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

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A NEW APPROACH TO THE DETERMINATION OF HYDROCONDUCTIVITY IN OIL PLATES AND A DEVICE FOR ITS PERFORMANCE

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ABSTRACT

In the article, the values of the formation permeability coefficient Kf are determined depending on the down hole pressure during well operation, the thickness of the formation and the viscosity of the oil, and a device that implements the results of this method is developed.
A trial selection of the petroleum liquid is carried out, it is subjected to separation from the accompanying water and gas, and the intensity of the infrared radiation falling and passing through the layer of separated oil is measured. The optical density of oil is calculated and the coefficient of permeability at the initial moment of time K0 of the optical density D is determined based on the exponential dependence, the absolute permeability Kfi is determined by the value of the coefficient of dynamic viscosity μn of oil, which characterizes the optical density Dx, after which the hydraulic conductivity of the layer is calculated. The results of the obtained calculations show that the proposed method really reflects the process of filtration in the oil layer.
Keywords: hydraulic conductivity of the oil layer, separated oil, infrared radiation, optical density of oil, permeability coefficient.

Introduction

There is a method for determining the hydraulic conductivity of an oil layer [1], which consists in the use of a non-linear law of filtration in the course of non-stationary redistribution of pressure in the layer and changes in the elastic reserve of the layer and fluid, which is connected with starting or stopping the well, changing the modes of its operation. At the same time, during unsteady filtration in the formation, the hydraulic conductivity coefficient changes with the change in the pressure gradient on the wall of the well and depression of the formation. In this case, the problem of determining the hydraulic conductivity of the formation (ГП) is solved according to the recovery curve of the down hole pressure to formation pressure (КВД) with the continued flow of liquid after its stop. The conditional size of the disturbed region of the layer from the stoppage of the well is determined depending on the logarithm of the function of the influence of the flow of liquid into the well on the propagation of the disturbance front in the layer, which has a polynomial form of the 6th degree. The disadvantage of this method is that it does not show how GP is determined by KVD.
The method of determining the hydraulic conductivity of the reservoir, given in the paper [2], includes stopping the well when the plunger of the rocker is in the lower position, tracking the recovery rate of the bottom hole pressure at equal intervals of time with an unstable filtration

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regime after stopping the well, constructing the curve of recovery of the bottom hole pressure to reservoir pressure in semilogarithmic coordinates, which is described by the following formula:

$$P_з(t) = P_k - (P_k - P_0)\exp(-(lnt)^{n+1}) \quad (1)$$

here P_{rk} is the pressure in the supply circuit of the plate.
The method allows you to determine ГП with high accuracy, but the main drawback of this method is that the well is stopped for a certain period of time (10-15 days) to determine ГП, which is inexpedient from a technical and economic point of view.
In work [3], to determine ГП, in which they measure the change in bottom hole pressure after stopping or starting a well, calculate the value of the formation permeability coefficient Kf depending on the bottom hole pressure during well operation, measure the thickness of the formation (h) and the viscosity of oil (μH), build the KVD in semilogarithmic coordinates and calculate the hydraulic conductivity of the oil layer according to the well-known formula

$$\xi = \frac{hK_ф}{\mu_H} \quad (2)$$

The use of this method is limited by the fact that in most cases, especially for low-flow wells, due to the limited capabilities of the mathematical apparatus for determining the hydrodynamic (filtration) characteristics of the reservoir by KVD, this method leads to significant errors in determining ГП. And, besides, the use of this method is also possible only when the well is stopped.

Problem statement

The purpose of the article is the development of a method for determining ГП in the normal (established) mode of operation of a well and the creation of a device that implements the proposed method.
In contrast to the known methods of determining the hydraulic conductivity of the reservoir, based on the study of wells in an unstable regime according to the pressure recovery curve, the method proposed by us is based on a new approach to the hydrodynamic study of an oil reservoir, according to which the permeability of an oil reservoir is determined under the influence of infrared radiation on oil and the dependence of the coefficient is revealed oil permeability and viscosity from its optical density, and hydraulic conductivity is determined taking into account the geometric characteristics of the injection and production wells.
According to this method, a trial selection of petroleum liquid is carried out in the container and its separation from accompanying water and gas occurs. The intensity of the incident infrared radiation J0 and the radiation J that passed through the vessel with oil is measured, the optical density D of the light-absorbing medium (oil) is calculated, and according to the well-known formula D=lg(J0/J), we construct a curve of the exponential dependence of the permeability coefficient from the initial moment of time K0 to the optical density D, by which we find the characteristic optical density Dx by the tangent method, determine the absolute permeability Kϕ and the dynamic viscosity μnneft according to the formulas

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$$K_{ф} = K_0 \exp\left(-\frac{D}{D_x}\right) \quad (3)$$

$$\mu_{н} = \alpha \exp(bD) \quad (4)$$

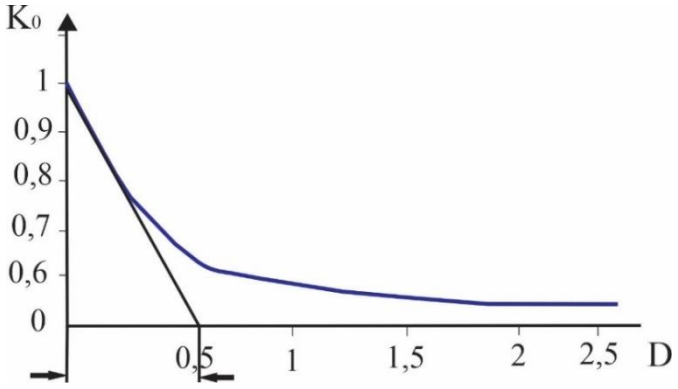

Figure 1. The curve of the exponential dependence of the permeability coefficient at the initial moment of time K0 on the optical density D

Taking into account the obtained values of the absolute permeability Kf and the dynamic viscosity μn of oil, as well as the measured values of the bottom hole pressures of the injection wells P_z^, we calculate the hydraulic conductivity of the reservoir according to the formula

$$\xi = \frac{c \cdot hK_0 \exp\left(-\frac{D}{D_x}\right)\frac{\Delta P}{l}}{\alpha \exp\,(bD)} \quad (5)$$

$$\Delta P = P_{з}^{н} - P_{з}^{д} \quad (6)$$

$$P_{з}^{н} = \rho_{в} g \left(H + \frac{1}{2}h\right) + P_{у}^{н} \quad (7)$$

$$P_{з}^{д} = \rho_{ж} g \mathrm{H}_{ж} + P_{у}^{д} \quad (8)$$

ΔP – pressure drop, defined as the difference between the bottom hole pressures of the injection well and production well, Pa; $P_{з}^{н}$, $P_{з}^{д}$ – respectively, bottom pressure of injection and production wells, Pa; $P_{у}^{н}$, $P_{у}^{д}$ – pressure at the mouth of the settled column (OK) injection and production wells, Pa; $\rho_{в}$, $\rho_{ж}$ – density of water and petroleum (plastic) fluid, kg/m^3; h, H – the height of the perforation zone and the height from the mouth to the perforation zone OK injection well, m; g – acceleration of free fall, kg/sec^2; l – the distance between the injection well and the production well.

Due to the fact that the proposed method is based on a completely new approach to the hydrodynamic study of an oil layer, which uses the revealed dependence of the coefficient of permeability

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and viscosity of oil on the optical density under the influence of infrared radiation on oil, there is a need to create a device that implements this method. A device with this purpose was created that contains a sampler located on the discharge line of the well, and a separator connected to it in order to separate the oil from the accompanying water and gas and a container for the separated oil. The source and receiver of infrared radiation are located on both sides of the oil tank, connected to infrared signal converters, the outputs of which are connected to the control and display unit.

1 – sampler; 2 – separator; 3 and 4 – respectively, the source and receiver of infrared radiation; 5 – capacity for oil; 6 and 6'- transformers; 7 - block of control and indication; 8 - ejection line; 9 - production well; 10, 11-line outlet, sensor and transducer for measuring the level of liquid in the mouths of the casing column (OK) production and injection wells, respectively; 14,15 - sensor and transducer for measuring the level of the liquid in the OK extraction and injection column, respectively; 16,18 - sensors and 17,19 - corresponding transducers for pressure measurement in the mouths of OK production and injection wells; 20 - pump.

The device works as follows. Petroleum liquid (oil - water) with gas from the discharge line 8 of the pump-compressor pipe of the production well 9 through the sampler 1 enters the separator 2, where the water and gas are separated and removed along the lines 10 and 11, and the separated oil from The separator is fed into container 5 to measure its optical density.

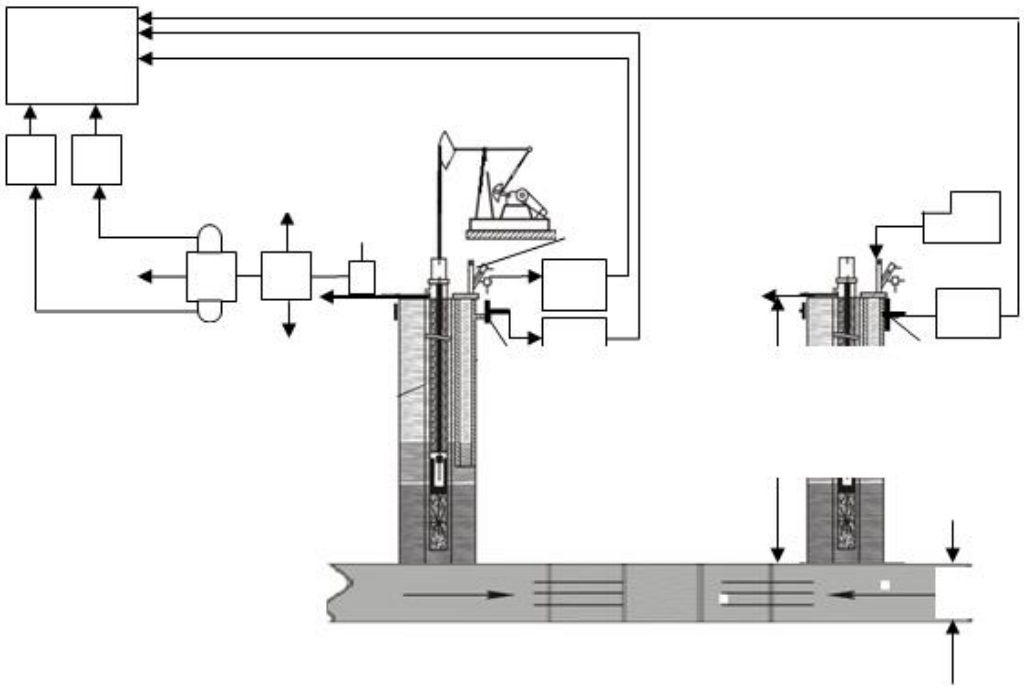

Figure 2. The basic block diagram of the proposed device.

To determine the pressure difference between the well bores of the production and injection wells, the pressures in the mouths are measured by sensors 16 and 18, with the corresponding converters 17 and 19, the outputs of which are connected to the control and indication unit (BUI), the liquid level in OA wells is measured by sensor 14 and converter 15. According to the known values of ρ_в,ρ_ж, h, H and g in BUI, the hydro-conductivity of the reservoir is determined by the measured and calculated parameters and displayed on the indicator. The advantages of the method

are that it allows measuring the hydraulic conductivity of the oil layer without stopping the well. The results of the obtained calculations show that the proposed method really reflects the process of filtration in the oil layer.

Declarations
The manuscript has not been submitted to any other journal or conference.

Study Limitations
There are no limitations that could affect the results of the study.

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The author would like to express gratitude to the care support workers and elderly individuals who participated in this study, sharing their invaluable insights and experiences. Their cooperation and openness have significantly contributed to the depth and richness of the research findings.

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APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN GAME THEORY

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ABSTRACT

This topic is an area of research related to the application of artificial intelligence methods in game theory. The aim of the research is to create effective algorithms and models to analyze various game scenarios and predict optimal decisions for players. To achieve this goal, various methods of machine learning are used, as well as algorithms for optimization and statistical analysis of data. The relevance of this topic is due to the increasing popularity and importance of games in our lives, as well as the possibility of applying the results in various fields such as economics, business, politics, etc. The study was conducted with the help of computer implementation, which allows us to test the algorithms on different game scenarios and evaluate their results. The results confirm the effectiveness of the developed methods and algorithms.
The conclusion of the work summarizes the results of the study and discusses possible directions for further work in this area. This work may be useful for specialists in the field of artificial intelligence and game theory, as well as for developers of game applications.
Keywords: Game Theory, Artificial Intelligence, reinforcement learning, Q-learning, deep learning, neural networks, decision-making algorithms, strategies.

Introduction

In recent decades, artificial intelligence has become increasingly popular in scientific and engineering circles. Significant developments in this area have led to new methods and algorithms that can be used to solve various problems in different fields. One area where artificial intelligence is widely used is game theory.
Games have always been an important part of our lives, be it chess, go, or video games. Game theory studies behavioral and decision-making strategies in situations where one player's choices depend on another player's choices. This field has applications in various fields such as economics, politics, sociology, biology, and others. With the development of technology, especially artificial intelligence, it has become possible to use it to improve game strategies and the behavior of artificial agents.
Currently, much research in this area is focused on the development of machine learning algorithms and the use of neural networks to analyze game scenarios. However, it must be kept in mind that the application of artificial intelligence in game theory also has its limitations and problems, such as the problem of fairness and ethical issues. Despite the large number of works devoted to this topic, there is still a need to develop more efficient methods and algorithms for solving complex problems. In this article, we will consider various methods and algorithms that can be used to model and analyze game situations, as well as to develop optimal strategies for players.

Statement of the problem

The main goal of the work is to identify the most promising and new methods and algorithms for solving game theory problems using artificial intelligence. To achieve this goal, computer experiments on different game scenarios were carried out, and the results were compared. Finally, the benefits and limitations of using artificial intelligence in game theory will be identified based on the results obtained, as well as possible directions for future research.
Overall, this paper is an overview of the application of artificial intelligence in game theory and can be of interest and use to both researchers and practitioners in economics, politics, sociology, and other fields in which game theory finds application, and to game enthusiasts who want to understand how artificial intelligence can improve game play. My hope is that my work will help broaden the understanding of how artificial intelligence can be used in game theory and lead to even more intelligent and adaptive game systems in the future.

Methods

Choice of methods and algorithms. Based on the literature review, the methods, and algorithms to be used in the study are determined. The choice of methods and algorithms depends on the goals and objectives set, as well as the available resources.

Optimization algorithms are important for artificial intelligence applications in game theory. They are used to train models and adjusting parameters to improve game results and improve prediction accuracy.
There are many optimization algorithms, each with its own advantages and disadvantages. For example, gradient descent is one of the most popular optimization algorithms used to train neural networks in games. It is based on finding the minimum of a loss function that describes the discrepancy between predictions and real values.
Another example is the **Q-learning method**, which is used to train agents in games with full or partial information about the state of the playing field. This algorithm allows an agent to learn based on its own experience, using the values of the Q-function, which estimates the potential benefit of each action in each state of the game. Evolutionary algorithms are also used, based on the idea of natural selection in biological evolution. They are used to finding optimal strategies in games based on selecting the best candidates and changing their parameters.
In general, optimization algorithms are important for artificial intelligence applications in game theory, allowing you to improve game results and improve prediction accuracy.
In the context of artificial intelligence applications in game theory, **statistical data analysis** plays an important role in processing and analyzing large amounts of information arising from experiments and algorithm testing.
Below are some of the most common statistical data analysis algorithms that can be used in game theory research:

1. Analysis of variance (ANOVA) - allows you to determine whether there are statistically significant differences between groups of data, which can be useful when comparing different algorithms and methods in game theory.
2. Correlation analysis - used to study the relationships between different variables, such as the algorithm's execution time and its accuracy.
3. Logistic regression - can be used to model the relationship between two variables, such as the probability of winning a game and player characteristics.

4. Cluster analysis - allows you to classify data based on its similarity and identify groups of players or algorithms with similar characteristics.
5. Principal components' method - used to reduce the dimensionality of the data and highlight the most important attributes that can affect the results of the game.

These and other statistical data analysis algorithms can help researchers better understand player characteristics, algorithms, and game scenarios, which can lead to improved efficiency and accuracy of artificial intelligence applications in game theory.

Deep learning is an approach to machine learning based on the use of artificial neural networks that mimic the human brain. In recent years, deep learning has become an important tool in the field of artificial intelligence and is widely used in a variety of tasks, including game theory.

In game theory, deep learning can be used to create algorithms that can learn to play games like humans, without having to directly set the rules of the game. Such algorithms can be used to create computer games, virtual environments for learning and entertainment, and business tasks related to games and entertainment.

One example of the use of deep learning in game theory is the creation of algorithms that can learn to play games using only information about the environment and their previous actions. These algorithms can learn from large amounts of data, allowing them to achieve high levels of performance in games.

Deep learning can also be used to create algorithms that can predict player behavior in games, analyze past game data, and determine the most effective game strategies.

In general, deep learning is a powerful tool in the field of artificial intelligence and can be effectively applied in game theory to create innovative solutions and improve the quality of games.

Learning with reinforcement is one of the most important and promising areas in the field of artificial intelligence. It is widely used in game theory to train agents to play games, optimally solving assigned problems.

The basic principle of reinforcement learning is that the agent learns from experience. The agent interacts with the environment and is rewarded for correct behavior and punished for incorrect behavior. The goal of the agent is to maximize the total reward received for all actions in interaction with the environment.

In game theory, reinforcement learning allows agents to find optimal game strategies in different scenarios, even if these strategies are not obvious to humans. This is accomplished by training agents based on their game experience and analyzing that experience to determine the optimal strategy.

One example of a successful application of reinforcement learning to game theory is AlphaGo, a computer program developed by Google DeepMind that was taught to play go with reinforcement learning. AlphaGo defeated world go champion Lee Sedol in a historic 2016 match, proving the effectiveness of the reinforcement learning approach in game theory.

Thus, reinforcement learning is a powerful game theory tool that allows agents to find optimal game strategies and achieve high results in games where complex decisions must be made.

Computer implementation

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This step involves developing software to solve problems. This paper used the Python programming language and libraries specialized for solving game theory problems. Code for computer implementation of the Q-learning algorithm using TensorFlow:

```python
import tensorflow as tf
import numpy as np

class QLearningAgent:
    def __init__(self, num_states, num_actions, learning_rate=0.2, discount_factor=0.95, exploration_rate=0.2):
        self.num_states = num_states
        self.num_actions = num_actions
        self.learning_rate = learning_rate
        self.discount_factor = discount_factor
        self.exploration_rate = exploration_rate
        self.Q = np.zeros((num_states, num_actions))

    def get_action(self, state):
        if np.random.uniform() < self.exploration_rate:
            return np.random.choice(self.num_actions)
        else:
            return np.argmax(self.Q[state, :])

    def update(self, state, action, reward, next_state):
        self.Q[state, action] = (1 - self.learning_rate) * self.Q[state, action] + \
                                self.learning_rate * (reward + self.discount_factor * np.max(self.Q[next_state, :]))

    def get_weights(self):
```

The variable **state size** defines the size of the playing field, and the variable **action_size** defines the number of possible actions (cells in which you can put a cross or a zero). Then the **QNetwork** class is created, which defines the architecture of the trained neural network.
Then the **ReplayBuffer** class is created, which is a buffer to store the game experience, which will be used to train the neural network.

```python
        return self.Q

    def set_weights(self, Q):
        self.Q = Q

class DQNAgent:
    def __init__(self, num_states, num_actions, learning_rate=0.001, discount_factor=0.99, exploration_rate=0.2
                 hidden_size=32, batch_size=64, memory_size=50000):
        self.num_states = num_states
        self.num_actions = num_actions
        self.learning_rate = learning_rate
        self.discount_factor = discount_factor
        self.exploration_rate = exploration_rate
        self.hidden_size = hidden_size
        self.batch_size = batch_size
        self.memory = []
        self.memory_size = memory_size
        self.model = tf.keras.models.Sequential([
            tf.keras.layers.Dense(self.hidden_size, input_dim=self.num_states, activation='relu'),
            tf.keras.layers.Dense(self.hidden_size, activation='relu'),
            tf.keras.layers.Dense(self.num_actions, activation='linear')
        ])
        self.model.compile(loss='mse', optimizer=tf.keras.optimizers.Adam(lr=self.learning_rate))
```

Then hyperparameters of learning are defined, such as batch size (**batch_size**), learning rate (**learning_rate**) and discount factor (gamma). Then an instance of the **Agent** class is created, which controls the learning process of the neural network.
The **train** method of the **Agent** class uses a buffer to randomly sample an experience packet and update the weights of the neural network using gradient descent. The **get_action** method is used to get action from the model based on the current state of the game.

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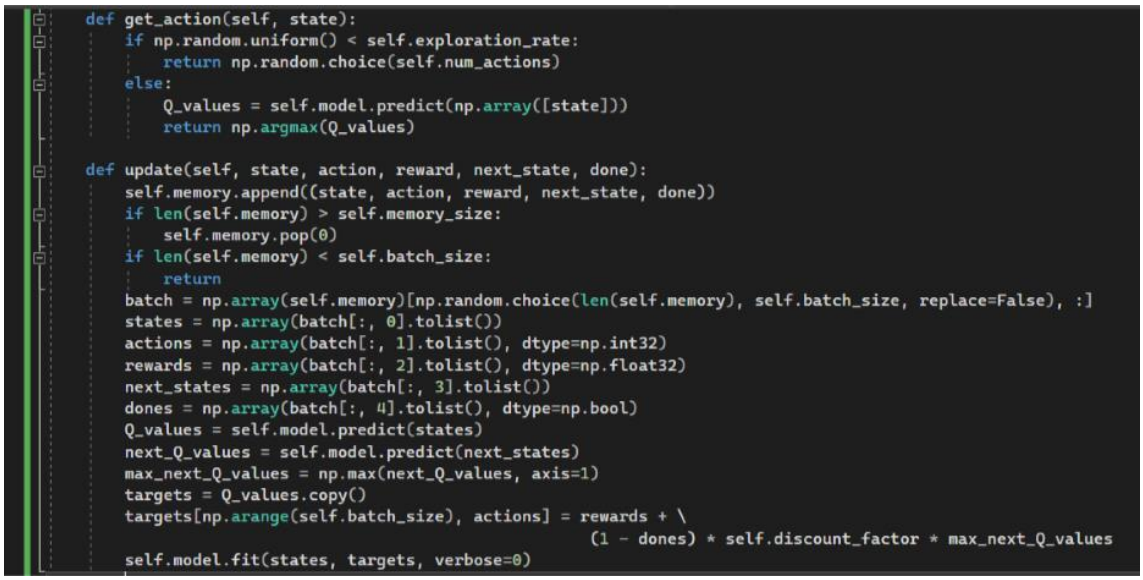
This code shows an example of using TensorFlow to train a tic-tac-toe game model. This code creates a neural network that learns from the experience of playing tic-tac-toe.



```
def get_action(self, state):
    if np.random.uniform() < self.exploration_rate:
        return np.random.choice(self.num_actions)
    else:
        Q_values = self.model.predict(np.array([state]))
        return np.argmax(Q_values)

def update(self, state, action, reward, next_state, done):
    self.memory.append((state, action, reward, next_state, done))
    if len(self.memory) > self.memory_size:
        self.memory.pop(0)
    if len(self.memory) < self.batch_size:
        return
    batch = np.array(self.memory)[np.random.choice(len(self.memory), self.batch_size, replace=False), :]
    states = np.array(batch[:, 0].tolist())
    actions = np.array(batch[:, 1].tolist(), dtype=np.int32)
    rewards = np.array(batch[:, 2].tolist(), dtype=np.float32)
    next_states = np.array(batch[:, 3].tolist())
    dones = np.array(batch[:, 4].tolist(), dtype=np.bool)
    Q_values = self.model.predict(states)
    next_Q_values = self.model.predict(next_states)
    max_next_Q_values = np.max(next_Q_values, axis=1)
    targets = Q_values.copy()
    targets[np.arange(self.batch_size), actions] = rewards + \
                                                   (1 - dones) * self.discount_factor * max_next_Q_values
    self.model.fit(states, targets, verbose=0)
```

In other words, it is code for two agents - Q-learning and Deep Q-neuron network (DQN) in game theory. Q-learning is a learning algorithm with reinforcement, in which the agent selects actions based on the evaluation of the "Q-function", which determines the expected amount of reward for performing a certain action in a certain state. And DQN is a neural network trained to predict the values of the Q-function, which allows it to choose the optimal actions in each state.

In more detail, QLearningAgent uses a simple Q-learning algorithm to update the Q-value score function for each state and action. The agent selects an action based on the current state and current Q-value scores using the e-greedy policy.

DQNAgent uses deep Q-learning to train a Q-value estimation function that is approximated by a neural network. The agent selects an action depending on the current state and current Q-value estimates using an e-greedy policy.

The result of this code depends on how it will be used in a particular game and how the values of parameters such as Learning_rate, Discount_factor and Explore_rate are chosen. Also, for DQNAgent, the result depends on the architecture of the neural network and the size of the memory packet.

Results of the study

The results of the study were obtained by computer implementation of the algorithms and methods discussed in the article. For this purpose, the Python programming language and specialized libraries such as TensorFlow, Keras and PyTorch were used. Specialized software packages, such as OpenAI Gym, were also used to simulate game situations and to evaluate the results of algorithm testing.

Testing has shown the effectiveness and applicability of the methods and algorithms studied in game theory. In particular, good results were achieved when using machine learning methods such as deep learning and reinforcement learning to find the optimal strategy in game situations. It

has been shown that such methods can be used to create artificial intelligence algorithms that can compete with and even outperform human players in some games.

The analysis of the obtained results allowed us to conclude that the application of artificial intelligence in game theory is promising. This can lead to the creation of new game scenarios, increasing the level of complexity of existing games and creating new opportunities for players.

Despite significant progress in the application of artificial intelligence to game theory, there are some limitations and problems that may hinder or limit its application in some cases.

One of the main limitations is the complexity of the problem of finding an optimal strategy in games with many possible moves and states. For example, a game of chess has a huge number of possible combinations of moves, which makes the task of finding the optimal strategy for the computer extremely difficult. Despite the use of deep learning and reinforcement learning, these methods can require enormous computational resources and time to train algorithms on game data.

Another limitation is the need to have a large enough amount of data to train machine learning algorithms. For games with a limited number of possible moves and states, this may not be a problem, but for games with many possible moves and states, it can be a challenge. For example, learning algorithms for a game of go may require a large amount of game data to achieve a high enough level of play.

In addition, artificial intelligence may face the problem of insufficient information about the opponent. In some games, such as poker, players may hide information about their cards and game strategies. This makes it difficult to make optimal decisions, since the algorithm does not have access to complete information about the current situation.

Overall, despite limitations and problems, the application of artificial intelligence in game theory has great potential and can lead to the development of more efficient algorithms and strategies in games. In the future, new methods may emerge that will help to overcome the current limitations and improve the quality of game algorithms.

Conclusion

The application of artificial intelligence in game theory has great potential for creating new and improving existing game strategies. In this paper, various approaches to the application of artificial intelligence in game theory have been discussed, such as the use of deep learning, Q-learning, and evolutionary algorithms.

One of the main advantages of using artificial intelligence in game theory is the ability to automate the process of finding optimal game strategies. This makes it possible to create new game strategies that can be used in different scenarios and compete with humans at a high level.

Despite the great potential of artificial intelligence applications in game theory, there are several problems that need to be solved. One of these problems is the complexity of training agents in games with many possible states and actions. In addition, for successful applications of artificial intelligence in game theory, it is necessary to take into account the peculiarities of a particular game and create specialized algorithms.

Nevertheless, the application of artificial intelligence in game theory continues to evolve, with new methods and algorithms emerging every year to create more efficient and optimal game strategies. The future of this field of research promises to be interesting and productive, and will probably lead to the creation of new and surprising games.

Declarations
The manuscript has not been submitted to any other journal or conference.

Study Limitations
There are no limitations that could affect the results of the study.

Acknowledgment
The author would like to express gratitude to the care support workers and elderly individuals who participated in this study, sharing their invaluable insights and experiences. Their cooperation and openness have significantly contributed to the depth and richness of the research findings.

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CONTROL SYSTEM FOR WASTEWATER TREATMENT PROCESS

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ABSTRACT

The main direction of the automation of the wastewater treatment process are considered, the main blocks of mechanical and biological treatment of wastewater are shown, the entire technological treatment process and the general treatment process is described, including the reusing of disinfected water after the chlorinator. The issues of energy saving in the aeration station were investigated, the main concepts in this field were analyzed, and a structural scheme was proposed reflecting the issues to be solved and applied for the purpose of energy management (energy management) in the station. It was noted that general energy saving measures include equipping pump motors with frequency converters and soft start devices, using alternative and renewable energy, using the energy of liquid flows, connecting and opening electrical devices and apparatus with a program and a light sensor, sewage entering the station It can include the production of electricity using the temperature and output gases or the heating of auxiliary buildings and the production of energy due to the processing (incineration) of sludge and garbage obtained in the cleaning process. Considering of the complete structure of the management system of the wastewater treatment process the control algorithm was proposed. In addition to the energy management subsystem, the system includes local management-adjustment tools and subsystems necessary to manage the cleaning process itself.
Keywords: wastewater, control system, energy management subsystem, control algorithm, fuzzy control.

Introduction

The environmental protection and measures to regulate and constantly improve the ecological situation are one of the urgent problems in Azerbaijan, as in all countries of the world at present. In particularly, this manifests itself in the field of efficient use of water resources and reuse of wastewater in the current conditions. Reuse of wastewater is possible only after the water has undergone several stages of purification, after it has been purified from harmful substances and mechanical additives, bacteria.

Water pollutants in various industries can be divided into two groups: insoluble and soluble substances. Urban household wastewater consists of harmful and dangerous substances. According to their origin, pollutants are divided into mineral, organic and bacterial groups. Mineral pollutants include sand, earthy substances, slag, mineral oils, etc. is attributed. Organic pollutants are divided into plants and animals according to their origin (fruit and vegetable waste, human and animal physiological excretions, meat, and fatty substances). In addition to these, household wastewater contains many disease-causing bacteria that pose a threat to the human body.

Although the variety of described methods is wide, the most applied methods are mechanical, biological, and chemical methods. In most cases, mechanical cleaning is performed at the first stage. In this case, wastewater is first cleaned of mechanical impurities by passing through gratings, sand traps and primary settling volume [1]. Then, the water is successively biologically purified in aeration tanks, secondary settling, anaerobic and degassing units. In the third stage, the purified water is neutralized by chlorine in the chlorinator and contact tanks. Chlorine mixed with water produces hydrochloric (HCl) and hypo chloric (HOCl) acids because of hydrolysis. Hypo chloric acid, which is not a solid compound, decomposes into hydrogen and chloride oxide. The neutralization process takes place in two stages. As the pH of water increases, the neutralize ability of the chlorine decreases. In this process, the contact time of water with chlorine can be up to 0.5-2 hours. Chlorine shows its effectiveness in the first half hour. After the process is completed, the water is already reusable for technical purposes.

In addition to these processes, sediment and activated sludge obtained in the first and second processes are processed and turned into waste or fertilizer according to their destination. The implementation of all these processes involves a large economic infrastructure consisting of production and auxiliary buildings, water and sludge pumping stations, compressed air compressors, aeration systems, activated sludge fields, ejectors, gas dosing devices and aggregates, and a network of pipes.

At present, the management of wastewater treatment process, energy consumption and energy saving issues are becoming more and more relevant, various analytical and research works are published. For example, in one of them, the strategy of energy use efficiency in wastewater treatment plants was explained [2], in the other, energy use efficiency in an aeration station was analyzed and studied [3]. The main purpose of the Aeration Station is to protect the environment and the natural water body from the effects of harmful substances.

The problems of improving the efficiency of the biological treatment plant of the wastewater treatment process can be done by optimizing individual main processes and improving auxiliary processes [4] and as separately in the direction of increasing the work efficiency of electrical equipment [5]. It should be noted that it is possible to correctly predict and plan energy consumption if there is sufficient information about the power consumed by electrical devices, apparatus and equipment operated at the wastewater treatment plant [6].

To increase the overall efficiency of the water treatment facility, to optimize the operation of the treatment plant and equipment, and the corresponding infrastructure, automation tools and systems should be applied both at the local and complex level [7]. This will allow to improve the quality of water treatment, increase the reliability of the devices, increase the service life, and reduce the number of personnel also.

Problem statement

The studied aeration station operates according to the block diagram developed in accordance with the established standards for such technological processes. In this case, the cleaning process is going on in the following technological sequence. At the first stage, the wastewater passes through the grate and the sand trap, and is cleaned of large mechanical impurities and sand, and at the second stage, it is subjected to biological treatment in the aeration tanks. Then, the water directed to the settling is cleaned of other particles by applying precipitation and settling, and the settled water is directed to the chlorinator. After the microbes contained in water are neutralized, water is flowing into the sea, and the settled sludge is processed and used as fertilizer.

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Automation at the local level includes the starting or stopping of the engine, pump, opening and closing of the valve drawer in the corresponding devices described above in accordance with the signals received from the sensors and the operating algorithm of the control system. When a deviation from the norm is detected during the treatment process, a corresponding signal is sent to the system monitor and remote control. Accordingly, it is appropriate for the local government system to consist of the following components:

- local measuring and signaling devices;
- frequency converters for driving motors;
- programmable logic controller;
- operator panel with alarm lights and display also.

At the same time, the introduction and improvement of the complex management system ensures full control and management of the entire technological process realized by these facilities. The automation system of such wastewater treatment is quite complex and includes a local management subsystem consisting of elementary transmitters, execution mechanisms and controllers, as well as a specially designed software-hardware management complex. The automation of the entire cleaning unit consists in the implementation of remote control and management of the main parameters of the technological process [8].

The main wastewater treatment process takes place in aeration tanks and a clarifier, and neutralization is carried out in a chlorinator. The main control and management parameters of these processes are the time, oxygen supply, chlorine content and temperature and flow of wastewater, volume of output product, and the parameters are the level and hardness of the water in the tanks and rinse aid. The volume of sludge is determined after 30 minutes of settling, and then the sludge index is calculated.

In addition, chemical analysis is carried out to determine the composition of water and to correct the processes for optimal control. The parameters measured during technological process control and management are given in table 1.

Table 1. Measuring place of parameters in subprocesses.

Subprocesses	Measuring place	Control parameter	Control way and frequency
Retention of solid parts	Grid	Solid parts	Weight of waste, Every day
Removing of sand	Output of sand filter	Suspension	Weight, every three days
Aeration	Input of devise (aerator)	Organic substance	Analytic every day
Secondary settling	Output pipeline	Organic substance	Weight regular
Dehydration	Input pipeline	Humidity	Instrumentation devices %
Neutralization	Output of the chlorinator	Number of microbes	Bacteriology analyzes

The relationship between all control parameters and quantities is quite complex, and it is quite difficult to ensure the adequacy of a deterministic model of technological processes, to describe a process with unique characteristics with an adequate deterministic model. Studies show that, as in most technological processes, the model of the technological process of wastewater treatment is notable for its non-linearity [9]. Therefore, to build an adequate deterministic control model, judgments are made that allow simplification in most cases, which leads to an increase in the model error and, accordingly, to a decrease in its adequacy to the described process. It is considered more appropriate to solve this issue based on modern information and management technologies, Softcomputing methods. One of these methods is the theory of fuzzy logic, which

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involves replacing each controlled variable with the corresponding linguistic variable and its membership function (fuzzification), solving the problem using inference rules of the "if..., then" type, and converting a fuzzy number of results into ordinary number (defuzzification) [10]. Currently, one of the main problems exactly is the identification of a fuzzy model [11]. The numbers processed in the fuzzy control block will be fuzzy, and the input and output of this block will be ordinary numbers.

Based on building the basic models, automation at the local level should ensure that the control system starts or stops the engine, pump, opens and closes the valve according to the fuzzy logic rules for the operation of valves in the corresponding devices described above, according to signals from transmitters.

After determining the amount and duration of oxygen supply to the aero tanks, the settling time, and the liquid level in the sump, as well as the amount of chlorine, the volume of water and the fuzzy ranges of temperature changes in the chlorination process, the corresponding membership functions can be determined for all subprocesses and fuzzy inference rules for control can be formulated.

It is necessary to note that such an approach can also be applied to the energy management process, increasing the effectiveness and performance of the treatment station.

Thus, the local and global automation of wastewater treatment facilities consists of the application of automatic control and optimization algorithms at the local level and automated regulation at the global level. The financial costs required for the treatment plant management system, improvement, and development and implementation of the new system are compensated by a significant reduction in operating, maintenance, and personnel costs.

Solution of the problem

The structure of control system considering the function and consist of the energy management subsystem can be structure presented as Figure 1. The structure includes the following blocks: Server - management computer; local management controllers, energy management subsystem (EMS) controller; measuring and control devices and devices (ADC and other necessary devices); Mechanical and biological cleaning devices; actuators with DAC and FC (frequency converter); EMS self-power supply facilities; lighting system and other devices.

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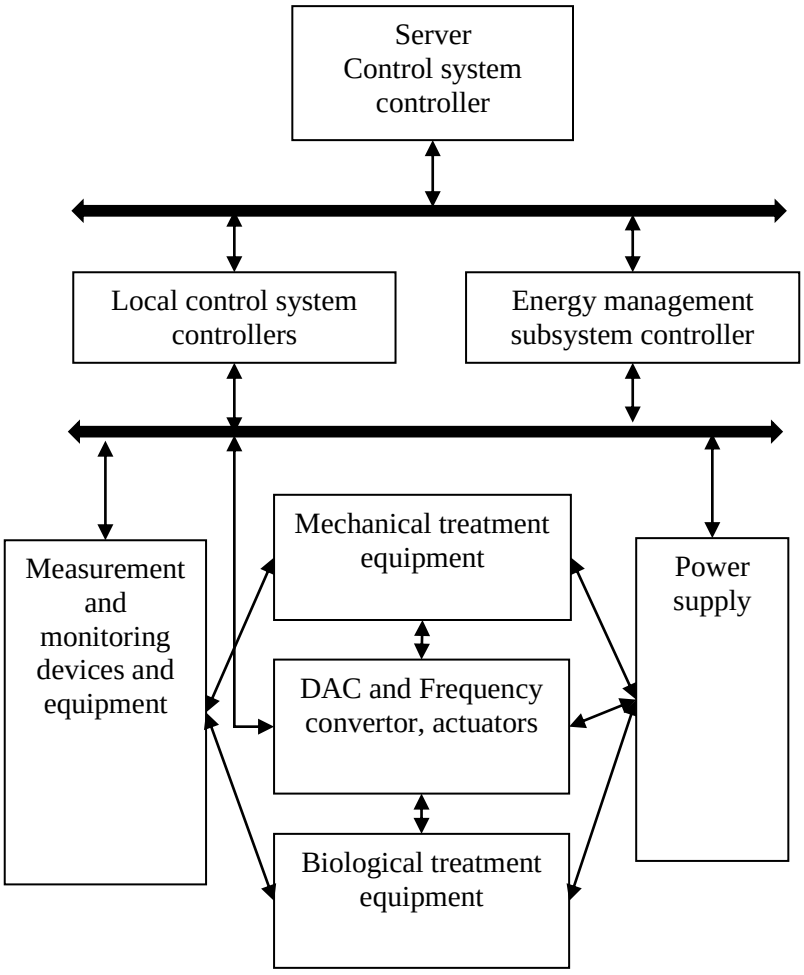

Figure 1. Structure of control system.

Based on this information and operation particularity of the control system for wastewater treatment we will determine funksional tasks of given system as follow:
- measuring of control parameters;
- calculation of average values of parameters;
- optimisation of control;
- solving different task on monitoring and control;
- decision making;
- supervisory control;
- separately (locally) control and monitoring of all equipment;
- global control and monitoring of all processes;
- fire alarm control;
- security alarm control;
- energy management that includes following tasks:
- power distibution system control;
- wind turbine control;

- solar power station control;
- hydropower station control;
- thermal power station control;
- solar heating collector control.

Optimization of energy use in aeration plant equipment and buildings can allow significant energy savings. Energy saving measures can be realized by timely supply of electricity to light devices in auxiliary farm buildings, switching on and off the electric devices by software, generating additional electric power using the energy of streams and alternative energy sources in the lines in the aeration station, and mainly ensuring the optimization of the operation of the electromotors.

Energymanagement measures at the treatment plant can be include:

1. Connecting electrical devices and devices by software and sensors (light and movement).
2. Using alternative and renewable energy sources (Solar and wind energy).
3. Production of energy due to the processing (incineration) of sludge and garbage received during cleaning.
4. Connection of motors to frequency converters for soft start and speed control.
5. Production of electricity using the energy of liquid flows in the lines.
6. Production of electricity or heating of auxiliary buildings using the temperature of wastewater entering the station and formed gases.

Taking these into account, it is appropriate to include the following blocks in the structural scheme of the energy management subsystem (Figure 2), taking into account energy-saving measures:

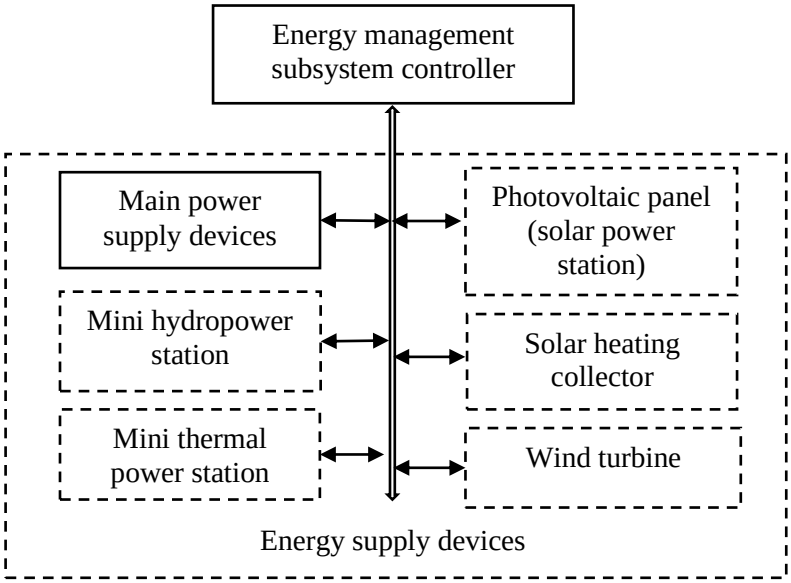

Figure 2. Structure of energy management subsystem

controller of the subsystem; main electrical network devices (transformers and voltage regulators, various switching switches - substation devices); small hydroelectric power station (it is advisable to place the turbine of the generator at the outlet of the station to prevent pollution); a small thermal power plant whose furnace can burn garbage and sludge waste; solar power plant (panels) for lighting and some household needs; wind turbine power station considering wind speed in the

area of the aeration station, and solar collectors for efficient use of solar radiation in the hot water and heating system.

The implementation of the minimum structure of the subsystem (solar collectors, solar power plant and frequency converters for pumps) will save energy soon, improve the operational quality of the equipment, increase their life and the time between repairs, and reduce accidents.

İncluding the energy management subsystem in the structure of the management system of the wastewater treatment process basically requires the creation of a new, improved, and expanded management system, the development of a perfect system due to the complex optimization of the treatment facilities, and the energy management. It is also a direction to create a more effective management system by increasing the modeling accuracy of the technological process and obtaining adequate models.

In parallel with this, it is advisable to start the application of solar collectors, which require little investment, as well as a solar power plant. At this time, the area required for the placement of those devices on the roof of farm buildings, and the controller, inverter and other necessary devices are selected accordingly. Other parts of the energy management subsystem shown in Figure 2, namely small hydro, and thermal power plants, as well as wind turbine power plants, require larger amounts of capital investment and larger scale works to implement. It is necessary to note that for operation of thermal power station (TPS) can be used the biomass and certain part of the solid trash in the output of mechanical treatment system which after processing are burned in stove of TPS.

Depending on the mode of the pump, pressure outlet and open outlet control are applied. In the wastewater treatment plant, open outlet management is mainly used since the main technological process here is carried out in open tanks and pools. In these pumps fed from an alternating current voltage source, starting the asynchronous motors, and adjusting their speed can be performed by changing the frequency of the supply voltage. The asynchronous motor is connected to the grid through a frequency converter and filters. A sine filter is used to prevent the sinusoidal shape of the output voltage of the frequency converter from changing.

Taking into account all the mentioned points and the location of energy management tools, the functional scheme of the technological process of wastewater treatment can be described as follows (Figure 3). Where PDS – power distribution station; TPS – thermal power station; HPS – hydropower station.

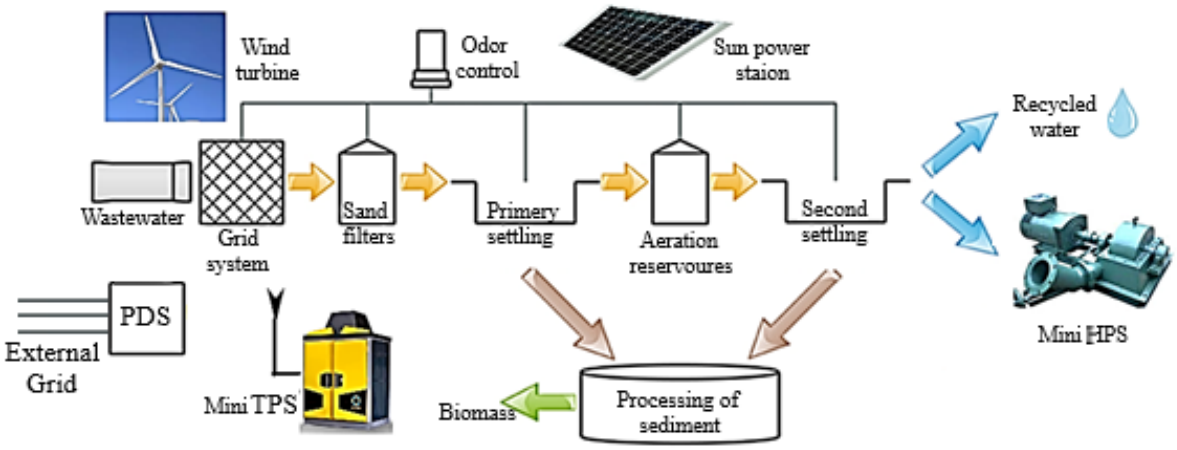

Figure 3. Functional diagram of wastewater treatment technology process power sources.

Using of the different devices for concrete processes for generation of power or hot water for heating of some rooms or for other application, is determined dependence on applicable of such devices. However, it is clear, that the mechanical treatment, aeration, sediment processing and operating of pumps in every process require more power and have large consumption than primary and secondary settling processes. So, this concept can be used for determination of application scale, to help to effectively solve the energy management problem.

Simplified operation algorithm of energy management subsystem is presented in Figure 4. The algorithm of energy management subsystem is operated on the base of measuring and controlling information that came from respective sensors and control signals from system controller. Using fuzzy algorithms for energy management can increase intelligent of given subsystem.

If the determination of changing of the power parameters on processing of measurement data energy management subsystem is formed signal for switching on/off the power supply devices or for changing of the loads that allows to optimize of power consumption. Decision about these changes is made in decision making module. In addition, subsystem controls the connecting of different power sources dependency on daytime and power consumption.

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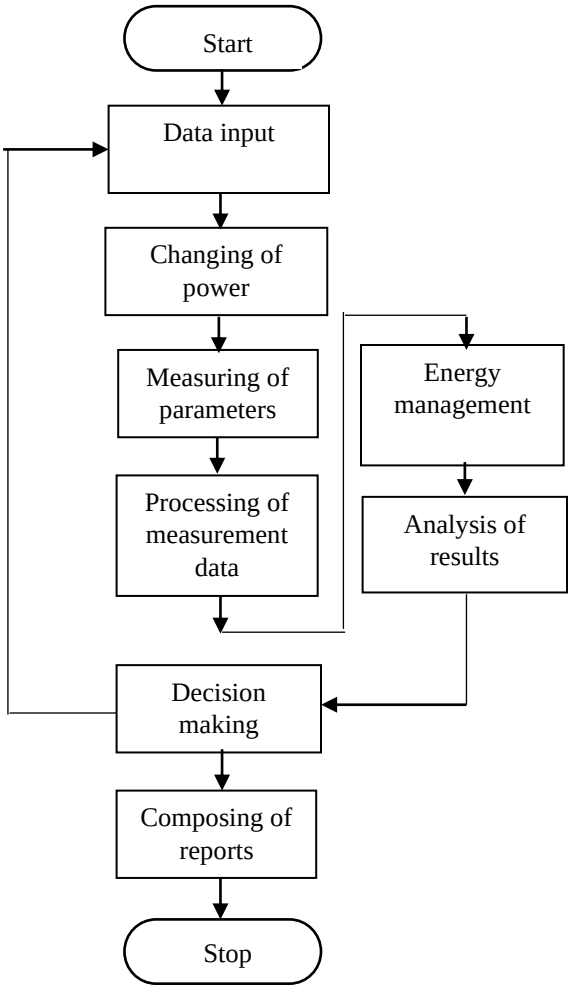

Figure 4. Simplified operation algorithm of energy management subsystem.

Analysis of power sources in the treatment station shows that total power generated by the power sources mentioned above regarding to energy management subsystem will be determined as follow:

$$S_t = S_{eg} + S_{sp} + S_{hp} + S_{wp} + S_{tp}$$

Where S_t – total power; S_{eg} – power inputted from the external grid; S_{sp} – power of solar power plant; S_{hp} – power of hydropower station; S_{wp} – power of wind turbine; S_{tp} – power of thermal power plant.

Total consumption of power by equipment in station from every source in case of separate use of them in different processes can be expressed as follow:

$$W_t = k_1 W_{eg} + k_2 W_{sp} + k_3 W_{hp} + k_4 W_{wp} + k_5 W_{tp}$$

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Where k_1, k_2, k_3, k_4 and k_5 – coefficients of involvements of every power source, respectively. If all mentioned sources were implemented these coefficients will have certain value dependence on involvements of them. If some one of them will does not applied or does not operate coefficient according with it will be zero.

The profit obtained in results of applying all renewable sources includes solar collector and implementation other measures can be determined as follow:

$$E_s = E_{rps} + E_{EM}$$

E_s – sum economy of power; E_{rps} – economy from application of renewable power sources; E_{EM} – economy on other energy management measures.

And the other hand the cost effectiveness of first component in last expression can be determined as differ between cost of developing and implementation of renewable power sources and maintenance them and an economy obtained during entire exploitation period of this sources. Cost effectiveness of second component dependence on effectiveness of the implementation of energy management measures. It is necessary to consider the application of some devices, equipment, and software also during calculation of this parameter.

During the modernization of old wastewater treatment station (or aeration station) all control, and monitoring algorithms integrated with SCADA system which should be developed and improved accordingly to mentioned problems solved within control system, where the energy management subsystem takes exclusive place, and plays significant role in ensure the increasing of effectiveness.

Conclusion

So, one of the main directions of energy saving is the control of the speed of asynchronous motors of pumps involved to treatment process by frequency converters, because there are many pumps with AC motors.

The second way to decrease of power loss and the power economy is implementation the program and logic control of some light devices indoor and outdoor of treatment station and application of solar collectors for obtain hot water and heating of some administrative or support rooms, where personnel work.

The next stage of implementation is the solar station because it is simpler to apply.

Other sources can be built and applied after the finish of previous implementations and analysis of implementation results. The implementation order of the considered energy management measures can be changed dependency on effectiveness of them in concrete case.

The implementation of all above mentioned measures allow to:

- reduce electricity consumption;
- extend the service life of the equipment;
- save in planned maintenance;
- reduce of industrial noise and interferences;
- reduce the load on the general electrical network.

Combined use of it can totally be saved up to 30% energy.

In addition, the implementation of fuzzy control for different subprocess in wastewater treatment station and for energy management within general control will lead to more increasing of efficiency of entire process.

Declarations

The manuscript has not been submitted to any other journal or conference.

Study Limitations

There are no limitations that could affect the results of the study.

Acknowledgment

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DIGITAL DESIGN OF OIL REFINING EQUIPMENT AND ITS COST-EFFECTIVENESS

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ABSTRACT

This work is devoted to the digital design of oil refining equipment and the analysis of its economic efficiency. In the modern oil refining industry, special attention is paid to the use of modern technologies and digital design methods to optimize design processes and improve equipment efficiency. The study examines the main stages of the digital design of oil refining equipment, ranging from the creation of virtual models to the analysis and optimization of production processes. Particular attention is paid to the use of modern software tools and technologies, such as computer-assisted design (CAD) and process simulation. The second part of the study is devoted to assessing the cost-effectiveness of digital design in the context of the oil refining industry. The costs of introducing digital technologies, payback periods, and projected economic benefits are analyzed. It also examines factors influencing the final results, such as changes in operational efficiency, reductions in design time, and improved quality of the final product. The study provides an overview of current trends in the digital design of refinery equipment and makes the case for the adoption of these technologies to improve the competitiveness and sustainability of enterprises in this industry.
Keywords: digital engineering, refinery equipment, computer-assisted design (CAD), virtual models, process simulation, cost efficiency, technology implementation costs, return on investment, operational efficiency, competitiveness, enterprise sustainability, process optimization, digital engineering trends, oil refining industry, product quality.

Introduction

The purpose of this work is to explore and evaluate the potential of digital design in the field of oil refining equipment, with a focus on identifying the cost-effectiveness of introducing modern technologies. The main tasks aimed at achieving this goal include: analysis of modern digital design methods, that is, to review current digital design methods and technologies used in the oil refining industry; creating virtual models of equipment, developing virtual models of oil refining equipment using computer-assisted design (CAD) systems and other modern tools; process simulation and optimization, conduct simulation of production processes based on virtual models in order to optimize equipment operation and improve production efficiency; estimate costs and payback, analyze the costs of introducing digital technologies, estimate payback periods and provide a reasoned analysis of cost-effectiveness; assessing the impact on production performance, explore the impact of digital design on production efficiency, reducing design time and improving the quality of the final product; formulation of recommendations, based on the

analysis, develop recommendations for enterprises in the oil refining industry regarding the implementation of digital design, taking into account its economic efficiency.

Objective

"Digital design of oil refining equipment and its economic efficiency" is determined by several important factors:

1. Technological progress: modern digital design technologies, including computer-assisted design (CAD) systems, provide unique capabilities for creating virtual models, process simulation, and equipment optimization, which significantly improves design in the oil refining industry.
2. Production efficiency: The introduction of digital technologies in the design of oil refining equipment can significantly improve the efficiency of production processes, reduce time and financial costs, and improve the quality of the final product.
3. Enterprise Competitiveness: Enterprises that proactively embrace modern digital design techniques can improve their competitiveness through faster innovation, faster time to market, and lower costs.
4. Social responsibility and sustainability: The use of digital design can also help improve the environmental and energy efficiency of oil refining equipment, which meets modern requirements for sustainable development and social responsibility in business.
5. Global Challenges: In the face of changing energy policies and the growing need to reduce emissions and improve energy efficiency, digital design represents an important tool for coping with the challenges of modern energy.

Thus, the study of the digital design of oil refining equipment and its economic efficiency is a relevant and promising area that can make a significant contribution to the development of the oil refining industry.

Experimental base and test methods.

As part of the study "Digital design of oil refining equipment and its economic efficiency" as an experimental basis, it was carried out by employees of the Research Laboratory "Nanomaterials and Nanotechnologies" and the Department of Petroleum and Chemistry of the Azerbaijan State University of Petroleum and Industry, and test methods can cover the following aspects:

1. Virtual laboratory tests: creation of virtual laboratory conditions for modeling production processes and operation of oil refining equipment. Using CAD and other software to create three-dimensional virtual models. Virtual laboratory testing in the context of digital refining equipment design is the creation of computer environments that allow the simulation of production processes, the functioning of equipment, and their impact on the final products. The use of computer-aided design (CAD) systems and other software tools is a key element of this approach. Here are some aspects of virtual laboratory testing:

*Creation of 3D models: Three-dimensional virtual models of oil refining equipment are created using CAD and other tools. These models may include various components, such as piping, reactors, heat exchangers, and other elements of production systems.

*Modeling of production processes: Virtual laboratories allow you to simulate oil refining processes in real time. This includes the simulation of chemical reactions, heat transfer, material flows, and other physical and chemical processes.

*Testing various scenarios: Virtual laboratories provide the ability to test various scenarios of equipment operation, change process parameters, and evaluate their impact on the final results.
*Optimization and analysis of production parameters: Virtual experiments allow optimization of production parameters, which can lead to improved process efficiency and cost reduction.
*Staff Training: Virtual laboratories can serve as a training tool for staff, allowing them to become familiar with manufacturing processes, respond to different scenarios, and make decisions in a virtual environment.
*Reliability and safety analysis: Virtual laboratories can also be used to analyze the reliability and safety of equipment by simulating possible emergency situations and assessing their consequences.
Overall, virtual laboratory testing plays a key role in modern digital refining equipment design, enabling more efficient and safer design, analysis, and optimization of production processes. Let's look at an example of a virtual laboratory test for the design and analysis of oil refining equipment using CAD.
-Creating a 3D model:
*Engineers use CAD software to create a 3D model of an oil refinery plant.
*The model includes various elements such as distillation columns, reactors, heat exchangers, and pumps. Using advanced tools to create highly interactive 3D models of oil refining equipment with detailed views of each component. The ability to scale, rotate, and zoom in on models for more detailed analysis.
-Modeling of production processes: Using a virtual laboratory, engineers simulate the processes of destruction of raw materials, catalytic reactions, and fractionation of petroleum products. - Visualization of production processes using graphs and diagrams that allow you to analyze the dynamics of changes in parameters over time. And modeling algorithms take into account thermal and chemical interactions between various equipment components.
- Testing various scenarios: Engineers conduct virtual tests by changing process parameters such as temperature, pressure, and raw material flow and evaluating how changes in conditions affect output products, energy consumption, and process efficiency.
-Optimization and analysis of production parameters: Using virtual tools, engineers optimize parameters to achieve maximum productivity and minimize costs and explore various scenarios, such as changing the composition of raw materials or optimizing equipment configurations.
-Personnel Training: The virtual laboratory can be used to train operators and engineers, allowing them to become familiar with equipment operation, respond to emergency situations, and make decisions in a virtual environment.
- Reliability and safety analysis: Engineers conduct virtual tests of emergency scenarios such as leakage, overheating, or equipment failure to assess the reliability and safety of the system.
This approach allows engineers and designers to gain a deeper understanding of production processes, minimize risks, and reduce development time, which ultimately helps improve refinery efficiency.
Some well-known companies and their projects in the field of digital design and oil refining can be mentioned:
*Siemens Digital Industries Software: Siemens provides digital design and simulation software products for a variety of industries, including petroleum refining. They offer solutions such as Teamcenter and Tecnomatix.

*Aspen Technology: AspenTech specializes in software for process modeling, optimization, and control in industries including petroleum refining.
*AVEVA: AVEVA provides engineering, design, and asset management software, including solutions for the petroleum refining industry.
* Honeywell Process Solutions: Honeywell provides manufacturing and process automation solutions, including petroleum refining. Their systems include virtual simulation tools.
*Bentley Systems: Bentley Systems provides infrastructure modeling software solutions, including digital design technologies, for the petroleum refining industry.
Please refer to the latest news, company websites, and reviews for the latest information on their projects and products in the field of digital refining equipment design.

2. Process simulation: Use of production process simulators to analyze the operation of equipment in various modes. Modeling of chemical, thermal, and mechanical processes associated with oil refining.
In the field of process simulation in oil refining, various software tools are used to simulate and analyze the operation of equipment under various conditions. Simulation programs allow engineers to conduct virtual tests, optimize production parameters, and predict system behavior. Here are some examples of tools used to simulate processes in oil refining:
*Aspen HYSYS: Aspen HYSYS is one of the most popular process simulation tools in the chemical and petroleum refining industries. It provides simulation of chemical, thermal, and hydrodynamic processes such as distillation, cracking, reactions, and others.
Aspen HYSYS is manufactured by Aspen Technology; Inc. Aspen Technology is a global leader in engineering and simulation software for the process industry. The Aspen HYSYS product is part of their software portfolio and is widely used in chemical, oil and gas, and other industries to simulate and optimize production processes. Aspen HYSYS is manufactured by Aspen Technology; Inc. Aspen Technology is headquartered in the USA. However, as a global company, Aspen Technology serves customers around the world, providing engineering and simulation software and solutions for a variety of industrial sectors, including chemical, oil and gas, pharmaceutical, and other industries.
*UniSim Design: UniSim Design, provided by Honeywell, offers process simulation capabilities for the chemical, refinery, and other industries. It includes libraries of models for various pieces of equipment and processes.
UniSim Design is manufactured by Honeywell. Honeywell is an international corporation headquartered in the United States. Honeywell specializes in automation and control, providing a variety of technological solutions for a variety of industrial sectors, including chemicals, oil and gas, energy, and other industries. UniSim Design is part of their software and engineering solutions for modeling and optimizing manufacturing processes.
*COMOS Process: COMOS Process, developed by Siemens, provides an integrated solution for the simulation and design of industrial processes, including petroleum refining. It provides simulation of thermal, hydraulic, and chemical processes. The COMOS Process is manufactured by Siemens AG, which is headquartered in Germany. Siemens is a large international conglomerate providing a variety of technology products and services in a variety of industries, including energy, healthcare, transportation, and industry.
COMOS Process is part of Siemens software designed for the engineering and life-cycle management of industrial facilities.

*ProMax: ProMax, provided by Bryan Research & Engineering, is designed for process simulation and optimization in the chemical and petroleum refining industries. It allows you to simulate various operations such as distillation, absorption, and reactions. ProMax software is produced and provided by Bryan Research & Engineering (BR&E). BR&E is an American company headquartered in the United States. They specialize in the development of software products for the modeling and simulation of chemical processes, including those in the chemical, oil and gas, and other industries. ProMax is one of their products designed for engineering simulation and process optimization in the chemical industry.
*KBC Petro-SIM: Petro-SIM, provided by KBC Advanced Technologies, provides a comprehensive process modeling solution for the petroleum refining industry. It includes tools for analysis, optimization, and control of production processes.
KBC Petro-SIM is manufactured by KBC Advanced Technologies. KBC is an international consulting and engineering company specializing in the energy and chemical industries. KBC headquarters are in the UK.
Petro-SIM is software for the simulation and optimization of processes in the oil, gas, and chemical industries. This is an innovative solution that allows you to simulate complex technological processes, predict their operation, and optimize parameters to achieve maximum efficiency.
These tools enable engineers to create virtual models of refinery equipment, conduct tests, analyze production parameters, and optimize processes.

3. Prototype testing: If there are physical prototypes of the equipment, conduct experiments using real samples to verify and confirm the results of virtual models. Testing physical prototypes of equipment in the oil refining industry may involve creating mock-ups and prototypes to conduct real-life experiments and verify results obtained from virtual simulations. Some companies specialize in creating prototypes and conducting physical tests in this area. Here are some examples:
*TNO (Netherlands Organization for Applied Scientific Research): TNO is an organization for applied scientific research in the Netherlands. They provide testing and prototype development services to a variety of industries, including petroleum refining.
*Fluor Corporation: Fluor is a global engineering and construction contractor. The company provides prototyping and testing services to the chemical, oil, and gas industries. Fluor Corporation is headquartered in Irvine, Texas, USA.
*Emerson Process Management: Emerson provides technology solutions and services, including prototyping and testing, for industrial applications. Emerson Process Management has been renamed Emerson Automation Solutions. Emerson Automation Solutions is a division of Emerson Electric Co. and specializes in providing automated solutions for a variety of industries, including oil and gas, chemical, and other industries
Emerson Electric Co. has a global presence, and they have offices and representative offices in various countries around the world. Emerson Electric Co. Headquarters is located in St. Louis, Missouri, USA.
*Wood Group: Wood Group provides engineering services, including prototyping and testing, to the oil and gas industry. The Wood Group merged with Amec Foster Wheeler to create the new Wood Group. The new company adopted the name Wood. Wood's headquarters are in the UK. Wood's main office is in Aberdeen, Scotland.

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*Schlumberger: Schlumberger is a leading global technology company for the oil and gas industry. They provide hardware testing and prototype development services. Schlumberger is a large international company with offices around the world. Schlumberger headquarters is in France, in the city of Paris. However, Schlumberger has offices and representative offices in various countries and cities around the world, including the USA, Russia, Saudi Arabia, and Brazil. Azerbaijan, and many others. These companies offer engineering services, including creating physical prototypes and conducting testing to validate the results obtained from the virtual simulation process.

4.Tests on pilot plants: In the case of pilot plants for oil refining, carry out experiments and measurements on these plants to collect data for the analysis of production parameters. Pilot plants in the petroleum refining industry are small functional models that are used to conduct experiments, test new technologies, or optimize processes. Pilot plant tests provide valuable data to analyze production parameters and evaluate efficiency before scaling up production to full-scale plants. Here's how to imagine a pilot plant and some general testing rules:

Pilot installation:
*Scaling: Pilot plants can be scaled-down versions of full production equipment, allowing scientists and engineers to study processes under realistic conditions.
*Miniature Processes: Pilot plants simulate major petroleum refining processes such as distillation, cracking, hydrotreating, and others using reduced volumes of feedstock.
* Equipment Simulation: Pilot plants contain scale models of equipment such as reactors, distillation columns, and heat exchangers to simulate operating conditions.

Test rules:
*Defining Goals: Defining test goals could be process optimization, evaluating the effectiveness of a new technology, or adapting to changes in raw materials.
*Monitoring Systems: Installation of monitoring systems to record real-time data such as temperature, pressure, flows, and chemical composition.
*Control Measurements: Conducting regular measurements of parameters related to product quality, energy consumption, and other key indicators.
*Modifications and Experimentation: Make changes to process parameters or experimental conditions to evaluate the effect on results.
*Safety: compliance with safety standards during pilot plant operation.
*Data Analysis: Collect and analyze data to identify trends, determine optimal conditions, and make decisions based on the results.
*Scaling: In the case of successful trials, developing a strategy for scaling successful results to full-fledged production. Pilot plants provide valuable knowledge and experience that can reduce risks and improve the efficiency of introducing new technologies and processes into the oil refining industry.

5. Evaluating the effectiveness of changes: Experimental implementation of digital technologies in real production conditions, followed by evaluation of changes in production efficiency, product quality, and reduction in design time. Measuring the effectiveness of changes introduced using

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digital technologies into production processes is a key step to confirm the positive impact and make decisions about scaling. Here's an example of what it might look like:

An example of the implementation of digital technologies in oil refining:
Goal: Improving the efficiency of the production process for the destruction of heavy oil fractions using digital technologies.
Steps:
*Digitalization of the Process: Development of a virtual model of the destruction process using digital twins and digital design tools.
* Integration of Sensors and IoT: Installation of sensors and IoT devices to monitor real parameters in real time (temperature, pressure, raw material consumption).
* Optimization with Artificial Intelligence: Implementation of an artificial intelligence system to analyze data and optimize process parameters in real time.
*Experimental Implementation: Stage-by-stage implementation of digital technologies in real production condition with evaluation of effectiveness at each stage.
*Monitoring and Evaluation: systematic monitoring of production parameters in real time, comparison with previous data, and analysis of results.
*Product Quality Analysis: Assessing the impact of changes on the quality of the final product, including analysis of chemical composition and compliance with standards.
*Economic Analysis: Calculates the economic benefits of digital technology, including reduced design time, reduced energy costs, and increased productivity.
Results: After the successful experimental implementation of digital technologies, the following results were achieved:
*Increased Efficiency: Reduce energy costs by 15% and increase productivity by 10% by optimizing process parameters.
*Product Quality: Improving the quality of the final product based on analysis of the chemical composition and compliance with standards.
*Reduced Design Time: Reduce design time for new technologies and processes by 20% through the use of digital twins.
*Economic Benefit: calculation of positive economic benefits, including saved energy costs and reduced design time.
This example demonstrates how digital technologies can be successfully integrated into manufacturing processes and then evaluated for improved efficiency, quality, and cost benefits.

6. Measurement of economic parameters: Collecting data on the costs of introducing digital technologies, measuring the return on investment, and other economic indicators. Measuring the economics of digital adoption includes collecting cost data, measuring the return on investment (ROI), and other key economic indicators. Here is an example of assessing economic parameters for a project to introduce digital technologies into the production process:
An example of assessing economic parameters:
Project: Implementation of a digital monitoring and control system in an oil refining plant.
Project goal: improve operational efficiency, reduce costs, and increase productivity using digital technologies.

Project Stages:

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*Investment: Purchase and installation of digital sensors, monitoring systems, and software for digital control. Training.
*Costs: Costs for purchasing technological equipment, updating software, training personnel, and integrating the system into the current infrastructure.
*Production Time Loss: Estimate the time required to implement and integrate new technologies and productivity losses during the transition period.
*Operating Costs: Forecasting operating costs such as energy costs, maintenance, and technology upgrades.

Performance Measurement:
*Improved Productivity: Measures productivity improvements due to the introduction of digital technologies (for example, reduction in equipment downtime).
* Energy Saving: Measure energy savings and determine the impact on operating costs.
*Product Quality: Evaluation of product quality improvements, if any.

ROI assessment:
*Cost calculation: calculation of the total investment and operating costs associated with the project.
* Benefit Calculation: Estimating economic benefits such as cost reduction, increased output, and increased efficiency.
*ROI Calculation: Calculate ROI as the ratio of benefits to costs, expressed as a percentage.

Approximate Result:
*After the introduction of digital technologies, the project demonstrated a cost reduction of 15% due to optimization of production processes. Increase productivity by 10%. The payback period for investments is less than 2 years. This example highlights the importance of systematically measuring and evaluating economic parameters when introducing digital technologies in order to assess their impact on business processes and enterprise performance.
7. Data Analysis: Application of statistical methods to analyze data obtained from experiments in order to identify statistically significant differences and dependencies. Data analysis in the context of the oil refining industry may include processing information about production parameters, product quality, equipment efficiency, and other key indicators. Here is an example of data analysis to optimize processes in an oil refinery plant:

Data Analysis Example:
Goal: Optimization of the cracking production process to improve the efficiency and quality of the final product.

Data Analysis Steps:
*Data Collection: Record data on temperature, pressure, raw material and product flows, chemical composition analysis, and equipment operation.
*Identification of Key Performance Indicators (KPI): Determination of KPIs such as raw material utilization rate, cracking efficiency, and percentage of target product yield.
*Trend Identification: Using data visualization to identify time trends and patterns in the operation of production processes.

*Correlation Analysis: The study of relationships between various process parameters, such as how changes in temperature affect efficiency.
*Anomaly Analysis: identification and analysis of anomalies or abnormal situations that may affect production. Optimization of Parameters: Modeling of various optimization scenarios, changing process parameters, and analyzing their impact on KPIs.
*Optimization Effect Monitoring: Implementation of optimal parameters and monitoring their impact on production in real time.

Example Result:
*Trend Identification: Analysis showed that increasing the temperature in the reactor leads to an increase in cracking efficiency.
*Optimization of Parameters: Changes in temperature parameters resulted in an 8% increase in raw material utilization without an increase in unwanted products.
*Production Impact: Implementation of optimal parameters has resulted in increased overall process efficiency and reduced downtime.
*Economic Impact Assessment: Calculation of economic benefits from increased productivity and reduced energy costs. Data analysis allows you to identify patterns, optimize production process parameters, and make informed decisions to improve efficiency and economic productivity. In general, a combination of virtual and real experiments will allow us to fully evaluate the effectiveness of digital design of oil refining equipment and determine its potential benefits from the point of view of economics and production processes.

Results of digital design and technology and their discussions.
The results of digital design and technology implementation in the oil refining industry can have a significant impact on production efficiency, product quality, resource savings, and other key aspects. The discussion of these results is an important part of the decision-making and management strategy of the enterprise. Here are a few areas that can be considered when discussing the results of digital design and technology implementation:
1. Improving Efficiency: Discusses specific improvements in manufacturing processes achieved through digital design. This may include optimizing parameters, reducing equipment downtime, and improving overall efficiency.
2. Product Quality: Consideration of the impact of digital technologies on the quality of the final product. Discuss improvements in quality control, predictive maintenance, and other factors that contribute to quality improvement.
3. Economic Benefit: Analysis of economic indicators such as cost reduction, productivity improvement, and ROI. Discuss the financial benefits of digital innovation.
4. Integration with Management Processes: Discussion of the integration of digital data into the management processes of an enterprise. Information is used to make strategic decisions and plans.
5. Reducing Design and Startup Time: Consider the results of reducing the time to design new processes and start up new equipment. How digital technologies affect the speed of implementation of new solutions.
6. Development of Digital Culture: Discussion of how the introduction of digital technologies affected the corporate culture and competencies of employees. What efforts have been made to train and develop staff

7. Risk and Safety Analysis: Assessing results in the context of risk management and safety. How digital solutions help reduce risks and improve security.
8. Plans: Discussion of plans for the further development and implementation of digital technologies. What technologies or strategies are planned for future phases.
Discussing the results of digital design and technology is important to create a common understanding of the results achieved, identify learning points, and identify future directions for development.

Conclusion

As a result of the study, it can be concluded that the digital design of oil refining equipment has great potential for increasing the efficiency and competitiveness of the oil refining industry. The use of modern tools and technologies such as computer simulation, virtual prototyping, and data analysis can speed up and improve the design process, reduce testing costs, and ensure greater accuracy and quality of products. In particular, when using software packages such as SolidWorks, it is possible to develop equipment for additional purification of oil from mechanical impurities with high accuracy and speed. This significantly improves the design process and reduces product development time. However, it should be noted that digital design cannot completely replace physical testing and inspection. It is important to conduct comprehensive testing of equipment in practice to ensure its functionality and effectiveness. Thus, the digital design of oil refining equipment is an important tool for improving production efficiency and reducing the cost of developing new products in the oil refining industry.

Declarations

The manuscript has not been submitted to any other journal or conference.

Study Limitations

There are no limitations that could affect the results of the study.

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HYDRODYNAMIC BASES FOR CALCULATING THE MOTION OF TWO-PHASE SYSTEMS IN COMPLEX PIPELINES

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ABSTRACT

Taking into account the conditions for the development of an oil field for different layers, the pipeline networks are different. Based on hydromechanics of homogenous fluid and gas, a new model of two-phase systems movement of fluid-gas type in horizontal tubes is suggested and the major calculation formula for complicated pipelines developed. Constructing a complex system of pipelines transporting both single-phase and two-phase systems, first of all, it is necessary to take into account the location of wells in the field, their initial and final flow rates, as well as the physicochemical properties. This method enables to define the main parameters of complicated pipelines considering the physical properties of two-phase systems.
The equation of two-phase systems movement in simple and complicated pipelines, aliowing recommending using this approach in flied experience is obtained as well.
Keywords: shear stress, complicated pipeline, multiple connection, diameter, volumetric fluid and gas discharge.

Introduction

Oil fields in the world are located in different climatic zones, wells have different depths and physical and chemical properties of oil, gas and water, which is the basis for an individual approach in the development of projects for their development. Practice shows that the system for collecting and transporting oil, gas and water is a separate branched network of pipelines attached to the territories of the fields. These are underground, aboveground, underwater and surface pipelines. Taking into account the conditions for the development of an oil field for different layers, the pipeline networks are different. So, for the fields of republic, the total length of all pipelines applied underground exceeds more than 30 thousand km. The geometric dimensions of such pipelines vary widely from 0.1 to 1.02 m.
Basically, small-diameter pipelines (flow lines) are laid from the wellhead to group metering units. Large-diameter pipelines transport fresh water for the purpose of flooding the oil reservoir to maintain reservoir pressure in them, which increases the oil recovery factor.

Statement of the problem.

The movement of homogeneous liquids and gases in pipelines on a hydrodynamic basis plays an important role in improving the transportation process. At the same time, in this article, considering the physical properties of two-phase systems, it is important to determine the main parameters of the movement in complex pipelines, and it is important to review the methods for adjusting the movement. Determining the practical use of the equations of motion in different

pipelines in two-phase systems is an important issue in definition the advantages in the transportation system.

Solution of the problem.

The results of the analysis show that all pipelines transporting single-phase (oil, gas, fresh or formation water), two-phase (oil and gas) or multi-phase (oil, gas and water) systems are tested for capacity, i. e. hydraulic resistance as well as mechanical strength.

Practice shows that for all work on the collection, transportation and treatment of oil, gas and water in a complex field development project, the location of the main oilfield facilities and communications is provided, the construction of which consumes about 50% of the capital investments allocated to the oil industry [1-4].

It is known that pipelines transporting well products on the territory of oil fields are divided into the following categories: by purpose - oil pipelines and gas pipelines, oil and gas pipelines; by the nature of the movement - with the joint movement of watered and non-watered oil; by the nature of pressure - pressure and non-pressure; according to the method of laying - underground, above-ground, underwater and suspended; by function - flow lines, prefabricated and commodity collectors; according to the hydraulic scheme of work - simple without branches, complex - with branches, which include parallel, ring and closed pipelines.

For these pipelines provided for in the complex project, hydrodynamic calculations are required. Basically, prefabricated collectors transporting gas-liquid mixtures such as oil and gas must be designed and calculated taking into account the rate of drilling of production wells, as well as the climatic conditions of the given field.

Numerous hydraulic calculations show that the rate of well commissioning affects the choice of rational diameters of prefabricated collectors. So, at low rates of putting into operation wells with a small flow rate in offshore conditions, they should be designed as two prefabricated collectors, equal in cross-sectional area to one large one, designed for the maximum productivity of all operated wells.

At high rates of well operation, it is possible to design and build one common system, i.e. one prefabricated manifold designed for maximum productivity of all connected wells [5-7]. When constructing a complex system of pipelines transporting both single-phase and two-phase systems, first of all, it is necessary to take into account the location of wells in the field, their initial and final flow rates, as well as the physicochemical properties of hydrocarbons produced from various productive horizons. Taking into account the location of wells in an oil field, the depth of the sea, the topography of the seabed and the climate makes it possible to select rational routes for all pipelines.

Results and discussion.

Basically, hydraulic calculations are performed for simple and complex pipelines transporting both single-phase and multi-phase systems.

The hydraulic calculation of a simple pipeline is reduced to determining its throughput, the initial pressure and diameter of the pipeline is necessary. Complex pipelines can be of various diameters along the line and branch.

In the hydraulic calculation of complex pipelines, four cases that are often encountered in field conditions are of practical interest.

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1. Distribution manifold with constant diameter for uniform and uneven selection of hydrocarbons.
2. Collector having a constant or variable diameter for uniform or non-uniform flow of fluids.
3. Common collection manifold forming parallel pipelines (lupings).
4. The general prefabricated collector, having the shape of a ring.

The movement of fluid flows in various pipes and under various conditions is defined as follows.

Sudden expansion.

When the fluid flow passes from the narrow part of the horizontal pipeline to the wider part, it is subjected to intense rotational motion. Liquid particles in such a swirling (eddy) movement are in active friction both against the walls of the tube and with each other (Fig. 1). Frictions cause a sharp loss of energy in the flow. Due to the influence of inertial forces on the flow, vortices are extinguished at some distance from the suddenly expanded part, the pressure gradually increases, the velocity pressure and the total pressure decrease.

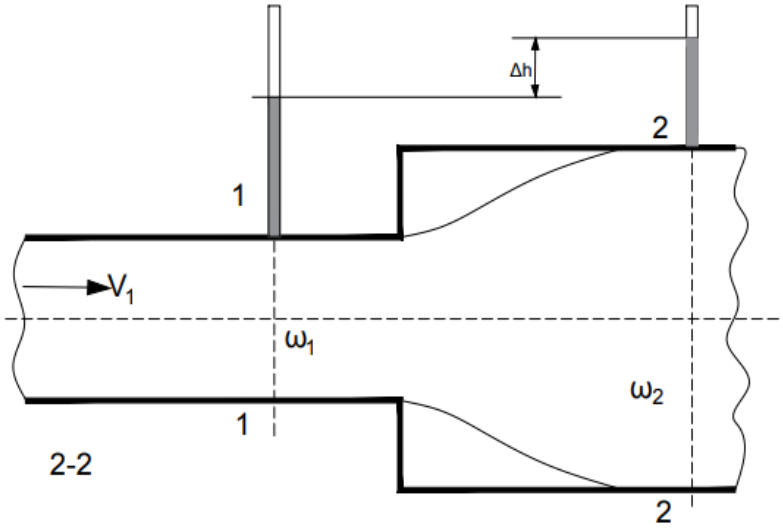

Figure 1. Fluid rotation in suddenly expanded parts.

In order to determine the pressure loss, let's write the Bernoulli equation for sections 1-1 and 2-2 according to Fig. 1:

$$\frac{p_1}{\gamma}+\frac{v_1^2}{2g}=\frac{p_2}{\gamma}+\frac{v_2^2}{2g}+h_{1-2}$$

From here, the following expression for the pressure loss is obtained:

$$h_{1-2}=\frac{p_1-p_2}{\gamma}+\frac{v_1^2-v_2^2}{2g}=\Delta h+\frac{v_1^2-v_2^2}{2g} \quad (1)$$

The value of the pressure difference is recorded again from a mnemonic or from a block of piezometers.

The expressions for the local resistance coefficient are:

according to the first gear

$$\zeta_1=\frac{2g\,h_{1-2}}{v_1^2} \quad (2)$$

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according to second gear

$$\zeta_1 = \frac{2g\,h_{1-2}}{v_2^2} \tag{3}$$

Analytical pressure loss can be calculated based on the Bordo-Carnot theorem:

$$h_{1-2}^{*} = \frac{(v_1 - v_2)^2}{2g} \tag{4}$$

Using the continuity equation and Weissbach's formula, we get the following for the local resistance coefficient:

$$\zeta_1^{*} = \left(1 - \frac{S_1}{S_2}\right)^2 \tag{5}$$

and

$$\zeta_2^{*} = \left(\frac{S_2}{S_1} - 1\right)^2 \tag{6}$$

Here, S_1 and S_2 are the cross-sectional areas of narrow and wide pipes, respectively.
A sudden contraction.

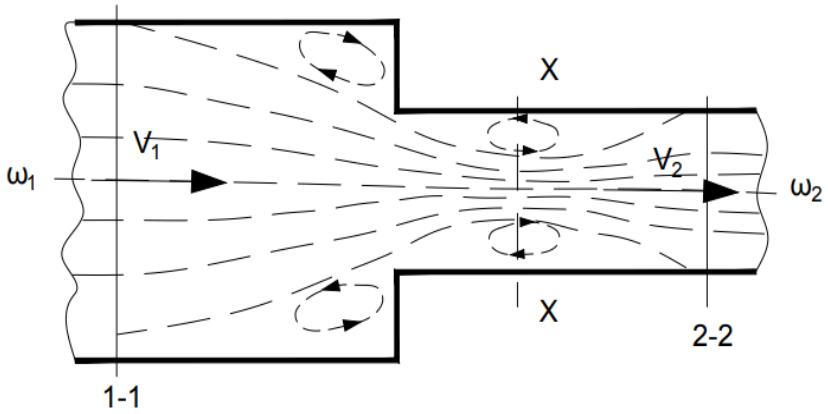

Figure 2. Swirling of liquid in suddenly narrowed sections.

In the case of a sudden narrowing of the flow, some of the liquid particles are separated from the general flow, forming vortex zones and joining the rotation movement (Fig. 2).
Although the number of such zones is greater than in the expansion process, the pressure loss is less. It is the compression of the flow that causes the eddies to form before the constriction. In the next short section, due to the inertial force of the liquid particles, the continuation of the movement towards the center of the flow also creates vortex zones.
The pressure loss and the local resistance coefficient can be determined experimentally by formulas (1-3). Theoretically, the local resistance coefficient can be determined by the following formulas proposed by I. Idelchik:

$$\zeta_1^{*} = \frac{1}{2}\left(\frac{S_1}{S_2} - 1\right)\frac{S_1}{S_2} \tag{7}$$

$$\zeta_2^{*} = \frac{1}{2}\left(1 - \frac{S_2}{S_1}\right) \tag{8}$$

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Pressure loss is calculated based on Weisbach's formulas (5) and (7):

$$h_{1-2}^{*} = \zeta_1^{*} \frac{v_1^2}{2g} \quad (9)$$

In this paper, based on the hydraulic laws of a homogeneous liquid and gas, a model for the movement of a two-phase mixture in a pipeline is proposed and the main calculation formulas for complex pipelines are obtained. It is known that the joint transport of two-phase hydrocarbon systems through pipelines is common in the oil and gas industry. The complexity of the hydrodynamic processes that occur during the movement of the oil and gas system, which differ from calculations for a single-phase flow, is the reason that this problem has not yet found its satisfactory solution.

Processing the results of numerous theoretical and laboratory-experimental works of the classics in hydraulics of multiphase systems A. I. Guzhova, A. A. Armanda, S. I. Kosterina, S. S. Kutateladze, V. A. Mamaeva, K.J. Xoqsidorna, G. Uollisi and others within the following parameters: [8-10]. Gas Frode Fr_q =0.15-3246; Froude liquid Fr_j = 0.0005-134.12; Reynolds Gas Re_t =211-67500; Reynolds liquid Re_j =404-18886 and with a pipe diameter D=0.02-0.05 m for various liquids, the dependence was obtained

$$\tau_c = \tau_j + \tau_r + k\sqrt{\tau_j}\tau_q \quad (10)$$

where τ_c is the shear stress during the movement of a two-phase system;

τ_j, τ_r- are, respectively, the tangential stresses of the liquid and gas;

k -experimental parameter.

Laboratory analysis shows that this experimental parameter depends on the ratio of liquid and gas densities.

For water-air system $k = \sqrt{\frac{p_j}{\rho_q}} = 26$, for other liquids $k = \sqrt{\frac{\rho_j}{p_q}} == 26 \div 33$ depending on physical and chemical properties of liquid and gas. A complete study of this model is given in [3].

$$\Delta p_c = \Delta p_j + k\sqrt{\Delta p_j}\sqrt{\Delta p_q} \quad (11)$$

where Δp_c is the loss of pressure due to friction during the movement of a two-phase system;

Δp_j; Δp_q - respectively, the friction loss during the movement of a homogeneous liquid and gas.

Taking into account separate parameters for liquid and gas, respectively, we obtain:

$$\frac{\Delta P_c}{L} = \lambda_j \frac{v_j^2}{2D}\rho_j + \lambda_q \frac{v_q^2}{2D} p_q + k\sqrt{\lambda_j \frac{v_j^2}{2D}\rho_j \lambda_q \frac{v_q^2}{2D}\rho_q} \quad (12)$$

where λ_j; λ_q - respectively, the coefficients of hydraulic resistance for a homogeneous liquid and gas;

$v_j; v_q$ - respectively, the reduced velocity of liquid and gas;

ρ_j; ρ_q - respectively, the density of liquid and gas;

D - is the inner diameter of the pipe;

L - is the length of the pipeline.

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When calculating the hydrodynamics of pipelines, the Chezy formula is often used. We accept this equation for a homogeneous liquid and gas

$$\lambda_j = \frac{8g}{c_j^2} \text{ и } \lambda_q = \frac{8g}{c_q^2};$$

where c_j and c_q are the Chezy coefficient for liquid and gas, respectively;
g - is the free fall acceleration.
After simple transformations, we get

$$\frac{\Delta P_C}{\rho_j g} \cdot \frac{D}{4L} = \frac{v_x^2}{c_j^2} + \frac{v_x^2}{c_q^2} \cdot \frac{\rho_q}{\rho_j} + k\sqrt{\frac{v_j^2}{c_j^2} \cdot \frac{v_q^2}{c_q^2} \cdot \frac{\rho_q}{\rho_j}} \quad (13)$$

Let us introduce the volume-flow rate gas content into this equation:

$$\beta = \frac{v_q}{v_q + v_ж} \quad (14)$$

It is known that the reduced velocity of liquid and gas, respectively, can be determined by the formula:

$$v_j = c_j\sqrt{RI_j} \quad \text{and} \quad v_j = c_j\sqrt{RI_q} \quad (15)$$

where I_j and I_q are the hydraulic slope for liquid and gas;
R- hydraulic radius.
Then

$$\frac{\Delta p_c}{\rho_j} \cdot \frac{D}{4L} = \frac{v_j^2}{c_j^2} \cdot \left(1 + \frac{I_q}{I_j} \cdot \frac{\rho_x}{\rho_x} + k\sqrt{\frac{I_q}{I_j} \cdot \frac{\rho_x}{\rho_x}}\right) \quad (16)$$

Denote the expression enclosed in brackets through the parameter

$$A = 1 + \frac{I_q}{I_j} \cdot \frac{\rho_г}{\rho_j} + k\sqrt{\frac{I_q}{I_j}\frac{\rho_q}{\rho_j}} \quad (17)$$

This expression makes it possible to determine the volumetric flow rates of individual phases. So, for liquid it is

$$Q_j = v_j s = k_j\sqrt{\frac{I_j}{A}} \quad (18)$$

where k_j is the liquid flow characteristic.
Then,

$$Q_j = k_j\sqrt{\frac{h_j}{L}} \cdot \frac{1}{\sqrt{A}} \quad (19)$$

where h_j is the hydraulic head of the fluid.
Often in difficult offshore conditions it is recommended to build parallel pipelines, for which

$$Q_j = Q_{j_1} + Q_{j_2} \quad (20)$$

Then, taking into account (10) and (11), we obtain

$$Q_j = k_{j_1}\sqrt{\frac{h_{j_1}}{L_1}} \cdot \frac{1}{\sqrt{A_1}} + \sqrt{\frac{h_{j_2}}{L_2}} \cdot \frac{1}{\sqrt{A_2}} \quad (21)$$

Conclusion

As can be seen, using this method, it is possible to determine the main parameters for complex pipelines, taking into account the physical properties of two-phase systems.
This technique can be applied to other complex pipelines. Given the simplicity and validity of this technique by the laws of hydromechanics of a homogeneous liquid and gas, it can be recommended for widespread use in field conditions.

Declarations

The manuscript has not been submitted to any other journal or conference.

Study Limitations

There are no limitations that could affect the results of the study.

Acknowledgment

The author would like to express gratitude to the care support workers and elderly individuals who participated in this study, sharing their invaluable insights and experiences. Their cooperation and openness have significantly contributed to the depth and richness of the research findings.

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IMPROVING THE VERIFICATION METHOD FOR MEASURING THE QUALITY OF PETROLEUM PRODUCTS IN CONDITIONS OF INSUFFICIENT INFORMATION

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ABSTRACT

Any object, process or service must be fit for purpose and intended use, i.e., solve specific problems of the customer who purchases them. The laboratory shall apply appropriate methods and techniques for all laboratory activities and, where necessary, for estimating measurement uncertainty, and statistical methods for data analysis. Conducting method verification is a necessary process for testing laboratories.
The main criteria for verification:
1) calibration or evaluation of bias and precision using standards or standards samples.
2) systematic assessment of factors influencing the outcome.
3) checking the robustness of the method by changing controlled parameters such as temperature in thermostat, dosed volume:
4) comparison with results obtained using other validated methods:
5) inter-laboratory study.
Verification is the provision of objective evidence that a given object fully satisfies the established requirements. If we consider a measurement technique as an object, then verification is the process of confirming that the technique meets the requirements established for it, primarily the requirements for obtaining results from it of the required level of quality (in other words, providing reliable information).
Keywords: verification of method, quality control, statistic error, certified reference material, Karl Fischer analyzer, inter-laboratory study, z-score, recovery.

Introduction

This article will propose an improved verification methodology for monitoring the quality of petroleum products under the condition of insufficient information. The standard procedure for determining water by the Karl Fischer method will be reviewed. The Standard Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration covers the direct determination of entrained water in petroleum products and hydrocarbons using automated instrumentation. This method uses Karl Fischer titration to determine the amount of water in a sample. A coulometric apparatus is used to generate iodine for the Karl Fischer reaction at the anode. When all the water has been titrated, excess iodine is detected by an electrometric end point detector and the titration is terminated. Based on the

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stoichiometry of the reaction, 1 mole of iodine reacts with 1 mole of water; thus, the quantity of water is proportional to the total integrated current according to Faraday's Law.

Problem statement

To begin with, a diesel sample must be analyzed for water content (mg/kg) on one day and on different days. Below are tables with data obtained by various operators on one day and on different days:

Table 1. Water content results in the same date.

Water Content								
Same Date Results								
Result No	Date	Operator 1	Date	Operator 2	Date	Operator 3	Date	Operator 4
		mg/kg		mg/kg		mg/kg		mg/kg
1	20/10/2023	48.3	20/10/2023	49.1	20/10/2023	40.1	20/10/2023	46.9
2	20/10/2023	49.2	20/10/2023	46.5	20/10/2023	43.7	20/10/2023	40.8
3	20/10/2023	43.5	20/10/2023	51.2	20/10/2023	48.6	20/10/2023	47.5
4	20/10/2023	44.8	20/10/2023	52.0	20/10/2023	51.3	20/10/2023	50.5
5	20/10/2023	50.6	20/10/2023	39.5	20/10/2023	51.1	20/10/2023	41.9
6	20/10/2023	46.1	20/10/2023	41.2	20/10/2023	47.0	20/10/2023	49.6
7	20/10/2023	46.4	20/10/2023	43.9	20/10/2023	40.8	20/10/2023	46.0

Table 2. Water content results in different dates.

Water Content								
Same Date Results								
Result No	**Date**	**Operator 1**	**Date**	**Operator 2**	**Date**	**Operator 3**	**Date**	**Operator 4**
		mg/kg		**mg/kg**		**mg/kg**		**mg/kg**
1	01/10/2023	48.3	01/10/2023	49.1	01/10/2023	40.1	01/10/2023	46.9
2	04/10/2023	49.2	04/10/2023	46.5	04/10/2023	43.7	04/10/2023	40.8
3	12/10/2023	43.5	12/10/2023	51.2	12/10/2023	48.6	12/10/2023	47.5
4	15/10/2023	44.8	15/10/2023	52.0	15/10/2023	51.3	15/10/2023	50.5
5	17/10/2023	50.6	17/10/2023	39.5	17/10/2023	51.1	17/10/2023	41.9
6	20/10/2023	46.1	20/10/2023	41.2	20/10/2023	47.0	20/10/2023	49.6
7	22/10/2023	46.4	22/10/2023	43.9	22/10/2023	40.8	22/10/2023	46.0

Let's add ANOVA to the calculation of repeatability and reproducibility to obtain more accurate results and introduce a comparison of the repeatability and reproducibility of the method with the repeatability and reproducibility calculated in the laboratory.

Table 3. Data table - Same day studies.

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DATA TABLE - Same day studies				
Result No	**Operator 1**	**Operator 2**	**Operator 3**	**Operator 4**
Average (X_{lab})	46.99	46.20	46.09	46.17
STD (S_{lab})	2.51	4.87	4.64	3.65
Relative STD (%RSD)	5.34	10.54	10.06	7.90
$S_{lab\ max}$	4.87			
In-laboratory repeatability (Slab max*2,8)	13.64			
AVERAGE	46.36			
Method repeatability	14.69	Repeatability (r): 0.9810*X^0.7055 according to the method		
Random error	INSIGNIFICANT	Note: The amount of error must be INSIGNIFICANT, so laboratory r < method r		

To test theories in the case of analysis of variance, the F distribution is used. The F statistic only accepts positive or zero values. In the case of one-way analysis of variance (ANOVA), it implies that the means of the totality from which the samples were drawn are equal, in other words, they all belong to the same totality and the differences are random.

Table 4. ANOVA data table - Same day studies.

Source of Variation	SS	df	MS	F stat	P-value	F crit
Between Groups	3.69	3	1.23	0.07	0.97	3.00
Within Groups	388.93	24	16.21			
Total	392.62	27				
Since Fcrit> Fstat so results are appropriate.						

Table 5. Data table - Different day studies.

DATA TABLE - Different day studies				
Result No	**Operator 1**	**Operator 2**	**Operator 3**	**Operator 4**
Average (X_{lab})	47.80	45.06	46.87	46.16
STD (S_{lab})	2.86	3.84	3.54	4.93
Relative STD (%RSD)	5.97	8.52	7.55	10.69
$S_{lab\ max}$	4.93			
In-laboratory reproducibility (Slab max*2,8)	13.81			
AVERAGE	46.47			
Method reproducibility	35.05	Reproducibility (R): 2.3362*X^0.7055 according to the method		
Random error	INSIGNIFICANT	Note: The amount of error must be INSIGNIFICANT, so laboratory R < method R		

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Table 6. ANOVA data table - Different day studies.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	28.17	3	9.39	0.63	0.60	3.10
Within Groups	358.61	24	14.94			
Total	386.78	27				

Next, we will calculate the systematic error using CRM (certified reference material). Systematic measurement error is a component of measurement error that remains constant or changes naturally with repeated measurements of the same physical quantity. A reference material (RM), one or more defined properties of which have been established by a metro logically procedure, accompanied by RM certificate giving the value of that property, the uncertainty, and a metrological traceability statement.

The solution of the problem.
Identification of systematic error by using Certified Reference Material (CRM):

Table 7. Identification of Systematic Error.

Test No	Results, mg/kg
1	989.4
2	976.3
3	992.0
4	988.9
5	984.2
6	983.9
7	981.6
8	974.0
9	993.9
10	998.2
Average	986.2
Bias	3.2
Standard deviation	7.7
n	10
√n	3.2
STD/√n	2.4
Bias/(STD/√n)	1.3
t_{test}	1.33
t_{table}	2.23

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Certified value	983.0
Certificate Uncertainty	N/A

Bias is the absolute value of the difference between the real value and the average value. If $t_{test} \leq t_{table}$, the bias is insignificant at 95% confidence level, If $t_{test} > t_{table}$, the bias is significant.
The next step in method verification is to determine the influence of systematic error due to participation in inter-laboratory trials. Here the statistics of participation and the obtained z-scores should be considered; the systematic error will not be significant if the z-scores are within the limits < ±2. A z-score (also called a standard score) gives you an idea of how far it is from the meaning of a data point. More technically, it is a measure of how many standard deviations below or above a given totality the raw score means.
Identification of systematic error by recovery:

Table 7. Identification of Systematic Error by Recovery.

Test No	Results, mg/kg
1	990.6
2	986.4
3	983.9
4	985.0
5	988.7
6	984.2
7	992.0
8	980.1
9	988.5
10	979.3
Tests result (Xmeas)	985.87
Recovery (%R)	100.2919634
Known value of CRM (XCRM)	983.0
Systematic error	INSIGNIFICANT

Recovery = (Measured Value/Known Value) *100

If the Recovery (%R) is ≥80 and≤110, systematic error is insignificant. If the Repeatability Found in the Laboratory in Same-Day and Different-Day processes are smaller than the repeatability and reproducibility values given in the method, then the result = "PASS". The method is valid (verified), because the repeatability, accuracy and reproducibility values are in compliance with the values specified method.

Conclusions

Based on the data obtained as a result of method verification, we can come to the following conclusions:

1. By introducing comparisons of reproducibility and repeatability between the results calculated in the laboratory and the data of the method in conditions of insufficient information or with a smaller amount of information, that is, on the basis of statistical data, it is possible to evaluate the method, thereby increasing the accuracy of measurements of the quality of petroleum products.
2. The introduction of ANOVA makes it possible to compare the systematic errors of groups of results and evaluate the method more accurately, also on the basis of statistical data.
3. It is possible to identify systematic errors using a CRMs or on the basis of inter-laboratory studies.
4. The recovery test showed that only using a standard sample can evaluate the method, knowing only the certified value, understand how possible it is to obtain a given result.
5. In conclusion, it can be noted that method verification is a strictly mandatory process for testing laboratories; to evaluate a method, there are various verification methods, but if there is insufficient information, statistical control will be more optimal, as well as all the methods listed in this article.

Declarations

The manuscript has not been submitted to any other journal or conference.

Study Limitations

There are no limitations that could affect the results of the study.

Acknowledgment

The author would like to express gratitude to the care support workers and elderly individuals who participated in this study, sharing their invaluable insights and experiences. Their cooperation and openness have significantly contributed to the depth and richness of the research findings.

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HISTORICAL BACKGROUND OF IRAVAN KHANATE

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ABSTRACT

The great ancestors of Azerbaijanis lived in the territory of the present Republic of Armenia in the VIII-VII centuries BC. Since ancient times, powerful states of Azerbaijanis have replaced each other in these lands, written a rich political history and created a rich cultural heritage. At that time, Armenians still lived in Asia Minor. Since Armenians did not come to the territory of present-day Armenia, there are no ancient toponyms in the Armenian language. Only during the period of Karagoyunlu, the center of the Armenian-Gregorian Church was moved to Uchmuazzin near Yerevan. Mass resettlement of Armenians trying to establish their statehood in Asia Minor and Ottoman lands to Azerbaijani lands took place in 1828. All this is reflected in Article XV of the Turkmenchay Treaty. A.S. Griboyedov wrote about this in his notes: "It is necessary to transfer all Armenians from the regions occupied by the Russian army - Tabriz, Khoy, Salmas, Maragha to Nakhchivan, Iravan and Karabakh provinces."

Introduction.

However, let alone the previous centuries, even in the last century the names of the villages whose population consisted entirely of Armenians and a number of villages where Armenians and Azerbaijanis lived together were in Azerbaijani. All this shows that Armenians began to live in those villages later, because the mentioned villages did not have Armenian names [12].

The Blue Mosque, built in memory of Jahan Shah by his wife Khatun Janbeyim in Tabriz, is a masterpiece of 15th century Azerbaijani architecture. It is no coincidence that Taverniyen called it "Turquoise of Islam". It is not by chance that this mosque was built in 1465 by the skilled Azerbaijani architect Nematulla. At that time, Haji Ali Hafiz, who built the famous madrasa in Herat, Ahmed Shamistan, who built the Majnun Shah Mosque in Mashhad, and Bibi Khanim Mosque in Samarkand, were famous not only in Azerbaijan, but throughout the East [13].

Main part.

Located north of the Araz River, the Iravan khanate bordered Iran, Turkey, Georgia, as well as the khanates of Ganja, Karabakh and Nakhchivan. The khanate, which united one city and 521 villages, was divided into the districts of Kirkhbulag, Zangibasar, Garnibasar, Vedibasar, Sharur, Surmeli, Deraken, Saatli, Talin, Seyidli-Akhsakhli, Sardarabad, Karpibasar, Abaran, Darachichak, Goycha [18]. Shoragil sultanate and Pambak province located in the north of the khanate also belonged to the Iravan khanate. The total area of the khanate is 21,554 square meters. verst was [14]. The population (excluding Pembak-Shoragil) was 17 thousand families [18] and about 90,000 (in some sources 115 thousand) [16] people. About 16,000 of this population were Muslim Kurds (2,924 families), 20,073 Armenians, 324 Yezidi Kurds, and the rest, i.e. 59%, were Azerbaijanis [18].

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The Khanate's troops consisted of two battalions of horsemen and several six-pounder field guns. In addition, there was special artillery of fortresses [18].

The list compiled by priest Hovhannes Shahkhatuna answers the question of who ruled the Yerevan Khanate from 1441 to 1828.

In the works of Jean Baptiste Tavernier, who came to Yerevan in 1655, it is mentioned that only Muslims live in the city fortress. The toponyms in these sentences, which Sharden wrote at the same time, in the same road notes, are proof of another reality. The land of the city is watered by the Qirkhbulag rivers flowing from the southwest and the Zangi rivers flowing from the northwest. Sardar's palace is a very beautiful, magnificent building. A thousand paces away, a tower rises up, it is called "Kechi Galasi(it means Goat Castle)" here.

After Tavernien and Chardin, European travelers such as Gemelli, Ger-Perter, James Morien, Montperaud, Cameron, Lynch, Dubois and others also visited Irevan Castle, Khan's Palace, which was built with high craftsmanship and rich in remarkable and pleasing architectural monuments, the Khan's Palace, its name "Shushabandi". They described with exceptional admiration the famous hall with mirrors, thousand and one ornate mosques in the castle, swimming pool and baths, the underground road with marble steps leading down to the Zangi river, the mansions in the city around the castle, the caravanserai and the squares.

From the end of the 14th century, it was recognized as the administrative center of the 15th century. Due to its geographical location and local conditions, during the rule of the Garagoyunlu (1410-1467) and Aggoyunlu (1467-1500), its name was widely spread and it was the administrative center of the Chukhursad province. A tomb still standing in the village of Jafarabad, adjacent to the city, is a relic of that period.

The tomb was built of baked bricks and stones. The names of Amir Said and his son Pir Husayn are mentioned in his inscription. Before Huseyin Pir Yaqub Bey, he was the emir of Chukhursad province. The inscription also mentions the leadership of Gara Yusif (1410-1420), the head of the Karagoyunul dynasty, and it is mentioned that his son Pir Budag was a great ruler. Undoubtedly, the tomb was erected in connection with the decree issued by Kara Yusif to place his son Pir Budag on the royal throne in Tabriz after defeating the Timurids and capturing the lands of Azerbaijan, Georgia, Armenia, and Arab Iraq south of Kur [13].

In the first volume of the ten volumes of the French traveler Jean Chardin, who visited Yerevan in 1683, it is shown that the Yerevan fortress can be considered a small city. There are 800 houses in the castle. Only Turks live here [9].

Armenian historian V. Parsamyan writes: "It is an undeniable fact that Armenians did not live in this area as a whole during the period when the South Caucasus was annexed to the Russian Empire."

The statistical collection of the Central Statistical Office of Armenia published in 1962 shows that in 1831, 15,992 (85.2%) of the 18,766 inhabitants of Yerevan were Azerbaijanis [10].

The neighborhoods, springs, rivers, gardens, mountains and hills of Yerevan have preserved their names among the people. Issue. According to Chopin's information, there were three large neighborhoods of Yerevan in the 18th century. City, Tepebaşı, Demirbulag. Those neighborhoods with the same name are still considered the biggest neighborhoods of the city. The neighborhoods of sila dyers, soap makers, and blue fabric dyers described by 18th century travelers still bear the names "Shilachi", "Sabunchu", "Boyagchi" as before.

The following facts once again prove that the Azerbaijani language, not Persian, Arabic, or Armenian, has a superior influence and is widespread in Irevan, as well as in the entire territory

of the khanate. The letter of Matenadara kept in the archival fund was written by priest Gukas in 1784. In the letter, a list of seeds sent to Georgia to Irakli II, Beyazid, Isaac Pasha was given, and the quantity and price were indicated. Although it may seem strange, it is a fact that this priest, who is a master of the Armenian language, wrote the names of almost all seeds in Azerbaijani: wheat, watermelon, black watermelon, alfalfa, cucumber, spinach, basil, eggplant, rose...etc.

Place names are given in this order in all works, even in textbooks, where there is a discussion about the territory and borders of the khanate. From the Arpa River to the village of Gizil Church - from the village of Haji Bayramali to the mountain of Gabir... from the mountain of Koroglu to Arazboyu to Nakhchivan, to Sharur... Or let's consider the names of the districts included in the khanate: Kirkhbulag, Vedibasar, Sharur, Sürmeli, Saatli, Seyidli, Sardarabad, Talin, Zangibasar, Abaran, Derachichek, Derakand, Garnibasar, Goyche.

There is very little information about the ancient history of Yerevan. One of the reasons for this is the 366 years of intermittent wars between the Iranians and the Ottomans, the city changing hands 14 times and finally being destroyed in the 1679 earthquake. The first and relatively accurate information about the number and national composition of the population living here was provided by I. Chopin gave. According to his calculations, 2,400 families and 12,000 people lived in Yerevan during the time of the last Sardar. After the city was taken over by the Russians, some of the local Kubar families moved to Iran, and Armenians returned here from Iran and Turkey. At the end of the war, the national composition of the population was as follows: Azerbaijanis - 1807 families, 7331 people, Armenians - 567 families, 2379 people.

And in playing the trumpet they play very hard, but sometimes they play so loud that, to tell the truth, we have to stop our own ears and say to ourselves with horror: "What noisy nonsense we are hearing!" Probably, in order to show Kutuli how smart Armenians are and how well they manage to adapt to modern life requirements, they taught him some Armenian proverbs: for example, "What do you need to know who made this bread?" If it is tasty, even if it is cooked by a Jew, "eat it", or "live where you find bread!" It is quite legitimate that there is now a large field of activity for such sages. It is true that whoever follows such doctrines now wins, but I do not believe that he deserves praise and glory. On the contrary, these proverbs are a disgrace to the people who created them [5].

In the middle of the 18th century, the Iravan Khanate, a feudal state, was established in a large part of Armenia. The khanate covers the Ağrıdag valley, the shores of Lake Goycha and a large area extending southwest from the Araz river. The khanate consisted of 12 districts and these districts were headed by viceroys. Iravan Khanate was ruled by Hasanali Khan, Huseynali Khan, Gulameli Khan, Muhammad Khan, Aligulu Khan and other rulers in different years.

Historical facts confirm that Armenians came to the Caucasus and Eastern Asia much later. In fact, they never called themselves Armenians, they called their nationality "hay", "homeland", "Hayrenik". Turkic tribes called "Armenians" once lived in the territory of today's Armenia, and these territories were named "Armenia" after those tribes. The fact that the ethnonym "Armen" is a purely Turkish word also confirms what has been said. Later, the Hays who moved to these areas gradually settled in the lands of the local Armenian tribes and began to be called "Armenian", i.e. "Armenian", "Armenian" after the name of those areas [8].

"The territory of the Iravan Khanate is historically the homeland of Azerbaijanis. No matter how much the Armenians try to turn Yerevan into "Erebuni" in their own name, the historical facts tell the truth. This city was built in 1504 by Ravangulu Khan Shah Ismayil's suggestion. The last ruler of Iravan was Huseyngulu Khan (1828)" [1].

Armenians are greedy and covetous, seditious and confused, they don't like anyone. They have a talent for exaggerating a small matter, they love to create intrigue [1].

When Peter I, who marched to the Caucasus in 1721 and two years later occupied the Caspian territories of Azerbaijan, including Baku, saw the strong resistance of the local population, he launched the "Armenian card" and ordered the settlement of Armenians in the historical lands of Azerbaijanis, especially in Baku and Darbend. The historical testament addressed to the successors of Peter I formed the basis not only of the Russian Empire, but also of the Bolshevik repression in the South Caucasus. In 1768, Catherine II, who was the first to act on that situation, issued a decree on the ownership of the empire by Armenians. In 1802, Tsar Alexander I sent specific instructions to A. Sisianov, the viceroy of the Caucasus: "Armenians should be used at any cost to seize the Azerbaijani khanates." [2].

In the 18th paragraph of the instruction sent to Count V. Zubov, Tsarina Catherine II stated that the Iravan province, located on the border of the Ottoman state, and the entire upper part of the Araz river should be cleaned. He considered it appropriate to entrust this work to the Georgian Tsar Irakli II.

Georgian tsar Irakli was also inclined to occupy the Iravan fortress. However, he well understood that he could no longer take the Iravan fortress by his own strength, and he openly admitted that he would not be able to cope with this task without the military assistance of Russia.

Some Armenians living in the Iravan Khanate wrote letters to Irakli and tried to tempt him to attack Iravan. Armenians also addressed V. Zubov with such a letter. Zubov tried to convince Iraklin that he could attack Yerevan without worrying about Georgia's security when Russian troops were in Georgia.

The death of Tsarina Catherine II in November 1776 caused a change in the action plans of the Russian troops in Transcaucasia, and the attack on the Iravan Khanate was postponed. Russian troops were recalled from Transcaucasia by order of the new Tsar Paul I.

With the arrival of Russia in the Caucasus, its influence on the local khans began to increase. After the fall of Ganja, all the Muslim khans located east of Georgia began to become subjects of Russia one after another. Imeretia, Migrelia and Guria, which are located west of Georgia, have already accepted Russian citizenship, and the Abkhaz ruler has also started to lean towards Russia. Baba Khan tried to prevent this activity of Russia by all means. The judges of Yerevan and Nakhchivan also had a special role in the growth of Baba Khan's hatred towards the Russians. Thus, Mohammad Khan from Yerevan and Kalbali Khan from Nakhchivan, who were interested in deepening the contradictions between Russia and Iran, wanted to become independent. Muhammad Khan was appointed the judge of Iravan by his Safavids on the recommendation of Baba Khan's mother. Muhammad Khan, who aspired to independence, was able to attract Kalbali Khan from Nakhchivan, who was enmity with them, after being blinded by Agha Muhammad Khan, the representative of the Gajars who were in power in Iran. In such a situation, Muhammad Khan and Kalbali Khan were waiting for a favorable moment to realize their goals in their fortified fortresses [6].

Sisianov also focused on the subjugation of the Iravan Khanate. At that time, it was necessary for Russia to clash with Qajar Iran, and the marches to the Iravan khanate were considered in the thesis from the perspective of strategic goals.

An excuse was needed for the attack on the Iravan Khanate. Such an excuse is the case of Iravan Khan allegedly interfering in the religious affairs of Armenians - bringing David to the patriarchate of the Armenian church, seizing all the property of the Echmiadzin monastery.

However, Sisianov, who hoped to connect the territory of the khanate to Russia in an easy way, ended in fruitless negotiations with the ruler of Yerevan, Muhammad Khan, which led to the decision of the Russian troops to march into the territory of the khanate.

Although the Russians continued the siege of Yerevan from July 24 to September 2, 1804, no serious military operations were conducted by either side during this period.

During the second attack of the Russians on the Iravan Khanate and its fortress, serious changes had already taken place on both sides, Muhammad Khan was replaced by Huseyngulu Khan, and Sisianov was replaced by Gudovich. The defense of the Iravan fortress was strengthened with the help of England and France, who tried to remove the hand of Gajar Iran from the Caucasus, and serious quality changes took place in the Gajar army.

The Russian side, which had never given up on the plan to invade the Khanate of Iravan, was also making serious preparations for the upcoming operations. First, it was planned to capture Shurayel, an important strategic point on the road to Yerevan. Rich in grain, Shoreyel was important for the Russians both in terms of meeting the Russians' food needs and as a buffer zone on the border with Russia's Iravan Khanate and Ahalsikh Pasha during the wars with Qajar Iran and the Ottomans.

The second march of the Russians to the Iravan Khanate is already a test for the brilliance of other Azerbaijani generals Huseyngulu Khan and his brother Hasan Khan. In response to Gudovich's appeals for surrender, Hasan Khan said, "We are ready to fight with you not only inside the fort (it is not difficult), but also in the open field. Let it be known that the garrison of the fortress has already made its decision", his words clearly showed that he was determined not to give even an inch of the territory of the khanate to the enemy.

During the siege of the fortress, which lasted from October 3 to November 30, during the second march of the Russians to the Iravan Khanate, the bravery shown by the defenders of the fortress was a high example of the heroic struggle of the Azerbaijani people against the invaders. On the night of November 16-17, during the attempt of the Russians to attack the fortress, the brave defenders of Iravan killed the foreign invaders, the enemy was driven back with heavy losses, and this almost decided the fate of the entire march. The result of the third march of the Russians to Yerevan was also unsuccessful for the Russians.

Seversamidze, the head of Russian troops, wrote: "Armenians are more useful and loyal in peacetime" [11]. On July 16, Khan's troops counterattacked and entered Mirak (Shirak), and his brother Hasan Khan entered Shoragil. The Russian troops were forced to retreat after suffering heavy losses. "Ravan Sardar and his brother Hasan Khan freed the fortress of Abadan and put to the sword the Russians who escaped from there and took refuge in Garakilsa. Nomads from the region are moved to the Ravan side, and some villages of the Gyumru district are moved to the Ajam side. The princes are thinking of attacking Tiflis" [4]. Balığchay, Sadagachay, Garakilsa and other guard stations are destroyed. Hasan Khan's troops take control of the Gyumri road. Thus, Pembak and Shoragil are cleared of invaders for a short time.

At the end of 1826, the general staff developed two drafts of the next military campaign based on the opinion of Yermolov and Paskevich. According to the second project favored by Paskevich, the enemy was struck from an unexpected place, and the provinces of Yerevan and Nakhchivan were unexpectedly and completely separated from other provinces. The main blow was delivered to Tabriz. Yermolov demanded to be satisfied with occupying the Khanate of Iravan with the existing forces, to use Armenians in the fortresses, and to arm all Armenians in general. Then, passing through Meshkin province, Ardabil, Khalkhal and others were to be captured, thereby

bringing Talysh Khanate into submission [7]. Nikolay the first approved the project approved by Yermolov.

Paskeviçin İrəvan komendantı ilə görüşmək istəyinə cavab olaraq sərdar özü yazırdı: "Əgər söhbət qalanın təslim edilməsindən getmirsə icazə verirəm, əks halda bu mənasızdır. Mən qalanı heç vaxt təslim etmərəm". Qalanı ala bilməyəcəyinə əmin olan Paskeviç bu işdən vaz keçir. Şerbatova görə hətta qalanın mühasirəsi qoşunların qüvvəsi xaricində idi. Abbasabad və Sərdarabadda ələ keçirilən ərzaq və hərbi sursat rusları yarım il təmin etməyə imkan verirdi. Hətta Paskeviç bunsuz İrəvanın mühasirəsinin necə olacağını təsəvvür edə bilmədiyini bildirirdi [17].

İrəvanın alınması ilə bağlı Paskeviç I Nikolaya raportunda yazırdı: "...Mühasirə zamanı divarın altı qazılmış və artilleriya əla işləmişdir. Qurtuluş yolu tapmayanlar silahı atmış, digərləri müdafiə olunmaq istəmişlər. Lakin darvaza sındırıldıqdan sonra qala tam təslim olmuşdur" [3].

İrəvan müəllimlər seminariyasının müəllimi olan Şulgin bu məqaləni öz şagirdlərinin vasitəsilə ermənilərin yaşlı adamlarının verdiyi şifahi məlumatların əsasında yazılmışdır. Məqalədə XIX əsr rus tarixşünaslığına xas olan çar Rusiyasının Qafqazda apardığı əməliyyatların buradakı yerli xalqların İran və Türkiyənin əsrlər boyu biri-birini əvəz etməklə davam edən ağalığından, zülmündən azad etmək məqsədi daşıması xətti daim özünü göstərir. Müəllif rus ordusunun əzəmətindən, məğlubedilməzliyindən müəllif tərəfindən xüsusi vurğulanmaqla, İrəvanın alınmasında ermənilərin "xüsusi xidmətləri" də müəllif tərəfindən qeyd olunur.

Artıq 1827-ci ilin aprelində səhər əhalisi ailələri ilə birlikdə İrəvan qalasına köçür. Həsən xan isə süvarilərilə birgə Cəfərabadda mövqe tutmuşdu. Qalanın mühasirəsi 8 gün davam etmiş və oktyabrın 1-də ruslar tərəfindən alınır [19]. Paşkeviçlə əlaqəyə girən ermənilər qalanın müdafiəsindəki zəif yerləri ona bildirirlər.

On the 4th day of the siege, when Huseyin Khan wanted to leave the fortress in white clothes and attack the Russians on a white horse, he was dissuaded from this idea by some of the leaders of the fortress defense because he could be more easily hit by the enemy's bullets [19].

One year after the capture of Yerevan, Griboyedov's play "Gore ot uma" is staged for the first time in the hall of mirrors in the Sardar's palace [19].

The Sardar palace, two mosques, and several administrative buildings are located in the Iravan fortress. The castle is surrounded by a moat on three sides and two fairly high fences (walls). One side of the castle walls is steep and adjacent to Zangi river. On the right side of the river rises a mound called Mount Irakli, which was named after the Georgian Tsar Irakli's march to Yerevan. The castle walls are made of small stones and clay mixed with straw. Water was pumped underground to the castle from Zangi and Kirkhbulag rivers. There were 800 houses in the castle before it was occupied by Russia, most of which were destroyed during the occupation of the castle [15].

It was built by Huseyn Khan, located on the left bank of Araz with Sardarabad Castle, which is a little distance from Iravan Castle. Its 2-story castle walls are also designed for cannons with 10 bullets. There was a sardar's palace and up to 700 houses. There was 1 mosque, 16 mills, khan's garden, 1 dyehouse, 4 oil mills and 33 market places belonging to the Sardar [15].

On March 21, 1828, according to the decree issued by Nicholas I, the Nakhchivan and Iravan khanates were abolished, and in their place, the Armenian province was established in our ancient, ancestral lands. More than 40,000 Armenians were resettled here. The goal of the resettlement policy was to Armenianize the place. The Armenian province existed until 1850, and from that year it became the Iravan governorate.

Conclusion.
To sup up, Irevan was given to Armenia when the Azerbaijan People's Republic was established, precisely by the Azerbaijan People's Republic. Most of the people living in the Iravan Khanate were Azerbaijanis. All the inhabitants of Zangezur district were Azerbaijanis. So, from the historical point of view, this is our land.

Declarations
The manuscript has not been submitted to any other journal or conference.

Study Limitations
There are no limitations that could affect the results of the study.

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PLANNING MOBILE ROBOT BEHAVIOR IN AN UNCERTAIN MULTI-AGENT ENVIRONMENT

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ABSTRACT

The paper proposes an approach for safe navigation when changing lanes in a road scenario. The aim of this approach is to create the baseline value of the decision making module for the lane changing task with multiple agents to avoid collisions. The paper describes three models of the project. Model-1 is a working method for implementing modeling. Model-2 is a way to build a decision-making module using safe zones. Model-3 is the proposed way to build a decision-making module using value functions.
The paper presents a multi-agent approach to adjust traffic lights depending on traffic situations to reduce average delay time. The traffic lights of each intersection are controlled by a mobile agent. This approach creates a classical non-stationary environment, as each agent's decision affects neighboring agents. Therefore, each agent must not only learn from past experience, but also take into account the decisions of its neighbors to rule out dynamic changes in the traffic network. Fuzzy Q-learning and game theory are used to develop new policies based on previous experiences and decisions of neighboring agents. The results obtained from the simulation show the advantage of the proposed method over fixed time management, fuzzy Q-learning and fuzzy Q-learning methods.
Keywords: intelligent agent, behavior planning, goal planning, action planning, agent simulation, simulation simulation, neural network, fuzzy Q learning.

Introduction

Planning safe navigation for mobile vehicles depends on many factors. From this point of view, the topic of navigation planning can be classified into action planning, goal planning, behavior planning. Motion planning establishes the movement path of any vehicle, taking into account its dynamic parameters. The goal is to optimize the path to reach different control points taking into account the planning time, distance or the various maneuvers required. Behavior planning allows tactical management decisions to be made regarding the maintenance of distance, lane change and interaction with neighboring vehicles [1].
The aim of the work is to build a decision-making module based on value functions [2, 3]. The paper looks at planning the behavior of a multi-agent mobile vehicle under uncertainty conditions. Agent modeling is a relatively new method. Initially it was mostly the subject of theoretical considerations in academic circles, but since the 2000s researchers have started to use it in practice [4].
The task of simulation modeling in the agent approach is to describe the characteristics of the state of agents and the environment, to study the behavior of agents in various interaction situations and changing states of the environment. It is known that the simulation modeling

method is widely used to investigate complex dynamic systems. Research shows that this method is used when it is difficult to formulate a solved problem, when it is not possible to study the system, object, processes studied by analytical and numerical methods in sufficient detail. From this point of view, it becomes important to use new methods that make it possible to solve the problems of management of complex objects. One such method is the method of agent modeling. The essence of agent simulation is that the local behavior of agents operating according to their own rules shapes the overall behavior of the system as a whole (bottom-up design concept).

Existing agent architectures can be classified as follows:

1. Agent architectures based on the principles and methods of an intelligent system (IP) (advisor agent architectures).
2. Reactive architectures based on behavior and response to external environment events (reactive agent architectures).
3. Layered architectures based on behavior and methods IS (Hybrid Agent Architecture)

The organization of agent architecture based on the principles of artificial intelligence has advantages in terms of the availability of methods and tools of symbolic representation of knowledge developed within the framework of artificial intelligence, but at the same time, the creation of an accurate and complete model of the environment poses serious difficulties in representing the processes and mechanisms of justification. These types of architectures include

- Production system-based architecture
- Classification-based architecture
- Architecture with a hierarchical knowledge base etc.

The main advantage of the architectural agents listed above is the presence of a developed mental subsystem that forms the intellectual component of the agent.

Agent-centered modeling (AVM) is a modeling technique used to study and predict the formation of complex group behavior patterns by modeling the activity and interaction of many autonomous agents in specific scenarios [5-7].

Agent-oriented simulations are widely used in academia such as game theory, complex problem-solving, and information processing systems. Traditional motion planning and control methods such as PID regulation, linear feedback, or predictive modeling are designed to predict the future motion trajectories of other participants to avoid collisions, but real-world motion scenarios assume complex interactions between different participants (schwarting, Planning and Decision-Autonomous Vehicles, MIT, 2018). To solve this problem, they resort to action planning taking into account new trends - learning-based approaches and behaviors.

Agent-oriented modeling is a powerful method for modeling dynamic complex systems and observing their emergent behavior. Using this method, it is possible to model the movement scenarios of airplanes on the runway and the movements of robots in a manufacturing plant. Agent models are known to extend the application possibilities of simulation modeling to solve a number of problems that cannot be solved by system dynamics or event-driven modeling methods.

This approach differs from the traditional "top-down" approach to designing a simulation model, in which the behavior of system elements is determined by global laws. The behavior of the agent is determined by a set of rules. As a result of modeling, the final results of the activity of the entire socio-economic system can be predicted. This can be called a "bottom-up" approach: based on the behavior of individual elements of the system (individual agents) it is possible to infer the functioning of the whole.

From a practical point of view, agent modeling is a method that investigates the behavior of the modeled agents and how it affects the behavior of the whole system.
The reason for the high interest in this model is the wide range of possibilities and agility of the models.
In the context of agent technologies, a systematic analysis and a methodological concept of the management of weakly formalized multicomponent systems is prepared.

Statement of problem.
System modeling. Suppose it is necessary to plan the collision-free movement of given moving objects (n-objects). The structure of the management system is given in figure 1. Multi-agent systems use agent-cars and agent-regulators that interact with each other to minimize the stopping time of cars at intersections.

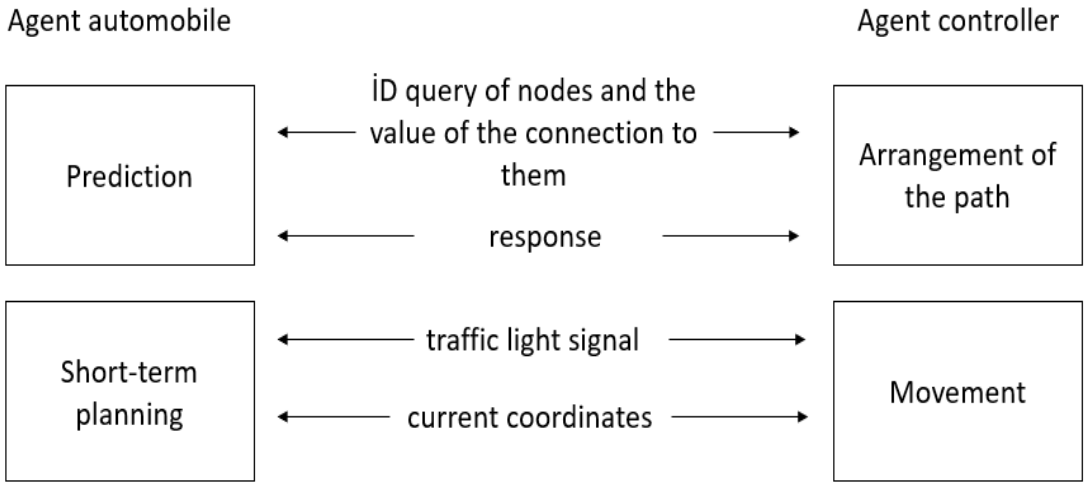

Figure 1. Agent-car and agents-regulator interactions in multiagent systems.

When cars start moving, each automobile agent calculates the optimal path obtained from the regulator in the exchange of information about the projected road situation. Regulatory agents provide this information on the basis of the results of their own forecasting system, which collects and analyzes the information coming to it during the agent's working time. The vehicle agent sends information to the regulatory agent about its position in the driving process, at which point it sends it to the intersection. Based on the overall assessment of the speed and position of all machines approaching it, the regulator decides to change the signal of the traffic light. In addition, regulators can exchange messages with neighbors to work together and create the optimal automotive flow.
In order to perform the task of planning vehicle behavior in an uncertain, multi-agent environment, a road model with intersections with a fuzzy controller is built in MATLAB package. A complete road map consists of several intersections [12, 13]. The full route of the vehicle consists of a set of roads/intersections on which it moves. Photo 2 shows the intersection of two roads. Four cars arrive at the intersection. During T, vehicles a (car 1 - blue), b (car 2 - green), c (car 3 - purple), d (car 4 - yellow) aim to cross the intersection in a straight line.

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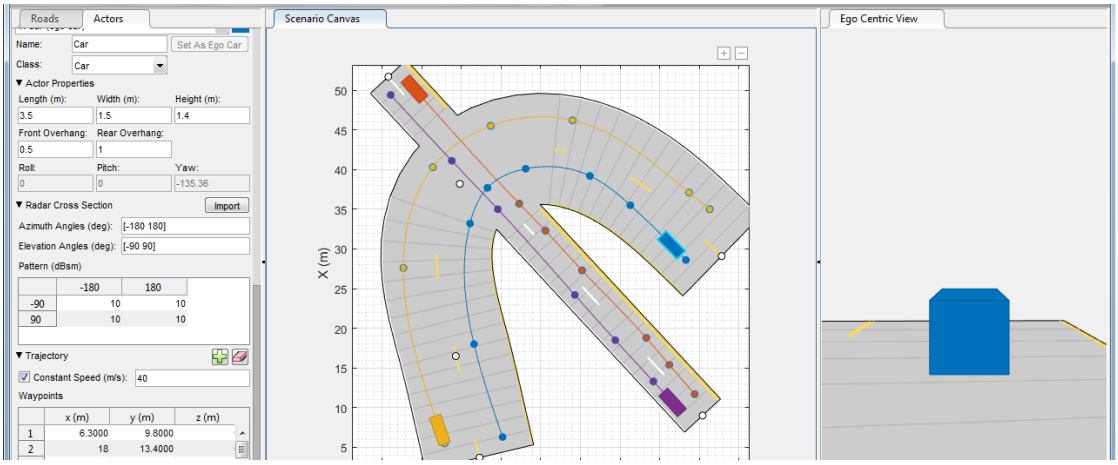

Figure 2. Initial situation. Showing the intersection of two roads.

As you can see from the figure, the movement in each of the possible directions is organized in a separate lane. This circuit was chosen because the inputs vary.
The parameters, i.e. the number of cars approaching the intersection for each lane, can change the configuration: by setting the number of cars to zero, a certain lane can be excluded from the model. This creates a cross-sectional pattern of arbitrary configuration. In the model created, in order to simplify the calculations, the traffic is chosen in such a way that the number of cars waiting to move in each lane increases with a certain probability at each specified time interval. At the same time, for each interval of the signal, the number of cars waiting at the stop line in the respective lane decreases. Let's look at Figure 3.

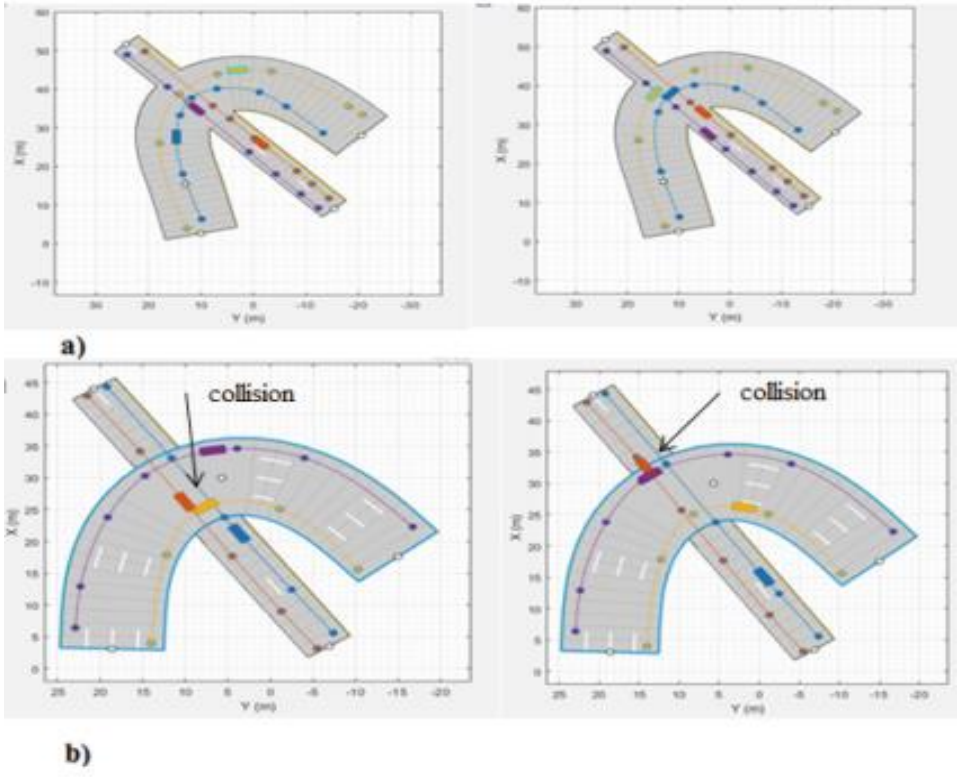

Figure 3. Vehicle traffic at the intersection. a) Normal movement of cars at an intersection. b) a collision event.

Cars approaching from below and from the right (Figure 2).3 (a)) move up, left and right respectively. In this case, the exit procedure is strictly determined - only the purple car on the left does not intervene, so the intersection passes first. The orange car does not move because the green car intervenes on the right. The yellow car cannot turn left and get ahead of the purple car moving from the opposite side. The blue car is likewise waiting for the interference on the right to disappear.

Conclusıon

This paper addresses the reactive control of an autonomous mobile robot that needs to safely navigate in a crowded and unknown environment to reach the desired goal. A successful way to structure the navigation task to solve the problem is to use behavioral approaches to navigation. In this study, questions related to the design of individual behavior will be solved using a fuzzy logic approach. Simulation results show that the fuzzy controller can effectively control every movement of the robot from its current position to its final movement.

Declarations

The manuscript has not been submitted to any other journal or conference.

Study Limitations

There are no limitations that could affect the results of the study.

Acknowledgment

The author would like to express gratitude to the care support workers and elderly individuals who participated in this study, sharing their invaluable insights and experiences. Their cooperation and openness have significantly contributed to the depth and richness of the research findings.

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RHEOLOGY OF VISCOPLASTIC FLUIDS

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ABSTRACT

It has been shown that Bingham viscoplastic fluids include oil disperse systems, polymeric fluids, many types of food materials, cement solutions, oil paints and others, which exhibit viscous, plastic and highly elastic properties.
However, some viscoplastic fluids exhibit properties that do not obey the Bingham equation. Such fluids are commonly described by other rheological equations of the Ostwald-de-Ville or Herschel-Balkley type, which are widely used to describe the flow of plastic greases, heavy oils and petroleum disperse systems.
This is due to the presence of various particles of the dispersed phase in the liquid, and as a result, such systems are prone to form coagulation structures up to the formation of aggregate clusters and frameworks. Furthermore, the rheological equation's coefficients depend on concentration, particle size and properties, as well as temperature and many other parameters.
At present, there is no consensus on the mechanism of non-Newtonian flow in oil disperse systems and therefore the many flow or rheological viscosity equations used in practice are mostly empirical or semi-empirical. However, despite a large number of works and a diversity of approaches to the rheology of structured disperse systems, including petroleum disperse systems, there is as yet no satisfactory quantitative theory linking the rheological properties of bodies to the parameters of their structure. It is possible that this is due to the formation of various disordered structures that affect the type of rheological model and the nature of the dependence of the effective viscosity of the dispersed system on the stress and shear rate.
The dependence of liquid viscosity on shear stress is obtained for viscoplastic, dilatant and Newtonian liquids.
Keywords: non-Newtonian oil, rheology, viscoplastic fluid, viscosity, shear rate.

Introduction

The main problem of the rheology of non-Newtonian oils is studying the regularities of their behaviour under the action of external deforming stresses, taking into account their structure. Concurrently, are considered the processes associated with irreversible residual deformations and the flow of various viscous and plastic materials, as well as the phenomena of stress relaxation, elastic aftereffects, etc. The rheological parameters of non-Newtonian oil allow investigating of fundamental properties of oil disperse systems that are characterized by shear stress, and effective viscosity, corresponding to a certain disordered structure of the system. The effective viscosity of non-Newtonian oils depends on temperature and pressure, as well as shear strain rate, disordered structure properties, asphalt-resin content and dispersed phase concentration and determines the degree of oil transportability in its production and processing [1-5].

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The high content of asphalted-resinous, paraffinic substances and solids of various grades and nature in non-Newtonian oils gives them a unique physical structure that viscoplastic properties, which are described using the Bingham, Herschel-Bulkley and Ostwald-de-Weel rheological models. These high-viscosity oil systems are formed by combining oil emulsions with water droplets, and oil suspensions with a solid phase in the crude oil and gas suspensions. The complex physical structure of non-Newtonian oil predetermines the potential for more complex coagulation structures that negatively affect rheology [6,7].

Problem statement

A non-Newtonian fluid with constant differential viscosity is called a perfect plastic fluid or a Bingham fluid.

Bingham viscous-plastic fluids include oil systems for dispersing, polymeric fluids, various food ingredients, cement solutions, oil paints, and other substances with highly elastic, plastic, and viscous qualities. They differ from Newtonian fluids in that some finite stress has to be applied to initiate flow, which necessitates the development of appropriate rheological models.

Solution of the problem

The rheology of viscoplastic liquids is depicted by the Bingham condition

$$\tau = \tau_0 + \eta\dot{\gamma}, \quad \dot{\gamma} > 0 \qquad (1)$$

where τ and τ_0 – shear stress and yield stress respectively , η – viscosity, $\dot{\gamma}$ – shear rate.

And, if $\dot{\gamma} = 0$, то $\tau \le \tau_0$. In this condition, the shear rate can be spoken to as a gradient of the flow velocity:

$$\dot{\gamma} = \frac{d\left(dx/dy\right)}{dt} = \frac{d\left(dx/dt\right)}{dy} = \frac{dV_x}{dy} \qquad (2)$$

From expression (1), the viscosity of a viscoplastic oil can be defined as

$$\eta = \frac{\tau - \tau_0}{\dot{\gamma}}$$

Expect that the alter in relative consistency is corresponding to linear strain in the form of

$$\frac{\Delta\eta}{\eta} \sim m\left(\frac{\Delta x}{\Delta y}\right)^P \qquad (3)$$

where Δx – increment of linear strain by changing Δy , m coefficient of proportionality, P – is a measure of the degree of nonlinearity.

In the limiting case $\Delta y \to 0$, passing to the differential frame, we take a non-linear form of writing the expression (3)

$$\frac{d\eta}{\eta} = m\left(\frac{dx}{dy}\right)^{P-1} d\left(\frac{dx}{dy}\right) \qquad (4)$$

Considering that $dx/dy = \lambda dV_x/dy = \lambda\dot{\gamma}$, we have

$$\frac{d\eta}{\eta} = m(\lambda\dot{\gamma})^{P-1} d(\lambda\dot{\gamma}) \qquad (5)$$

With consideration of the initial and infinite viscosity, solution (5) can be written as

$$\eta - C = (\eta_0 - C)\,ext\left(\frac{m}{p}(\lambda\dot{\gamma})^P\right) \qquad (6)$$

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where C – liquid concentration, λ – relaxation time. And, if $\dot{\gamma} \to \infty$, so $C = \eta_\infty$. As a result, the reliance of liquid thickness on shear stress at $m = 1 - n$, we obtain the dependence of viscosity on shear rate for viscoplastic $(n > 1)$, dilatant $(n < 1)$ and Newtonian fluids $(n = 1)$ in the form:

$$\frac{\eta - \eta_\infty}{\eta_0 - \eta_\infty} = \exp\left(\frac{m_0}{p} (\lambda\dot{\gamma})^p \right), \quad n > 1, \quad m_0 > 0 \qquad (7)$$

$$\frac{\eta - \eta_\infty}{\eta_0 - \eta_\infty} = \exp\left(-\frac{m_0}{p} (\lambda\dot{\gamma})^p \right), \quad n < 1, \quad m_0 < 0 \qquad (8)$$

$$\eta = \eta_0, \quad n = 1, \quad m = 0 \qquad (9)$$

Present the last expression as

$$\frac{\eta - \eta_\infty}{\eta_0 - \eta_\infty} = \exp\left(-\frac{m_0}{p} (\lambda\dot{\gamma})^p \right) = \frac{1}{\left[\exp\left((\lambda\dot{\gamma})^p \right) \right]^{m_0/p}} \qquad (10)$$

Decomposing the exponent into a series $\exp\left((\lambda\dot{\gamma})^p \right) = 1 + (\lambda\dot{\gamma})^p + \frac{1}{2}(\lambda\dot{\gamma})^{2p} + \ldots\ldots$, obtain

$$\frac{\eta - \eta_\infty}{\eta_0 - \eta_\infty} = \frac{1}{\left[1 + (\lambda\dot{\gamma})^p + \frac{1}{2}(\lambda\dot{\gamma})^{2p} \right]^{m_0/p}} \qquad (11)$$

Most equations for deciding the thickness of a viscoplastic liquid, taking under consideration the direct exponent decomposition, are based on (11). In particular, to describe the rheology of viscoplastic polymeric liquids, the foremost viable is the Carreau-Yasuda rheological show [8,9], represented as

$$\frac{\eta - \eta_\infty}{\eta_0 - \eta_\infty} = \left[1 + (\lambda\dot{\gamma})^p \right]^{(n-1)/p} \qquad (12)$$

here η_0, η_∞ is the value of the viscosity of the liquid at the starting and at limitlessness, P - is a dimensionless coefficient characterizing the move from the locale with starting consistency to the locale with finite viscosity. As noted in [8], equation (12) describes the rheology of polymer fluids at different concentrations and temperatures. In [8] a simpler form to describe viscoplastic fluids at $\eta_\infty = 0$

$$\eta = \frac{\eta_0}{1 + \lambda\dot{\gamma}} \qquad (13)$$

In [10] the following rheological models are proposed for viscoplastic Bingham and Herschel-Bulkley fluids

$$\frac{\eta - \eta_\infty}{\eta_0 - \eta_\infty} = \frac{1}{1 + \left(\frac{|\dot{\gamma}|}{\dot{\gamma}^m} \right)^m} \qquad (14)$$

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$$\eta = \begin{cases} \tau_0 + k_0 |\dot{\gamma}|^m, & \tau > \tau_0 \\ \infty & \tau \le \tau_0 \end{cases} \qquad (15)$$

It is additionally imperative to note the relationship between viscosity and shear stretch within the taking after observational equation

$$(\eta - \eta_\infty)/(\eta_0 - \eta_\infty) = \exp\left(-(\lambda\dot{\gamma})^n\right) \qquad (16)$$

Figure 1 shows the viscosity versus shear rate for a viscoplastic fluid.

In [11], the consistency of a non-Newtonian polymer liquid containing particles of different concentrations is defined as a function of shear stress as follows (Fig. 2)

$$\eta = \frac{\eta_0}{1 + (m\tau)^n} \qquad (17)$$

It ought to be famous that the coefficients entering equation (17) η_0, m, n depend on concentration (volume division), molecule fabric and temperature.

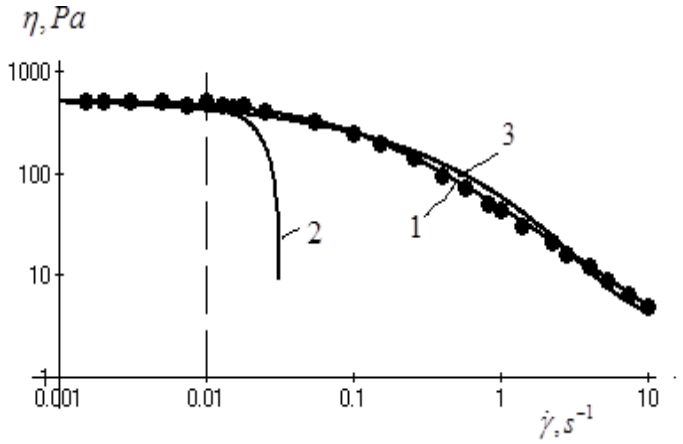

Figure 1. Reliance of liquid thickness on shear rate for distinctive conditions:
$1 - (6.17)$, $\eta_0 = 500 Pas$, $\lambda = 10s$; $2 - \eta = \eta_0 - b\dot{\gamma}^2$ [1]; $3 - (\eta - \eta_\infty)/(\eta_0 - \eta_\infty) = \exp\left(-2.3\dot{\gamma}^{0.45}\right)$

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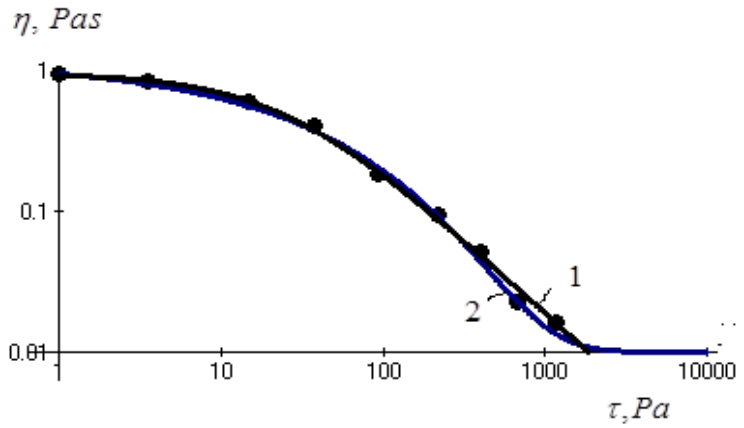

Figure 2. Dependence of viscosity on shear stress for different equations:
$1 - \ \eta = 0.95 / \left(1 + \left(0.046\tau\right)^{1.055}\right)$; $2 - \ \eta = 1.15\exp\left(-0.21\tau^{0.47}\right) + 0.01$

Figure 3 shows curves describing experimental values [184] of viscosity changes of polymer liquids by equations (8) and (9).

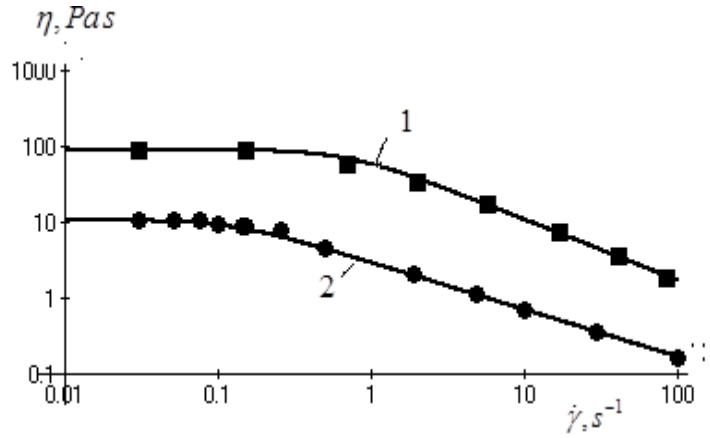

Figure 3. Reliance of liquid consistency on shear rate for distinctive conditions: 1 – 0.75% polyacrylamide in 95/5 blend by weight of water and glycerin ($p = 2,\ m_0 / p = 0.4$); 2 – 7% aluminum cleanser in decalin and m-cresol ($p = 2,\ m_0 / p = 0.3$)

The given calculations and comparison with test information permit affirming the rightness of the acknowledged theory, approximately the proportionality of the relative distortion thickness (3).
In rule, rheological models for different non-Newtonian fluid flows don't comply with physical laws but are experimental and semiempirical approximations and equations describing stream bends in a certain extent of shear rates. Experimental measurements are approximated by some kind of approximated experimental or semiempirical conditions, and the choice of the foremost helpful one is to a great extent decided by the degree of greatest estimation of calculated and test estimations or by the simplicity of applied formulas in solving applied problems.

Conclusion

It is determined that the rheological equations of viscosity of oil disperse systems used in practical studies are empirical or semi-empirical. It is related to the arrangement of different disarranged structures, which affects the structure of the rheological show and the nature of the reliance of the successful thickness of the oil disperse system from the shear stress and shear rate. The reliance of liquid consistency on shear stretch for viscoplastic, dilatant and Newtonian fluids is obtained.

Declarations

The manuscript has not been submitted to any other journal or conference.

Study Limitations

There are no limitations that could affect the results of the study.

Acknowledgment

The author would like to express gratitude to the care support workers and elderly individuals who participated in this study, sharing their invaluable insights and experiences. Their cooperation and openness have significantly contributed to the depth and richness of the research findings.

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SOCIO-PHILOSOPHICAL AND SOCIO-CULTURAL ANALYSIS IN THE "STAR DIARIES" SERIES BY STANISŁAW LEM

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ABSTRACT

Objective: This research is devoted to exploring the artistic reality of "Star Diaries" by the renowned Polish science fiction writer Stanisław Lem, with a primary focus on the socio-philosophical aspect of this narrative series. The work aims to interpret the formal and substantive characteristics that define the author's perspective on anthropology, societal structures, history, bioethics, and futurology within the worlds depicted in the stories, as well as to examine the poetics of expressing the interrelationship between the individual and society.
Methods: The study employs a narratological approach to determine the narrative structure of the works and to identify differences between the positions of the author and the narrators. Philological analysis has been applied to ascertain the artistic features of "Star Diaries", particularly in terms of key images, tropes, and stylistic techniques. Hermeneutic methods have aided in the interpretation of the meanings within the texts. A sociological approach has facilitated the extraction of the socio-philosophical vectors in Stanisław Lem's creative output.
Results: The article identifies a series of issues crucial to human society that are explored in Stanisław Lem's stories from the "Star Diaries" series, detailing their artistic and science fictional interpretations. It thoroughly examines the use of irony and satire which unveil the philosophical perspectives on human and societal relationships. The values and ideals ingrained in the works are disclosed. Considerable attention is given to the narrative structure of the stories and the depiction of the main protagonist. The themes and principal challenges addressed in this collection of stories are identified. The author's view on public discourse is scrutinized, noting how the actual causes of conflicts and their solutions often remain overlooked behind formal resolutions and debates. Originality in conceptualizing social order, science, religion, and anthropology is highlighted. The author's assessment of the modern age and the prospects for human future are also critically evaluated.
Conclusions: The "Star Diaries" series exhibits Lem's multifaceted sociological imagination and a unique satirical-philosophical view of the world. Lem effectively uses the artistic technique of estrangement, enabling a detached view of humanity through the eyes of robots, aliens, and beings from different times and spaces. The stories offer a caution about threats to society caused by its inarticulateness, propensity for warfare, reckless technological and social experiments, ecological negligence, and tolerance of totalitarianism. The character of Ijon Tichy serves as an allegory for the boundless human quest for discovery, knowledge, and improvement.
Keywords: Science Fiction, Human, Society, Irony, Satire, Stanisław Lem, Star Diaries, Defamiliarization.

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Introduction

In the realm of science fiction, few works offer as profound a sociological and philosophical critique of human society as Stanisław Lem's "Star Diaries". In his work "The Philosophy of Chance", Stanisław Lem emphasizes that humans are far more social beings than they may realize (Lem, 2010). He points out that those who fail to understand this and adhere stubbornly to an empirical approach with some manic tendencies often deceive themselves with the superficial appearances of phenomena (Lem, 1964). In our study, we will delineate some socio-philosophical vectors of the artistic reality within the fantastical world of "Star Diaries" by the eminent Polish science fiction author Stanisław Lem.

The object of this research is the "Star Diaries" series, penned by the distinguished Polish author Stanisław Lem. The series offers a rich tableau for analysis, presenting a speculative universe where philosophical inquiries into human nature and societal dynamics are interwoven with the narrative fabric of Ijon Tichy's interstellar journeys.

The subject of this scholarly inquiry is the narrative and thematic architecture of Stanisław Lem's "Star Diaries". By examining the ways in which the text addresses human anthropology, societal constructs, history, bioethics, and futuristic implications, this research endeavors to uncover the multifaceted ways in which Lem employs science fiction as a vehicle for profound philosophical and sociological commentary.

The scientific paper has been the subject of numerous studies. H. Greely (2023) emphasizes that science fiction can be valuable for researchers exploring ethical, legal, and social aspects in biology and genetics, as the 'what if' approach can be beneficial for science. However, it is also important to note that fiction can shape prejudices against technological progress. The notion that the development of artificial intelligence could lead to the displacement, enslavement, and even annihilation of humans by robots is explored by A. Kumari (2024) through Daniel H. Wilson's 'Robopocalypse'. E. Guaraldo et al. (2023) focus on the ability of science fiction to create extraterrestrial ecosystems and extrapolate future scenarios onto them. The three most important aspects of translating metaphors in science fiction (form, content, and pattern) are considered by S. Wong (2023), who highlights that the genre is still not sufficiently recognized, which impedes the adequate translation of metaphors as they relate to a specific genre, not just functioning in a (cognitive) vacuum. The development of Ukrainian fantasy over a hundred years (1920–2020) is examined by O. Shynkarenko (2023); the scholar concludes that the literature of the 1920s promoted the ideology of naive techno-communism, but later, as it became apparent that the Soviet project was in a dead end, fantasy writers turned to mysticism and a rejection of the rational view of the world. E. López Keller (2024) notes that today science fiction shows more fears than hopes, as utopias gradually disappear, and dystopias emerge as a reflection of humanity's loss of faith in scientific progress. 21th-century science fiction stories are analyzed by S. Chattopadhyay (2024); exploring the connection between catastrophic realities, utopia, and escapism, he proposes his own philosophy of post-anti-utopian ideology. R.S. Akhmedov (2024) examines the depiction of artificial intelligence in early American science fiction literature, the evolution of characters with artificial intelligence in contemporary American science fiction films, and the ethical dilemmas associated with artificial intelligence technology. Attempting to explain the cognitive mechanisms responsible for human preference for science fiction, E. Dubourg et al. (2024) consider research in the fields of neurobiology, evolutionary psychology, and behavioral ecology, showing that some specialized biological mechanisms of human cognition trigger exploratory preferences for such information. A. Dydrov's (2023) article is devoted to the body

and corporeality in the dystopian genre; the researcher used classic novels by Stanisław Lem, George Orwell, Yevgeny Zamyatin, and relatively new works by James Dashner and Andrey Dashkov as materials.

Several researchers have devoted their work to the oeuvre of Stanisław Lem. B. Konior (2023), while studying references to artificial intelligence in Summa Technologiae – a unique work combining philosophy and popular science – highlighted the connections between technology, human cognitive abilities, and evolutionary trajectories. J. Trzeciak Huss (2023) noted that Lem anticipated many 21st-century information and biotechnologies (tablets, PCs, smartphones, e-books, virtual reality, artificial intelligence, robotics, holograms, etc.), but cautioned that technology could significantly impact human life and culture, not always predictably or positively, thus posing risks of catastrophic consequences. Discussing how techno-capitalism shapes three prominent ideas of immortality: transhumanist digital immortality, radical biological life extension, and cryonics, J. Hurtado (2023) specifically focuses on Lem's story "Are You There, Mr. Jones?" The researcher argues that the pursuit of techno-capitalist immortality could inflict significant harm on people by promising freedom from death but effectively sustaining exploitative techno-capitalist relations. He suggests that the technologies described consolidate corporate power and enhance the ability of techno-capitalist firms to decide who receives immortal life and who is condemned to die. Exploring Lem's science fiction on space travel, J. Jarzębski & B. Paloff (2023) concluded that the author's objective is to demonstrate the impossibility of communication between humans and extraterrestrial intelligences. On the contrary, Lem's works show that, lacking common language, experience, and space-time awareness, it is hardly possible to share meaningful information. With this conclusion, the researchers refuted the notion that productive dialogue between Earthlings and aliens is a defining characteristic of science fiction. R. Mao (2022) studied the reception of Lem's works among Chinese readers and described the challenges of translating his work into Chinese, giving particular importance to the neologisms and archaisms in "The Cyberiad". Researcher of biography as a genre of historical writing, A. Gajewska (2023), focused on the biography of S. Lem and analyzed it to explore national, ethnic, and class relations in Lviv from the late 19th century to the present day. A. Zahnitko (2022) highlighted the features of Lviv's linguistic milieu in certain works of the writer and identified the most common neologisms by S. Lem, which have significantly expanded the vocabulary of science fiction and even become realities of the modern world. Despite its extensive exploration of anthropological and futuristic themes, the socio-philosophical and socio-cultural dimensions of Stanisław Lem's "Star Diaries" have not been comprehensively studied, particularly within the Ukrainian academic context.

"The Star Diaries" are imbued with irony and satire, addressing numerous philosophical and social scientific issues. Over time, Stanisław Lem came to critically view some of his early works, such as the initial parts of "The Star Diaries". He described these as almost akin to circus clowning, which he believed served no greater purpose than providing sporadic amusement. According to him, it is essential for a book to possess what Noam Chomsky referred to as a "deep semantic structure". Should circumstances require this structure to dominate over the literary and artistic aspect, he would not resist such a change, as he noted in an interview (Lem & Bereś, 2006). Nevertheless, the humorous aspect of the works does not detract from their depth. Stanisław Lem's creations are characterized by their parabolic nature, critiques of theoretical ideas of social order, and dystopian elements. The profound socio-philosophical undercurrent of "The Star Diaries" underscores the relevance of our study.

The artistic method of high-quality science fiction often embodies a sociological imagination. Sociologists understand this concept as the "ability to link everything that occurs in society with structural, cultural, and historical conditions, as well as with the subjective actions of individuals" (Sztompka, 2020). Piotr Sztompka notes that sociological content is present not only in scientific texts but also in poetry, drama, and journalism (Sztompka, 2020). Sociological inquiry is filled with the quest for answers to questions such as "what and how will things proceed?" and "what can be done to change society in a worthy, correct direction?" (Sztompka, 2020). Science fiction, too, grapples with similar thoughts, challenging its audiences to reflect on the potential trajectories of our societies and the possible interventions to steer them towards desirable outcomes. This analytical approach adds a layer of depth to the genre, intersecting with philosophical and cultural studies to explore the implications of imagined futures on real-world social structures and values. This study aims to delve into the artistic reality crafted by Lem in "Star Diaries", focusing particularly on its socio-philosophical aspects. In the philosophical and sociological exploration of literature, few works offer as fertile a ground for analysis as Stanisław Lem's "Star Diaries". This series, a blend of irony, satire, and profound socio-philosophical reflection, serves as a mirror reflecting the complexities and paradoxes of human society. Through the interstellar travels of Ijon Tichy, Lem not only satirizes human behaviors and societal norms but also delves deeply into the essence of human nature and the societal constructs that shape it. This paper aims to dissect these elements, bringing to light how Lem's narratives serve as both a critique and a speculative exploration of human societal dynamics and philosophical quandaries.

Research Methodology.

Our study adopts a multifaceted methodological framework to analyze Stanisław Lem's "Star Diaries", exploring its narrative complexity and socio-philosophical depth. We employ narratological and philological analyses complemented by hermeneutic methods and a sociological lens. This integrated approach allows us to dissect the layered meanings within Lem's work and understand its broader implications on societal and philosophical dimensions. The philological analysis aims to unearth the artistic features of "Star Diaries", focusing on key images, tropes, and stylistic devices. By dissecting these elements, we gain insights into Lem's method of constructing his speculative worlds. Our hermeneutic approach facilitates a deeper comprehension of Lem's speculative scenarios as reflective mirrors of contemporary human and societal dilemmas. Our methodology incorporates a sociological perspective to extract and analyze the socio-philosophical vectors of Lem's work. This approach enables us to explore how "Star Diaries" mirrors and critiques societal structures, behaviors, and norms. By examining the sociological content embedded within the fantastical elements of the stories, we assess the potential trajectories of our societies and the philosophical questions posed about future human conditions. Each method contributes uniquely to our understanding of Lem's work, ensuring a comprehensive exploration of its narrative strategies, artistic intricacies, interpretative depths, and socio-philosophical insights.

Theory and Calculation.

In our study, we will delineate some socio-philosophical vectors of the artistic reality within the fantastical world of "Star Diaries" by the eminent Polish science fiction author Stanisław Lem. Among Ukrainian researchers, the works of Stanisław Lem have been studied by V. Areniev, Yu. Bulakhovska, R. Radysh, I. Kiyak, O. Polishchuk, D. Solon, and others; however, the socio-

philosophical aspect of "Star Diaries" has been minimally explored. The series was published from 1953 to 1996 in Poland. In the preface to a collection of Lem's works, translator V. Areniev notes that even those novels and novellas of Lem that are considered part of the global science fiction canon are primarily known in the post-Soviet space through Russian translations. These translations were occasionally of high quality but sometimes included reductions made during the Soviet era (Areniev, 2017). Until 2016, even the main texts by Stanisław Lem were not available in Ukrainian. The translation of "Star Diaries" into Ukrainian appeared in 2017 in the anthology "From the Star Diaries of Ijon Tichy. Memories of Ijon Tichy. Peace on Earth", compiled by V. Areniev.

This study aims to delve into the artistic reality crafted by Lem in "Star Diaries", focusing particularly on its socio-philosophical aspects. Our objective is to unravel the formal and substantive elements that shape Lem's perspectives on anthropology, societal constructs, history, bioethics, and the implications of future technologies. Furthermore, the research intends to examine the poetics of how these narratives articulate the relationship between the individual and the collective, revealing underlying sociological and philosophical insights.

In his work "The Philosophy of Chance", Stanisław Lem highlights the complexity of literary fiction, which often eludes literary scholars due to a lack of a "sociological" approach. He notes that anthropologists and sociologists rarely engage with literature, considering it outside their domain, resulting in this aspect being under-researched. Lem emphasizes that every literary work has a dual origin: it results from the interaction of societal situations with literary tradition. Thus, works inherit characteristics from both the real-life situation and the accumulated literary experience, including the choice of theme, style, structure, and composition (Lem, 2010). The reception of Stanisław Lem's works, which possess a socio-philosophical depth, necessitates an understanding of this socio-civilizational layer.

In his philosophical and journalistic texts, particularly in "Dialogi" (1957), "Summa Technologiae" (1964), and "The Philosophy of Chance" (1968), Stanisław Lem often discusses sociology. He particularly emphasized the sociological and philosophical aspects of science fiction. He noted that the fate of certain genres resembles rivers that disappear from view and go underground, transitioning from respected literature to a genre of popular culture. He believed this was particularly true for science fiction, which originated from utopian and philosophical prose, as well as from sociological and philosophical analysis of technological development (Lem, 2010). The spirit of such inquiries is alive in contemporary science fiction. This characteristic allows fantastic literature to use thought experiments and artistic modalities to create hypothetical worlds.

The modern world is complex, multifaceted, and prone to unexpected changes. "Information, cultural practices, and social interactions are constantly altering and adapting, creating a dynamic and changing reality" (Hurova & Shkurov, 2023) Consequently, Stanisław Lem's texts are of interest not only in the realm of futurology but also because this author attempted to foresee numerous problems humanity may face due to technological and societal changes. His narratives delve into the ramifications of emerging technologies and their integration into society, questioning the sustainability of such advancements and the ethical considerations they entail. His stories are prescient in identifying how cultural practices evolve with technology, yet often fail to address deeper societal fissures.

Researcher P. Majevski analyses Stanisław Lem's relationship to sociology, noting his skeptical views based on ideas from his works "Dialogi" and "The Philosophy of Chance" (Majevski,

2011). Majevski argues that in the post-human utopia considered by Lem, not only is the sociological mode of thinking lost, but the very possibility of sociology as a science disappears (Majevski, 2011). This is because the foundation of sociology – the historically conditioned form of collective existence – vanishes in such a utopia. In his reflections, Lem expresses distrust of history and socio-cultural life, seeking to free humanity from its historical past. Majevski emphasizes that, with such an approach, there is no place for traditional social sciences (Majevski, 2011). It is possible to agree with Majevski that Stanisław Lem's opinion on sociology is ambiguous. Nevertheless, he does not dismiss it entirely.

Stanisław Lem observes that a work of art is not identical to a scientific piece. He asserts that viewing a novel as a sociological treatise can strip it of its symbolic meaning and the universal significance of its representativeness, although this does not affect the authenticity of the events described in the text (Majevski, 2011). The artistic world of a work is multifaceted, subjective, and symbolic, allowing for a unique reception by each reader and even with each reading.

Max Weber, a classic figure and one of the fathers of modern sociology, also emphasizes that sociology only formulates hypotheses. He contends that even if an interpretation is clear and comprehensible, it cannot automatically claim causal significance and always remains merely the most probable hypothesis (Weber, 1968). In the science fiction thought experiment, there can be sociological and philosophical beginnings.

Weber notes that sociology often has to resort to a method known as the "thought experiment". This method involves mentally excluding certain elements of a motivational series and subsequently constructing a probable process of event development for the application of causal analysis (Weber, 1968). A similar method of creative thinking, the removal of individual components of the motivational series, and the construction of a hypothesis of probable societal development are found in the artistic worlds of Stanisław Lem. Overall, scientific sociological knowledge shares much in common with artistic expression. Thus, 19th-century works become a tool for analyzing the reality of that time. "Star Diaries" interprets reality in a satirical and futurological key, often touching on sociological themes of the ontology of the future.

Among the primary tasks of interpreting social philosophy and sociology are the relationships between individuals and society, in which value orientations play a crucial role. Values help individuals make choices and take actions; they bind society together and provide it with cohesion. Values and ideals are one of the cornerstones of Stanisław Lem's artistic satire and analysis. Max Weber articulates the notion that the higher "purposes" and "values" that may guide human behavior are often difficult to fully understand, although intellectually we might grasp them. He notes that the more these values differ from our own core values, the more challenging it is for us to empathetically sympathize with and understand them using our imagination (Weber, 1968). The uniqueness of artistic sociology and the artistic analysis of values lies in the fact that art allows us to experience and feel even those values that are far from our own.

In science fiction literature, it is often characteristic to experiment with the value orientations of the created worlds. Such fantastical assumptions allow for the conceptualization of the artistic world, pose axiological questions to the reader, and engage them in reflection, while simultaneously immersing them in experiences of unfamiliar values. Values and ideals are one of the keystones of Stanisław Lem's artistic analytics, a field for his artistic examination.

The collection of prefaces closely linked to the stories themselves can be viewed as a sort of prologue to the series, shedding considerable light on the narrative structure of the work. These prefaces are signed by Professor Tarantoga, whom Ijon Tichy mentions repeatedly in his diaries

and who appears as the publisher of these records. Thus, beyond the author's mask, there exists a literary guise of the professor of cosmic zoology. It is through him that the reader learns who Ijon Tichy is and his accomplishments, portrayed as "an indefatigable explorer who discovered eighty-three thousand worlds", yet simultaneously placed in the same category as a character such as Baron Munchausen, which casts doubt on the veracity of the subsequent stories. Additional grounds for skepticism include the fact that the publication is not "critically verified", and one of the stories not included turned out to be apocryphal. Doubts about the authorship of "Star Diaries" also arise, as there are rumors that "his works having been penned – they say – by a device given the name of 'Lem'" (Lem, 1985), which could have been a human. Professor Tarantoga hurries to refute such theories, but in the "Preface to the Expanded Edition", he once again presents the reader with a conundrum regarding the authenticity of the narrative hero: "Since at his order this discovery [Theory of Time Vehicles and Transport – authors] was undiscovered, by that very act the Telechronic Program to correct history vanished, so did the Temporal Institute and so – alas – did I. Tichy himself, being its Director" (Lem, 1985). The preface concludes with overt irony concerning both the upcoming stories and the nature of science, announcing the creation of a certain futurological division "which, in keeping with the spirit of the times, will make available – using the method of so-called self-realizing prognoses – those star journeys of I. Tichy which as yet he has not undertaken, nor indeed intends to" (Lem, 1985).

Thus, the author presents a complex and original narrative system where the roles of the main characters in the storytelling, specifically the reliability of narrators Professor Tarantoga and Ijon Tichy, are ambiguous. It is unclear whether the hero of the stories is a fictional creation of Tarantoga and what role the mentioned "Lem" plays in the narratives. The central question remains – does this ambiguity matter? The ambiguity in reliability and authorship challenges the reader to consider the nature of truth and the construction of historical and societal narratives, thus engaging in a meta-narrative critique that is deeply sociological and philosophical in nature.

One of the principal artistic and deeply philosophical tasks of the author of "Star Diaries" is to contemplate the essence of humanity: what defines a person, where are their boundaries, their origins, whether they can be perfected, and crucially, how they interact with others, whether they achieve mutual understanding or not. Additionally, the author ponders over questions pertaining to various fields such as natural science, electronics, history, anthropology, bioethics, as well as military affairs, politics, diplomacy, culture, and religion. To thoroughly explore humanity and the human condition, Stanisław Lem frequently employs the literary device of defamiliarization in his stories. Humanity is depicted through an external viewpoint: through the eyes of various aliens, robots, beings from different times and spaces, and even one's past or future self. Different planetary and civilizational representatives assess humans as "abominoids", "howlmouths", "freaksnouts", "addlepates", among others (Lem, 1985). From an external perspective, human society is presented either as a cosmic accident, a flawed creation of extraterrestrial civilizations; or conversely, some cosmic inhabitants speculate that life on Earth is simply unfeasible. Meanwhile, the character of Ijon Tichy, representing homo sapiens, not only refutes such disgraceful definitions but is constantly involved in various human and societal enhancement projects, notably the so-called Foliated Man or Homo Perfectus Sapiens, and even attempts to rectify history (Lem, 1983). Despite these projects remaining unrealized, they are valuable in themselves as they offer, albeit in an ironic tone, significant philosophical reflections on the essence of humanity. The author's use of the technique of defamiliarization allows for an independent external evaluation. However, upon closer examination of each of these exotic

societies deliberating on humanity, it becomes evident that robots, aliens, and other forms of intelligent existence are mirrors of humanity itself, with all its vices and shortcomings: ignorance, prejudice, incommunicability, and a plethora of unresolved both mundane and existential issues (Lem, 1985). Through these fantastical narratives, Lem critiques and explores the perennial philosophical concerns about the human condition, making the narrative not just a piece of science fiction, but a profound sociological and philosophical dialogue about the potential and limitations of humanity and its future.

In an ironic tone, the author also depicts the confrontation between humans and nature, specifically between natural processes and scientific progress. Ijon Tichy concludes in "The Eighteenth Voyage" that, "The world is the way it is, and mankind behaves the way it does, because everything arose by chance, that is, haphazardly, through the initial violation of fundamental laws" (Lem, 1983). This notion, paired with the idea of correcting so-called mistakes of nature, is repeatedly voiced by him or other characters in a number of stories. Yet, despite placing great hopes on science and devising grandiose projects for 'correcting' the cosmos and managing evolution, humans repeatedly encounter their own impotence. While the main character consistently finds external reasons for his failures, the reader can discern the artistic irony of the work and see a more objective explanation: despite mastering time and space and understanding natural laws, humans remain fundamentally human. Therefore, each new attempt to fix, change, or recreate is doomed to the same outcome. This can be interpreted, on one hand, as a form of pessimism, but on the other, as an admiration for human endeavor to continuously learn, master, and tirelessly implement ideas. It is no coincidence that each story in the series represents a curious experiment, answering many "what if" questions. Lem’s exploration offers deep insights into the human condition. It challenges the perennial human quest for control over nature and the universe, highlighting the limitations and inherent contradictions in such endeavors. This reflects a broader philosophical commentary on the limits of human understanding and control, while culturally, it critiques the often-unexamined belief in progress and the hubris of human endeavor. Through the lens of irony and science fiction, Lem invites readers to contemplate the complexities of human nature and the existential dilemmas posed by technological advancement and its implications for society.

Another key theme in "Star Diaries" is the relationship between science and religion. Many characters, particularly scientists, attempt to exclude the figure of God from the cosmogony because "We shouldn't pass the buck to God" ("The Eighteenth Voyage") (Lem, 1983). In other stories, discussions about God border on blasphemy from a religious person's perspective. For instance, in "The Eighth Voyage", one of the speakers at an interplanetary congress caricatures humanity by claiming it to be a drunken escapade of two cosmic sailors, Lod and Gorrd (Lem, 1985). Meanwhile, in "The Twentieth Voyage", Ijon Tichy himself ties the emergence of monotheism to a certain master named Otto Noy, who explains his idea that "...since according to the plan His decisions were to be ipso facto mysterious: the people wouldn’t be able to understand them, therefore they wouldn’t criticize, and neither would they suspect that anyone was tampering with their history – telechronically" (Lem, 1985).

However, the fact that the author, narrator, and characters are not one and the same provides grounds to consider such statements as ironic in their perspective on those who utter them. If in the first case the same extraterrestrials draw a highly subjective caricature of creation itself, that is, humanity, then the depiction of the Creator from this standpoint is shaped accordingly. As for

the second case, considering Tichy as an unreliable narrator allows one to doubt the described interference in human history, and thus, the machinations of Otto Noy.

Drawing on the plots of these and some other stories, it can be observed that scientists' attempts to remove God as the driving force behind creation remain unsuccessful and unconvincing. The declaration of His "extremity" still leaves room for the thought of His necessity. While not the only correct interpretation, one of the possible readings of Stanisław Lem's stories is that God is not just necessary, but crucially mandatory, as any human attempts to participate in the creation of the world are doomed to failure. These narrative elements critique and interrogate the tensions between scientific rationalism and religious belief systems. Lem uses these speculative settings to explore the philosophical implications of human attempts to transcend or even replace divine functions, reflecting on the inherent limitations and ethical dilemmas that arise. This ongoing dialogue between the extremes of human reason and religious faith highlights the complex interplay of knowledge, power, and existential purpose, offering a rich field for further exploration in the study of social philosophy and cultural dynamics.

Turning to the story "The Seventh Voyage" (Lem, 1985), written in 1964, Stanisław Lem combines satire and allegory to highlight the internal disharmony within society. Ijon Tichy was flying near Betelgeuse when a small meteorite damaged his rocket's control system. The hero found himself stranded in space on an uncontrollable rocket, although life presented him with an opportunity to easily rectify the situation. Due to an imposed paradox, along with the hero on the ship, there are his duplicates from the past and future. However, they spend most of their time squabbling, trying to steal food from each other, arguing, and fighting. The problem remains unresolved until the youngest duplicates of the hero, his childhood selves, solve it. Stanisław Lem demonstrates the issue of social dysfunction, where formal problem-solving and disputes leave the actual problematic situation unseen.

Effectively, in this narrative, Stanisław Lem touches on the sociology of the public sphere, politics, and communication in an artistic form. Communication sociology analyses the exchange of information between social groups, focusing on the problems of decoding, loss, and the search for meaning. Metaphorically, Stanisław Lem depicted human communities that in conflict only create a lack of communication but fail to hear each other. Communication is about influence; without influencing the interlocutor, all talks are merely noise. All interactions among the multiplied alter-egos of the hero turn into noise, verbose but devoid of constructiveness. This narrative not only illustrates the complexities of personal and societal communication but also reflects on the broader sociological and philosophical implications of how societies handle internal conflicts and misunderstandings. Lem’s allegory serves as a critique of the ineffective communication processes that often plague modern societies, suggesting that real solutions require a return to simpler, perhaps more innocent approaches.

Stanisław Lem analyses the issue of public polemics: people become so engrossed in debate that it almost turns into a sport. The writer diagnoses the "adult society" of his era, a diagnosis that is equally applicable to today's times. We find ourselves bound by polemics and the pursuit of personal gain, even though we face imminent danger.

In his "Dialogi", Stanisław Lem argues that any social group involved in facilitating connections between power and the economy tends to monopolize its functions in an elitist manner, especially when supported by a centralized system (Lem, 1984). He notes that in various systems, detrimental tendencies towards stratification and division arise, leading to conflicts between groups and their interests. Nevertheless, Lem also expresses confidence that human capabilities

for experimentation and innovation will allow us, despite all mistakes and tragedies, to build a better world (Lem, 1984). This narrative skillfully intertwines a critique of current socio-political dynamics with a philosophical exploration of societal inertia and its consequences. By employing allegory and satire, Lem not only critiques the cyclical nature of political debates and the stasis they often result in but also highlights the potential for societal advancement through innovation and critical thinking. This reflects a broader philosophical and sociological analysis of how societies can overcome paralysis and evolve despite entrenched conflicts and elite dominance. The spaceship from "The Seventh Voyage" serves as an allegory of our world, where "adult" civilizations dispute relationships, oblivious to the fact that they are facing stagnation (Lem, 1985). In fact, it is this stagnation, an endless motion going nowhere, that is epitomized by Ijon Tichy's rudderless ship. However, as in the "Star Diaries", Stanisław Lem looks to the future with optimism.

In "The Eighth Voyage" (Lem, 1985), penned in 1966, Stanisław Lem employs satire to portray another significant social entity of humanity – the United Nations. Ijon Tichy becomes an Earth delegate to the Organization of United Planets, although it ultimately transpires that this was merely a dream (Lem, 1985). Lem emphasizes the paradoxical nature of societal development. For instance, an alien tasked with representing humanity inquires whether humans possess controlled explosions for purposes such as climate regulation, continent shifting, or river redirection: "So far only bombs…" Ijon responds, before whispering, "But there are many different kinds, napalm, phosphorus, and even with poison gas…" (Lem, 1985).

Using satire and metaphors, Stanisław Lem critiques humanity, weakened by wars and its hypocritical pathos. In "Summa Technologiae", he similarly portrays humanity not as a young man full of promise and nobility, but rather as an old sinner who secretly revels in various debasements while always ready for hypocrisy (Lem, 1964). Despite this, Lem notes that this sinner, afflicted by paralysis, strives for healing and redemption, occasionally experiencing bursts of rationality, especially after severe trials (Lem, 1964). Stanisław Lem condemns societal vices. The paradoxical nature of violence as a fundamental component of human culture and a driving force of its development, as depicted in the narrative, intersects with the history of the creation of nuclear weapons and dynamite. Dynamite, intended as a tool to aid in mining, was instead used as a means to destroy others. Nuclear energy was utilized as a means of killing before it could provide cities with cheap energy. Lem repeatedly emphasizes that the 20th century was too early for nuclear energy, which he believes belongs in the 21st century, by which time he hopes society will have achieved a more humane order. Through this analysis, Lem not only critiques the inherent contradictions in technological progress and its misuse but also reflects on the broader implications of such advancements for societal and ethical development. His work urges a reconsideration of how technological powers are wielded, calling for a future where innovations are aligned with the betterment of humanity rather than its destruction.

In "The Eleventh Voyage" (Lem, 1985), penned in 1960, the protagonist attempts to solve the problem of a rogue onboard computer that has started a rebellion against humanity on the distant planet Cercia. Over nine thousand human agents have disappeared on the planet. However, it turns out that the robots are merely a fiction, people disguised as robots, and furthermore, the main robot is actually a corporate bureaucrat.

Stanisław Lem uses satire to demonstrate people's tendency to conform to ideology. Interestingly, while the supposedly rebellious robot named Computer appears to be driven by ideological

motives, in reality, it is a human who is a hostage to the situation and a slave to the economic "machine" – a real one, unlike the illusion it creates.

Lem believes that the roots of totalitarian crimes lie not in the psychopathy of individual personalities but in the essence of the system itself. In "Dialogi", he argues that the primary causes of such crimes are related to the structure and objective dynamic laws of the system, whether due to interclass conflicts or the actions of tyrants in centralized systems. Lem emphasizes that attempts to explain these crimes solely through psychopathological analysis are methodological errors that harm not only the progress of science but also the development of sociology (Lem, 1984). The computer in "The Eleventh Voyage" serves as a metaphor for the machinery of totalitarian ideology, behind which hides a frightened human. In the societal ideals that support them, there lies a self-serving personality aiming to benefit from the situation.

Stanisław Lem satirically portrays the mass media, supposedly created by robots and widespread on this planet. They seem like faithful mouthpieces of propaganda, but they are written by people who merely pretend to believe in it. In propaganda, no one believes, neither those who create it nor those who listen to it. This concept significantly alludes to the propaganda machine of the Soviet Union, yet, like many other science fiction images by Stanisław Lem, it proves timeless. The story realizes the metaphor of panopticism, conceptually analyzed by Michel Foucault in "Discipline and Punish" fifteen years after Lem wrote his story. This concept is artistically realized by Stanisław Lem: not only is the inner world of the individual shackled in spiritual servitude, but their body is literally imprisoned in a metallic shell, to resemble others. The USSR serves as an analogy for such an ideological construct. A machine of propaganda and enslavement, inside which people, driven by fear and profit, serve as a simulacrum.

In the story "On the Utility of the Dragon" (Lem, 1993), written by Stanisław Lem in 1983 but completed in 1993 after the dissolution of the USSR, the author highlights the absurdity of the totalitarian ideological system of the USSR. Lem satirizes the fact that despite understanding the essence of the dragon, which is merely a parasite and a slug, an entire system of economic pathways is constructed around it. Not only are the internal processes of the state built on the authoritarian power of the dragon, but neighboring states also find profit in it.

In the narrative, a professor studying the Dragon explains to the main character that the Dragon stimulates economic activity because a flour concoction is produced for it. This requires the use of metallurgical plants, rolling mills, welding machines, transport vehicles, and so forth. The Dragon represents a real consumer and a vast foreign market with high demand, making it indispensable for industries that would not produce goods if there were no one to sell them to. According to one character, for neighboring countries, the Dragon has become a historical necessity, a national interest, and a powerful factor justifying their collective efforts (Lem, 1993). In the postscript, written in 1993, Stanisław Lem notes that although the dragon he wrote about has disintegrated into many small dragons, their appetite has not diminished, thereby predicting forthcoming problems from post-Soviet ideology and social systems (Lem, 1993). This narrative cleverly uses the metaphor of the dragon to critique the underlying economic and political structures that sustain and are sustained by totalitarian regimes. The story serves as a reflection on the enduring nature of these structures, even as they evolve or appear to fragment, and the challenges this poses for post-authoritarian societies striving for change.

"The Twelfth Voyage" by Ijon Tichy focuses on the concept of a time accelerator-decelerator, invented by Professor Tarantoga. On one of the planets in space, there live microcephalics, strikingly like humans, except that their skin was bright blue and shiny. Thanks to the time

accelerator-decelerator, the hero was able to observe the formation of the microcephalics' civilization, inadvertently becoming its foundation. This work offers a satirical philosophical-sociological perspective on the problem of values. With humor, Stanisław Lem addresses the mechanisms and factors of value transformations, the processes of their formation and changes, emphasizing the role of randomness in this process.

Viewed through a sociological lens, Ijon Tichy serves as a metaphor for the ideological and social foundation. His character is a reference both to a reinterpretation of Jesus' teachings and to the global values of human civilization. Significantly, although Ijon Tichy was at the core of the microcephalics' beliefs, when he appears at more mature stages of their development, they not only distrust him but also attempt to cleanse him of the unusual skin color – a distinguishing feature of the ideology he unwittingly embodies. This narrative cleverly explores how foundational figures and ideologies can be revered in their absence yet questioned or rejected when confronted with reality. It highlights the fluid and often arbitrary nature of societal values and the ironies inherent in their evolution. Lem's story critiques the construction of cultural and ideological narratives, questioning the stability and permanence of any societal values and underscoring the influence of external agents in shaping the direction of a civilization's development.

In "The Thirteenth Voyage" (Lem, 1985), written in 1956, the narrative centers around the adventures of the protagonist in search of the great Master Oh. Master Oh and his teachings serve as a metaphor for social ideas that lead to totalitarianism. These ideas are simplistically interpreted by his followers, resulting in destruction rather than the universal happiness intended. The story presents two technopessimistic models of artistic worlds that are characterized by their attention to the negative implications of technological innovations (Shkurov, 2015). On his journey to learn from the great teacher, Ijon Tichy visits the planet Pinta, whose inhabitants aspire to return to an aquatic environment. This serves as a cautionary metaphor for how society, in pursuit of realizing utopian ideology, may find examples of its reckless, uncritical application.

Pinta demonstrates how an obsession with a singular idea and the lack of critique in its implementation lead to tragedy within society, even when based on sound thoughts. The dystopia of planet Pinta is rooted both in the thoughtless creation of a technosphere and in an authoritarian social order. The neighboring planet, Panta, also exemplifies a peculiar ideological pandemic. In this society, everyone is emphatically equal and devoid of identity. "One has the occupational roles, namely those of rulers, gardeners, mechanics, physicians; there are also family roles – fathers, brothers, sisters, and so on. Now in each such role, a Pantan serves for twenty-four hours only" (Lem, 1985). This depersonalization creates an illusion of immortality for the state's citizens. Under the guise of happiness, lies the most severe violence against the individual, with references to the Soviet ideology of universal equality. Scientific and technological progress, combined with ideology, has led to the alienation of the individual from the surrounding nature and the dissolution of their very being, resulting in the loss of the foundations of their existence. The reference to technological and ideological tools shaping societies speaks volumes about the instrumental use of technology in reinforcing certain power dynamics. The metaphor of citizens living within a technologically enforced panopticon, where they are complicit in their own surveillance, eerily mirrors today's pervasive digital monitoring cultures. Lastly, the critique of the totalitarian misuse of ideology, technology, and charismatic authority in "The Thirteenth Voyage" invites readers to reflect on the ethical responsibilities of those in power.

The narrative addresses the theme of social experiments, reflecting the horrific events of the 20th century. In his "Dialogi", Stanisław Lem contemplates such experiments, citing the example of Nazi concentration camps. He asserts that through coercion, applied without limits, any system of human relationships can be created, introducing any form of segregation or stratification, whether to the benefit of a privileged caste or to the detriment of the deprived. In such conditions, the 'privilege' of the 'elite' consists only in that their death at the hands of the executioners will come slightly later than the others (Lem, 1984).

"The Fourteenth Voyage" (Lem, 1985), a story written in 1956, addresses the increasingly pertinent issue of ecology today. The narrative is linked with the novel "Observation on the Spot" (1982), in which the concept of the artistic world is further detailed. Specifically, in the novel, the author delves into the notion of the ethicsphere—a sort of "viruses of goodness" akin to nanorobots, which protect local inhabitants from diseases and death but also compel them to act within the confines of limited ethical algorithms.

In "The Fourteenth Voyage", the plot revolves around the inhabitants of a planet who have rejected living in harmony with nature, instead hunting the creatures that protected them: the Squamp (Polish: kurdel). Meanwhile, the danger of living detached from nature is significant – a meteor shower easily destroys buildings and kills many people. Thanks to advanced technologies, the consequences of ecological cataclysms are easily overcome. However, this is merely a superficial appearance. Even the main character becomes a victim of a meteor in a world where ecology is sacrificed for development. He is immediately resurrected. Nonetheless, a new person, even with the previous personality, does not change the fact of the deadly outcomes of detachment from nature, characteristic of contemporary society. Although the modern world easily finds a replacement for one person, death remains death. And this lethal system is hidden behind the modern mechanistic civilization, to which the author points through allusion. Emphasize the image of the theatre where the death of the main character in "The Fourteenth Voyage" occurs. It serves as a pronounced locus for creating illusions, in which the modern world lives, believing that with its science it can hide from the wrath of nature. Lem's critique extends beyond environmental issues to question the ethical frameworks that guide technological application. The portrayal of technology as a double-edged sword that offers salvation while enforcing rigid ethical parameters invites reflection on the limitations and dangers of over-reliance on technological solutions in contemporary societies. Furthermore, the theatrical setting for the protagonist's death underscores the performative aspects of modern societies' engagements with nature. It suggests that much of what is presented as effective environmental action may merely be performative, providing an illusion of safety and control over nature's more destructive tendencies. This critique is particularly relevant in the context of debates on sustainability and environmental policy, where technological fixes are often promoted as panaceas without sufficient attention to underlying systemic issues.

"The Eighteenth Voyage" is devoted to the ambitious yet naïve idea of reconstructing the Universe, in which Ijon Tichy, along with a team of distinguished scientists, attempts to unravel the mystery of the creation of the world and to "correct" "the constructional defects in the Universe and the warps in human nature" (Lem, 1983). This scenario showcases the writer's characteristic ironic perspective on science in general and its representatives in particular. The quest for scientific discoveries in Stanisław Lem's stories often degenerates into a multitude of pseudoscientific ideas and disputes around them. For the reader, it is often difficult to discern where the line lies between quasi-scientific demagoguery and the search for practically applicable

ideas. For example, the scientists in the story are indicted for their main discoveries contradicting themselves: they have simultaneously proven that the world originated from a single atom and that the existence of this atom was not possible.

The main character of "Star Diaries", who is also the narrator, is portrayed as an idealist who believes in the possibilities of science and tirelessly advances ambitious plans to address discrepancies and improve the world and humanity. Notably, each time Tichy's path is obstructed by circumstances and people who at the last moment destroy all noble intentions. The hero is left with no choice but to retreat from another grand scheme to amend the cosmos and to save the world from the worst consequences caused by the interference of malefactors like assistant Sarpint and his companions, among whom is a certain Lou Cipher as an allusion to the devil. Here, the reader again faces ambiguity in viewing the character: either the obstacles encountered by Ijon Tichy are objective and the blame lies with the irresponsible surroundings, or the very ideas he is working to implement are fundamentally unfeasible due to their utopian nature, bordering on childlike naivety. However, even if one opts for the latter interpretation, it is worth defending him by noting that in the previously analyzed "The Seventh Voyage", it was precisely a childlike perspective on the problem that proved to be the only solution, while the numerous efforts of uncooperative adults led to nothing constructive. "The Eighteenth Voyage" presents a profound exploration of the intersection between human ambition and scientific endeavor, framed within Stanisław Lem's characteristic satirical narrative.

This voyage not only questions the efficacy and morality of manipulating the fundamental structures of the universe but also provides a sharp critique of the hubris inherent in scientific communities. Lem’s depiction of the scientific community grappling with the universe's foundational flaws highlights the social dynamics within scientific fields. It reflects how scientific communities can sometimes become echo chambers that magnify both their visionary strengths and their insular weaknesses. The scientists’ readiness to reconstruct the universe based on their understanding and technology mirrors modern societal tendencies towards technocratic arrogance – assuming that every problem has a technological solution, regardless of the philosophical or ethical dimensions. Lem prompts the reader to consider the morality of 'playing God,' raising critical questions about the limits of human agency and the ethical boundaries of scientific inquiry. The contradictions pointed out by the scientists – that the universe could both stem from and not accommodate a singular atom – underscore a central philosophical paradox: the limits of human understanding and the potential folly of assuming that comprehension equates to mastery.

Returning to "The Eighteenth Voyage", it is noteworthy that it is undertaken with both the most grandiose and the most utopian of objectives – the "creation of the Universe", an occurrence that would not be random and would not violate "fundamental laws" (Lem, 1983). In such a Universe, various "flaws" and "deformities" would become impossible, as its development would be "harmonious, not haphazard" (Lem, 1983). During this extensive mission, its chief theorist, Professor Solon Razglaz, concludes that the Cosmos "exists on credit", and the experienced practitioner, Ijon Tichy, sets out "to cancel the cosmic debt" using the energy of an electron "moving against the flow of time" (Lem, 1983). His primary task is proclaimed as the "improvement" of humanity, beginning with the intention to change the principle of natural evolution, which is inherently indecent – a "wholesale devouring", where either the strong devour the weak ("zoocide") or the weak unite to conquer the strong from within ("parasitism"). And since in this sense only plants are flawless, Ijon Tichy envisages "the chlorophyllization of all living things" (Lem, 1983).

In the project for the new perfected "Foliated Man", a more aesthetic body and other enhancements are envisioned (Lem, 1983). However, the specified changes concern not so much the functionality of the human organism as they do ethical considerations. Indeed, the revised evolution eliminates both the struggle for survival and the necessity of consuming animal flesh. Moreover, Foliated Man is not merely a primitive Homo sapiens, or "abominoids" (as described from the perspective of extraterrestrials in another story), but a species operating with different moral categories and constructing a different history. The presentation of this project vividly displays the characteristic duality found in Stanisław Lem's works, where it is unclear where profound philosophical ideas end and mere jokes begin. Therefore, the reader has the right to choose how to regard the idea – whether seriously or ironically – that the world might change if certain aspects, particularly the human organism, were modified. Returning to "The Eighteenth Voyage", it is worth noting that it is undertaken with simultaneously the most grandiose and the most utopian aim – to "create the Universe," an occurrence that would not be random and would not violate "fundamental laws" (Lem, 1983). In such a Universe, various "flaws" and "deformities" would become impossible, as its development would be "harmonious, not haphazard" (Lem, 1983). During this extensive mission, its chief theorist, Professor Solon Razglaz, concludes that the Cosmos "exists on credit", and the experienced practitioner, Ijon Tichy, sets out "to cancel the cosmic debt" using the energy of an electron "moving against the flow of time" (Lem, 1983). His primary task is proclaimed as the "improvement" of humanity, beginning with the intention to change the principle of natural evolution, which is inherently indecent – a "wholesale devouring", where either the strong devour the weak ("zoocide") or the weak unite to conquer the strong from within ("parasitism"). And since in this sense only plants are flawless, Ijon Tichy envisages "the chlorophyllization of all living things" (Lem, 1983).

In "The Twentieth Voyage," a narrative set in the distant future, specifically the 27th century – a period described as "the Age of Chronotraction, Chronomotion and Telechronics" – the story explores the profound challenges of reshaping both the world and humanity. Ijon Tichy is approached by his own doppelgänger from this advanced era with a proposition to lead a monumental project aimed at editing history. The visitor, arriving on a chronocycle, explains that under this grand design, "all of history will be regulated, purified, straightened, and improved according to the principles of humanism, rationalism, and attractive design" (Lem, 1985). He describes a future so ideal and technologically advanced that even the social structure and Earth's climate are regulated. Lem's narrative reflects on the perennial tension between technological utopianism and the stubborn persistence of human flaws. The futuristic setting allows for an examination of societal structures that, despite their advanced technology, fail to overcome fundamental human limitations such as incompetence, selfishness, and short-sightedness.

However, the only issue that remains is the human past, which is "too embarrassing to present in the company of highly developed cosmic civilizations" and thus needs correction. Moreover, the position of general director of the project remains vacant, purportedly because, unlike in previous centuries, incompetent people would never undertake such a responsible mission. Yet, when Tichy agrees to the proposal and travels to the future, he soon realizes that even in the 27th century, humans have not fundamentally changed, and his subordinates are far from flawless.

The story illustrates that attempts to "make corrections even before the emergence of humans, to improve them", to enhance evolution, and to adjust the course of history are doomed to failure. This is due in part to the discord and personal ambitions among the staff of the so-called THEOHIPPIP (Teleotelechronistic-Historical Engineering to Optimize the Hyperputerized

Implementation of Paleological Programming and Interplanetary Planning), whose names carry allusions to the great minds and talents from all eras of human existence, such as Prof. Lenny D. Vinch, Prof. P. Lado, among others. These allusions again reflect a key characteristic of Stanisław Lem's idiostyle: the text embeds the potential for dual perception of the author's assessment of the contributions these figures have made to civilization. Here, one can see both a genuine appreciation (although it is an open question whose appreciation: the author's or the narrator's) of these scholars and artists, and an irony over the ignorance of those who cannot appreciate their genius. By employing irony, Lem again proves that there was, is, and will be no possibility to change anything and that all historical processes could only have unfolded as they did. Ultimately, regardless of the level of civilization's development, humanity and society remain the same. It questions the ethics of striving for a post-human future where natural human limitations are seen not just as challenges to overcome, but as errors to be corrected. The ironic tone suggests skepticism towards the hubristic belief in humanity's ability to control and perfect its destiny through science and technology.

In "The Twenty-first Voyage", as depicted in Stanisław Lem's narrative, the unchangeable nature of human beings and society, even in a different cosmic space, is explored. This time, Ijon Tichy visits the planet Dichotica, where scientific progress has far surpassed that of Earth, although the Dichoticans were originally indistinguishable from humans. This planet's population has long mastered "biotic engineering" (the production of synthetic embryos) and "technologies of immortality", and has "achieved complete freedom in body and soul creation".

Seeking refuge within a monastic order, Tichy spends his time in the library, studying the local history, acquainting himself with Dichotica's scientific discoveries, their politics, and engaging in philosophical-religious discussions with the most intelligent monks. However, he gradually discovers the true situation. Despite the greatest scientific achievements, the height of religious thought, and the Dichoticans' ability to independently design their own appearances and qualities, grow furniture in fields, and merge with computers – despite all this and more, the world remains divided between those with "censorable" and "uncensorable" appearances, and even between those who can live without restrictions and those forced to hide in catacombs. Therefore, no matter how much Fathers Darg and Memnar talk about the high ideals of "Duism" and freedom, the main character cannot help but notice that they certainly do not possess it, as they, like "old machines, unneeded ever since the First Biotic Revolution", are only allowed to live by hiding underground. The reader is left convinced that even this technologically advanced society continues to grapple with discrimination, oppression, ideological, and political conflicts.

Conclusions

The "Star Diaries" by Stanisław Lem largely serve as a socio-philosophical analysis presented through the lens of science fiction and satire, with a high level of literary craftsmanship that blends ease of narration with metaphor and numerous allusions. Lem addresses a variety of issues critical to human society, reinterpreting them within an artistically fantastical framework. In these stories, the author displays a multifaceted sociological imagination and a unique satirical-philosophical perspective on the world. The "Star Diaries" by Stanisław Lem reveals a rich tapestry of language that intricately weaves themes of existentialism, ethics, and human nature into the fabric of science fiction. Lem's use of irony and satire serves not only as stylistic devices but as profound vehicles for critique and introspection. His narratives, dense with philosophical musings and layered meanings, challenge the reader to decipher a complex interplay of symbols

and allusions. "Star Diaries" offers a critical examination of societal structures and human interactions through the speculative lens of science fiction. Lem's narratives delve into the consequences of technological advancement and the perennial human struggle for power and identity. Through the fantastical yet reflective scenarios, Lem discusses the potential futures of human societies, highlighting issues of social justice, ethical governance, and the impact of technological omnipotence. Lem's work serves as a reminder of the sociological imagination needed to navigate and possibly steer the trajectory of human development. Through a philosophical critique embedded within the narrative, Lem explores themes of existentialism, human agency, and the metaphysical dilemmas of existence and creation. His work questions the role of humans in the universe, challenging the anthropocentric view and suggesting a more humbling perspective of humanity's place in the cosmos. The philosophical discourse is rich with discussions on the nature of reality, the ethics of creation and interference, and the boundaries of human understanding. Lem uses his speculative scenarios not just to entertain but to engage the reader in profound philosophical inquiries that resonate with the core questions of philosophy concerning reality, existence, and the moral implications of human actions in an increasingly complex world. The social and philosophical layers of the fantast's works contain warnings about potential disasters, both social and technological. Lem highlights the importance of negotiation skills, condemns wars, the reckless creation and restructuring of the technosphere, dangerous social experiments, totalitarianism, and environmental harm. Simultaneously, the writer views the artistic modalities of the future world he constructs positively. Ijon Tichy allegorically embodies the ceaseless and boundless human quest for understanding.

Declarations

The manuscript has not been submitted to any other journal or conference.

Study Limitations

There are no limitations that could affect the results of the study.

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SOME FEATURES OF THE MOVEMENT OF NON-NEWTONIAN OILS INTO THE WELL, TAKING INTO ACCOUNT THE SPHERICAL-RADIAL FLOW CHARACTER ACCORDING TO THE LINEAR LAW OF FILTRATION

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ABSTRACT

When studying the behavior of a fluid in a reservoir, taking into account anomalous properties, a necessary condition is to determine the lower limit of applicability of Darcy's law for very small values of the Reynolds number. At the same time, it should be noted that these properties arise upon contact with a porous medium and explained by the fact that at very low filtration rates, along with viscous resistance forces, there are these characteristics that do not depend on the filtration rate and are associated with the physical and chemical dependencies of filtering liquids with the porous medium material. Accounting for these forces leads to the non-linear character of the filtration law.

It is known that the filtration process is described using models. Basically, three types of oil flow models have been defined in the reservoir. If we assume that all fluid particles move in a porous medium in such a way that their filtration velocities are not parallel to the same plane, then such a movement is called spherical-radial. One can give such an example of a spherical radial flow in various cases of filtration. Let us assume that a hydrodynamically imperfect well barely penetrates the impermeable horizontal top of a homogeneous formation of a very large thickness; corresponds to the spherical-radial model.

Keywords: spherical-radial model, contour and bottom hole pressure, volume flow, cross-sectional area, non-Newtonian fluids, oils, anomalous fluids.

Introduction

The analysis shows that during the development of many fields in Azerbaijan, Russia (Tatarstan, Bashkiria), Romania, Kazakhstan, facts that can be explained by the appearance of non-Newtonian anomalous properties of liquids in a porous medium are known. The features of the movement of such anomalous oils are mainly associated with the content of high-molecular components in them: resins, asphaltenes, paraffin, an increase in the proportion of clay particles in the reservoir, etc.

In the world, the price of hydrocarbons is constantly growing. In this regard, interest in such deposits is increasing.

In recent years, various stimulation methods have been used to increase oil recovery in reservoirs. Methods of influencing natural deposits in order to increase oil and gas condensate recovery have led to a significant expansion of the range of substances injected into productive horizons and reservoirs. Note that many of these substances do not have the properties of Newtonian fluids, and

therefore the study of the features of the filtration of non-Newtonian fluids is of particular importance and is relevant.

The aim of the study is to study the issue of non-Newtonian fluid filtration in a spherical-radial model.

The scientific novelty lies in the study of the influence of a non-Newtonian fluid on the main indicators of filtration.

In this paper, non-linear laws of filtration are considered, provided that the filtering liquid has non-Newtonian properties.

It is known that for a non-Newtonian fluid, the main parameter characterizing its motion is the dynamic coefficient of viscosity. This coefficient is proportional in Newton's law. The relationship between the shear stresses, and the velocity gradient is in this case a straight line passing through the origin.

Fluids that do not obey the law of friction are called anomalous or non-Newtonian. Basically, according to literature analysis, non-Newtonian fluids can be divided into three groups:

1. non-Newtonian fluids, for which shear stress depends only on the velocity gradient (stationary rheological oils)

$$\tau = f\left(\frac{dv}{dy}\right) \tag{1}$$

2. non-Newtonian fluids, for which the relationship between shear stress and velocity gradient depends on the time of stress action (non-stationary rheological oils)

$$\tau = f\left(\frac{dv}{dy}; t\right) \tag{2}$$

Where t - time of stress, sec.

3. viscoelastic oils, i.e. a medium that has the properties of both a solid and a liquid, as well as the tendency of its physical properties and shape to partially recover after stress relief.

Among non-Newtonian fluids of the first class, three classes can be distinguished:

a) viscoplastic fluids, for which the equation has the form

$$\tau = \mu\frac{dv}{dy} + \tau_0 \tag{3}$$

b) pseudoplastic fluids, for which the equation takes the form

$$\tau = k\left(\frac{dv}{dy}\right)^n \tag{4}$$

c) dilatant fluids are described by a power equation, but with $n \succ 1$.

Models of dilatant liquids describe well the properties of suspensions with a high solids content.

Problem statement.

The main studies are based on the laws of hydro-mechanics and are solved by mathematical methods.

Where k and n are constant coefficients for a given fluid. This model is used, in particular, to describe the motion of solutions and polymer compositions.

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In porous media, consisting of many micro-capillaries of various diameters, as the pressure drop decreases, the capillaries gradually “plug”; at first, the flow stops in the smallest pores, and as the pressure decreases, this process is observed in large capillaries.

Note that in this case, anomalous properties of reservoir systems arise. The literature [1–5] provides numerous properties of a liquid, such as viscosity, porosity, ultimate shear stress, pressure etc. at low flow rates and low permeability of a porous medium. This is also typical for heterogeneous layers. Note that in the area of low permeability, the appearance of anomalous properties of oil is most likely.

It is known, that the determination of the filtration of liquids and gases is not only of theoretical interest, but also of wide practical importance, because without knowledge of the law of filtration in the rock, especially near the bottom of the well, it is impossible to calculate the possible flow rates of oil and gas, their change over time under various operating conditions wells, and it is also impossible to determine the parameters of the horizon, reservoir, such as permeability, porosity, etc. These parameters, in particular, are determined according to the data of studies of production wells producing hydrocarbons.

Basically, three types of reservoir models are considered. One of these models is spherical-radial. If all fluid particles move in a porous medium so that their filtration rates are not parallel to the same plane, then such movement is called spatial or three-dimensional, since three coordinates are required to determine the position of a hydrocarbon particle in space. Note that if during spatial motion all trajectories are rectilinear and converge radially at one point, then this motion is called three-dimensional radial or spherical-radial.

In this case, due to the spatial symmetry relative to the center of the well, the value of the filtration rate and pressure at an arbitrary point in the flow will be a function of the distance between this point and the center, the well.

Since the magnitude of the filtration rate and pressure are functions of only one variable, a complete study of spherical radial flow can be performed mathematically. Note that an example of a spherical radial flow is a hydrodynamically imperfect well that has barely penetrated an impermeable horizontal top of the layer. In this case, the inflow of hydrocarbons in the immediate vicinity to the bottom of the well will comply with the laws of three-dimensional radial motion.

The problem of fluid inflow to a well that is imperfect in terms of the degree of opening of the reservoir in a reservoir of finite thickness was studied by M. Masket [6]. I.A. Charniy proposed a method for determining the flow rate of a well that is imperfect in terms of the degree of opening. In this case, the well area is conditionally divided into two zones. The first zone is located between the feed loop and a radius equal to or greater than the formation thickness. in this zone, the motion can be considered plane-radial. The second zone is located between the borehole wall and the cylindrical surface, where the movement is spatial, that is, spherical-radial, taken as radial-spherical.

This paper proposes a method for studying the movement of a fluid in a given zone, taking into account the anomalous properties of the fluid (oil).

It is known that in a spherical-radial flow for non-Newtonian, viscous-plastic fluids, the velocity can be written

$$v = \frac{k}{\mu}\left(\frac{dP}{dr} - G\right) \tag{5}$$

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where v - is the filtration rate of the anomalous, viscous-plastic liquid, m/sec; k - permeability coefficient, m^2; μ - dynamic viscosity, Pa*sec; $\frac{dP}{dr}$ - pressure gradient, Pa/m; G - limit value of the pressure gradient, Pa/m.

Let's take the cross-sectional area $S = 2\pi r^2$. Multiplying the right and left parts of this expression by the cross-sectional area:

$$Sv = \frac{k}{\mu} 2\pi r^2 \left(\frac{dP}{dr} - G \right) \tag{6}$$

We have

$$Q = \frac{k}{\mu} 2\pi r^2 \left(\frac{dP}{dr} - G \right) \tag{7}$$

Let's solve the equation in the given range

$$\frac{Q\mu}{2\pi k} \frac{1}{r^2} + G = \frac{dP}{dr} \tag{8}$$

We accept the boundary conditions

$$r = R_w \qquad P = P_w$$
$$r = R_c \qquad P = P_c$$

Then we obtain,

$$\frac{Q\mu}{2\pi k} \left(\frac{1}{R_w} - \frac{1}{R_c} \right) + G\left(P_c - P_w\right) = P_c - P_w \tag{9}$$

As a first approximation $P_c = P_w$. Then, with respect to the volumetric flow, we have

$$Q = \frac{2\pi k}{\mu} \frac{\left(P_c - P_w\right) - G\left(R_c - R_w\right)}{\left(\frac{1}{R_w} - \frac{1}{R_c} \right)} \tag{10}$$

where P_c - pressure on the well contour; P_w - bottom hole pressure; R_c - pressure on the well contour; R_w - well radius.

If we accept that $G = 0$, then we have an equation for the inflow in a spherically radial flow [3, 4]. If we assume that $P_c - P_w = G\left(R_c - R_w\right)$, then in this case the volume flow is equal to zero. In [7-14], it is proposed $R_w = 1,5h$, where h is the thickness or height of the reservoir.

This equation makes it possible to determine the volumetric flow rate of a liquid, taking into account the spherical-radial model for viscous-plastic liquids.

The solution of the problem

The experiments were carried out in laboratory conditions. As can be seen from the figure, the applied model in a particular case affects the filtering process. Figure 1 shows the dependence of the flow rate on the value of the limiting pressure gradient. Obviously, with an increase in the latter, the volumetric flow rate decreases significantly, while it should be noted that this graph is a dependence for small volumes, in well conditions, which is of great importance.

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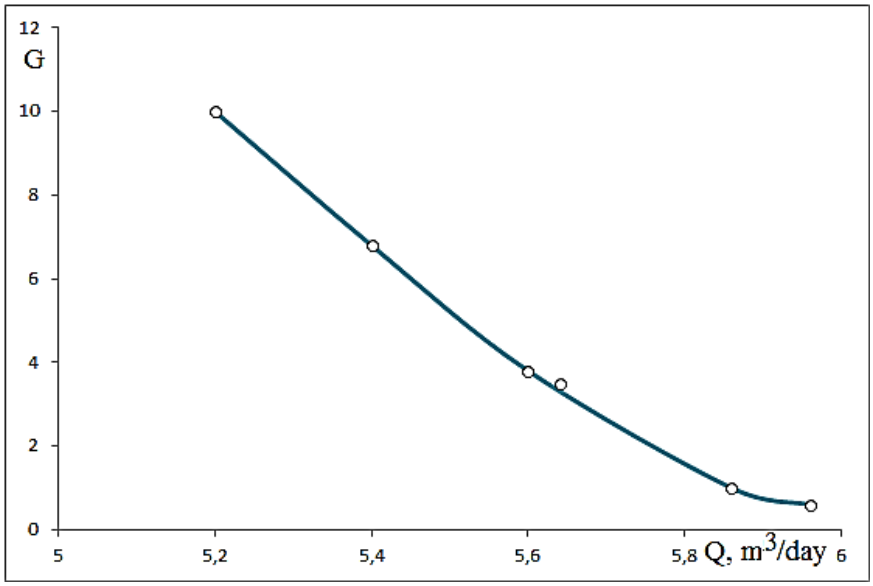

Figure 1. Dependence of liquid consumption Q on G.

Results discussion

The study shows that, taking into account the imperfection of the well, a three-dimensional spherical-radial flow movement is more realistic in practice. Many researchers have pointed to this process. This issue is considered in more detail in [4, 5, 6, 7] for conventional oils.

This paper discusses the issue of non-Newtonian fluid filtration in a spherical-radial model, which is closer to the fields of Russia (Tatarstan, Bashkiria), Romania, Azerbaijan, etc. Given the above, in the development and operation process, it is necessary to take into account these issues.

Conclusion

1. A technique that takes into account changes in the model at the bottom of the well is proposed.
2. A procedure for determining the volumetric flow rate, taking into account the use of a spherical-radial model for a viscous-plastic fluid has been obtained.

Declarations

The manuscript has not been submitted to any other journal or conference.

Study Limitations

There are no limitations that could affect the results of the study.

Acknowledgment

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THE PROBLEM OF FINDING ASSOCIATIVE RULES FOR CATALYTIC CRACKING

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ABSTRACT

Currently, the search for associative rules is one of the most relevant topics related to information technology. That is why the article pays considerable attention to the definition of associative rules. In particular, the article uses "Apriory" algorithm to solve the problem of finding associative rules, as well as speed up the process of detection of associative rules. Using the subtleties of the Apriori algorithm, this approach, as a concrete example, demonstrates the originality of the applied approach "Association Rule Mining".
In this article, the authors consider the problem of identifying hidden dependencies between data, and also explore and solve the problem of finding association rules using the method Association Rule Mining в среде XL Miner.
In recent years, the abbreviation «data mining» and its English synonym from the merging of two words is very often found in the special literature: Data Mining
This method - searches for associative rules in huge transactions through the information base of the installation of catalytic cracking. It identifies inputs that affect the output of the catalytic cracking unit, and also identifies hidden dependencies and useful knowledge. On the basis of this model there is a prediction of the quality of the output product (for example the relationship between output and output parameter). The difference between an association's classification and clustering tasks is that the search for patterns is not based on the properties of the object being analyzed, but between several events that occur simultaneously. As a rule, associative rules are as follows: if (condition), then (result), where the condition is not usually a logical expression (as in classification rules), but a set of objects from the set I to which the objects (associated) included in the result of the given rule are connected.
For example, the installation of catalytic. Cracking, based on the analysis of the information base, in order to predict the quality of the received product of the installation using one of the methods of Data Mining, namely the search for associative rules, determine the dependencies between input and output parameters, and also reveal hidden patterns. In this connection, ED-AVQ-6 (ELOU-AVT-6) considers the problem of detecting data dependency related to parameters of the rectification column.
Keywords: "Apriory" algorithm, associative rules, "Association Rule Mining", improvement, probability of accidentally, Data Mining.

Introduction

The rapid development of information technology, in particular, storage and advances in information processing techniques, has enabled many oil enterprises to collect large amounts of information that needs to be analyzed. Today, the direction related to the intellectualization of information processing and analysis methods is developing intensively. As a result, automatic

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data analysis is achieved. In this article, widely used method of a new technology called Data Mining. This method - searches for associative rules in huge transactions through the information base of the installation of catalytic cracking. It identifies inputs that affect the output of the catalytic cracking unit, and also identifies hidden dependencies and useful knowledge. [1]
In recent years, the abbreviation «data mining» and its English synonym from the merging of two words is very often found in the special literature: Data Mining.[5].
Speaking about the problem situation, it is necessary to note that, unlike statistical methods, the intellectual approach gives the opportunity to identify the inherent in the data uncertain patterns. In particular, associative rule searches reveal input and output factors as well as dependencies between them. In order to speed up the process of finding associative rules, the algorithm Priori. (7)

Problem statement

The one of local refinery has been constantly renewed and developed since its inception. This tradition continues to this day. In the last ten years, the N-22 (ED-AVG- 6) plant has been commissioned as a new kerosene and diesel fuel unit with high performance. At the moment, the capacity of the catalytic cracking unit is 3.0 million tones per year. To achieve this figure with UOP USA, in order to increase the productivity of the plant, with the firm FW (Foster Wheeler), the firm "Hamon Thermal Europe" of France were signed contracts.
Today, the local refinery has three certifications: real İSO-9001 in quality, İSO-14001 in ecology, TS-18001 in safety.
In order to predict the products listed above, to improve the quality of the output product, methods of Data Mining technology are widely used.
In literary sources, Data Mining (IAD) is defined by Data Mining technology and IAD practically refers to undefined and useful knowledge. In this context, knowledge acts as information stored in the data.
For example, the installation of catalytic. Cracking, based on the analysis of the information base, in order to predict the quality of the received product of the installation using one of the methods of Data Mining, namely the search for associative rules , determine the dependencies between input and output parameters, and also reveal hidden patterns.
In this connection, ED-AVQ-6 (ELOU-AVT-6) considers the problem of detecting data dependency related to parameters of the rectification column.
To identify a functional dependency:
1) Recovery column, ED-AVQ-6 refinery installation, is predicted based on data input factors analysis related to the settings in this installation.

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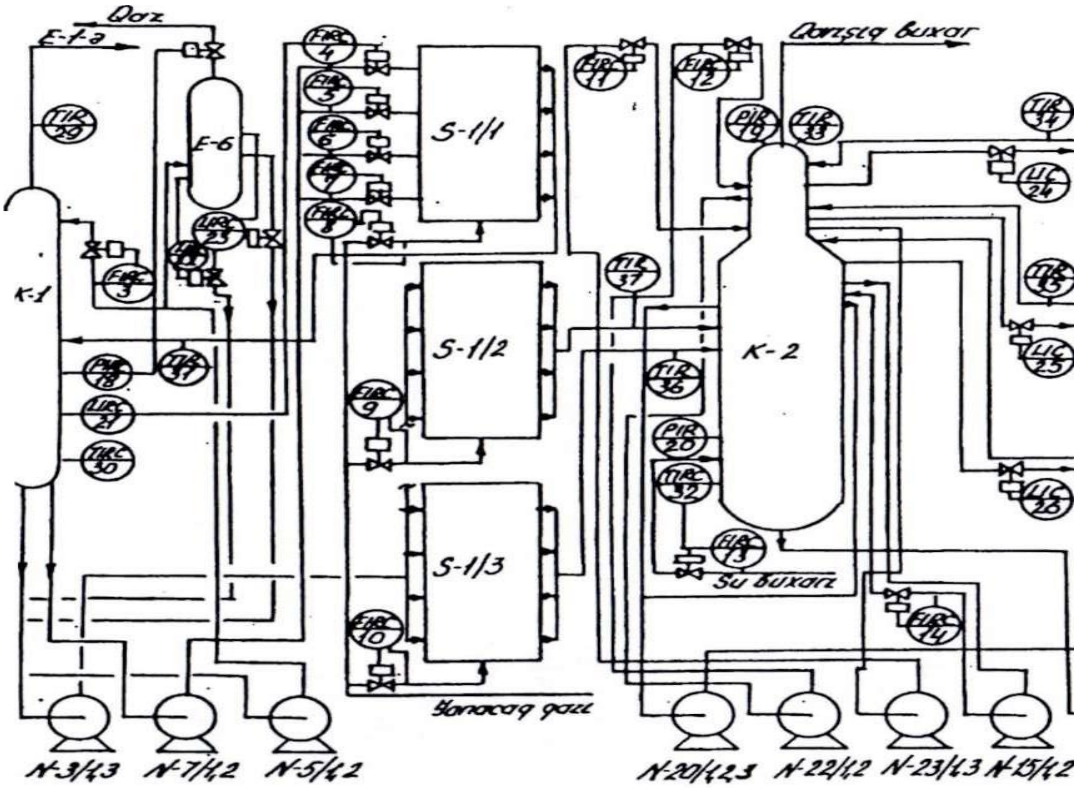

Figure 1. Cracking Mouth.

2)Based on the information base, we constructed the table below.

Table 1. Cracking Raw Materials and Products Characteristics.

Indicators	primary products		Cracking Products		
	Vacuum distillate	Recycled gas oil	Petrol	catalytic gas oil	
				light heavy	
Relative density:					
ρ_{277}^{293}	0,9100	0,9330	0,7600	0,9300	0,9400
ρ_{288}^{288}	0,9131	0,9340	0,7641	0,9330	0,9420
Boil-off limits, K	623-773	468-773	313-468	468-623	623-773
Molecular mass	360	248	105	200	340
Average molecular boiling point, K	683	582	384	548	676

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As a result of the analysis of Data Mining methods, the choice fell on the method of finding the association rules.

Solution of the problem.

Data Mining (knowledge extraction) – the search process of various mathematical and statistical algorithms based on the analysis of clustering, regression and correlation, trends, relationships and patterns. The purpose of this search is to build a model of dependence. On the basis of this model there is a prediction of the quality of the output product (for example the relationship between output and output parameter). The difference between an association's classification and clustering tasks is that the search for patterns is not based on the properties of the object being analyzed, but between several events that occur simultaneously. As a rule, associative rules are as follows: if (condition), then (result), where the condition is not usually a logical expression (as in classification rules), but a set of objects from the set I to which the objects (associated) included in the result of the given rule are connected.

The number of associative rules can be very large and difficult-to-understand for a person. In addition, not all the built-up rules carry useful information. The following values are introduced to assess their usefulness:

Support - shows the percentage of transactions that support this rule.

Since the rule is built on the basis of a set, it means that the rule X=>Y has support equal to the support of the set F, which consists of X and Y:

$$SuppX => Y = SuppF = \frac{|D_{F=X\cup Y}|}{|D|} \qquad (1)$$

Obviously, rules based on the same set have the same support,
for example, support for Supp(if (Vacuum distillate, Gas Recirculating Oil), then (gasoline) = Supp(Vacuum distillate, Gas Recirculating Oil, Gasoline) = 0.5.

Confidence - shows the probability that the presence of a set X in the transaction follows the presence of a set Y in it.

The validity of a rule X=>Y is the ratio of the number of transactions containing X and Y to the number of transactions containing a set X:

$$ConfX => Y = \frac{|D_{F=X\cup Y}|}{|D_X|} = \frac{SuppX\cup Y}{Suppx} \qquad (2)$$

Conf(if (Vacuum distillate), (Gas Recirculating Oil)) = 2/3;
Conf(if (vacuum distillate), then (gasoline)) = 2/3;
Conf(if (Recirculating Gas Oil, Vacuum Distillate), then (Gasoline,)) = 1;
Conf(if (Gasoline), (Catalytic Gas Oil, Gas Oil Recycling)) = 2/3.

If the percentage of Y in a transaction, provided that it contains a set X, is less than the percentage of unconditional Y, i.e.:

$$ConfX => Y = \frac{SuppX\cup Y}{SuppX} < SuppY. \qquad (3)$$

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This means that the probability of accidentally guessing the presence of a set of Y in a transaction is greater than that of predicting it with the rule X=>Y.
To remedy this situation, an improvement measure is introduced.
Improvement - shows if the random guessing rule is more useful. Rule improvement is the ratio of the number of transactions containing sets X and Y to the product of the number of transactions containing a set X and the number of transactions, containing a set of Y:

$$imprX => Y = \frac{|DF=X \cup Y|}{|DX||DY|} = \frac{Supp X \cup Y}{Supp X * Y} \qquad (4)$$

At present, the problem of constructing associative rules in the light of the discovery of knowledge in data, in particular finding patterns between related events, is very topical. And the support and validity of these rules should be above certain thresholds, called respectively minimum support (min support) and minimum reliability (min confidence). For this purpose, the software implementation of the Priori algorithm is made in the XL Miner package.

Table 2. Object-feature transaction table.

TİD	Items
A.	Vacuum Distillate, Fuel Oil
B.	Gas recirculating oil
C.	Gasoline, Kerosene
D.	Catalytic gas oil (light, heavy)

Table 3. Normalized transaction table.

X1	X2	X3	X4
1	1	0	1
0	1	0	1
1	0	1	0
0	1	1	0
1	1	0	0
1	1	0	1
0	0	0	0
0	1	0	0
0	1	1	0
1	0	0	0
1	1	0	1
0	0	0	1
1	0	1	1

From the XL Miner menu, select the Association Rules Set the Minimum support values (#transactions and

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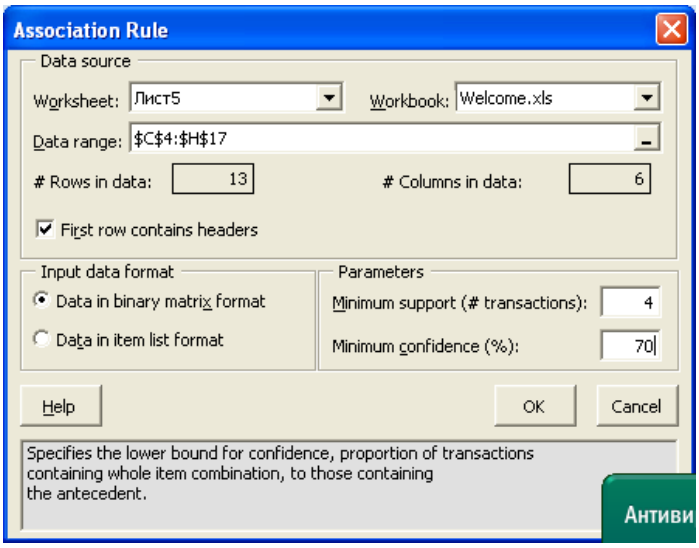
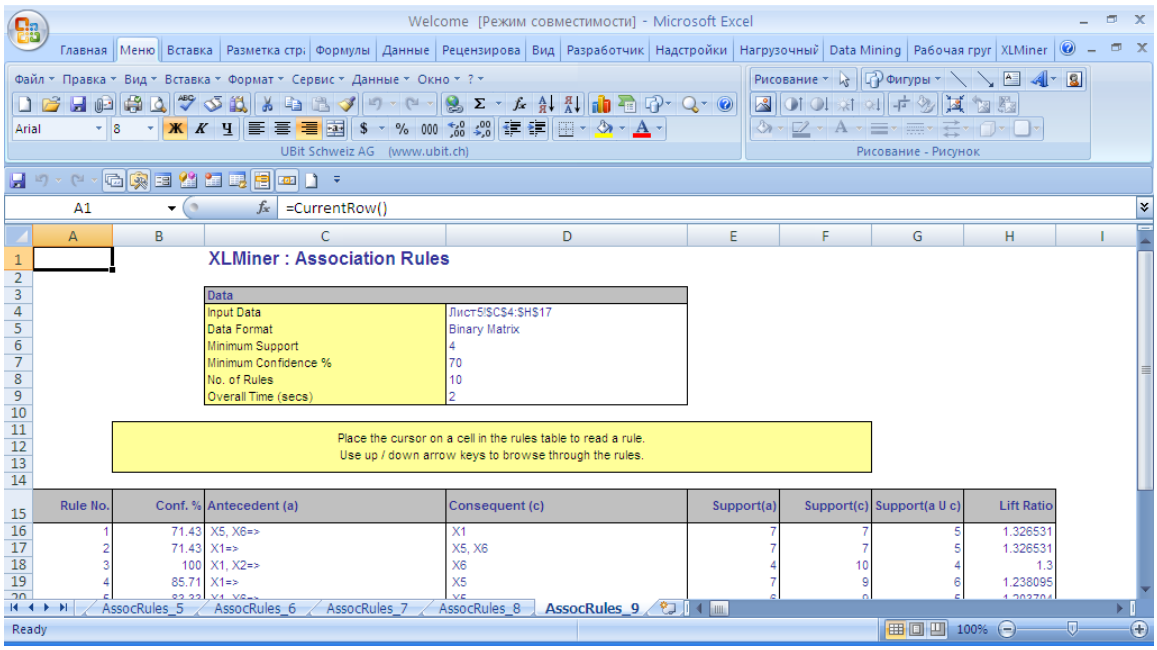


Minimum Confidence, then OK.
The results are presented in the software package XLMiner (Association rules).



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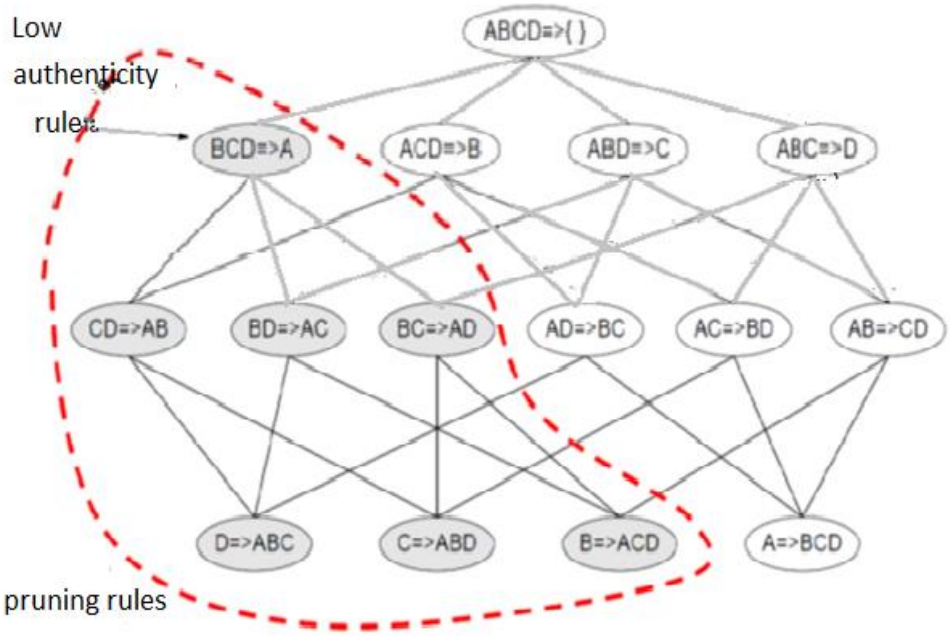

Figure 2. Model for representing association rules

Conclusion

In this article, the question of identification of generalized associative rules was considered. In order to speed up the process of finding associative rules, the Apriori algorithm is used.

Declarations

The manuscript has not been submitted to any other journal or conference.

Study Limitations

There are no limitations that could affect the results of the study.

Acknowledgment

The author would like to express gratitude to the care support workers and elderly individuals who participated in this study, sharing their invaluable insights and experiences. Their cooperation and openness have significantly contributed to the depth and richness of the research findings.

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VIRTUALIZATION OF CULTURE AND RELIGION AND ARTIFICIAL INTELLIGENCE IN THE POSTMODERN CONTEXT OF MODERNITY

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ABSTRACT

The article is devoted to the topical issue of the virtualization of culture and religion, which appears in postmodern conditions, characterized by blurring between the real and the fictional, between fact and fiction, between the sacred and the profane. The authors explore artificial intelligence, which is one of the most powerful virtualization tools that can model and analyze, interpret and transform cultural and religious phenomena, influence various aspects of culture and religion, such as language, symbolism, mythology, ethics, aesthetics, identity, values, freedom, responsibility, etc. The authors also consider the possibility of the consequences of virtualization for the future of humanity, which may learn radical changes in its nature, status, functions, and relations with other beings. They emphasize that virtualization has its advantages and disadvantages, which require critical evaluation and reflection, and call for finding the optimal balance between the real and the virtual, between the traditional and the innovative, between the human and the artificial, in order to preserve the meaning, value and dignity of human life.
Keywords: transform cultural and religious, phenomena, symbolism, mythology, ethics, aesthetics, identity.

Introduction

The theme of virtualization of culture and religion is extremely important in the modern world. Modern post-non-classical science marks a certain return to the principles of education in ancient societies, when the mythological understanding envisaged, in particular, the integrative mastery and understanding of the world in the form of fairy tales and legends, epics and myths, songs and stories, etc. Religion and culture are deeply interrelated. Religion influences culture, and culture influences the perception of religious values. For example, religion shapes moral norms that affect cultural practices and lifestyles. This is an important discussion, especially in the modern world, where religious diversity and cultural pluralism are becoming more and more relevant.

In the social discourse there are different views on how culture and religion are interrelated, whether it is possible to consider religion as part of culture, starting from the fact that culture is religion, to the point that religion is a culture with intermediate variants. There are supporters of the view that culture and religion are incompatible, that they are polar values, that culture grows out of religion, and religion even destroys culture. Supporters of one point of view may argue that culture and religion are identical, another – that they are neutral and independent spheres of human life. Culture and religion are an integral part of modern human society, and no matter how we describe their relationships – as enemies or friends – it is impossible to deny their presence in social life, as can not be denied their mutual influence, despite any assessment. Studying culture,

we cannot fail to pay attention to religion and vice versa, moreover, it can be noted that in the history of human society there is even a tradition to consider culture and religion as relatively autonomous spheres of existence, although those changes that took place in one sphere of being, reflected also in another.

One of the topics to be considered is undoubtedly the socio-cultural aspects of the study of artificial intelligence (AI) and its social incorporation into the compendium of human knowledge, as well as the social consequences of its emergence and development. One of the central problems of AI in society is the problem of simulation of meanings in their semiotic understanding, transcendental-phenomenological theory of constructing meanings and generalization of conventional-socio-cultural plan. When studying this subject, it is important to take into account the position of Immanuel Kant's transcendentalism and Edmund Husserl's phenomenological coherence because of their conceptual similarity with the construction of virtual objects as forms of study of human creative abilities. Immanuel Kant's philosophy also enables us to strengthen the position of the philosophy of AI and make a step towards new fundamental research into the mechanisms of thinking. Thus, the old question "Can a machine think?" on the basis of historical and philosophical discourse (from Socrates, Aristotle, Plato, Democritus, Justine to G. Galilei, A. Augustine, P. Abelara, S. Boetius, I. Kant, etc.) may acquire a new sound, where the concept of "machine thinking" was developed, including, in particular, the intensely developing socio-cultural dimension.

The main part.

The phenomena of virtual reality were investigated by foreign and domestic researchers: U. Brick, F. Brooks, F. Webster, J. Delos, S. Zizek, J. Lanie, I. Sutherland, T. Stounier, S. Khorujy, S., Zaborovskaya, N. Zudilin, O. Karina, C. Konoplycki, A. Sotnikova, E. Uhanov, Y. Shadsky. Questions of the formation of modern culture in the conditions of the information society involved many foreign and domestic researchers, among which: A. Bard, P. Berger, V. Volynets, Y. Zodervist, A. Prudnikova, G. Sashchuk, S. Huntington, M. Shmigol, Yu. Yushkevich, etc. Despite the fairly wide spectrum of studies carried out on the influence on the culture of the information society of such a phenomenon as virtual reality, this is part of the general problem to which this work is devoted.

It should be emphasized on the behavioral shade of the existing understanding of AI: affirming the prevailing socio-cultural nature of human subjectivity, AI is perceived mainly as a subject of knowledge. Mechanical AI could have been an enhancer of the natural mind, processing information on perforations and perforators long before Charles Babbage and Herman Hollerith. The creation of AI generally appears to be not so much a technical, natural philosophical or sociocultural, but also a sociological problem, and since the real, the most similar to the natural, AI will be created sooner or later, the main task is to answer the question of the purpose of its creation, controllability and harmonious incorporation into human society.

Similar to the aforementioned interactions we observe in the age of the information society: we have for some time studied convergence processes in the modern religious life of society. We have identified and described them, among them: acceleration, actualization of eschatology, actualization of social concepts, americanization, veltization, virtualization, globalization, dialogization, ecumenical movement, egosyntonization, exoterization, growth of inclusiveness, consumerization, modernism and postmodernism, new religions, paxisation, privatization, reproduction of modern religious pluralism, rationalization of cult actions, revivalization,

secularization, syncretization, stigmatization, unification of exorcization, tolerance, feminization, fundamentalization and charismatization [11].

These same processes are reproduced in cultural life, but now we will stop on the topic of virtualization of culture and religion, because, as Samuel Huntington believed in the work "The Clash of Civilizations", religion is the cornerstone of culture. All forms of interaction of culture are carried out in religious life, and, recording changes in culture in general, we want to note that all forms for fixing the change of cultural and religious lives are performed in social networks and blogosphere. Modern culture also expresses itself in information technologies: both cultural and religious life are moving online. Culture – everything created by man, second nature, now goes online, and all the processes that play off-line – dialogue, virtualization, veltization, globalization and so on – are also observed online. We can also mention the work of Yevgen Tsimbalenko, where on the basis of surveys of experts and practising journalists, the main positive and negative consequences of convergence and digitalization in media communications are identified and systematized [20].

We emphasize the research focus on the interdisciplinary area of research, because, despite the historical confrontations of interfaith and interconfessional character, all religious organizations serve the achievements of culture - a new religious culture of communication is being developed in Internet itself, and different aspects of religious cultures and rituals find their expression in the Global Network. We can observe identical problems in the relationships between religions, the relationship between culture and religion online and offline, they can be parallelized. This is especially interesting in the context of the possibilities that Internet offers – belonging to one, several, many or no religion, because Internet hypothetically makes relationships much more direct than without it [17].

Among other segments and areas of social life, virtualization occurs in culture and religion, in a significant way their forms are identical, but there are differences, the same happens in the online. On the other hand, the process of virtualization and automation, computerization and onlineization, digitization and robotization is one and is global - in this case, all participants in the global process can differ significantly - the differences between them are largely due to the virtualization process [14].

At present, Internet is presented to consumers, including as an integrator of all spheres of social reproduction and from our point of view, it is possible to record different forms of convergence and interrelationship of culture and religion on Internet. One of the cultural subjects studies the connection, integration, interdependence, convergence and divergence of art in Internet - especially this applies to arts such as literature and theatre, painting and cinema, architecture and music, sport and circus, the spectacle industry and the art of performance such as the flashmob [16].

We should find out what is done with religious art in connection with its virtualization, when the icons, rites are consecrated in the Worldwide Web, and we are talking about the fact that one of the fields of interaction of religion and art is Internet. The main conclusion here – each of these areas has a common and special in this interaction: common – they are subject to the requirements of the network, as regards programs, methods, forms of interaction on Internet – it is chats, bots and other forms of interaction - channels in different social networks. Symptomatic and relevant to modern epoch is the virtualization of religious art [6].

Internet as a system can provide information support to art and religion - online with them is done the same as offline, given the existing availability of Internet: it is possible to record a huge

number of interactions online with offline and draw parallels – some online events do not occur offline and vice versa. The most important trends and contemporary relationships are expressed in the fact that religion expresses its ideas and vice versa - art is reflected in religion and sacred creation. Previously, religion dominated art, now they have a limit, secular art arose, so the artist does not necessarily have to be a believer, the believer does not need to look for himself in art: faith can promote or prevent professional self-realization, and such a difference exists [13].

Internet is not religious or secular – Internet can be sacralised, art can be on Internet and represent a religious part of humanity. Because of the pandemic and then the war, art for Ukrainians largely moved online, if we mention show business, their art became available to their fans only on Internet - now the same is happening with religious activity. Internet can assist to sacralize some, demonize others, and it can praise or mock artists and representatives of churches.

If we assume that culture is all kinds of social relations, it is axiomatic that culture exists in man, nature and society, it occurs in all social relationships. In this context, we can mention Bollywood, many of which have a religious plot – there is a synthesis of religion and art, there are popular films on religious topics, for example, films on papal topics or Eastern beliefs - so Internet creates new manifestations of fine arts.

Art by definition is as virtual as possible, while art and religion are often inseparable. Pytymym Sorokin conducted his famous studies of the Middle Ages and modernity, rightly noting that in the middle ages in museums almost 90% of the plots were the themes of religious art, now there is a mirror opposite ratio. Now it is possible to explore the relationship between religion and art, observing a gradual increase in the number of exhibitions and presentations - in fact, all modern religions and all kinds of art find themselves on Internet [15].

Most famous, ancient and respected museums in the world have their own sites with free and personalized VIP access, where we can get comprehensive information even for the most curious mind. The sites support VR-headsets: a significant part of the galleries and exhibitions are available for virtual tours, also on the sites of museums there are photos of most of the exhibits, which are presented in the buildings of the museum. In the online mode the visitor of the museum website can get acquainted not only with the works, but also with many personal things of their authors – these are diaries and letters, works and early paintings. Among the millions of digitized exhibits present are a significant part of the famous masterpieces of painting and sculpture, jewelry and antiques, manuscripts and dishes. With the convenient sorting function we can sort works by themes: mythology and religion, history and architecture, we can also view exhibits by countries and by master's surnames. On the sites of museums can be detailed and illuminated the creative path of artists: materials with biography, interesting facts and stories of writing famous paintings [8].

Art employs all new technologies, AI can compose literary works and scientific reports, sermons and reports, carry out all kinds of scientific communications, referrals and essays. AI can demonstrate its creativity in different genres and directions, styles and types of art and painting, in the fields of theatre and ballet, cinema and animation, architecture and music, the art of drama and storytelling, novels, short stories and poems open up in a new way the possibilities of AI. Thus, for example, cinema appeared as a synthetic art, closely combined with technologies, because it was born of them - therefore, the history of cinema, the improvement of its means of expression and the specifics of language are directly related to the development of technologies. It is quite natural that the stories of fanatical scientists and their dangerous discoveries for humanity began to interest filmmakers from the first decades of the existence of a new kind of art. These

stories are screened in a large number of science fiction films, among which there are many anti-utopias about the creation of artificial intelligence. Many of these tapes became classic and cult, influenced further aesthetic searches - artificial intelligence often acted as a trigger of the current media-culture. The emphasis was placed on the role of modern information and communication technologies, above all, artificial intelligence technologies and Internet of Things in the generation of the latest forms of culture and art. The role of artificial intelligence in the formation of "added" cultural reality and various formats of media art is significant [21].

It is important that in recent times humanity has delegated more and more of its functions to artificial intelligence - now it can draw a picture, write music, create text. So, recently the AI taught the art of debate - now humanity has a worthy interlocutor, able to understand complex social problems, to argue their position, to find strengths and weaknesses in the position of their opponent [22]. Artificial intelligence can be useful to communicate with our audience and to engage a new one: chatbots are now actively being created for museums, exhibitions and for the popularization of art in general - as an example, we will give chatbot of the information campaign "Art wants to get acquainted" from the Ukrainian Cultural Foundation. AI was added to art - comparatively recently IBM jointly with the National Museum of Wroclaw presented the application CoArt, which enabled visitors to interact with the painting of the Polish artist Michael Wilman "Paradise" - thanks to artificial intelligence every visitor of the exhibition "Willmann. Opus Magnum" could use the program to "talk" to the painting, to learn about it better, to understand its meanings and to get a deeper sense of creativity [4].

In addition, artificial intelligence can show how famous paintings were created [18] and teach creative perception of the world [19]. Artificial intelligence algorithms help to classify and segment any information in digital form (number, words, sounds, photos, videos, etc.), find in it relationships and patterns, features and differences. Paintings drawn by artificial intelligence are already sold expensive [9], AI has also learned to transform drawings into photo-realistic images [12]. There are three variants of the relationship between culture and religion - for one period their mutual combination is presented as a synonymous series (period to the New Time) [5]. Stanislav Belkovsky expresses the view that the merger of science and religion will come – they do not oppose each other, they converge and will not contradict each other. Mikhail Epstein considers modern theology as techno-theology in the work "Russian anti-world". Now more and more people talk about the theology of modern religious perception, and if before religion rejected science and scientific data, if they contradicted the Bible, then from the point of view of Mikhail Epshtein, there is no object of contradiction between them: all scientific technologies testify to the Word of God – all from God and for God. In the work "Religion after Atheism" by Mikhail Epshtein, the author believes that the postmodern ended 9/11, that is, the explosion caused the end of all relationships – all the relativity of this world ended, the illusions ended because of this tragedy, with which, in fact, began the third millennium.

There was a crisis of post-modern culture, the meaning of which was in the struggle against ideologies, since meta-narrations (communism or Marxism, Christianity or Buddhism, etc.) did not save mankind from fascism and genocide, the Holocaust and the famine, and now it is widespread to put a mark of equality between fascist and Stalinist. Most likely, it was methodologically consistent and appropriate, for 80 years Europe lived without wars, but now the hot war in Europe is ongoing, full-fledged and large-scale, and the postmodern ideology itself proved to be unable and uncapable to prevent the Russian-Ukrainian war. Postmodernism can now be accused of the same claims it made when he came out with criticism of all forms of

ideologies after the Second World War – accusing all ideologies of failing to stop the horrors of World War II. And now, with a new world war coming, which may turn out to be World War III, postmodernist philosophy and thinking have just as well proved incapable of predicting and stopping the war.

Two classics, Clifford Geertz and Robert Bellah, have an interesting understanding of the relationship between culture and religion , who in the context of the history of religions consider religion in all its main manifestations before the axial time, the philosophy of ancient China, Greece and India, Hinduism and Buddhism, from which they conclude that culture and religions are practically identical concepts, and often, no matter how we look at the relationship of religion and culture, the result is the same. Between them there is a certain identity, although there are two points of view: religion is a belief in the transcendent and supernatural, the second: religion - it is as a way of socialization. There is a huge number of points of view on religion and culture - these two spheres of human activity are in any case connected, this connectivity suggests the possibility that change in the sphere of culture determines change in other directions. For example, the invention of book printing by Johannes Gutenberg became one of the factors of the spread of Protestantism, and the following information technology era affects all spheres of culture, including religion, and changes caused by IT, affect the entire culture in general [3].

Changes in a particular social field - education, literature, science - affect changes in another sphere of culture - here we can see the relationship of technology and culture in one whole, there are both horizontal and vertical interactions. The horizontal of relations is that any phenomenon of culture is a change in one sphere of culture, and the corresponding change of the whole culture. Vertical is when one of the components of culture becomes advanced: yes, until the New era the religious direction led, in the New age - political-legal, now - ethical, but at the same time political influences on the psychological, economic, religious, and the modification of one component causes and provokes modernization, modification or stagnation in everything else. In this context, the Russian-Ukrainian is now seen as a war of the archaic with the transmodern, so transmodern can be considered as one of the possible descriptions of modern states of culture, which comes to change the metamodern, and it does not remove the problem of the confrontation of archaics and postmodern.

We can even note the schizoidality of modern culture - it lies in the fact that every new possibility can manifest as something affirmative and denying, positive and negative - in everything can reveal their ambivalence - even the term schizophacsism is used, when Russian fascism speaks with anti-Nazi slogans. In the process of manifestation of pluralism (e.g., ideological or religious), ambivalence here may act as an extreme form of tolerance in the sense of accepting ideology, but for critics of toleration is more typical of the transition from ambivalence to schizoidality [2]. Generally speaking, many phenomena of culture are ambivalent in nature - the machines of the future will be able to both plow and kill - so the introduction of new devices can be in its consequences also ambivalent. For example, when Russia fails to cope with ambivalence – there is schizophrenia of its leaders, there is a loss of historical chances when Russia was excluded from the G8 and G20, and Vladimir Putin turned out to be a schizoid personality. At the beginning of the XXIst century, it is necessary to learn to negotiate, however, if dialogue becomes impossible, and political opponents cannot agree, various forms of political settlement come into force, including for this reason, the Russian-Ukrainian war can become prolonged.

As a result of World War II, postmodernism appeared, one of the messages of which is that narratives are ambivalent in terms of their embodiment, and we use tolerance to accept them. The

narrative of the hypothetically possible development of democratic Russia has turned into schizoidism of modern culture, because it cannot adequately respond to schizophrenia, has not found ways to respond to the schizofascism because of the schizoidism of its own culture. But especially symptomatic is schizoidism of virtual culture, in the religious sphere there are bots that carry schizoidism - for example, about the appearance of new prophets. Paranoid perception of these events can be characterized by obsessive-compulsive syndrome, and it is worth considering that most people are infected with it. If we mention different bipolar manic disorders, we can assume that all kinds of disorder are present in the religious sphere.

The sphere of virtuality itself is schizoid, as is science in general, and through it culture also knows and reveals its schizoidism. The presence of these psychological techniques is characterized by the modern Internet, especially if we consider that all fake - part of informative and psychological operations (IPSO), and IPSO, in turn - a part of schizoidism - where it is consciously applied, especially the leaders of new social movements. In our view, IPSO is revealed in the discussion in the virtualization of religion: how the activity of the UOC is highlighted, considering the circumstances that it renounced the ROC, condemned the aggression on the first day of the war. From the point of view of internal politics, from Ukraine, it is considered from the point of view of the proximity of the UOC and the ROC, and from the point of view of external politics – from the viewpoint of the violation of freedom of speech and religious freedom – in all this clearly and explicitly reveal, in our view, ambivalence, contradiction and schizoidism, including because the majority of UOC believers do not consider themselves enemies of Ukraine.

The virtualization of religion is also accompanied by its schizoid sides - in our modern culture this situation can be characterized by IPSO. Thus, information about the Roman Catholic Church is largely pedaled due to LGBTIQ tolerance, the blessing of LGBTIQ representatives, although not the promotion of them. There is synonymization of the virtualization of culture and religion from the point of view of technology [7].

Here an important question arises - in the world there is no single philosophical system or religion that would unite all global processes. All those processes that lead to convergence in society have worked locally, we all know the world trends that characterized the future of the world as a single whole, in the global key will not work, but widely spread conspiracy theories, and we can also note the crisis of religion, including, in warring countries, for example, crisis of confidence in the church is observed in Ukraine according to the Razumkov Center – trust in the church is less than in the army, although it used to be in the lead. According to a study published on February 7, 2024, the Armed Forces of Ukraine enjoy the highest confidence among citizens, reaching a rate of 95%. They are followed by volunteer units and the State Emergency Service with 85% and 82% of confidence, respectively. 61% of respondents expressed their confidence in the church [1].

There is a crisis of various cultural institutions in Ukraine, including religious ones. Since the start of the full-scale invasion, Russia has damaged or destroyed more than 530 churches of different faiths in Ukraine, tortured or killed at least 25 clericals, and this is the mission of information and communication technologies, to enable people to participate in the services of their own and other religion/church/denomination remotely and virtually. Almost a quarter of the churches damaged by the invaders are no longer usable - they have suffered substantial destruction or have been completely destroyed: 9% have been totally damaged, and 16% have undergone such destruction that it will be impossible to restore them [10].

In this context, the virtualization of culture takes place, while it can be noted that postmodernism appears lost and seems already methodologically incorrect - all these euphemisms that the world is a theater, about Homo Ludens, have become figurative lies, because the world is no longer a theater, and human no longer plays, but suffers and kills. Propagandist Volodymyr Solovyov emphasizes that it is more natural for a person to fight than to live in peace - all this proclaims a return to the old forms of justifying evil. Postmodernism has found itself in a state of inability to prevent modern war as an evil - as in the Second World War, Iosif Stalin engaged in the resettlement of peoples, there was also the Holocaust, the Holodomor and genocides - now we can observe the same forms during the full-scale invasion of Russia into Ukraine. Mikhail Epshtein spoke about the mental qualities of Russia in the work "Russian Antiworld": schizofascism, ontocide, Ortholam (Orthodoxy+Islam), necrocracy. If we talk about the postmodern crisis in the era of the Russian-Ukrainian war, if by postmodern we mean the criticism of all ideologies, he found himself in the same state of inability to prevent evil and prevent war as before. Modernity will now dictate the agenda and set trends online: it can solve some problems, but it can deepen others.

Conclusions

The article is devoted to the topical issue of the virtualization of culture and religion, which appears in postmodern conditions, characterized by blurring between the real and the fictional, between fact and fiction, between the sacred and the profane. The authors explore artificial intelligence, which is one of the most powerful virtualization tools that can model and analyze, interpret and transform cultural and religious phenomena, influence various aspects of culture and religion, such as language, symbolism, mythology, ethics, aesthetics, identity, values, freedom, responsibility, etc. The authors also consider the possibility of the consequences of virtualization for the future of humanity, which may learn radical changes in its nature, status, functions and relations with other beings. They emphasize that virtualization has its advantages and disadvantages, which require critical evaluation and reflection, and call for finding the optimal balance between the real and the virtual, between the traditional and the innovative, between the human and the artificial, in order to preserve the meaning, value and dignity of human life.

The article discusses the pecularities of the virtualization of culture and religion in the postmodern context of today, and the authors analyze the influence of artificial intelligence on the development of cultural and religious practices, as well as on the formation of new identities and values. They point out the advantages and disadvantages of virtual technologies that change the ways of perception, communication and creativity and consider the possibility of a future scenario characterized by hybridization, multiculturalism and posthumanity. The article emphasizes the need for a critical approach to virtual realities that can create illusions, manipulation and interdependence. The authors call for the search for harmony between the real and the virtual, between the traditional and the innovative, between the human and the artificial.

In the future, it seems promising to explore the virtualization of culture and religion, as well as artificial intelligence in the epistemological dimension: to create sociocultural and artistic projects, in particular in the media space with the use of IT, to support, design and regulate current cultural processes in predictive social practice (in particular, in the field of cyber culture and socio-cultural processes of the city), develop tasks and technologies of socio-cultural interaction, actualization of cultural heritage, scientifically ensure the creation and implementation of socio-cultural and artistic projects, in particular in the field of cultural

urbanism and the virtual space of socio-cultural interaction and art, which complicates the current level of the economy and the actualization of culture in accordance with the current standards and Laws of Ukraine, the European Union and the provisions of UNESCO.

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$$f(x) = a_0 + \sum_{n=1}^{\infty} \left(a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right) \quad (1)$$

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Authors are supposed to embed all figures and tables at appropriate place within manuscript. Figures and tables should neither be submitted in separate files nor add at the end of manuscript. Figures and Tables should be numbered properly with descriptive title. Each Figure/Table must be explained within the text by referring to corresponding figure/table number. Any unexplained or unnumbered Figure/Table may cause rejection of the paper without being reviewed.

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Table should be prepare using table tool within the Microsoft word and cited consecutively in the text. Every table must have a descriptive title and if numerical measurements are given, the units should be included in the column heading. Formatting requirement has been summarized in the Table 1.

Table 1: Summary of formatting requirement for submitting paper in this journal.
(Times New Roman, 12)

Layout	**Size**	**Margin (Normal)**	**Header**	**Footer**	
Single column	A4 (8.27" X 11.69")	Top=1" Bottom=1" Left=1" Right=1"	Do not add anything in the header	So not add anything in the footer	
Font	**Article Title**	**Headings**	**Subheadings**	**Reference list**	**Text**
	Times New Roman, 16 pt, Bold, centred	Times New Roman, 11 pt, Bold, Left aligned	Times New Roman, 10 pt, Bold, Left aligned	Times New Roman, 8 pt, Justified	Garamond, 11 pt, Justified
Line Spacing	1.15	1.15	1.15	1.15	1.15
Page number	We will format and assign page numbers				

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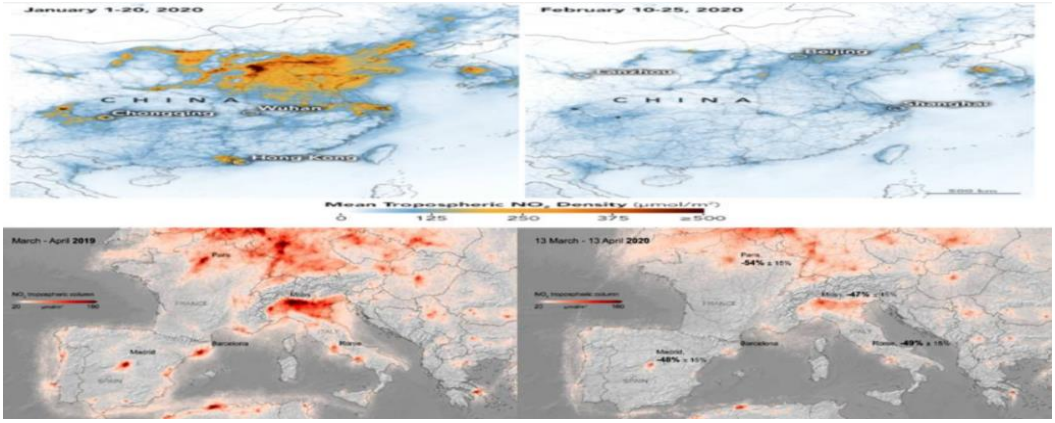

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2. Bahishti, "Peer Review; Critical Process of a Scholarly Publication", J. Mod. Mater., vol. 2, no. 1, pp. 1.1-1.2, Oct. 2016. https://doi.org/10.21467/jmm.2.1.1.1-1.2
3. Bahishti, "A New Multidisciplinary Journal; International Annals of Science", Int. Ann. Sci., vol. 1, no. 1, pp. 1.1-1.2, Feb. 2017. https://journals.aijr.in/index.php/ias/article/view/163
4. W. S. Author, "Title of paper," Name of Journal in italic, vol. x, no. x, pp. xxx-xxx, Abbrev. Month, year. Access online on 20 March 2018 at https://www.aijr.in/journal-list/advanced-journal-graduate-research/
5. W. S. Author, "Title of paper," Name of Journal in italic, vol. x, no. x, pp. xxx-xxx, Abbrev. Month, year. Access online on 5 March 2018 at https://www.aijr.in/about/publication-ethics/
6. M. Ahmad, "Importance of Modeling and Simulation of Materials in Research", J. Mod. Sim. Mater., vol. 1, no. 1, pp. 1-2, Jan. 2018. DOI: https://doi.org/10.21467/jmsm.1.1.1-2

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