resistant tuberculosis (MDR-TB), where the disease became resistant to first-line treatment drugs like rifampicin and isoniazid. The rise of MDR-TB was attributed to poor treatment adherence, irregular medication use, and inadequate diagnostic facilities. This period marked a significant turning point in India's fight against TB, as new drug regimens and treatment protocols were needed.

The introduction of the Revised National Tuberculosis Control Program (RNTCP) in 1997 sought to address these challenges with a more structured, decentralized approach using Directly Observed Treatment, Short-course (DOTS). The program was initially successful, but the emergence of extensively drug-resistant TB (XDR-TB) further complicated the issue.

Current Impact and Ongoing Challenges

Today, India has the highest TB burden in the world, with an estimated 2.7 million cases annually, accounting for about a quarter of the global burden. The rise of MDR-TB and XDR-TB remains a major challenge. Despite significant progress in diagnosing and treating TB, issues such as malnutrition, overcrowding, inadequate access to healthcare in rural areas, and the high prevalence of HIV/AIDS complicate efforts to eliminate TB.

The Indian government, along with global health organizations like the World Health Organization (WHO), is working toward the goal of eliminating TB by 2025, ahead of the global target of 2030. This includes enhancing diagnostic facilities, improving treatment adherence, and providing financial and nutritional support to TB patients.

Economic and Social Impact

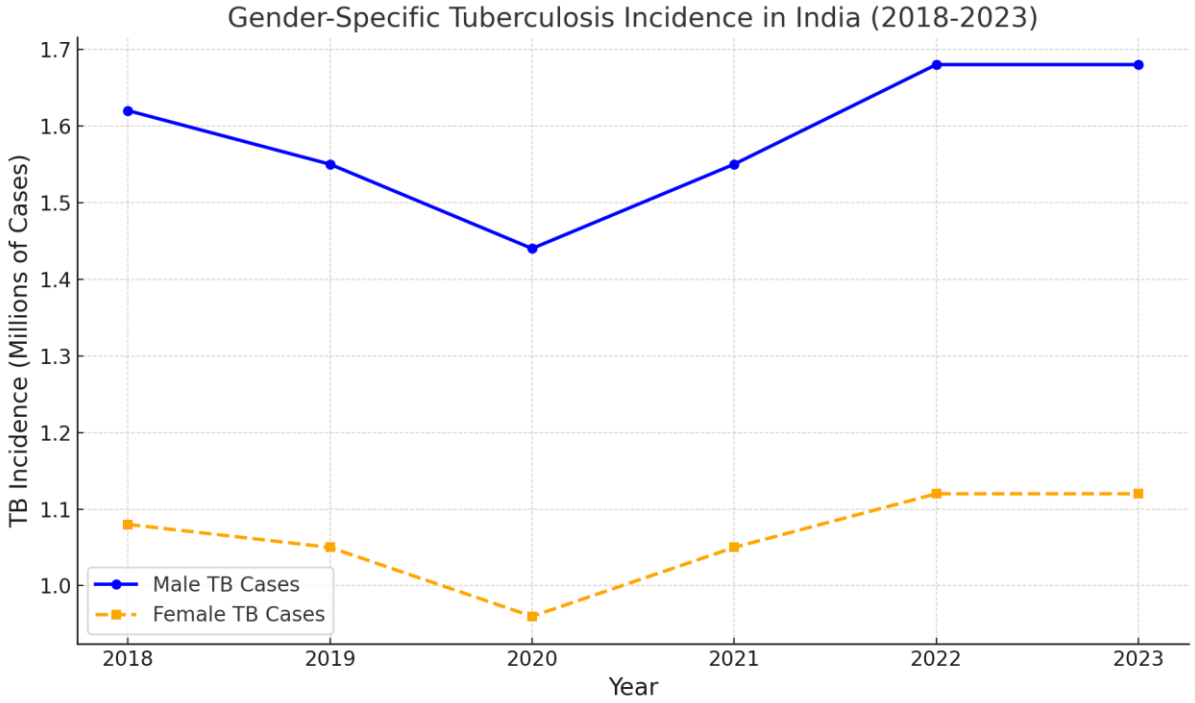
TB has had a substantial economic impact in India due to lost productivity, medical costs, and the strain on the healthcare system. The stigma surrounding TB also affects individuals' social lives, leading to discrimination and social exclusion, especially in rural communities.

Moreover, TB remains a significant cause of death among India's impoverished populations, perpetuating cycles of poverty and hindering overall development efforts. The government's initiatives, such as the National Strategic Plan (2017-2025), aim to address these challenges through a comprehensive approach that includes improved diagnostics, patient support, and efforts to prevent the disease.

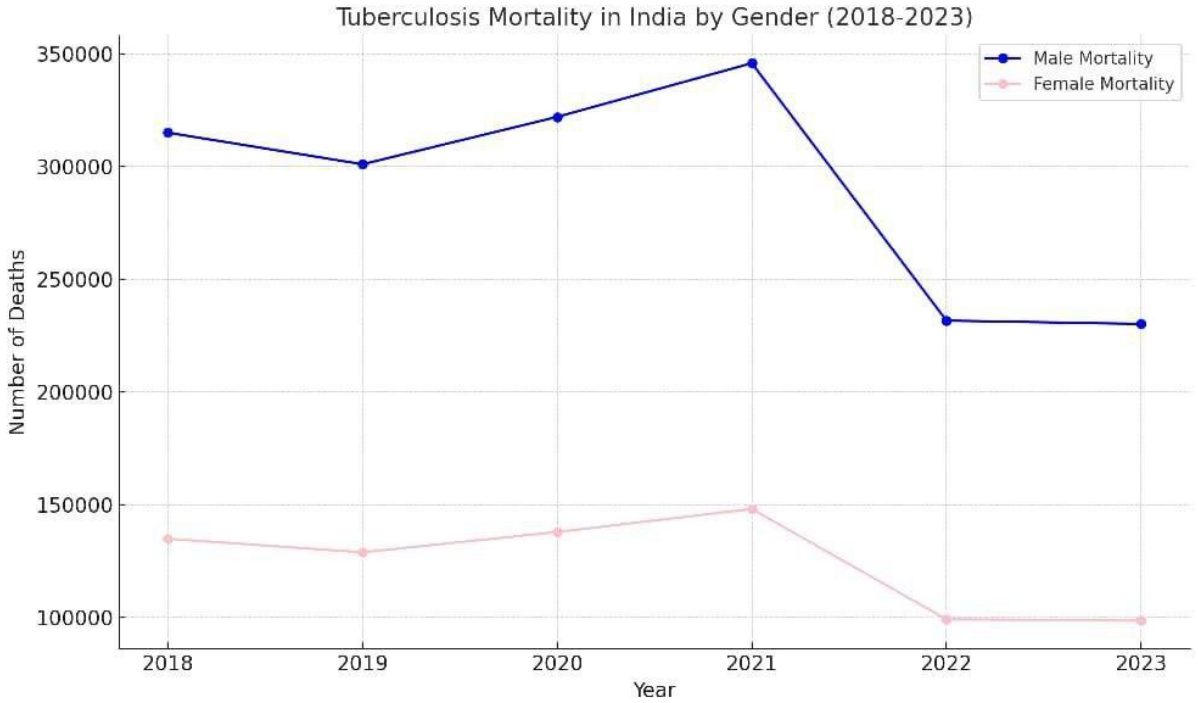
In summary, tuberculosis has played a significant role in shaping India's public health systems and continues to be a major challenge for the country. Ongoing efforts to improve diagnosis, treatment, and prevention are essential to addressing the historical and current impact of TB in India.

Statistical approach of Tuberculosis in india

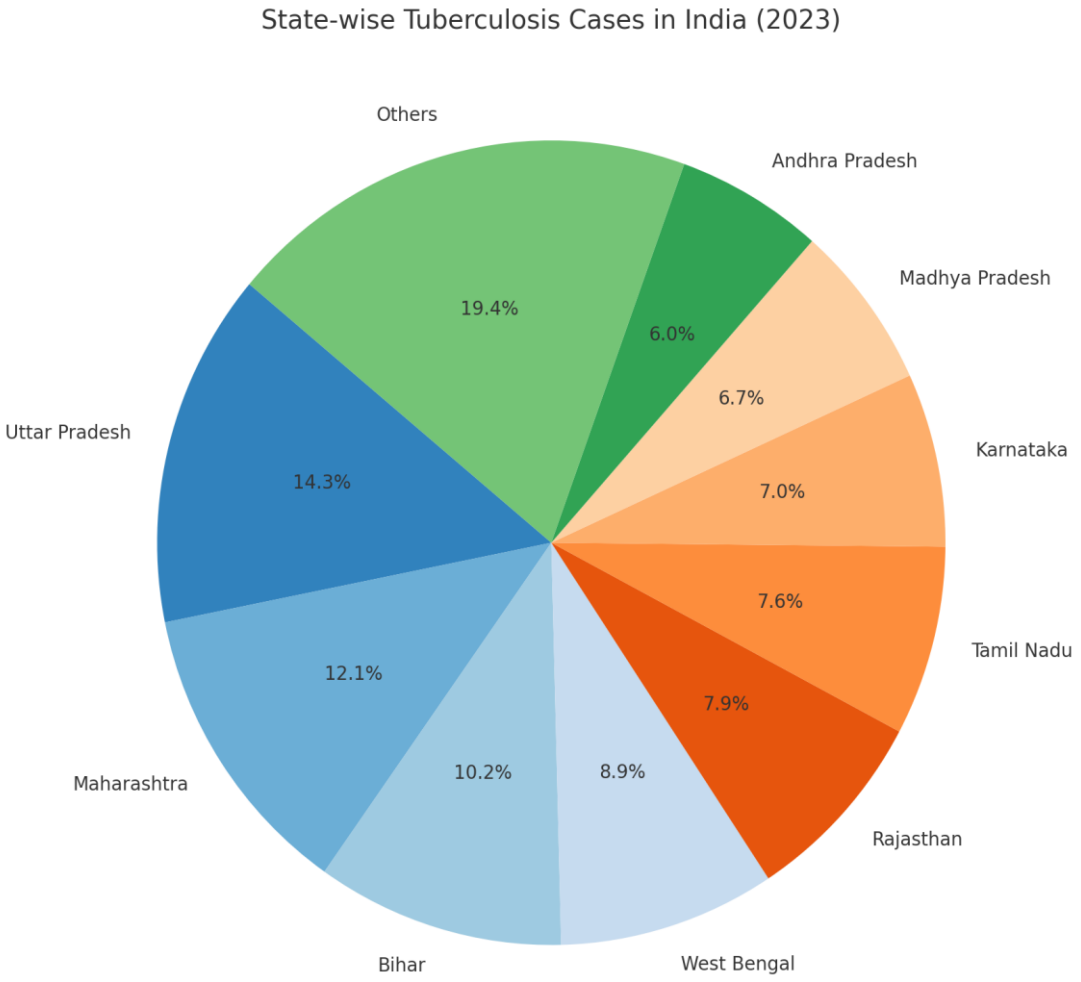
Tuberculosis incidence in India (2018-2023), disaggregated by gender. It shows consistently higher TB incidence among males compared to females, reflecting global and regional patterns.



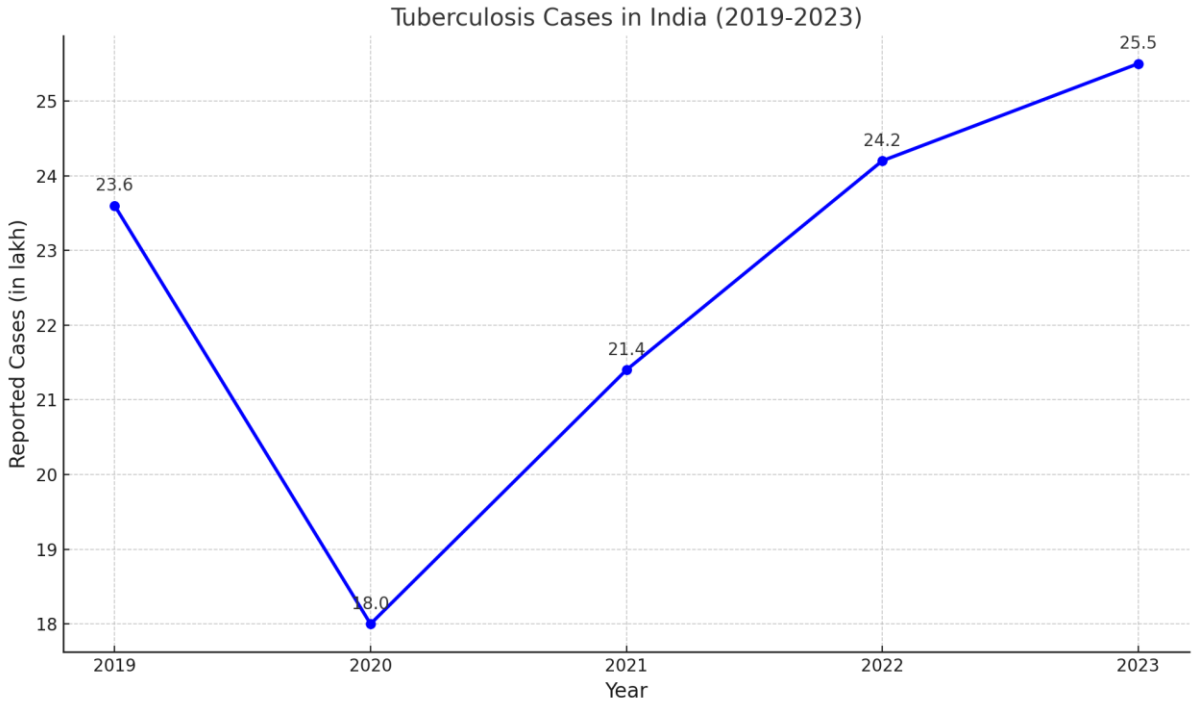
Tuberculosis mortality in India by gender from 2018 to 2023. The data reflects higher mortality among males compared to females.



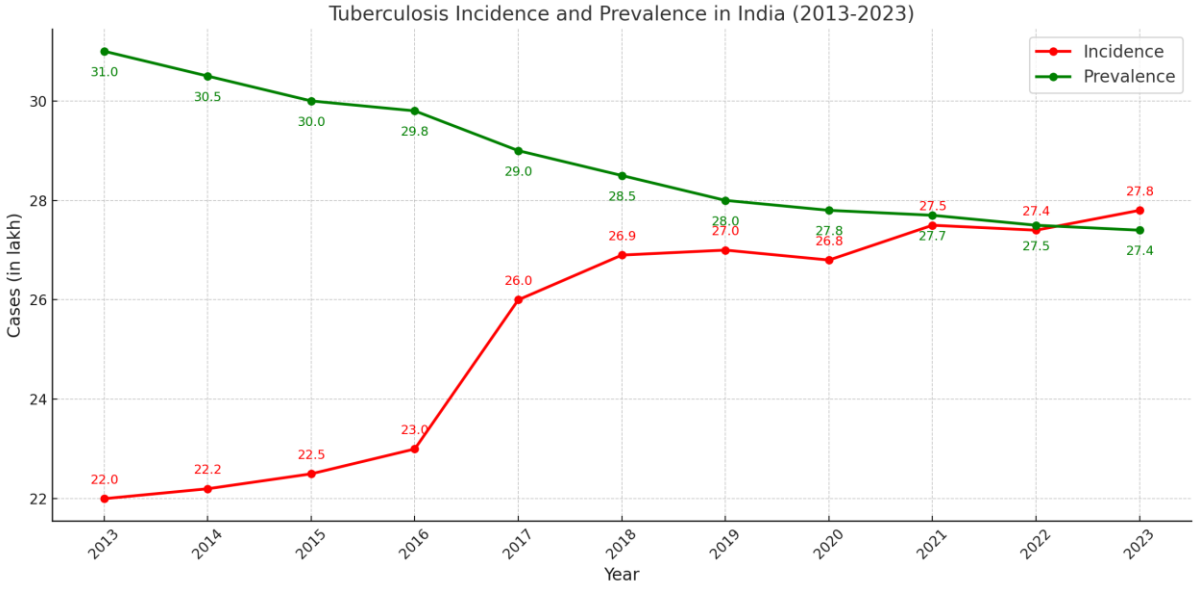
State-wise distribution of tuberculosis (TB) cases in India for 2023. States like Uttar Pradesh and Maharashtra have a significant share of cases, reflecting their large populations and TB burden



Here is a graph showing the reported tuberculosis (TB) cases in India over the last five years (2019–2023).



Here is the graph showing the incidence and prevalence of tuberculosis (TB) in India from 2013 to 2023. The incidence reflects new cases, while prevalence includes both new and existing cases, showing a gradual decline in prevalence and relatively stable incidence over the decade.



Futuristic approach

India continues to face significant challenges with tuberculosis (TB), particularly multidrug-resistant TB (MDR-TB). The latest India TB Report (2024) highlights that TB remains a substantial health issue, with an estimated 27.8 lakh cases in 2023, a slight increase from the previous year. However, the mortality rate from TB has decreased over the years, from 4.94 lakh in 2021 to 3.31 lakh in 2022.

A major concern is the rising incidence of MDR-TB, which is resistant to the two most powerful anti-TB drugs, isoniazid and rifampicin. Approximately 1,24,000 cases of MDR-TB were reported in India by 2021, and the mortality rate for these cases is around 20%. The spread of MDR-TB is exacerbated by factors like poor treatment adherence, undernutrition, and co-morbidities such as HIV and diabetes.

The Indian government has launched a National Strategic Plan (NSP) to end TB by 2025, focusing on four key pillars: detection, treatment, prevention, and capacity building. This includes improving early diagnosis, ensuring effective treatment, and enhancing community and healthcare sector participation. In addition, the country is addressing TB's risk factors, such as malnutrition and alcohol consumption, which complicate treatment outcomes. Despite these efforts, the

country is still grappling with challenges like inadequate private sector reporting and high-risk populations such as HIV patients and people with diabetes.

Efforts to tackle TB, particularly MDR-TB, include improved drug regimens and support programs like the Nikshay Mitra initiative, which provides nutritional support to TB patients. However, overcoming the MDR-TB crisis requires greater attention to treatment adherence, access to healthcare, and infection control.

Vaccinations in India

In India, the Bacillus Calmette-Guérin (BCG) vaccine is the primary vaccination used to prevent tuberculosis (TB). The BCG vaccine is a live attenuated form of Mycobacterium bovis, a strain closely related to Mycobacterium tuberculosis. The vaccine has been shown to be effective in preventing severe forms of TB in children, particularly childhood meningitis and disseminated TB, although its efficacy in preventing adult pulmonary TB is limited.

Vaccination Strategy:

•The BCG vaccine is administered to newborns soon after birth in India, as part of the country's universal immunization program.

•India has been actively working towards TB elimination by 2025, in line with the National Tuberculosis Elimination Program (NTEP). Vaccination is seen as a preventive tool, especially for vulnerable populations.

However, the BCG vaccine does not offer complete protection, and TB remains a significant public health challenge in India. Additionally, the effectiveness of BCG may vary in different populations, and it is not sufficient to control the disease alone, which is why other TB control measures such as early diagnosis and treatment are crucial.

India has also been improving its surveillance and diagnostic infrastructure for TB, alongside vaccination efforts, to reduce the disease burden further. There are ongoing studies on new vaccines, as the current BCG vaccine does not fully protect against all forms of TB, especially drug-resistant strains.

Preventive measures in India

Tuberculosis (TB) prevention in India focuses on a multi-pronged approach, given the country's high TB burden. Key measures include:

1. National Tuberculosis Elimination Program (NTEP): Formerly the Revised National Tuberculosis Control Program (RNTCP), it aims to eliminate TB by 2025, ahead of the global target of 2030.Emphasizes early detection, free diagnosis, and treatment for all, including in the private healthcare sector.

2. BCG Vaccination: The Bacillus Calmette-Guérin (BCG) vaccine is administered to newborns to protect against severe forms of TB, such as meningitis and disseminated TB. Part of India's Universal Immunization Program.

3. Active Case Finding (ACF): Health workers conduct door-to-door screening in high-risk populations, including urban slums, prisons, and areas with high TB prevalence. Aims to identify and treat latent TB cases before they become infectious.

4. Nutritional Support: The Nikshay Poshan Yojana provides monthly nutritional support of ₹500 to TB patients undergoing treatment, addressing malnutrition—a significant risk factor for TB.

5. Preventive Therapy: Contacts of TB patients, especially children under five, are given isoniazid preventive therapy (IPT) to prevent latent TB infection from progressing to active disease.

6. TB Awareness Campaigns: Public education campaigns focus on reducing stigma, improving knowledge about symptoms, and encouraging timely medical help. Use of mass media, social media, and local outreach efforts.

7. Engagement with the Private Sector: The program collaborates with private practitioners for standardized TB care under the Public-Private Partnership model. Encourages private providers to notify all TB cases to the government.

8. Strengthened Diagnostics: Availability of advanced diagnostic tools like GeneXpert and TrueNat for rapid and accurate detection of TB and drug-resistant TB. Free chest X-rays for presumptive TB cases in many areas.

9. Addressing Multidrug-Resistant TB (MDR-TB): Specialized treatment regimens and second-line drugs are provided for MDR-TB patients. Use of newer drugs like bedaquiline and delamanid.

10. Focus on Social Determinants: Efforts to improve living conditions, reduce overcrowding, and enhance ventilation in homes and workplaces. Special initiatives targeting TB in vulnerable populations, such as migrants and tribal communities.

11. Digital Interventions: Platforms like Nikshay, a digital tool, help track patient care, treatment adherence, and notification of TB cases. Use of AI and machine learning for predictive analytics and resource allocation.

India's TB prevention efforts are ambitious but face challenges such as drug resistance, stigma, and socio-economic barriers. Achieving elimination by 2025 will require sustained commitment and innovation.

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PHILOLOGICAL SCIENCES

БИЛИНГВАЛЬНЫЙ ТЕКСТ КАК ПРЕДМЕТ ХУДОЖЕСТВЕННОГО ПЕРЕВОДА И МЕЖКУЛЬТУРНОГО ДИАЛОГА

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BILINGUAL TEXT AS A SUBJECT OF LITERARY TRANSLATION AND INTERCULTURAL DIALOGUE

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АННОТАЦИЯ

В условиях двуязычия или многоязычия вопросы обучения, перевода и межкультурного диалога приобретают особую значимость. В зависимости от учебных задач это языковая, учебная и творческая ситуация актуальна для всех типов образовательных учреждений; она, как интегрированный процесс, требует комплексного подхода к её пониманию и организации. Исходя из этого, в статье акцентируется внимание на понятиях «билингвальное обучение» и «билингвальный художественный текст».

Привлечённые к исследованию произведения русской, кыргызской и азербайджанской литератур хотя и написаны на русском языке, определены нами как билингвальные. Среди многочисленных точек зрения о билингвальном художественном тексте, более подходящей считаем следующую: «Художественный билингвизм – оригинальное творчество, основанное на взаимодействии двух языков и культур» (Туксаитова, 2005, 199). В данном мнении нет намёка на соотношение текстовых элементов, относящихся к языку произведения; подчёркивается только их взаимодействие.

Наши наблюдения над текстами «турецкой сказки» М.Ю. Лермонтова, повести «Джамиля» и романа «И дольше века длится день» Ч. Айтматова, романа «Фатальный Фатали» Ч. Гусейнова и других произведений свидетельствуют о роли культурологических элементов в процессе обучения, о своеобразном подходе к передаче или комментированию их на втором языке.

ABSTRACT

In the context of bilingualism or multilingualism, the issues of teaching, translation and intercultural dialogue become particularly important. Depending on the educational tasks, this linguistic, educational and creative situation is relevant for all types of educational institutions; as an integrated process, it requires an integrated approach to its understanding and organization. Based on this, the article focuses on the concepts of "bilingual learning" and "bilingual literary text". Russian, Kyrgyz and Azerbaijani literature works involved in the study, although they are written in Russian, have been identified by us as bilingual. Among the numerous points of view about a bilingual literary text, we consider the following to be more appropriate: "Artistic bilingualism is original creativity based on the interaction of two languages and cultures" (Tuksaitova, 2005, 199). In this opinion, there is no hint of the relationship of textual elements related to the language of the work; only their interaction is emphasized.

Ключевые слова: билингвальный художественный текст, билингвальное обучение, произведения русской, кыргызской и азербайджанской литератур, взаимодействие.

Keywords: bilingual fiction text, bilingual education, works of Russian, Kyrgyz and Azerbaijani literature, interaction.

Во-первых, нам необходимо определиться с понятием «билингвальный художественный текст», который, по нашим представлениям, служит лишь одним из средств или инструментов «билингвального обучения». Модель обучения – это лишь форма, а «билингвальный художественный текст», как инструмент или средство обучения, является выражением и олицетворением идеи и содержания. В данном случае сочетание данных понятий объясняется с точки зрения методики и методологии преподавания иностранного языка в иноязычной аудитории, когда лексические выражения, мифологемы, другие культурные символы и коды родного языка обучающегося могут служить ключом к пониманию глубины авторской идеи, мотивацией учебной деятельности учащихся.

Во-вторых, оба эти понятия рассматриваются нами как факты взаимообогащения языков и культур, металингвистики, компоненты межкультурного диалога, что дает возможность обсуждать их в едином контексте. Билингвальные тексты русской литературы, литератур постсоветского пространства представляют интерес не только в структурно-семантическом отношении, в плане языковых ресурсов оригинала, но и по своему идейно-тематическому своеобразию. Автор, принадлежащий к определённой национальной культуре, преднамеренно вводит в текст её элементы, актуализирует их, тем самым, расширяя круг и пространство актуальных национальных проблем. Если принадлежащие к африканской и азиатской культуре писатели-ми-

гранты, являясь гражданами США или Великобритании, пишут на английском языке, и прибегают к выражающим их национальную идентичность понятиям, благодаря им мир осведомляется о насущных проблемах названных континентов; освещение этих проблем американскими или британскими мигрантами создает новое восприятие наболевших вопросов. В другом социокультурном положении находятся писатели, которые, имея два языка, т.е., свободно владея ими, чтобы выйти на более широкую читательскую аудиторию, предпочитают сочинять не на родном, а на языке, имеющем международный статус. Таковым для многих авторов стран, образовавшихся после распада СССР, был русский язык. Дело даже не в том, что они не хотели писать на родном; они намного лучше творили на русском, так как получили русскоязычное образование. Русский язык со своими богатыми ресурсами, выразительностью служил им инструментом изящного описания и самовыражения. В то же время под зонтом, под внешним оформлением текста скрывалась личность с национальным сознанием и памятью, духовно-нравственным восприятием мира. Это было уникальное языковое явление, когда, служа обогащению языка описания новыми реалиями и лакунами, писатели в то же время твердили о существовании, своеобразии и неповторимости своей культуры. Мы привыкли рассматривать тексты с точки зрения лингвокультурных, метаязыковых, интертекстуальных и других влияний. А ведь в так называемых русскоязычных национальных текстах символы, коды, архетипы и другие реалии обозначали больше, чем сам связный текст с его структурно-словесным оформлением. В данном случае будем опираться на мысли В. А. Масловой, по мнению которой «правила построения текста зависят от контекста культуры, в котором он возникает. Текст созидается из языковых единиц низших уровней, которые при соответствующем подборе могут усилить культурный сигнал», благодаря чему формируется «набор специфических сигналов, которые… вызывают у читателя, воспитанного в традициях данной культуры, не только непосредственные ассоциации, но и большое число косвенных». [*Маслова, 2007, 87*]. А что имеет в виду учёный, говоря «о большом числе косвенных»? Это то, что выходило за рамки филологических исследований, носило глубоко философское и сугубо политическое значение. Наглядными примерами тому являются айтматовские сюжеты: легенда о мангурте и повесть «Белое облако Чингисхана». Герой Ч.Айтматова Абдурахман уличён в пропаганде абстрактных буржуазных идей и осуществлении какого-то англосаксского сговора. Он же не один, там ещё учёные-историки, филологи, утверждавшие о существовании в их республике каких-то национальных государственных образований, что противоречило знакомой всем нам из школьных учебников истории информации о нахождении центральноазиатских народов до установления здесь советской власти на стадии развития рабовладельческого общества. В данном случае уместно процитировать известную мысль М.Бахтина о том, что человека можно изучать только через тексты, созданные или создаваемые им, что «в … своей ипостаси текст несет смысл прошлых и последующих культур, он всегда на грани, он всегда диалогичен, поскольку всегда направлен к «Другому» (*Бахтин, М. М., 1986*, http://teatr-lib.ru/Library/Bahtin/esthetic/#_Toc225599030)). Абдурахман, со своими подразумеваемыми текстами входит в диалог с самим автором. Эти сюжеты почерпнуты из народной памяти; в 30-50-е годы они преследовались, трактовались как антисоветские, антикоммунистические. Живи в те годы, наверно, и дед Момун был бы арестован и осужден за свою сказку о Матери-оленихе.

В-третьих, билингвальные тексты, являясь объектом и предметом взаимопроникновения языков и культур, естественного и непринужденного вхождения в «чужую» культуру, подразумевают адаптацию одних культурных элементов, кодов, ценностей в контексте другой литературы. Это довольно часто встречающееся явление наблюдается на многих этапах литературных контактов народов, сосуществовавших в общем культурно-историческом ареале или имевших между собой тесные экономические и человеческие отношения. Наглядным примером являются тексты русской средневековой литературы, такие как «Слово о полку Игореве», «Хождение за три моря» Афанасия Никитина, «Повесть о Темир-Аксаке», «Сказание о Магмет-салтане» И.Пересветова, историческое повествование «Казанская история», повесть «Посольство Ивана Новосильцева в Турцию» и др., тексты которых были пронизаны тюркскими элементами. Эту традицию продолжили путевые очерки и повести А.Бестужева-Марлинского, «Путешествие в Арзрум» А.С.Пушкина, лермонтовская сказка «Ашик-Кериб», стихи и поэма Я.Полонского «Агбар» и др. Проявление мотивов тюркской тематики, а также античной, ренессансной литературы в поэзии авторов «серебряного века» соответствовало их творческим принципам.

Иначе обстоит дело с произведениями двуязычных национальных авторов, свободно сочинявших на русском и родном языках. Некоторые представляли читателям свои авторизованные переводы. Русские тексты выполняли функцию выпячивания вопросов национальной истории, своеобразия своей ментальности, злободневных проблем социальной и общественной жизни своего региона, восстановления национальной памяти. «Особый случай присутствия диалога в литературе наблюдается тогда, когда он происходит в сознании писателя, который принадлежит двум культурам одновременно. Взаимодействие разных национальных культурных традиций в рамках одного творческого сознания оригинально преломляется в художественных текстах» (*Маслова, 2007, 5*). В.А.Маслова логически подытоживает свои наблюдения над творчеством этих авторов: «Взаимодействие различных культур создает особый тип языковой личности, который можно охарактеризовать как марги-

нальный, воспринимающий свою этническую культуру как бы со стороны… При чтении билингвистического произведения читатель погружается в национально специфический мир образов, вещей, явлений, отношений. В этом случае в тексте воплощается мировидение того народа, которому принадлежит писатель». (*Маслова, 2007, с. 5*) Нам кажется, что произведения Чингиза Айтматова на русском языке можно рассматривать в качестве яркого примера воплощения мировидения кыргызского и казахского народов (*перекличка одних и тех же проявлений в образе жизни и мышления этих народов без особого подчеркивания и сопоставления их свидетельствует о надуманном, несправедливом разделении некогда единой историко-географической, ландшафтной и культурной среды на разные регионы*). Так же интересно было бы проследить за творческими поисками казахского поэта и исследователя Олжаса Сулейменова и азербайджанского писателя Чингиза Гусейнова в их русскоязычных текстах.

В повести «Джамиля» Ч.Айтматов повсеместно внедряет в текст общетюркскую лексику: *намаз, адат, кетман, кичи-ана, кичине-бала, кайын, сеит, камчы, ишак, тандыр, аксакал, ата, марал, бешик, Алабаш, джайлоо, чабаны* и др. Есть немало слов, характеризующих быт, традиции и образ жизни народов Туркестана[1]: *юрта, байбиче, Энесай, Бугубай, Караульная гора, Сулейманова гора* и др. Эти слова и выражения, данные без перевода и комментирования, незаметно растворяются в текстах Ч.Айтматова, так как читатель ощущает себя в ареале культурной среды автора. «– Ну, если вы так уж боитесь за свою невестку, то вот ее *кайни*, – с радостью указал он на меня, – никому не позволит близко к ней подойти» (*Айтматов, 2022, 186*). В данном эпизоде сам сюжет подсказывает читателю, что речь идет о брате мужа Джамили, ее девере). Легко угадать читателю русскоязычного текста реплику безнравственного Осмона в отношении к Джамиле: « – Вот и я говорю! Война – ты и бесишься без мужниной *камчи*!.. – Эх, была бы ты моей бабой, тогда бы ты не то запела. (*Айтматов, 2022, 291*). Следующий пример из текста – не только яркое этнографическое, но и пейзажное описание степи: «Там, за рекой, где-то на краю казахской степи, отверстием горячего *тандыра* пламенело разомлевшее вечернее солнце косовицы» (*Айтматов, 2022, 291*).

В «Белом пароходе», особенно в легенде о матери-оленихе, Ч. Айтматов чаще применяет тюркскую лексику, составляющую ядро кыргызских и казахских притч, легенд и мифов. Весь текст читается (поется) как песня, одни пословицы и афоризмы порождают другие, как бы служа внутренним рефреном: «Прибежала Рогатая мать-олениха. На рогах своих, подцепив за дужку, принесла она детскую колыбель – бешик. Бешик был из белой березы, а на дужке бешика серебряный колокольчик гремел. И поныне гремит тот колоколец на бешиках иссык-кульских»; «При виде марала бугинец сходил с седла, уступая дорогу. Красоту любимой девушки сравнивали с красотой белого марала». (*Айтматов, 2022, 493*)

Исследователю-переводоведу интересно сравнить текст повести «Белый пароход» с его переводами на тюркские языки, пронаблюдать нахождение переводчиками удачных соответствий на родном языке. Самой оригинальной находкой азербайджанского переводчика повести Дж. Алибеева стала передача сочетания «дед Момун» как «Mömin baba» («религиозный дед»). Можно привести множество примеров сохранения на азербайджанском языке национальных элементов оригинала.

Айтматовские тексты отделяют землю кыргызов и казахов от остального мира. Автор символизирует её как Восток, с которого поезда идут на Запад или оттуда на Восток. Этот мир, данный культурный ареал с его легендами, сказками, афоризмами и пословицами, очеловечением природы, характерами и судьбами автор русского текста окутал своими мифическими и мистическими представлениями о родном крае.

История литературы также свидетельствует о фактах, когда «читатель погружается в национально специфический мир образов, вещей, явлений, отношений», в тексте воплощается мировидение не того народа, «которому принадлежит писатель», а – народа, чьим фольклором и мотивами соткан записанный или созданный им художественный образец. В этом плане оригинальна запись русским поэтом М.Ю.Лермонтовым азербайджанского любовного народного дастана «Ашыг Гариб» во время его пребывания на Кавказе и в Азербайджане в октябре-ноябре 1837 года. Услышав дастан из уст азербайджанца (предполагается, что он услышал его из уст своего учителя азербайджанского языка драматурга, поэта и философа Мирзы Фатали Ахундзаде – «учёного татарина Али»), русский поэт сохранил не только сюжет дастана, но и структуру пословиц и поговорок, внёс их в текст с сохранением азербайджанского написания и произношения. Лермонтовская «турецкая сказка» «Ашик-Кериб» – это уникальный способ передачи культурологической информации с одного языка на другой, в котором сливаются в единое целое роли информатора и регистратора. Тот, кто пересказывает текст с присущими ему национальными компонентами, и тот, кто записывает и обрабатывает его с принадлежащими своему языку художественными и стилистическими чертами, демонстрируют читателю бесподобный пример сотворчества. Это сказка – не оригинальное произведение, не переделка-переложение и не перевод, так как тогда еще дастан не был записан. Полная версия дастана была издана намного позже, в 1892 году. Немалый интерес вызывает ещё другой аспект записи азербайджанского сказания: после издания лермонтовской сказки появились парадоксальные

[1] *Термин «Туркестан» подразумевает здесь Центральную Азию, но логично отнести к этому культурно-историческому ареалу весь тюркский мир, включая Турцию и Азербайджан.*

версии о её армянских и грузинских источниках. Но факты остаются фактами: лермонтовский текст пестрит словами и пословицами, антропонимами, топонимами с азербайджанским произношением, самое главное, свойственными общему культурно-историческому ареалу и зафиксированными в азербайджанском фольклоре: *сааз, бек, паша, ана, оглан, кериб, ашик, караван-сарай, ага, рашид, намаз, селям-алейкум, Хадериляз и др.* Среди них также пословицы и поговорки*: «Как тебя зовут? – Рашид. Раз говори, другой раз слушай, Рашид»; «Что написано у человека на лбу при его рождении, того он не минует»; «Если человек решился лгать с утра, то должен лгать до конца дня»; «В доказательство истины сабля моя перерубит камень»; «Если же я лгу, то да будет шея моя тоньше волоска».*

К сожалению, у странствующего молодого поэта не было времени упорядочить свою запись, в которой наблюдаем много разночтений, немотивированность, о чём мы писали в своём специальном труде «Рецепция проза М.Ю. Лермонтова в Азербайджане» (*Джафаров (Велиханлы), 2015*). Это можно охарактеризовать даже как творческий эксперимент поэта. Известно, что некоторые мотивы своей «турецкой сказки» он развил и расширил в романе «Герой нашего времени», в частности, в повести «Фаталист».

«Ашик-Кериб» Лермонтова относится к новому времени, к периоду формирования русского литературного языка. Хорошо, что текст сохранён так, как был записан. К сожалению, билингвальные тексты предыдущих периодов постигла иная участь. В тексте-толковании «Слова о полку Игореве» едва можно различить два-три выражения из первоначального варианта памятника *(«ортмами», «ходына»* и др.). Памятник XV века – «Хождение за три моря» Афанасия Никитина также мы находим в толковании, что лишает нас возможности рассмотреть его как билингвальный текст. Понятно, что тексты древнерусских памятников не представляют для нас актуальности в качестве обучающего материала. Однако они вызывают интерес для других наблюдений как образцы билингвальных художественных текстов с тюркскими мотивами.

Изучение текстов авторов-билингвов, принадлежащих к двум культурам, предполагает множество аспектов для филологических, культурологических, этнопсихологических, философских и других исследований. И у каждого двуязычного писателя своя судьба, своя задача представления реалий своей национальной культуры. Некоторые авторы считают, что нет общепринятого понятия «художественный билингвальный текст» и вопрос о том, кто является билингвальным писателем и какой текст дифференцируется как двуязычный, до сих пор остаётся открытым (*Абдрахман; Нарбекқызы, 2020, 125*).

Особого внимания заслуживает исторический роман азербайджанского писателя Чингиза Гусейнова «Фатальный Фатали», авторизованный перевод которого на азербайджанский язык появился после русского текста произведения. По признанию автора, задержка выхода книги на родном языке была связана с тем, что местные цензоры нашли в романе тему «*колонизации Кавказа…*». (*Гусейнов Ч., 2014*). В целом роман является наглядным примером демонстрации сложных исторических процессов включения Кавказа, в том числе Северного Азербайджана в состав Российской империи. Трагичность этих процессов болезненно воспринималась автором исторического трактата «Гюлистани-Ирем», переводчиком наместника Кавказа, участником Туркменчайского договора между Россией и Персией полковником Аббаскули Ага Бакихановым. Роман Чингиза Гусейнова посвящён другому переводчику канцелярии наместника – М.Ф. Ахундзаде. Ведь включение в состав нового государства сопряжено у азербайджанцев не только с осознанием разделения исторических земель, но и с фактом оказания в совершенно иной культурно-исторической обстановке. Ч. Гусейнов восстанавливает эту память спустя примерно полутораста лет: «Азербайджанскую землю разделили на две части – северную и южную. К России отошли все города, села, горы и долины, ручейки и озёра, леса и кустарники по эту сторону Аракса, и река стала границей, чтобы войти строкой и мелодией в причитания и плачи: «Ты, Аракс, кинжальный мой…». (*Гусейнов Ч., 1988, 214*). Эта строка символизирует фатальность судьбы не одного поколения авторов, ищущих путь духовного спасения собственного народа, разделённого надвое. Н.Иванова – автор предисловия к книге Ч. Гусейнова – признаётся, что чтение его произведений никак нельзя назвать «лёгким»... Эта историческая проза плотна и насыщена мыслью, требует серьёзной работы ума… громоздкая повествовательная структура даёт возможность автору наиболее адекватно воспроизвести не только внутренний мир героя, но и историческую обусловленность этого мира и ненавязчиво показать перекличку проблем, мучивших Фатали, с проблематикой наших дней. Сознание автора, ярко окрашивающее повествование, делает этот исторический роман современным». (Иванова, 1988, 5) Выясняется, что перевод данного романа Ч. Гусейнова «с его родного русского на родной азербайджанский» не был творческим замыслом писателя. Это было спасением идеи «языковой личности» благодаря его двуязычию.

Обращение к писателям, чьи тексты характеризуются как билингвальные, к приведённым из них примерам выявляет интересные для филологов, переводчиков, педагогов и психологов перспективы интегрированного сотрудничества в аспекте культурологии, компаративистики, сравнительного языкознания, а также в плане изучения русского языка как иностранного. Согласитесь, что благодаря переводам на русский и с русского на национальные языки, а также билингвальным текстам русской и русскоязычных литератур сформировался уникальный культурно-исторический ареал, аура, платформа сожительства и переклички литератур, языков и культур десятки народов, чего лишились мы после развала Союза. Для националь-

ных литератур, подобной азербайджанской, которая столетиями развивалась и обогащалась в контексте с восточными и западными культурами, наступил новый этап поиска более широкого литературного пространства. Рассматриваемые в статье тексты русской и русскоязычных национальных литератур, представляя собой полезный историко-культурологический и этнографический материал, создают мотивацию для интенсивной работы над ними. Способы передачи, комментирования, объяснения, адаптации или растворения этнографических компонентов в билингвальных текстах требуют специального рассмотрения.

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PHYSICS AND MATHEMATICS

FEATURES OF PLUTO'S ROTATION AROUND ITS AXIS AND AROUND THE SUN

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ABSTRACT

Pluto's orbit differs significantly from the orbits of the large planets of the Solar System. After all, if they are almost circular and close to the plane of the ecliptic, then Pluto's orbit is inclined to the ecliptic by more than 17°, and with an eccentricity value of 0.249 it is significantly elongated. Therefore, the average distance between Pluto and the Sun varies from 39.53 AU at perihelion to almost 49.31 AU at aphelion. This leads to the fact that the intensity of illumination from the Sun changes on the surface by a factor of 2.8. Pluto's rotation period around the Sun is almost 248 years. Due to the elongated orbit, Pluto periodically approaches Neptune. On September 5, 1989, it last passed the perihelion point. And at this moment, from 02/07/1979 to 02/11/1999, for more than 20 years, Pluto was closer to the Sun than Neptune. Before that, the same situation occurred for 14 years, from 07/11/1735 to 09/15/1749. However, due to the large inclination of Pluto's orbit to the plane of the ecliptic, it does not intersect with Neptune's orbit, since passing the perihelion point, Pluto is at a distance of 10 AU above the plane of the ecliptic. For this reason, Pluto cannot approach the planet Neptune closer than 17 AU. But Pluto can sometimes approach Uranus by almost 11 AU. Such an orbital resonance between Neptune and Pluto is very stable and persists for millions of years. And since the argument of Pluto's perihelion is close to 90°, this value provides a significant distance both to the ecliptic plane and to the nearby giant planets when passing through the perihelion point. Such characteristics allow Pluto to avoid approaching Neptune. The period of rotation of Pluto around its own axis is 6.387 Earth days. The same value is equal to the period of rotation of Charon around Pluto and around its axis. Therefore, Pluto and Charon always face each other with the same side. They are the largest bodies in the Solar System with mutual synchronous rotation. The Pluto-Charon system of bodies is distinguished by the fact that due to the large mass of the satellite Charon; their center of mass is located outside the limits for both bodies. Therefore, they are sometimes called a double planet. The last equinox for Pluto took place on 16.12.1987.

Keywords: Pluto, dwarf planet, orbital features, double planet, synchronous rotation.

It is known that the orbits of the large planets [12-14, 25-29] of the Solar System (except Mercury) are almost circular and close to the ecliptic plane. And as follows from the data in Table 1, the orbit of the dwarf planet [9, 15, 23] Pluto (Fig. 1) differs significantly from them.

Fig. 1. Mosaic of images of Pluto taken by the New Horizons space probe on July 14, 2015, from a distance of 450,000 km (https://pluto.jhuapl.edu/Galleries/Featured-Images/pics/BIG_P_COLOR_2_TRUE_COLOR1.png).

Table 1.

Main characteristics of Pluto and its orbit.

Orbital characteristics	
Semi-major axis	5906.38 million km 39.482 AU
Perihelion	4436.82 million km 29.658 AU
Aphelion	7375.93 million km 49.305 AU
Eccentricity	0.249
Orbital period	247.94 Earth years
Orbital period	14179 Pluto solar days
Mean orbital velocity	4.67 km/s
Mean anomaly	14.86°
Orbital inclination to the ecliptic	17.14°
Orbital inclination to the Sun's equator	11.88°
Longitude of ascending node	110.303°
Longitude of pericenter	224.067°
Time of last pericenter	5 September 1989
Pericenter argument	113.763°
Physical characteristics	
Average radius	1187±4 km
Oblateness	<1 %
Surface area	17.7 million km ^{2}
Mass	$(1.303 \pm 0.003) \times 10^{22}$ kg 0.0022 of the Earth's mass
Average density	1.860 ± 0.013 g/sm^3
Surface acceleration due to gravity	0.617 m/s² (0.063 g)
Second cosmic velocity	1.210 km/s
Rotation period	−6.387 s
Equatorial rotational velocity	13.5 m/s
Axis inclination to orbit	122.53°
Right elevation of the north pole	132.99°
North pole inclination	−6.16°
Bond albedo	0.4-0.6
Geometric albedo	0.5-0.7
Surface temperature	33-55 K
Apparent magnitude	>13.65 (average 15.1)
Apparent angular size	0.06-0.11"
Axis inclination to orbit	122.53°
Atmosphere	
Surface pressure	1 Pa (as of 2015)
Altitude scale	about 60 km
Composition	nitrogen with admixtures of methane and carbon monoxide

It turned out to be more than 17° inclined to the ecliptic and significantly elongated. The average distance between Pluto and the Sun is 39.53 AU (5.913 billion km). But due to the large value of the eccentricity of the orbit (0.249), the distance to the Sun varies from 29.66 AU at perihelion to almost 49.31 AU at aphelion (4.437-7.376 billion km). The intensity of illumination differs by a factor of 2.8. This leads to a change in the temperature on its surface from 33K to almost 60K [22, 24]. The period of Pluto's rotation around the Sun is about 248 years.

It last passed the place of perihelion on September 5, 1989, and at this time it began to move away from the Sun [6]. Pluto's motion along its orbit is quite chaotic and is described by highly nonlinear equations. Therefore, it can only be predicted a few million years back or forward. And this can be noticed only after fairly long observations of it. The typical time for the development of such changes for Pluto is about 10-20 million years [6].

If observations are made over shorter periods of time, its movements will seem to be almost regularly periodic along an elliptical orbit. Although in reality, Pluto's orbit shifts slightly with each revolution, and over time it changes significantly from the initial movements.

Therefore, predicting Pluto's movements for more distant moments in time is quite difficult [10, 32]. Pluto is in a 3:2 orbital resonance with the giant planet [7, 13, 20] Neptune. That is, Pluto periodically approaches Neptune [30]. In each such cycle, when Pluto passes through perihelion, Neptune is 50° behind Pluto; and when Pluto passes perihelion a second time, Neptune will have already made one and a half revolutions around the Sun and will be at about the same distance, but already in front of Pluto. And when Neptune and Pluto will be on the same line with the Sun and on the

same side of it, Pluto will be at aphelion. Thus, for part of its orbit, Pluto is even closer to the Sun [18, 22-24] than Neptune (Fig. 2). The last time this happened was from 02/07/1979 to 02/11/1999. Calculations have shown that before that, Pluto occupied the same position for 14 years from 07/11/1735 to 09/15/1749.

Due to the rather large inclination of Pluto's orbit to the plane of the ecliptic, it does not intersect with the orbit of Neptune. After all, passing the perihelion point, Pluto is at a distance of 10 AU above the plane of the ecliptic. For this reason, Pluto cannot approach the planet Neptune closer than 17 AU. But Pluto can approach Uranus by almost 11 AU [10, 32].

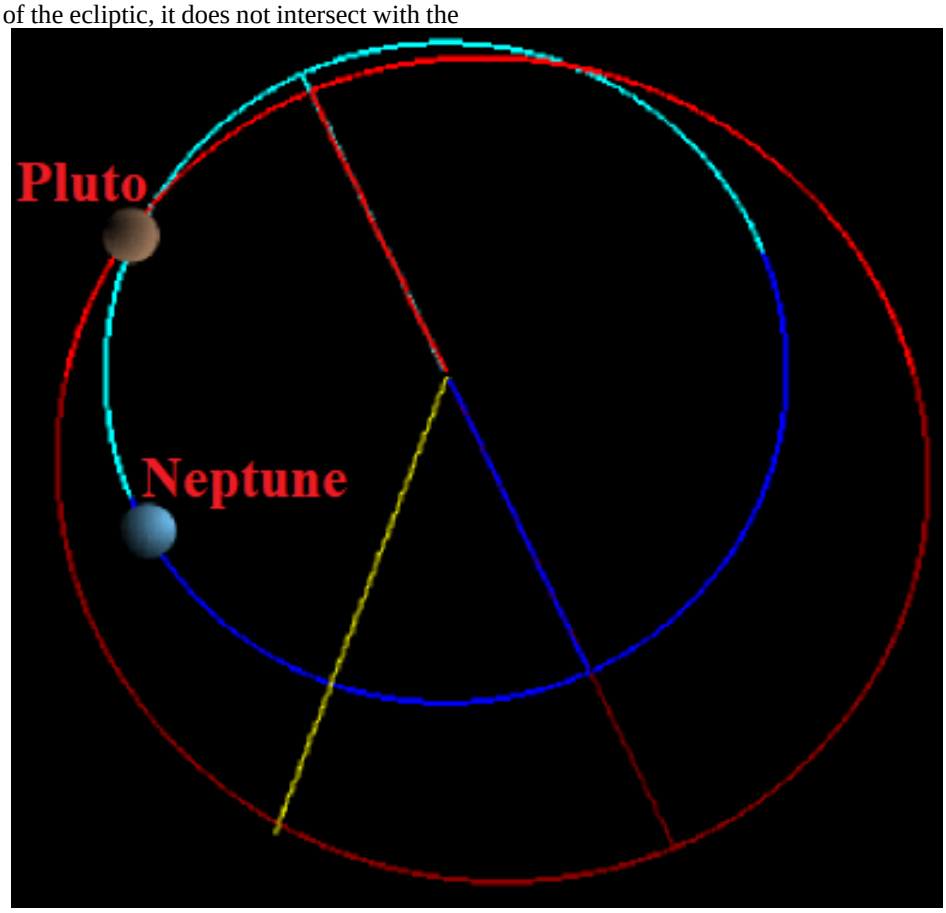

Fig. 2. The scheme of the intersection of the orbits of Pluto and Neptune (https://static.wixstatic.com/media/195ad9_30ec8c1b35374b28999628e7d7f4f8bd~mv2.png).

Such an orbital resonance between Neptune and Pluto is very stable and persists for millions of years [30, 31]. It is believed that Pluto acquired a resonance with Neptune over billions of years of numerous approaches, and this changed its orbit. However, it turned out that in addition to the 3:2 orbital resonance, several other resonances and influences [11, 17, 19, 21] are of great importance, which are also reflected in certain features of their relative motion and additionally stabilize the features of Pluto's orbit.

The argument of the perihelion of Pluto is close to 90° [31]. It is this value that provides a significant distance both to the plane of the ecliptic and to the nearby giant planets during the passage of perihelion. All this together allows avoiding the rapprochement of Pluto with Neptune. This is a direct consequence of the so-called Kozai effect [30], which compares the values of the eccentricity and inclination of Pluto's orbit relative to a more massive body, which, in this case, is Neptune. The moments when the angular difference between the inclination of Pluto’s perihelion and Neptune’s orbit is the smallest occur approximately every 10,000 years [1]. The longitudes of the ascending nodes for the orbits of these two planetary bodies (i.e., the points at which they cross the ecliptic plane) are in resonance with the aforementioned oscillations. If these two longitudes coincide, then the perihelion point of Pluto’s orbit will make an angle of 90° with the ecliptic (Fig. 3). At such moments, Pluto will be in a 1:1 super resonance above the plane of Neptune’s orbit and will be furthest away from it [30]. The full cycle is completed in approximately 20,000 years [1, 6].

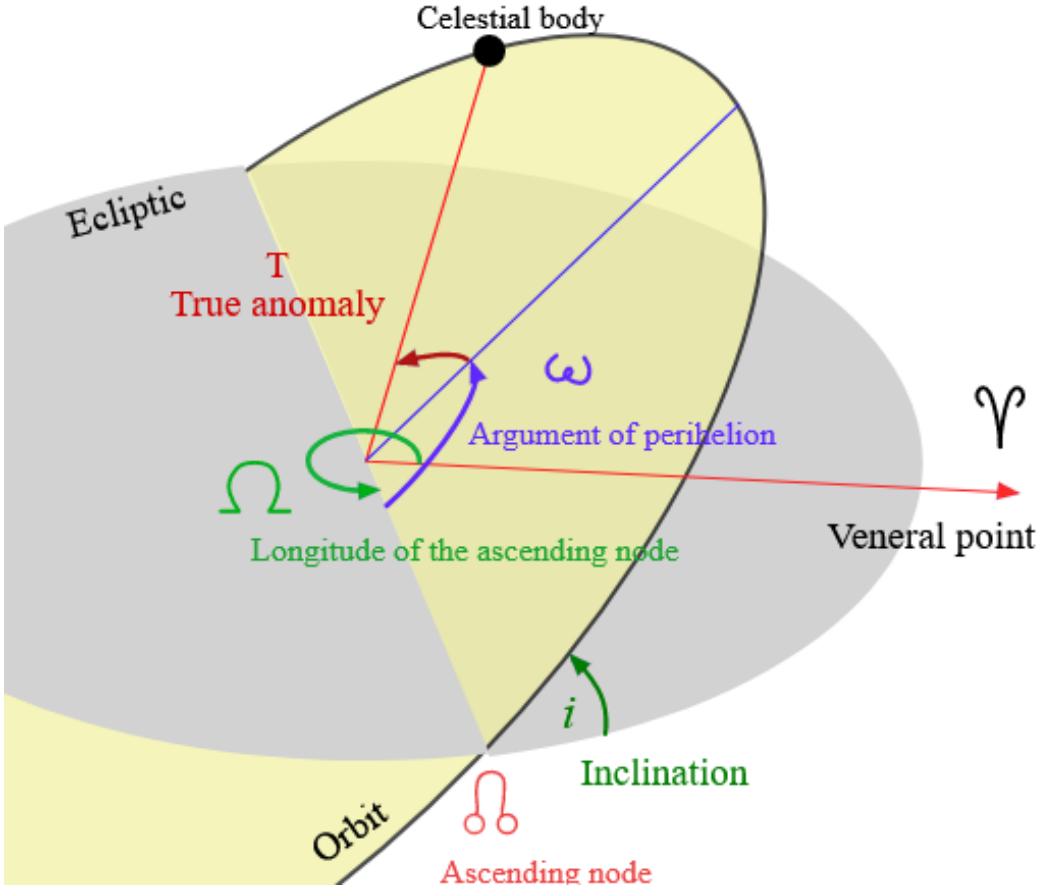

Fig. 3. Kepler orbital elements relative to the main plane (https://upload.wikimedia.org/wikipedia/commons/0/01/Orbit.svg).

The period of rotation of Pluto around its own axis is 6.387 Earth days. The same value is equal to the period of rotation of Charon around Pluto and around its axis. For this reason, Pluto and Charon are always turned with the same side to each other. They are the largest bodies in the Solar System with mutual synchronous rotation [3]. This phenomenon was used as a natural point for starting longitudes. That is, the zero meridian on Pluto passes through the center of the hemisphere facing Charon [2, 16].

The system of bodies “Pluto – Charon” [4] is distinguished by the fact that due to the large mass of the satellite Charon, their center of mass is located outside the limits for both bodies. Therefore, they are sometimes called a double planet [8].

Pluto's axis of rotation is oriented relative to the orbital plane in much the same way as Uranus'. Its inclination exceeds 122°. Therefore, Pluto also practically "lies on its side" and rotates around its axis in the opposite direction to most planets. The last equinox for Pluto occurred on December 16, 1987 [5]. And the solstice will occur in the late 2020s [5]. Thus, the equinox on Pluto now almost coincides with the moment of passing the perihelion of the orbit.

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TWO SPECIAL GRAPHS FOR δ-B-OPEN SETS

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ABSTRACT

We introduce the concepts δ-b-closed graphs and contra δ-b-closed graphs for δb-open sets and obtain some properties of them.

Keywords: δb-open sets, δ-b-closed graphs, contra δ-b-closed graphs, contra δ-b-continuous functions.

1. INTRODUCTION

Some various of sets is important in topological spaces as they are studied desely. Several topologists introduced and studied types generalizations properties and conditions containing them in topological spaces. In this paper, we introduce two special graphs related to δb-open sets and investigate some properties of them.

In this study, spaces (Y,ξ) and (Z,ω) (briefly, Y and Z) always state topological spaces without any separation axiom. If $S\subseteq Y$, closure and interior of S in X are indicated by Cl(S) and Int(S) respectively. Since the concept of regular open sets is important several in branches of mathematics, recall it. A subset S is called be regular open if S=Int(Cl(S)). Similarly, a subset S is called be regular closed[11] if (Y-S) is a regular open. In other words, a subset S is regular closed[11] iff S= Cl(Int(S)). The δ-interior of a subset S of Y is the union of all regular op. sets of Y contained S and it is indicated by δ-Int(S). S is called δ-open[12] iff S=δ-Int(S). In other words, S is called δ-open iff for each $y\in S$, there exists a regular open set R so that $y\in R\subseteq S$. Besides, δ-open sets in Y forms a topology ξ_δ so that $\xi_\delta\subseteq\xi$ and the regular open sets of Y form a base for ξ_δ. The δ- closure of a subset S of Y is the intersection of all regular closed sets of Y containing S and it is indicated by δ-Cl(S). S is called δ-closed[12] iff S=δ-Cl(S).

As a sequel, we need the next definitions and knowledges.

Definition 1.1. A subset S of a space (Y,ξ) is called

(1) z-open[4] (or δb-open[3]) if $S\subseteq Cl(\delta\text{-}Int(S))\cup Int(Cl(S))$,

(2) δ-semi-open[9] if $S\subseteq Cl(\delta\text{-}Int(S))$,

(3) preopen[6] if $S\subseteq Int(Cl(S))$,

(4) α-open[7] if $S\subseteq Int(Cl(Int(S)))$.

Remark 1.2. The next diagram holds for a subset S of a space Y. Each one of the converses of these implications isn't true in general. One can find the in related papers.

Regular open → δ-open → δ-semi-open → δb-open
↓ ↑
open → α-open → preopen

Diagram

The δ-interior of a subset S of Y is the union of all δb-open sets of Y contained S and it is indicated by δ-b-Int(S). The complement of a δb-open set is called δb-closed. The δ-b-closure of a subset S of Y is the intersection of all δb-closed sets of Y containing S and it is indicated by δb-Cl(S)([5]). The family of all δb-open subsets containing a point $y\in Y$ is denoted by δBO(Y,y). The arbitrary union of any family of δb-open sets in Y is a δb-open set.([4])

Definition 1.3. A space (Y,ξ) is called

(1) Urysohn[10] if for each $y_1, y_2\in Y$ with $y_1\neq y_2$, there exist open sets U and V so that $y_1\in U$, $y_2\in V$ and $Cl(U)\cap Cl(V)=\emptyset$.

(2) δ-b-T_1[5] if for each $y_1, y_2\in Y$ with $y_1\neq y_2$, there exist δb-open sets U and V so that $y_1\in U$, $y_2\in V$, $y_1\notin V$, $y_2\notin U$.

(3) δ-b-T_2[5] if for each $y_1, y_2\in Y$ with $y_1\neq y_2$, there exist δb-open sets U and V so that $y_1\in U$, $y_2\in V$ and $U\cap V=\emptyset$.

Definition 1.4. A mapping $f:(Y,\xi)\to(Z,\omega)$ is called

(1) δb-continuous[4] if $f^{-1}(V)$ is δb-open in Y for every open sets V of Z.

(2) δb-open[5] if f (U) is δb-open in Z for every open sets U of Y.

2. CHARACTERIZATIONS δ-B-CLOSED AND CONTRA δ-B-CLOSED GRAPHS

Firstly, it is well known that the subset $\{(y,f(y))|\ y\in Y\}\subseteq Y\times Z$ for a mapping $f:(Y,\xi)\to(Z,\omega)$ is called the graph of f and is denoted via G_f.

Definition 2.1. The graph G_f of a mapping $f:(Y,\xi)\to(Z,\omega)$ is said to be

(1) δ-b-closed if for each $(y,z)\in[(Y\times Z)-G_f]$, there exist δ-b-op. set $A\subseteq Y$ and open set $B\subseteq Z$ such that $y\in A$, $z\in B$ and $(A\times B)\cap G_f=\emptyset$.

(2) contra δ-b-closed if for each $(y,z)\in[(Y\times Z)-G_f]$, there exist δ-b-op. set $A\subseteq Y$ and closed set $B\subseteq Z$ such that $y\in A$, $z\in B$ and $(A\times B)\cap G_f=\emptyset$.

Proposition 2.2. Let $f:(Y,\xi)\to(Z,\omega)$ be a map. Then the graph Gf of f is δ-b-closed in $(Y\times Z)$ iff for each $(y,z)\in[(Y\times Z)-G_f]$ there exist $A\in\delta BO(Y,y)$ and $B\in\varphi$ $(z\in B)$ such that $f(A)\cap B=\emptyset$.

Proof. We must prove that $f(A)\cap B=\emptyset$ iff $(A\times B)\cap G_f=\emptyset$. Assume that $(A\times B)\cap G_f\neq\emptyset$. Then there exist $(y,z)\in(Y\times Z)$ such that $(y,z)\in(A\times B)$, $z\neq f(y)$ and $(y,z)\in G_f$. Therefore, one can obtain $f(y)\in f(A)$ from $y\in A$. In this state; since $f(y)\in f(A)$ and $z\in B$, $f(A)\cap B\neq\emptyset$.

Proposition 2.3. The graph G_f of a mapping $f:(Y,\xi)\to(Z,\omega)$ is contra δ-b-closed in $(Y\times Z)$ iff for each $(y,z)\in[(Y\times Z)-G_f]$ there exist $A\in\delta BO(Y,y)$ and

$B\in\omega^t(z\in B)$ such that $f(A)\cap B=\varnothing$ (ω^t denotes the family all closed sets in (Z,ω).).

Proof. This proof is similar to that of Proposition 2.2.

Theorem 2.4. If $f:(Y,\xi)\to(Z,\omega)$ is contra δ-b-continuous and (Z,ω) is Urysohn space, then G_f is contra δ-b-closed in $(Y\times Z)$.

Proof. Suppose that $(y,z)\in[(Y\times Z)-G_f]$. Then, according to definition of graph map, $z\neq f(y)$ and since (Z,ω) is Urysohn space, there exist open sets $F,G\subseteq Y$ such that $f(x)\in F$, $y\in G$ and $Cl(F)\cap Cl(G)=\varnothing$. Besides since f is contra δ-b-continuous, there exist $A\in\delta BO(Y,y)$ where $f(A)\subseteq Cl(F)$. This implies that $f(A)\cap Cl(G)=\varnothing$. Then by using Proposition 2.3, G_f is contra δ-b-closed in $(Y\times Z)$.

Theorem 2.5. If $f:(Y,\xi)\to(Z,\omega)$ is δ-b-continuous and (Z,ω) is T_1-space, then G_f is contra δ-b-closed in $(Y\times Z)$.

Proof. Let $(y,z)\in[(Y\times Z)-G_f]$. Hence $z\neq f(y)$ and since (Z,ω) is T_1-space, there exist $B\in\omega$ such that $f(y)\in B$ and $z\notin B$. Besides, since f is δ-b-continuous, of course there exist $A\in\delta BO(Y,y)$ such that $f(A)\subseteq B$. Therefore, we have $f(A)\cap(Z-B)=\varnothing$ and $B\in\omega^t(z\in B)$. Finally, one obtains that G_f is contra δ-b-closed in $(Y\times Z)$ via Proposition 2.3.

Lemma 2.6. ([5]) Let (Y,ξ) be a topological space and A,B be two subsets of X. If $A\in\delta BO(Y)$ and $B\in\delta BO(Y)$, then $(A\cap B)\in\delta BO(Y)$.

Theorem 2.7. Let f, $g:(Y,\xi)\to(Z,\omega)$ be functions and (Z,ω) is Urysohn space. If f is contra δ-b-continuous and g is contra super continuous, then $A=\{y\in Y:f(y)=g(y)\}$ is δ-b-closed in Y.

Proof. Let $y\notin A$. It is obvious that $f(y)\neq g(y)$. Since (Z,ω) is Urysohn space, there exist open sets $U,V\subseteq Z$ such that $f(y)\in U$, $g(y)\in V$ and $Cl(U)\cap Cl(V)=\varnothing$. Also f is contra δ-b-continuous and g is contra super continuous then $f^{-1}(Cl(U))$ is a δ-b-open sets and $g^{-1}(Cl(V))$ is a δ-open in Y, respectively. Take $M=f^{-1}(Cl(U))$ and $N=g^{-1}(Cl(V))$, then M and N are subsets of Y containing y. Set $K=M\cap N$, then K is δ-b-open sets in Y according to Lemma 2.6. Therefore, we have $f(K)\cap g(K)=f(M\cap N)\cap g(M\cap N)\subseteq f(M)$. Consequently, we have $A\cap K=\varnothing$ and thus $y\notin\delta b\text{-}cl(A)$. Hence, $\delta b\text{-}cl(A)\subseteq A$. This shows that A is δ-b-closed in Y.

Theorem 2.8. Let $f:(Y,\xi)\to(Z,\omega)$ is a surjective which has δ-b-closed graph function. Then, (Z,ω) is T_1-space.

Proof. Assume that $z_1, z_2\in Z$ when $z_1\neq z_2$. Since f is a surjective function, there exists an $y_1\in Y$ so that $f(y_1)=z_1$ and $f(y_1)\neq z_2$. Hence $(y_1,z_2)\notin G_f$ and so via Proposition 2.2, there exist $A_1\in\delta BO(Y,y_1)$ and $B_1\in\omega(z_2\in B_1)$ so that $f(A_1)\cap B_1=\varnothing$. Then $z_1\in f(A_1)$, but $z_1\notin B_1$. In similar way, there exists a $y_2\in X$ so that $f(y_2)=z_2$ and $f(y_2)\neq z_1$. Then, $(y_2,z_1)\notin G_f$ and using Proposition 2.2, there exist $A_2\in\delta BO(Y,y_2)$ and $B_2\in\omega(z_1\in B_1)$ so that $f(A_2)\cap B_2=\varnothing$. Hence $z_2\in f(A_2)$ but $z_2\notin B_2$. Therefore, $B_1\in\omega(z_2\in B_1)$ and $B_2\in\omega(z_1\in B_2)$ but $z_1\notin B_1$ and $z_2\notin B_2$. This shows that (Z,ω) is T_1-space.

Theorem 2.9. If $f:(Y,\xi)\to(Z,\omega)$ is δ-b-open and surjective function and G_f is δ-b-closed graph, then (Z,ω) is δ-b-T_2-space.

Proof. Let $z_1, z_2\in Y$ when $z_1\neq z_2$. Since f is a surjective function, there exists an $y_1\in Y$ so that $f(y_1)=z_1$ and $f(y_1)\neq z_2$. Hence $(y_1,z_2)\notin G_f$ and then there exist $A\in\delta BO(Y,y_1)$ and $B\in\omega(z\in B)$ so that $f(A)\cap B=\varnothing$ by utilizing Proposition 3.2. Since f is δ-b-open function, $f(A)$ is δ-b-open set containing z_1. According to Diagram, B is a δ-b-open set containing z_2. Hence, (Z,ω) is δ-b-T_2-space.

3. FUNDAMENTAL PROPERTIES OF STRONGLY CONTRA δ-b-CLOSED GRAPHS

In this part, we introduce another class of graphs, namely, strongly contra δ-b-closed graphs and investigate various properties concerning of such this class of generalized graphs.

Definition 3.1.([2]) The graph G_f of a function $f:(Y,\xi)\to(Z,\omega)$ will be termed δ-b-strongly closed if for each $(y,z)\in[(Y\times Z)-G_f]$, there exist $A\in\delta BO(Y,y)$ and $B\in\omega(z\in B)$ such that $(A\times Cl(B))\cap G_f=\varnothing$.

Regarding the strongly contra δ-b-closed graph, we can the following lemma.

Lemma 3.2. The graph G_f of a function $f:(Y,\xi)\to(Z,\omega)$ is strongly contra δ-b-closed in $Y\times Z$ if for each $(y,z)\in[(Y\times Z)-G_f]$, there exist $A\in\delta BO(Y,y)$ and $B\subseteq Z$ is regular closed$(z\in B)$ such that $f(A)\cap B=\varnothing$.

Definition 3.3.([2]) A function $f:(Y,\xi)\to(Z,\omega)$ will be termed weakly δ-b-continuous if each $y\in Y$ and for each open set B of Z containing $f(y)$, there exist $A\in\delta BO(Y,y)$ such that $f(A)\subseteq Cl(B)$.

Theorem 3.4. Let $f:(Y,\xi)\to(Z,\omega)$ is weakly δ-b-continuous function and (Z,ω) is Urysohn space, then G_f is δ-b-strongly closed.

Proof. Let $(y,z)\in[(Y\times Z)-G_f]$. According to definition of G_f, $z\neq f(y)$. Since (Z,ω) is Urysohn, there exist open sets $U,V\subseteq Z$ such that $f(y)\in U$, $z\in V$ and $Cl(U)\cap Cl(V)=\varnothing$. Besides since f is weakly δ-b-continuous, there exists $A\in\delta BO(Y,y)$ so that $f(A)\subseteq Cl(U)$ and $f(A)\cap Cl(V)=f(A)\cap Cl(Int(V))=\varnothing$ is a regular closed set in Z. Consequently, using Lemma 3.2, obtained that G_f is δ-b-strongly closed.

Definition 3.5. ([8]) A function $f:(Y,\xi)\to(Z,\omega)$ will be termed almost δ-b-continuous if $f^{-1}(B)$ is δ-b-open set in Y for every regular open set B of Z.

Lemma 3.6. ([8]) A function $f:(Y,\xi)\to(Z,\omega)$ is almost δ-b-continuous iff each $y\in Y$ and for each regular open set B of Z containing $f(y)$, there exist $A\in\delta BO(Y,y)$ such that $f(A)\subseteq B$.

Theorem 3.7. If $f:(Y,\xi)\to(Z,\omega)$ is almost δ-b-continuous and (Z,ω) is T_2-space, then G_f is δ-b-strongly closed in $(Y\times Z)$.

Proof. Consider $(y,z)\in[(Y\times Z)-G_f]$. Thus $z\neq f(y)$. Since (Z,ω) is T_2-space; there exist open sets $U,V\subseteq Z$ such that $f(y)\in U$, $z\in V$ and $U\cap V=\varnothing$. This is equivalent to $Cl(U)\cap Int(Cl(V))=\varnothing$. Besides, since f is almost δ-b-continuous and V is regular open, then there exists $W\in\delta BO(Y,y)$ so that $f(W)\subseteq V\subseteq Int(Cl(V))$ via Lemma

3.6. This implies that $f(W)\cap Cl(U)=\varnothing$ and consequently by using Lemma 3.2, we obtain G_f is strongly contra δ-b-closed in (Y×Z).

To obtain next two theorems, now we give a definition which is related to δ-b-closed set and characterizations of this notion.

Definition 3.8. A function $f:(Y,\xi)\to(Z,\omega)$ will be termed contra δ-b-continuous if $f^{-1}(B)$ is δ-b-closed set in Y for every open set B of Z.

The next theorem can be obtained by using the same technique of the similar result involving δb-continuity.

Theorem 3.9. For a function $f:(Y,\xi)\to(Z,\omega)$, the following properties are equivalent:

(1) f is contra δ-b-continuous;

(2) For every closed subset C of Z, $f^{-1}(C)$ is δ-open set in Y;

(3) For each $y\in Y$ and each closed subset C of Z containing $f(y)$, there exists $B\in\delta BO(Y,y)$ such that $f(B)\subseteq C$.

Theorem 3.10. If G_f is contra δ-b-continuous, then $f:(Y,\xi)\to(Z,\omega)$ is contra δ-b-continuous.

Proof. Consider U is an open set of Z, then Y×U is an open set of Y×Z. According to hypothesis G_f is contra δ-b-continuous, we have $f^{-1}(U)=g^{-1}(Y\times U)$ is δ-b-closed in Y. Therefore, f is contra δ-b-continuous.

Definition 3.11. ([1]) A function $f:(Y,\xi)\to(Z,\omega)$ is called contra-super-continuous if for each $y\in Y$ and each closed subset C of Z containing $f(y)$, there exists $B\in\delta BO(Y,y)$ such that $f(B)\subseteq C$.

Definition 3.12. A subset A of a space (Y,ξ) will be termed a δ-b-dense in Y if $\delta b\text{-}c(A)=Y$.

Theorem 3.13. Let $f,g:(Y,\xi)\to(Z,\omega)$ be any two functions, (Z,ω) be an Urysohn space and $B\subseteq Y$ be a δ-b-dense set. If f is contra δ-b-continuous and g is contra super continuous, $f=g$ on B, then $f=g$ on X.

Proof. Since f is contra δ-b-continuous, g is contra super continuous and (Z,ω) is Urysohn; we have $A=\{y\in Y: f(y)=g(y)\}$ is δ-b-closed in Y according to Theorem 2.6. By hypothesis, $f=g$ on B, $B\subseteq A$. Besides, B is δ-b-dense set in (Y,ξ) we get $Y=\delta b\text{-}Cl(B)\subseteq\delta b\text{-}Cl(A)=A$. This shows that $f=g$ on Y.

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TECHNICAL SCIENCES

FENTON-TYPE HETEROGENEOUS OXIDATION OF PAPER MILL EFFLUENT IN BATCH AND CONTINUOUS REACTORS

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ABSTRACT

The application of heterogeneous Fenton-type systems was studied, using an industrial paper mill effluent and a model solution of sodium acetate. The reaction was investigated in a batch and a fixed bed reactor, at 70 °C. Different copper-based catalytic materials were supported on commercial spheres of gamma alumina. Besides, Zn, Fe, and Ce-containing catalysts were prepared and preliminarily tested for the acetate peroxidation, with comparative purposes. All the catalysts were calcined at 900 °C to improve the anchorage of active species on the support. For the experiments performed with acetate solution in the batch system with Cu^{2+}/Al_2O_3 catalyst (C1 and C2), the TOC conversions were approximately 20%. With the industrial effluent, the TOC conversions were close to 45%, with leaching levels below 0.1 ppm Cu. In the continuous system, TOC reductions of the effluent were 20-30% after 4 h of operation. The decolorization degrees and oxidant consumptions were complete and the estimated reductions in aromatics content were near 70% (SUVA 254 nm), with a COD reduction of ca. 40%. The impact of two reaction parameters (oxidant concentration and residence time) was investigated, with a slightly positive effect.

Keywords: Heterogeneous Fenton, CuO/Al2O3, paper mill effluent, fixed bed reactor.

1. Introduction

Advanced Oxidation Processes (AOP) have been the subject of increasing research since the key work of Glaze et al., in 1987 [1]. The AOP group diverse techniques that take advantage of the high oxidation potential of hydroxyl radicals (HO•). These radicals can react with a large variety of pollutants, as arises from numerous studies and reviews in the field [2-12]. On this basis, the AOP are set as processes of choice for degrading recalcitrant contaminants [8]. Among catalytic AOP, Fenton oxidation processes combine simplicity and effectiveness, using available reactants (Fe^{2+} and H_2O_2) that are also easy to handle and environmentally benign. Classical Fenton oxidation has been widely investigated for the treatment of different wastewater streams, like paper mill effluents [13-17], and it was proposed as a "green" option for sludge conditioning and treatment [18]. More recent adaptations of the reaction system use heterogeneous species to activate the formation of HO• [10-11,19-20]; solid catalysts are preferred as they can be recovered by simple separation and reused [8]. Besides, selecting adequate catalytic material allows for overcoming some main drawbacks of Fenton oxidation, such as the narrow range of acidic pH requirements and the excessive sludge generation [11]. Most heterogeneous Fenton studies dealt with iron-based catalysts; however, other cations with multiple redox states (e.g., copper, cerium, chromium, ruthenium, cobalt) might directly decompose H_2O_2 into HO• through conventional Fenton-type pathways [7,21,22]. Non-ferrous systems have shown interesting results through a broader range of operational conditions [7-8]. It should be remarked that the hydrogen peroxide activation mechanism shows a specific dependence on the nature of the catalyst and its composition. In previous work, a summary of copper catalysts used for the degradation of recalcitrant organics was presented [22-24] evaluating different reaction parameters for the CuO/Al_2O_3-H_2O_2 batch oxidation of effluents from the industrial alkaline sulfite treatment of wood (chemomechanical pulping). As these processes do not have a chemical recovery system, spent liquors are generally discharged into the receiving body. The wastewaters from the paper industry have a complex variety of chemical species, and several of its components are refractory to typical microbiological degradation and require more suitable technologies, as they are difficult to treat or to accomplish before discharge. Among the existing technologies, there are different AOP under study, such as ozonation, photocatalysis, classic Fenton, and heterogeneous Fenton-type oxidation [3-4,25-26].

To the present, there are a limited number of publications dealing with non-irradiated heterogeneous Fenton-like oxidation of industrial effluents (pulp bleaching, olive mill, pharmaceutical, textile, and tannery wastewater), mainly summarized in these reviews [20, 27-30]. Even fewer are the recent studies that applicated copper-based catalysts for the continuous peroxidation of model pollutants [31-33]. Suraj et al. [34], synthesized a copper ferrite catalyst (using a co-precipitation method) and studied the oxidation of a pulp and paper effluent in a fixed bed laboratory scale reactor. The influence of process variables such as pH, concentration of H_2O_2, bed height and reaction time was optimized by analyzing statistical parameters. After 2 h of reaction time, about 78% chemical oxygen demand removal was achieved, with improved parameters. Catalyst reusability and stability was evaluated for four consecutive runs; the concentrations of Fe and Cu in treating effluent were below discharge limits.

The applicability of alumina supported catalysts in the peroxidation of wastewaters from the chemomechanical processing of biomass has been incipiently ex-

plored in batch reactors, with promising results. Covinich et al. [22] studied different homemade catalysts based on CuO, Fe_2O_3, NiO, and ZnO, supported on gamma-Al_2O_3 pellets (2.5 mm), for the catalytic oxidation of an industrial pulping effluent. The investigated variables were the hydrogen peroxide concentration, the catalyst loading, active species, and the reaction temperature. The best performance was registered using a CuO/Al_2O_3 system (chemical oxygen demand and total organic carbon reduction were between 40 and 50%, aromatic fraction reduction was >80% and the decolorization was 90%). In a further work, these authors [24] used CuO/Al_2O_3 pellets (1.8 mm), to conduct a kinetic study for the heterogeneous Fenton-type oxidation of mixed recalcitrant compounds in a real industrial effluent from the alkaline sulfite treatment of wood. TOC reductions near 50% were measured at 80 ºC, using a lab-scale batch reaction system.

Based on this background, we set out to explore the application of CuO/Al_2O_3 catalysts at different operation conditions, to reduce the organic loading of effluent from the processing of biomass, using a fixed-bed continuous reactor. This offers a pathway towards more practical industrial application. In order to improve the anchorage of active species onto the solid support, a high calcination temperature was selected, according to di Luca et al. [35]. In the first instance, some preliminary batch-mode experiments were performed, using different active species impregnated over alumina spheres. From these results, further experiments were carried out to test the selected catalyst under continuous operation in a fixed bed reactor.

2. Material and Methods

2.1. Reagents

The reagents used for the catalysts preparation were commercial spheres of gamma alumina (particle diameter=2.5 mm, Axens), $Cu(NO_3)_2 \cdot 2.5H_2O$ (p.a., Cicarelli), $Ce(NO_3)_3$ (Sigma Aldrich, pa) $Zn(SO_4) \cdot 7H_2O$ (Riedel-de Haën, pa), citrate Fe(III) (BioPack, pa). For the catalytic tests and analytical determinations $NaCH_3COO$ (p.a., Cicarelli), H_2O_2 (p.a., Cicarelli, 30%) and bidistilled water were used.

2.2. Preparation of the Cu^{2+}/Al_2O3 catalysts

Two different catalysts were prepared, using the commercial spheres of gamma Al_2O_3 as support. The impregnation solution consisted in cupric nitrate dissolved in bidistilled water. For catalyst C1, only one step of impregnation was used, followed by drying at 100 °C (12 h) and calcination in a muffle at 900 °C for 2 h (heating rate: 15 °C/min, under air atmosphere). In the case of the sample named C2, a similar amount of copper ions was loaded onto the support, but a two-step impregnation procedure was used. First, a certain mass of γAl_2O_3 was left in contact with an aqueous solution containing half the total amount of Cu^{2+}. The wet solid was dried and calcined (at the same conditions than C1). Then, a second impregnation procedure was performed, with its subsequent drying and calcination stages.

In both catalyst samples the final copper content was similar, near 2% wt. of Cu species (2.5% wt. as CuO).

For comparative purposes, a third copper catalyst was prepared. The procedure was a one-step impregnation similar than for C1, but with twice the total copper content. This sample was named C1-4%.

2.3. Preparation of other catalyst systems

With the purpose of testing the behavior of a variety of active ions in the peroxidation of acetate species, the impregnation method was used to prepare different catalysts. The procedure was similar to the one described for catalyst C1. The samples obtained were: catalyst Fe_2O_3 (2.5%$Fe_2O_3/\gamma Al_2O_3$); catalyst ZnO (2.5% $ZnO/\gamma Al_2O_3$); catalyst CuO-Fe_2O_3 (1.25%CuO-1.25%$Fe_2O_3/\gamma Al_2O_3$); catalyst CuO-CeO_2 (1.25%CuO-1.25%$CeO_2/\gamma Al_2O_3$).

Two commercial catalysts were also included in this series of experiments. Catalyst “Engelhard” (ENGELHARD Cu0226S, 12.5% CuO-0.32% NiO) and catalyst “Topsoe” (TOPSOE LK821, 52% CuO-2% ZnO).

2.4. Catalytst Characterization techniques

The catalysts C1 and C2 were characterized by means of different techniques:

X-Ray Diffraction (XRD). The presence of different crystalline phases was determined using a PANalytical X‟Pert Pro diffractometer, using CuKα radiation (1,54056Å) and graphite monochromator at 40 kV and 40 mA (scanning speed: 0,02º/seg).

Scanning Electron Microscopy (SEM). The surface morphology of the samples was determined using a Philips SEM 505, equipped with a EDAX DX APOLLO X probe to quantify Cu and Al surface contents.

Nitrogen physisorption. The measurement of particle surface areas and pore sizes were carried out by N_2 adsorption/desorption isotherm analysis at 77 K, using a Micromeritics Gemini 2380 equipment. The catalysts were ground and degassed at 150 °C (12 h).

Zero Charge Point (PZC). The pH value for zero charge of the solids was determined by the rapid titration method described by Mahmood et al. [36].

Copper content determination. The solid samples were mineralized using concentrated HNO_3, and a colorimetric method was used using CuVer ® reagent (HACH).

2.5. Reaction experiments

Two different target solutions were used. One is a liquor obtained from “Papel Prensa S.A” (San Pedro, Argentina), characterized elsewhere [22]. The effluent was a black liquor from the chemomechanical pulping; it was diluted (1:50), and the resultant initial COD and TOC were 931 and 433 mg/L, respectively; total dissolved solids were 1.2 g/L and sodium acetate content was 0.65 g/L. One of the major organic components of the effluent matrix is the acetate ion. So, parallel experiments were performed using a sodium acetate solution (1 g/L) as synthetic effluent, for the sake of comparison.

Batch reactor experiments. A PYREX glass batch reactor of 250 mL was used; it was equipped with a glass stopper, a condenser, a thermocouple, and a pH-meter. An agitation speed of 1000 rpm was selected to avoid mass transfer limitations. The experiments were performed at atmospheric pressure and 70 °C. The experimental set up was detailed in a previous work [22].

Heterogeneous experiments were conducted using catalyst spheres (5 g/L) in a reaction volume of 100 mL. Through all the catalytic tests, after the solution reached the desired temperature, the mass of catalyst sample was incorporated. Then the corresponding amount of oxidant agent was added (0.67- 1 mL; H_2O_2 30%) to get an initial concentration of 0.12-0.24 mol/L. The addition of hydrogen peroxide was taken as the start of the reaction (t =0 min). The experiments lasted 4 hours.

Fixed Bed Reactor experiments. A lab-scale fixed bed reactor (FBR) was also used, with an experimental setup similar to the one reported by [35]. The reactor consisted of a glass jacketed column (Internal diameter: 3 cm) operated at 70 °C. The catalyst load (25 g) was packed between inert glass spheres. The feed solution was pumped to the column in up-flow mode and the total flow rate was Qliq = 2.5-5.0 mL/min. The oxidant initial dosage was adjusted between 0.12-0.18 mol/L.

The residence times of the liquid phase in the packed-bed reactor were calculated according to Martinez et al. [37].

Analytical methods. For both reaction systems, liquid samples were taken at adequate time intervals. The remaining concentration of oxidant was analyzed, pH, UV-VIS spectrum, and Total Organic Carbon (TOC) were determined (on filtered samples). For selected runs, also Chemical Oxygen Demand (COD) was quantified.

At least three reaction experiments were carried out for each catalytic experiment. For the reported results, the coefficients of variation were in the range <4%.

H_2O_2 concentration was analyzed via standard iodometric titration, using KI and $Na_2S_2O_3$ 0.1 mol/L. TOC values were obtained using a TOC Analyzer (Shimadzu, TOC-VCPN model). The initial carbon mass (or mass $TOC_{initial}$) was measured from a sample obtained prior H_2O_2 addition. COD was measured following the technique described in American Standard Test Methods [38]. Specific UV absorbance (SUVA) is defined as the UV absorbance of a water sample at a given wavelength normalized for dissolved organic carbon concentration. $SUVA_{254}$ values were obtained by dividing the UV absorbance (A) at λ = 254 nm by the organic carbon concentration (mg/L) [39]. Decolorization was also determined from visible absorbance measurements at 465 nm (Shimadzu Spectrophotometer).

3. Results and discussion

3.1. Characterization of the fresh Cu^{2+}/Al_2O_3 catalysts

By means of SEM analysis, irregular surface morphologies were detected, with comparable characteristics to the alumina support. For both C1 and C2 catalysts, active copper species were concentrated at the more external zones. For catalyst C2, the two successive impregnation-calcination steps gave rise to a more homogeneous distribution through the cross-section of the spheres (Fig. 1). EDAX results are the average from five measurements and confirmed the different active species distributions that could also be detected by visual examination of the samples. These results were consistent with the global Cu% determined by acid dissolution and colorimetric tests. Copper accumulation on the surface is expected due to the preparation procedure and the physical properties of the support (such as particle diameter, and density). A more prolonged thermal treatment could probably give samples with a more homogeneous concentration of copper cations on the support matrix; however, more direct and economical alternatives are studied at this stage.

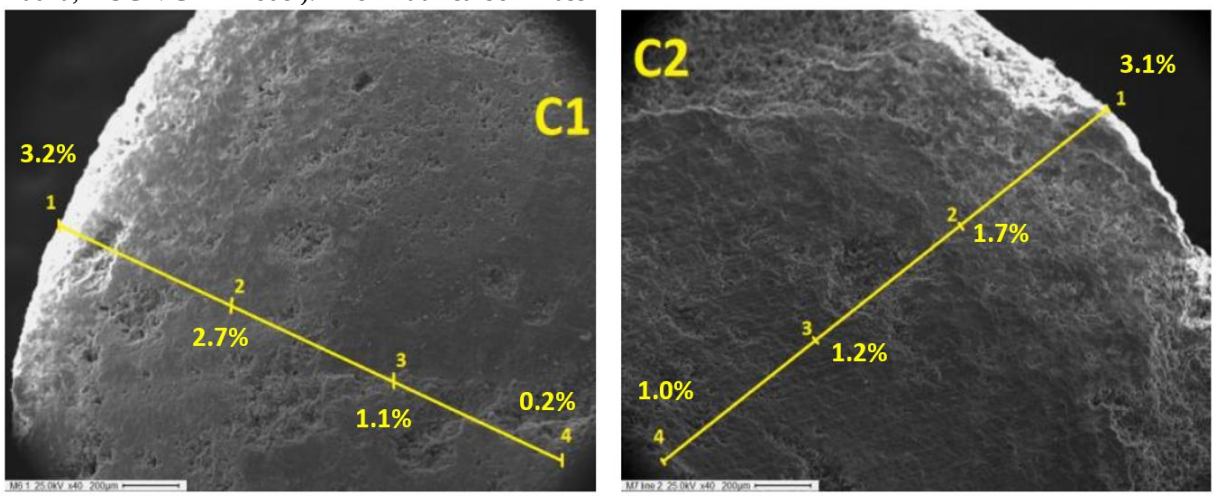

Figure 1. SEM images of the cross section of fresh catalysts C1 and C2. For the positions 1-4 of the spheres cross-sections, the average Cu % wt. (EDAX) is shown.

No significant differences were observed between the XRD patterns of the catalysts and the alumina support (Figure 2). The comparison of the diffractograms for as-received and calcined gamma-Al_2O_3 was also included. Due to the low copper content incorporated and the relatively high surface area of the samples, it was expected that neither CuO nor cupric aluminate phases were segregated. From these observations, it could be assumed that copper species are well-dispersed onto the alumina [40]. Alpha alumina characteristic peaks were not observed; when detected, the presence of alpha alumina could be indicating an anticipated transition of gamma phase, promoted by the presence of Cu ions [41].

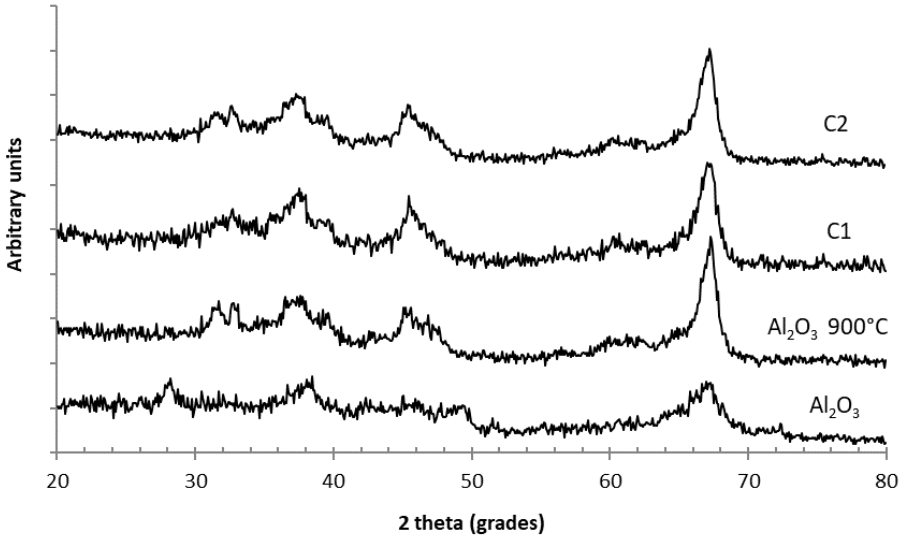

Figure 2. XRD patterns for fresh catalyst2 C1 and C2, γAl2O3 (as-received); γAl2O3 calcined at 900 °C

The results obtained by N_2 physisorption are summarized in Table 1. The reduction in surface area and pore volume of the catalysts is consistent with the thermal treatment of the samples. The pore size distribution corresponded to mesoporous materials (the average pore size was near 15 nm for the catalysts and the calcined alumina). Catalyst C1 and alumina calcined at 900 °C showed similar results; no significant changes were induced by the presence of copper ions in the support. This correlates with the previous mentions of cupric species being well-dispersed or incorporated in the framework of the alumina [42]. Stronger interactions between the active phase and the support promote the structural stability of the catalyst. In the case of catalyst C2, the surface area and pore volume reductions seem even more pronounced as two successive calcination steps at a high temperature were carried out.

Table 1.

Summary of characterization results for the support and fresh catalysts C1 and C2

Sample	Cu content (% wt.)	BET Surface area (m^2/g)	Pore volume (cm^3/g)	PZC (pH)
γAl_2O_3	-	214	0.36	7.8
γAl_2O_3 a 900°C	-	94	0.34	8.2
C1	2.0%	92	0.33	9.0
C2	2.1%	82	0.27	9.1

Table 1 also shows the pH determinations of the zero charge points. The catalysts registered PZC values that are above the circumneutral pH at which the reaction processes take place. Different authors have reported [43] that the efficiency of the oxidation process under these reaction conditions is strongly affected by the PZC of the catalyst and the pKa of the contaminants studied. Below the PZC, the catalyst surface tends to be positively charged, favoring the interaction with anionic species in an aqueous solution, such as those investigated in the present study.

3.2. Reaction results

Batch reactor. Initial experiments were performed to investigate the peroxidation of model acetate solution. Figure 3 summarizes the final TOC and H_2O_2 conversions in the batch reactor system at 70 °C. Different active phases were explored (Cu^{2+}, Fe^{+3}, Zn^{2+}, Ni^{2+} and combinations). It can be observed that only a slight fraction of acetate ions (20% or below) could be mineralized by these Fenton-type systems, under mild conditions. Copper-based catalysts (selected from a previous work, [22]) could exhibited better performances than iron or zinc-based materials, as reported by different authors [7, 42]. This behavior is strongly associated to the lower potential of the Cu^{2+}/Cu^{+} couple and the higher hydroxyl radical formation rates.

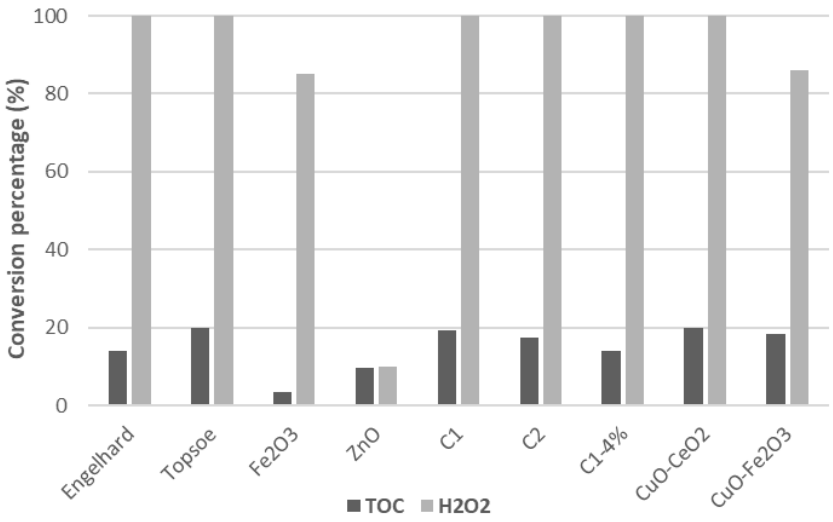

Figure 3. Sodium acetate degradation exploratory tests: TOC and hydrogen peroxide conversion percentages (after 4 h of reaction time), using different catalysts. Experimental conditions: [acetate]$_0$=1g/L; [H_2O_2]$_0$= 0.12 mol/L; 5 g catalyst/L; 70 °C.

Short-chained organic acids exhibited good biodegradability in water. However, they affect the acidic properties of the aqueous medium and are refractory during chemical oxidation processes. Thus, they are frequently responsible of TOC abatement limitations of the wastewaters. These characteristics keep the organic compounds such as acetate, out of the sight of advanced oxidation studies. Acetate ions are one of the most refractory and a main component of the organic loading of the black liquor. Thus, it was selected as target compound to conduct preliminary/comparative peroxidation studies.

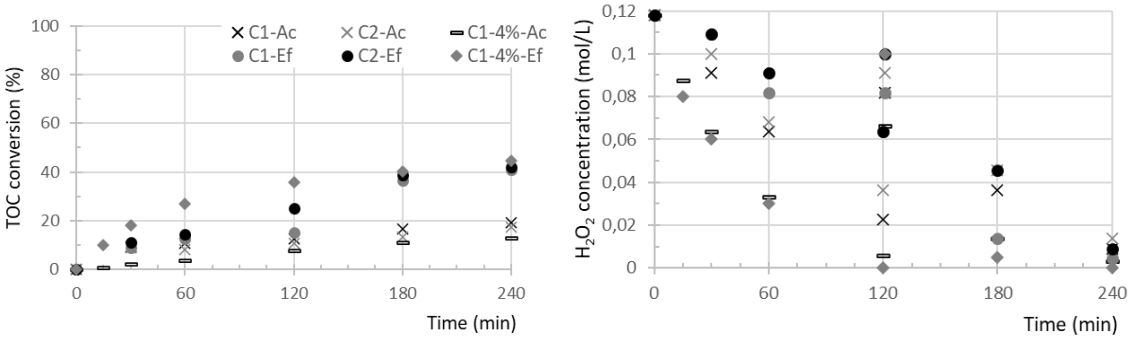

Figure 4. a) TOC conversion and b) remnant H_2O_2 concentration for batch experiments performed with C1, C2 and C1-4% catalysts ("Ac", corresponds to sodium acetate solution, and "Ef", to the diluted black liquor). Experimental conditions: [H_2O_2]$_0$= 0.12 mol/L; 5 g catalyst/L; 70 °C.

Figure 4 exhibits reaction results (TOC conversion and remnant H_2O_2 concentration) for the batch experiments, using sodium acetate and the industrial effluent. Table 2 summarized final TOC and H_2O_2 conversion, and pH values (after 4 h of reaction).

Table 2.

Reaction results after 4 h of reaction time in the batch reactor at 70 °C. Between parentheses, COD final percentage conversions.

Catalyst Sample	Target solution	TOC conversion (%)	H_2O_2 conversion (%)	pH
γAl_2O_3 900°C	NaCH3COO	3	<1	8.0
C1	NaCH3COO	17	96	7.1
C2	NaCH3COO	19	95	7.2
C1-4%	NaCH3COO	13	100	7.8
γAl_2O_3 900°C	Industrial effluent	5	3	8.5
C1	Industrial effluent	41(48)	97	7.4
C2	Industrial effluent	43(49)	97	7.2
C1-4%	Industrial effluent	44(51)	100	8.1

As observed in Figure 4 b), there is an anomalous behavior in the profile of H_2O_2 consumption. Due to the high ratio of H_2O_2 decomposition for both catalysts C1 and C2, and additional dose of hydrogen peroxide was added to the system at 120 min. This addition corresponded to half of the total initial amount of oxidizing agent (the reaction volume was not significatively modified). The procedure allows the oxidation to continue, preventing the reaction from being stopped by depletion of the oxidant.

Some authors have estimated the H_2O_2 consumption efficiency [33-42] for peroxidation reactions. For the experiments reported in Figure 4, the efficiency was 7-10% (after 4 h of reaction), mainly due to the low TOC conversion levels. As previously mentioned, the activity of the copper species towards H_2O_2 decomposition was high, and complete consumption of the initial oxidant dose (after approximately 150 min) was registered (the remnant concentration of H_2O_2 after 4 h of reaction was <5% of the total two-step addition). However, from these observations, it is likely that an important amount of the added H_2O_2 participates in parasitic reactions, not only through HO• radicals formation [5,35]. This aspect is reported as one of the drawbacks of the application of copper-based heterogeneous Fenton-type systems, as more H_2O_2 is required to obtain high pollutant abatement (molecular oxygen disturbs the redox cycle, and part of the oxidant is lost during the process) [10]. However, as the high rate of oxidant decomposition promotes a complete depletion of the H_2O_2, the resultant solution does not need further destruction of the oxidant excess to be accomplished for discharge or subsequent treatment stages.

For catalyst C1-4%, a higher concentration of copper ions on the catalyst surface occurred (4.8% wt. Cu, according to average EDAX results), that also induced higher consumption rates of H_2O_2 (Fig. 5). Though, no marked increased in the TOC conversion were determined for catalyst C1-4%, compared to C1 and C2. Different causes might be considered: high consumption of oxidant through secondary reactions, rapid scavenging of HO• radicals, and/or less dispersed Cu species, that left relatively fewer active sites for the pollutant's oxidation [5, 32].

Blank experiments were also performed, in order to evaluate the incidence of adsorption processes (in the absence of H_2O_2 oxidant, using C1 or Al_2O_3 support). Negligible variations in TOC determinations were registered. The conversion of acetate in the presence of H_2O_2 without catalyst was also insignificant (<1%).

Low leaching levels of copper ions (< 0,1 ppm) were confirmed during all the batch experiments. According to pH measurements, circumneutral conditions were maintained during the oxidation process, minimizing the solubilization of copper species. However, leaching could be also promoted by the presence of organic complexing agents. Based on the negligible concentration of copper ions in the final solution, a reinforced catalyst stability is confirmed, probably due to the good anchorage/strong interaction of copper ions in the support framework (promoted by the thermal treatment of the catalysts). Tentatively, four consecutive runs were performed reusing catalyst C1 in the presence of effluent (for a total of 16 hours). The conversions of TOC, H_2O_2, and the final pH of the reaction remained unchanged.

Although the liquor has a high initial loading of acetate ions (near 50% of the initial TOC could be associated to this species), the aqueous matrix contains other organic species that could be more easily oxidized than refractory acetate ions. Thus, as shown in Table 2, TOC conversions are higher for the industrial effluent. Complementary oxidation parameters of the wastewater were satisfactory: the black liquor was almost completely decolorized, 70% reduction of the aromatic fractions was registered, and 50% of COD removal after 4 h of reaction time. Regarding the H_2O_2 consumption, the time profile was comparable to that observed for model acetate solution. The initial dose of oxidant was completely consumed, and after 2 or 3 h of operation, an extra aliquot (+50%) of H_2O_2 was added. When the experiment finished, the remnant concentration of hydrogen peroxide was approximately 0.01 mol/L or lower.

So far, if the number of steps, the operation conditions and the reactants used during the treatment are to be taken into consideration, the experimental results seem promising, with a very positive respond to this non-irradiated Fenton-type oxidation process. Compared with previous results in batch mode, at 70 °C [22], similar conversion levels were reached in the present study. It should be noted that the prior adjustment

of optimized conditions might be now affected by the changes in the catalytic system. Although gamma alumina spheres were used in both works, the two supports have different textural properties. Frequently, throughout the scale-up, heterogeneous catalytic materials must be modified, as we pass from studies with powdered solids to studies with supported or pelletized systems. This process affects the physicochemical properties of the catalysts and their performances.

Fixed bed reactor. According to the results obtained using the batch reactor, no significant differences were found between C1 and C2 catalysts. Due to the simplicity of the one step impregnation method, the following experiments in the continuous operation mode, were performed only with catalyst C1.

Figure 5 shows the temporal TOC conversion profiles for a typical experiment using the model acetate solution and the industrial effluent (for the latter, H_2O_2 conversion, $SUVA_{254}$ percentage reduction and pH were also presented). Based on preliminary tests, a final time of 240 min was selected for each run, in order to achieve pseudo steady-state conversions.

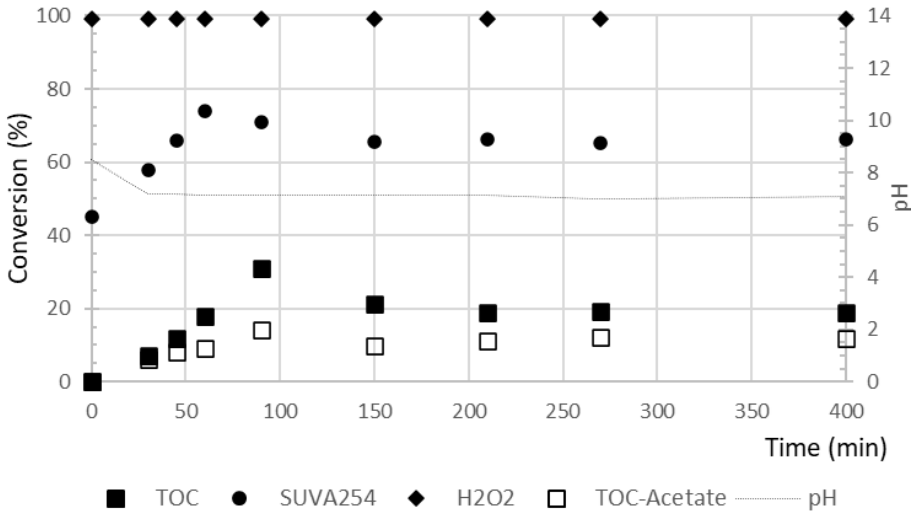

Figure 5. Conversion profiles vs time, in the FBR at 70 °C: TOC and H_2O_2 conversion, $SUVA_{254}$, pH evolution using the diluted black liquor (TOC conversion for the acetate solution was also shown). Experimental conditions: $[H_2O_2]_0$= 0.12 mol/L; Q_{liq}=2.5 mL/min; 70 °C.

For the experiments using acetate solution, the TOC conversions were between 10-18%, with complete depletion of the H_2O_2 during reaction (initial oxidant concentrations were between 0.12-0.24 mol/L). The impact of increasing the residence time and the oxidant dose was investigated, as summarized in Table 3. In the range of residence times tested, the impact of an increasing initial H_2O_2 concentration was minor. In general terms, very poor mineralization levels were achieved; however, both variables showed a positive effect on TOC conversions. The solid/liquid ratio in this reactor configuration could be responsible of an even more rapid H_2O_2 decomposition through the catalytic bed. Thus, the slower acetate oxidation reaction could not be significantly improved when higher oxidant concentrations were used. A similar behavior might be inferred for increased residence times: if the oxidant is promptly depleted, longer residence times would not favor the acetate oxidation performance.

Table 3.
Reaction results obtained at the FBR, at 70 °C, with catalyst C1 after 4 h of reaction. Between parentheses, COD final percentage conversions.

Target solution	Qliq (mL/min)	T min	$[H_2O_2]_0$ (mol/L)	TOC conversion (%)	Aromatics reduction (%)
$NaCH_3COO$	5	1,6	0.18	13	-
$NaCH_3COO$	5	1,6	0.12	10	-
$NaCH_3COO$	2.5	3,3	0.24	17	-
$NaCH_3COO$	2.5	3,3	0.12	10	-
Industrial effluent	5	1.6	0.18	19 (35)	67
Industrial effluent	5	1.6	0.12	15 (31)	62
Industrial effluent	2.5	3.3	0.18	21(39)	68
Industrial effluent	2.5	3.3	0.12	19 (34)	66

When the black liquor was used as target solution, the TOC conversions were in the range of 15-21%. TOC reduction levels were markedly lower than those reached during batch experiments. This is a common observation when these two types of reaction systems are compared, due to their distinctive features (e.g., solid/liquid ratio, contact time between phases) [35].

FBR are attractive configurations that allow accelerating the oxidation of the organics and increases the treated volume of effluent by using shorter contact times. The main advantages over stirred-tank reactors are the well specified residence time, and fixed catalyst bed, which avoids separation of the solid catalyst and mechanical degradation. In our case, the higher solid/liquid ratio in the FBR, lead to relatively higher reduction in the aromatic fraction, estimated from $SUVA_{254}$. That is, with almost half of the "mineralization" conversions, the continuous process could give similar aromatics degradation than the batch mode. COD was also determined for some selected experiments with the industrial effluent, reaching near 40% of reduction. Complete decolorization was also obtained.

At constant residence time, a slightly positive effect of higher initial H_2O_2 dose was observed for the results obtained using the FBR. The changes in the reactor configuration parameters and residence time induce an increase in the conversion levels.

The maximum leached concentration of copper ions was far below the limit in Argentine legislation (1 ppm): 0.05 ppm for the experiments with higher initial concentration of H_2O_2 and 0.01 ppm for the experiments performed with 0.12 mol/L of H_2O_2.

The results obtained are satisfactory, so it is expected to advance the investigations to adjust the operative conditions to improve the levels of pollutants degradation, through simple and cost-effective strategies, with reduced environmental impact. The results support the hypothesis of the feasibility of the application of these treatment systems, as preliminary findings. The optimized operation conditions are not yet accomplished and must be adjusted. During the peroxidation process, the organic loading of the effluent was reduced, and the resultant parameters show good chances for further biological treatment. Toxicity tests and biodegradability tests are required to complete the final system characterization.

4. Conclusions

The use of Cu^{2+}/Al_2O_3 catalysts in a heterogeneous Fenton process effectively reduced the organic load and aromatic content of industrial paper mill effluent, both in batch and fixed bed reactor configurations. The thermal treatment of catalytic materials allowed a good retention of active Cu species, reducing its leaching. The continuous reactor experiments highlight the possibility of treating larger effluent volumes, with a 70% removal of the aromatic content. The catalyst showed good stability and reusability in preliminary experiments. Further research will focus on optimizing process parameters and exploring the long-term stability of the system, as well as the costs and biodegradability of the final solutions, as this is a key parameter when a continuous industrial application is envisioned.

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ИННОВАЦИОННАЯ ПЛАНЕТАРНАЯ КОРОБКА ПЕРЕДАЧ С УЛУЧШЕННОЙ КОНСТРУКЦИЕЙ И ФУНКЦИОНАЛЬНОСТЬЮ

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INNOVATIVE PLANETARY GEARBOX WITH ENHANCED DESIGN AND FUNCTIONALITY

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АННОТАЦИЯ

В статье представлена усовершенствованная конструкция планетарной коробки передач, разработанная для трансмиссий транспортных средств. Предложенная конструкция включает инновационные элементы управления: два тормоза и две муфты, а также переключающее устройство, соединённое с валом и центральным колесом. Эти проработки обеспечивают расширение диапазона передаточных чисел и увеличивают надёжность. Система управления обеспечивает плавное и эффективное переключение, оптимизируя работу трансмиссии и её долговечность.

ABSTRACT

The article presents an improved design of a planetary gearbox for vehicle transmissions. The proposed design features innovative control components, such as two controlled brakes and clutches, alongside a switching device connected to the main shaft and central gear with internal teeth. These enhancements expand gear ratios while simplifying the construction and increasing reliability. A control system ensures smooth and efficient gear shifting, optimizing performance and durability. The innovation represents a significant step forward in planetary gearbox development.

Ключевые слова: планетарная коробка передач, инновационный дизайн, трансмиссия транспортных средств, передаточные числа, надежность, экономичность.

Keywords: planetary gearbox, innovative design, vehicle transmission, gear ratios, reliability, efficiency.

Введение:

Планетарные коробки передач традиционно применяются в различных типах транспортных средств благодаря их способности обеспечивать плавное и эффективное распределение крутящего момента. Однако с увеличением требований к скорости, надежности и универсальности трансмиссий возникла необходимость в усовершенствовании этих механизмов. Новая планетарная коробка передач, представленная в данном исследовании, направлена на решение этих задач, сочетая упрощенную конструкцию с широким диапазоном передаточных чисел.

Разработка включает несколько ключевых элементов, которые обеспечивают её преимущества:

1. Входной и выходной валы, соединенные с основным механизмом, позволяют передавать крутящий момент на колеса автомобиля.

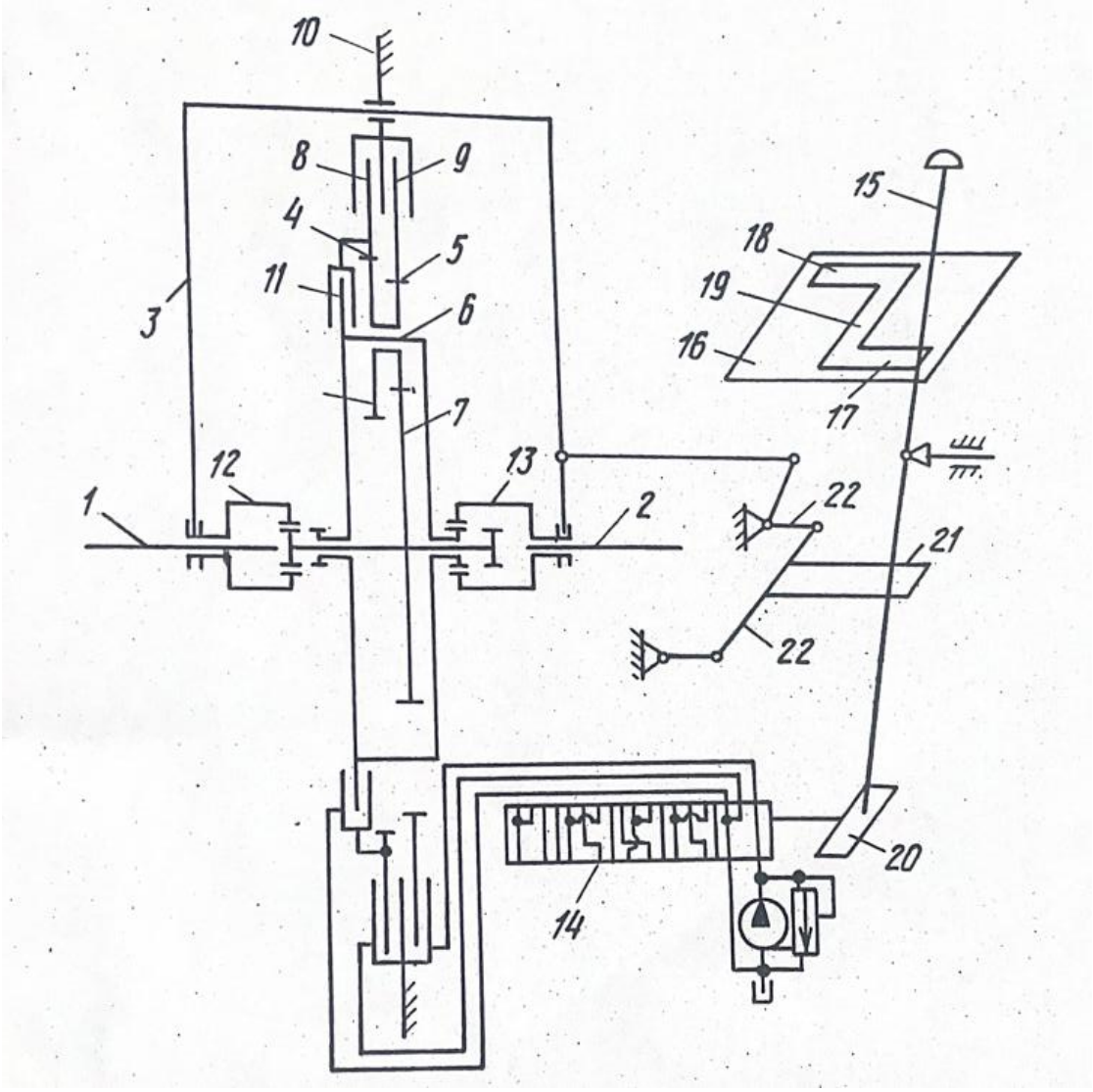
2. Планетарный механизм с двумя коронными шестернями: наружной с зубьями и внутренней, связанной с центральным колесом, что позволяет распределять крутящий момент с минимальными потерями.

3. Водило и солнечная шестерня, работающие в синхронной связке с центральным колесом, что обеспечивает плавное переключение передач.

4. Три фрикционных устройства, которые отвечают за переключение передач, создавая сцепление между различными элементами механизма.

5. Два управляемых тормоза и две управляемые муфты, обеспечивающие необходимую гибкость управления и возможность плавного перехода между передачами.

6. Переключающее устройство, расположенное между основным валом и центральным колесом, что повышает надежность и управляемость коробки передач.



Схема, приведенная в описании изобретения, иллюстрирует ключевые компоненты и их взаимосвязь в разработанной планетарной коробке передач. Разберем её более детально, чтобы понять, как взаимодействуют основные элементы конструкции и какую роль выполняет каждый из них.

Описание элементов схемы и их функций

1. Входной вал (1) — это главный элемент, через который подается крутящий момент от двигателя к коробке передач. Входной вал соединен с муфтами и другими элементами, которые распределяют усилие на планетарный механизм.

2. Выходной вал (2) — элемент, через который передается крутящий момент от коробки передач к колесам или другим системам транспортного средства. Схема демонстрирует, как выходной вал может переключаться между различными передаточными числами для достижения нужного крутящего момента и скорости.

3. Планетарный механизм (3) — это центральная часть коробки передач, содержащая солнечную шестерню, планетарные шестерни и водило. Планетарный механизм обеспечивает передачу крутящего момента и управление переключением передач, что позволяет достигать высокого диапазона скоростей и моментов.

4. Коронная шестерня с наружными зубьями (4) и внутренними зубьями (5) — коронные шестерни являются неотъемлемой частью планетарного механизма. Коронные шестерни взаимодействуют с планетарными шестернями и водилом, обеспечивая распределение крутящего момента в зависимости от выбранной передачи.

5. Фрикционные устройства (6, 7, 8) — данные элементы служат для переключения передач. Они обеспечивают сцепление между различными компонентами коробки передач и позволяют эффективно управлять передаточным числом. Фрикционные устройства включаются и выключаются в зависимости от желаемой передачи, контролируя движение вала и других элементов.

6. Тормоза (9, 10) — два управляемых тормоза на схеме отвечают за остановку или замедление определенных элементов коробки передач для изменения передаточного числа. Они играют ключевую роль в управлении коробкой, так как их использование позволяет изменять направление и величину передаваемого момента.

7. Муфты (11, 12) — управляемые муфты соединяют или разъединяют различные элементы ме-

ханизма, позволяя включать или отключать передачи. Муфты работают в паре с тормозами, обеспечивая плавное и бесшумное переключение передач.

8. Распределитель управления (13) — это устройство контролирует, какой из тормозов или муфт будет задействован в зависимости от выбранной передачи. Распределитель связывает органы управления коробкой с фрикционными элементами, выполняя команды переключения.

9. Переключающее устройство (14) — ключевой элемент для перехода между различными передаточными числами. Оно соединено с основным валом и центральным колесом, позволяя менять направление вращения и выбирать подходящее передаточное отношение.

10. Рычаг управления (15) — элемент управления, позволяющий водителю или системе выбрать нужную передачу. Рычаг посылает команды распределителю, активируя нужные тормоза и муфты для переключения на необходимую передачу.

Принцип работы по схеме:

Схема показывает, как крутящий момент проходит через входной вал, распределяется на планетарный механизм и управляется с помощью тормозов и муфт. Каждая передача определяется включением и выключением различных фрикционных устройств, что позволяет гибко управлять скоростью вращения и крутящим моментом на выходном валу. Переключение между передачами обеспечивается распределителем, который направляет сигналы на муфты и тормоза, активируя нужные элементы в зависимости от заданных условий.

Некоторые плюсы:

Надежность. Система крайне редко выходит из строя, по оценкам специалистов планетарная трансмиссия не нуждается в ремонте как минимум 400 – 500 тыс. км пробега. Ломаться там фактически нечему: основные компоненты трансмиссии – это шестерни и валы.

Компактность. Небольшие размеры механизма позволяют устанавливать планетарную трансмиссию в любые автомобили – от минивэнов до ультракомпактных кей–каров, а возможность использования большого количества планетарных механизмов – повысить динамику автомобилей.

Высокий КПД. Такая трансмиссия обеспечивает работу ДВС и электромотора с максимальной отдачей. Если традиционные ступенчатые КПП, «автоматы» и вариаторы с 4 –6 ступенями имеют ограниченный диапазон регулирования передач (как правило, в пределах от 4 до 5,5, данный показатель демонстрирует, на сколько первая передача отличается от самой высокой), то у планетарной трансмиссии это число варьируется в пределах 10–15. Это значит, что двигатель при минимуме «оборотов» выдает максимум Нм.

При работе коробки передач обеспечивается пять передач, что позволяет достигать различных скоростей вращения выходного вала при постоянной скорости входного вала.

- Первая передача активируется путем соединения входного вала с центральным колесом через муфту.

- Переход на вторую передачу осуществляется за счет включения дополнительного механизма управления и активации распределителя, соединяющего водило с центральным колесом.

- Третья и последующие передачи обеспечиваются сложным взаимодействием всех элементов системы, включая блокировку одного из планетарных механизмов для изменения передаточного числа.

Ключевым аспектом работы данной коробки является эффективное управление тормозами и муфтами. Управление осуществляется с использованием распределителя, который позволяет выбирать нужную передачу, активируя или блокируя определенные элементы коробки передач. Это способствует повышению плавности переключений и уменьшению износа фрикционных элементов.

1. Широкий диапазон передаточных чисел позволяет использовать коробку передач в различных условиях эксплуатации, начиная от низких скоростей при старте до высоких скоростей при движении по трассе.

2. Повышенная надежность обеспечивается благодаря использованию двух управляемых муфт и тормозов, что минимизирует вероятность поломки и необходимость частого обслуживания.

3. Снижение сложностей производства и обслуживания, благодаря продуманной конструкции, включающей минимальное количество подвижных элементов при сохранении высокой функциональности.

4. Оптимизация работы трансмиссии, достигаемая за счет плавного переключения передач и эффективного распределения крутящего момента между выходными элементами.

Представленная коробка передач может найти широкое применение в автомобилях различных классов, включая легковые автомобили, грузовики и автобусы. Благодаря возможности адаптации конструкции под разные типы транспортных средств, она может стать основой для разработки новых поколений трансмиссий, обладающих высокой экономичностью и надежностью.

Разработка новой конструкции планетарной коробки передач была вызвана необходимостью повышения надежности и долговечности трансмиссионных систем, особенно для транспортных средств, работающих в условиях интенсивных нагрузок. Традиционные планетарные коробки передач, как правило, включают множество фрикционных элементов, таких как муфты и тормоза, что усложняет конструкцию, увеличивает износ и снижает КПД за счет внутренних потерь.

Преимуществом разработанного решения является снижение количества фрикционных деталей и повышение устойчивости к износу, что было достигнуто благодаря изменению кинематической схемы. В новой конструкции применяются два управляемых тормоза и две управляемые муфты, соединенные с центральными колесами с внутренними и внешними зубьями, что позволило уменьшить количество механических соединений, подверженных износу.

Основными требованиями при разработке конструкции были:

Повышение надежности. Меньшее количество подвижных частей способствует снижению риска поломки и упрощению обслуживания.

Снижение сложности конструкции. Применение оптимального числа передач позволило снизить вес и габариты коробки, что важно для улучшения энергоэффективности транспортных средств.

Экономичность производства. Простая кинематическая схема позволяет снизить производственные затраты за счет уменьшения количества дорогостоящих фрикционных компонентов.

В традиционных планетарных коробках передач нередко применяется два и более планетарных механизмов, что позволяет обеспечить широкий диапазон передаточных чисел, но при этом усложняет конструкцию и требует установки дополнительных фрикционных элементов. В разработанном изобретении использован один планетарный механизм с двумя коронными колесами, что позволяет значительно сократить объем необходимого обслуживания и повысить надежность системы в целом.

Кроме того, благодаря уменьшению числа звеньев в кинематической цепи, коробка передач стала легче и компактнее. Это особенно важно для транспортных средств, где каждый килограмм веса может влиять на расход топлива и маневренность.

Таким образом, выбранная конструкция планетарной коробки передач обеспечивает:

Снижение эксплуатационных затрат и повышение срока службы.

Увеличение надежности системы за счет уменьшения количества фрикционных элементов.

Возможность применения в тяжелых условиях эксплуатации без риска быстрой поломки.

Важным этапом проектирования коробки передач является выбор передаточных чисел для каждой передачи. Передаточные числа были определены таким образом, чтобы обеспечить оптимальный баланс между максимальным крутящим моментом на низких передачах и эффективностью работы на высоких передачах. Для этого использовался следующий подход:

Первая передача обеспечивает высокое передаточное число для увеличения крутящего момента, что необходимо для трогания с места и работы под нагрузкой.

Последующие передачи имеют уменьшенное передаточное число, что позволяет повысить скорость вращения выходного вала и снизить расход топлива на высоких скоростях.

Передаточные числа рассчитывались на основе кинематической схемы коробки и взаимного расположения шестерен, что позволило получить требуемое распределение скоростей.

Для оценки прочности и долговечности элементов коробки передач были рассчитаны максимальные нагрузки, которые могут возникнуть на каждом этапе передачи крутящего момента. Эти расчеты помогли определить критические элементы конструкции и подобрать оптимальные материалы для их изготовления. Основные этапы расчета включали:

Определение крутящего момента, передаваемого от входного вала к планетарному механизму.

Расчет нагрузок на коронные шестерни, центральное колесо и водило.

Оценку сил трения, действующих на фрикционные устройства, и их влияние на износ при длительной эксплуатации.

Для фрикционных элементов были выбраны высокопрочные материалы, устойчивые к трению и высокой температуре, чтобы обеспечить их долговечность. Прочностные расчеты показали, что выбранные параметры позволяют системе выдерживать длительные нагрузки без риска преждевременного износа.

После расчетов была проведена компьютерная симуляция работы коробки передач в различных условиях эксплуатации. В моделировании учитывались:

Влияние высоких и низких температур на рабочие характеристики коробки.

Поведение коробки при интенсивном ускорении и торможении.

Пиковые нагрузки при резких изменениях скорости.

Результаты моделирования подтвердили, что конструкция выдерживает высокие нагрузки, сохраняя стабильность работы. Симуляции показали, что фрикционные элементы и шестерни функционируют в оптимальном режиме, обеспечивая плавное переключение передач даже при резких перепадах нагрузки.

Заключение:

Планетарная коробка передач с улучшенной конструкцией представляет собой значительный шаг вперед в развитии трансмиссионных систем. Она сочетает в себе расширенные функциональные возможности, повышенную надежность и упрощение конструкции, что делает её конкурентоспособной на рынке современных автомобильных технологий.

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