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ACTUAL PROBLEMS OF MATHEMATICS, PHYSICS AND MECHANICS

UDC: 535.3 OPTIMIZING AXIAL ABSORPTION IN END-SIDE PUMPED SOLAR LASERS

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Annotatsiya. Toʻgʻridan-toʻgʻri quyosh nurlari bilan ishlaydigan qattiq holatdagi faol muhitli lazerlardagi asosiy muammolardan biri termal boshqaruvdir. Termal effektlar quyosh lazerining chiqish xarakteristikasini sezilarli darajada pasaytrib yuborishi mumkin. Shu nuqtai nazardan, biz boʻylama va kondalang sxmeasida damlanadigan quyosh lazerlarda simulyatsiya modellari yordamida boʻylama oʻq bo'yicha yutulish taqsimotini optimallashtirish uchun kompozit faol muhit potentsialini o'rganib chiqdik. Biz birinchi marta radial voʻnalishda Nd:YAG/YAG koʻrinishidagi kompozit faol muhitni oʻz ichiga olgan quyosh nurlari bilan ishlaydigan lazerlarning simulyatsiya modelini ishlab chiqdik. Simulyatsiya model natijalari shuni koʻrsatadiki, kompozit faol muhit boʻylama oʻq boʻyicha yutulish taqsimoti profilini sezilarli darajada qayta taqsimlaydi, bu termal yuk muammolarini yengillashtirish va umumiy issiqlik boshqaruvini yaxshilash potentsialini koʻrsatadi.

Kalit soʻzlar: Quyosh lazerlari, kompozit muhit, Nd:YAG/YAG, Monte-Karlo foton kuzatish yoʻli metodi.

Аннотация. Одной из ключевых проблем в твердотельных лазерах с прямой солнечной накачкой является управление температурой. Термальные могут значительно ухудшить выходные характеристики эффекты солнечного лазера. В этой связи был исследован потенциал композитных оптимизации распределения сред для поглощения активных с использованием симуляционных моделей в лазерах с торцевой накачкой на солнечной энергии. Впервые была разработана симуляционная модель лазеров с солнечной накачкой, включающую композитную активную среду Nd:YAG/YAG направлении. Результаты В виде В радиальном композитная структура значительно моделирования показывают, перераспределяет профиль поглощения, демонстрируя свой потенциал для смягчения проблем тепловой нагрузки и улучшения общего управления температурой.

Ключевые слова: Солнечные лазеры, композитные среды, Nd: YAG/YAG, трассировка фотонов методом Монте-Карло.

Abstract. One of key problems in directly solar pumped solid-state lasers is thermal management. It can significantly degrade solar laser output characteristic.

In this respect, we investigated the potential of composite active media to optimize absorption distribution using simulation models in end-side pumped solar powered lasers. For the first time, we developed a simulation model of solar-pumped lasers incorporating a composite active medium in the form of Nd:YAG/YAG in radial direction. The simulation results indicate that the composite structure significantly redistributes the absorption profile, showing its potential to alleviate thermal load issues and improve overall thermal management.

Keywords: Solar lasers, composite media, Nd:YAG/YAG, Monte-Carlo photon tracing method.

Introduction

Applied and fundamental studies on converting incoherent, non-monochromatic, unconcentrated solar radiation into coherent, monochromatic, and focusable laser beams have gained renewed interest due to the increasing global attention on renewable energy sources. The prospect of generating high-power, focused laser beams directly from abundant solar energy is both exciting and promising, with potential applications extending beyond terrestrial boundaries. The field of solar-pumped lasers, once primarily focused on solid-state active media, is now expanding to explore novel concepts and applications [1, 2].

Literature Review

Directly solar-pumped solid-state lasers, while studied most [3-7], still have significant room for improvement to reach their theoretical performance limits. Besides spectral imperfections and technical constraints, thermal effects and nonlinear processes pose significant challenges to the performance of solar-powered lasers, primarily due to the highly non-uniform pumping and excessive thermal load [8-9]. Recently, we proposed that structuring active media could be a promising approach to mitigate these adverse effects enhancing the efficiency of solar-powered lasers. Our experimental results with a composite active medium in the form of YAG/Ce:Nd:YAG/YAG [10] have demonstrated the feasibility of this approach, indicating that structured media can withstand high thermal loads and deliver improved performance. In this study, we explore the potential of a composite active media to further optimize absorption distribution via simulation models.

Research Methodology

For the development of simulation models, we adopt a cylindrical coordinate system, as it's used for rod type shapes, which are commonly employed in solid-state laser rods. Then, we can classify them in three orthogonal radial – r, azimuthal – ϕ and axial – z directions.

Analysis and Results

Figure 1 illustrates various compositional configurations, including radial, azimuthal and randomized composites, demonstrating the wide range of possibilities for tailoring the absorption profile. Here colored segments represent different properties.



Figure 1. Schematic representation of various composite configurations.

In composite media, each segment, defined within a cylindrical coordinate system as in Figure 2, represents a distinct material. While theoretically, we could infinitely segment the medium, practical considerations suggest that a few segments in orthogonal directions should suffice for shaping any desired absorption profile.

Simulating solar lasers with composite active media requires precise photon tracing to accurately determine the probability of physical processes occurring within each distinct segment of the composite medium.



Figure 2. Schematic representation of a single segment.

In this section, we investigate and estimate the potential of composite media to shape absorption profiles, aiming to mitigate thermal and nonlinear effects in solar lasers. To assess the potential of composite media, we will adapt the pumping scheme and cavity design of our conducted cavity experiments. We will compare the performance of solar lasers based on single, isotropic bulk media in Figure 3(left) to those using composite active media in Figure 3(right) with varying degrees of compositeness. From this general case, we now examine specific configurations to analyze the resulting absorption distribution profiles. For the initial analysis, we consider a straightforward, a more simpler radially composite rod structure, where the inner core is composed of Nd:YAG and the outer layer is undoped YAG as in Figure 4. We investigate how this configuration impacts the pumping characteristics and analyze the effects of varying the width of these radial layers on absorption behavior and overall performance.



Figure 3. The simulation model of solar laser with Ce:Nd:YAG isotropic medium and a composite active medium.

In Figure 4, the rod radius $r = r_{Nd:YAG} + r_{YAG}$ and we here first consider $r_{Nd:YAG} = 0.9 \times r$ and $r_{YAG} = 0.1 \times r$ for the development of simulation model.



Figure 4. The radially composite crystal – Nd:YAG/YAG.

Since the absorption distribution is generated as a 3D array from simulation models, we can analyze it more effectively by separating it into axial and radial components. This approach allows us to compare the distribution patterns along both dimensions to better understand the behavior of energy absorption within the composite structure.



Figure 5. Axial absorption profiles in Nd:YAG/YAG rod.

Simulation results in Figure 5 illustrate the impact of introducing a small radial layer within the rod on the axial absorption distribution. This modification effectively redistributes the absorption profile, demonstrating its potential to alleviate thermal load issues and enhance overall thermal management.

Conclusions

The investigation into the use of composite active media, specifically Nd:YAG/YAG, within solar-pumped solid-state lasers reveals significant potential for optimizing absorption distribution and enhancing thermal management. The developed simulation models demonstrate that structuring the active medium can effectively redistribute the absorption profile, thereby mitigating thermal load issues commonly encountered in traditional laser configurations. The findings suggest that employing composite structures not only improves performance but also paves the way for more

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efficient and reliable solar-powered lasers, making them a promising avenue for future research and application in renewable energy technologies.

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UDC: 536.2 TWO-DIMENSIONAL TRANSIENT HEAT TRANSFER PROBLEMS FOR INHOMOGENEOUS BODIES SIMULATED USING FEM

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Annotatsiya. Maqolada bir jinsli boʻlmagan material plastinasida ikki oʻlchovli issiqlik oʻtkazuvchanlik masalasini chekli elementlar usuli bilan yechish oʻrganiladi. Issiqlik oʻtkazuvchanlik masalasini yechish uchun toʻgʻri tomonli uchburchakli chekli elementlardan foydalaniladi. Asosiy munosabatlar chiziqli uchburchak chekli elementlar uchun keltirilgan. Ishlab chiqilgan algoritmi asosida markazda izolyatsiyalangan kvadrat kesimni oʻz ichiga olgan ikki oʻlchovli issiqlik oʻtkazuvchanlik masalasining dasturiy ta'minotni yaratildi, sonli yechimi berilgan va harorat maydonining taqsimlanishi oʻrganildi. Olingan natijalar toʻr usulida olingan natijalar bilan solishtitiladi. Plastikadagi harorat taqsimoti izotermalari keltirilgan.

Kalit soʻzlar: nostatsionarlik, issiqlik oʻtkazuvchanlik, bir jinsli boʻlmagan, CHEU.

Аннотация. В статье исследуется процесс теплообмена в пластине из неоднородного материала решения двумерной на основе задачи теплопроводности методом конечных элементов. Для решения плоской задачи теплопроводности используются прямолинейные треугольные конечные элементы. Приведены основные соотношения для линейных треугольных конечных элементов. На основе разработанного алгоритма решения и программного обеспечения исследовано численное решение двумерной задачи теплопроводности пластины из неоднородного материала и пластины, содержащей изолированный квадратный вырез в центре. Решения тестовой задачи соответствуют результатам, полученным методом конечных разностей. Исследованы распределения температурного поля и приведены изотермы распределения температуры в пластине.

Ключевое слово: нестационарность, теплопроводность, неоднородное тело, МКЭ.

Abstract. The process of heat transfer in a plate of inhomogeneous material is investigated in the article, based on the solution of a two-dimensional problem of heat conduction by the finite element method. Straight-sided finite elements are used to solve the plane problem of heat conduction. Basic relations for linear triangular finite elements are given. On the basis of the developed solution algorithm and software, the numerical solution of a two-dimensional problem of thermal conductivity of a plate made of an inhomogeneous material and a plate containing an isolated square cutout in the center is investigated. The solutions to the test problem correspond to the results obtained by the finite difference method.

The temperature field distributions are studied and isotherms of the temperature distribution in the plate are given.

Keywords: non-stationarity, thermal conductivity, inhomogeneous body, *FEM*.

Introduction

The theoretical study of heat transfer processes is currently based largely on their numerical simulation using computer technology. Numerical simulation of heat transfer processes is acquiring an increasingly substantial role due to the fact that modern science and technology need a reliable forecast of such processes.

The authors research Kuznetsov G.V. and Sheremet M.A. are provides basic information on methods, algorithms and software for the numerical solution of a number of heat conduction problems [1]. Examples of solving linear, nonlinear, onedimensional and two-dimensional non-stationary problems are given. In Mandrik P.A. method for solving systems of parabolic differential equations of thermal conductivity on a model of thermal contact between two bodies with different thermophysical characteristics is proposed in the presence of mixed boundary conditions in the plane of their contact [2]. The case of contact between two semi-bounded bodies is considered. In that case, a heat source of low heat capacity acts in a circular domain of finite radius on the contact surface; and outside this domain, the initial temperature is maintained throughout the entire period of heat transfer, Kosmakova M.T. et al. considers a homogeneous boundary value problem for the heat equation in a noncylindrical domain system, namely, in an inverted pyramid with the apex at the origin, two faces of which lie in coordinate planes [3]. The solution to the problem is presented as a sum of generalized thermal potentials. It is assumed that the heat capacity depends only on the time variable, i.e. the density in each time section is considered constant. As a result, the system of integral equations is reduced to the homogeneous Volterra integral equation of the second kind. It is shown that this equation is uniquely solvable in the class of continuous functions. The study in [4] is devoted to the presentation of the fundamentals of the finite element method - one of the most effective modern methods for the numerical solution to engineering, physical and mathematical problems using computer technology. The basic principles of the finite element method and their application to the problems of heat conduction theory and potential theory are considered. In [5], guidelines to the finite element method are given, which allow one to obtain numerical solutions to engineering, physical and mathematical problems. A detailed discussion of the main concepts of the method is accompanied by examples that illustrate the technique of its application. Ikramov A.M. et al. examines the process of heat transfer in mechanical systems. The solution of a two-dimensional heat conduction problem for inhomogeneous bodies is investigated on the basis of the finite element method [6]. To solve the plane problem of heat conduction, straight-sided triangular finite elements are used. The basic relations of finite elements are given taking into account the influence of point heat sources. On the basis of the developed software, specific problems were numerically solved and the influence of non-homogeneity on the distribution of the temperature field was studied.

Research Methodology



The problem of the temperature distribution at different time points is solved in a plane formulation [4].

The temperature in a finite element is set as the product of two independent functions:

$$T^{(e)} = N(x, y)T(t)$$

or in matrix form:

$$T^{(e)} = \left[N_i(x, y) N_j(x, y) N_k(x, y) \right] \begin{cases} T_i(t) \\ T_j(t) \\ T_k(t) \end{cases}.$$
(1)

The extremum condition of functional [5] leads to the following system of differential equations for one finite element:

$$\left[c^{e}\right]\frac{\partial\{T\}}{\partial t}+\left[k^{e}\right]\{T\}+\left\{f^{e}\right\}=0,$$
(2)

here

$$[c^e] = \int_{V^e} \lambda[N][N]^T dV, \qquad (3)$$

$$[k^{e}] = \int_{V^{e}} [B^{e}] [D^{e}] [B^{e}]^{T} dV + \int_{S_{a}} h[N] [N]^{T} dS, \qquad (4)$$

$$\{f^{e}\} = \int_{S_{1}} q[N]^{T} dS - \int_{S_{2}} hT_{\infty}[N]^{T} dS , \qquad (5)$$

where

 V^e - is the volume of the finite element;

[N] - is the matrix that contains shape functions;

 $[B^e]$ - is the matrix that contains the derivatives of shape functions;

 $[D^e]$ - is the matrix of material properties that contains thermal conductivity coefficients.

Integral (3) is a damping matrix; when solving a two-dimensional heat conduction problem, it has the following form:

$$[c^{e}] = \frac{\lambda A a_{t}}{12} \begin{bmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 2 \end{bmatrix},$$
(6)

where

A is the area of the finite element; a_i is the element thickness.

In the absence of convection, the thermal conductivity matrix in the two-dimensional case has the following form:

$$[k^{e}] = \frac{k_{xx}a_{t}}{4A} \begin{bmatrix} b_{i}b_{i} & b_{i}b_{j} & b_{i}b_{k} \\ b_{j}b_{i} & b_{j}b_{j} & b_{j}b_{k} \\ b_{k}b_{i} & b_{k}b_{j} & b_{k}b_{k} \end{bmatrix} + \frac{k_{yy}a_{t}}{4A} \begin{bmatrix} c_{i}c_{i} & c_{i}c_{j} & c_{i}c_{k} \\ c_{j}c_{i} & c_{j}c_{j} & c_{j}c_{k} \\ c_{k}c_{i} & c_{k}c_{j} & c_{k}c_{k} \end{bmatrix},$$
(7)

where $b_i = y_j - y_k$; $c_i = x_j - x_k$; (the rest of the quantities are obtained by circular permutation of indices *i*, *j*, *k*).

If the side i, j of the finite element is subjected to convection, then the second integral in (4) has the following form:

$$\int_{S_2} h[N][N]^T dS = \frac{ha_t L_{ij}}{6} \begin{bmatrix} 2 & 1 & 0 \\ 1 & 2 & 0 \\ 0 & 0 & 0 \end{bmatrix},$$
(8)

where L_{ii} is the length of the element side between nodes *i* and *j*.

If heat is lost by convection between sides with nodes j and k or k and i, then matrix (8) is transformed accordingly.

If there are no heat sources inside the plate and the flow of heat on the side of the element with angles i, j is in the form of a heat flux q, the "load vector" of the element is:

$$\int_{S_1} q[N]^T dS = \frac{qL_{ij}a_t}{2} \begin{cases} 1\\1\\0 \end{cases}.$$
 (9)

If convective heat exchange occurs on the side with nodes *i* and *j*, then the "load vector" when solving the heat conduction problem is:

$$\int_{S_2} hT_{\infty}[N]^T dS = \frac{hT_{\infty}L_{ij}a_i}{2} \begin{cases} 1\\1\\0 \end{cases}$$

For a finite element mesh, a system of ordinary differential equations is written as:

$$[C] \frac{\partial \{T\}}{\partial t} + [K] \{T\} + \{F\} = 0,$$
(10)
$$[C] = \sum_{e} [c^{e}]; \quad [K] = \sum_{e} [k^{e}]; \quad [F] = \sum_{e} [f^{e}].$$

where

Replacing the time derivative in equation (10) with its finite-difference analog, an implicit difference scheme is obtained to solve the following heat conduction equation [5]:

$$\left(\frac{[C]}{\Delta t} + [K]\right) \{T\}^{n+1} = \frac{[C]}{\Delta t} \{T\}^n - \{F\}^{n+1}$$
(11)

Thus, if the temperature vector $\{T\}^n$ at time t_n is known, then the temperature of the plate at $t_{n+1} = t_n + \Delta t$ is obtained by solving the system of linear algebraic equations (11) based on the square root method.

Analysis and Results

Problem. A non-stationary heat transfer process in a rectangular plate with an isolated square-shaped cavity in the center with dimensions l = h = 0.2 m is considered. Copper plate has dimensions L = H = 0.5 m. Copper has the following thermophysical characteristics: $\lambda = 384$ W/(m·°C), $\rho = 8800$ kg/m³, c = 381 J/(kg·°C).

A constant temperature is maintained at the side vertical boundaries of the plate: $T_h = 100 \,^{\circ}C$ at x = 0 and $T_c = 0 \,^{\circ}C$ at x = L. The horizontal and internal boundaries are adiabatic. The initial temperature of the plate is $T_0 = 50 \,^{\circ}C$.

Figures 1 a-d show temperature isotherms for different time parameters t = 10, 100, 200, and 300 sec (time step is $\Delta t = 5 \text{ sec}$).



Figure 1. Temperature isotherms (°C) at different time parameters.

Analysis of the calculation results indicates that the presence of a cavity in the center of the plate redistributes the temperature field. Since the boundaries of the cavity are adiabatic, the heat flux flows around it and an inhomogeneous temperature field is formed. The heat flux flowing around the cavity forms symmetry about the central vertical line of the plate and the boundary conditions on both sides of the rectangular plate. This confirms the correspondence of the solution of the problem to the physical process.

The numerical values of the effect of the cavity on the temperature distribution at different time points are presented in Table 1. Analysis of the calculation results shows that, since the vicinity of the cavity is isolated and the flow bends around it, and with increasing finite time, a concentration of higher temperature values is observed in the vicinity of the lateral sides of the cavity.

Configuration	10 sec	100 sec	200 sec	300 sec
without cavity	50.15°C	69.58°C	74.12°C	74.86°C
with cavity	50.15°C	79.31°C	87.86°C	89.53°C

Table 1. Numerical values of temperature at points (0.125 m, 0.25 m).

Conclusions

1. The correctness of the algorithm for solving the problem is proved by comparison with numerical values obtained by the grid method.

2. The process of heat transfer in a rectangular plate containing an isolated square cutout in the center is considered. With increasing time, the heat flux flowing around the cavity forms symmetry with respect to the central vertical of the plate and the boundary conditions on both sides of the plate.

3. Analysis of numerical results indicates that with increasing time, a concentration of elevated temperatures is observed in the vicinity of the sides of the

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cavity. This is due to the fact that the vicinity of the cavity is isolated and the temperature flow envelopes it.

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UDC: 53, 535 CHANGES IN THE ELECTROPHYSICAL PROPERTIES OF THE SEMICONDUCTOR-DIELECTRIC BOUNDARY REGION UNDER THE INFLUENCE OF AN EXTERNAL FIELD AND ITS EFFECT ON THE CHARACTERISTICS OF FIELD-EFFECT TRANSISTORS

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Annotatsiya. Ushbu maqolada, sirtiy holatlar mavjud boʻlganda, tashqi kuchlanish boʻlmaganda ham, yarimoʻtkazgichning energetik zonalari egilgan boʻlishi, ya'ni yarimoʻtkazgich – dielektrik ajralish chegarasida kiritilgan elektr maydon mavjud ekani nazariy tahlil etilgan. Bunday maydonning mavjudligi kanalning berkitilish kuchlanishi kattaligiga, volt-amper xarakteristika qiyaligiga, toʻyinish sharoitidagi oqim tokiga, tranzistorning chastotaviy va temperaturaviy parametrlariga ta'sir koʻrsatadi. Misol sifatida n – turdagi oʻtkazuvchanlikli kiritilgan kanalli ajratilgan zatvorga ega KP 102 maydoniy tranzistor zatvoriga qoʻyilgan kuchlanishning har xil qiymatlarida hona haroratida olingan volt-amper xarakteristikalari turkumi keltirilgan. Natijalar shuni koʻrsatdiki, oqim va manba orasidagi kuchlanish 4 V dan oshganda, tranzistorning oqim toki toʻyinishga yetadi va kuchlanishga bogʻliq boʻlmay qoladi.

Kalit soʻzlar: Ultratovush toʻlqinlari, energiya oqim zichligi, chastota, ultratovush impulslari generatori, tushuvchi toʻlqin, qaytuvchi toʻlqin, qayd qilinuvchi defekt (nuqson), elektroneytrallik.

Аннотация. В данной статье теоретически проанализировано, что при наличии поверхностных состояний и отсутствии внешнего напряжения энергетические зоны полупроводника искривлены, то есть возникает электрическое поле, введенное на границе разделения полупроводникдиэлектрик. Наличие такого поля влияет на величину замыкающего напряжения канала, крутизну вольт-амперной характеристики, запас тока в условиях насыщения, а также частотные и температурные параметры транзистора. В качестве примера приведен вольт-амперных ряд характеристик, полученных при комнатной температуре при различных значениях напряжения, приложенного к затвору полевого транзистора КП 102 с изолированным затвором входного канала с проводимостью п-типа.

Как видно из результатов, когда напряжение между стоком и истоком превышает 4 В, стоковый ток транзистора достигает насыщения и не зависит от напряжения.

Ключевые слово: Ультразвуковые волны, плотность потока энергии, частота, генератор ультразвуковых импульсов, падающая волна, возвратная волна, регистрируемый дефект (дефект), электронейтральность.

Abstract. In this article, it is theoretically analyzed that when there are surface states and there is no external voltage, the energy zones of the semiconductor are bent, that is, there is an electric field introduced at the border of the semiconductor-dielectric separation. The presence of such a field affects the closing voltage of the channel, the slope of the volt-ampere characteristic, the stock current in saturation conditions, and the frequency and temperature parameters of the transistor. As an example, a series of volt-ampere characteristics obtained at room temperature at different values of the voltage applied to the gate of the field-effect transistor KP 102 with an input channel isolated gate with n-type conductivity is presented. As can be seen from the results, when the voltage between the stock and the source exceeds 4 V, the stock current of the transistor reaches saturation and does not depend on the voltage.

Keywords: Ultrasonic waves, energy flow density, frequency, generator of ultrasonic pulses, incident wave, returning wave, recorded defect (defect), electroneutrality.

Introduction

As we know, many scientific studies are currently being conducted to convert solar energy into electricity. In addition, in modern technologies, many new developments in the field of semiconductors are rapidly entering the field of improving the working characteristics of compact micro-nano-sized circuits. Based on this, in our scientific work, we focused on the tolerance of electrons in MDS structures as a result of external influences, changes in the density of states in the boundary region, and their reliable operation, increasing their efficiency [1]. As we know, in the structures of MDS or MShYa, we have studied the state of changes in the sample under the influence of ultrasound waves. The external impact is carried out as an elastic vibration of the ultrasound medium above 20 kHz. The successive thickening and rarefaction observed during the propagation of ultrasound waves in a solid body leads to changes in the properties of these bodies. The fact that ultrasound waves have a small length can be the basis for considering their propagation among the methods of geometric acoustics. Physically, it presents a luminous picture of dispersion. This shows features such as geometric return and refraction of ultrasound, as well as focusing of sound. Practically, the importance of the ultrasound feature is the possibility of obtaining a large intensity even at relatively small vibration amplitudes, and the energy flow density at such amplitudes is proportional to the square of the frequency [2].

Ultrasonic methods of research are based on the fact that the characteristics of the desired waves depend on the properties of the media in which the waves propagate. Change of one or more parameters associated with the passage of high-frequency

ultrasound waves through the substance (transition time, attenuation level, scattering level and frequency content characteristic) of the substance hardness, elasticity, density, homogeneity, micro and shows a change in its physical properties such as the presence of macro connections [3]. Since ultrasound waves have a small length, they are extremely sensitive to changes in the environment they are propagating. In ultrasound methods, ultrasound frequencies with a frequency range of 2.5 MHz are often used. Sounded ultrasonic pulses are also used in the study of the properties of various phase separation boundaries. When passing through solid bodies, such pulses return from the boundaries of the solid body and various defects located at the boundary and indicate their location.



Figure 1. Echo-impulse mode of ultrasound defectoscope: 1-layer of glass, 2-Al metal, 3 and 4-ultrasounds, 5-semiconductor.

The main methods of ultrasound defectoscopy are ultrasound and acoustic methods. Ultrasound methods include: echo method, shadow, resonance and velocimetric [4]. Acoustic methods include: impedance method and free vibration method. When ultrasonic pulses are transmitted through matter, they are transmitted and received by piezoelectric transducers. In some cases, one transducer placed on one side of the studied material is used as a transmitter and receiver (echo - pulse mode). In other cases, mainly in the inspection of materials with high scattering or attenuation of ultrasound, two transducers are used (one of them is a transmitter, and the other is a receiver) [4], which are placed on opposite sides of the sample. In the echo-impulse mode, the ultrasonic wave passes through the studied material and returns to the transducer. Figure 1 shows the mode of operation of echo-impulse defectoscopy. In this picture, 1 - sample under study, 2 - generator of ultrasonic pulses, 3 - incident wave, 4 - returning wave, 5 - recorded defect (defect) [5].

It is known that the semiconductor surface contains a large number of surface electronic states with the possibility of exchanging electrons with the allowed energy zones [1-3]. These electronic states are based on the discontinuity of the periodic crystal lattice on the surface and the presence of various adsorbed entrances on it [6]. The energy levels of these surface states are localized in the forbidden zone of the semiconductor. The presence of energy levels on the surface that can exchange electrons with the allowed zone on the surface affects the properties of the field-effect transistor. As an example, we will look at the effect of charge localized in surface states with density Ns on the metal-dielectric-semiconductor energy diagram (Fig. 2) [7]. Let there be one discrete energy level E with an acceptor located below the Fermi level at

the glass-semiconductor separation boundary. The total charge Qs of the surface state can be represented by localized electrons in these cases:

$$Q = q n_s \tag{1}$$

$$n_S = \frac{N_S}{exp\left(-\frac{\Delta E}{kT}\right) + 1}$$
(2)

 N_s – density of surface states, $\Delta E\,$ - energy state of the surface, k – Boltzmann's constant, T – temperature.

Taking into account the surface condition, we find the following

$$\Delta E = E_1 - \varphi_0 + F \tag{3}$$

$$n_{S} = \frac{n_{S}}{\exp\left(-\frac{E_{1} - \varphi_{0} + F}{kT}\right) + 1}$$
(4)

$$\frac{d^{2\varphi}}{dx_2} = \frac{qp(x)}{\varepsilon\varepsilon_0} \tag{5}$$

from here we can find the volume charge density [6-7]:

$$\rho(x) = \frac{\varepsilon \varepsilon_0}{q} \, \frac{d^2 \, \varphi}{dx^2} \tag{6}$$

We express the charge in the semiconductor by its density;

$$Q_0 = \int_0^\infty \rho(x) \, dx = \frac{\varepsilon \varepsilon_0}{q} \int_0^\infty \frac{d^2 \varphi}{dx^2} \, dx = -\frac{\varepsilon \varepsilon_0}{q} \frac{d\varphi}{dx} \int_{x=0}^{\infty} (7)$$

Then we use the condition of electroneutrality [8]. According to this condition, the charge Q0 formed as a result of the transition of a part of electrons to acceptor surface states in a semiconductor is equal to the charge of surface states QS:

$$Q_s = Q_0 \tag{8}$$

Using the equation (8), (7), (1), we find the magnitude of the bending of the semiconductor energy zones

$$\varphi_0 = \varphi_0(\mathbf{n}, \mathbf{p}, \mathbf{n}_s, \boldsymbol{\rho}) \tag{9}$$

It can be seen from the obtained expression that in the presence of surface states, even in the absence of external voltage, the energy zones of the semiconductor are bent, that is, there is an electric field introduced at the boundary of the semiconductordielectric separation.





Figure 2. The energy diagram of the new structure in the presence of surface conditions.

Figure 3. Output volt-ampere characteristics of the field transistor of the KP 102 type.

The presence of such a field affects the closing voltage of the channel, the slope of the volt-ampere characteristic, the current in saturation conditions, the frequency and temperature parameters of the transistor [9].

As an example, Figure 3 presents a series of volt-ampere characteristics obtained at room temperature at different values of the voltage applied to the gate of the KP 102 field-effect transistor with an input channel isolated gate with n-type conductivity [10]. As can be seen from the picture, when the voltage between the stock and the source exceeds 4 V, the stock current of the transistor reaches saturation and does not depend on the voltage. It is better to oxidize the surface before preparing the tool. However, even after the tool is prepared, it can be covered with an oxide film. For this purpose, methods of heating the sample in an ozone atmosphere or anodic oxidation in a water-free solution at room temperature are used to obtain an oxide film on the surface of the finished device at relatively low temperatures.

We can say that as an analysis of the results obtained in our work. Protective dielectric films (layers) play a major role in the preparation of semiconductor devices and integrated microcircuits according to planar technology. The surface states in the considered semiconductors were based on the changes in the volume properties of the semiconductor material in its limited state, i.e. directly due to the broken part of the crystal lattice [11].

However, in real conditions, when any crystal is cut or broken, the unsaturated bonds of atoms or other types of defects formed on its surface tend to occupy a state of thermodynamic equilibrium for this condition. Therefore, when studying the electrophysical properties of semiconductor materials, it is necessary to know and take into account the properties of this layer, in particular, the processes at the semiconductor-oxide boundary, and to take them into account when preparing various electronic devices from them. Since all oxides are dielectric in terms of electrical conductivity, such systems are called semiconductor-dielectric type structures. To study the properties of this structure, due to metal contacts, our structure will have the appearance of a metal-dielectric-semiconductor (MDS). In this structure, the dielectric (i.e., oxide) layer is sensitive to electric field, temperature [12-13], radiation, and the properties of the semiconductor layer change relatively less, and the laws of these changes are mainly studied and given to researchers. as it is known, we see that the movement of current carriers in such a structure mainly depends on the properties of the semiconductor-dielectric boundary [14].

Conclusions

Ultrasonic methods of research were based on the fact that the characteristics of the desired waves depend on the properties of the media in which the waves are propagating. The change of one or more parameters associated with the passage of high-frequency ultrasound waves through the substance (transition time, attenuation level, scattering level and frequency content characteristic) of the substance, hardness, elasticity, density, bi, micro and shows changes in physical properties such as the presence of macro-connections. Since ultrasound waves have a small length, they are extremely sensitive to changes in the environment they are propagating. Ultrasound methods often use ultrasound frequencies with a frequency range of 2.5 MHz. Sounded



ultrasonic pulses are also used in the study of the properties of various phase separation boundaries. When passing through solid bodies, such pulses return from the boundaries of the solid body and various defects located at the boundary and indicate their location. A series of volt-ampere characteristics obtained at room temperature at different values of the voltage applied to the gate of the field-effect transistor is presented.

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UDC: 53, 536,7 **PROBLEMS AND PROSPECTS FOR THE USE OF CONCENTRATED ENERGY PLANTS WITH PHOTOCONVERTERS**

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Annotatsiya. Quyosh energiyasini yarimo'tkazgichli elementlar yordamida konversiyalash samaradorligi quyidagi yo'nalishlarda ishlab chiqishda: yangi materiallar va ularni qayta ishlash usullarini izlash orqali fotoelementlarning samaradorligini oshirish; quyosh energiyasi kontsentratorlaridan foydalanish; quyoshni yoʻnaltirish tizimlarini ishlab chiqish; quyosh energiyasidan samaraliroq foydalanish uchun kogeneratsiya stansiyalarini yaratish. Mavjud ishlab chiqilgan quyosh batareyalari turlaridan kremniyli fotokonvertorlar (arzon narxlari va yaxshi yoʻlga qoʻyilgan ishlab chiqarish jarayoni tufayli) va eng yuqori samaradorlikka ega boʻlgan koʻp birikmali geterostrukturalar (GaInP/GaIn/Ge) qiziqish uygʻotadi. Fotoelementlarning oxirgi turi 100...1000 kontsentratsiya faktoriga ega bo'lgan konsentrlangan quyosh nurlanishida eng yuqori samaradorlikka ega. Yuqori konsentratsiyali omillarni Fresnel linzalari bilan olish eng oson. Fotoelementlarni sovutish uchun issiqlik energiyasidan foydalanish, faol sovutish tizimidan foydalanish tavsiya etiladi. Shu munosabat bilan Fresnel linzalari asosidagi quyosh energiyasini kontsentratori bilan tajriba qurilmasini ishlab chiqish vazifasi qoʻyildi.



Kalit soʻzlar: parabolik olukli kontsentrator; chiziqli kontsentrator; polivinilxlorid; analog-raqamli konvertor; tranzistor-tranzistorli mantiq; universal sinxron-asinxron qabul qiluvchi-uzatuvchi; yarimo'tkazgichning tarmoqli oraligʻi, quvurdagi sovutish suvining oʻrtacha harorati, orbitada Yerning burchak siljishi.

преобразования Аннотация. Эффективность солнечной энергии С использованием полупроводниковых элементов развивается по следующим направлениям: повышение эффективности фотоэлектрических элементов за счет поиска новых материалов и методов их обработки; использование солнечной энергии; разработка систем концентраторов солнечной ориентации; создание когенерационных установок для более эффективного использования солнечной энергии. Из разрабатываемых в настоящее время интерес представляют типов солнечных элементов кремниевые дешевизны отлаженной технологии фотопреобразователи (из-за И изготовления) и многопереходные гетероструктуры (GaInP/GaIn/Ge), обладающие наибольшим КПД. Последний тип фотоэлементов имеет наибольшую эффективность в концентрированном солнечном излучении с 100...1000. коэффициентом концентрации Высокие коэффициенты концентрации легче всего получить с помощью линзы Френеля. Для охлаждения фотоэлектрических элементов рекомендуется использовать тепловую энергию, использовать активную систему охлаждения. В связи с этим была поставлена задача разработать экспериментальное устройство с концентратором солнечной энергии на основе линз Френеля.

Ключевые слова: концентратор параболического желоба; линейный концентратор; поливинилхлорид; аналого-цифровой преобразователь; транзисторно-транзисторная логика; универсальный синхронноасинхронный приемник-передатчик; запрещенная зона полупроводника, средняя температура теплоносителя в трубке, угловое смещение Земли на орбите.

Abstract. The efficiency of solar energy conversion using semiconductor elements is being developed in the following areas: increasing the efficiency of photovoltaic cells through the search for new materials and methods of their processing; use of solar energy concentrators; development of solar orientation systems; creation of cogeneration plants for more efficient use of solar energy. Currently different type of solar cells are being developed, silicon photoconverters (due to their low cost and well-established manufacturing technology) and multijunction heterostructures (GaInP/GaIn/Ge), which have the highest efficiency, are of interest. The latter type of photocells has the greatest efficiency in concentration factors are most easily achieved using a Fresnel lens. To cool photovoltaic elements, it is recommended to use thermal energy and use an active cooling system. In this regard, the task was set to develop an experimental device with a solar energy concentrator based on Fresnel lenses.

LE RECENCICA EN L

Keywords: parabolic trough concentrator; linear concentrator; polyvinyl chloride; analog-digital converter; transistor-transistor logic; universal synchronous-asynchronous receiver-transmitter; the band gap of a semiconductor, the average temperature of the coolant in the tube, the angular displacement of the Earth in orbit.

Introduction

Researchers among the world and production companies have been working on prototypes of photovoltaic power plants with high concentration factors for the past 20 years and are testing large enough power plants based on them. Active development of concentrated photovoltaic power plants began in 1976 at Sandia National Laboratories (SNL) - USA. Their first devices had the ability to direct the sun in two axes, included concentrators based on Fresnel lenses, and had a degree of concentrating devices based on photocells. Strebkov D.S., Kharchenko V.V., Mayorov V.A., Husarov V.A. published a series of works describing the possibilities of using photocells with vertical pn junctions, the production technology of which was developed by the same institute [1-5]. Such photocells show good results when operating at a light flux with a concentration factor of up to 20.

Literature Review

The basic principle of concentrating photovoltaic systems is to use optics to focus sunlight onto a small photocell [1]. Thus, it was shown that the solar cell area can be reduced by a factor equal to the concentration factor and the radiation intensity can be increased by the same factor.

$$A_{pv} = A_c \frac{I_o}{Ic}$$

 A_{pv} - absorber (photocell) active surface area, m²; A_c - hole area of the concentrator, m²; I_0 - the intensity of solar radiation on a surface perpendicular to the direction of unconcentrated sunlight, Vt/m²; I_c - concentrated solar energy flux density, Vt/m²;

In order to direct the light to the solar cell, medium and high-concentration systems require a system that is clearly focused on the sun. This leads to higher system costs and higher operating costs. Compared to conventional semiconductor converters, solar cells designed for concentrated sunlight have advantages. They require less area of the semiconductor crystal, their efficiency is higher than conventional photovoltaic cells, and calculations show that a power plant using them at high concentration will be cheaper than a plant without CSE [2].

Silicon cells with point contacts about 1 cm in size have motivated the development of several concentrated power plants, among which the Amonix version has been the most successful [3].

Despite significant progress in the development of high-concentration solar cells, their production has been small-scale. Increasing the efficiency of single-junction solar cells is limited by the Shockley-Quyser limit, which is in the range of 25-40%, depending on the band gap of the photovoltaic cell [4]. This is because photovoltaic cells are two-level devices that effectively convert light with wavelengths corresponding to near-lattice energy. In the band gap, photons with lower energy are



completely lost, and those with higher energy are limited by the energy of the band gap, which means that they do not use their full potential.

Research Methodology

-Development of a mathematical model to simulate the dynamics of cogeneration power plants with solar energy concentrators.

-Construction of an experimental device utilizing Fresnel lenses and multijunction photovoltaic cells.

-Implementation of an automated system for real-time monitoring of temperature and electrical performance using various sensors.

-Calibration and performance evaluation of the prototype under different concentration ratios and environmental conditions.

-Quantitative comparison of experimental results against the theoretical model to assess system efficiency.

-Creation of a custom program for performance simulation and optimization of design parameters.

This integrated approach aimed to enhance the efficiency of solar energy conversion in cogeneration power plants.

Analysis and Results

The scientific and technological breakthrough in this field is related to the creation of III-V heterostructures, in which the highest efficiency has been achieved to date. The maximum possible theoretical efficiency for multi-junction solar cells is 86%, which exceeds the Shockley-Quieser limit for photovoltaic cells with a single p-n junction, and the currently realized efficiency is about 40% [5]. Such solar cells make full use of the spectrum of sunlight.

Systems operating at concentrations of 400 and 1000 times based on multi-pass elements have already been created (from Concentrix and Isophoton). These systems use microphotocells with a diameter of 2 and 1 mm, respectively. The maximum efficiency of a power plant based on GaAs photovoltaics was 26.2% at a concentration level of 1000 [6]. Of three-junction cascade photovoltaic cells at high concentration levels are described. It has been shown to be 29% effective under real light concentration modules using triple junction photocells with a GaInP/GaAs/Ge structure. Modules are based on small area Fresnel lenses. The efficiency of the module is higher than 26%, and the efficiency of the photoconverter is higher than 31% at a concentration level of 1000. Later, three-pass solar cells were created that achieved 35% efficiency at a concentration level of 700. At present, solar cells are commercially produced with a practical efficiency of 38% at a concentration level of 1000 and a temperature of about 50 [7].

For solar energy concentrators to work together with photocells, it is desirable to have a single light flux that allows full use of the photoconverter's capabilities [6]. Proposed a design of a parabolic concentrator that can be used together with photoconverters to produce electricity in a uniform diffuse light flux. Work [8] solved the problem of analytical determination of open circuit voltage depending on temperature. It was shown that the known theoretical relationships do not fully reflect the experimental data, and additional parameters were introduced for a more accurate assessment, and the following relationship was obtained:

$$U_{xx} = \frac{E_{gx}}{e} exp\left[-\left(\frac{T_{pv}}{\sigma_{St}}\right) \frac{E_{gSt}}{E_{gX}}\right] \left\{2 - exp\left[-\frac{I_X}{K_0 I_0} \left(\frac{T_{pv}}{T_0}\right)^4\right]\right\}$$
(1.2)

 E_{gX} band gap of a semiconductor; E_{gSi} -silicone band gap, eV; I_X – current and standard value of illumination level, Vt/m²; T_{pv} - current value of photocell temperature, K; K_0 indicator parameter reflecting the individual characteristics of the studied photocell; E - electronic charge.

Figure 1 shows the results of applying the obtained expressions for silicon and gallium arsenide [9].



Figure 1. Calculated dependences of the open circuit voltage on temperature (the markers show the experimental results).

As can be seen from the graph, the open circuit voltage decreases at an equivalent rate as the temperature increases, so the cooling system plays an important role for both types of photovoltaic cells [10].

It is impossible to study the problems related to the optimization of the parameters of the combined enrichment plants and the improvement of their efficiency without the use of electronic calculators, automation systems and measuring complexes. The creation of a complex for monitoring the parameters of photoelectric converters. The described installation allows measuring several temperatures, open circuit voltage, short circuit current and other parameters. It enables qualitative and quantitative research with high accuracy and reliability. Modern research is impossible without automated data recording systems. Computer simulation can significantly reduce the time of calculations and optimization of design parameters. The possibility of double irradiation of such photocells is actively used.

Advances in the field of creating such dual solar cells designed for more efficient conversion of solar energy are [11]. Considers the use of stationary prismatic concentrators in conjunction with photovoltaic cells with vertical p-n junctions. As a result, the cost of the power plant is reduced by 35% compared to conventional solar panels. Experimental thermophysical coefficients showing the degree of reduction of the current and voltage of the photocell during heating were also the use of an

asymmetric parabolic trough concentrator with two-way multiconductor photocells. Such a concentrator shown gives uneven radiation, as a result of which an increase in the power of the light flux in some parts of the photocell is achieved up to 5 times, and the power at the output of the installation increases by 2 times [12]. Also consider an asymmetric parabolic trough concentrator filled with angled shutter heliostats. The installation has an average concentration level of 4, two-way multi-junction photocells are also used as receivers. The paper examines the effect of receiver shadow bands on the output characteristics of the setup. Shown with parallel connection.

Among the existing software solutions, there are no specialized integrated software systems capable of solving several problems at the same time and capable of simulating the operation of integrated systems. Therefore, the task of developing a computer program for modeling integrated concentration systems was set. The program should be able to calculate the heat field in the installation elements, obtain the current-voltage characteristics of the photoconverters, simulate the concentration of solar energy depending on the distance from the concentrator to the receiver, and conduct virtual tests. different design schemes in different weather conditions, taking into account the astronomical and geographical features of the area and the current environmental parameters [13-14].

Conclusions

In conclusion, it can be said that the purpose of the work has been determined: justification and development of technical solutions for increasing the efficiency of cogeneration power plants with solar energy concentrators. To achieve this goal, the following tasks were set:

1. Development of a mathematical model of a cogeneration power plant with solar energy concentrators.

2. Development of an algorithm and computer program for implementing a mathematical model of a cogeneration power plant with solar energy concentrators.

3. Creating a methodology for using computer software for modeling cogeneration power plants with solar energy concentrators using theoretical and experimental preliminary data.

4. Development and production of the automatic registration system of experimental data.

5. Development of technology and method of production and assembly of modular cogeneration power plant with solar energy concentrator based on Fresnel lenses and automatic solar orientation system.

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UDC: 53, 536.7, 537.3, 537.5 COLD PLASMA SYSTEMS: PRINCIPLES AND APPLICATIONS

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Annotatsiya. Issiqlik boʻlmagan plazma texnologiyasi past gaz haroratida reaktiv turlarni yaratish qobiliyati tufayli atrof-muhitni qayta tiklash, energiyani aylantirish va kimyoviy qayta ishlash uchun koʻp qirrali vositaga aylandi. Ushbu sohadagi eng istiqbolli yutuqlardan biri bu issiqlik boʻlmagan plazmalarning reaktsiya tezligini, selektivligini va energiya samaradorligini sinergik tarzda oshiradigan katalitik tizimlar bilan integratsiyalashuvidir. Ushbu sharh issiqlik boʻlmagan plazma katalizator tizimlarining tamoyillari, mexanizmlari va qoʻllanilishini har tomonlama tahlil qiladi. Adabiyotlardan olingan asosiy topilmalar, jumladan, plazma-katalizatorning fundamental o'zaro ta'siri. katalizator dizaynining roli va quvvat, gaz tarkibi va reaktor konfiguratsiyasi kabi muhim parametrlarning tizim ishlashiga ta'siri muhokama qilinadi. NOxni olib tashlash, uchuvchi organik birikmalar degradatsiyasi, vodorod ishlab chiqarish va CO₂ ni kamaytirish kabi muhim ilovalar batafsil yoritilgan. Maqolada katalizatorni deaktivatsiya qilish va energiya samaradorligi kabi masalalar aniqlanadi plazma katalizatori texnologiyalarini sanoatlashtirishni va jadallashtirish uchun ilgʻor materiallar va innovatsion reaktor konstruksiyalarini ishlab chiqish kabi kelajakdagi tadqiqot yoʻnalishlari haqida tushunchalar beradi.

Kalit soʻzlar: termal boʻlmagan plazma, energiya konvertatsiyasi, NO_x ni olib tashlash, CO_2 ni kamaytirish, plazma katalitik texnologiyalar.

Аннотация. Технология нетермической плазмы стала универсальным инструментом для восстановления окружающей среды, преобразования энергии и химической обработки благодаря своей способности генерировать реактивные виды при низких температурах газа. Одним из

наиболее многообещающих достижений В этой области является интеграция нетермической плазмы с каталитическими системами, которые синергетически скорость повышают реакции, селективность И энергоэффективность. В этом обзоре представлен всесторонний анализ принципов, механизмов и применений систем технология нетермической плазмы-катализатор. Обсуждаются основные выводы из литературы, включая фундаментальные взаимодействия плазмы и катализатора, роль конструкции катализатора и влияние критических параметров, таких как мощность, состав газа и конфигурация реактора, на производительность системы. Подробно рассматриваются важные приложения, включая NOx. деградацию летучих органических удаление соединений, производство водорода и снижение СО2. В статье определяются такие проблемы, как дезактивация катализатора и энергоэффективность, а также предлагается информация о будущих направлениях исследований, включая разработку передовых материалов И инновационные конструкции реакторов, ускорения промышленного внедрения технологий для плазменного катализатора.

Ключевые слова: нетермическая плазма, преобразование энергии, удаление NO_x, снижение CO₂, плазменные каталитические технологии.

Abstract. Nonthermal plasma technology has emerged as a versatile tool for environmental remediation, energy conversion, and chemical processing due to its ability to generate reactive species at low bulk gas temperatures. One of the most promising advancements in this field is the integration of nonthermal plasma with catalytic systems, which synergistically enhance reaction rates, selectivity, and energy efficiency. This review provides a comprehensive analysis of the principles, mechanisms, and applications of nonthermal plasma -catalyst systems. Key findings from the literature are discussed, including the fundamental plasmacatalyst interactions, the role of catalyst design, and the influence of critical parameters such as power, gas composition, and reactor configuration on system performance. Prominent applications, including NO_x removal, volatile organic compound degradation, hydrogen production, and CO₂ reduction, are examined in detail. The paper identifies challenges such as catalyst deactivation and energy inefficiency, offering insights into future research directions, including advanced material development and innovative reactor designs, to accelerate the industrial adoption of plasma-catalyst technologies.

Keywords: nonthermal plasma, energy conversion, NO_x removal, CO_2 reduction, plasma-catalyst technologies.

Introduction

In recent years, nonthermal plasma (NTP) has garnered significant attention as a promising technology for applications in environmental remediation, energy conversion, and chemical processing. Unlike thermal plasma, which operates at extremely high temperatures, nonthermal plasma is characterized by the ability to generate a high density of energetic electrons without significantly increasing the bulk gas temperature. This unique feature allows NTP to initiate a variety of chemical reactions under mild conditions, making it suitable for processes where thermal degradation of sensitive materials is a concern [1-3].

One of the most promising applications of nonthermal plasma is its integration with catalytic systems to enhance reaction efficiencies. The synergy between nonthermal plasma and catalysts can lead to the generation of highly reactive species, such as radicals, ions, and excited molecules, which can significantly accelerate reaction rates and improve selectivity. This plasma-catalysis hybrid approach has shown potential in applications such as NO_x removal, volatile organic compound (VOC) degradation, hydrogen production, and CO_2 reduction, among others.

However, optimizing the performance of plasma-catalyst systems requires a detailed understanding of the interplay between various parameters. Both plasma operating conditions (e.g., power, frequency, gas composition) and catalyst characteristics (e.g., material, surface area, morphology) play crucial roles in determining the overall efficiency and effectiveness of these systems. Despite numerous studies in this area, the complex mechanisms governing plasma-catalyst interactions are not fully understood, and the optimization of these systems remains a significant challenge [2, 4-6].

The objective of this literature review is to comprehensively examine the influence of key parameters on the performance of nonthermal plasma-catalyst systems. By investigating recent advancements and identifying current research gaps, this review aims to provide insights into optimizing these systems for enhanced performance in various applications.

Research Methodology

This review paper employs a systematic approach to investigate the principles, mechanisms, and applications of nonthermal plasma (NTP) systems integrated with catalysts. The methodology consists of the following key steps:

1. Literature Collection and Selection

A comprehensive search of peer-reviewed journals, conference proceedings, books, and technical reports was conducted using databases such as ScienceDirect, Web of Science, IEEE Xplore, and Google Scholar. The keywords used included "nonthermal plasma," "plasma-catalyst interactions," "cold plasma applications," and "plasma for environmental remediation."

• Inclusion Criteria: Studies published in reputable journals, addressing NTP fundamentals, plasma-catalyst mechanisms, and specific applications such as NOx removal, VOC degradation, hydrogen production, and CO_2 reduction.

• Exclusion Criteria: Papers lacking experimental or review-based data and those not focusing on the integration of plasma with catalysts.

2. Categorization of Findings

The collected literature was categorized into thematic areas:

• Fundamentals of nonthermal plasma, including types of discharges and their operating principles.

• Plasma-catalyst interactions, focusing on catalyst materials, surface reactions, and synergy mechanisms.



• Applications across environmental remediation, energy conversion, and chemical synthesis.

• Optimization of plasma-catalyst systems, including operational parameters and reactor configurations.

Analysis and Results

Nonthermal Plasma Fundamentals

1.1.1 Principle of Nonthermal Plasma (NTP)

Nonthermal plasma is a partially ionized gas that is generated when energy is supplied to a neutral gas, leading to the formation of energetic electrons, ions, and reactive radicals. Unlike thermal plasma, where electrons, ions, and neutral species are in thermal equilibrium, NTP operates with electrons at much higher temperatures (up to 10,000 K) compared to the bulk gas temperature (close to ambient conditions). This temperature disparity allows for the initiation of chemical reactions at low energy costs, making NTP an energy-efficient solution for various applications [2, 3, 6].

1.1.2 Types of Nonthermal Plasma Discharges

Several types of nonthermal plasma discharges are commonly used in plasmacatalyst applications, each offering unique advantages [2, 3, 7, 8]:

Dielectric Barrier Discharge (DBD): One of the most widely used configurations, DBD involves applying a high-voltage alternating current (AC) across electrodes separated by a dielectric barrier. This setup produces micro-discharges that generate a uniform plasma, making it ideal for applications such as air purification and pollutant degradation.

Corona Discharge: This type involves a non-uniform electric field generated between a sharp electrode and a grounded plate. Corona discharges are particularly effective for treating flue gases and can operate under atmospheric pressure.

Gliding Arc Discharge: Combining features of both thermal and nonthermal plasmas, gliding arc discharges offer higher power density while maintaining a relatively low gas temperature. This discharge type is effective for the efficient decomposition of hydrocarbons and synthesis of hydrogen.

Microwave and Radio Frequency (RF) Plasmas: These types of plasmas are generated using electromagnetic waves and are characterized by their ability to sustain stable plasma at low pressures. Microwave plasmas are often used in advanced material synthesis and surface treatment applications.

1.1.3 Applications of Nonthermal Plasma

Nonthermal plasma has been extensively studied for applications that require selective chemical reactions under mild conditions. Key applications include[2, 7, 8]:

Environmental Remediation: NTP has demonstrated effectiveness in removing harmful pollutants such as NO_x , SO_x , and VOCs from industrial emissions, thereby reducing environmental impact.

Hydrogen Production: Plasma-catalyst systems have shown promise in enhancing the efficiency of hydrogen production from methane reforming and water splitting, paving the way for cleaner energy solutions.



 CO_2 Reduction: The utilization of plasma technology to convert CO₂ into valueadded products like syngas (a mixture of CO and H₂) offers potential solutions for reducing greenhouse gas emissions.

Chemical Synthesis: NTP facilitates the synthesis of ammonia, hydrocarbons, and other chemicals without the need for high temperatures and pressures typically required in conventional processes.

1.2 Catalyst-Plasma Interaction Mechanisms

1.2.1 Catalyst Types in Plasma Systems

Catalysts play a critical role in plasma-catalyst systems by promoting surface reactions that are initiated by the reactive species generated in the plasma. Commonly used catalysts include [2, 5, 6]:

Metal Oxides: Catalysts such as TiO₂, Al₂O₃, and CeO₂ are known for their high surface areas and stability. These metal oxides can enhance the decomposition of pollutants and increase selectivity in plasma reactions.

Noble Metals: Catalysts like Pt, Pd, and Rh are often employed due to their superior catalytic activity. When combined with plasma, these metals can effectively reduce activation energy and improve conversion rates.

Zeolites: The porous structure of zeolites provides a large surface area for adsorption and reaction of plasma-generated species, making them suitable for applications in gas purification and chemical synthesis.

Bimetallic and Doped Catalysts: Recent advancements involve the use of bimetallic catalysts and doped materials to improve selectivity, stability, and resistance to deactivation in plasma environments.

1.2.2 Mechanisms of Plasma-Catalyst Interaction

The interaction between nonthermal plasma and catalysts is a complex process involving both gas-phase and surface reactions. Key mechanisms include [2, 4, 9]:

Surface Activation by Plasma Species: Energetic electrons and reactive species generated in the plasma can activate the catalyst surface, creating active sites for chemical reactions. This can lead to enhanced adsorption of reactants and increased reaction rates.

Synergistic Effects: The combination of plasma and catalysts can generate synergistic effects, where the plasma environment enhances catalyst performance by increasing the number of reactive species and lowering activation energy barriers. For instance, plasma-activated oxygen species can improve the oxidative degradation of pollutants on catalyst surfaces.

Enhanced Electron Transfer: Plasma-induced electrons can directly interact with catalyst surfaces, facilitating reduction-oxidation (redox) reactions that are critical for processes like NOx reduction and hydrogen generation.

Catalyst Regeneration: Plasma exposure can help regenerate deactivated catalysts by removing surface deposits and contaminants, thereby extending the catalyst's lifespan.

1.3 Key Parameters Influencing Plasma-Catalyst Systems

Optimizing the performance of nonthermal plasma-catalyst systems requires a thorough understanding of various parameters that influence reaction outcomes. The interaction between plasma-generated reactive species and catalyst surfaces is highly

dependent on the operating conditions of the plasma as well as the physicochemical properties of the catalyst. This section examines the critical parameters that affect plasma-catalyst performance [1-3, 6, 9].

1.3.1 Plasma Parameters

1.3.1.1 Discharge Power and Voltage

The power and voltage applied to generate nonthermal plasma significantly affect the density of reactive species produced. Higher discharge power generally leads to an increase in electron energy and concentration, enhancing the generation of radicals, ions, and excited molecules. However, excessive power can cause catalyst deactivation due to localized heating or unwanted side reactions.

Impact on Reaction Efficiency: Studies have shown that increasing the discharge power enhances pollutant degradation and hydrogen production rates. For instance, in the case of NO_x removal, a higher power input results in greater NO_x conversion but may also increase the formation of by-products like N_2O .

Optimization Considerations: Balancing power levels is crucial to prevent catalyst overheating while maximizing reaction efficiency. For packed-bed reactors, a moderate power range (e.g., 10-50 W) is often optimal for maintaining the stability of the catalyst.

1.3.1.2 Frequency and Type of Discharge

The frequency of the applied voltage (e.g., low-frequency AC, high-frequency AC, or microwave) affects the plasma's electron energy distribution and, consequently, the types of reactive species generated. Different discharge types (e.g., DBD, corona, or RF) offer unique advantages depending on the target reaction [2, 3, 5, 6].

Low-Frequency & High-Frequency Discharges: Low-frequency discharges are more effective in generating ions, while high-frequency discharges are better for producing excited molecules and radicals.

Microwave Plasmas: These are particularly effective for high-energy processes like methane reforming and are known for their energy efficiency and stability at low pressures.

1.3.1.3 Gas Composition and Flow Rate

The composition of the feed gas plays a critical role in determining the plasma chemistry and catalyst performance. For example, the presence of oxygen can enhance the formation of reactive oxygen species (ROS), which are essential for oxidation reactions.

Effect on Pollutant Degradation: In NO_x removal applications, the addition of oxygen can improve NO_x conversion efficiency but may also lead to the formation of undesired by-products.

Gas Flow Rate: The residence time of reactants in the plasma zone is controlled by the flow rate. Higher flow rates can reduce the contact time between plasma species and the catalyst, potentially lowering conversion efficiency, whereas too low flow rates may result in catalyst deactivation due to excessive surface coverage [2, 5].

1.3.1.4 Reactor Configuration

The design of the plasma reactor significantly affects the interaction between plasma species and catalysts. Common configurations include packed-bed reactors, surface discharge reactors, and gliding arc reactors [2, 3, 6, 8].

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Packed-Bed Reactors: These are widely used for plasma-catalyst applications due to their high surface area and effective plasma-catalyst contact. However, optimizing the packing density is essential to avoid excessive pressure drops and ensure uniform plasma generation.

Surface Discharge Reactors: These reactors are designed to maximize the exposure of catalysts to plasma species by confining the plasma to the surface layer, which can enhance surface reactions.

Conclusions

The investigation of nonthermal plasma-catalyst systems has demonstrated significant potential in applications ranging from environmental remediation to sustainable hydrogen production. While substantial progress has been made in understanding the underlying mechanisms and optimizing performance, challenges related to catalyst stability, energy efficiency, and selectivity remain. Addressing these challenges through advanced catalyst design, innovative reactor configurations, and integration with renewable energy sources will be essential for the widespread adoption of plasma-catalyst technologies. Future research should focus on developing robust materials, optimizing system parameters, and leveraging computational tools to accelerate the transition of these technologies from the laboratory to industrial scales.

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MODERN PROBLEMS OF TECHNICAL SCIENCES

UDC:62,539.3, 539.5 NEUTRALIZATION OF THE HARMFUL EFFECTS OF IMPURITIES IN FOUNDRY MAGNALIAS

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Annotatsita. Turli xil oʻlchamdagi va zichlikdagi aralashmalarning Mg tarkibidagi turli xil qotishmalarning mikro tuzilishi va mexanik xususiyatlarining evolyutsiyasiga ta'siri oʻrganildi. Fazali tahlil shuni koʻrsatdiki, oʻrganilayotgan qotishmalarda alyuminiy asosli qotishmaning murakkab qattiq eritmasining kristallaridan tashqari, dendritik hujayralar chegaralarida joylashgan evtektik yoki peritektik kelib chiqishning tarkibiy qismlari mavjud. Fazalarni tahlil qilish va faza morfologiyasi natijalariga koʻra, Mg₂Si, (Al, Fe, Mn, Ni, Cu), S (Al₂CuMg), β (Al₃Mg₂) fazalari yoki strukturaviy komponentlari mexanik ta'sirni sezilarli darajada kamaytirishi kerak deb taxmin qilish mumkin. xususiyatlari. xossalari va ayniqsa quyma holatda qotishmalarning egiluvchanligi).

Kalit soʻzlar: ortiqcha fazalar, tarkib, metallografik xususiyatlari, strukturaviy komponentlar, kontrast darajasi, morfologiya, yuqori haroratda qotib qolish, neytrallash, zararli ta'sir.

Аннотация. Изучено влияние примесей различного размера и плотности на эволюцию микроструктуры и механических свойств сплавов с различным содержанием Mg. Фазовый анализ показал, что в исследованных сплавах, помимо кристаллов сложного твердого раствора сплава на основе алюминия, присутствуют структурные компоненты эвтектического или перитектического происхождения, расположенные по границам дендритных ячеек. По результатам фазового анализа и фазовой морфологии можно предположить, что фазы или структурные компоненты Mg₂Si, (Al, Fe, Mn, Ni, Cu), S(Al₂CuMg), β (Al₃Mg₂) должны наиболее существенно снижать механические свойства и особенно пластичность сплавов в литом состоянии).

Ключевые слова: избыточные фазы, состав, металлографические особенности, структурные компоненты, степень контрастности, морфология, высокотемпературная закалка, нейтрализация, вредное воздействие.

Abstract. The influence of impurities with different sizes and number densities on the evolution of the microstructure and mechanical properties of alloys with different Mg contents has been studied. Phase analysis showed that in the studied alloys, in addition to crystals of a complex alloy solid solution based on aluminum, there are structural components of eutectic or peritectic origin located along the boundaries of dendritic cells. Based on the results of phase analysis and phase morphology, it can be assumed that the phases or structural components of Mg₂Si, (Al, Fe, Mn, Ni, Cu), S(Al₂CuMg), β (Al₃Mg₂) should most significantly reduce the mechanical properties and especially the ductility of cast alloys condition).

Keywords: excess phases, composition, metallographic features, structural components, degree of contrast, morphology, high-temperature hardening, neutralization, harmful effects.

Introduction

Insoluble phases formed by the most harmful impurities of iron and silicon make it difficult to use low-grade charge in the production of industrial primary alloys based on the Al – Mg system, not to mention the use of scrap and waste. The negative impact of these impurities can be reduced by changing the morphology, distribution and structure parameters of excess phases of crystallization origin. In casting alloys, this is achieved mainly by introducing small additives that could modify the structure of the alloys, or by using various heat treatment methods.

Literature Review

No data on practical methods for improving the shape of Fe and Si-containing phases in cast aluminum-magnesium alloys (and therefore a method for neutralizing iron and silicon impurities) has been found in the literature. There is information about the modifying effect of small additions of beryllium on the morphology of inclusions of ferrous phases in silumins [6] and on the crystallization of the FeAl3 phase in highstrength cuprous silumin VAL 8 [1, 8]. The change in the structure of cast aluminum alloys during homogenization annealing and heating for quenching is considered in detail [2] in alloys of the Al – Mg, Al – Cu, Al – Zn – Mg, Al – Cu – Mg, Al – Mg – Zn – Cu and etc. Using the example of the AlCuFeMnSi phase in the D16 alloy, it was shown [5] that a significant change in its chemical composition occurs during homogenization annealing. An assumption has been made about the possibility of a slight increase in the compactness of the shape of the "insoluble" phases during prolonged heating, which is one of the ways to neutralize the harmful influence of the crystallization transformation phases.

Research Methodology

The study employed a systematic approach to investigate the influence of impurities on the microstructure and mechanical properties of aluminum-magnesium alloys with varying magnesium content.

Various compositions of aluminum-magnesium alloys were prepared, incorporating different levels of impurities such as silicon, iron, and copper. Phase analysis was conducted to identify the presence of complex alloy solid solutions and the structural components resulting from eutectic or peritectic origins. This analysis helped determine the detrimental phases that could affect mechanical properties.
High-temperature homogenization treatments were carried out to optimize the morphology and distribution of harmful impurities. The homogenization temperature was set at 520±5 °C, with varying exposure times (5 to 20 hours) to assess its effects on microstructure and mechanical properties.

Mechanical properties, including tensile strength (σ_B), yield strength ($\sigma_{0,2}$), and ductility (δ), were evaluated post-treatment using standardized testing methods. Measurements were recorded and compared across different alloy compositions and heat treatment conditions. Metallographic techniques were utilized to observe the microstructure of the alloys before and after heat treatment, focusing on the morphology of inclusions and the distribution of different phases.

The results were analyzed to establish correlations between the microstructural characteristics and mechanical properties, leading to conclusions about the effectiveness of high-temperature hardening in mitigating the negative effects of impurities. This comprehensive methodology allowed for a detailed understanding of how impurities affect the performance of aluminum-magnesium alloys under different heat treatment regimes.

Analysis and Results

Optimization of heat treatment regimes for foundry magnalium with a high content of impurities. As can be seen from Figure 1, hardening according to generally accepted conditions does not give a noticeable effect. In this regard, it was decided to try high-temperature homogenization before hardening. At high temperatures, the most likely change in the morphology of particles of the Mg₂Si phase is especially harmful in the studied alloys. In addition, for foundry magnalium, according to [3], quenching from these temperatures can significantly reduce the isothermal holding time.

Experiments were carried out with alloys 2.3, 5.6, 8.9, the compositions of which are presented in Table 1.

The temperature of the equilibrium and nonequilibrium solidus of these alloys was determined by the method of thermal analysis. Depending on the magnesium content, the temperature of the equilibrium solidus fluctuates in the range $525 \div 550 \pm 3$ °C. The nonequilibrium solidus temperature for all studied alloys is 450 ± 3 °C. Taking into account the technical capabilities of the furnaces for heat treatment, a homogenization temperature of 520 ± 5 °C was chosen. Optimization of the heating mode for quenching over time was carried out on an Al + 6% Mg alloy with an impurity concentration of Si, Fe, Cu - 0.6% (maximum content of the most harmful impurities), Zn, Mn - 0.3%, Sn and Pb - 0.1%, Ni - 0.2%.

The obtained dependences of the mechanical properties ($\sigma_{B,}$, $\sigma_{0,2} \delta$, HB) on the exposure time are presented in Figure 1. From the analysis of the curves it follows that high-temperature heating for hardening provides a significant increase in ductility, as well as tensile strength. The optimal holding time when heating for hardening is 10 hours. A further increase in heating time does not provide a significant increase in mechanical properties.



Figure 1. Dependence of the mechanical properties of the Al + 6% Mg alloy with impurities at an average level on the exposure time when heated for hardening at 520 ± 5 °C.

From the results of mechanical tests presented in Table 1, it follows that the heating mode for hardening 520 ± 5 °C, 10 hours helps to increase the mechanical properties of aluminum alloys with a magnesium content of 4 to 8%, and impurities at various levels, cast into a steel mold. Moreover, if in the cast state an increase in the content of magnesium and impurities leads to a sharp decrease in the ductility of the alloys, then in the hardened state the temporary resistance and the nominal yield strength $\sigma_{0,2}$ increase with high ductility.

During the process of homogenization, changes occur in the structure of alloys associated with the partial dissolution of excess phases containing Mg, Cu and fragmentation, and then coagulation of particles of the structural component (Mg, Si, S, Pb) (see in Figure 2). These changes determine the observed increase in mechanical properties - an increase in δ of the alloys by 3-5 times, $\sigma_{B,}$, $\sigma_{0,2}$ by 20-30%. The microstructure of alloys after high-temperature homogenization is characterized by a highly uniform distribution and compactness of inclusions (Mg, Si, Sn, Pb).

It is known that increasing the content of magnesium and silicon in magnesium improves their casting properties (according to experimental data presented in Chapter 3 and data [1, 4, 7]. Therefore, it was necessary to establish the maximum concentration of these elements at which high-temperature hardening could still be effective. For this purpose, we studied the mechanical properties of the compositions) AI - 6% Mg - 1% Fe - 0.6% Cu - Si (in which the concentration of Si was changed) and AI - Mg - 0.6% Si - 0.6% Cu - 1% Fe (in which the Mg concentration was changed) in a quenched state after high-temperature heating and heating in an accelerated mode known in industry.

Table 1. Mechanical properties of Al-Mg system alloys with different impurity contents after high-temperature hardening.

No	Alloy base	Impurity level	Mechanical properties				
JN⊡			σ _B , MPa	σ 0,2, MPa	δ, %	HB, MPa	
1.	Al + 4% Mg	lower	231±14	110±15	10±1	-	
2.	Al + 4% Mg	average	244±13	132±10	7±1	800±30	

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3.	Al + 4% Mg	upper	265±10	173±10	5±1	-
4.	Al + 8% Mg	lower	284±10	171±10	7±1	-
5.	Al + 8% Mg	average	323±14	177±14	8±1	1030±20
6.	Al + 8% Mg	upper	249±14	195±10	5±1,5	-
7.	Al + 6% Mg	lower	253±10	144±10	7±1	850±20
8.	Al + 6% Mg	average	280±15	165±10	7±1	880±20
9.	Al + 6% Mg	upper	285±10	189±10	5±1	930±10



(c) X 500
(d) X 1000
Figure 2. Microstructure of the Al + 6%Mg alloy with impurities at an average level after high-temperature quenching a – 5h; b – 10 h; c – 15 h; d – 20h.

The research results are presented in tables 2 and 3. From the analysis of the results of mechanical tests it follows that with a silicon content of $\geq 2\%$, high-temperature hardening does not increase the ductility of the alloys (~2.5%). The strength properties also turned out to be low ($\sigma_{B,=} 211$ MPa, $\sigma_{0,2} = 135$ MPa). The decrease in the values of δ , $\sigma_{B,}$ and $\sigma_{0,2}$ is well explained by the microstructures of alloys with 1 and 2% Si (see in Figure 3 and Figure 4).

High-temperature hardening leads to fragmentation and then to coagulation of inclusions (Mg, Si, Sn, Pb) and complete dissolution of the $S(Al_2CuMg)$ phase. But in a melt with a silicon concentration of ~2%, the volume fraction of particles of the structural component (Mg, Si, Sn, Pb) is so large that high values of mechanical properties, especially plasticity, were not obtained. From here (as well as from the data in Table 2 and Table 4) it follows that the silicon content in the studied alloys must be limited to 1-1.5%. In order to optimize high-temperature hardening (HTZ) modes, the Al + 6% Mg + 0.8% Si + 0.6% Fe + 0.6% Cu alloy was heated in various modes (Table 4) and its mechanical properties were determined properties.



Figure 3. Microstructure of the alloy Al +6%Mg₂%Si + 1.0%Fe + 0.6%Cu in cast (a) and hardened (b) states x400.

Heating mode for hardening	Content Si, %	δ, %	σ _B , MPa	σ _{0,2} , MPa
High temperature mode 520±5 °C,	0,5	10±1	280±20	147±15
10h	1,0	7±1	280±20	165±15
	1,5	4±1	275±20	158±15
	2,0	2,5±1	212±20	145±15
	2,2	1,3±0,5	205±20	142±15
Known mode 435±500 °C, 6h + 460±50 °C, 4h	0,5	1,5±0,5	226±20	134±15

Table 2. Mechanical properties of alloys based on the composition Al - 6% Mg - 1% Fe - 0.6% Cu – Si after hardening depending on silicon content.

Table 3. Mechanical properties of composition-based alloys Al - Mg - 0.6% Si - 1% Fe - 0.6% Cu after hardening depending on magnesium content.

Heating mode for hardening	Content Mg, %	δ, %	σв, МРа	σ0,2, MPa
High temperature mode	2,0	12±2	200±20	105±15
520±5 °C, 10 h	4,0	8,5±2	275±20	135±15
	6,0	8±2	280±20	148±15
	8,0	8±2	300±15	180±15
	10,0	оплавление	большей час	ги образцов
Known mode 435±50 °C, 6h + 460±50 °C, 4h	2-10	1,5±1	200-280	105-134



Figure 4. Microstructure of the alloy Al + 6%Mg + 1%Si + 1%Fe + 0.6%Cu in cast (a) and hardened (b) states x400.

Table 4. Mechanical properties of the alloy Al + 6%Mg + 0.8%Si + 0.6%Fe + 0.6%Cu after hardening in different modes (cooling in water).

Heating modes for hordening	Mechanical properties				
Heating modes for hardening	σ _B , MPa	σ _{0,2} , MPa	δ, %		
510°C, 20 h	240 ± 20	134 ± 15	$1,5 \pm 0,5$		
520°C, 10 h	280 ± 15	170 ± 15	$7,5 \pm I$		
530°C, 10h	300 ± 20	165 ± 15	$8,0 \pm I$		
540°C, 5 h	280 ± 20	170 ± 15	$7,0 \pm 1,5$		
550 °C, 10 h	165 ± 20	160 ± 15	$0,8 \pm 0,5$		
430 °C, 6h+460 °C, 4 h	240 ± 20	140 ± 15	$1,7 \pm 0,8$		

Conclusions

A comparison of σ_B , $\sigma_{0,2}$, δ of the studied alloy, heat-treated according to the industrially known accelerated two-stage mode (430 °C, 6 hours + 460 °C, 4 hours) and according to the VTZ mode clearly shows the advantages of high-temperature heating. Based on the results of mechanical tests presented in tables 2-4 and structural observations, a new mode of heat treatment of foundry magnesium containing 4-10%

Mg and up to 1.5% Si was developed, consisting of heating to temperatures 10 °C below the equilibrium solidus (520...540 °C) for 5-20 hours, followed by quenching in oil or water. High-temperature hardening partially neutralized the harmful effects of silicon and copper impurities. However, it was not possible to eliminate the negative effect of iron impurities on the mechanical properties by heat treatment. In order to neutralize iron impurities, an attempt was made to modify the structure of the studied alloys with small additives.

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ACTUAL PROBLEMS OF NATURAL SCIENCES

UDC: 542, 54.05, 66 STUDY OF THE CATALYTIC PROPERTIES OF SYNTHESIZED HYDROTREATING CATALYST CARRIERS

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Annotatsiya. Maqolada karbonat-paligorskit gilmoyasiga asoslangan sintezlangan gidrotozalash katalizatorlarining katalitik xususiyatlarini oʻrganish koʻrib chiqilgan. Sintez qilingan katalizatorlarni sinovdan oʻtkazish natijasida shuni koʻrsatadiki, dizel distillyatini gidrotortish uchun karbonat-paligorskit gili bilan modifikatsiyalangan yangi katalizator tashuvchisi import qilingan katalizator tashuvchisiga nisbatan katalitik faollikda qolishmaydi.

Kalit soʻzlar: gidrotartish, alyuminiy-nikel-molibden katalizatori, karbonat paligorskit, vodorodlanish, tayanch, dizel yonilgʻisi.

рассматривается обзор Аннотация. В статье об исследование свойств синтезированных носителей каталитических катализатора основе карбонатно-палигорскитовой При гидроочистки на глины. проведении испытаний синтезированных катализаторов показывают, что катализаторов, модифицированный новый носитель карбонатнопалыгорскитовой глиной для гидроочистки дизельного дистиллята, не каталитической уступает активности импортному носителю ПО катализаторов.

Ключевые слова: гидроочистка, алюминий-никель-молибденовый катализатор, карбонатный палигорскит, гидрирование, носитель, дизельное топливо.

Abstract. The article examines the study of the catalytic properties of synthesized hydrotreating catalysts based on carbonate-palygorskite clay. The tests of the

synthesized catalysts show that the new catalyst carrier modified with carbonatepalygorskite clay for hydrotreating diesel distillate is not inferior in catalytic activity to the imported catalyst carrier.

Keywords: hydrotreating, aluminum-nickel-molybdenum catalyst, carbonate palygorskite, hydrogenation, carrier, diesel fuel.

Introduction

The processes of hydrotreating oil fractions, including hydrotreating and hydrocracking processes, are the largest-scale oil refining processes and are of key importance for the production of motor fuels that meet the requirements of modern environmental standards. In accordance, the sulfur content in the produced diesel fuel should not exceed 10 mg/kg, the content of polyaromatic compounds should not exceed 8% by weight, the cetane number should not be less than 51 [1].

Literature Review

Hydrotreating catalysts play a crucial role in the refining and petrochemical industries, primarily for removing sulfur, nitrogen, and metal impurities from hydrocarbon streams and for saturating aromatics. Their performance largely depends on the properties of their carriers, which act as supports for the active catalytic phases. This literature review summarizes key findings and developments in the field, focusing on the synthesis, characterization, and catalytic properties of these carriers [3-4].

Importance of catalyst carriers-the carrier material impacts the catalyst's mechanical strength, thermal stability, and pore structure, which in turn influence the dispersion of active metals and overall catalytic performance. Commonly used carriers include alumina, silica, titania, and their composites. Studies have shown that modifying carrier materials can significantly enhance hydrotreating efficiency by optimizing surface area, pore size distribution, and acidity levels [5].

Synthesis of catalyst carriers-synthesis techniques such as sol-gel, hydrothermal, and precipitation methods are widely used to produce catalyst carriers with controlled physicochemical properties. The addition of dopants, such as phosphorus or transition metals, can further enhance carrier properties by altering acidity or improving resistance to sintering [6]. Recent advances have explored the use of mesoporous materials and hierarchical structures to improve the accessibility of active sites and enhance catalytic activity.

Studies highlight that carriers with high surface areas and tailored pore structures enhance the dispersion of active metals like MoS_2 and Co-Mo-S, resulting in higher catalytic efficiency [7-9].

Challenges and opportunities- challenges in this field include deactivation due to coke deposition, sintering, and the formation of undesired by-products. Future research focuses on developing carriers with enhanced stability and recyclability while reducing environmental impact [8].

Research Methodology

Catalytic performance in hydrotreating- the performance of hydrotreating catalysts is evaluated based on:

Hydrodesulfurization (HDS): The removal of sulfur-containing compounds.

Hydrodenitrogenation (HDN): The elimination of nitrogen impurities.

Hydrogenation Reactions: The saturation of aromatics.

In aluminum-nickel-molybdenum catalysts, active aluminum oxide is used as a carrier of active components, the content of which in the catalyst is 80-82%. In the process of obtaining active aluminum oxide, large amounts of environmentally hazardous wastewater are formed [2]. To clean and dispose of these wastes, the construction of special treatment plants is required, which leads to an increase in the cost of production. Replacing an expensive carrier, active aluminum oxide, with affordable, cheap carriers that are not inferior in physical–chemical properties is an urgent task.

The catalyst carriers are prepared using local raw materials modified with carbonatepalihorsite clay [10].

Analysis and Results

The research was carried out in the central factory laboratory of Bukhara Refinery LLC. The results obtained are shown in Table 1.

1 71 4141			
N⁰	Indicators	Raw materials	ANMP-211
	Operating mode of the unit:		
1.	hydrogen pressure, MPa		3,5-4,5
	temperature, °C		340
	Feed rate of raw materials, h ⁻¹		$2 h^{-1}$
	circulation VSG nl/l .s		300
	Quality of raw materials and hydrogenate:		
	yield of hydrogenate, vol. %		
	density, kg/m ³	833	828
2.	refractive index	1,4625	1,4120
	sulfur content, wt. %	1,31	0,144
	hydrogenation depth:		
	sulfur compounds, %		89
	Fractional composition vol % °C		
	N K 5	197	146
	10	215	212
	20	223	219
	20	230	226
	30 40	249	244
3.	40	266	252
	50	276	260
	00	289	269
		307	285
		325	310
		345	332
	Output	96/360	97/360

Table 1. Results of hydrotreating of diesel distillate of Bukhara Refinery LLC on the new ANMP - 211 catalyst.

As can be seen from the results obtained, when using the developed new catalyst carrier at a temperature of 340 °C, a pressure of 4 MPa, a feed rate of 2 h⁻¹ circulation of hydrogen-containing gas (HCG) 300 nl/hp, the residual sulfur content in diesel fuel is 0.144% by weight (Table 1).



Thus, the test results show that the new catalyst carrier modified with carbonate - palihorsite e clay for hydrotreating diesel distillate is not inferior in catalytic activity to the imported catalyst carrier [9].

Conclusions

This study investigated the catalytic properties of synthesized hydrotreating catalyst carriers. The main objective of the research was to analyze the composition, structural properties of catalyst carriers, and their associated catalytic activity indicators. It provided new directions for the development of efficient catalysts. The obtained results can contribute to improving efficiency in industrial processes and reducing harmful environmental emissions.

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ACTUAL PROBLEMS IN MODERN AGRICULTURE

UDC: 63, 631.5 WISE USE OF NATURAL RESOURCES IN SUSTAINABLE DEVELOPMENT OF AGRICULTURE

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Annotasiya. Mazkur maqolada Respublika qishloq xoʻjaligining barqaror rivojlanishida tabiiy resurslardan oqilona foydalanish yoʻllari koʻrib chiqilgan. Jumladan, yer-suv resurslariga nisbatan munosabat ilmiy jihatdan asoslangan. Qishloq xoʻjaligi ishlab chiqarishida yer resursi asosiy vosita ekanligi tahlil qilingan. Oʻzbekiston respublikasi milliy iqtisodiyotining asosiy tarmogʻi hisoblangan qishloq xoʻjaligini rivojlantirishning 2020-2030 yillarga moʻljallangan strategiyasini mazmun mohiyati atroflicha oʻrganilgan.

Kalit soʻzlar: Qishloq xoʻjaligi, barqaror rivojlanish, yer resursi, suv resursi, strategiya, yoʻnalishlar, oqilona foydalanish, suv ta'minoti, ishlab chiqarish.

Аннотация. В данной статье рассматриваются пути рационального использования природных ресурсов в целях устойчивого развития сельского хозяйства республики. В частности, научно обосновано отношение к земельным и водным ресурсам. Проанализировано, что земельный ресурс является основным средством сельскохозяйственного производства. Подробно изучено содержание Стратегии развития сельского хозяйства на 2020-2030 годы, которое считается основной отраслью национальной экономики Республики Узбекистан.

Ключевые слова: Сельское хозяйство, устойчивое развитие, земельные ресурсы, водные ресурсы, стратегия, направления, рациональное использование, водоснабжение, производство.

Abstract. This article examines the ways of rational use of natural resources in the sustainable development of the republic's agricultural network. In particular, the attitude to land and water resources is scientifically substantiated. It is analyzed that the land resource is the main means of agricultural production. The content of the Strategy for the Development of Agriculture for 2020-2030, which is considered the main branch of the national economy of the Republic of Uzbekistan, was studied in detail.



Keywords: Agriculture, sustainable development, land resources, water resources, strategy, directions, rational use, water supply, production.

Introduction

In the following years, the reform of the agricultural sector of our country, in particular, the rational establishment and improvement of the state management system in the sector, the widespread introduction of the mechanism of market relations, the strengthening of the legal basis of the relations between the entities that grow, process and sell agricultural products, the wide attraction of investments in the improvement sector, specific works are being carried out to introduce resource-efficient technologies and to provide agricultural production entities with modern equipment.

If we pay attention, the absence of a long-term strategy for the development of agriculture hinders the effective use of land and water resources, the wide and effective attraction of investments in this field, the high income of producers and the increase of competitiveness of products.

Diversification of agricultural production, rational improvement of land and water relations, creation of a favorable agribusiness environment and a high added value chain, support for the development of cooperative relations in a wide range, wide application of market mechanisms and information and communication technologies to the agricultural sector, as well as, effective and rational use of scientific and technical achievements and increase of human resources have become the demand of the time.

Taking into account that this wide-ranging process in the field of agriculture is one of the main directions of the rational socio-economic policy carried out in our Republic, an important law on "Approving the strategy for the development of agriculture of the Republic of Uzbekistan for 2020-2030" was adopted (October 23, 2019, PF - No. 5853). The main goal of the timely adopted law and the approved strategy is directed to the fundamental improvement of state policy in the more sustainable deepening of reforms aimed at increasing the competitiveness of the agricultural sector and the food chain, and covers the following important priorities:

-Ensuring food safety of the population of our republic;

- -creation of a favorable agribusiness environment and added value chain in the field;
- -reducing state participation in agricultural management and increasing investment attractiveness;
- -ensuring rational use of available natural resources and environmental protection;
- -development of modern systems of state management in agriculture;
- -gradual diversification of state expenditures aimed at supporting the agricultural sector;
- -development and improvement of the system of science, education, information and consulting services in agriculture;

-development of rural settlement areas;

-development of a transparent system of agricultural statistics [1].

Research Methodology

One of these areas is the rational use of natural resources and the provision of environmental protection. Because more and more attention to land and water resources and their rational use is attracting everyone's attention. As we know, about 20.7 percent of the 20.2 million hectares of agricultural land is irrigated land. Over the past 15 years, irrigated land per capita has decreased by 24 percent (from 0.23 ha to 0.16 ha).

This situation occurred as a result of the continuous growth of the population, a specific reduction in the volume of water supply, and the transfer of land intended for agricultural production to other categories of the land fund. According to forecasts, the available irrigated land area may decrease by another 20-25 percent over the next 30 years. The insufficient guarantee of the right to use land resources strongly hinders the improvement of management efficiency of production farms and limits the attraction of investments to a certain extent.

Currently, clear and transparent mechanisms and ways of rational distribution of land plots and protection of the rights of land users have not been fully created. Also, the lack of provision for secondary lease of plots of land prevents the transfer of agricultural land to relatively potential land users.

Approximately 80 percent of the republic's water resources are formed at the expense of transboundary water bodies. Such a situation determines the importance of regional cooperation for sustainable management of water resources in the Central Asian region, in particular in the Republic of Uzbekistan. 70% of the irrigation networks in the republic do not have anti-filtration coating, as a result, a certain part of the water is lost in the process of delivering it to the irrigation field.

Most of the existing irrigation infrastructure, pumping stations, are in use for more than 30-40 years and need reconstruction or capital repair. Currently, only 1.7 percent of the available irrigated land is drip irrigation. Due to the high dependence of the agricultural sector on irrigation, the current situation may be further complicated by the continued use of traditional irrigation methods and the dramatic increase in droughts due to climate change.

According to the forecasts of the Institute of World Resources, by 2040, the country of Uzbekistan will become one of the 33 countries with the highest water shortage. The reduction in current productivity has serious negative consequences for food security and the balance of payments, which creates the need for rational management of water resources and the use of resource-efficient technologies in the cultivation of agricultural crops.

The lack of a mechanism for covering the costs of water supply for agricultural needs prevents the widespread implementation of water-saving technologies. The introduction of new modern water legislation in line with the European Union Parliament's Water Directive (2000/60/EU) will ensure the development of the necessary legal framework for future water policy and the introduction of harmonized methods of water resources management.

One of the main components of the country's natural resources is forest fund land, which is 11.1 million hectares or 25% of the total area. Areas covered with forests are equal to 3.2 million hectares (29 percent).

Today, in the policy aimed at the protection of natural resources carried out by our state, special attention is paid to the management of existing forest resources. In 2017, the State Forestry Committee was established, a number of measures were implemented to expand the area of forests by 2.3 million hectares, establish 12 new

forestry farms, and strengthen the material and technical base. Also, works were carried out to establish forests on the dry surface of the Aral Sea, to expand the areas of protective forests, to increase the number of green corridors that protect against wind on agricultural lands, to create a perfect monitoring system, and to improve environmental education programs.

At the same time, effective management of natural resources is the main priority for the sustainable development of agriculture and rural areas, aimed at reducing the negative consequences for the environment and climate as a result of unreasonable use of natural resources.

Although there are minimum agroecological standards in the country, most of them are based on old technologies. Environmental factors are not taken into account when developing agricultural practices. Improvement of agroecological practices and the development of standards and mechanisms for the protection of natural resources are required to integrate environmental factors.

Land resources are an incomparable wealth of any country. National report on the state of land resources in the Republic of Uzbekistan on January 1, 2024, approved by the Cadastre Agency under the Ministry of Economy and Finance of the Republic of Uzbekistan, based on information on all changes in the land of enterprises, institutions, farms and organizations in 2024, and by the decisions of district, city and regional governors, and as a result of generalization of annual land reports for the republic, it was compiled and put into production.

Analysis and Results

As of January 1, 2024, the total land area within the administrative territorial borders of the Republic of Uzbekistan was 44,892.4 thousand hectares, of which 4,342.5 thousand hectares or 9.7 percent of the total land area were permanently irrigated. The land fund of the Republic of Uzbekistan has its own characteristics according to the purpose and procedure of land use, which are divided into 8 categories based on Article 8 of the Land Code of the Republic of Uzbekistan (as given in Table 1) [2].

T /#	I and fund astagories	Total	land area	Including irrigated land	
1/1	Land fund categories	Total	In interest	Total	In interest
1	Agricultural land	26 132.2	58.21	4 226.2	9.41
2	Lands of settlements	226.7	0.51	50.9	0.11
3	The amount of land intended for industry, transport, communication, defense and other purposes	786,9	1.75	12.6	0.03
4	The amount of land intended for nature protection, health and recreation purposes	3 223.3	7.18	0.9	0.002
	Amount of lands of historical and cultural importance	15.0	0.03		
6	Forest fund lands	12 092.5	26.94	45.4	0.10
7	Water fund lands	827.3	1.84	4.6	0.01

Table 1. Categories of the land fund of the Republic of Uzbekistan (in thousand hectares, 2024)

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8	Reserve lands	1 588.5	3.54	1.9	0.004
	Total lands:	44 892.4	100.0	4 342.5	9.67

Any resource entrusted to humanity by nature has its own value. This value is so great that we cannot measure it in money. Because we do not know how much money was spent on its formation and creation. If we pay attention, our soil is equal to gold, every inch of our land is priceless. Because land is the source of our sustenance. Therefore, it is our duty to use the land correctly and wisely, to protect it from negative influences without harming our generous land.

Unfortunately, our attitude towards the land, our efforts to improve its productivity are not up to the demand. Throughout the history of human existence, more than 2 billion hectares of fertile land have become unusable. In addition, 5-7 million hectares of land are lost every year due to soil salinization, erosion and its abandonment. Such situations are also happening in our lands.

It is true that the sense of ownership of land has increased in our country over the last quarter of a century, serious attention is being paid to the issues of its effective use, increasing its productivity and improving its properties. However, the soil is being eroded under the influence of water and wind, there are cases of anthropogenic factors, deforestation, improper feeding of livestock, and non-compliance with agricultural laws.

The process of desertification in agriculture is also a serious threat. In this regard, the work of blocking the road of shifting sands, dunes, and the establishment of tree groves in the case of field edges and terraces is very slow. Also, excessive use of mineral fertilizers and toxic substances in order to increase productivity is allowed, all of which are causing damage to the environment, water bodies, flora and fauna, and ecological balance.

Greening of agriculture is important in solving such environmental problems. Natural management of agrocenoses, biological control of plants against diseases and pests, transition to planting multiple crops instead of one crop, deep and comprehensive study of ecological consequences, and the use of land will gradually ensure ecological balance.

Conclusions

Ensuring rational and effective use of natural resources and environmental protection in the sustainable development of agriculture is the main goal of this priority direction. To achieve this goal, the following tasks are defined:

-development and implementation of acceptable agricultural and environmental practice (GAEP);

-development of guidance on compliance with the principles of acceptable agricultural and environmental practice (GAEP) intended for producers of agricultural products;

-to take measures to help agricultural producers to implement good agricultural and environmental practices (GAEP), as well as good manufacturing practices (GMP) for agribusiness and other quality standards;

-promoting environmentally and climate-safe practices in agriculture;

-To improve the ways of protecting the right to use land in the Land Code of the Republic of Uzbekistan and to introduce the procedure of giving farm lands for temporary use while preserving the right to inherit them for life and to land users in the adjacent (neighboring) area when the rights to land plots are canceled in the prescribed manner making amendments and additions that provide for the right of first refusal;

-by 2030, the water consumption used to irrigate one hectare of land will be reduced by 20%;

-improvement of state support mechanisms for producers and buyers of local watersaving technologies;

-improvement of the personnel training and retraining system in the field of forest resource management;

-adoption of the national plan of actions to prevent the effects of climate change;

-maintain and increase soil fertility by introducing effective practices of fertilizer use based on soil and climate conditions by purchasing mobile laboratories for soil analysis;

-to improve the cadastral system of accounting for agricultural land and to integrate a single information system with the system of accounting for the ownership of real estate for keeping records of land use and property rights;

-revision of the system for determining the cadastral value of agricultural lands;

-improvement of the water resources management system;

-development of a procedure for covering the costs of water supply in agriculture using smart technologies (mini measuring stations and "smart stick");

-improvement of the forest resource management system;

-introduction of modern methods of assessment and monitoring of forest resources;

-development of a system of criteria and indicators that ensure the accounting of forest resources at the market price;

-strengthening the institutional capacity to ensure biological safety, control the use of natural resources, pesticides and chemical agents in agriculture;

-development of minimum environmental standards and requirements based on the Acceptable Agricultural and Environmental Practice (GAEP) for monitoring the impact of agricultural production on the state of the ecosystem and biotopes;

-development of the cadastral system of agricultural lands, modernization of facilities and infrastructure of institutions in the field of land resources management;

-in order to increase the efficiency of the rational use of land and water resources and to attract private investments in agriculture, to develop public-private partnership projects in the field of irrigation and to introduce them as a pilot test, etc.

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ACTUAL PROBLEMS OF HISTORY, PHILOSOPHY AND SOCIOLOGY

UDC: 305, 308, 331.1 ACHIEVING WORK-FAMILY BALANCE: THEORETICAL APPROACHES

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Annotatsiya. Ushbu maqolada oila va ish oʻrtasidagi balansga erishish: nazariy yondashuvlar tahlil qilingan. Oila-mehnat balansining turli xil ta'riflari, oila va mehnat oʻrtasidagi balansning sotsiologik tahlili, oila va mehnat xususiyatlarining sohalar oʻrtasidagi balansga erishishga ta'siri, oila va mehnat balansini oʻrganish sohasida nazariya va gipotezalar, balansga qanday erishish mumkinligini belgilovchi omillar, oila-mehnat balansi siyosatini tadqiq qilish va amalga oshirish boʻyicha jahon tajribasi kabilar tahlil qilingan. Yakuniy qismda taklif va tavsiyalar berilgan.

Kalit soʻzlar. Oila, ish, balans, nazariy yondashuvlar, erkak, ayol, mehnat, gender, shaxs, omillar.

Аннотация. В данной статье рассматриваются теоретические подходы к достижению баланса между семьей и работой. Анализируются различные определения семейно-трудового баланса, социологический анализ баланса между семьей и работой, влияние характеристик семьи и труда на достижение баланса между сферами, теории и гипотезы, а также факторы, определяющие способы достижения баланса. Также рассматривается мировой опыт в исследовании и реализации политики семейно-трудового баланса. В заключении статьи представлены предложения и рекомендации.

Ключевые слова: семья, работа, баланс, теоретические подходы, мужчина, женщина, труд, гендер, личность, факторы.

Abstract. This article analyzes theoretical approaches to achieving work-family balance. It explores various definitions of work-family balance, the sociological analysis of the balance between family and work, the impact of family and work characteristics on achieving balance between domains, theories, and hypotheses, as well as factors that determine ways to achieve balance. It also reviews global experiences in researching and implementing work-family balance policies. The conclusion provides suggestions and recommendations.

Keywords: family, work, balance, theoretical approaches, male, female, labor, gender, individual, factors.

Introduction

As the study of familial and professional responsibilities of men and women gained recognition in social sciences, various theories and approaches concerning work-life balance began to emerge. These developments were based on pre-existing theories in sociology, which directed their focus and methods towards a new research subject. Approaches to studying work-life balance, such as role theory, conflict theory, human capital theory, and demand-resource theory, among others, have gained prominence.

Before exploring the various sociological approaches to studying work-life balance issues, it is essential to consistently present two key definitions: "Work-life balance" itself and "Work-life balance policies." Achieving a balance between family and work is one of the significant issues in contemporary life. This matter has become particularly relevant as the interaction between work and personal life continues to increase.

Research Methodology

There are various definitions of work-family balance. Notably, researchers often describe it as the absence of conflict between work and family or the frequency of "interference" between these domains. J. Greenhaus, K. Collins, and J. Shaw define work-family balance as "the level of satisfaction individuals derive from both their work and family life"[1]. In more recent studies, J. Greenhaus and T. Allen describe work-family balance as "the alignment of individual effectiveness and satisfaction in both family and professional roles with personal life priorities"[2].

According to P. Voydanoff, "Work-family balance" is "the feeling that work resources align with family demands and family resources align with work demands, enabling an individual to be effective in both areas" [3].

As noted by G. Joseph, G. Grzywacz, and D. Carlson, the main issue with defining the category of "family and work balance" from the perspective of satisfaction is that it separates individuals and their work and family activities from the organizations and families where these activities take place [4]. The definitions of work-family balance policies focus on the environments in which individuals operate, emphasizing the need to create conditions necessary for achieving balance between these domains.

J.V. Chernova, E.Yu. Rozhdestvenskaya, and Jane Lewis write: "Work-family balance policies provide institutional support that enables working adults to optimally combine professional, family, and parental responsibilities. The aim of such policies is to create the most favorable conditions for working adults to harmonize the key aspects of their lives. Achieving balance between work and family is viewed as finding compromise between the professional and personal interests of adult family members and children, ultimately promoting the well-being of all family members in the broadest sense" [5].

Additionally, the literature describes work-family balance policies as practices implemented by organizations and workplaces aimed at supporting the needs of employees with family obligations who seek balance between work and family domains [6].

Analysis and Results

When discussing the sociological analysis of work-family balance, it is important to note that there are two contrasting traditions in studying the influence of family and professional factors on establishing this balance. The chosen tradition ultimately determines the subsequent direction of the research, its hypotheses, and the interpretation of the obtained results. It is generally accepted that an individual's family and professional characteristics (for example, the number of children in the family or the length of the workday) affect their ability to perform roles effectively in different areas of activity. The difference in scientific traditions lies in whether family and professional characteristics should be viewed as phenomena of the same order, without emphasizing their individual impact on the balance, or whether each of them should be studied separately, necessitating an independent analysis of their effects.

Some researchers argue that the impact of family and work characteristics on achieving balance between domains should be studied as a whole, as they are inherently inseparable [7]. This approach is based on the idea that every individual has the same amount of time available for fulfilling both family and professional functions. Each function demands time, so it does not matter whether the individual performs family or professional tasks, as the same time resource is being used-time spent on one set of tasks cannot be used for another. The fulfillment of both roles collectively influences the ability to achieve balance. Therefore, balance can be achieved by coordinating the demands of both domains and aligning their time requirements.

Others, however, emphasize that professional and family characteristics have different impacts and should be studied as separate and independent phenomena. Advocates of this perspective also note that the conflict between work and family is expressed when professional roles interfere with a person's ability to fulfill family roles. Conversely, conflict between family and work arises when family roles interfere with fulfilling professional roles. Additionally, different directions of conflict lead to different outcomes [8].

The primary basis for the argument put forth by proponents of this approach is that family and professional characteristics may have different effects on achieving balance between domains for men and women. For men, the main factor determining balance between domains is professional characteristics, while for women, it is family characteristics [9].

Another foundation for developing theories and hypotheses in the study of workfamily balance is role theory. In research approaches based on role theory, there are opposing views on the impact of role integration on achieving balance. This is based on the idea that individuals who combine family and professional responsibilities have more social roles compared to those whose responsibilities are concentrated in only one domain. Consequently, two approaches have emerged for studying the effects of multiple professional and family roles: the role accumulation approach and the role conflict approach. Traditionally, these can be described as positive and negative, respectively.

The positive approach focuses on the benefits individuals gain from integrating multiple roles. These roles can influence the balance between work and family. This approach is based on the idea that engaging in multiple social roles allows individuals to accumulate human and social capital, gain experience, knowledge, skills, and access to both material and non-material resources. Roles accumulate and enable individuals to use skills and experiences gained at work to perform family roles more effectively and vice versa; skills acquired in family life can contribute to greater success in

professional domains. Thus, the positive approach emphasizes the qualitative aspects of work and family that can reduce conflicts between these domains [10].

Conversely, the negative approach focuses on the adverse effects of integrating multiple family and professional roles. The demands of family and professional roles regularly or occasionally conflict with each other, leading to role conflict and tension. The inability to fulfill all assigned roles tends to accumulate, causing persistent role strain, which ultimately lowers the overall level of work-family balance and creates a sense of imbalance in life. Proponents of this perspective focus primarily on the time spent by an individual fulfilling a particular role and the flexibility of that role-how much a person can adjust their roles in terms of time and space.

A significant body of sociological research is dedicated to the impact of job characteristics on the ability to harmonize family and professional responsibilities. Within this framework, the "Job Demands and Resources" and "Job Demands-Control" approaches have been developed [11].

According to these approaches, paid work not only demands that individuals perform professional functions, requiring them to invest time, energy, and other resources, but it also provides resources (control) that can be used to perform assigned tasks more effectively. The balance between job demands and resources largely determines an individual's ability to fulfill both family and professional roles. From the perspective of harmonizing work and family, resources can act as equalizers, reducing imbalances between domains and even helping to establish balance.

For example, a resource like a high income may reduce conflicts between domains by outsourcing certain household tasks to market professionals. Typically, the more complex the job, the more it demands and provides resources. High-skilled jobs that positively impact balance often involve high levels of control over work time, the ability to plan workdays, set initial schedules, delegate tasks within a team, and so forth.

However, in most cases, such resources are not sufficient to correct imbalances. Most researchers agree that high-skilled jobs and leadership positions often intensify conflicts between domains. One of the main factors in this scenario is that people engaged in such activities tend to work longer hours than others and have "permeable" boundaries between work and family life: they frequently bring work home, remain mentally occupied with work issues, and are not fully engaged in household tasks and family matters [12].

Job demands can be categorized into those that require significant time (time-based) and those that, due to job intensity, demand considerable physical and emotional energy (strain-based). Working beyond regular hours, unexpected calls, and similar factors primarily impact time expenditure, while job complexity, poor psychological conditions, stress, and constant overload affect strain. Additionally, time conflicts can lead to strain conflicts. It has been found that if one spouse spends a significant amount of time at work, the amount of household tasks falling on the other spouse increases. Many researchers agree that, without downplaying the influence of other factors, the temporal aspects of work remain the most significant in affecting the establishment of balance between domains. Therefore, much of the current work-family balance policy focuses on regulating the time aspects of work [13].

Summarizing the findings of various authors, we recommend categorizing all factors that influence an individual's ability to achieve balance into three groups: 1) personal and family characteristics; 2) job characteristics; and 3) socio-cultural environment (see Figure 1).



Figure 1. Factors determining how balance can be achieved.

According to these groups, achieving a balance between work and parenting is determined by the actions within three processes: family (utilizing personal and family resources), corporation (creating favorable conditions and implementing specific measures), and the state (carrying out measures shaped by a combination of family policy and labor and employment policies).

The first group includes a set of factors associated with an individual's family characteristics, personal values, and ideas and attitudes toward the division of paid and unpaid labor between spouses. Additionally, factors like the number and age of children, spouses' attitudes toward paid and household work, and family characteristics such as childcare and upbringing influence the opportunities to find a balance between work and parenting.

Having children imposes additional responsibilities on spouses. This often restricts not only their ability to participate in paid activities but also transforms their daily routine, time structure, and lifestyle. The parent responsible for care plans their day based on the child's needs and interests. Parents face the most significant limitations

during the period when the child is entirely dependent on adults. At this stage, the demands on their time and efforts within the family increase severalfold. Therefore, families with young children need to harmonize work and parenting. This is particularly true for women, who, despite active participation in paid work, are still primarily responsible for childcare, household chores, and parental responsibilities in most countries. The birth of children often acts as a catalyst for the traditional model of labor division in the family.

All these factors limit women's opportunities to participate in paid labor and turn achieving a balance between family and work into a primary issue. Researchers have repeatedly noted that women's position in the labor market often deteriorates after the birth of a child. Women seek balance by adjusting their practices and adapting personally to objective conditions. This aligns with Russian researcher I.M. Kozina's conclusion that "having more children encourages fathers to engage in more work, while conversely, it 'removes' mothers from the labor market." [14] This can be explained by the fact that many women in Russia work full-time. Part-time work is rare but, along with flexible work schedules and benefits for employees with family responsibilities, provides a good opportunity for achieving work-family balance.

The second group of factors affecting balance establishment includes all workrelated dominants. These are primarily the characteristics of an individual's work, such as position, salary, time spent in paid activities, work schedule, ability to control the duration of work independently, characteristics of the work itself, autonomy, scheduling abilities, individual or team labor, psychological climate, corporate culture, and benefits provided to employees with family responsibilities. In other words, these are the overall demands and resources set and provided by one's work.

Global experience in researching and implementing work-family balance policies indicates that different aspects of combined activities significantly influence the potential for harmonious integration of these domains. This cumulative effect of characteristics is crucial, as some may positively impact balance, while others may negatively affect it or even have a dual impact depending on the circumstances.

At the employment level, various mechanisms exist for implementing family-work balance policies. These include mechanisms regulating the temporary and spatial aspects of work, mechanisms enhancing employee control over their time and duties, and other support forms for employees with family responsibilities, such as organizing childcare at the workplace, offering additional benefits, and providing leave. Measures regulating work hours focus on minimizing the time employees spend on professional activities. These measures are divided into those that reduce overall work hours and those that do not.

The main drawback of mechanisms that reduce total work hours is the inevitable proportional reduction in pay. Part-time work is typically less skilled, more routine, often individual, and may increase psychological stress while reducing control over working hours, which researchers link to increased inter-domain conflicts. Nevertheless, reduced work hours remain a primary mechanism for achieving family-work balance, benefiting both mothers and fathers by helping reduce conflicts for both partners.

Considering the drawbacks of short-term employment, mechanisms regulating the temporary aspect of paid work play a significant role in the system of aligning family and professional responsibilities. These mechanisms aim to minimize the time an employee cannot reconcile family and professional responsibilities.

All of these mechanisms can be unified under the concept of a "Flexible Work Organization System." This includes flexible schedules, telecommuting via phone or internet, task-focused control without tracking time spent on site, independent planning of the workday, and working at convenient times, with hours recorded monthly instead of daily. Flexible work organization enhances employees' control over their time, facilitating balance between family and work responsibilities.

Additionally, this system is economically beneficial for employers. Many European companies are transitioning from daily time tracking to monitoring the completion of assigned tasks within a specified timeframe. Studies on the impact of flexible work forms on work-family balance have shown a tendency toward gender equality. Women tend to use flexible work schedules to help balance responsibilities, though it may reduce income. Transitioning to part-time work has a positive influence on achieving balance for both genders, though this effect is more pronounced for women.

At the workplace level, the attitude of managers and colleagues towards employees with family responsibilities is essential. A positive attitude enhances an employee's ability to manage time and take advantage of available benefits. Balance cannot be achieved outside the established culture of family-friendly work organization.

The family-work culture system can be defined as the set of ideas, beliefs, and values created within an organization that supports employees in balancing work and family responsibilities. Supporting employees in balancing family and professional responsibilities has been found to alleviate conflict between these domains, reduce stress, enhance work engagement, increase job satisfaction, and make the search for balance easier.

The significance of work characteristics in role integration implies that "women facing specific family challenges show flexibility in choosing a workplace and, if necessary, change jobs to those with more suitable conditions. Work-life balance is becoming a more critical factor than salary in job selection."

The third group of factors defines the field of balance opportunities for individuals and includes the objective conditions and rules of gender-based interaction in paid and unpaid work, as well as cultural notions of male and female roles. State family policy is of particular importance, as it primarily establishes the institutional opportunities set for achieving harmonious integration of family and professional domains.

Government policy directly and indirectly impacts men's and women's participation in paid and unpaid labor. In countries where social policies support women's participation in paid work, more women work full-time. Additionally, women in these countries make significantly greater use of services designed to help balance family and work. Countries focused on gender equality and those that create institutional mechanisms to reconcile family and professional demands tend to experience lower levels of work-family conflict.

Evidence also shows that flexible, extended, and paid parental leave for both mothers and fathers positively affects the balance between work and parenting for both partners.

The availability of flexible conditions for leave—such as leave duration, eligibility criteria, and periods of leave—contributes significantly to a higher level of work-family balance.

The cultural norms and values related to gender equality in labor also play a substantial role in shaping the possibilities for integrating family and work responsibilities. Childcare services for children of various ages support parents by allowing them to allocate some of their caregiving duties to private or public agencies, freeing up time to balance work and parenting more effectively. This measure is especially impactful for mothers who are solely responsible for childcare.

When men share household and childcare responsibilities equally with women, it supports women in achieving balance and makes it easier for them to return to work after maternity leave. Promoting and normalizing the equal distribution of unpaid labor and encouraging fathers' involvement in parenting practices can be part of the state's family-work balance policy. Supporting employers who implement measures to improve employees' ability to harmonize work and parenting is also a critical aspect of government policy, which encourages the creation of positions that meet employees' family responsibilities.

Conclusions and Recommendations

Achieving a balance between family and work is a contemporary demand.

Theoretical approaches and practical recommendations on this topic include the following:

- Organizational Approaches: Listening and effective communication between family members and work teams help identify and adjust to needs.

- Time Management: Task planning, prioritizing essential duties and responsibilities for effective time management.

- Step-by-Step Implementation: Setting daily, weekly, and monthly goals, creating strategies to reach these goals.

- Psychological Approaches: Stress management through meditation, yoga, sports, and other methods, which support the psychological well-being of family members.

- Conflict Resolution in Family: Effectively managing conflicts, adapting, and finding compromises.

- Organizational and Company Policies: Hybrid work models in the workplace that emphasize family relationships and create favorable conditions for employees.

- Improvement of Work Performance: Implementing internal reforms in organizations concerning family matters.

In conclusion, achieving a balance between family and work requires effective approaches at both individual and group levels. Serious attention to family issues and enhancing flexibility in the workplace contribute to overall development.

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FACTORS DETERMINING THE PROCESSES OF LEGAL AWARENESS FORMATION AMONG YOUTH

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Annotatsiya. Yoshlarning huquqiy savodxonligini shakllantirish nafaqat ularning huquq va majburiyatlari haqidagi bilimlarini, balki oilaviy qoʻllab-quvvatlash, huquqiy ta'lim va raqamli resurslarga kirish imkoniyatlari kabi muhim omillarni ham hisobga olishni talab qiladi. Tadqiqotlar shuni ta'kidlaydiki, ijtimoiy va huquqiy masalalar muhokama qilinadigan oilaviy muhit yoshlarning huquqqa qiziqishi va huquqiy ongining rivojlanishiga hissa qoʻshadi. Raqamli makonda yoʻnalishni belgilash uchun tanqidiy fikrlash va media savodxonlik zarur, chunki u koʻpincha dezinformatsiya bilan toʻyingan. Davlat qoʻllab-quvvatlovi, ta'lim dasturlarini yaxshilash va moslashuvchan mehnat sharoitlarini oʻz ichiga olgan kompleks yondashuv yoshlarning huquqiy xabardorligini oshirish va ularni zamonaviy huquqiy chaqiriqlarga moslashtirish imkonini beradi.

Kalit soʻzlar: huquqiy savodxonlik, yoshlar, oila, ta'lim, media savodxonlik, tanqidiy fikrlash, davlat qoʻllab-quvvatlovi, dezinformatsiya, raqamli xavfsizlik, ijtimoiy mas'uliyat

Аннотация. Формирование правовой грамотности молодежи требует не только знаний о правах и обязанностях, но и учета ключевых факторов, таких как поддержка семьи, доступ к правовому образованию и цифровым подчеркивают, ресурсам. Исследования что семейная среда, гле обсуждаются социальные и правовые вопросы, способствует развитию у молодежи интереса к праву и правосознанию. Критическое мышление и медиаграмотность необходимы ориентирования цифровом для В пространстве, насыщенном дезинформацией. Комплексный подход, включающий государственную поддержку, улучшение образовательных гибкие условия труда, позволит укрепить программ И правовую осведомленность и адаптацию молодежи к современным правовым вызовам.

Ключевые слова: правовая грамотность, молодежь, семья, образование, медиаграмотность, критическое мышление, государственная поддержка, дезинформация, цифровая безопасность, социальная ответственность.

Abstract. Developing legal literacy among youth requires not only knowledge of rights and responsibilities but also consideration of key factors, such as family support, access to legal education, and digital resources. Research highlights that a family environment where social and legal issues are discussed contributes to young people's interest in law and legal awareness. Critical thinking and media literacy are essential for navigating the digital space, which is often saturated with

misinformation. A comprehensive approach, including government support, improved educational programs, and flexible work conditions, will strengthen youth's legal awareness and adaptability to modern legal challenges.

Keywords: legal literacy, youth, family, education, media literacy, critical thinking, government support, misinformation, digital security, social responsibility.

Introduction

In New Uzbekistan, significant attention is paid to the development of an active civil society composed of responsible, literate, and critically thinking citizens. Today, amidst the rapidly changing social and economic realities, legal literacy plays a crucial role in enabling individuals to confidently navigate the legal complexities of modern society. Legal literacy provides people with the ability to protect their rights, understand their responsibilities in various life situations, and develop confidence in safeguarding their interests and making critical legal decisions.

Building a rule-of-law state requires the formation of an active civil society. This goal can only be achieved through fostering sustainable legal literacy among the youth, which is based not only on understanding their fundamental rights and responsibilities but also on nurturing a generation capable of consciously participating in public life, upholding the rule of law, and responding appropriately to various threats [1].

This is especially relevant for the youth living in an era of digitization and globalization. Legal literacy becomes a vital tool for protecting their civil rights since digital interactions are associated with various risks, such as cyber threats and the spread of misinformation. In the age of expanding information spaces and digitization, the youth must possess legal knowledge to recognize the risks and opportunities they may encounter while interacting on the internet and social media platforms.

Literature Review

The study of legal literacy formation begins with the foundational works of Rudolf von Jhering. In his book *"The Struggle for Law"*, he emphasizes that every citizen must actively participate in and protect legal culture. According to Jhering, understanding the law and striving to uphold it is the foundation of public order and individual legal consciousness [2]. This awareness is particularly vital for youth in modern realities.

Hans Kelsen, the founder of the "Pure Theory of Law," argued that it is essential to establish a foundation for legal literacy based on knowledge of legal norms and their hierarchical structure [3]. In his view, young people should perceive the legal system as a logically structured chain of legal documents rooted in specific norms, which they study and base their lives upon.

The concept of legal culture, grounded in the principles of solidarity and respect for social obligations, was proposed by Léon Duguit [4]. Duguit believed that by fostering respect for legal culture in society, particularly among the youth, we can instill a sense of social responsibility and the understanding that the law is not merely a punitive tool but an essential means of ensuring societal welfare.

Eugen Ehrlich, regarded as the founder of sociological jurisprudence, asserted that youth should view legal literacy not only as knowledge of legal norms and laws but also as an understanding of the social significance and role of law in daily life [5]. He



argued that young people must grasp how the law influences real-life circumstances and social relationships, enabling them to adapt to the ever-changing social environment and understand the importance of maintaining social justice in society.

Research Methodology

This research involved reviewing various studies that examined predictors for enhancing legal literacy among youth. The methods used included content analysis, comparative analysis, and theoretical analysis (the theory of social learning).

Analysis and Results

The study of factors influencing legal literacy formation among youth highlights the crucial role of quality legal education supported by families and access to reliable online resources.

Families that actively discuss social, legal, and political changes and reforms are more likely to instill an understanding and interest in legal rights and responsibilities in their children. Research has shown that such families significantly influence the level of legal literacy among their children.

Youth raised in families where relatives and acquaintances actively engage in discussions about new legal norms and social debates tend to show greater interest in legal knowledge and have a better understanding of their rights and responsibilities [6]. This can be theoretically explained through the social learning theory, where children acquire new skills and knowledge by observing and interacting with their surrounding society. In the future, this positive upbringing manifests in actions based on legal norms and a conscious attitude toward rights and responsibilities.

According to scholars studying the impact of legal upbringing on youth legal literacy, positive results are achieved when parents' involvement continues beyond the home and extends to their participation in children's education at schools.

They argue that programs targeting both parents and teenagers create a sustainable foundation for legal literacy, fostering respect for law and public values while nurturing responsible citizens among the younger generation [7].

This theory was confirmed by research conducted in the U.S. on the Youth.gov platform, created by the U.S. government to provide resources and guidance for supporting youth development. Findings indicated that the more parents and close relatives are involved in their children's legal and civic education, the more positive results were observed in teenagers' civic engagement and social responsibility [8].

In our view, this approach to fostering legal literacy among youth, which relies not only on knowledge taught during school, college, or university legal courses but also on family support and positive family examples, will equip young people with critical thinking skills and enable them to navigate legal issues confidently. It will also positively correlate with their active participation in public life.

In addition to the family's influence on youth legal literacy, the study examined the impact of social media and the internet on how young people perceive legal norms and respect the law. Research conducted by T. Krasilnikova et al. analyzed the influence of social and technological changes on legal literacy. The scholars emphasized how media and the internet shape youth attitudes toward laws and regulations. They noted

that legal information encountered online and on social media is often unreliable, leading to distorted perceptions of law.

Furthermore, open access to social media and modern technologies creates new challenges related to privacy and copyright protection. The authors stressed that without critical thinking skills, young people might become victims of misinformation, negatively affecting their legal literacy [9].

In this context, it is essential to develop critical thinking and media literacy skills among youth. Such knowledge will help the younger generation critically assess the legal information they encounter online and distinguish between reliable and unreliable sources.

The perception of legal norms by youth through the lenses of gender aspects and cultural traditions was extensively explored in research by Smith and Davis. The authors highlighted the apparent connection between legal norms and cultural beliefs and customs. They argued that this is especially evident in patriarchal societies where women's rights and traditional roles are restricted by social and legal frameworks. Cultural traditions in these societies support gender inequality, limiting women's rights and access to legal tools. This creates a negative perception among youth about women's roles and places in the legal system, influencing their legal identity [10].

Research by F. Radey pointed out that the clash between religious and cultural autonomy and gender equality is a widespread challenge in ensuring fundamental constitutional rights and enhancing young women's legal literacy. According to her, achieving the best outcomes requires considering the interplay between cultural traditions and access to legal information, particularly concerning gender equality [11].

Thus, it can be concluded that gender identity and cultural norms directly affect legal literacy and awareness, creating barriers to equal access to rights and freedoms. Women are particularly adversely affected by these challenges.

Conclusions

Based on the research, successfully enhancing youth legal literacy in the modern world requires an ecosystem approach, taking into account the role of family, education systems, and state support while balancing gender equality with cultural values.

In this context, the following recommendations are proposed:

1. Strengthening family-based legal education by developing programs that educate parents on the basics of legal education and organizing joint educational activities with parents in schools and other institutions to promote legal literacy among youth.

2. Developing educational materials on safe online behavior and data protection and integrating media literacy and critical thinking courses into school and university curricula to mitigate cyber threats, youth rights violations, and skills for recognizing reliable sources of information from disinformation.

3. Creating inclusive educational programs that consider cultural and religious specifics, based on respect for local traditions, illustrating the necessity of equality before the law and access to rights for everyone, regardless of gender. These programs should employ adaptive teaching methods that emphasize the universality of human rights.



By addressing these factors, not only can we better understand the processes of forming legal literacy among youth, but we can also identify directions for fostering sustainable legal awareness and literacy skills in the face of various contemporary challenges.

In summary, it can be concluded that fostering legal literacy among youth requires consideration of a wide range of factors, such as family upbringing, social media, modern technologies, and the cultural and religious foundations of society.

The research indicates that the quality of legal education directly depends on family support and close social circles. Families and relatives who are actively engaged in discussions about legal and social issues help cultivate a natural interest in legal norms and the foundations of legal consciousness among young people. Moreover, family and community support in the educational processes of schools and higher education institutions contribute to creating a solid foundation of legal knowledge and skills for the youth while fostering respect for the law and societal values.

In today's world, with the growing popularity of social media and internet communication among youth, it is crucial for them to develop the skills and knowledge required for critically evaluating the information they encounter. Access to legal information is often accompanied by the risk of misinformation and unreliable sources. Thus, media literacy, critical thinking skills, and the ability to analyze information are essential to help young people navigate the legal landscape effectively and become responsible citizens.

Additionally, the cultural and religious characteristics of a society should not hinder gender equality or the assurance of women's rights. International standards must play a key role in supporting women's rights to legal literacy. However, this process should respect the cultural autonomy of communities. Striking a balance between universal human rights and cultural specificities is essential. Such an approach will not only enhance the legal literacy of young people but also facilitate the smoother integration of international standards into local communities.

Understanding these factors will not only provide a deeper insight into the processes of shaping legal literacy among youth but also highlight pathways for developing sustainable legal awareness and knowledge skills amidst various contemporary challenges.

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MODERN PROBLEMS OF PEDAGOGY AND PSYCHOLOGY

UDC: 37, 376, 378 TRENDS IN THE DEVELOPMENT OF THE TUTORING INSTITUTE IN UZBEKISTAN

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Annotatsiya. Ushbu maqolada Oʻzbekistonda tyutorlik instituti rivojlanish tendensiyalari koʻrib chiqilgan boʻlib, uning ta'lim jarayonidagi oʻrni hamda zamonaviy texnologiyalarni joriy etish bilan bogʻliq oʻzgarishlar ta'kidlanadi. Tadqiqot usullari ilmiy adabiyotlar, xalqaro tajriba va statistik ma'lumotlarni tahlil qilishni oʻz ichiga oladi va milliy xususiyatlarni hisobga olgan holda tyutorlik tizimini rivojlantirish imkoniyatlarini taqdim etadi. Shuningdek, maqolada tyutorlarning kasbiy rivojlanish dasturlaridagi yutuqlar, raqamli yondashuvlarni joriy etish va Oʻzbekistonda inklyuziv ta'limni rivojlantirish haqida soʻz yuritiladi.

Kalit soʻzlar: tyutorlik, ta'lim jarayoni, rivojlanish tendensiyalari, pedagogik yondashuvlar, xalqaro tajriba, raqamli texnologiyalar, inklyuziv ta'lim, kasbiy rivojlanish, milliy xususiyatlar.

Аннотация. В статье рассматриваются тенденции развития института тьюторства в Узбекистане, подчёркивается его роль в образовательном процессе, а также изменения, связанные с внедрением современных технологий. Методы исследования включают анализ научной литературы, международного опыта и статистических данных, представляя возможности для развития системы тьюторства с учётом национальных особенностей. Кроме статье описывается прогресс программах того. В В профессионального развития тьюторов, внедрение цифровых подходов и продвижение инклюзивного образования в Узбекистане.

Ключевые слова: тьюторство, образовательный процесс, тенденции развития, педагогические подходы, международный опыт, цифровые технологии, инклюзивное образование, профессиональное развитие, национальные особенности.

Abstract. This article examines the trends in the development of the tutoring institute in Uzbekistan, highlighting its role in the educational process as well as changes associated with the implementation of modern technologies. Research methods include the analysis of scientific literature, international experience, and statistical data, presenting opportunities for the development of the tutoring system with consideration for national specifics. Additionally, the article outlines the progress in the professional development programs for tutors, the adoption of digital approaches, and the advancement of inclusive education in Uzbekistan.



Keywords: tutoring, educational process, development trends, pedagogical approaches, international experience, digital technologies, inclusive education, professional development, national specifics.

Introduction

In recent years, the Republic of Uzbekistan, under the leadership of President Shavkat Mirziyoyev, has initiated significant reforms in the education sector. Among these transformative measures is the introduction of the tutor position within higher education institutions, a step aimed at cultivating students' ability to acquire knowledge and develop skills independently. During his 2021 address to the Oliy Majlis (Parliament), President Mirziyoyev underscored the critical importance of improving the quality of education through tailored approaches that cater to individual students. He advocated for strengthening tutoring services and emphasized the need to establish supportive conditions to facilitate this initiative. This strategy is pivotal in providing personalized assistance to students, thereby fostering their academic and personal growth as well as enhancing their overall success [1].

The enactment of Presidential Decree \mathbb{N} PQ-4391, dated July 11, 2019, institutionalized the role of tutors across all higher education institutions. The decree mandates that tutors focus on improving educational outcomes, offering individualized guidance, encouraging students' potential, and promoting independent thought. Over time, this decree has played a central role in advancing tutoring practices within Uzbekistan's educational framework. Its progressive implementation reflects a continued commitment to refining the role of tutors and enhancing the overall educational experience [2].

Literature Review

The role of tutoring has increasingly been recognized as a cornerstone of effective education systems worldwide. In countries like the United Kingdom and the United States, tutoring is an established practice, integral to fostering personalized learning experiences. In the UK, for example, university-based tutoring programs not only assist students in achieving academic success but also support their personal and professional development. Research highlights that tutors provide tailored guidance and foster individualized learning environments, enabling students to thrive academically while also cultivating essential life skills [3].

In Uzbekistan, tutoring as an educational practice is still in its formative stages but has shown rapid progress due to strong governmental support and the integration of international best practices. Drawing inspiration from global models, including those implemented in Russia, Uzbekistan is actively developing its tutoring framework. These efforts include creating specialized training courses and structured programs aimed at ensuring the effective application of tutoring practices. Such initiatives seek to empower students by enhancing their individual capacities and aligning the tutoring process with global educational standards [4].

Research Methodology

This article was prepared through a comprehensive analysis of scientific literature, international practices, and relevant statistical data. The research methodology

involved a systematic examination of the evolution of tutoring systems, with particular attention to their development in both national and international contexts. Additionally, the study evaluated the effectiveness of newly emerging teaching methods, drawing insights from comparative analyses to identify best practices and their applicability within Uzbekistan's educational framework.

Analysis and Results

Factors Influencing the Development of Tutoring in Uzbekistan. A range of strategic decisions initiated by President Shavkat Mirziyoyev has played a crucial role in fostering the development of tutoring and enhancing the overall quality of education in Uzbekistan. Among these initiatives, Presidential Decree № PQ-5001, issued on July 5, 2022, stands out as a transformative measure. This decree underscores the integration of advanced technologies into the educational process, enabling tutors to leverage modern tools for managing and enriching the learning environment [5].

President Mirziyoyev has consistently emphasized the state's commitment to unlocking the potential of every young individual within the education system. As he stated, "Today, one of the primary duties of our state is to fully realize the potential of every young person in the educational process and to support them" [6]. This vision extends beyond academics, advocating for a more holistic approach to student development. The President highlights the need for tutors to play a pivotal role not only in fostering academic success but also in providing essential social and psychological support. By guiding students in discovering and pursuing their unique paths, tutors contribute significantly to their personal and professional growth.

International Experience and National Specificity. International practices demonstrate that developed countries have successfully implemented systematic frameworks to provide personalized support and assistance to students. In the United States, for instance, specialized tutoring programs focus on delivering education tailored to the unique needs and abilities of each student. These programs emphasize individualized learning strategies, ensuring that students receive support aligned with their specific academic and personal development goals.

Adopting such practices in Uzbekistan presents a valuable opportunity to enhance the effectiveness of its education system. By integrating personalized approaches into the tutoring process, the country can address the diverse needs of students while fostering a more adaptive and inclusive learning environment [7].

Tutoring and Modern Technologies. The rapid shift to remote education, driven by the COVID-19 pandemic, has significantly broadened the scope and impact of tutoring through the integration of modern technologies. Platforms such as Zoom, Microsoft Teams, and Google Classroom have revolutionized the way tutors deliver support, offering flexible and efficient solutions. These technologies have not only made learning more accessible but have also leveled the playing field for students in remote or underserved areas. By harnessing digital tools, tutors can enhance the effectiveness of distance learning, fostering a more inclusive and engaging educational environment [8].

Digital education technologies provide a range of transformative opportunities, including:

1.*Interactive and Collaborative Learning.* Digital platforms create dynamic learning environments where students can actively participate in discussions, collaborate on group projects, and express ideas freely. Tools like Google Jamboard and Miro function as interactive whiteboards, encouraging teamwork and enabling students to co-create solutions, resulting in deeper engagement and more meaningful outcomes.

2. Enhanced Transparency and Accountability. Remote learning platforms maintain detailed records of tutors' activities, lesson materials, and student progress, ensuring transparency throughout the educational process. Tools like Google Classroom and Moodle allow both students and tutors to monitor performance, identify areas for growth, and maintain accountability, ultimately boosting the overall effectiveness of the learning experience.

3. *Mobile Accessibility for Remote Learning*. The mobile compatibility of platforms such as Microsoft Teams and Zoom ensures that students can access learning resources and participate in sessions anytime, anywhere. This feature is particularly impactful for students in rural or remote areas, providing equal learning opportunities regardless of geographical constraints.

4. *Data-Driven Personalized Learning*. Digital platforms offer advanced analytics to assess student performance and learning patterns. Tutors can leverage these insights to design personalized strategies, addressing each student's strengths and areas of improvement. This targeted approach helps maximize learning outcomes and nurtures individual growth.

5. *Automated Assessment and Feedback*. Automated tools on platforms like Quizlet and Kahoot streamline the evaluation process, allowing tutors to efficiently monitor student progress and provide instant feedback. These tools empower students to independently assess their understanding, making the learning process more interactive and self-directed.

6. *Engaging Multimedia and Interactive Resources*. Modern technologies enrich the educational experience through diverse multimedia resources, including video lessons, presentations, interactive games, and simulations. These tools enhance comprehension, improve retention, and make learning enjoyable, fostering a deeper connection between students and the material.

7. *Virtual Labs and Simulated Environments*. For students in technical or scientific disciplines, virtual labs and simulations offer invaluable opportunities for hands-on practice. Platforms like Labster provide realistic, controlled environments for conducting experiments, allowing students to build practical skills and deepen their technical knowledge safely [9].

By incorporating these technological advancements into tutoring, the educational process becomes more dynamic, accessible, and effective. Modern technologies not only address the challenges of distance learning but also elevate the overall learning experience, equipping students with the tools and skills they need to succeed in an increasingly digital world.

Future Directions for the Development of Remote Tutoring. The remote tutoring system, which proved its value during the pandemic, continues to present significant opportunities for growth and innovation. To unlock its full potential, several key areas

require strategic focus and development. One essential aspect is the enhancement of digital pedagogy and teaching methods. Tutors need to be equipped with the skills to navigate virtual environments effectively, and this can be achieved through specialized training programs and workshops. By improving their proficiency with online tools and methodologies, tutors will be better prepared to provide personalized guidance and support. These initiatives will enable them to tailor their teaching strategies to meet the unique needs of each student, thereby fostering a more responsive and dynamic learning environment [10].

The adoption of cutting-edge technologies, such as artificial intelligence (AI) and machine learning, represents another critical area of advancement. These technologies have the potential to revolutionize the delivery of education by automating the analysis of student performance, identifying learning gaps, and offering tailored recommendations. AI-driven personalization can significantly enhance the effectiveness of remote tutoring, creating an engaging and impactful learning experience. By leveraging these tools, tutors can provide individualized support that adapts to the evolving needs of their students, ensuring better educational outcomes and fostering a deeper connection to the material [11].

Inclusivity and equal access to education are fundamental principles that must be integrated into the development of remote tutoring platforms. These platforms should be designed to accommodate diverse learners, including those with disabilities. Technologies such as speech-to-text tools, screen readers, and adaptive learning resources play a vital role in making education accessible to all students. By addressing the varied needs of learners, inclusive platforms can help bridge educational disparities and ensure that every student has access to quality education, regardless of their physical or cognitive abilities. Such efforts are critical for creating a more equitable and inclusive education system that leaves no one behind [11].

Investing in infrastructure and platform development is also essential for sustaining and expanding remote tutoring. Financial resources must be allocated to develop robust local digital platforms that offer high-quality, affordable tools for both students and tutors. Enhancing infrastructure, such as improving internet connectivity and ensuring the availability of reliable digital resources, is particularly important for reaching underserved regions. By addressing these logistical challenges, remote education can become more accessible and equitable, allowing students in all areas to benefit from high-quality learning opportunities [12].

Focusing on these strategic priorities—enhancing digital pedagogy, adopting innovative technologies, fostering inclusivity, and investing in infrastructure—will enable remote tutoring to evolve into a transformative educational model. These advancements promise a future where learning is not only effective and personalized but also universally accessible, irrespective of geographic or socioeconomic barriers. By embracing this vision of inclusive and innovative education, remote tutoring has the potential to redefine how knowledge is delivered and experienced on a global scale, paving the way for a more equitable and connected world of learning.

Developing and Enhancing Tutors in Uzbekistan. Improving the qualifications of tutors has become a cornerstone of efforts to enhance the quality of education in Uzbekistan. Guided by the educational reforms introduced by President Shavkat
Mirziyoyev, various specialized programs, workshops, and training initiatives have been launched. These efforts aim to equip tutors with contemporary pedagogical, psychological, and technological skills. By continuously updating their expertise, tutors are better positioned to provide tailored support to students, fostering more effective and personalized learning experiences [13].

effective and personalized learning experiences [13]. *Psychological Preparedness and Personal Development*. Training in psychological preparedness is a key component of tutor development. Workshops focus on building empathy, active listening, and problem-solving skills, enabling tutors to engage more deeply with students on an individual level. These sessions help tutors better understand students' academic and personal challenges, allowing them to offer meaningful and practical guidance that promotes holistic development.

Methodological and Didactic Preparedness. To ensure effective teaching, tutors are trained to adapt educational materials to meet the diverse needs of their students. Courses emphasize the use of innovative teaching strategies, techniques for simplifying complex concepts, and the incorporation of modern instructional tools. This approach enhances tutors' ability to deliver engaging and accessible lessons that improve students' understanding and academic outcomes.

Digital Competency Development. As digital tools become increasingly vital in education, tutors are provided with specialized training in using platforms like Zoom, Microsoft Teams, and Moodle. These programs focus on developing digital literacy and the ability to design and deliver online content that meets the unique needs of individual students. Strengthening these skills ensures that tutors can effectively support students, including those in remote or underserved areas, making education more equitable and inclusive.

Adoption of International Best Practices. Collaboration with global organizations, such as UNESCO and UNICEF, has enabled tutors in Uzbekistan to learn from international expertise. Workshops and training sessions organized with these institutions introduce tutors to globally recognized teaching methodologies, fostering a modern and dynamic approach to education. By integrating these practices, tutors can enhance their teaching strategies and align with global educational standards.

Leadership and Communication Skills. Beyond academic instruction, tutors are encouraged to serve as mentors and role models for their students. Training sessions are designed to develop strong communication, leadership, and decision-making skills. These competencies enable tutors to guide students not only in their studies but also in their personal growth, empowering them to navigate academic and life challenges successfully.

New Initiatives and Projects in Tutoring Development in Uzbekistan. To further advance the role of tutoring in Uzbekistan's education system, several innovative projects and programs have been introduced. Among these, the "For the New Generation" initiative has emerged as a transformative effort to provide equitable educational opportunities, particularly for students in remote areas. This program leverages modern technologies to enhance the effectiveness of tutoring, equipping tutors with essential tools such as tablets, laptops, and reliable internet access. Advanced digital platforms integrated with artificial intelligence are also being introduced, enabling automated assessment of student progress and tailored

recommendations for learning materials. These innovations aim to make distance learning more effective and accessible, bridging the gap between urban and rural education.

Another significant component of these reforms is the promotion of open access to educational resources through online platforms. Massive Open Online Courses (MOOCs) now allow students and teachers to explore additional knowledge in their areas of interest. These resources, often available free of charge or at minimal cost, play a crucial role in fostering equal opportunities for competitive education. They ensure that students from even the most remote areas can access high-quality learning content, empowering them to pursue personal and academic growth on par with their peers in more developed regions.

The professional development of tutors has also been prioritized through extensive training programs, seminars, and international collaborations. Partnerships with organizations such as UNESCO and UNICEF have facilitated the introduction of advanced competencies in digital pedagogy, psychological support, and innovative teaching methodologies. By participating in these programs, tutors gain the skills needed to address diverse student needs effectively. This emphasis on professional growth not only enhances the quality of education but also equips tutors to guide students in overcoming academic and personal challenges [15].

In addition to these initiatives, the establishment of national tutoring standards has laid a strong foundation for quality assurance in the education system. These standards outline the core principles and requirements for tutoring practices, ensuring consistency and efficiency across institutions. Aligned with international best practices, they provide a framework for evaluating tutors' knowledge and skills, fostering an environment of continuous improvement. Furthermore, the introduction of a student advisory system has added a new dimension to tutoring. Advisory tutors now play a vital role in supporting students' personal and academic development by offering career guidance, identifying individual talents, and addressing social challenges. This system helps students adapt to academic life while fostering a supportive and secure learning atmosphere [14].

To further expand access to tutoring, online consultation centers have been established across Uzbekistan. These centers allow students to seek guidance remotely, ask questions, and receive personalized assistance on challenging topics. By maintaining continuous communication, tutors can significantly enhance the effectiveness of the learning process, ensuring that students receive timely and relevant support. Additionally, the introduction of an innovative mentor-tutor program has paired experienced educators with new tutors, fostering a culture of mentorship. This approach helps novice tutors refine their skills under the guidance of seasoned professionals, ensuring a smooth transition into their roles.

International collaboration has been another key focus area. By partnering with leading global institutions, tutors in Uzbekistan have gained access to advanced teaching methods and cutting-edge technologies. These partnerships have enabled them to participate in international training programs and exchange initiatives, empowering them to adopt globally recognized practices and integrate them into their work. These experiences have strengthened Uzbekistan's education system, aligning it with global standards and fostering innovation.

The cumulative impact of these initiatives is expected to transform Uzbekistan's tutoring landscape. By integrating modern technologies, fostering personalized learning, and promoting inclusivity, the country is bridging educational gaps and empowering tutors to support students more effectively. These efforts aim to unlock the full academic and creative potential of students while creating an education system that is competitive on a global scale. As Uzbekistan continues to implement these reforms, it is paving the way for a more modern, inclusive, and equitable learning environment that meets the evolving needs of its society [13].

Conclusions

The development of the tutoring system in Uzbekistan marks a transformative step toward modernizing the national education framework. This progress is not only elevating the quality of education but also fostering individualized support for every student. Current reforms and presidential decrees have established a robust foundation for enhancing tutoring practices, aligning them with international standards, and adapting them to meet contemporary educational needs.

One significant outcome of these efforts is the introduction of specialized training courses for tutors across higher education institutions. These programs have expanded opportunities for tutors to refine their pedagogical and methodological expertise, explore international practices, and better understand student needs. By incorporating modern educational tools and interactive methods, these training initiatives equip tutors with the skills necessary for effective tutoring, contributing to a more adaptive and responsive education system.

The integration of digital technologies into tutoring activities has emerged as another key advancement. Platforms like Zoom, Microsoft Teams, and Google Classroom have proven indispensable for remote teaching, facilitating personalized instruction and expanding access to quality education. The pandemic highlighted the critical role of digital tools in ensuring equitable learning opportunities, and their continued use is vital for creating a more inclusive and accessible educational environment.

Adapting international experiences to Uzbekistan's context has also been a pivotal aspect of these reforms. Practices from countries such as the United Kingdom, the United States, and Russia provide valuable insights for enhancing tutoring systems. By tailoring these international strategies to national needs, Uzbekistan is introducing innovative approaches that boost efficiency and enrich the quality of education, positioning the system to meet global standards.

Psychological and pedagogical training for tutors has further strengthened their ability to address the individual needs of students. These programs emphasize the importance of empathy, effective communication, and adaptive teaching strategies. By equipping tutors with these essential skills, Uzbekistan is fostering a system where tutors play a central role in students' personal and academic development, guiding them in overcoming challenges and achieving their goals.

The emphasis on creating equal opportunities in education reflects a commitment to inclusivity. By leveraging digital technologies and remote learning platforms, the

tutoring system ensures access to quality education for students in remote areas. Additionally, innovative approaches such as fostering inclusive education for students with disabilities demonstrate a forward-thinking effort to address diverse learning needs and provide equitable opportunities for all.

Government support has been instrumental in advancing these initiatives. Backing from the state has facilitated training programs and professional development for tutors, enabling them to adopt modern teaching methods and integrate international practices effectively. These government-driven efforts have created the conditions necessary for tutors' professional growth, ensuring they are well-prepared to meet the demands of a dynamic and evolving education system.

In summary, Uzbekistan's commitment to developing its tutoring system is reshaping the education landscape. By prioritizing individualized support, integrating digital technologies, adapting international practices, and fostering inclusivity, the country is building a competitive and innovative education model. These efforts not only address current challenges but also position Uzbekistan's education system as a forward-looking and globally aligned framework capable of meeting the needs of future generations.

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UDK: 378, 519.2, 004.42 CONCERNING THE IDEAL MATHEMATICS COURSE FOR STUDENTS WHO DO NOT MAJOR IN MATHEMATICS AND PHYSICS.

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Annotatsiya. Tadqiqot ishimizda biz matematika oʻqitishning amaliy va ixtisoslashgan hamda texnika yoʻnalishi talabalari uchun, amalga oshirishning alohida yoʻllarini aniqlangan. Amaliy mazmun bilan masalalarni yechishni oʻrgatish, kontekstli yondashuv, mazmun tanlashda turli yondashuvlarni taqdim jamiyatni axborotlashtirish sharoitida matematikani etdik. Biroq, fanlar bilan uzviy bogʻlash uchun ixtisoslashtirilgan ushbu sohalar tushunchalarini taqqoslash va sintez boʻlgan umumiy ilmiy tilni ishlab chiqish imkonini beradigan yagona kontseptual sxemani shakllantirish kerak. Bizning fikrimizcha, eng samaralisi talabalarning matematik tayyorgarligining profili va amaliy yoʻnalishini matematik modellashtirish usuli bilan bogʻlashdir.

Kalit soʻzlar: kontekst, axborot, sxema, kontseptual, modellash, komplement, ixtisoslash, tadqiqot, amaliy va nazariy, uzviy bogʻlanish.

Аннотация. В нашей исследовательской работе мы определили особые пути реализации математического образования студентов практических и специально-технических направлений. представили Мы различные подходы к обучению решению задач с практическим содержанием, контекстным подходом, выбором содержания. Однако для того, чтобы связать математику со специальными науками в условиях информатизации общества, необходимо сформировать единую концептуальную схему, позволяющую выработать единый научный язык, представляющий собой синтез и сопоставление понятий этих областей. На наш взгляд, наиболее эффективным способом является соединение профиля и практического направления математической подготовки студентов методом с математического моделирования.



Ключевые слова: контекст, информация, схема, концептуальное, моделирование, дополнение, специализация, исследование, практическое и теоретическое, органическая связь.

Abstract. In our research work, we have identified special ways to implement mathematical education for students in practical and special technical areas. We presented various approaches to teaching problem solving with practical content, contextual approach, and choice of content. However, in order to connect mathematics with special sciences in the context of informatization of society, it is necessary to form a unified conceptual scheme that makes it possible to develop a single scientific language, which is a synthesis and comparison of the concepts of these areas. In our opinion, the most effective way is to combine the profile and practical direction of mathematical training of students with the method of mathematical modeling.

Keywords: context, information, scheme, conceptual, modeling, complement, specialization, research, practical and theoretical, organic connection.

Introduction

The current stage of society's development is aimed at the continuous improvement of comprehensive, general and professional competence, and requires the training of a person capable of independent work, able to act and make decisions in conditions of uncertainty. Taking into account that today mathematics penetrates more and more deeply into all fields of science and technology, we can say that the level of professional qualification of future specialists also depends on the level of knowledge of mathematics. In this regard, the demands placed on the quality of mathematical education of students, and therefore on the level of mathematical knowledge of school graduates, are increasing. In modern pedagogy, one of the important factors of increasing the quality and fundamentality of education is specialized education, because it is a means of guiding the implementation of the activity of a high school student, propaedeutic function, and introducing schoolchildren to knowledge. At the same time, it allows to master the school stage of learning pre-professional skills and qualifications in some subjects that should be studied at school in technical fields in higher education [1].

Literature Review

Currently, there are profiles in which mathematics is studied at the basic or specialized level in secondary school. Differences in the mathematical preparation of students of different profiles are determined attitude to mathematics as a tool for future professional activity. According to the state program "Development of education and innovative economy in 2009-2012 [2-3]: introduction of modern education model," the innovative development of our country until 2015 will include all educational programs, educational-methodical complexes and educational methods from elements of competence. requires updating using [3]. The grounded approach determined that the main idea of this approach is to strengthen the practical, scientific and professional direction of education. Many experts say that the function of "mathematical education itself" prevails in the current methodical education system, which leads to a negative

result, such as doubting the necessity of learning mathematics at the higher level of school. - math lessons. with the low results of the final attestation of mathematics graduates in classes, there is a need to introduce a practical direction in the teaching of mathematics at the primary level and, to a greater extent, a specialized direction at the higher levels of the school [4].

Numerous well-known mathematics elective programs, including those that employ mathematical modeling, are available to science students; however, they are all distinct from one another and do not guarantee the continuity of mathematics instruction at various educational stages. All students take a unified exam in mathematics regardless of their profile, however it has no bearing on how they prepare for the combined state exam; there is insufficient pedagogical and methodological literature, as well as limited expertise in administering such trainings. The degree of discipline integration is modest [5].

One of our objectives is this - the urgent demand for continuous provision is determined by the quick changes in technology, the ever-increasing and changing flow of information, and the requirement to continuously refresh expertise. The issues of continuity and continuity of mathematics education are particularly pressing in today's classrooms, necessitating the development of a vertical model of students' ongoing mathematical activity and the application of the gradual formation of knowledge, skills, and experience from simple to complex [6]. In order to guarantee the ongoing, objective, and subjective development of pupils at each subsequent time interval, a series of consistent educational tasks that become one another during continuous education are used in problem-based learning and project research.

After examining several interpretations of the idea of "continuity in teaching" (Batarshev A.V., Pyshkalo A.M., Tamarin V.E., etc.), we concluded that the foundation of such an educational process should be continuity in mathematics instruction [7]. Flexibility is necessary for the relationship and development of the material, teaching strategies, and forms of mathematics, as well as the link between all the beneficial things that students have learned in earlier phases of mathematics and new information that enhances the learning process and students' personalities.

Avalanche-like flow of information, modern methods of its presentation, including visualization, a new method of studying complex systems and processes, computational experience, and also the use of mathematical modeling methods in teaching mathematics, information and communication technologies (ICT) in the educational process) defines continuous use in various forms (from electronic textbooks to specialized mathematical and integrated software complexes). The following contradictions can be identified between the study of the requirements of the state educational standard for general education, psychological, pedagogic and educational literature, as well as the generalization of the results of dissertation research and the study of the work experience of mathematics and chemistry teachers [8].

1. Socially defined requirements of the society and higher educational institutions for the school graduate and the low level of mathematical preparation of the modern specialized school graduate;



2. The need to ensure the continuity and continuity of mathematics education for students in natural sciences and the absence of a system of integrated mathematics profile facultative and optional courses that ensure the continuity and continuity of mathematics training;

3. The need to strengthen the profile direction of the content of mathematical education based on the method of mathematical modeling with the continuous use of ICT, and the low level and weak potential of using the method of mathematical modeling in the content of mathematical education. Use of ICT tools in teaching mathematics to students in natural sciences.

The level of natural sciences determines the need to resolve identified contradictions, determines the relevance of research and its scope and object [9].

Research problem: To develop a system of specialized mathematics and specialized courses for students of natural sciences, to ensure continuity and continuity of mathematics education, as well as a high level of integration of mathematics with specialized sciences [10-11].

Research Methodology

Learning object: the process of teaching mathematics to science students.

The subject of research: the system of integrated mathematics and specialized courses for students of natural sciences and the methodology of its implementation.

Analysis and Results

In the process of applying scientific research to practice. Research Hypothesis: A system of integrated mathematics electives and elective courses will promote students' mathematical development. The continuous use of ICT tools and the use of mathematical modeling with a comparative approach in the selection of the content of the integrated course system related to mathematics in the teaching of mathematics to students in natural sciences provide a high level of integration [11]. A system of mathematical profile courses integrating mathematics with special subjects, including the pre-specialization elective course "Introduction to Mathematical Chemistry," the profile elective course "Introduction to Mathematical Modeling," the optional course "Mathematical Modeling of Chemical Processes," the optional course "Mathematics" mathematical knowledge and which integrates and systematizes skills.

The implementation of specialized staff training presents a genuine chance to close the current training gap and provide educational continuity, which in part prepares students for their future careers and personal growth. makes it possible to resolve the perception issue. The development of a student's whole personality, his intellectual and communication skills, initiative, independence, responsibility, self-awareness, and self-esteem are all resolved by professional activity.

The model of a general education school with a high level of specialized education implies the possibility of various options for the combination of training courses, which should provide a flexible system of specialized education. This system should include basic general education courses, specialized and elective courses. In addition, elective courses may be introduced.

Organization of facultative and elective courses in mathematics allows to create conditions for high school students to study in accordance with their professional

interests and intentions for continuing education, and this is another way to prepare school students to pass the unified state exam. is a possibility. and, as a result, will be admitted to higher educational institutions.

The main point of the organization of a specialized education system in a modern school is the organization of education that ensures the continuity of education during the transition from one stage to another and enables the formation of students' readiness for continuous education throughout their lives.

Today, one of the most effective and widely used methods of scientific research is the method of mathematical modeling as a way to consolidate knowledge and acquire professional skills. Issues of using mathematical modeling as a method of knowledge are covered.

Today, mathematical modeling is one of the most popular and successful ways to conduct scientific research in order to build professional abilities and consolidate information. Problems with mathematical modeling as a knowledge-gathering technique are discussed [9-10].

A new phase of mathematical modeling's evolution is currently underway, known as "absorption" into the frameworks of the so-called information society. Global tendencies of growing complexity and interpenetration in many facets of human activity are met by notable scientific and technological advancements. Today, having access to and using information resources correctly is becoming essential to solving many of the issues the global society faces. For analysis, forecasting, decision-making, and implementation monitoring, such data is frequently insufficient.

We need reliable methods of processing information flows into a finished "product," i.e. becomes clear knowledge.

Conclusions

The development of chemistry as a science cannot be imagined without close contact with mathematics, without the widespread use of mathematical modeling in the study and analysis of all types of chemical processes and phenomena. In modern chemistry, there is a special branch dedicated to the new application of mathematics to chemical problems - mathematical chemistry, in which mathematical modeling of chemical phenomena and processes is more studied. The most complete integration of the content of mathematics with specialized subjects and implementation of interdisciplinary relations is expressed in the form of integrated courses.

By "integrated learning course" we mean a course created by synthesizing previously existing educational content arrays.

Presented independently of each other, it ultimately reflects interdisciplinarity and ensures the integrity and consistency of the pedagogical process, as well as implements the principles of profile differentiation of teaching.

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ACTUAL PROBLEMS IN MODERN ART AND ARCHITECTURE

UDC: 7, 7.01/.09, 7.05, 7.035, 391, 76 THE OPPOSITE OF THE COSTUME OF THE ERA KHANS IN ART SAMPLES AND THEIR ANALYSIS

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Annotatsiya. Ushbu maqolada oʻzbek milliy kostyumining oʻrni oʻganilgan, erkaklar va ayollar an'anaviy liboslarini miniatyuralarda aksi koʻrilib, ular tahlil etilgan. Buxoro amirligi, Qoʻqon xonligi, Xiva xonligi davrlari liboslarining bir biridan farqi keltirilgan. Liboslardagi barcha yoʻnalishlar oʻz aksini topgan.

Kalit soʻzlar: Miniatura, san'at, libos, kaba, kurta, peroxan, ezor, joma, faradjiya, kaltacha, munisak, zabigardon, tillaqosh, xayxal, tumor, peshonaband, choch-popuk.

Аннотация. В данной статье рассматривается роль узбекского национального костюма, рассматриваются и анализируются традиционные мужские и женские костюмы в миниатюрах. Приведены отличия одной от другой одежды времен Бухарского эмирата, Кокандского ханства, Хивинского ханства. Все направления в одежде нашли свое отражение.

Ключевые слова: Миниатюра, искусство, платье, Каба, Курта, перохан, эзор, Джома, фараджия, калтача, мунисак, забигардон, тиллагаш, хайхал, амулет, лба, волосы-попук.

Abstract. In this article, the role of the Uzbek national costume was played, men's and women's traditional costumes were seen in miniature, and they were analyzed. A distinction is made from one of the dresses of the Times of the emirate of Bukhara, the Khanate of Kokand, the Khanate of Khiva. All directions in dresses are reflected.



Keywords: Miniature, art, dress, kaba, kurta, perokhan, ezor, joma, faradjiya, katcha, munisak, zabigardon, tillakosh, khaikhal, amulet, pehoband, choch-popuk.

Introduction

The late medieval period in Central Asia witnessed a remarkable flourishing of miniature painting, leaving behind a rich artistic legacy that vividly captures the lives, attire, and social dynamics of the time. Artists such as Kamoliddin Behzod, Mukhammad Chagri, Muzarin Abdullo, and Mukhammad Murad Samarkandy skillfully portrayed the diverse classes of society, illustrating not only their physical appearances but also the intricate details of their clothing and lifestyles. This body of work serves as a crucial resource for understanding the historical trajectory of costumes in Central Asia, as well as broader influences from Iranian, Indian, and Turkish traditions.

Miniatures reflect the nuances of fashion, from the elaborate outer garments down to the subtle details of undergarments, revealing insights into both everyday life and ceremonial occasions. For instance, the depiction of men's and women's clothing showcases a variety of styles, from open-front robes and tunics to richly adorned headdresses, often signifying social status and cultural identity. The clothing in these artworks not only serves aesthetic purposes but also acts as a visual language that conveys social norms, gender roles, and the intersection of culture and identity in Central Asia.

Despite the wealth of information presented in these miniatures, written sources from the period often provide limited details on women's attire, suggesting that women's lives were predominantly confined to domestic spheres. Nevertheless, the surviving miniature works offer vital glimpses into the types of garments that women wore, such as the kurta, faraj, and munisak, along with their accompanying accessories and jewelry.

This study aims to explore the significance of clothing as depicted in Central Asian miniature paintings from the 15th to 17th centuries, analyzing its role in shaping social imagery and identity. By examining the artistic representations and contextualizing them within the broader cultural landscape, we seek to uncover the intricate relationships between clothing, social status, and gender during this vibrant historical period.

Literature Review

The study of late medieval miniature painting in Central Asia has attracted considerable scholarly attention, particularly concerning its role in documenting the social, cultural, and historical contexts of the time. This literature review examines key contributions and perspectives within the field, focusing on costume representation, gender dynamics, and the broader implications of these artworks [1-5].

One of the foundational works in the field is by Struve, who emphasizes the importance of miniature paintings as valuable historical documents that reflect the societal norms and customs of the period [5]. Struve argues that these artworks serve as a visual archive, providing insight into the attire, social hierarchy, and everyday practices of Central Asian communities during the 15th to 17th centuries. In this context,

the costumes depicted in miniatures are not merely artistic embellishments but critical elements that convey social status, ethnic identity, and cultural exchange.

Recent scholarship has increasingly focused on how clothing functions as a marker of identity in miniature paintings. Rahman explores the intricate relationship between clothing and identity in Central Asian art, noting that the patterns, colors, and styles of garments often signify various social and cultural affiliations [4]. This study highlights how miniatures encapsulate the complexities of identity politics in a multi-ethnic region, where clothing becomes a means of asserting individuality and belonging.

Similarly, Ashtiani E.M. provides a comparative analysis of clothing in Persian and Central Asian miniatures, illustrating how regional variations in attire reflect broader cultural interactions [2]. This work emphasizes the role of trade and cultural exchange in shaping clothing styles, suggesting that Central Asian miniatures are crucial for understanding the syncretic nature of fashion in the region.

The representation of gender in miniature paintings is another area of significant interest. Babar investigates the visibility of women's clothing in these artworks, noting the challenges in interpreting women's attire due to the restrictive social environments they inhabited [3]. Babar posits that while women's clothing is less frequently documented, the miniatures that do depict women provide vital insights into their social roles and the intersections of gender and class within the broader cultural landscape.

Moreover, Zhang examines the symbolism of women's clothing, particularly the use of veils and capes, as indicators of modesty and social status [6]. This analysis reveals how clothing served not only practical purposes but also communicated societal expectations regarding femininity and respectability. The author underscores the need for a nuanced understanding of women's attire, as it often reflects complex negotiations of power and identity.

In addition to thematic explorations, scholars have also focused on the artistic techniques used in miniature painting. Alimov discusses the meticulous attention to detail in depicting garments, arguing that such artistry enhances the viewer's understanding of the cultural significance of clothing [1]. Through an examination of the materials, patterns, and colors used, Alimov's work highlights how artists skillfully conveyed the textures and aesthetics of clothing, enriching the narrative quality of their artworks.

Research Methodology

Conduct a review of existing scholarship on Central Asian miniature painting, focusing on costume and social context from the 15th to 17th centuries. Analyze selected miniature artworks to identify and categorize clothing, accessories, and their social implications. Compare images with historical texts and artifacts to contextualize clothing styles within broader cultural frameworks. Examine the symbolism of clothing in the miniatures, exploring how they reflect social norms and identities. Incorporate insights from anthropology and sociology to deepen the understanding of clothing's role in social identity. Create a catalog of findings, including descriptions and historical contexts of the miniatures analyzed. Synthesize findings to draw conclusions about the significance of clothing in shaping social imagery in Central Asian miniature art.

Analysis and Results

Miniature painters of the late medieval period of Central Asia had left a rich legacy in art. Artists such as Kamoliddin Behzod, Mukhammad Chagri, Muzarin Abdullo, Mukhammad Murad Samarkandy with high skill portrayed all classes of the population of this period, their lifestyle, appearance, dresses they wore. Miniatures have been successfully studied to illuminate some periods of the history of Iranian, Indian, Turkish, and to a lesser extent – Central Asian costume (as given in Figure 1).



Figure 1. The examples of miniature works K.Behzod in 15th century.

The elegant images are mainly well illustrated with tops, headdresses, shoes and inserts. Underwear is usually visible from the bottom of the top, but it can also be studied; sometimes people in images are depicted only in underwear, or it can also be depicted separately, for example in scenes about drying washed clothes, and this allows one to meditate on his physique (see in Figure 2).



Figure 2. An example of Oriental miniature works. 1.Z. M. Bobur, 2. Navo, XV century.

Men's suit. Men's clothing consisted of upper and inner, shoulder and waist clothing. Men's outerwear is represented by a robe (collar) type of clothing or several types of chakmon. The most common of the civilian population of Central Asia in the 15th -19th centuries was the type of pre-open top, with chopsticks that differ in parts, decoration, length, way of wearing [7].

Several species of "koba" have been found in the short-sleeved robe. The length of the sleeve was up to the middle of the wrist, while the skirt of the Chopin was extended and made a hollowed-out Loop. Koba was shorter than the long-sleeved joma or faradji. During this period, there were also sleeveless, wide-shoulder robes brought by the Mongols. The specific received open, the type of clothing – asymmetry is a

button-down chopper "jubba". The garment was found in the nobility, soldiers, settlers, and sometimes towns (as given in Figure 3).



Figure 3. An asymmetrical cropped klta-sleeved choppon.

In addition to open-front outerwear, the miniatures also depict closed-front outerwear. In Central Asia in the 15th -18th centuries, closed-front clothing was less common than open-front clothing. In the 15th -16th centuries they were usually long, in the 17th -18th centuries they were long and short (to the knee). The sleeves are narrow, long or short, and there are also sleeveless ones. The shape of the dress was tunic-like. The triangular collar could be cut to the chest or to the waist [8].

Under the top, they wore various dresses. Often, they wore two of them one after the other. The inner shirt "perohan" is made of thin white fabric, and the top "peshvoz" is made of blue, blue, green and brown fabrics. Central Asian miniatures of the 15th and 16th centuries show a man with a futa, a long piece of broad cloth of blue, blue, or rarely green color, usually two laterals, has a longitudinal border consisting of one wide and several narrow black bands [9].

A scholar, theologian, Sufi of the $15^{\text{th}} \cdot 17^{\text{th}}$ centuries of Central Asia was a component of his robes – a scarf that was thrown over the shoulder by taylason – Muslim men who wore a top with a belt. In the 15^{th} and 17^{th} centuries, it was almost an integral part of men's clothing in Central Asia, with a belt on the right side, and rarely on the left (mainly from the middle of the 16^{th} century) there was a rectangle-shaped Apron.

According to Zahiriddin Muhammad Babur in the 16th century, the word "collar" was treated in the sense of a robe, that is, as a top. He said that "Umar Shaikh-Mirzo would wear very thin robes, tie a belt, pull his belly inside, and also tie the Belt, and if he gave himself freedom, the belts would be stripped away". During this period, the festival was accompanied by the distinctive-looking, satin and Silk cloak farajia.

The choppon had a hole in the sleeve, from which it was possible to pull out a hand, while in fact the sleeve was considered a decorative decorative decorative part. The headdress of the inhabitants of the palace was considered a turban – dastor, sewn from white fabric in a dice thread. The headdresses were very varied. The most common, according to the elegant images of the XV-XIX centuries, were telpaks and caps of various shapes made of fabrics. Telpaks made from felt were very common.

In Central Asia, the main male headdress in the late 15th -19th centuries was considered a turban [10].

Written sources of the 16th and 17th centuries mention very little women's clothing, perhaps because women's lives were spent in a closed environment, when the clothes were named as follows: faraj, kaba and jubbe, etc., which indicates the only terms for men's and women's clothing of that time, but there is absolutely no way to distinguish (see in Figure 4).



Figure 4. Miniature of women musicians.

Women's suit. In elegant images, Movarounnahr consists of women's outerwear, components like men's. Such dress types are a tunic-like shirt with long sleeves, white, worn from the inside to the body, with a horizontal or vertical collar, and are called kurta in written sources.

Another, colored, tunic-shaped, long-sleeved shirt-peroxan, a shirt is worn over it, the collar of which is horizontal or deep vertical. Over the dress is worn an open dress - cape, which has a central cut along its entire length, or skirts are rolled from right to left.

From the bottom of the inner shirt, drawers – long to the ankle – wearable. At the end of the women's dress, like that of men, a top robe-joma is worn, which protects against bad weather. In ceremonial cases, bashang chopsticks – faradjiya - were worn, made of silk or shockproof fabrics, long to the ground, with very long sleeves, almost to the hem.

Women had a distinctive Choppon, which was considered non – munisak (mursak) in men. The chest had a deep groove, with the skirts covered, and from the sides it was folded into small folds. Such a cloak continued to be worn in Central Asia until the 19th century, when it became a funerary garment. In elegant images, munisak is depicted in a worn position over the CAPE [11]. Kaba, joma, farajiya and kaltacha are the ones who have a lining made of other fabrics (originally – from shoyi, and farajiya – from Otter, almakhon, fox fur). Women's bashang Chopo in images the lining is always depicted in a different color from the dress, or in a fur-like way (as given in Figure 5).





Figure 5. Miniature detail. Nizami. Khamsa, 1495.

Another, more feminine outfit was the dress and paranji, which she would throw on the shoulder on the street. In the 16th century, a garment that, in contrast to the previous time, was thrown over the shoulder as an exit garment – a closed – fitting, rectangular shape, which served as a garment that better hid the qaddi-qomat from other glances. In the elegant images of Iran and Movarounnahr, women throw it on their heads, covering the shoulders but certainly leaving their faces open [12].

Jewelry decorations in elegant images of Movarounnahr are depicted in courtiers, mistresses, princesses, as well as City Women. Basically, these are earrings and beads, Pearl shokilas holding headgear, rings, leg and arm bracelets, zebigardon, tillaqosh, haikhal and amulets.

The above jewelry is worn by princesses, noble women, musicians, City Women, ladies-in-waiting, and so on, mostly by giraffes. Older women wore only nose armor – springs-from jewelry jewelry. It is worth noting that the jewelry was not removed during mourning [13, 14].

Conclusions

As a conclusion, we can say that the materials presented by miniature art make it possible to see the variety of dresses that existed in Movarounnahr in the 16th and 17th centuries extremely valuable. The study of the image of clothing by medieval miniaturists shows that in the image of miniature color, it is clothing that plays a decisive role in creating the social image of a person, since clothing and its parts have always been important social indicators for Medieval Oriental Society.

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NAMING OF THE FINAL PARTS OF UZBEK "MAQOMS" AND ANALYSIS OF THE MODE STRUCTURE

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Annotatsiya. Ushbu maqolada oʻzbek maqomot tizimi Shashmaqomdagi "Ufar", Xorazm olti yarim maqomidagi "Ifor", Xorazm urfiy maqomlaridagi "Ufori" atamalari, lad tuzilishlari, usul taxlili va taqqoslash va ularning bir-biridan farqlari toʻgʻrisidagi ma'lumotlar keltirilgan.

Kalit soʻzlar: Talqini Uzzol, olti musiqa poemasi, tanbur sozlanishi, bas kaliti, skripka kaliti, doira usuli, suporish, oʻlchov.

Аннотация. В данной статье представлена информация о терминах, аккордовых структурах, методическом анализе и сравнении, а также их различиях между "Уфар" в узбекской системе макамота Шашмаком, "Ифор" в шести с половиной макаматах Хорезма и "Уфори" в макамате Урфи Хорезма.

Ключевые слова: Интерпретация Уззола, шесть музыкальных стихотворений, настройка танбура, басовый ключ, скрипичный ключ, метод круга, подметание, измерение.

Abstract. This article provides information about the terms, modal structure, methodological analysis and comparison, as well as their differences between the names "Ufar" in the Uzbek maqomat system Shashmak, "Ifor" in the Khorezm six and a half maqomats and "Ufori".

Keywords: Talkini Uzzola, six musical poems, tanbur tuning, bass clef, doira instrument, rhythm, treble clef, meter.

Introduction

In the genre of Uzbek classical music Maqomah, the final part is the Ufari of each maqom. The lexical root of the word "Ufar" in the Uyghur language means "ipar" (fragrant). Fitrat A. approaches this problem in his own way and presents his concepts in the following way: "Each of these six maqoms is divided into three branches, the first branch is instrumental music, melodies accompanied only by an instrument. This part is called "Mushkilot." The second branch - the song is also accompanied by an instrument. This part is called "Nasr". The third branch is dance music, musical instruments, songs, games (dances) or musical instruments accompanied by dance. This part is called "Ufar" [1].

In each maqom of the "Khorezm Tanbur Notation" written in the second half of the 19th century, during the reign of the Khiva Khan Muhammad Rahimkhon Saniy

(Feruz)," the final parts of the maqoms are called Ifor. And in every maqom they are designated this way Ifori maqom Rost, other maqoms are also called Ifori maqom Navo, Ifori maqom Segah, Ifori maqom Dugah, Ifori maqom Buzruk, Ifori maqom Iraq [2].

Ifor [in Arabic – dust, pollen; smell] Good smell, fragrant; It generally means an aromatic smell [4]. It is no coincidence that the Ifor part of each maqom written in the "Khorezm Tanbur Notation" means aroma. Because this part consistently uses the modal tones and melodies of some parts used in maqom. And this influenced the main name.

The structure system (parda) of the mode used in the genre of Uzbek classical music maqom can be presented as following:

Rost- Nasri Ushshak, Navrozi Sabo, Panjgokh.

Buzruk - Nasrullai (Rakhovi), Nasri Uzzol, (Chorgokh Mukhayar).

Navo - Nasri Bayot, Nasri Dugokh Husayni Navo, Nasri Orazi Navo.

Dugokh - Nasri Chorgo, Nasri Dugo Husaini, Nasri Orazi Dugo.

Segkhokh - Nasri Hijaz, Nasri Navrozi Ajam, Nasri Navrozi Khoro.

Irak - Nasri Mukhayari Irak, Navrozi Turk, Shakhnoz (Gulyor-Shakhnoz) [2].

The general system of arrangement of the scale of steps in this order has remained practically unchanged. Due to the fact that this general form of the Shashmaqom scale system was written on the basis of living traditions, it is natural that some of its aspects were changed under different names in accordance with the requirements of the time and became generally accepted.

In particular, the vocal part of the music, mentioned under the name Chorgokh Mukhayari in ancient treatises and bayazas (literary recordings of song lyrics), was preserved in subsequent stages of time only under the name "Namudi Mukhayari Chorgokh". And it also became a tradition to call "Nasri Khijaz" "Nasri Seghokh", the culmination part of the song in Seghokh makom "Navrozi Turk" is called "Avji Turk", "Shakhnoz" is called "Zebo pari" - these are names and terms derived from them.

This point of view arises when we analyze "Ifori" and the final parts of the Khorezm six and a half maqoms. Ifori, which is performed at the end of each maqom, is composed on the basis of the modal structure associated with the name of this maqom. For example, Ifori Rost, Ifori Buzruk, Ifori Navo, Ifori Dugokh, Ifori Segokh, Ifori Irak, that is, the name makom is added to Ifori, associated with the original name of each maqom.

Research Methodology

To analyze this song, we studied the opinions of teachers and musicologists. To explore the topic, we used practical instructions and an interview with Doctor of Philosophy in the field of art history R. Boltaev.

Analysis and Results

In the genre of Uzbek classical music maqom, Ufari was created as the final part of each maqom, and now we will analyze the names of these parts. For example: In

Bukhara Shashmaqom, the first maqomi is Buzruk, Nasr is the vocal part and the final of the vocal part is called Ufari Uzzol.



Khorezm Urfiy maqom - the name of the final part of the vocal section of the maqom Buzruk is called Ufori Buzruk.



Khorezm six and a half maqoms, the first maqom is called Rost, the final part is called maqom Ifori maqomi Rost [2].

Now we will analyze the melodic structure of the final part of Ifori maqomi Rost, analyzing the example of the structure of the maqoma Rost mode, the system of modes and melodies used can be shown in the following order.

Ifori Maqomi Rost



The melody used at the beginning of the instrumental part of Maqoma Rost is the tone of the melody of the fireward section (this is the initial part of the vocal melody) Ifori maqoma Rost. For example, this melody tone is used in the Ifori part of the maqomi of Rosta, but in a unique way. For example:

Maqoma Rost



In the Ifori maqomi Rost part it is used in another size $6\8$ and the movement of the melody is not changed.



In Tani maqomi Rost, the middle part is called miyonhat, which is the melody that is used in Ifori maqomi Rost in the second structure (2-khona) of the melody.

Also, in the 4th structure (4-khona), Ifori maqomi Rosta, the melodies of the beginning of the Navo maqoma are included. Because as part of Tanya, maqomi Rosta is used as a nomud (model), nomudi Navo.

In the 5th structure (5-khona), Ifori makom Rost, we see that the melody of the culmination (avzh) of Tanya maqom Rost, which is given in the rhythmic structure of the Ifori style.



In the 6th structure (6-khona) of Ifori maqom Rost, the melody part of the dunasra is used, and the 7th structure (7-khona) descends to the original starting level of the melody, that is, to the tonic.

Conclusions

In conclusion, we can say that the Bukhara Shashmaqoms, the Khorezm six and a half maqoms are masterpieces of classical musical art, which are the national wealth of the Uzbek people, and it is the need of the time to study them in a deeper, practical and theoretical study.

In this article, we conducted a study of the problem of naming the final parts of the Bukhara Shashmaqom, Khorezm six and a half maqams, Shashmaqom. We also paid attention to the theoretical aspects of the analysis of the mode and melody of the vocal part of the Maqom Ifori, which is the final part of the Maqom Rost.

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THE SIGNIFICANCE OF THE METHODOLOGY OF THE WORLD MUSIC EDUCATION SYSTEM

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Annotatsiya. Mazkur maqola jahon musiqa ta'lim tizimining respublikamiz standartlariga mosligi va dolzarbligiga bagʻishlanadi. Jahon musiqa ta'lim tizimi metodikasi, tizimi va nazariyalarining ahamiyati haqida soʻz yuritilgan. Bir qator olimlar tomonidan oʻrganilgan tadqiqotlar natijasiga koʻra, musiqaning va ladlarning inson organizmiga, psixikasiga ta'siri, san'atning vazifalari bayon etilgan. Bugungi kunda musiqaning yangi sohasi funksional musiqaning ijobiy tomonlari, xulosa va takliflar keltirilgan.

Kalit soʻzlar. Musiqa ta'limi, tizim, metodika, nazariya, musiqiy tarbiya, ijodiy qobiliyat, lad, pedagogik texnologiya, jarayon, mutaxassislik.

Аннотация. Данная статья посвящена соответствию и актуальности образования мировой системы музыкального стандартам нашей республики. В ней говорится о важности методики, системы и теорий образования. мировой системы музыкального По результатам исследований, проведенных рядом ученых, было сформулировано влияние музыки и ладов на организм человека, психику, задачи искусства. Приведены выводы и предложения о положительных сторонах новой сферы музыки на сегодняшний – функциональной музыки.

Ключевые слова. Музыкальное образование, система, методика, теория, музыкальное воспитание, творческие способности, лад, педагогическая технология, процесс, специальность.

Abstract. This article is devoted to the compatibility and relevance of the world system of music education with the standards of our republic. It talks about the importance of methodology, system and theories of the world system of music education. According to the results of studies conducted by a number of scientists, the effects of music and rhythms on the human body and psyche, and the functions of art have been described. Conclusions and proposals are presented about the positive aspects of the functional music, which is a new sphere of music today.

Keywords: Music education, system, methodology, theory, musical upbringing, creative abilities, harmony, pedagogical technology, process, specialty.

Introduction

In the world music education system, creative technologies of developing students' creative abilities, providing musical education to the younger generation are being applied to the educational process.

In particular, the method Marteno in the French music education system, the method "Tonic-sol-fa" in Hungary, the application of the "Educazione musicale" methods in Italy to the educational process, and the international organization of the International Society for Contemporary Music - ISCM (International Society for Contemporary Music) are carrying out systematic work on the exchange of experience, presentation of new works of composers, practicing pedagogues, music specialists, development of musical-creative abilities and practical application in all directions of music.

Literature Review

Educational and scientific research institutions around the world are conducting scientific research on the study of the theoretical heritage of impressionism and neoclassicism, the development of musical and creative abilities of students, the creation of musical works that serve to elevate a person and perform them with artistic skill. Special attention is paid to scientific research based on artistic reflection of students' musical-creative abilities in teaching according to D. Kerven's "Tonic-sol-fa," "Relative" system, J. Jacques-Dalcroze's "Musical creation" theory, R. Munich's "Yalsi" theory [1-11].

The Greek philosopher Plato believed: "The power of the state is directly related to what kind of music, what tone and rhythm is played in it." Plato and his followers believed: "The state needs music that helps to raise a person to the heights." In ancient China, music was considered a symbol of order and civilization, it is the most important means of education [2].

The great philosopher Aristotle in the work "Poetics" philosophically analyzes the normative laws of artistic creation. Aristotle sees the possibility of art in existence in active, creative, high artistic expression. In his opinion, "The task of art is not to reproduce reality mechanistically, but to reflect it creatively" [3]; Aristotle made the following comments about musical modes that change the psyche: "Music in one tone can make a person gentle and compassionate, while another can cause excitement and nervousness." In his opinion, phrygian, dorian, and lydian tones have a positive effect on the health and soul of a person, and he recommended that music in other tones should not be brought to the ears of the younger generation. It is impossible to talk about a spiritually mature person without developing his or her sense of beauty. Music is one of the powerful means of forming and nurturing these delicate feelings. Music is loved and understood only by people whose hearts are familiar with beauty. Listening to music, its perception is brought up and inculcated from childhood [4].

Today,one of the most urgent issues is to study the functional music, a new appeared sphere of music that effects on the human psyche and physiology. The subjects of the "Music Education" direction are distinguished by their mixed lesson type (structure), means of expression (language) and active psychological influence. Therefore, music education plays an important role in the formation of students' personality and outlook. In L. Burbo's book "Emotions, feelings and forgiveness," Creative ability means opening or creating something new that people need. Divine grace is defined as a transcendental event that accidentally creates ability, talent, genius, divine grace, that is, it is a gift "given by God" [5]. There is creativity

everywhere in existence. If it originates from the inner environment of a person, any craftsman will work with love and taste, he will create new creations by inspiration in the sense of adding his personality to the work [6]. According to VA Engelhardt, "Creativity... is the essence of art. It is also the essence of science. In both cases, the ability of a person to create, that is, to express himself, is important. Scientific discovery, like art, preserves certain characteristics of the creator and becomes the wealth of all mankind during his next life" [7].

Basin E.Ya. in his article "Creativity and empathy" wrote, that "Scientific creativity is an important sign of a person - a form of manifestation of rational vision and activity. Expressing his opinion, he said: It is not just emotional reception or intellectual activity, but seeing the world in such a way that emotions, intelligence, and feelings are reflected in an organically harmonized way" [8]. According to N.A. Berdyaev, the main feature of creativity is freedom. The originality of his philosophy is, first of all, that he based creativity not on existence, but on freedom. Man is drawn to creation with the help of divine power. And creation is his human duty, the duty of man when he was sent to earth [9]. Bugrova S.I. stated that "Scientific creativity is related to the direct life activity of a person, and it is characterized by more objectivity and systematicity" [10]. "Creativity is the thought of searching for the meaning and truth of life," says I.N. Efimova [11].

Research Methodology

Methodology aims to provide a comprehensive understanding of how innovative teaching practices influence the development of students' musical and creative abilities, contributing valuable insights for future educational practices.

Analysis and Results

In the course of education, textbooks, training manuals, teaching-methodical manuals, pedagogical technologies, educational-methodical developments, handouts are used. However, it is necessary to develop new methods and ways of teaching, to use new modern pedagogical technologies, not to be limited to these. Modern technologies not only ease the work of the pedagogue, but also increase the quality of education. If the teaching process is organized using didactic games, it will be easier for students to master this subject. Every pedagogue should be the creator of his lesson. In the process of analysing a work, it is necessary to take an individual approach, taking into account the ability and state of mastery of each student. Only if the student mentally understands the work given in the course of the lesson, he can work on himself in the process of independent education and, as a result, increase and develop his potential.

Currently, deep reforms are being carried out in the field of science and education in our country. It is necessary to use these opportunities efficiently and productively and become mature experts in the field. It can carry out scientific-research works on the basis of research in the established order. Improvement of the educational process, newly developed methods within the framework of research work have a good effect on the development of musical and creative abilities of students of higher educational institutions. Students should be able to demonstrate their musical and creative abilities, work on themselves and conduct creative research during their activities. Development of musical and creative abilities in students is also considered as an important factor. As it has been noted, their musical and creative abilities play an important role in the future pedagogical, scientific-research, spiritual-educational and organizationalmanagement activities of students. A special approach is necessary for the formation of each specialist, and it would be appropriate to conduct specialized subjects individually and to increase the number of class hours. Each subject on specialty has its own goals and objectives. Each discipline is based on certain requirements, while learning textbooks, manuals, educational literature, collections and a number of literature related to the field, their interrelationship, their application in life is studied. In the development of musical-creative abilities in students, it is necessary to take a creative approach by thoroughly studying each subject included in the curriculum and developing skills.

- Conducting specialized subjects as a group lesson reduces the quality level in the preparation of mature personnel and the full fulfilment of qualification requirements. Most parents take their child to a tutoring session so that they can master a particular subject better. What is the reason for this? The reason is that, in contrast to group lessons, the child expresses his opinion freely and independently in individual lessons, takes responsibility for the given tasks even in the process of communication with the teacher, and the process of brain activity is activated. Therefore, the process of mastering specialized subjects for future specialists is considered to be an effective and appropriate method in all respects. During the development of students' musical and creative abilities, it is necessary to develop them perfectly based on the specialization of the field:

• Perfection of the educational process in the development of musical and creative abilities of students, newly developed methods using the methodology of the world music education system will give good results.

• The methodology of the music education system should be developed in accordance with world standards, taking into account the provision of continuity and coherence.

Conclusions

In conclusion, the integration of innovative teaching methods and creative technologies in music education significantly enhances students' musical and creative abilities. This study emphasizes the importance of individualized and specialized instruction, modern pedagogical approaches, and a global perspective in curriculum development. By fostering an environment that values creativity and personal expression, educators can better prepare students for future pedagogical, scientific, and artistic endeavours, ultimately contributing to their holistic development as musicians and individuals.

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THE ARTISTIC SOLUTION OF DESIGNING THE NATIONAL COSTUME OF SAMARKAND WOMEN AT THE END OF THE 19th CENTURY - THE EARLY OF THE 20th CENTURY

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Annotatsiya. Ushbu maqolada Samarqand ayollari milliy an'anaviy liboslari koʻp qavatliligi, bichimi, qoʻllanilgan matolar sirasi, badiiy bezak elementlari oʻrganilgan va tahlil etilgan. Maqolani yoritib berishda tarixiy manbalar, muzey eksponatlari yordam bergan. Unda ayollar zargarlik buyumlari, ularning nomi va tahlili, ramziy ma'nolari keltirilgan.

Kalit soʻzlar. Milliy, an'anaviy, libos, bichim, bozband, zulfitillo, haykal, choʻlpi, gajak, qamchin, naycha, peshonaband, kaltapushak, kaltacha, munisak, roʻmol, lachak, loki, kurtayi peshkusho.

Аннотация. В данной статье изучаются и анализируются многослойность, фасон, тип используемых тканей, элементы художественного оформления



самаркандских национальных традиционных костюмов. Освещению статьи способствовали исторические источники, музейные экспонаты. Здесь собраны женские украшения, их названия и анализ, символические значения.

Ключевые слова: Национальное, традиционное, платье, бичим, бозбанд, зульфитилло, статуя, чолпи, гаджак, кнут, трубка, пешонабанд, калтапушак, калтача, мунисак, платок, лачак, локи, куртайи пешкушо.

Abstract. In this article, the multi-layered, style, type of fabrics used, elements of artistic decoration of Samarkand women's national traditional costumes are studied and analyzed. Historical sources, museum exhibits helped to illuminate the article. It contains women's jewelry, their names and analysis, symbolic meanings.

Keywords: National, traditional, dress, bichim, bozband, zulfitillo, statue, cholpi, gajak, whip, tube, peshonaband, kaltapushak, kaltacha, munisak, scarf, lachak, loki, kurtayi peshkusho.

Introduction

Samarkand women have always been famous for their beauty. Dress has a special role in giving them a look. Women's clothing is a common set. Usually, traditional clothes include a shirt, a scarf, an outer garment, a headgear, and shoes. As outerwear, they used munisak, veil, cloak. It should be noted that the style of everyday and ceremonial clothes was the same. However, the dresses were completely different in their fabrics and decorations.

In the collection of women's clothes, the shirt was in the main place. Over the centuries, traditional dresses have changed, and new dresses have entered the tradition. In particular, dresses began to be sewn based on new designs such as koketka, that is, breast folds.

Literature Review

The sleeves of Samarkand women's dresses are narrow, narrow, the width of the wrist part is 20 centimeters. In fact, in Bukhara, it was customary for women to wear several dresses one after the other. The sleeves of the dress were twice as long as her width.

The side seam is sewn straight or slightly obliquely from the bottom of the sleeve. Women's dresses, kurtayi peshkusho, usually have a longitudinal seam from the neck to the waist. The cuts shown on the dress had a symbolic meaning.

The more open the collar of the shirt is, the happier the woman is with her fate (as shown in Figure 1).





Figure 1. Digital camera image of the women's top. Samarkand, the end of the 19th century, the beginning of the 20th century. From State History Museum of Uzbekistan, Tashkent.

The dresses of Samarkand women are as beautiful as the Bukhara dresses, and the kurtayi peshkusho collar is also sewn with wide stripes. In some cases, the jiyak is also decorated with gold threads in the Bukhara style [1].



Figure 2. Digital camera image of the women's top. Samarkand, the end of the 19th century, the beginning of the 20th century. From Kh.H. Kamilova's personal collection, Tashkent.

But the jiyak on the Samarkand women's shirt is often a fabric, embroidered on it in the Iraqi style. By the beginning of the 20th century, the peshkusho cloak was worn only by older women. The reason was that by this period, wearing a peshkusho was left over from the duty. In some cases, the two sides of the neckline of the dress are cut so that the dress passes easily through the head. The excess space of the fabric is concentrated in the twine-twine fold. The chest was tied with a belt buckle and fastened with a button.

Also, two braided and double braided hems were used for girls' dresses. The tip of such nails was pointed. The pattern on the fringes and the popuk are mandatory, and the history of its appearance goes back to the distant past. The color of women's dresses was different. But women also followed certain rules when choosing the color of their dress.

According to scientists T.A. Abdullaev, S.A. Khasanova: "Mourning clothes are very simple and modest, mostly worn by young people and women. In Samarkand, women's mourning clothes are prepared from a young age. These are mursak, romol, maxi and kavush" [2].



Figure 3. Model drawing of a women's top. Bukhara, the end of the 19th century, the beginning of the 20th century. From "Mohi Khosa" Museum of Applied Art, Bukhara.

Women's robes differed from men's robes in decoration. Men's robes are decorated with ziyak, but women's robes are an exception (Figure 4).



Figure 4. Digital camera image of the women's shorts. Samarkand, the end of the 19th century, the beginning of the 20th century. From Faizulla Khojayev House-Museum, Bukhara.

However, in the adipulation, the core fabric was used. Also, fabrics for women's and men's coats are selected differently. For women's robes, silk and abri patterns were chosen. As an outer garment, not only a cloak, but also a munisak (short) and a veil are worn. The shape of the Munisak is tunic-like, it has a lock and a collar, the waist is folded and reinforced with several shells.

Research Methodology

The upper part of the Samarkand munisak sleeves is wide and narrows towards the wrist. Munisaks are made with and without lining. An unlined munisak made of Olacha cloth was called kaut. The quality of munisak fabrics was chosen depending on the status of women. Wealthy women chose expensive fabrics for munisak. In particular, they wore silk, adras, banoras, i.e., white silk fabric with thin black stripes, Bukhara dukhobas, pieces and velvet munisaks.

Expensive jewelry is usually lined. A brightly colored farovez lining was chosen for such munitions. The dresses had an embroidered lock and side slits at the hem. They

are also decorated with shirazy stripes. Samarkand women also wore burqas. A special blue fabric was chosen for the veil [3].

By the first half of the 19th century, women began to wear a turban-like headdress. This headdress was called loki. Before putting on the loki, a scarf made of white cloth is passed over the chin and wrapped around it. A loki is draped over a leafy headdress.

Analysis and Results

A type of women's headdress is a scarf. In the 70s of the 19th century, young women usually wore two headscarves. The first scarf is loosely closed on the head, and the lower part is left at the back. The two ends of the second scarf are passed between the braids of hair and put on the forehead. Women also used white scarves (as given in Figure 5).



Figure 5. Digital camera image of the Lizard. Samarkand, the end of the 19th century, the beginning of the 20th century. From Bukhara State Art and Architecture Museum-Reserve.

The color of the headbands is chosen depending on the age of the women. Initially, the forehead band was wide and high, but over time, its shape became shorter (Figure 6).



Figure 5. Digital camera image of the women's headdress - Peshaband. Samarkand, the end of the 19th century, the beginning of the 20th century. From Samarkand Regional Museum of Local History.

Jewelry. The main task of Samarkand ornaments was to attract the attention and love of the spouse along with providing aesthetic pleasure. Also, they had the idea that with the help of ornaments, a young woman can be protected from evil eye contact and misfortunes. Therefore, at the wedding ceremony, the woman was decorated with many ornaments.

For women, there were head ornaments as well as ornaments for every part of the body. Among the decorations, it was necessary to wear a koshitillo and a pepper-shaped gajak with a leaf. Zulfakli tube decoration is mainly worn by brides. The tube is worn behind the ear. The threads connecting the tubes are in turn reinforced together at the top of the head.

Hairpins and leaves are also attached to the silver decorations. Such ornaments are among head ornaments. A whip consisting of several coral branches was an ornament worn on the chest [4].

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Conclusions

Zibigardon is decorated with rare stones such as cerdoliki, turquoise and coral. Women also wore amulets in the shape of a rectangular case decorated with turquoise stone and black silver. Amulets also come in several forms, one of which is the bozband. The bozband is quite large, attached to a long chain and worn under the armpit.

By the beginning of the 19th century, a zulfitillo ornament entered the set of decorations. This ornament was considered an ornament worn over the women's turban. The ornaments made for women's hands and fingers were very elegant. Usually, different rings are worn on several fingers at the same time. It was customary to wear rings and bracelets in pairs. Such wear has its own meaning.

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MODERN PROBLEMS OF PHILOLOGY AND LINGUISTICS

UDC: 801.8, 811.11 UZBEK STUDENTS LEARNING EFL: CORPUS-BASED ERROR ANALYSIS

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Annotatsiya. Ushbu tadqiqot ingliz tilini chet tili sifatida oʻrganayotgan oʻzbek talabalari tomonidan yoʻl qoʻyiladigan tipik lingvistik xatolarni oʻrganadi. Tahlil Urganch davlat universiteti bakalavriat talabalari tomonidan yozilgan 40 ta akademik insho asosida tuzilgan. Sketch Engine platformasidan foydalanib, xatolar aniqlandi, 13 xil turga ajratildi va ularning chastotasi va naqshlari uchun tekshirildi. Natijalar imlo, maqoladan foydalanish, tinish belgilari va soʻz tanlashdagi xatolar eng koʻp uchraganini, jumla tuzilishi va bogʻlovchi soʻzlardan foydalanish bilan bogʻliq muammolar kam uchraydi. Bundan tashqari, tadqiqot xatolik shakllaridagi genderga asoslangan farqlarni oʻrganadi va ona tili tuzilmalarining ingliz tilini oʻzlashtirishga qanday ta'sirini oʻrganadi. Ushbu tushunchalar oʻqitish strategiyalarini takomillashtirish va ingliz tilini oʻrganuvchilar duch keladigan muayyan muammolarni hal qilish uchun qimmatli koʻrsatmalar beradi.

Kalit soʻzlar: Xatoliklarni tahlil qilish, ingliz tili chet tili sifatida(EFL), korpus lingvistikasi, til oʻrganish.

Аннотация. В этом исследовании изучаются типичные лингвистические ошибки, допускаемые узбекскими студентами, изучающими английский язык как иностранный с помощью подхода "корпус обучающегося". Анализ основан на 40 академических эссе, написанных студентами Ургенчского государственного университета. С помощью платформы Sketch Engine ошибки были выявлены, классифицированы по 13 различным типам и исследованы на предмет их частоты и закономерностей. Результаты подчеркивают, что ошибки в орфографии, использовании артиклей, пунктуации и выборе слов являются наиболее распространенными, тогда как проблемы со структурой предложений и использованием связующих слов встречаются реже. Кроме того, в исследовании изучаются гендерные различия в закономерностях ошибок и изучается, как структуры родного языка влияют на усвоение английского языка. Эти идеи дают ценные рекомендации по совершенствованию стратегий обучения и решению конкретных проблем, с которыми сталкиваются изучающие английский язык.

Ключевые слова: Анализ ошибок, английский как иностранный язык (EFL), корпусная лингвистика, изучение языков.

Abstract. This study investigates the typical linguistic errors made by Uzbek students learning English as a foreign language through a learner corpus approach. The analysis is based on 40 academic essays written by undergraduates at

Urgench State University. Using the Sketch Engine platform, the errors were identified, categorized into 13 distinct types, and examined for their frequency and patterns. The findings highlight that errors in spelling, article usage, punctuation, and word choice are the most common, whereas issues with sentence structure and the use of linking words are less frequent. Additionally, the research explores gender-based differences in error patterns and examines how native language structures influence English acquisition. These insights provide valuable guidance for enhancing teaching strategies and addressing the specific challenges faced by English learners.

Keywords: Error Analysis, English as a Foreign Language (EFL), Corpus Linguistics, Language Learning

Introduction

Language is one of the strong pillars of confidence in human communication and helps individuals share their ideas and information in situations. Among the thousands of languages spoken all over the world, English has become an international lingua franca that is playing a significant role in international discussion, education, and trade [1]. As a result, English proficiency is highly valued in non-native English-speaking nations, including Uzbekistan, where it is widely taught as a foreign language (EFL).

Mastering English poses distinct challenges, especially in academic writing, which demands a high level of linguistic competence. Academic writing requires not only grammatical precision but also appropriate word choices, cohesive sentence structures, and adherence to established conventions of written discourse [2]. For EFL learners in Uzbekistan, these challenges are compounded by linguistic and cultural differences between Uzbek and English. Addressing these obstacles is essential for delivering effective language instruction.

This study investigates the linguistic errors made by Uzbek undergraduate students learning English through a corpus-based approach. Analyzing 40 academic essays written for IELTS tasks, the research aims to identify prevalent error types, uncover their underlying causes, and provide actionable pedagogical insights. As a diagnostic tool, error analysis plays a critical role in understanding learner difficulties and optimizing teaching strategies, particularly in resource-constrained environments [3].

This research aims to contribute to the broader field of applied linguistics by shedding light on the unique challenges faced by Uzbek EFL learners. The findings are intended to guide educators and curriculum developers in creating targeted strategies to enhance students' English writing skills and overall proficiency.

Literature Review

Error analysis has long been a central focus in second language acquisition (SLA), providing valuable insights into learners' difficulties and shaping effective teaching practices. The field emerged as a shift from contrastive analysis, which concentrated on comparing differences between learners' first language (L1) and the target language (L2), to a deeper exploration of the interlanguage phenomenon [4]. Coined by Selinker, the term "interlanguage" refers to the dynamic and evolving linguistic system that learners develop as they work toward achieving proficiency [5].

Principles of Language Learning and Teaching. Effective theories of language learning highlight the interconnected roles of cognitive, social, and cultural factors. Early frameworks, such as behaviorist approaches, emphasized habit formation through repetition and reinforcement. Over time, these theories have been largely replaced by cognitive and constructivist models, including Krashen's Monitor Model and Vygotsky's sociocultural theory [6]. These contemporary perspectives underscore the value of meaningful interaction and scaffolding as essential components in supporting language acquisition.

Error Analysis in SLA. Error analysis emerged as a response to the shortcomings of contrastive analysis, providing a systematic approach to identifying, classifying, and addressing learner errors [7]. Unlike mistakes, which are typically accidental, errors reveal deeper, systemic gaps within a learner's interlanguage and offer critical insights into their developmental progress [8]. James describes error analysis as the study of "the incidence, nature, cause, and consequences of unsuccessful language use" [9]. The methodology involves detecting errors, categorizing them, and diagnosing their underlying causes, which often stem from factors such as L1 interference or the overgeneralization of L2 rules [10].

Use of Corpora in Language Learning. The emergence of corpus linguistics has transformed error analysis, enabling large-scale, data-driven investigations. Learner corpora, such as the International Corpus of Learner English (ICLE), have made it possible to systematically examine linguistic patterns among L2 learners [11]. Advanced tools like the Sketch Engine platform offer powerful capabilities for detecting and classifying errors, significantly improving the reliability of research findings [12]. Recent studies highlight the value of corpus-based methods in uncovering error trends and shaping effective pedagogical strategies [13].

Uzbek EFL Learners and Error Patterns. The linguistic distance between Uzbek and English presents distinct challenges for Uzbek learners. As a Turkic language, Uzbek differs markedly from English in its phonological, morphological, and syntactic structures, often leading to errors in areas such as article usage, word order, and spelling [14]. Research on Uzbek EFL learners has consistently highlighted the prevalence of L1 transfer errors, emphasizing the need for targeted teaching interventions [15]. However, few studies have fully utilized learner corpora to investigate these patterns in depth.

This research expands on previous findings by employing a corpus-based error analysis of Uzbek EFL learners' academic writing. Through the categorization of errors by type and the analysis of their frequency and distribution, the study seeks to bridge the gap between theoretical insights and practical strategies in second language acquisition pedagogy.

Research Methodology

This study employs a corpus-based approach to analyze common linguistic errors in academic writing among Uzbek EFL learners. The methodology includes the creation of a learner corpus, data collection procedures, and the systematic classification of errors. The steps involved are outlined below.


Data Collection. The data for this study comprises 40 academic essays written by undergraduate English philology students at Urgench State University, Uzbekistan. The essays were collected during the spring semester of the 2020–2021 academic year. Participants, aged between 17 and 26, were volunteers enrolled in English as a Foreign Language (EFL) courses. To ensure diverse content and minimize topic bias, the essays were based on two types of IELTS writing tasks: Task 1, which involves data description, and Task 2, which requires argumentative or opinion-based writing.

Corpus Creation. The essays were digitized and uploaded to the Sketch Engine platform, a widely used corpus analysis tool. The platform facilitated the compilation of the learner corpus and provided functionalities for detailed linguistic analysis. The corpus was structured to include metadata such as the writer's gender, age, and study year, allowing for demographic-based comparisons.

Error Detection and Classification. Errors in the essays were identified and extracted using a combination of automated and manual methods to ensure accuracy. The errors were then classified into 13 categories, adapted from established taxonomies in error analysis. These categories include:

- Spelling errors
- Punctuation errors
- Article usage errors
- Word choice errors
- Sentence structure errors
- Preposition errors
- Word form errors
- Linking word errors
- Confusing or unclear expressions
- Noun errors
- Verb errors
- Deletion errors
- Insertion errors

Each error type was quantified to determine its frequency and distribution within the corpus.

Analysis Framework. The analysis followed a three-step process:

- 1. **Error Identification**: Each essay was reviewed for linguistic inaccuracies, with particular attention to recurring patterns.
- 2. Error Categorization: Identified errors were grouped into one of the 13 predefined categories.
- 3. Error Frequency Analysis: The frequency of each error type was calculated and compared across demographic groups to identify trends.

Ethical Considerations. All participants provided informed consent before contributing their essays. Anonymity was maintained throughout the study to protect participants' privacy.

By employing this methodology, the study aims to provide a detailed and systematic analysis of the linguistic errors made by Uzbek EFL learners, contributing valuable insights to the field of second language acquisition.



Analysis and Results

The corpus analysis revealed significant insights into the linguistic errors made by Uzbek EFL learners in their academic writing. A total of 1,248 errors were identified across 40 essays, with error frequency varying based on the type and demographic factors such as gender and academic year. The most frequent error types were related to spelling, article usage, punctuation, and word choice. Less frequent but noteworthy errors included sentence structure issues and inappropriate linking words.

Error Frequency and Distribution. The following table summarizes the frequency of errors by category:

Error Type	Frequency	Percentage
Spelling	320	25.6%
Article Usage	210	16.8%
Punctuation	180	14.4%
Word Choice	160	12.8%
Sentence Structure	100	8.0%
Preposition	90	7.2%
Word Form	80	6.4%
Linking Words	50	4.0%
Confusing Expressions	30	2.4%
Noun Errors	15	1.2%
Verb Errors	10	0.8%
Deletion Errors	2	0.2%
Insertion Errors	1	0.1%

Table 1. Investigated error types, their frequency in the copus, and percentage

Key Findings:

- 1. **Most Common Errors**: Spelling errors accounted for the highest proportion of mistakes, reflecting potential issues with phonetic and orthographic differences between Uzbek and English. Article usage errors, such as the omission or misuse of "a," "an," and "the," were also prevalent, likely due to the lack of a direct equivalent for articles in the Uzbek language.
- 2. **Gender-Based Error Comparison**: Female students exhibited fewer spelling and punctuation errors compared to their male counterparts, suggesting potential differences in attention to detail. However, gender did not significantly influence other error categories.
- 3. **Influence of Native Language**: Errors such as word choice and preposition misuse were attributed to L1 interference. For instance, the direct translation of Uzbek expressions into English often resulted in incorrect collocations or awkward phrasing.
- 4. **Rare Errors**: Errors related to noun and verb usage, as well as insertion or deletion, occurred infrequently, indicating a relatively strong grasp of these foundational elements among the learners.

Error Analysis by Task Type



- **Task 1 (Descriptive Writing)**: Errors in this category were dominated by spelling and word choice issues, often arising from the need to describe complex data or visual information.
- Task 2 (Argumentative Writing): Punctuation and sentence structure errors were more common, reflecting challenges in constructing coherent arguments and maintaining logical flow.

Implications for Teaching

The findings underscore the need for targeted interventions, such as:

- Enhanced focus on spelling and vocabulary development through phoneticsbased exercises.
- Specific training on article usage, leveraging contrastive analysis between Uzbek and English.
- Practice in sentence structuring and argumentation to address errors in Task 2 essays.

By addressing these error trends, educators can significantly improve the writing proficiency of Uzbek EFL learners.

Conclusions

This study analyzed common linguistic errors in the academic writing of Uzbek EFL learners using a corpus-based approach. Spelling, article usage, punctuation, and word choice emerged as the most frequent error types, influenced by linguistic differences between Uzbek and English. Gender-based comparisons showed nuanced differences, with female students generally demonstrating fewer surface-level errors. The findings emphasize the value of error analysis in enhancing teaching methodologies. Targeted instruction and the integration of corpus tools, such as Sketch Engine, can address common challenges and foster autonomous learning. Future research could broaden this scope by analyzing larger datasets or spoken errors to refine pedagogical strategies further.

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MODERN PROBLEMS OF TOURISM AND ECONOMICS

UDC: 338.48, 339.1 339.3 TOURISM AS A FACTOR IN THE DEVELOPMENT OF ISOLATED ENCLAVE REGIONS

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Annotatsiya. Ushbu maqolada periferik iqtisodiyotga ega anklav hududlardagi mavjud muammolar va ularning yechimlari tahlil qilingan. Jumladan, turli koʻrinishdagi anklav hududlardagi geosiyosiy, iqtisodiy va madaniy jarayonlarga e'tibor qaratilgan hamda xorij tajribasi oʻrganilgan. Anklav hududlar iqtisodiyotini rivojlantirishning bosh omili sifatida turizmning ahamiyati ochib berilgan, taklif va tavsiyalar ishlab chiqilgan.

Kalit soʻzlar: anklav, eksklav, turizm, identifikatsiya, marginalizm.

Аннотация. В данной статье анализируются существующие проблемы и их решения в анклавных территориях с периферийной экономикой. Особое внимание уделено геополитическим, экономическим и культурным процессам в различных типах анклавов, а также изучен зарубежный опыт. Рассмотрена роль туризма как основного фактора развития экономики анклавных территорий, предложены рекомендации и предложении.

Ключевые слова: анклав, эксклав, туризм, идентификация, маргинализм.

Abstract. This article analyzes the existing problems and their solutions in enclave areas with peripheral economies. Special attention is given to the geopolitical, economic, and cultural processes in various types of enclaves, and foreign experience is examined. The significance of tourism as a key factor in the development of the economies of enclave regions is discussed, with proposals and recommendations provided.

Keywords: enclave, exclave, tourism, identification, marginalism.

Introduction

This study critically examines the impact of territorial disputes involving enclaves and exclaves on conflict dynamics and sovereignty, along with the role of tourism in fostering economic and cultural revitalization in isolated regions. By reviewing significant scholarly works, the study aims to understand why territorial disputes persist and explore how tourism can serve as a catalyst for place-making and identity REAL PROPERTY IN THE REAL PROPERTY INTERPOPERTY IN THE REAL PROPERTY IN THE REAL PROPERTY IN THE REAL PROPERTY IN THE REAL PROPERTY INTERPOPERTY IN THE REAL PROPERTY IN THE REAL PROPERTY IN THE REAL PROPERTY INTERPOPERTY INTERP

formation. This research is driven by an interest in discovering alternative strategies to reduce geopolitical tensions and enhance the well-being of marginalized communities.

Literature Review

A comprehensive literature review was conducted, focusing on research by Walter (2003), Jones (2009), Quackenbush (2010), Carter (2010), Shin (2017), Gherghina et al. (2020), Jumakhanov & Toshpulatov (2021), and Abrahams (2014). The analysis involved a critical evaluation of theories and case studies related to territorial disputes, sovereignty, ethnic enclaves, and the socio-economic impacts of tourism. The approach concentrated on identifying core arguments, methodological strengths, and gaps within the existing literature from a critical geographical perspective.

The Impact of territorial disputes over enclaves/exclaves. Territorial disputes involving enclaves and exclaves pose unique challenges that exacerbate conflicts, obstruct peace negotiations, and complicate governance. The complex interplay between nationalist ambitions, strategic interests, and the human rights of enclave residents highlights the intricate nature of resolving such disputes.

Walter (2003) emphasizes the intractability of territorial civil wars in the latter half of the 20th century, noting that, between 1940 and 1996, combatants in these conflicts were 70% less likely to enter into peace negotiations than those in other types of civil wars. Even when negotiations were initiated, they seldom led to lasting peace; in only 17% of cases involving independence or regional autonomy did governments agree to accommodate the rebels [10]. This reluctance to negotiate over land extends to the international arena, where territorial disputes between states are more likely to escalate, cause higher casualties, and be more conflict-prone than non-territorial disputes. Walter's analysis underscores a crucial point: governments display a marked reluctance to negotiate over territory, even when such negotiations could prevent or end protracted and costly conflicts.

The case of enclaves along the India-Bangladesh border exemplifies how nationalist narratives can prioritize sovereignty and territorial integrity over human rights. Jones (2009) argues that South Asia's shift from colonial rule to independent statehood involves the adaptation of social identities to new territorial boundaries, a process facilitated by the naturalization of social boundaries through physical demarcations like markers, fences, and maps [4]. Yet the presence of nearly two hundred enclaves challenges the notion of an unbreakable link between states, territories, and peoples. In practice, both India and Bangladesh have struggled to exercise full sovereignty within these enclaves. This region had been a center of conflict for a long time. Subsequently, political will was demonstrated between the countries, leading to mutual agreement. Through this, in 2015 the governments of the two states intended to replace many enclaves, giving citizens the opportunity to choose their citizenship [16]. The exchange of enclaves is scheduled to take place in stages from July 31, 2015 to June 30, 2016. On July 31, 2015, many enclaves were exchanged, and on November 30 this year, the resettlement of the enclave population was completed. After the implementation of this project, the enclave/exclave areas in the world were reduced by half and many problems in the Ganges basin were eliminated. This means that for a long time, the main part of the model in the Cooch Behar region, which was "divided" by ethnic and religious factors, "became history" [9].

Residents frequently cross international borders for everyday activities, and some enclaves have formed elected councils that function independently of the states asserting sovereignty over them. This situation highlights a discrepancy between sovereignty claims and the practical administration of territories, creating "stateless spaces" that compromise human rights.

Quackenbush (2010) emphasizes the impact of territorial disputes on governance, security, and the daily lives of enclave and exclave residents [6]. His research shows that dyads in territorial disputes tend to experience more frequent conflicts and shorter peace durations. However, he notes that conflict recurrence literature often overlooks the role of territorial issues, focusing instead on dispute resolution methods. This gap suggests a need for a more nuanced understanding of how territorial disputes specifically drive conflict recurrence and escalation.

Carter's (2010) study examines how target states in territorial disputes consolidate control over contested territories to enhance military effectiveness [2]. He concludes that strategically valuable territories increase the likelihood of consolidation by target states, which subsequently deters challenger states from escalating. When territorial features favor consolidation, target states are more inclined to secure these regions, especially when facing stronger adversaries. This strategic approach shows that states consolidate not only for immediate security but also to influence adversaries' perceptions regarding escalation.

Shin (2017) examines the territoriality of ethnic enclaves within the framework of geopolitical relations and power dynamics between societies of origin [7]. By analyzing the Korean transnational enclave in New Malden, London, Shin challenges the traditional view of ethnic enclaves as homogenous, static spaces. Instead, he demonstrates that these enclaves are continuously re-territorialized through the interactions between migrants from South Korea, North Korea, and the Joseonjok community. The enclave's territoriality is shaped by geopolitical hierarchies and tensions among these groups, with more established migrants and recent arrivals often facing disadvantages due to ingrained power structures. Religious and ethnic organizations play a pivotal role, embedding the lives of individual migrants within the power dynamics of their homelands. Shin's work highlights the role of transnational practices and geopolitical relationships in shaping the lived realities within ethnic enclaves.

Together, these studies reveal that territorial disputes over enclaves and exclaves extend beyond simple land disagreements; they are deeply linked to issues of national identity, strategic security, and human rights. The persistent unwillingness of governments to negotiate over these territories, even at the cost of prolonged conflict and human suffering, underscores the need to reconsider how sovereignty and territorial integrity are often prioritized over the welfare of affected populations.

Addressing these disputes requires a multi-layered approach that considers not only the strategic and nationalist goals of states but also human rights and the daily experiences of enclave residents. The complex dynamics presented in these works



suggest that sustainable solutions will require innovative diplomatic approaches and a readiness to question established narratives surrounding sovereignty.

Research Methodology

This review highlights the multi-dimensional nature of territorial disputes, emphasizing the need to understand the intersection of sovereignty, nationalism, human rights, and the daily experiences of those living in contested territories. The works discussed here reveal significant gaps in the literature, particularly in terms of understanding the role of territorial issues in conflict recurrence, the dynamic nature of ethnic enclaves, and the socio-economic consequences of territorial disputes.

Analysis and Results

Tourism as a Catalyst for identity formation. While territorial disputes over enclaves and exclaves often exacerbate conflict and hinder governance, alternative approaches, such as tourism, can provide pathways to mitigate these challenges by fostering economic development and cultural revitalization. Tourism is increasingly recognized as a key factor in bridging socio-economic and ontological divides, enhancing cultural ecosystem services, and promoting local group identities in isolated regions.

Gherghina et al. (2020) explore the relationship between the political economy of tourism and ethnic cultural revitalization in southwest China [3]. They argue that cultural revitalization is a process of "place-making," in which identities are purposefully localized to connect with broader political and economic structures. This process challenges static notions of culture and economy by highlighting the dynamic interplay between local and global influences. The authors critique traditional Marxist analyses for their inadequacy in theorizing the spatial relationship between political economy and culture. They argue that historical materialism perpetuates an idealized construct of the past by focusing predominantly on the economic power of capital while relegating culture to a passive, reactive status.

Their theoretical framework suggests that the local is not an antithesis to the global but a site of dynamic cultural negotiation within shifting political and economic structures. Gherghina et al. (2020) question the assumption that postmodern identities emerge solely from the erasure of space by time in global capitalism. Instead, they emphasize the contested nature of "place" creation within broader systems of power, pointing out that identity is never solely determined by a naturally bounded location but is continuously negotiated across multiple geographical scales [3]. This perspective underscores the importance of recognizing the agency of local actors in shaping their identities within the context of global influences.

Similarly, Abrahams (2014) examines the role of tourism in strengthening the identities of ethnic minority groups in rural Guangxi, China, and analyzes the impact of China's inclusive policies of ethnic and economic assimilation through tourism [1]. During China's post-1978 reform period, tourism was utilized as a tool for economic and social development in rural areas, leading to significant transformations for ethnic minority communities. Drawing on Tajfel and Turner's social identity theory, Abrahams investigates how minority groups adapt to social change to construct positive group identities.

Abrahams (2014) finds that tourism fosters the creation of local group identities rooted in ethnic and rural distinctions, effectively challenging broader negative discourses about rural areas and ethnic minorities [1]. By highlighting ethnic and social differences, tourism becomes an empowering force within the Dong host community, counteracting the inclusive and socio-economic ideologies embedded in state tourism policies for ethnic minority areas. This suggests that tourism can empower minority communities to assert their identities and resist homogenizing state narratives.

These studies emphasize that tourism can act as a catalyst for economic and cultural revitalization in isolated regions, offering an alternative approach to address the challenges posed by territorial disputes and state-centric approaches to sovereignty and identity. By promoting place-making and reinforcing local group identities, tourism allows communities to engage with broader political and economic structures on their own terms.

However, a critical analysis reveals potential pitfalls in relying on tourism as a panacea for cultural and economic challenges. Gherghina et al. (2020) acknowledge the contested nature of place-making within systems of power, emphasizing that the negotiation of identity is complex and often fraught with challenges [3]. The commercialization of culture for tourism can result in the essentialization of identities, reducing nuanced cultural practices to marketable stereotypes. This not only risks undermining authentic cultural expressions but also reinforces existing power hierarchies by privileging certain narratives over others.

Abrahams (2014) highlights the paradox inherent in state policies that simultaneously promote ethnic diversity through tourism while pursuing integrative and assimilative goals. This duality can create tensions within minority communities, which are caught between the expectations of tourists seeking exotic experiences and the pressures of state-led assimilation [1]. The empowerment provided by tourism may prove superficial if the underlying structural inequalities and discriminatory practices are not addressed.

Furthermore, the economic benefits of tourism are not always evenly distributed within communities. Local elites or outside investors may capture the majority of profits, leaving marginalized groups with minimal gains. This can exacerbate existing socio-economic inequalities, foster resentment, and undermine social cohesion. Additionally, an over-reliance on tourism can make communities vulnerable to external shocks, such as economic downturns or pandemics, which can severely disrupt tourist flows and destabilize local economies.

Although tourism holds the potential to contribute to cultural revitalization and economic development, it must be approached with caution. Sustainable tourism development requires inclusive planning that involves local communities in decisionmaking processes, ensuring that their needs and perspectives are prioritized. Cultural representations promoted through tourism should be authentic and reflect the diversity within communities to avoid reinforcing monolithic representations and stereotypes.

Thus, tourism presents a complex set of opportunities and challenges for isolated regions seeking cultural and economic revitalization. It can facilitate place-making and strengthen local identities by providing a platform for communities to assert themselves within a broader political and economic context. However, without careful



management and a critical understanding of the inherent power dynamics, tourism can inadvertently reinforce inequalities and undermine the very cultural structures it seeks to celebrate. Therefore, it should be integrated into broader strategies that address structural issues, promote equitable development, and respect the agency and authenticity of local cultures.

The review reveals that territorial disputes over enclaves and exclaves exacerbate conflict, shorten periods of peace, and complicate negotiations due to entrenched nationalist and strategic interests (Walter, 2003; Jones, 2009; Quackenbush, 2010; Carter, 2010). Governments often prioritize sovereignty and territorial integrity over human rights, leading to the creation of "stateless spaces" and significant governance challenges.

In contrast, tourism has emerged as a powerful tool for economic and cultural revitalization. Studies indicate that tourism can promote place-making, strengthen local group identities, and challenge negative state discourses by engaging local actors in broader political and economic structures (Gherghina et al., 2020; Abrahams, 2014).

The findings highlight the paradoxical nature of territorial sovereignty and its impact on marginalized regions. While governments cling to territorial claims that exacerbate conflicts and undermine human rights, tourism offers an alternative path by empowering local communities.

The process of place-making through tourism challenges static notions of identity and culture, revealing a dynamic negotiation between local and global influences (Gherghina et al., 2020). However, this approach is not without risks. The commercialization of culture and the potential reinforcement of power hierarchies necessitate careful, inclusive planning to ensure equitable benefits and authentic cultural representation.

Conclusions

Addressing the intractable challenges of territorial disputes requires a shift towards policies that reconcile sovereignty with human rights and community well-being. A practical recommendation is to promote sustainable tourism that provides economic opportunities and encourages cultural revitalization. Policymakers should:

- Promote inclusive tourism development that involves local communities in decision-making processes.

- Ensure an equitable distribution of economic benefits to prevent exacerbating socio-economic inequalities.

- Preserve authentic cultural expressions by avoiding the commercialization and stereotyping of minority cultures.

- Integrate tourism into broader socio-economic strategies that address structural inequalities and promote resilience to external shocks.

Adopting these guidelines has the potential to reduce territorial conflicts while enhancing the socio-economic fabric of remote regions, fostering a more sustainable and inclusive approach to development.

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