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CONTENT

CHEMISTRY

<i>Isakova D., Aronbaev S., Aronbaev D.</i> DETERMINATION OF SELENIUM (IV) BY INVERSION VOLTAMMETRY USING SCREEN PRINTED ELECTRODES	4
<i>Kipiani G., Gasviani N., Khustisvili M., Kokilashvili R., Andguladze Sh.</i> CORROSION-RESISTANT ALUMINUM ELECTROCHEMICAL COATINGS	13

<i>Tapdigov Sh., Guliyeva J., Mammadova S., Humbatova S., Malikov E., Gulamirov A.</i> SPECTROSCOPIC INVESTIGATION OF POLY-N- VINYLPIRROLIDONE MODIFIED MAGNETITE NANOPARTICLES ADDED CONCRETE	16
---	----

COMPUTER SCIENCES

<i>Mahmudova S.</i> SOCIAL NETWORKING SERVICES	24
---	----

EARTH SCIENCES

<i>Isgandarov E., Nagieva N., Isgandarova L.</i> PREDICTION OF DENSITY HETEROGENEOUSITY OF ROCKS ACCORDING TO GRAVITY PROSPECTING DATA	26
---	----

ECONOMY

<i>Behbudov U.</i> OBJECTIVE AS THE BASIS OF STRATEGY	34
<i>Ibrahimova N., Aliyeva N.</i> OPTIMIZING PRODUCTION MANAGEMENT: STRATEGIES FOR EFFICIENCY AND QUALITY	36

<i>Israilov B.</i> CHARACTERISTICS AND ANALYSIS OF FACTORS AFFECTING BUSINESS	40
<i>Kokashvili N., Vanishvili M.</i> PECULIARITIES OF THE COMPANY'S STRATEGIC MANAGEMENT OF HUMAN RESOURCES IN GEORGIA	46

ELECTRICAL ENGINEERING

<i>Skrypnyk V., Semenov A., Bychkov Y., Farisieiev A.</i> RESULTS OF DETERMINING THE INFLUENCE OF MOISTURE CONTENT ON THE FLOW OF SUBSTANCES IN MEAT UNDER THE COMBINED ACTION OF HEAT FLOW AND ELECTRIC CURRENT	50
--	----

HISTORY OF ART

<i>Nadirova M., Aliyeva H.</i> THE RHYTHM OF HUMANITY: HOW MUSIC SHAPES CULTURE AND SOCIETY	57
---	----

MATERIALS SCIENCE AND MECHANICS OF MACHINES

<i>Doschechkina I., Sazonov O.</i> INCREASING THE FATIGUE STRENGTH OF MACHINE PARTS USING SURFACE ENGINEERING METHODS	61
--	----

MATHEMATICS

<i>Ramani J.V., Dinesh Kumar</i> AN EFFICIENT METHOD FOR THE NUMERICAL SOLUTION OF FOURTH ORDER INITIAL VALUE PROBLEMS.....	68
--	----

NORMAL AND PATHOLOGICAL PHYSIOLOGY

**Bukach O., Ventoniuk V., Fratsiian M.,
Tanasesku D., Shkvarchuk V.**

INTRODUCTION OF T-786C ENDOTHELIAL NO-
SYNTHASE FOR INTERRUPTIONS AND DEVELOPMENT
OF RHEUMATOID ARTHRITIS..... 72

PEDAGOGY

Pashayeva P.

CULTURE OF SPEECH AND LISTENING IN THE PROCESS
OF BUSINESS COMMUNICATION 77

Kovalenko T.

LEADERSHIP QUALITIES OF STUDENTS: THEORETICAL
ANALYSIS 80

Mazur S.

FREEDOM AND SELF-SUFFICIENCY OF THE
INDIVIDUAL IN THE FORMATION OF POSITIVE MORAL
AUTONOMY 83

Pashayeva P.

EFFECTIVE USE OF INTEGRATION IN CONDUCTING
LANGUAGE CLASSES 85

Koldoshev M., Toychiev Sh.

VALUE ATTITUDE TO THE HORSE AS A FACTOR OF
EDUCATION OF KYRGYZ YOUTH BASED ON
ANCESTRAL TRADITIONS (ON THE EXAMPLE OF THE
KYRGYZ FOLK HEROIC EPIC «MANAS») 87

PHILOLOGY

Ahmadova S.

A COMPARATIVE QUALITY ASSESSMENT OF CHATGPT
MODELS AND HUMAN TRANSLATION OF SCIENTIFIC
TEXTS 90

Karimova A.

GREAT MASTER OF TURKISH POETRY 95

PHYSICS

Khalilov S.

STUDY OF ELECTRICAL CONDUCTIVITY AND
DIELECTRIC PROPERTIES OF POLYETHYLENEFIMINE
CURED OLIGOSTYNE EPOXY RESIN 97

CHEMISTRY

ОПРЕДЕЛЕНИЕ СЕЛЕНА (IV) МЕТОДОМ ИНВЕРСИОННОЙ ВОЛЬТАМПЕРОМЕТРИИ С ПРИМЕНЕНИЕМ SCREEN PRINTED ЭЛЕКТРОДОВ

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DETERMINATION OF SELENIUM (IV) BY INVERSION VOLTAMMETRY USING SCREEN PRINTED ELECTRODES

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Аннотация

В работе проведена оценка аналитических возможностей screen printed электродов в инверсионно-вольтамперометрическом определении ионов селена (IV). Изучено электрохимическое поведение нативных и модифицированных screen printed электродов в вольтамперометрическом определении селенит-ионов в анодной и катодной областях потенциалов. Показана применимость углеродсодержащих сенсоров, изготовленных методом трафаретной печати в определении селена в анодной области потенциалов на уровне 10 мкг/л. Проведен анализ образцов питьевой воды, продуктов питания, растений, витаминной продукции, показавший возможность определения Se(IV) инверсионно-вольтамперометрическим методом на уровне 10 мкг/л. Также показана возможность применения Bi-модифицированного SPCE в определении микро- и субнаномолярных концентраций Se(IV) методом катодной инверсионной вольтамперометрии.

Abstract

The paper evaluates the analytical capabilities of screen printed electrodes in the inversion-voltammetric determination of selenium (IV) ions. The electrochemical behavior of native and modified screen printed electrodes in the voltammetric determination of selenite ions in the anode and cathode potential regions has been studied. The applicability of carbon-containing sensors manufactured by screen printing in the determination of selenium in the anode region of potentials at the level of 10 micrograms/L is shown. The analysis of samples of drinking water, food, plants, and vitamin products was carried out, which showed the possibility of determining Se(IV) by the inversion-voltammetric method at the level of 10 micrograms/L. The possibility of using Bi-modified SPCE in the determination of micro- and subnanomolar concentrations of Se(IV) by cathode inversion voltammetry is also shown.

Ключевые слова: Селен (IV), вольтамперометрическое определение, нативные и модифицированные висмутом screen printed электроды, анодная и катодная развертка потенциалов.

Keywords: Selenium (IV), voltammetric determination, native and bismuth-modified screen printed electrodes, anode and cathode potential scanning.

I. Введение

Селен - микроэлемент, повсеместно присутствующий в окружающей среде и биологических системах, и, хотя он является крайне важным микроэлементом для всех живых организмов, включая человека и животных в ничтожных количествах, селен может быть чрезвычайно токсичным, если доза потребления превышает 400 мкг в день [1,2].

Естественное содержание селена в природе

может значительно варьироваться, так как существуют районы с высокими концентрациями селена, с одной стороны, и очень низкими концентрациями - с другой [3,4].

Рекомендации по содержанию селена в источниках питьевой воды были изложены Европейским союзом и Агентством по охране окружающей среды США с рекомендуемыми максимальными концентрациями 10 мкг/л и 50 мкг/л, соответственно [5,6].

Все это диктует очевидную необходимость в простой методологии для его мониторинга в соответствующих образцах [7,8].

В окружающей среде селен существует в нескольких степенях окисления (+6, +4, 0, +2), причем селен в степени окисления +4 является наиболее токсичным, что позволяет варьировать различными аналитическими приемами с применением физико-химических методов анализа, включая атомно-флуоресцентную спектрометрию с непрерывным генерированием гидридов, атомно-эмиссионную (ICP-AES) и масс-спектроскопию с индуктивно связанной плазмой (ICPmass), целый ряд электрохимических методов – ионометрию и вольтамперометрию [9-14]. Было проведено определения селена (IV) в пищевых продуктах, атмосферных осадках и в природных источниках вод, растениях, биологических жидкостях.

Уже не раз нами отмечалось, что электрохимические методы особенно привлекательны из-за их высокой чувствительности, потенциально низкой стоимости и ключевой способности проводить полностью или частично автоматизированный анализ в полевых условиях. Все эти преимущества электроаналитики становятся еще более заметными при использовании вольтамперометрических сенсоров, изготовленных методом трафаретной печати. Трафаретная печать позволяет изготавливать экономичные одноразовые сенсоры, которые можно использовать для быстрого, чувствительного и портативного анализа многих целевых аналитов в различных областях науки и техники. В дополнение к этому, технология трафаретной печати позволяет еще большей степени миниатюризировать сенсоры, что не только сделает такие преобразователи информации компактными, но и позволит работать с микролитровыми объемами аналитов. К углеродсодержащим screen printed электродам можно применить приемы модификации поверхности ртутью, серебром, золотом, висмутом, оксидами полупроводников, драгоценных металлов, наночастицы различных аллотропных модификаций углерода и прочие наноконструкции [15].

В [16] представлен подробный обзор известных электрохимических методик определения селена. Так, катодной инверсионной вольтамперометрией с линейной и квадратно-волновой разверткой потенциала на ртутной висячей капле определены ионы Se(II), [17], Se(IV), [15,18,19], Se(VI) [20-22] в диапазоне содержания селена 10^{-10}

– 10^{-6} моль/л с пределом обнаружения нано- и пикомолярных концентраций. Для определения селена (IV) также был применен стеклоуглеродный электрод с нанесенной ртутной пленкой, чистой [23] и модифицированной медью [24], фотоокисленным 3,3'-диаминбензидином [25]. При использовании инверсионной вольтамперометрии с квадратно-волновой и дифференциально-импульсной разверткой потенциала чувствительность определения Se(IV) достигала 10^{-10} моль/л в широких диапазонах концентраций, охватывающих несколько порядков (10^{-9} – 10^{-7} моль/л) [26].

Интересным представляется использование углеродсодержащих электродов, модифицированных наночастицами золота [27-31], с применением квадратно-волновой и дифференциально-импульсной вольтамперометрической техники, позволяющей также определять субнаномолярные концентрации Se(IV).

Упоминание screen printed электродов, модифицированных наночастицами золота, висмута, меди для определения Se(IV) приводится в [32-37]. При использовании таких модифицированных SPCE также были достигнуты низкие пределы обнаружения (10^{-9} моль/л) в достаточно широком диапазоне содержания. При этом в ряде случаев были использованы проточно-инжекционные методы [38] измерения с применением миниатюрных электрохимических ячеек, что допускает возможность проведения анализов во внелабораторных (полевых) условиях.

Из приведенной информации следует, что screen printed электродам еще только предстоит реализация этой аналитической цели.

Целью исследования является разработка и изучение электрохимического поведения модифицированного SPCE чувствительного к микроконцентрациям Se(IV).

II. Материалы и методы

В начальных исследованиях нами был применен нативный SPCE, выполненный в классическом стиле: трехэлектродная конфигурация с площадью рабочего электрода диаметром 3 мм, с электродом сравнения Ag/AgCl и угольным противэлектродом. Screen printed электроды были предоставлены ООО «Русенс» (Москва, РФ).

Поверхность рабочего электрода была исследована методами сканирующей электронной микроскопии с увеличением в 500 и 15000 раз. (рис.1.)

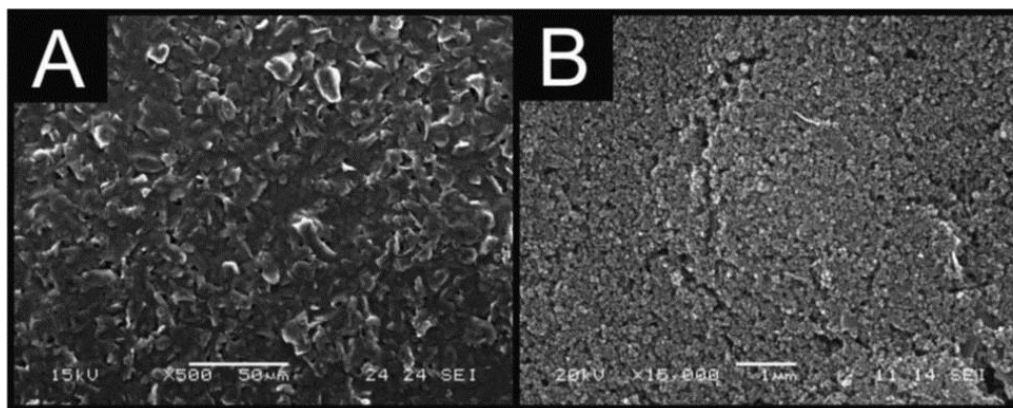


Рис. 1. Микрофотографии СЭМ, изображающие поверхность рабочего угольного SPCE при увеличении 500 (А) и 15 000 (В).

Рентгенодисперсионный анализ выявил присутствие 78,4% углерода; 4,6% кислорода; 6,8% хлора; 10,2% натрия, входящих в состав чернил, предназначенных для печатания таких планарных электродов.

В работе также были использованы SPCE, модифицированные методами in-situ и ex-situ пленкой висмута.

Вольтамперные кривые снимали с помощью компьютеризированного полярографа ПУ-1 [39] и потенциостата-гальваностата Р-40Х фирмы "ELINS" (Черноголовка, Россия).

В работе применяли реактивы квалификации х.ч., а также государственные стандартные образцы раствора Se(IV) 1000 мг/л. Необходимые концентрации Se(IV) для построения калибровочного графика получали методом последовательного разбавления исходного раствора в мерных колбах вместимостью 50 мл бидистиллированной водой с добавлением 0,1 мл концентрированной HNO₃.

III. Результаты и обсуждение

3.1. Электрохимическое поведение селена(IV) на нативном SPCE в анодной области потенциалов

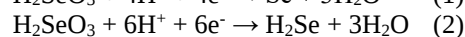
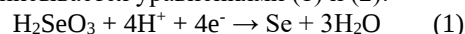
Учитывая переходную степень окисления селена(IV) для его определения инверсионной вольтамперометрией (ИВ) возможно использование как анодного, так и катодного ее вариантов. Анализ литературы показывает, что наиболее часто при идентификации селена применяют катодную ИВ с использованием ртутных электродов [12, 40-42].

Несмотря на то, что многими исследователями была показана возможность предела обнаружения субнаномолярных концентраций Se(IV), следует подчеркнуть, что одним из недостатков катодной вольтамперометрии при определении селена, является мешающее влияние кислорода, который следует удалять из анализируемого раствора. Другой – применение ртути содержащих электродов.

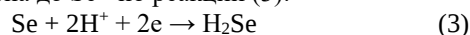
Рядом исследователей отмечается, что подобных недостатков лишена анодная инверсионная

вольтамперометрия с применением золотых индикаторных электродов и углеродсодержащих, модифицированных золотой пленкой [43,44]. Однако такие электроды и на сегодня остаются дорогими, пленка золота быстро истощается, а также сказывается мешающее влияние хлоридов, которые образуют с золотом прочные комплексы и сдвигают потенциал его растворения в катодную область, маскируя ток анодного пика селена [45].

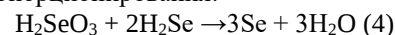
Предполагается [45,46], что в кислых средах восстановление селена (IV) происходит двумя различными путями, определяемыми потенциалом, приложенным во время электрохимического анализа, как описывается уравнениями (1) и (2):



Было высказано предположение [47], что реакция по уравнению (2) есть прямой результат реакции (1), за которой следует дальнейшее восстановление селена до Se²⁻ по реакции (3):



Когда для реакции восстановления выбирают высокие потенциалы (обычно от 0,0 В до -0,4 В, в зависимости от используемого электрода сравнения), то соблюдается уравнение (1) [48]. При более электроотрицательных потенциалах образование H₂Se по реакциям, описанным в уравнениях (2) и (3), становится предпочтительным. В дополнение к этому, известно, что селеноводород в кислой среде в присутствии селенистой кислоты приводит к реакции конпропорционирования:



Исходя из приведенных рассуждений, следует, что электрохимический процесс буде регулироваться уравнениями (1) – (4), а это значит, что для вольтамперометрического определения селена на нативном SPCE следует руководствоваться оптимальными значениями потенциала и времени накопления (предъэлектролиз).

На рисунках 2 и 3 показаны зависимости аналитического сигнала от приложенного потенциала и времени накопления

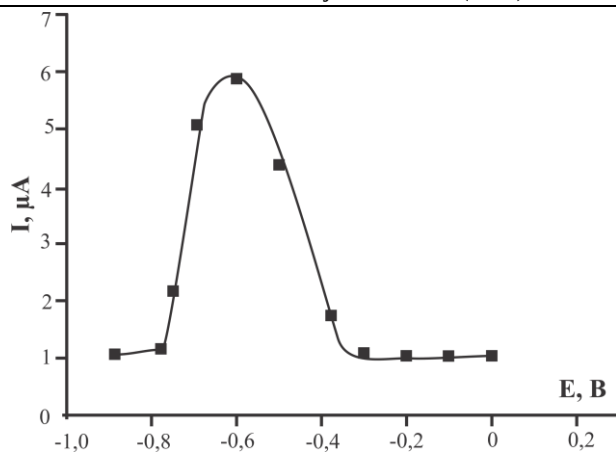


Рис. 2. Влияние потенциала осаждения на высоту вольтамперометрического пика для определения концентрации 10 $\mu\text{г/л}$ селена(IV) в 0,1 моль/л HClO_4 при времени осаждения 90 секунд с использованием SPGE. Скорость сканирования: 50 мВ/с.

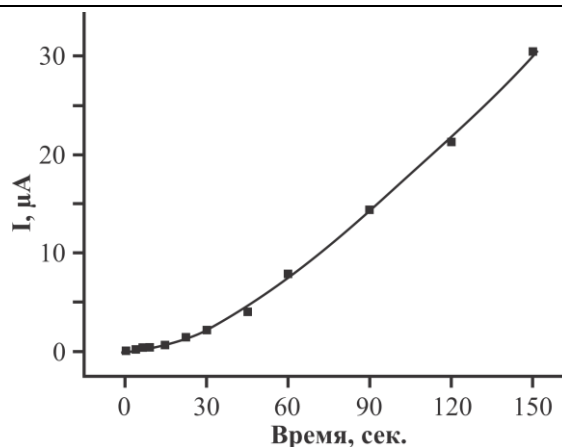


Рис.3. Влияние времени накопления на вольтамперометрическую характеристику высоты пика для 10 $\mu\text{г/л}$ селена(IV) в 0,1 моль/л HClO_4 с использованием SPGE. Потенциал осаждения: - 0,6 В. Скорость сканирования: 50 мВ/с.

Из рисунка 2 следует, что при потенциалах от 0 до -0,4 В аналитический сигнал очень мал, и начинает проявляться лишь около - 0,6 В, что, очевидно, является оптимальным.

С увеличением времени (рис.3) накопления также наблюдается увеличение аналитического сигнала, но здесь не следует забывать о возможном протекании реакций в соответствии с уравнениями (1-4). Поэтому, на наш взгляд, оптимальным временем накопления может быть 90-120 секунд.

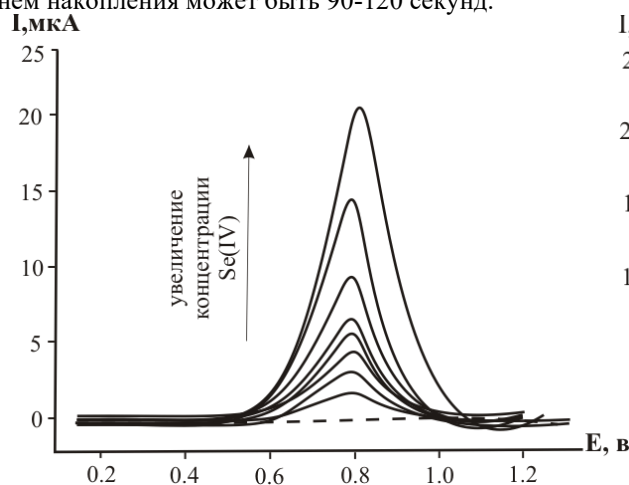


Рис. 4. Вольтамперометрический отклик SPCE при возрастающих концентрациях селена (IV) (0-1000 $\mu\text{г/л}$) в 0,1 М HClO_4 . Потенциал осаждения: - 0,6 В; время осаждения 120 секунд. Скорость сканирования: 50 мВ/с

Как отмечено, в качестве фонового электролита был выбран 0,1М HClO_4 с добавкой KCl.

На рисунке 4 показаны вольтамперограммы для различных концентраций Se(IV) и соответствующий калибровочный график (рис.5).

На всех полученных вольтамперограммах при этих условиях наблюдается четкий пик электроокисления Se(IV) в районе +0,8 В в диапазоне концентраций 0 – 1000 $\mu\text{г/л}$ Se(IV).

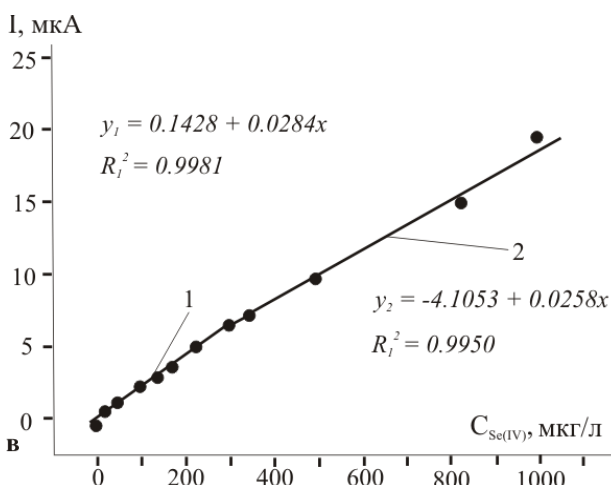


Рис. 5. Калибровочный график, соответствующий добавлению селена (IV) (10-1000 $\mu\text{г/л}$) в раствор 0,1 моль/л HClO_4 с использованием различных SPCE для каждого добавления. Потенциал осаждения: - 0,6 В; время осаждения 120 секунд. Скорость сканирования: 50 мВ /сек.

Тщательный анализ калибровочного графика (рис.5.) показывает наличие двух линейных участков зависимости величины тока анодного пика от концентрации Se(IV). Первый из них наблюдается в диапазоне 10 -250 мкг/л с $R^2=0.992$ и второй до 1000 мкг/л Se(IV) с $R^2=0.984$. При этом предел обнаружения (3σ) селена (IV), рассчитанный с использованием первого линейного диапазона, соответствует 4,4 мкг/л, что позволяет использовать SPCE в анализе питьевых вод как при разовом применении электрода, так и его неоднократного использования с введением в электрохимическую ячейку стандартных добавок.

В таблице 1 приводятся результаты определения вольтамперометрического определения Se(IV) в образцах питьевой воды с SPCE методом добавок.

Контроль осуществляли по ГОСТ 19413-89 [49] с применением анализатора жидкости «ФЛЮОРАТ®-02» с комплектом светофильтров выделяющими линию спектра 366 нм, и вторичными светофильтрами, дающими максимум флуоресценции при 520 нм. Диапазон измеряемых массовых концентраций селена этим методом составляет 0,1–5 мкг/л без разбавления пробы

Таблица 1.

Результаты определения селена (IV) в образцах питьевой воды ИВА методом добавок с применением screen printed электродов ($P=0,95$; $n=3$)

№/№	Добавка Se(IV), мкг/л	ВА определение	Recovery (%)	Флуориметрическое определение с «ФЛЮОРАТ®-02»
Образец №1	0	4.32±0.32	-	-
	10	14.05±10.94	94	14.64±0.49
	20	24.05±10.94	93,75	24.64±0.49
Образец №2	0	3.03±1.02	-	-
	10	13.37±0.80	111	13.82±1.03
	20	23.17±0.80	105	25.82±1.03
Образец №3	0	6.18±0.43	-	-
	10	16.02±0.56	97,5	17.15±1.05
	20	26.34±0.56	102,6	27.15±1.05
Образец №4	0	-	-	-
	10	10.6±0.35	106	-
	20	20.6±0.35	106	-
Образец №5	0	-	-	-
	10	13.6±1.26	118	-
	20	23.6±1.26	118	-

Из результатов, представленных в таблице следует, что два независимых метода анализа хорошо коррелируют между собой $R^2=0,9833$, что подтверждает правильность разработанной методики определения селена вольтамперометрическим методом с применением SPCE.

Разработанная методика была применена в определении содержания селена в некоторых продуктах питания, объектах растительного происхождения и витаминных комплексов. Результаты сведены в таблицы 2 и 3.

Таблица 2

Результаты определения селена в продуктах питания вольтамперометрическим методом

Наименование продукта	Содержание в 100 г, (мкг)	s_r , %
Орехи очищенные	1326,24 ± 24,30	7,10
Пшеница (зерно)	76,26 ± 2,80	2,80
Гречка (ядрица)	82,60 ± 2,24	5,20
Рыба (кап)	68,40 ± 1,82	1,90
Куриная печень	60,84 ± 1,22	5,70
Креветки	56,52 ± 2,14	2,30
Семечки подсолнечные	53,42 ± 2,21	2,70
Сардины в масле	45,83 ± 1,62	3,50
Хлопья овсяные	34,21 ± 0,82	1,74
Мясо (говядина)	27,82 ± 0,54	1,57
Хлеб пшеничный	21,42 ± 0,34	2,85
Хлеб ржано-пшеничный	19,34 ± 0,28	3,13
Яйца куриные (мкг/шт.)	15,22 ± 2,04	7,10
Яйца перепела (мкг/шт.)	29,24 ± 2,64	2,80

Таблица 3

Результаты определения селена в продукции растительного происхождения и витаминных добавках
вольтамперометрическим методом

Образец (содержание Se, мкг/100 г)	Найдено Se, мкг. 100 г	Sr, %
Кожира зеленого грецкого ореха		
Образец 1	1405,5±0,4	7,10
Образец 2	1413,3±0,5	2,80
Грибы Шампиньоны (сухая масса)		
Гриб белый (сухая масса)	131,6±0,3	5,10
Гриб белый (сухая масса)	134,6±0,2	1,90
Кокосовая стружка		
Образец 1	14,5±0,3	5,70
Образец 2	14,2±0,2	2,30
Пижма (цветки)		
Образец 1	7,3±0,2	2,70
Образец 2	6,8±0,4	3,50
Валериана (корневища)		
Образец 1	2,62±0,01	1,74
Образец 2	2,73±0,01	1,57
Витаминная продукция		
Поливитамины VITRUM (20 мкг 1 табл)	18,2±0,2	2,85
Selenium (Yeast Free), 200 мкг/табл.	196,8±2,46	1,25
Компливит-селен 70мкг/капсула	66,4±1,18	1,80
Селен-актив, 50 мкг/табл	49,5±3,8	7,6

3.2. Определение селена (IV) методом вольтамперометрии на screen printed электродах, модифицированных пленкой висмута в катодной области потенциалов

Применение висмут модифицированных электродов в анодной области потенциалов ограничено в виду окисления самой висмутовой пленки. Также было установлено, что формирование висмутовой пленки наиболее успешно протекает при потенциале -0,6 вольт отн. насыщенного хлорид серебряного электрода [50,51]. В ходе предыдущих экспериментов, нами также было установлено, что формирование висмутовой пленки на поверхности измерительного электрода SPCE более предпочтительно методом in situ [51]. Используя эти данные нами проведено изучение электрохимического поведения Bi-SPCE в электролите, содержащем микроколичества селенит-ионов, в катодной области потенциалов. При этом следует помнить, что в катодной области потенциалов может происходить восста-

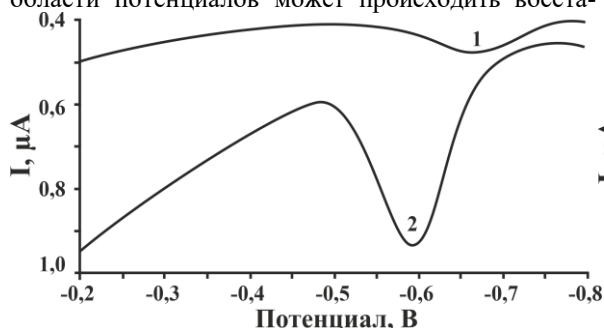


Рис. 6. Вольтамперограммы Se(IV), полученные из раствора: (а) без добавления Bi(III); (б) при добавлении $2,5 \times 10^{-5}$ моль/л. Концентрация селена: 10 мкг/л Se(IV), в 0,1 М натрий-ацетатном буфере с pH 4,5

новление растворенного в анализе кислорода, искажающее вольтамперограмму, в связи с чем, настоятельно рекомендуется удаление кислорода продувкой азотом или инертным газом, или ультрафиолетовым облучением раствора [45]. В работе также использовали в качестве фонового электролита 0,1М натрий-ацетатный буфер с pH 4,5 и эталонные образцы ГСО Селен (IV,1.0), фон 0,1 моль/дм³ HNO₃, ГСО 7340, МСО 0087:1999 (24К-1).

Предварительно было проведено сравнение электрохимического поведения нативного и модифицированного in situ висмутовой пленкой screen printed электродов в фоновом электролите в катодной области.

На рисунке 6 показано, что модификация висмутом, делает электрод более чувствительным к Se(IV), что может быть связано с совместным накоплением висмута с селеном, образующим бинарный сплав [52-54].

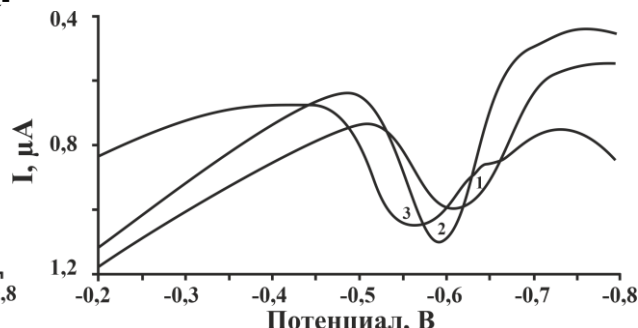


Рис. 7. Вольтамперограммы Se(IV), показывающие влияние концентрации Bi(III) на пиковый ток и потенциал. Концентрация Bi(III): (1) 5×10^{-6} моль/л; (2) $2,5 \times 10^{-5}$ моль/л; (3) $2,5 \times 10^{-4}$ моль/л. Условия те же.

Затем, чтобы изучить взаимосвязь между концентрацией висмута и пиковым током при 10 мкг/л селена, количество висмута в анализе варьировали в диапазоне концентраций от $5 \cdot 10^{-6}$ моль/л до $2,5 \cdot 10^{-4}$ моль/л. Изучая приведенную выше зависимость, можно заметить, что пиковый ток увеличивался с увеличением концентрации висмута до $2,5 \cdot 10^{-5}$ моль/л и, наконец, уменьшался при более высоких концентрациях. Как можно дополнительно наблюдать на рис. 7, вольтамперометрический пиковый потенциал смещался в сторону более

положительных потенциалов с увеличением концентрации висмута.

На основании этих результатов концентрация Bi(III), равная $2,5 \cdot 10^{-5}$ моль/л, была выбрана в качестве оптимальной для дальнейших исследований.

Также было установлено, что аналитический сигнал становится наибольшим при проведении электроосаждения селена при $-1,6$ В отн. Ag/AgCl и времени накопления от 5 до 40 секунд. Это иллюстрируется рисунками 8 (а,б).

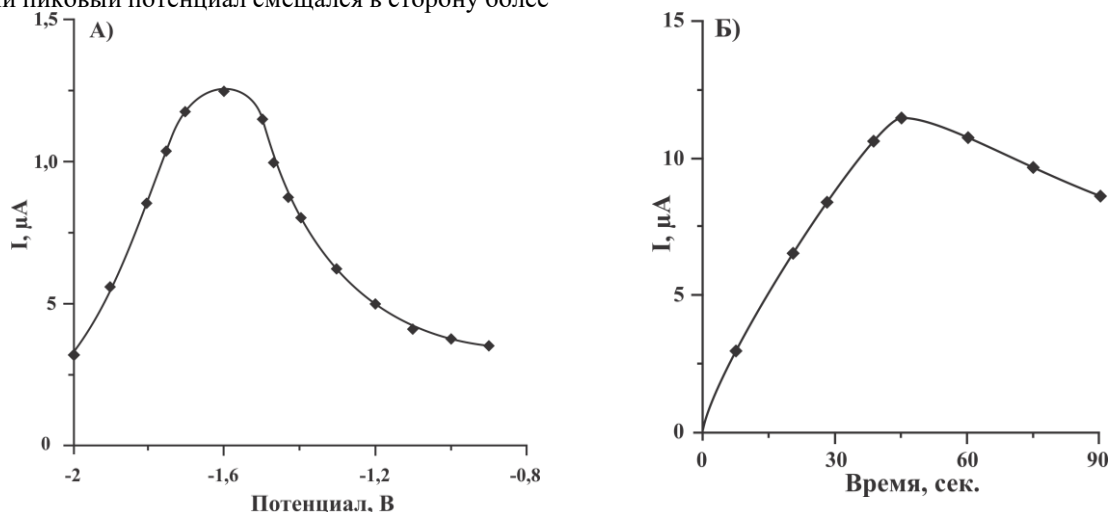
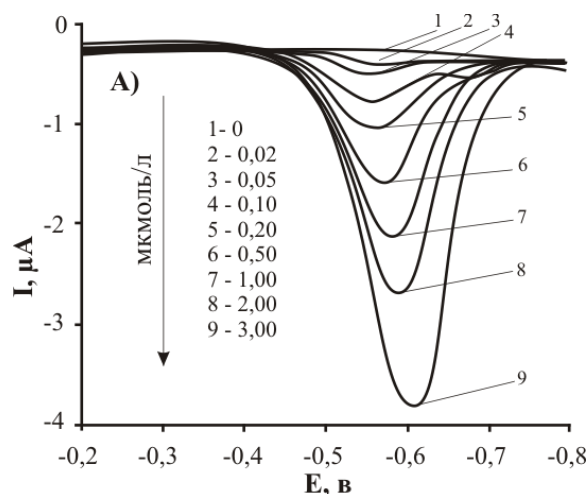


Рис. 8. Зависимость аналитического сигнала Bi-SPCE от потенциала (А) и времени накопления (Б) при определении 10 μ г/л Se(IV) в 0,1М натрий-ацетатном буфере, pH 4,5 с $2,5 \cdot 10^{-5}$ моль/л Bi(III).

Непропорциональное увеличение пика при времени накопления более 5 сек. мы связываем с восстановлением растворенного кислорода в этой области потенциалов.



Исходные данные были приняты нами для построения градуировочного графика зависимости величины пика катодного тока от концентрации ионов Se(IV). На рисунке 9 приведена эта зависимость и показан градуировочный график на Se(IV).

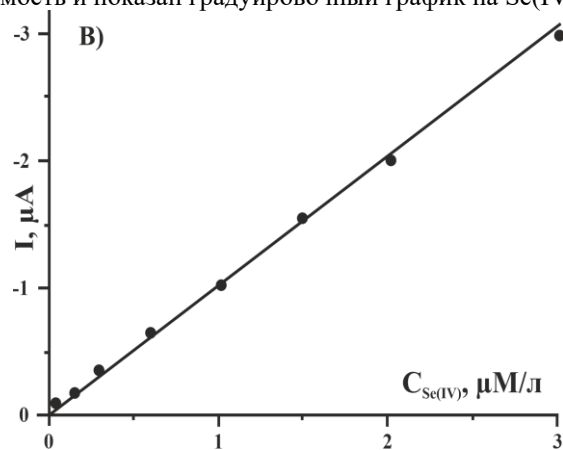


Рис. 9. Катодные вольтамперограммы, полученные на BiSPCE в фоновом электролите, содержащем возрастающие концентрации Se(IV) (А) и калибровочный график (В)

Выводы

В результате проведенных исследований показана возможность использования нативного и модифицированного пленкой висмута screen printed электродов в инверсионно-вольтамперометрическом определении селена (IV). Изучено поведение SPCE сенсоров в анодной и катодной областях потенциалов. Установлено, что зависимость величины тока анодного пика от концентрации Se(IV)

имеет два линейных участка, первый в диапазоне 0-250 мкг/л, второй в – вплоть до 1000 мкг/л, что позволяет практически определять концентрацию селенит-ионов в широком диапазоне их содержаний. При этом предел обнаружения (3σ) селена (IV), рассчитанный с использованием первого линейного диапазона, соответствует 4,4 μ г/л, что позволяет использовать SPCE в анализе питьевых вод как

при разовом применении электрода, так и его неоднократного использования с применением стандартных добавок. Проведен анализ образцов питьевой воды, продуктов питания, растений, витаминной продукции, показавший возможность определения Se(IV) инверсионно-вольтамперометрическим методом на уровне 10 мкг/л. Также показана возможность применения Bi-модифицированного SPCE в определении микро- и субнанолярных концентраций Se(IV) методом катодной инверсионной вольтамперометрии.

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КОРРОЗИОННОСТОЙКИЕ АЛЮМИНИЕВЫЕ ЭЛЕКТРОХИМИЧЕСКИЕ ПОКРЫТИЯ**Кипиани Г.Н.**

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Аннотация

Из низкотемпературного хлоридного расплава на подложках стальных изделий, получены гальванические покрытия алюминия, модифицированные разными металлами (Mn, Pb, Ti, Mg). Изучена коррозионная стойкость полученных покрытий в искусственно создаваемых коррозионных средах, методом ускоренных испытаний. Установлено, что металлы-модификаторы улучшают качество и коррозионную стойкость покрытий в ряду металлов Pb → Ti → Mn → Mg.

Abstract

Electroplated aluminum coatings modified with various metals (Pb, Ti, Mn, Mg) were obtained from a low-temperature chloride melt on the substrates of steel products. The corrosion resistance of the resulting coatings was studied by accelerated testing in artificially created corrosive environments. It has been established that modifier metals improve the quality and corrosion resistance of coatings in a number of metals Pb → Ti → Mn → Mg.

Ключевые слова: расплавленные соли, коррозионностойкие электрохимические покрытия, алюминий.

Keywords: molten salts, corrosion-resistant electrochemical coatings, aluminum.

Введение

Защита от коррозии металлических изделий, конструкций и оборудования, приводящая к ежегодным миллиардным потерям, является важной

проблемой сегодняшнего дня. Эти потери в промышленно развитых странах составляют от 2 до 4% валового национального продукта (ВВП). Помимо нерациональных расходов природных ресурсов,

большой экологический вред в результате коррозии наносится и окружающей среде.

Исходя из вышесказанного, становится необходимым, усовершенствование как уже существующих методов, так и поиск путей, создания новых технологий в которых будут учтены энергоэффективность процессов, экологическая безопасность и минимальный расход природных ресурсов. Для получения антикоррозионных покрытий на изделиях из железа в основном используется металлический алюминий и цинк. Покрытия этими металлами обеспечивают, как механическую, так и анодную защиту основного металла от коррозионной среды. Известно, что огромное количество производимого дефицитного цинка-40-45%, олова-35% и стратегических металлов-никеля и хрома расходуется на получение защитных покрытий от коррозии. Мировые запасы этих металлов почти исчерпаны. Поэтому получение дешёвого и недефицитного алюминиевого покрытия для защиты металлов приобретает большое значение. Алюминиевые покрытия в 6 раз надёжнее цинковых покрытий при равных весовых условиях и в 3 раза при одинаковой толщине. Они защищают железные изделия не только от атмосферной коррозии, но и обеспечивают коррозионную стойкость при высоких температурах эксплуатации (700°C) в течение нескольких часов и характеризуются 85% отражением тепла и света. Исходя из всего этого, лучшим альтернативным решением проблемы антикоррозионной защиты является алюминиевые покрытия.

Алюминированное железо широко применяется в автомобильной и авиационной промышленности, энергетике, сельском хозяйстве, химической и нефтеперерабатывающей промышленности.

Известны труды, касающиеся получения алюминиевых покрытий как физическими (алитирование), так и электрохимическими методами (1-4). Нами были проведены многочисленные исследования по получению алюминиевых покрытий (5-8). Установлена возможность получения покрытий алюминия из низкотемпературного хлоридного расплава ($100\div 120^{\circ}\text{C}$). Изучена кинетика электрохимических процессов, определены оптимальные параметры получения высококачественных алюминиевых покрытий (плотность тока, продолжительность электролиза и температура), а также влияние различных органических добавок и металлов модификаторов (Mn, Mg, Ti, Pb) на стабильность электролита, физико-механические характеристики, толщину и качество покрытия. Экспериментальные данные показали, что незначительные добавки металлов ($10^{-6}\div 10^{-5}$ гр.ат/моль. значительно влияют на качество, толщину и устойчивость покрытий.

Для получения антикоррозионных алюминиевых покрытий нами был выбран низкотемпературный хлоридный электролит, следующего состава: масс%

(AlCl_3 -73÷77)-(NaCl-17÷21)-(BaCl₂—4÷7), $T_{\text{пл}}=94^{\circ}\text{C}$

Эксперименты проводились в стеклянной или фарфоровой чашке. Электролит заранее подготавливался сплавлением обезвоженных солей, катодом

(подложкой) использовались соответствующие обработанные стали (ст.-40, X-18), низкокачественные стали (ст-3) и сложно-профильные винтовые изделия (болты и гайки 25 ХМФ, 35 МФ) от долговечности которых зависит надёжность и устойчивость конструкций электропередач высокого напряжения. Анодом служили как алюминиевые пластины, так и вспомогательные аноды разных металлов, в которых подаваемая сила тока была в ($100\div 500$) раз меньше в сравнение с основным алюминиевым анодом. Этим регулировалась концентрация модифицированного металла в расплаве.

Катодная плотность тока менялась в пределах ($0,01\div 0,05$) А/см², а продолжительность электролиза в интервале ($15\div 35$) мин., температура процесса составляла ($100\div 120^{\circ}\text{C}$). Получены покрытия толщиной $20\div 25$ мкм. Концентрация металлов - модификаторов определялась с помощью рентгенофлуоресцентного спектрофотометра - BDX-3600H и атомно-абсорбционного спектрометра - А.Analyst. 200. Структура полученных покрытий определялась, металлографическим и рентгенодифракционным методом. Толщину покрытия определяли весовым методом.

Алюминиевые покрытия, полученные методом алитирования практически безпористые, в отличие от покрытий, полученных электрохимическим методом. Следует отметить, что для металлов, которые осуществляют анодную защиту от коррозии, наличие определённого количества пор обеспечивает протекторную защиту стальным изделиям, так как при их отсутствии анодный характер не проявляется. Кроме того, чем больше разность потенциалов между основным металлом и алюминиевым покрытием и выше электропроводность коррозионной среды, тем эффективнее защита от коррозии. Другим важным фактором оказывающим влияние на скорость протекания коррозии является пропорциональное соотношение размеров анода и катода, в частности, если размер анода больше катодного, анодный процесс протекает медленно и повышаются защитные свойства алюминиевых покрытий, так как анодные и катодные реакции должны быть эквивалентны друг другу.

Критериями оценки коррозионной стойкости покрытий является внешний вид покрытий, время до появления первого очага коррозии, масса образца, электрические, механические и оптические свойства (9). Нами был выбран метод появления первого очага коррозии.

Контроль качества полученных покрытий начинается с их визуального осмотра, затем определяется толщина покрытия, коррозионная стойкость и пористость. Антикоррозионные свойства покрытий определялась методом ускоренных испытаний в искусственно создаваемых коррозионных среда (10).

Одной из разновидностей коррозионных испытаний является метод обрызгивания образцов раствором поваренной соли (5весс%). Для этого была изготовлена специальная камера в центре которой помещались алюминированные образцы, модифи-

цированные разными металлами. Детали обрызгивались 5% раствором хлорида натрия для создания влажной атмосферы. Продолжительность эксперимента в зависимости от толщины покрытия составляла (24÷200) часов. Процесс испытаний периодически контролировался. Считается, что покрытие удовлетворительно защищает изделия до появления первых очагов коррозии в течение 72 ч. Для удаления продуктов коррозии образцы обрабатывали в горячей воде (60÷70)°C в течение 30÷45 мин, после промывали водой и сушили. Количество пор в покрытиях определяли посредством наложения фильтровальной бумаги, пропитанной реактивами, дающими окрашенные соединения с ионами металла (сталь). Перед испытанием поверхность покрытия тщательно очищали и обезжизивали. Ис-

следуемый образец, служащий анодом, выдерживали в течение 30÷60 с в электролите: $K_4Fe(CN)_6$ - 40 г/л и Na_2SO_4 -2г/л, при комнатной температуре, в качестве катода использовался свинец. Пористость рассчитывали по количеству появившихся на поверхности покрытия синих точек турбулевого сини. Покрытие считается хорошим, если число пор не превышает 3÷4 на cm^2 . Критериями оценки коррозионной стойкости покрытий является внешний вид покрытий, время до появления первого очага коррозии, масса образца, электрические, механические и оптические свойства. Нами был выбран метод появления первого очага коррозии.

Контроль качества полученных покрытий начинается с их визуального осмотра, затем определяется толщина покрытий, коррозионная стойкость и пористость.

Таб.1

Коррозионная стойкость алюминированных покрытий модифицированных металлами Pb, Ti, Mn, Mg.

№	металл	Содержание в сплаве, масс%	Толщина, мкм	Пористость на cm^2	Коррозионная стойкость, час.
1	Pb	1.0	62.0	6	80
2	Ti	2.9	35.0	5	95
3	Mn	3.2	30.0	5	125
4	Mg	3,6	37.0	7	175

Результаты эксперимента показали, что добавка металлов-модификаторов повышают коррозионноустойчивости покрытий в ряду металлов Pb,Ti,Mn,Mg, а также изменяют некоторые физико-механические характеристики. Так например, содержание 2 масс% марганца повышает твердость и износостойкость покрытий, а добавка до 1,0 масс% свинца увеличивает интенсификацию процесса (плотность тока 0.1 А/см²) и соответственно увеличивается толщина покрытия в 2-2.5 раза.

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SPECTROSCOPIC INVESTIGATION OF POLY-N-VINYLPYRROLIDONE MODIFIED MAGNETITE NANOPARTICLES ADDED CONCRETE

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Abstract

In the presented research, the nature of the chemical interactions formed by simultaneously introducing poly-N-vinylpyrrolidone (PVPr) and magnetite nanoparticles into the composition of the cement has been studied. For this purpose, concrete samples were prepared by filling cement with 1% PVPr and 1-2% magnetite nanoparticles at a water/cement ratio of 0.5. FTIR and XRD spectra of the obtained concrete samples were comparatively analyzed. It has been determined that the PVPr macromolecule forms coordination bonds with di-, tri-, and Al silicates in the cement. In the cement paste containing 1% and 2% Fe₃O₄ magnetite nanoparticles with PVPr, the absorption band associated with carbonyl shifted chemically from 1646 cm⁻¹ to 1653 cm⁻¹. It has been showed that magnetite nanoparticles interact chemically with both PVPr and water molecules present in the cement composition. The addition of PVPr-coated magnetite nanoparticles to the concrete composition results in a decrease in the intensity and shifting of peaks characteristic to concrete in XRD. As a result of the inclusion of magnetite nanoparticles into the structure, new low-intensity XRD patterns are observed at $2\theta = (30.17^\circ), (43.31^\circ), (54.61^\circ)$ and (62.75°) . These changes proved that magnetite nanoparticles entered into chemical interaction with Ca and Al di-, trisilicates in cement.

Keywords: poly-N-vinylpyrrolidone, magnetite nanoparticles, cement concrete, FTIR characterization, XRD characterization.

Introduction

In recent decades, the technology of concrete production with various additives has been developing rapidly[1]. In order to obtain the desired properties in concrete, water-soluble polymers, fibers, polymer dispersions and dispersed powders are added to the cement paste as dopants[2,3].

It is known that superabsorbent polymers (SAP) can absorb and retain large amounts of water by increasing their volume[4]. They are applied in various fields such as medicine[5,6], agriculture[7], and the food industry[8]. In recent years, they have been frequently used as repairing agents[10,11] for filling micro-cracks in cement-based materials[9]. SAPs on the surface of the cement coating can absorb water on the surface of micro-cracks, preventing the penetration of leachate by swelling[12]. The application of smart polymers in concrete mixtures gives them an advantage in the cementation of oil wells and the sealing of mud zones in the oil industry. Calcium ions in cement products reduce the water absorption capacity of acrylic acid-based polymers, preventing the formation of large masses[13]. pH-sensitive polymers with high absorption capacity in formation water can be a good choice for cementing oil wells[14]. Cement composites sometimes have disadvantages such as low splitting strength, poor resistance to deformation and susceptibility to cracking[15]. The creation of new composite concrete for modern engineers and concrete technologists is a genuine challenge, not only to provide mechanical properties but also to ensure other physico-chemical

characteristics, especially for structures exposed to aggressive environments. From this point of view, researches are being conducted in the direction of obtaining high-performance and multi-functional cement composites with excellent mechanical properties, durability and structural material, which are easy to produce[16,17].

It is known that nanoparticles, due to their unique physico-chemical properties, improve most of its properties by changing the microstructure of cement[18]. Si, Al, Ti, ZnO, TiO₂ nanoparticles were included in the cement composition in the researches[19-21]. Iron oxides (nano-Fe₂O₃ and nano-Fe₃O₄) specifically belong to this group of nanomaterials [22,23].

Concrete with added Fe₃O₄ magnetite nanoparticles has been obtained, and it has been determined that it exhibits lower water absorption capacity and higher tensile strength compared to ZrO₂, Al₂O₃, and TiO₂ nanoparticles[25,26]. Additionally, it has been observed that the addition of a small percentage of nano-magnetite to the cement paste enhances its compressive strength throughout all stages of the hydration process [27,28]. Research has shown that the incorporation of nanoparticles into cement results in significant improvements in the microstructures of cement composites [22,23]. The effect of nanoparticles is determined by their location in the microstructure[24].

In this study, cement paste modified with 1% (by mass) poly-N-vinylpyrrolidone (PVPr) was further supplemented with 1.0 and 2.0% (w/w) magnetite nanoparticles characterized by dimensions ranging from

30-50 nm. Their structures were analyzed using FTIR and X-ray diffraction spectroscopy methods. Characterization aims to determine the type of chemical interaction of the polymer and magnetite nanoparticles with cement components. Additionally, it aimed to identify the functional groups involved in the composite structure and delineate the spatial arrangement of macromolecular chains and nanoparticles within the concrete formulations.

Experimental

Materials

In the preparation of the concrete mixtures, G-class Portland cement (API Specification 10A-2011) intended for wellbore plugging, high average molecular weight PVPr (CAS 9003-39-8, $M_n=1.3 \times 10^6$), and distilled water were used. The predominant oxides in the composition of the cement are as follows: CaO 62.4%, SiO₂ 20.7%, Al₂O₃ 5.2%, MgO $\leq 1.24\%$, and Fe₂O₃ 4.3%. The composition of silicates comprises 59.2% C₃S, 2.18% C₃A, 16.75% C₄AF, and 9.16% C₂S, where C represents calcium, S represents silicate, A represents aluminum, and F represents ferrite. Iron chloride salts of both II and III valence states were utilized for the synthesis of magnetite nanoparticles, followed by their conversion to hydroxide form using a 25% NH₄OH solution.

Sample Preparation

The mixture of tamponage cement with water was prepared at a water/cement ratio of 0.5. PVPr constituted 1.0% of the dry mass of the cement it was added to. For the preparation of PVPr/Fe₃O₄ modified concrete samples, polymer/magnetite nanoparticles were initially synthesized following the method[29]. The preparation of concrete samples with 1.0 and 2.0% PVPr/Fe₃O₄ in the mass of the cement was carried out as follows: First, a 0.5-1.0 wt% PVPr/Fe₃O₄ mixture

was dispersed in 25 ml distilled water and stirred for 2 hours. The resulting solution was then added to 50 wt% Portland cement in a mixer. The mixture was poured into cylindrical molds and allowed to set for 24 hours. After one day, the samples were removed from the molds, dried at 30°C for 48 hours, and then pulverized for X-ray and IR spectroscopic analyses.

Characterization

The nature of the chemical interaction between macromolecules and cement particles in simple cement paste, also PVPr and PVPr/Fe₃O₄ nanoparticle-added samples was identified using Fourier-transform infrared (FTIR) spectroscopy (Nicolet FT-IR Avatar 360). The crystalline phase in cement paste, PVPr, and PVPr/Fe₃O₄-containing concrete samples was investigated using X-ray diffractometry on an X' Pert-Pro MPD diffractometer (Cu-K α source, $k=0.15405$ nm).

Result And Discussion

It is known that concrete possesses a rigid structure primarily composed of calcium and aluminum silicates formed through ion interaction. The composition of hydrated cement differs to some extent from dry cement powder. In hydrated cement, the hydroxide forms of di- and tri-calcium and aluminum silicates are also present. During our research, serial samples were prepared to evaluate the chemical involvement of PVPr-coated magnetite nanoparticles in the concrete structure. For comparison, X-ray spectra of hydrated cement, PVPr-containing concrete, and PVPr/Fe₃O₄-containing concrete stones were obtained. It is known that in the XRD spectrum of concrete prepared from cement[30] specific peaks are observed at $2\theta = (26.58^\circ, (29.55^\circ), (32.49^\circ), (34.12^\circ), (41.32^\circ), (47.23^\circ), (50.68^\circ), \text{ and } (51.87^\circ))$ for di- and tri-calcium silicates, as well as calcium-aluminum silicates (Figure 1).

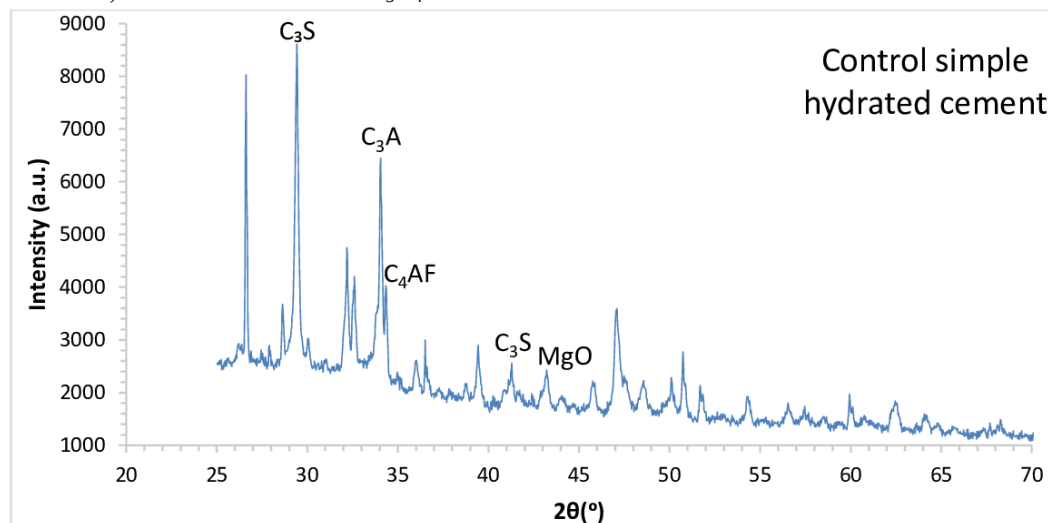


Fig 1. XRD diffractogram of the control concrete sample after 28 days of curing

To conduct comparative analyses, different concrete samples were prepared. X-ray analyses of concrete stones with PVPr and PVPr/ Fe_3O_4 were conducted

to determine the function of both the polymer and magnetite nanoparticles in the structure. Notably, concrete prepared with 1% PVPr incorporation into the cement (Figure 2) displays subtly differentiated XRD patterns.

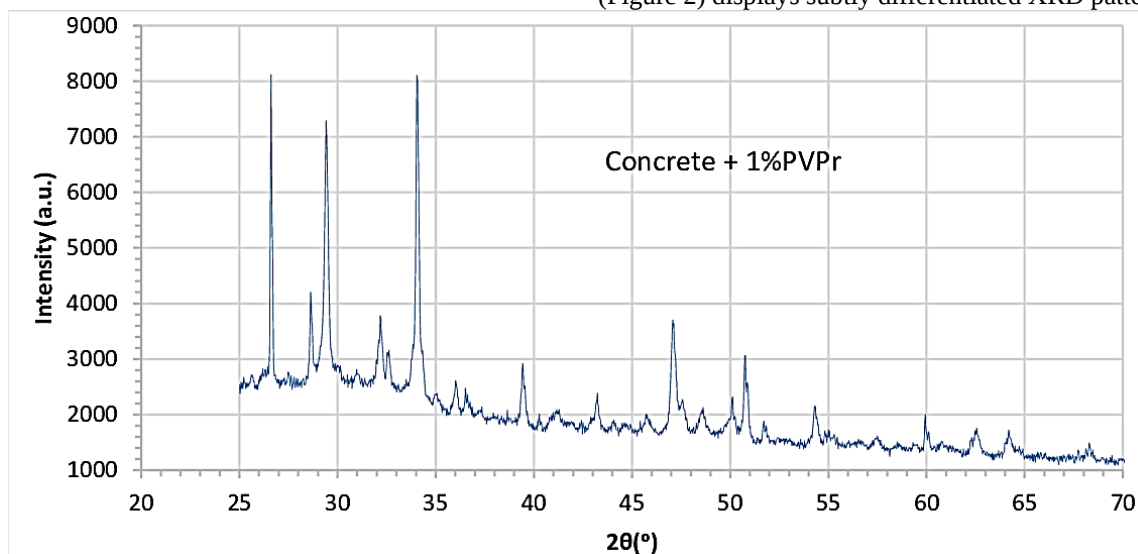


Fig 2. XRD diffractogram of concrete stone with 1% PVPr after 28 days

PVPr is an amorphous substance, and due to its 1% composition, it does not cause distinct separate peaks in the X-ray spectrum [31]. However, because the polymer interacts with Ca-Al silicates in the cement, it may lead to a decrease in the intensity or a shift of certain lines at specific 2θ values. Shifts at $2\theta =$

(39.32°), (43.42°), and (54.62°) are observed. At $2\theta =$ (56-58°), the formation of a second line indicates the immobilization of PVPr in the cement structure. After filling the concrete with both PVPr and magnetite nanoparticles, the XRD spectrum was examined (Figure 3).

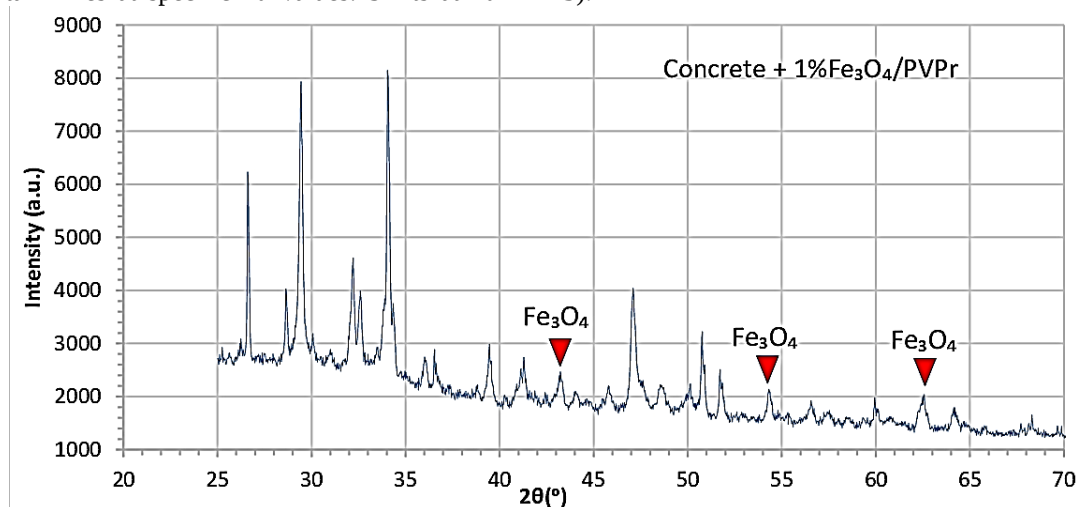


Fig 3. XRD diffractogram of concrete stone filled with 1% Fe_3O_4 /PVPr after 28 days

The characteristic peaks of iron oxide in the X-ray spectrum are observed at $2\theta =$ (30.17°), (43.31°), (54.61°), and (62.75°) with very low intensity. To con

firm that these observed peaks are attributed to magnetite nanoparticles, concrete samples with doubled quantities of nanoparticles were prepared, and X-ray spectra were obtained (Figure 4).

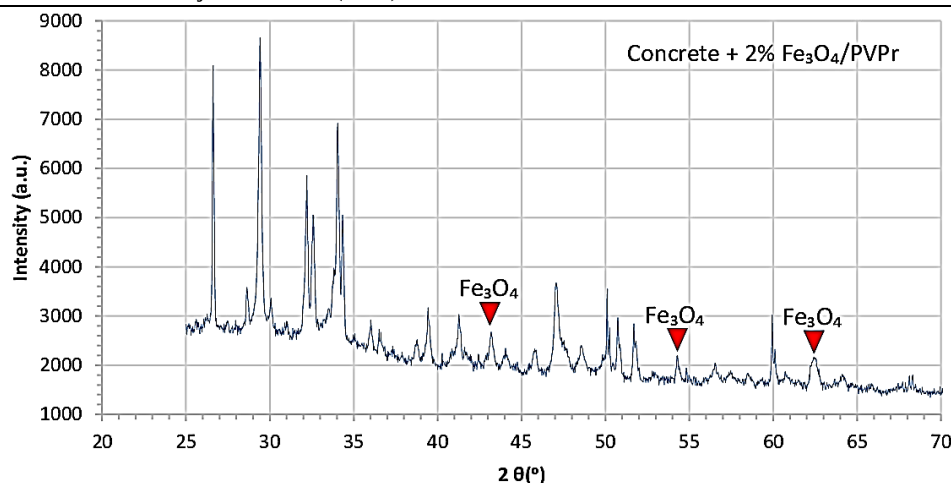


Fig 4. XRD diffractogram of concrete sample filled with 2% $\text{Fe}_3\text{O}_4/\text{PVPr}$ after 28 days.

It has been determined that an increase in the quantity of magnetite nanoparticles in the composition of concrete leads to a clearer delineation of characteristic peaks and a discernible increase in their intensity in the X-ray spectrum. Moreover, the harder crystal structure of magnetite nanoparticles strengthens the X-ray spectrum of concrete even further. It is known that the iron atoms in magnetite nanoparticles are not in ionic form but rather comprise particles ranging in size between 30–45 nm. Observing these characteristic peaks

at 2θ where magnetite nanoparticles are expected indicates that the size of the nanoparticles remains unchanged in the concrete. Furthermore, the arrangement of magnetite nanoparticles in the concrete, maintaining both physical and chemical states, contributes to enhancing certain properties of concrete. To better understand the chemical position of magnetite nanoparticles, concrete stone samples were prepared with the participation of iron salts in cement paste and compared with polymer participation (Figure 5).

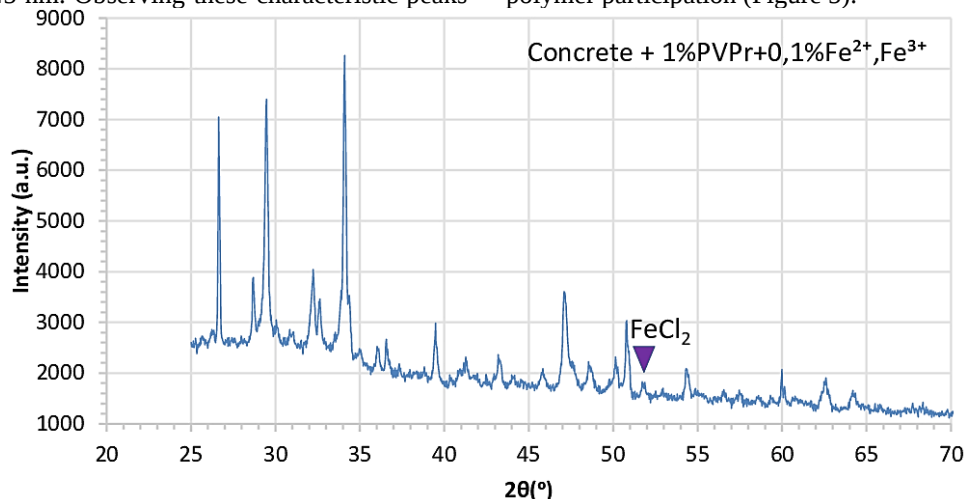


Fig 5. XRD diffractogram of 1% PVPr/concrete filled with 0.1% FeCl_3 and 0.1% FeCl_2 after 28 days.

It has been determined that the addition of iron ions significantly affects the hydration and hardening processes of cement. Metal ions hinder the hydration of calcium and aluminum silicates in the concrete, resulting in the formation of a rigid structure. This effect is visually apparent on the surface of concrete (Figure 6). According to XRD results, the decrease in intensity of

peaks at $2\theta = (29.7^\circ), (34.45^\circ), (39.69^\circ), (47.88^\circ),$ and (51.27°) is associated with a change in the characteristic crystal structure of pure concrete. Fe(II) and Fe(III) ions manifest as minor yet discernible lines with low intensity at $2\theta = (43.47^\circ)$ and (51.95°) in the X-ray spectrum.



Fig 6. Concrete samples filled with magnetite nanoparticles PVPr and $\text{Fe}^{2+}/\text{Fe}^{3+}$ salts after 28 days of curing.

X-ray analyses indicate that the addition of 1% PVPr does not affect the crystal structure of concrete. On the contrary, it ensures coordination between calcium and aluminum silicates, providing long-distance connectivity in the structure. The introduction of magnetite nanoparticles along with the polymer into the

concrete further strengthens the structure, filling certain voids in the process. The type of chemical bonds formed between particles was determined using the FTIR method. Initially, the FTIR spectrum of control concrete was obtained (Figure 7).

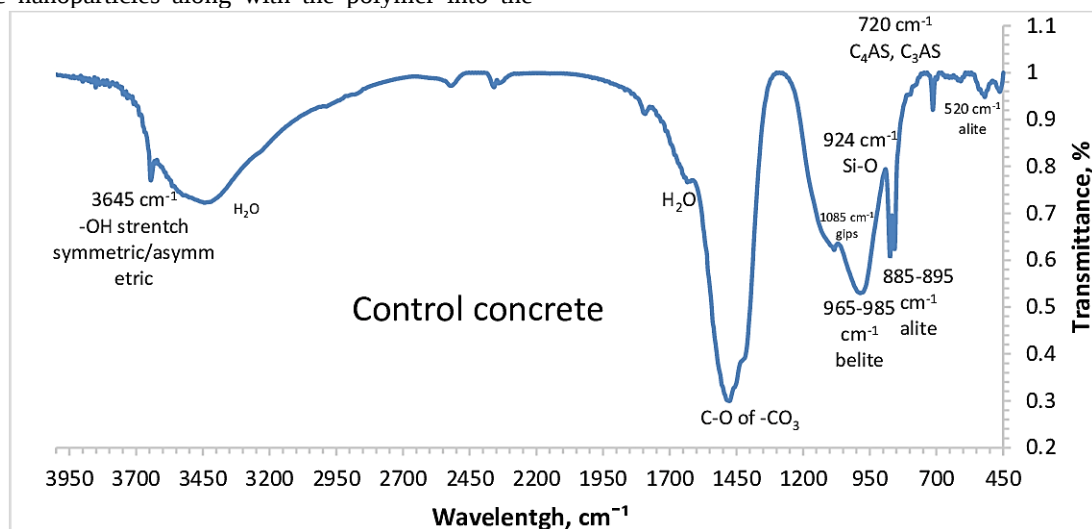


Fig 7. FTIR spectrum of concrete prepared with a water-to-cement ratio of 0.5 cured in 28 days.

The characteristic peaks in the FTIR spectrum of hydrated cement and the relationships and bonds in the corresponding functional groups depicted in Figure 7. The introduction of PVPr macromolecules into the concrete composition leads to the observation of specific peaks related to the polymer in certain regions. Additionally, the chemical interaction of PVPr functional groups with the elements in the cement induces chemical shifts in some regions characteristic of concrete (Figure 8). It is known that characteristic peaks for PVPr in the FTIR spectrum are related to the carbonyl

(>C=O) and hydroxyl (-OH) groups in the regions of 1646 and 3450 cm^{-1} , respectively [32]. Furthermore, at 2950 cm^{-1} , the asymmetric stretching of CH_2 in pyrrolidone cycles is observed, and at 2922 cm^{-1} , the vibrations of CH_2 in the polymer chain are detected. Peaks at 1286 cm^{-1} represent the vibrational bending of CH_2 attached to C-N [33]. Although new peaks with different intensities are not observed in the FTIR spectrum of PVPr-concrete, small variations in absorption bands are noticed.

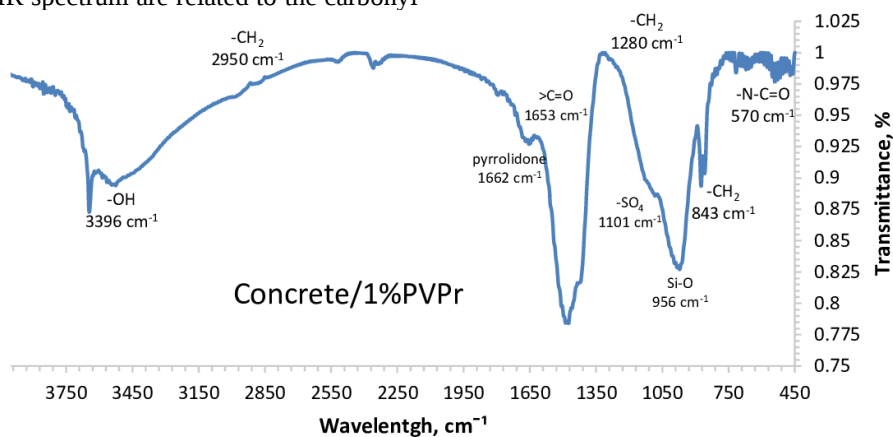


Fig 8. FTIR spectrum of concrete containing 1% PVPr cured in 28 days.

Based on the FTIR results of PVPr-containing concrete, the polymer has participated in active chemical interactions with silicates and has been immobilized in the concrete matrices along with metal silicates. The main chemical interaction relies on the carbonyl groups in PVPr. Specifically, the carbonyl group at 1646 cm^{-1} , characteristic for pure PVPr, chemically shifts to the region around 1653 cm^{-1} in the concrete. This indicates chemical interactions with some silicates in the concrete, suggesting a complex chemical reaction. All

these observations support the conclusion that PVPr macromolecules immobilized in concrete matrices with silicates, and similar results encountered in research [34].

The addition of PVPr-coated magnetite nanoparticles to the concrete composition results in the adsorption bands related to oxides in the FTIR spectrum, as shown in Figure 9.

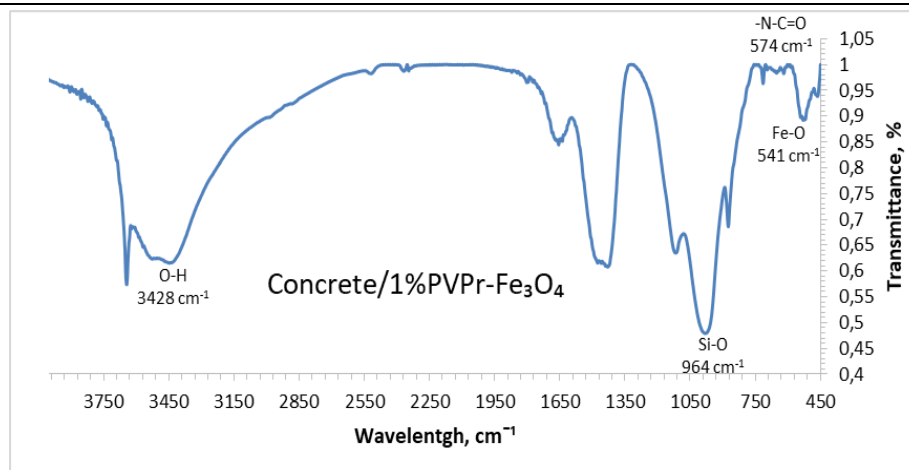


Fig 9. FTIR spectrum of concrete containing 1% PVPr/ Fe_3O_4 magnetite nanoparticles cured in 28 days.

As seen in Figure 9, the characteristic absorption band of magnetite nanoparticles is observed in the 541 cm^{-1} region, while the peak corresponding to the carbonyl group in PVPr, which is actively involved in chemical interaction with Fe_3O_4 nanoparticles, undergoes chemical shifting up to the 1635 cm^{-1} region. In other regions, chemical shifts are minimal, indicating relatively passive chemical interaction with silicates in the cement. This proves that the magnetite nanoparticles exhibit a more active chemical interaction with PVPr within the concrete structure, while their interaction with cement components appears to be relatively

passive. This can be explained by the more rapid mutual interaction of Ca and Al silicates with water molecules and PVPr during the hydration stage of cement. Furthermore, considering that magnetite nanoparticles are mixed with cement powder in complex with PVPr macromolecules, it can be understood that iron oxide molecules are more densely coordinated around the polymer.

To determine the chemical interaction of magnetite nanoparticles with PVPr or silicates, concrete specimens were prepared with the participation of iron salts and polymer, and FTIR spectra were obtained (Figure 10).

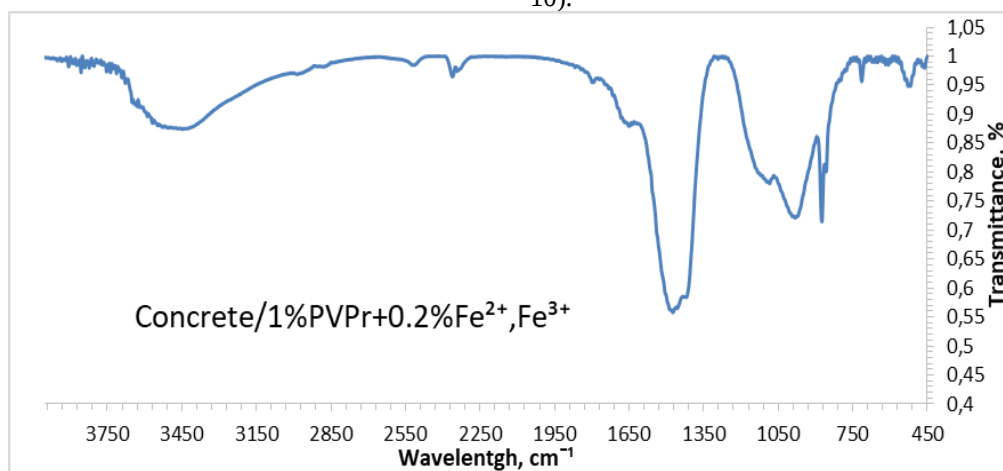


Fig 10. FTIR spectrum of 1% PVPr/concrete filled with 0.1% FeCl_3 and 0.1% FeCl_2 after 28 days.

It has been determined that the characteristic band at 540 cm^{-1} for magnetite nanoparticles does not observed in the spectrum. However, the active complexation of iron ions with PVPr leads to the appearance of the absorption band associated with carbonyl in a different region compared to the polymer. The results suggest that PVPr chains serve as a bridge between cement

particles and magnetite nanoparticles in the concrete. This role of magnetite nanoparticles in such an interaction has observed in various research studies [35]. The chemical interaction of iron ions with silicates in the cement also becomes apparent in the FTIR spectrum of the concrete/Fe salt sample in the absence of polymers (Figure 11).

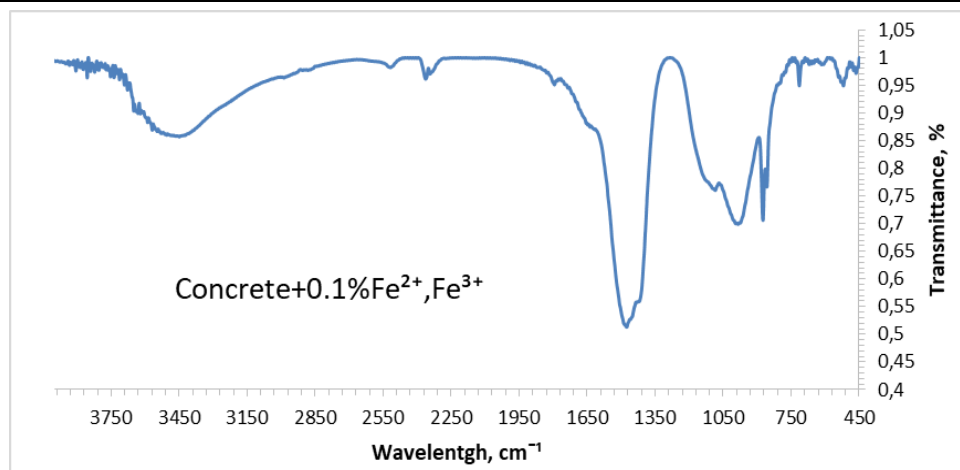


Fig 11. FTIR spectrum of concrete filled with 0.1% FeCl_3 and 0.1% FeCl_2 after 28 days.

Despite the iron ions constituting only 0.1% of the mass of the cement, their active interaction with silicates is evident in the tracking of characteristic lines in the spectrum. The active chemical interaction of iron ions with silicates has led to a sharp decrease in the intensity of the characteristic peak at 964 cm^{-1} corresponding to Si-O. On the other hand, the passive participation of PVPr in the composition showed by the shift of the broad band characteristic of -OH groups to the region of $3400\text{--}3500\text{ cm}^{-1}$. Based on the comparative analysis of FTIR spectra, the addition of PVPr-coated magnetite nanoparticles to the cement paste does not hinder the hydration process. The homogeneous distribution of polymer and iron oxides in the structure ensures the distribution of PVPr-silicate and PVPr/ Fe_3O_4 /silicate interactions not only locally but throughout the entire volume and surface. This confirms that mechanical properties are maintained equally in all directions throughout the concrete. Research studies often encounter enhanced mechanical properties in polymer-cement systems attributed to the reinforcement of the matrix by polymer macromolecular chains [36].

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Abstract

In the article, the services of Internet-media and social networks, this potential world trade, implementation of network monitoring, as well as production in the field of monitoring Internet-media resources, etc. investigated in studies. Nowadays, everyone can benefit from social networks. It can be network usage or otherwise oriented. Shab provides the abundance and availability of information, making the learning process more optimal and comfortable. Over the past 10 years, online social networks have become integral parts.

Keywords: Internet-media, network services, monitoring services, social network monitoring.

As a result of the possibilities of information and communication technologies, informatization acts as one of the main factors that stimulate the development of civilization. Wide use of these opportunities has led to the development of new approaches and trends in journalism. One of the main goals of the information policy of the state in our country is the application of ICT to mass media and its development according to world standards. Modern web technologies make it possible to more accurately and objectively determine the rating of electronic media, individual articles published in them, and the social composition of the readership. This is very important for the media to be able to establish their activities correctly. The application of such a system makes it possible to manage the quality of mass media.[1]

Media monitoring is the collection, systematic recording and analysis of published information. Media monitoring includes identifying and monitoring data sources, collecting and storing data, selecting the most relevant data through categorization and filtering, and analyzing the data collected. Media organizations conduct monitoring in order to effectively establish their activities in competition with other media organizations. Systematic collection of information allows obtaining accurate and reliable information on a given topic, evaluating the reputation of media organizations in the region or the country, and having an idea about the channels that transmit information. The evaluation of the obtained results enables more effective establishment of media resources activity and optimal decision-making. In modern times, monitoring of media resources does not only involve the analysis and search of information in traditional mass media, but also work with Internet resources, and at the same time forums with various topics that do not have the direct meaning of the term "media" but can have a significant impact on the formation of public opinion and serve as a source of information. also includes monitoring of blogs.[3]

Social media means creating virtual social communication and sharing information between people through Internet technologies. It transforms communication into an interactive dialogue using more accessible and web-based technologies. Social media tools include information sites broadcast over the Internet, social networks, blogs, micro blogs, instant communication programs, forums. Social networks are

a virtual form of our physical world. Currently, terrorist groups use social networks, e-mail, etc. they communicate with means. It is clear that among the types of information transmitted in such means of communication, texts are predominant. Therefore, in order to prevent possible terrorist acts and ensure the security of the state, the analysis of the texts circulating in the virtual environment, including social media, is of great importance.

Currently, Big Data analytics technologies (data mining, text mining, etc.) are used to discover examples, keywords and relevant information from texts.

When studying modern social network analysis, you can look at the experiments conducted by Stanley Milgram. After the attacks of September 11, 2001, social network experts began to give more priority to the use of network methodology in the fight against terrorism. Publications such as the Washington Post and the Dallas Morning News have written articles about network analysis. Many models (agent-based models, etc.) have been developed to help study the dynamic nature of social networks, and to study criminal or terrorist networks. [2]

Monitoring is a systematic process of collecting and analyzing data to ensure that a network (program, etc.) is progressing toward its goal and getting the right results. Social media monitoring helps to solve the issues mentioned below.

- to take into account the interests of the audience, people to accurately define their wishes and desires;
- create an interactive relationship with people;
- social media information that the audience needs spread through;
- to analyze the future activity of the institution.

During social media monitoring, information is initially monitored, texts are analyzed, and spam comments are determined. In the next steps, a more detailed analysis is carried out according to the various characteristics of the regions. Later, visualization and measures are taken against possible threats.[3]

Media monitoring is done through services offered by online media monitoring companies. These services are software that uses automated robots that automatically monitor the content of newspapers, magazines, TV channels, as well as free online news sources. The monitoring process is as follows: After the software has finished reading the text, it identifies the news text or

social media shares containing each customer's search term (keyword) and automatically presents relevant articles or social media "snippets" for each customer. Internet search systems or specialized mass media databases are usually used during monitoring. CyberAlert, the world's most well-known media monitoring company, monitors 50,000 online news sources in more than 75 languages in 189 countries every day. This company controls over 50 million social media blogs, 100,000 message boards, forums, complaint sites, over 200 video sharing sites and Twitter.[4]

It is known that social media means information sites, social networks, blogs, microblogs, forums, etc., broadcast over the Internet. includes. Many media organizations, in addition to monitoring news, also monitor social media and analyze information about them on social media. There are over 100 different social media monitoring and evaluation services. The most famous free blog monitoring service companies are Technorati, Blog Pulse, IceRocket, and Google Blogs. Technorati, one of the giant companies in the field of web services and software of the United States, claims that 75 thousand blogs with 1.2 million new posts containing opinions about the products and services of companies are created every day. Social media monitoring helps to solve the following issues: a) Listening to the audience, accurately determining people's wishes and desires; b) Creating an interactive relationship with people; c) Disseminate the necessary information through social media channels; d) To analyze the activity of the institution aiming at the future. Recently, journalists have been using their accounts on social networks to interact with people and learn about problems in society, and exchange ideas on topics of interest to them.[4]

Although the Internet-media is still in the formative stage in our country, there are enough online media resources related to Azerbaijan: blogs, forums, news portals. Currently, the commission on Internet media resources operates within the Press Council (MSC) to control Internet media resources in our country. This

commission reviews the complaints received by the Council about online mass media, monitors the trends in the current field, the innovations noticeable on the international scale, and also aims to help eliminate negative situations related to journalistic responsibility in the Internet media. "Media Tracking Center", "Net-trends" media monitoring company, "A-Vision" media and communication company, Azerbaijan Media Monitoring Institute, engaged in media monitoring and analysis in Azerbaijan, analyze media and social networks and build marketing strategies and tactics in accordance with current trends they offer a wide range of operative and professional services. The service areas of these companies include national media monitoring, foreign media monitoring, social media monitoring, news agency monitoring, media advertising monitoring.

The conducted research proves the importance of media monitoring today. As the media has a direct influence on public opinion and people's choices, one of the main goals of media professionals around the world today is to take advantage of the positive effects of the media and use them for the right purposes. For this purpose, mass media should conduct monitoring in order to establish their strategies correctly, and by making effective decisions, they can achieve an increase in the reputation of the site.

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EARTH SCIENCES

PREDICTION OF DENSITY HETEROGENEOUSITY OF ROCKS ACCORDING TO GRAVITY PROSPECTING DATA

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Abstract

The article is devoted to the issue of predicting areas and boundaries of density heterogeneity of rocks based on gravity survey data. This question belongs to the category of solving the inverse problem of gravity exploration, which, as is known, can be solved ambiguously. So, in this case everyone has to use a priori information in order to solve such a problem at the right level. To predict areas and boundaries of density heterogeneity of rocks based on gravity survey data, two approaches are currently used. The first is the analytical continuation of the field into the lower half-space with the subsequent calculation of the full normalized gravity gradient, and the second is the use of a statistical connection between geological and geophysical data to predict the boundaries of the density heterogeneity of rocks.

Keywords: Gravity anomaly, analytical continuation, full normalized gradient, boundary prediction, density inhomogeneity.

Introduction

Analytical continuation of the potential field into the lower half-space followed by calculation of the full normalized gravity gradient along the profile is widely used in gravity exploration. Among these methods, the Berezkin method should be noted, according to which the observed gravity curve is subjected to a Fourier transform [2]. After this, the desired curve is represented as a sum of harmonic functions with various harmonics. This curve is then analytically continued into the lower half-space to various depths with a certain step. Next, at these depths, the full normalized gravity gradient is calculated, on the basis of which gradient maps along the section are constructed, which reflects the picture of the density heterogeneity of rocks. These maps highlight the maxima and minima of the total normalized gradient corresponding to areas of increasing or decreasing rock density. A sufficient number of publications are devoted to this problem [5,7,9-14].

Probability-statistical methods are used to predict interfaces with different densities. In this way, statistical relationships are determined between geological and geophysical data, such as, for example, between the gravity anomaly, or its transforms, and the depth of the interface between rocks with different densities according to seismic or drilling data. Such an analysis is first carried out on a reference territory with known values

of geological and geophysical parameters. Based on the principle of analogies, using correlations established on the standard, areas and boundaries of density heterogeneity of rocks are predicted. In both cases, due to the complexity of the calculations, a computer is used. The use of gravimetric data to predict the boundaries of rock heterogeneity using mathematical methods is currently widely used [1,3,6,8,15-18].

Means, methods and results

To predict areas of density heterogeneity of rocks based on gravity survey data, the Department of Geophysics has developed the Force-Fortran PNG program, which allows, based on the observed curve along the profile, to calculate the values of the full normalized gravity gradient (FNG) in the lower half-space at various depths [7,10,12]. To test this program, a model of the gravity curve along the observation profile was first compiled using the EXCEL program (Fig. 1). As can be seen, the curve has the shape of maximum gravity. The length of the profile is 12 km, the intensity of the anomaly is 7 mGal. This curve possibly represents an oval body with positive excess density in the section being studied.

To work with the PNG program, the initial data was first prepared in accordance with the program input statements. These data and calculation results are shown below.

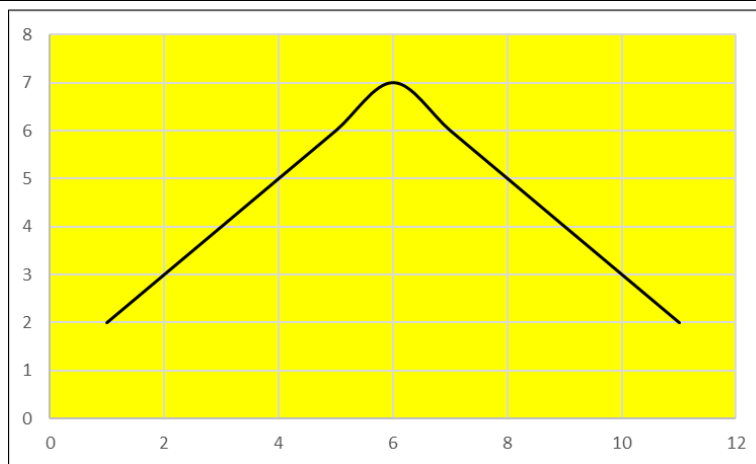


Fig.1. Profile gravity curve model

Initial data:

Number of point M= 11

Gravity values in integers

20000 30000 40000 50000 60000 70000 60000
50000 40000 30000
20000

Format factor FOR=10000.00 DX= 1.00

Starting, ending points and step along the profile in km

XH= 0.00 XZL= 9.00 DDX= 1.00

Start, end points and depth step of analytical continuation in km

ZH= 0.00 ZMAX= 7.00 HDZ 1.00

Initial, final number of harmonics and its step of change

NH= 10 NMAX= 30 ND= 10

Gravity values in mGals

2.0000 3.0000 4.0000 5.0000 6.0000 7.0000 6.0000
5.0000 4.0000 3.0000 2.0000

Gravity values without linear background

0.0000 1.0000 2.0000 3.0000 4.0000 5.0000 4.0000
3.0000 2.0000 1.0000 0.0000

Number of harmonics in Fourier expansion N=10

B_n - Fourier transform coefficients

4.0863 -0.0000 -0.4852 0.0000 0.2000 -0.0000 -0.1260
-0.0000 0.1025 0.0000

List= 1

Depth step of analytical continuation in km

0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00

Values of the total normalized gravity gradient (in depth)

: 9.00: : 0.81 0.68 0.44 0.23 0.41 0.64 0.80 0.89
: 8.00: : 0.86 0.68 0.51 0.62 0.75 0.85 0.92 0.96
: 7.00: : 1.00 0.83 0.47 1.05 1.17 1.12 1.07 1.04
: 6.00: : 1.25 1.53 2.04 1.89 1.62 1.36 1.20 1.11
: 5.00: : 1.38 1.93 2.84 2.37 1.83 1.47 1.25 1.13
: 4.00: : 1.25 1.53 2.04 1.89 1.62 1.36 1.20 1.11
: 3.00: : 1.00 0.83 0.47 1.05 1.17 1.12 1.07 1.04
: 2.00: : 0.86 0.68 0.51 0.62 0.75 0.85 0.92 0.96
: 1.00: : 0.81 0.68 0.44 0.23 0.41 0.64 0.80 0.89
: 0.00: : 0.79 0.63 0.25 0.03 0.27 0.56 0.76 0.87

Number of harmonics in Fourier expansion N= 20

B_n - Fourier transform coefficients

4.0863-0.0000-0.4852 0.0000 0.2000-0.0000-0.1260
-0.0000 0.1025 0.0000-0.1025 0.0000 0.1260 0.0000
-0.2000 0.0000 0.4852-0.0000-4.0863 0.0000

List= 1

Depth step of analytical continuation in km

0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00

Values of the total normalized gravity gradient (in depth)

: 9.00: : 0.76 0.56 0.77 0.87 0.93 0.96 0.98 0.99
: 8.00: : 0.80 0.66 0.85 0.93 0.97 0.98 0.99 1.00
: 7.00: : 0.91 0.88 1.02 1.03 1.02 1.01 1.01 1.00
: 6.00: : 1.12 1.43 1.27 1.14 1.08 1.04 1.02 1.01
: 5.00: : 2.08 2.41 1.43 1.20 1.10 1.05 1.03 1.01
: 4.00: : 1.12 1.43 1.27 1.14 1.08 1.04 1.02 1.01
: 3.00: : 0.91 0.88 1.02 1.03 1.02 1.01 1.01 1.00
: 2.00: : 0.80 0.66 0.85 0.93 0.97 0.98 0.99 1.00
: 1.00: : 0.76 0.56 0.77 0.87 0.93 0.96 0.98 0.99
: 0.00: : 0.74 0.53 0.74 0.85 0.92 0.95 0.97 0.99

Number of harmonics in Fourier expansion
N=30

B_n - Fourier transform coefficients

4.0863-0.0000-0.4852 0.0000 0.2000-0.0000-0.1260
-0.0000 0.1025 0.0000-0.1025 0.0000 0.1260 0.0000
-0.2000 0.0000 0.4852-0.0000-4.0863 0.0000 4.0863
-0.0000-0.4852-0.0000 0.2000 0.0000-0.1260-0.0000
0.1025 0.0000

List= 1

Depth step of analytical continuation in km

0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00

**Values of the total normalized gravity gradient
(in depth)**

: 9.00: : 0.38 0.43 0.55 0.37 0.32 0.62 0.79 0.89
: 8.00: : 0.77 0.80 0.80 0.90 0.77 0.84 0.91 0.95

: 7.00: : 1.17 1.17 0.92 0.35 1.07 1.11 1.07 1.04
: 6.00: : 1.59 1.59 1.51 1.71 1.64 1.39 1.21 1.12
: 5.00: : 2.16 1.86 2.03 2.92 2.09 1.53 1.27 1.14
: 4.00: : 1.59 1.59 1.51 1.71 1.64 1.39 1.21 1.12
: 3.00: : 1.17 1.17 0.92 0.35 1.07 1.11 1.07 1.04
: 2.00: : 0.77 0.80 0.80 0.90 0.77 0.84 0.91 0.95
: 1.00: : 0.38 0.43 0.55 0.37 0.32 0.62 0.79 0.89
: 0.00: : 0.03 0.18 0.43 0.41 0.33 0.55 0.75 0.86

As you can see, the initial number of harmonics is set to 10. The calculated values of the total normalized gravity gradient along the profile for this number of harmonics were entered into the SURFER graphic program and, based on the compiled "grid," a map of the FNG field was constructed to a depth of 7 km with a step of 1 km (Fig. 2). As can be seen, at approximately a depth of 2 km, a large FNG maximum with an intensity of 2.8 dimensionless FNG units is clearly observed. This maximum on the left and right is outlined by two minima of the full normalized gradient with an intensity of approximately 0.4 FNG units, reflecting areas of decreased rock density.

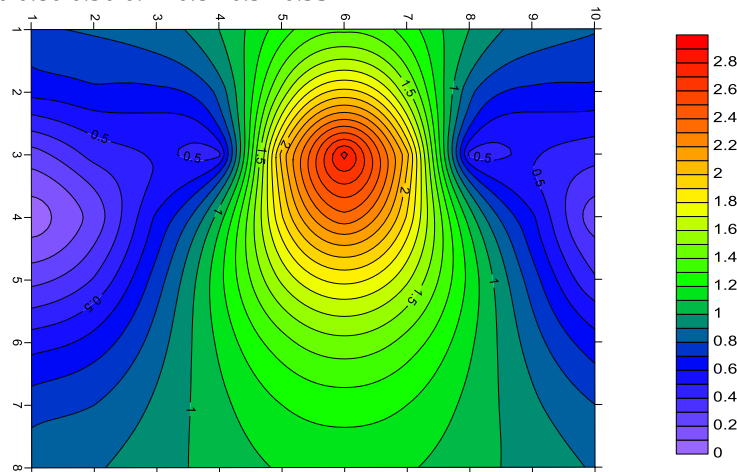


Fig.2. Field of the full normalized gravity gradient from the model curve (number of harmonics 10)

The same picture is observed on the constructed map of vectors of the total normalized gravity gradient for the number of harmonics 10 (Fig. 3).

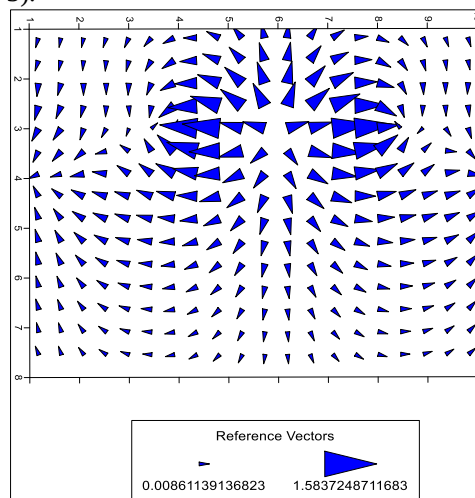


Fig.3.

Field of the full normalized gravity gradient from the model curve in vector form (number of harmonics 10)

Next, a similar FNG map was constructed for the number of harmonics equal to 20 (Fig. 4). As can be seen, the FNG maximum with an intensity of approximately 2.5 units has shifted upward to a depth of 1 km. As can be seen, the exact location of areas of density heterogeneity in rocks depends on the optimal selection

of the number of harmonics. Below is the constructed FNG section of the observed model curve for the number of harmonics $N=30$ (Fig. 5). As can be seen, the FNG

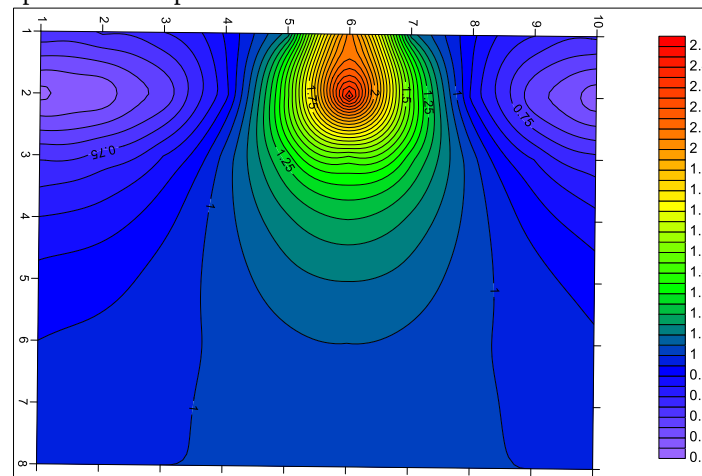


Fig.4. Field of the total normalized gravity gradient from the model curve (number of harmonics 20)

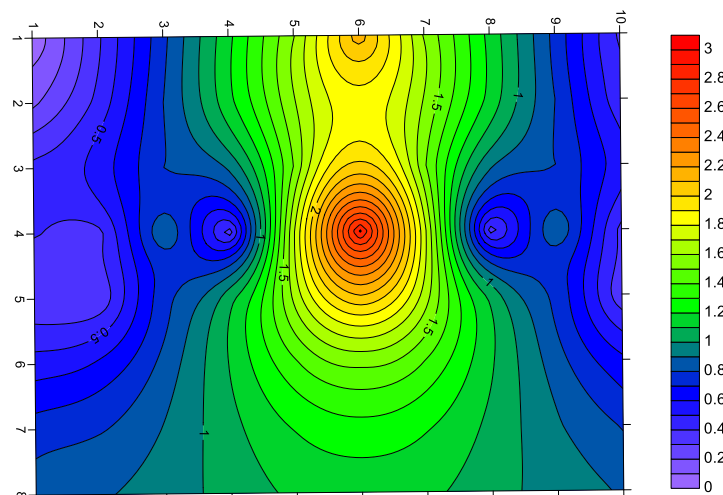


Fig.5. Field of the total normalized gravity gradient from the model curve (number of harmonics 30)

maximum shifted to a depth of 3 km and its intensity reached 3.0 FNG units. For the condition of the absence of a priori information, we have developed a technique for selecting the optimal number of harmonics according to the criterion of the maximum intensity of the APG values [10]. Therefore, in all likelihood, the depth of the heterogeneity zone is approximately 3 km.

To predict the boundaries of density heterogeneity of rocks, as stated above, statistical methods are used to construct structural map on the base of gravity and seismic data or drilling data on the depth of the desired boundary of density heterogeneity. These methods are used in modifications of multidimensional regression analysis (MRA) and correlation methods of separation of anomalies (COMS) [1,16-18]. At the Geophysics department of the ASOIU, where such studies were constantly carried out because this technique makes it possible to predict the boundaries of heterogeneity in hard-to-reach areas (mountainous areas, cultivated areas, marshy areas, etc.), where there is a sufficient amount of gravity and magnetic survey data. To implement

these methods, appropriate software has been developed.

According to the MRA method, at the beginning, correlation connections are established between the depths of the boundaries of different sedimentary strata accordingly to seismic exploration or drilling data also gravity anomalies and their results of processing, and in extrapolation of such connections to areas unstudied by seismic prospecting and drilling. Thereby the complex seismic geological conditions of individual areas of Azerbaijan, it is not possible to obtain unambiguous reference seismic data on the structure of the lower Mesozoic stage; the Department of Geophysics has developed a method of MRA with using only a representative part of conditional seismic horizons (CSH) with detailed and high-precision gravity reconnaissance. The representative part of density heterogeneity boundaries is understood as that part of the CSH which coincides in plan with the curve of the local gravity anomaly. The select of such a measure is based on the fact that in the case of one density contact boundary,

the local structure of the studied surface of density inhomogeneity in the gravitational field should be reflected in plan with much greater accuracy.

The correlation method of field separation (COMS) differs from methods of trend analysis in that it allows one to isolate from the observed field value a local anomaly that is best correlated with the depth of the inhomogeneity surface under study. According to the concept of correlation methods for converting anomalies, developed at the Moscow Institute of oil and gas named after Gubkina by I.I. Shraibman, M.S. Zhdanov, O.V. Vitvitsky, the initial gravitational field is represented as a sum [16]:

$$G_{\text{obser}} = G_{\text{res}} + G_{\text{back}}, \quad (1)$$

Here G_{obser} is the observed value of gravity parameter; G_{res} is a residual (local) component of gravity force; G_{back} is the regional component of gravity.

The background (regional) component of gravity is represented as a next polynomial:

$$G_{\text{back}} = \sum_{p=1}^N a_p f_p(x, y) \quad (2)$$

Here: a_p are the coefficients of the transformation polynomial; $f_p(x, y)$ are a basis functions depending on x, y, x^2, xy, y^2 and et al; N is a length of the transformation polynomial; x, y are the coordinates of measuring points. This polynomial is called a transformation polynomial. The residual or local component of gravity may be presented below:

$$G_{\text{res}} = \sum_{i=1}^{k-1} b_i j_i + c, \quad (3)$$

Here b_i, c are the coefficients of the linear equation of regression; k is number of geological or geophysical parameters reflected the density heterogeneity; j_i is a corresponding geological or geophysical parameter.

The coefficients of the regression equations a_p, b_i, c are determined from the condition of the minimum standard deviation of functional F :

$$F = [G_{\text{obser}} - \sum_{p=1}^N a_p f_p(x, y) - \sum_{i=1}^{k-1} b_i j_i - c]^2 \rightarrow \min \quad (4)$$

To do this, the following condition must be met:

$$\begin{cases} \frac{\partial F}{\partial c} = 0 \\ \frac{\partial F}{\partial a_p} = 0 \quad (p \in N), (i=1, 2, \dots, k-1) \\ \frac{\partial F}{\partial b_i} = 0 \end{cases} \quad (5)$$

From this condition one can determine the coefficients a_p, b_i, c .

This way to finding regression coefficients is called COMR-A. Within the framework of correlation methods for dividing fields, another approach is possible (KOMR-B), when a geological parameter, for example H (the boundaries of density heterogeneity of rocks) is considered as a function of its residual component G_{res} . For this case, the coefficients are determined from the condition:

$$\Phi = [H - b(G_{\text{obser}} - \sum_{p=1}^N a_p f_p(x, y) - c)]^2 \rightarrow \min \quad (6)$$

Nevertheless, in this approach the formulas for solving the system of equations became very complicated.

It should be noted that this approach is rational to use in the case when the boundaries of density heterogeneity of rocks is well reflected in the gravity field.

When the studied complex of heterogeneities is faintly reflected in the gravity field, such as, for example, a highly dislocated Upper Mesozoic complex of sediments which lying below the eroded surface of Upper Cretaceous sediments ("P" horizon), the MRA method turned out to be more effective [1,16-18]. The desired burial depth of the boundary of heterogeneities H in this case is represented as a next polynomial:

$$H = a_0 + a_1 \cdot \Delta g_{\text{Boug}} + a_2 \cdot \Delta g_5 + a_3 \cdot \Delta g_{\text{Boug}}^2 + a_4 \Delta g_{\text{Boug}} \cdot \Delta g_5 + a_5 \cdot \Delta g_5^2 \dots \quad (7)$$

Where a_0, a_i are the regression equation coefficients; $\Delta g_{\text{Boug}}, \Delta g_5$ are Bouguer anomaly, local anomaly and other gravity transformers.

The essence of correlation methods for predicting the boundaries of density inhomogeneities of rocks can be illustrated by the example of a model of a separate seismic-gravimetric profile pro file (Fig. 6). The quantized values of the initial data are shown below (Table 1). This figure shows a gravity curve along a 10 km profile, and at the bottom of the section the interface between two media with different densities is shown. As can be seen, there is a correlation between gravity survey data and the depth of the interface according to seismic survey or drilling data. Moreover, from a mathematical point of view, this relationship will be inverse, so we will predict this boundary using the formula:

$$H_{\text{pi}} = \frac{a}{\Delta g_i} \quad (8)$$

Here H_{pi} are the predicted depth values; Δg_i - gravity values; a is the coefficient of the regression equation.

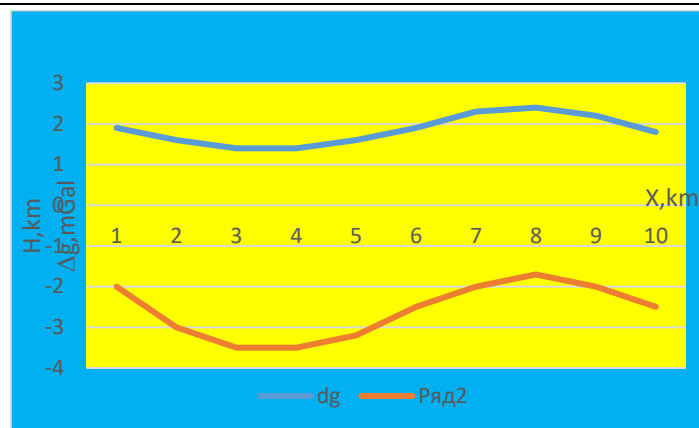


Fig.6. Model of a separate seismic -gravimetric profile

Table 1

Values of gravity and depth of the density boundary on the reference profile

N ₀	1	2	3	4	5	6	7	8	9	10
Δg_i	1.9	1.6	1.4	1.4	1.6	1.9	2.3	2.4	2.2	1.8
H_i	-2.0	-3.0	-3.5	-3.5	-3.2	-2.5	-2.0	-1.7	-2.0	-2.5

The coefficient of the regression equation is found using the least squares method using the formula:

$$a = \frac{\sum_{i=1}^n \frac{H_i}{\Delta g_i}}{\sum_{i=1}^n \frac{1}{\Delta g_i^2}}, \quad (8)$$

where H_i , Δg_i are the current values of depth and gravity on the model reference profile.

Using this formula on the computer, the calculated value is $a = 4.67$. The results of calculating the predicted values of the interface depth and the initial data are shown below (Table 2). Based on the calculation results using the EXEL program, a graph of the predicted seismogravimetric profile was constructed (Fig. 7). As can be seen, the predicted interface between the two media (shown in black on the graph) coincides well with the actual boundary and the standard deviation does not exceed approximately 200 m.

Table 2

Results of calculation of predicted values of interface depth

N ₀	1	2	3	4	5	6	7	8	9	10
Δg_i	1.9	1.6	1.4	1.4	1.6	1.9	2.3	2.4	2.2	1.8
H_i	-2.0	-3.0	-3.5	-3.5	-3.2	-2.5	-2.0	-1.7	-2.0	-2.5
$H_{i\text{progn}}$	-2.4	-2.9	-3.3	-3.3	-2.9	-2.5	-2.0	-1.9	-2.1	-2.6

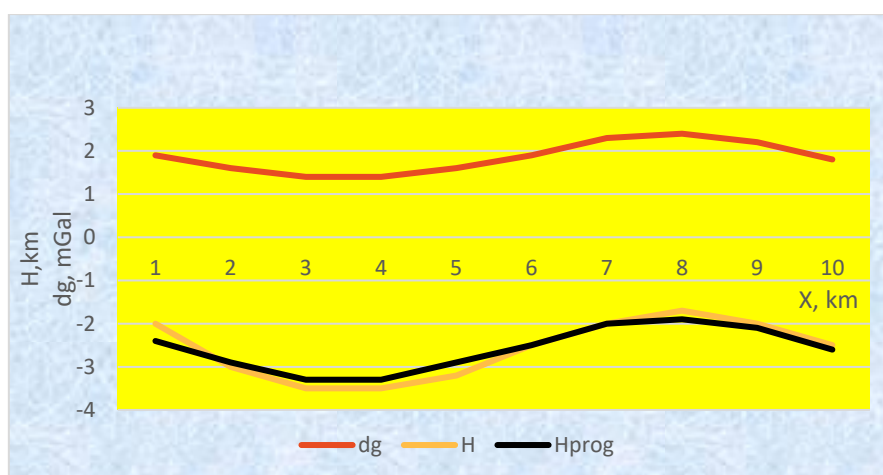


Fig.7. Predictive seismic-gravimetric profile model

Conclusions:

1. Methods for predicting areas and boundaries of density heterogeneity of rocks based on gravity survey data are analyzed. It is shown that these methods belong to the class of problems for solving inverse problems of gravity exploration.

2. The model curve along the gravity profile with a length of 8 km was compiled to predict areas of density heterogeneity of rocks using the GNORM Force-Fortran program, which developed at the Department of Geophysics.

3. Based on the compiled model of the gravity curve, the initial data were prepared for work using the GNORM program in accordance with the input operators and calculations of the full normalized gravity gradient along the profile were performed for the number of harmonics 10, 20 and 30 in the Fourier expansion.

4. Based on the results of calculating the values of the full normalized gravity gradient using a graphical program, sections of the full normalized gravity gradient along the profile were constructed for depths up to 7 km with a step of 1 km. Analysis of these sections showed, firstly, the effectiveness of the GNORM program for predicting areas of density heterogeneity of rocks, and secondly, the possibility of selecting the optimal number of harmonics in the absence or insufficiency of a priori information.

5. The mathematical foundations of methods for interpreting gravimetric data in combination with seismic geological data are considered by establishing correlations between them to predict the geological boundaries of density heterogeneity of rocks on the bases of results of statistical analysis.

6. Correlation methods of interpreting gravitational data, correlation methods of field separation and multidimensional regression analysis are analyzed, as well as algorithmic support for these method was developed at the Department of Geophysics.

7. A correlation connection has been established between gravity and seismic model data on the reference profile of the study. A feedback relationship has been established between geophysical data on this profile. Based on the established feedback, the values of the depths of the interface of the density heterogeneity of rocks were predicted using modern graphical software.

8. The research results obtained can be used to guide further gravimetric survey and to identify oil and gas promising areas of density heterogeneity of rocks.

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ECONOMY

MƏQSƏD STRATEGİYANIN ƏSASI KİMİ

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OBJECTIVE AS THE BASIS OF STRATEGY

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Xülasə

Tədqiqatın məqsədi – Məqsədin strategiyada rolunun qiymətləndirilməsi.

Tədqiqatın metodologiyası – Araşdırmada müqayisəli təhlil üsulundan istifadə olunmuşdur.

Tədqiqatın tədbiqi əhəmiyyəti – Araşdırmanın əsas müddəaları məqsədin düzgün müəyyən edilməsi ilə strategiyaların hazırlanmasında müsbət nəticə əldə olunması.

Tədqiqatın nəticələri – Məlum olur ki, müəssisənin adekvat məqsədləri məhsulun inkişafı, daxili mühit, xarici mühit amilləri ilə sıx bağlıdır.

Tədqiqatın elmi yeniliyi – İdarəetmədə strategiyaların məqsəddən istifadə asılılığı əsaslandırılmışdır.

Abstract

The purpose of the study – Assessing the role of goals in strategy.

Methodology of the research – The comparative analysis method was used in the research.

The applied importance of the research – The main provisions of the research are to achieve a positive result in the development of strategies with the correct definition of the goal.

Results of the study – It turns out that adequate goals of the enterprise are closely related to product development, internal environment, and external environment factors.

Scientific novelty of the research – The dependence of strategies in management on the purpose of use is justified.

Açar sözlər: strategiya, məqsəd, layihə, missiya, müəssisə.

Keywords: strategy, goal, project, mission, enterprise.

Giriş. Strategiya, ən ümumi formada, qarşıya qoyulmuş məqsədə nail olmaq üçün proqramdır: layihələr və planlar, onların mərhələləri, aralıq məqsədləri, son tarixlər, resurslar və s. Üstəlik, qarşıya qoyulan məqsəd nədən ibarətdirsə, ona nail olmaq üçün konkret strategiya da belə olacaq. Əldə edilən nəticə təxminən eyni olacaq, çünki məqsəd gözlənilən nəticədir. Və nəticə ilk növbədə məqsədin özündən asılıdır. Məqsəd az qiymətləndirilsə, nəticə də aşağı qiymətləndiriləcəkdir. Məqsəd çox yüksəkdirsə, heç bir nəticə əldə etməyə bilərsiniz. Məqsəd üçün əsas tələblərdən biri də onun əldə edilə bilən olmasıdır. Ancaq optimal məqsəd qoymaq - maksimum, lakin əldə edilə bilən, təcrübənin göstərdiyi kimi, müasir idarəetmənin ən çətin məsələsidir.

Materiallar və metodlar. Məqsədin müəyyənləşdirilməsi mərhələlərinə nəzər salaq. Əksər müəssisələrin ümumi məqsədi sosial-iqtisadi məqsəddir - müəssisə cəmiyyətdə nəyə nail olmaq istəyir, hansı iqtisadi effekt əldə etmək istəyir və hansı fəaliyyət sahəsindədir. Fəaliyyət dairəsi isə məqsəd qoymazdan əvvəl yaranan ilk sualdır, müəssisənin missiyası, onun cəmiyyətdə mövcudluğunun sosial mənası. Və onun əldə edilə bilən sosial və iqtisadi məqsədləri əsasən müəssisənin hansı missiyanı seçməsindən asılıdır.

Məqsəd təyin etmədən əvvəl ikinci sual müəssisənin siyasətidir: normalar, onun fəaliyyətinin

qaydaları, prinsipləri. Məqsədlər də, strategiya da onlardan asılıdır. Məsələn, biz üçüncü tərəflərin vəsaitlərinin cəlb edilməsi siyasətini qəbul etsək, o zaman bizim məqsədlərimiz və strategiyamız eyni olacaq, ancaq öz daxili ehtiyatlarımızdan istifadə etsək, fərqli olanlarımız olacaq [1, s.97]. Missiya və siyasət haqqında qərar verərək, biz, prinsipcə, müəssisənin məqsədini təyin edə bilərik, lakin bu, yalnız daxili və xarici mühitin biliyi və proqnozlaşdırılması əsasında adekvat şəkildə edilə bilər.

Qətiyyətlə deyə bilərik: məqsədsiz strategiya yoxdur. Halbuki, Belinskinin 200 il əvvəl dediyi kimi, maraqsız məqsəd, məqsədsiz isə fəaliyyət yoxdur. Bunu həm psixoloqlar, həm də sosioloqlar daha sonra göstərdilər. Və fəaliyyət olmadan heç bir nəticə olmayacaq. Bu, qarşıya qoyulmuş məqsədə çatmaq, verilmiş yekun nəticəni əldə etmək üçün motivasiya məsələsidir. Və bu çox vacib sualdır: istifadə olunan motivasiya sistemindən asılı olaraq əldə edilə bilən nəticə 100 il əvvəl Frederik Taylorun göstərdiyi kimi faizlə deyil, bir neçə dəfə dəyişir [2, s.79]. Müvafiq olaraq, müəssisənin qarşısına qoya biləcəyimiz məqsəd qəbul edilmiş motivasiya sistemindən asılıdır. Və məqsəd qoymazdan əvvəl yenə də motivasiya məsələsini nəzərdən keçirmək lazımdır və əgər motivasiya sistemi komandanı maksimum məqsədlər qoymağa və onlara nail olmağa yönəltmir və səfərbər etmərsə, işlənilən hazırlanan strategiyada hədəfləri

dəyişdirmək üçün müvafiq layihələri təmin etmək lazımdır. Eynilə müəssisənin yekun nəticələrinə təsir edən digər məsələlər: fəaliyyətin təşkili (motivasiya yalnız təşkilatın bir hissəsidir), texniki təchizat və s.

Beləliklə, məqsəd qoymazdan əvvəl daxili mühitin bütün digər məsələlərini diqqətlə nəzərdən keçirmək, müəssisənin əldə edə biləcəyi maksimum əldə edilə bilən məqsədləri müəyyən etmək lazımdır. Burada son dərəcə vacib bir fakt var: əgər komanda yüksək məqsədlərə çatmağa həvəslidirsə, o, özü maksimum əldə edilə bilən məqsədləri dəqiq müəyyənləşdirəcək və qarşıya qoyacaq, bu məqsədlərə çatmağın yollarını müəyyən edəcək. Əks təqdirdə, komanda minimal məqsədlər qoyacaq və əsaslandıracaq və bununla inzibati üsullarla mübarizə aparmaq praktiki olaraq faydasız olacaq.

Həqiqətən əldə edilə bilən məqsədlər müəssisənin məhsullarını istehlak edən və müvafiq iqtisadi nəticə verən xarici mühitdən və əlbəttə ki, müəssisənin məhsullarının özündən asılıdır - məhsullar tələblərə cavab vermirsə istehlakçıların ehtiyacı olsa, onu heç kim almayacaq, müəssisə iqtisadi effekt verməyəcək və sosial olmayacaq. Müəssisənin məqsədini yalnız xarici mühiti nəzərə almaqla, zərurət yarandıqda onu lazımi istiqamətdə dəyişdirmək üçün strategiya layihələrini daxil etməklə müəyyən etmək olar.

Bundan əlavə, rəqiblərin və analoqların təhlili bizə onların siyasətlərini, təşkilini, performans nəticələrini müəyyən etməyə və onları özümüzlə müqayisə etməyə imkan verir. Və bu, zahiri olaraq müəssisənin məqsədləri üçün müəyyən məhdudiyyətlər qoya bilər - aşağı hədd rəqəbat qabiliyyətinin astanasındadır, yuxarı həddi isə sənayesindəki maksimum nəticələrdən bir qədər yuxarı səviyyədədir.

Məhsulları araşdırdıqdan, daxili və xarici mühiti təhlil etdikdən və maksimum səmərəliliyi təmin etmək üçün onların nə olması lazım olduğunu başa düşdükdən sonra həqiqətən, rəqəbat mühitində müəssisəmiz haqqında ümumi baxış əldə edirik. Qəbul edilmiş siyasətlər çərçivəsində maksimum əldə edilə bilən məqsədləri təyin etməyə və onlara nail olmağa, maksimum səmərəliliyə və rəqəbat qabiliyyətinə nail olmağa imkan verən müəssisənin vizyonu daxildir. Yalnız qeyd olunan bütün məsələlərin kompleksini nəzərdən keçirdikdən sonra müəssisənin əldə edilə bilən maksimum məqsədini adekvat şəkildə təyin etmək olar və sonra ona nail olmaq üçün strategiya hazırlamağa - bu məqsədə çatmağa aparan bir sıra tədbirləri müəyyən etməyə başlaya bilərsiniz [3, s.30].

Missiya, qeyd edildiyi kimi, müəssisənin cəmiyyətdəki məqsədi, sosial zəruri məqsədlərin formalaşdırılması, müəssisənin öhdəsinə götürdüyü nailiyyətlər, müəssisənin əsas siyasətidir. Missiya nəinki müəssisənin fəaliyyət istiqamətini göstərir, həm də komandanın fəaliyyətini məqsədlərinə çatmağa yönəldən güclü qeyri-maddi stimuldur.

Eyni zamanda, müəssisənin formalaşmış missiyası bizə birbaşa müəssisənin məqsədini təyin etməyə imkan vermir. Məqsəd kimi missiya motivasiyada rol oynayır. Bazar yeri isə daxili və xarici mühitdə, müəssisənin məhsullarındadır.

Nəticələr və müzakirə. Beləliklə, məqsəd qoymağın əsas yolları üç sahədə göstəricilərə əsaslanır: məhsullar, xarici və daxili mühit. Yalnız bu göstəricilərə malik olmaqla, müəssisənin adekvat

məqsədlərini və müəssisənin inkişafı üçün ən sərfəli istiqamətləri müəyyən etmək olar:

- *məhsulun inkişafı;*
- *daxili mühit (məhsul istehsalının təmin edilməsi);*
- *xarici mühit (məhsulların istehlakının təmin edilməsi).*

Xüsusilə qeyd etmək lazımdır ki, müəssisənin nəticəsini mülküyyətçi, müəssisənin direktoru deyil, müəssisənin bütün kollektivinin əməyi ilə əldə edir. Ona görə də hər kəs, o cümlədən müəssisə rəhbəri, iyerarxiyanın bütün səviyyələrində olan struktur bölmələrinin rəhbərləri və hər bir işçi maksimum əldə edilə bilən hədəfin qarşıya qoyulması və ona nail olunmasında maraqlı olmalıdır. Hər kəsin öz istehsal məqsədi və ona nail olmaqda marağı (motivi) olmalı və öz şəxsi gözlənilən nəticəsini bilməlidir.

Müvafiq olaraq, yalnız müəssisənin maksimum əldə edilə bilən məqsədini deyil, həm də müəssisə iyerarxiyasının bütün səviyyələrində "məqsədlər ağacı", maksimum əldə edilə bilən məqsədləri inkişaf etdirmək lazımdır. Ancaq bu sadə və aydın sualdan uzaqdır; bu, strategiyalar ağacının, məqsədlər ağacının, təşkilati strukturun özünün (müəssisənin məqsədi və strategiyasına ən uyğun olanı), iyerarxiik planların, biznes proseslərinin sinxron inkişafıdır. Eyni zamanda, həm məqsədlərin üfqləri, həm də onlara nail olmaq üçün planların təfərrüatları iyerarxiyanın müxtəlif səviyyələrində fərqli olacaqdır. Müxtəlif səviyyələrdə məqsəd və strategiyaların sabitliyi də fərqlidir. Daxili və xarici mühitin sapmalarından maksimum dərəcədə asılı olaraq aşağı səviyyələrin məqsədləri və ətraflı strategiyası qısamüddətli və kifayət qədər dinamikdir. Dəyişən şəraitdə yuxarı səviyyələrin strategiyasının sabitliyini və müəssisənin məqsədlərinə çatmasını təmin etmək üçün onlar dinamikdir.

Yekun nəticə. Artıq qeyd etdik ki, o, maksimum əldə edilə bilən məqsədləri (təbii ki, etik standartlara uyğun olaraq) müəyyən etmək və onlara nail olmaq iqtidarında olan effektiv müəssisədir. Səmərəliliyin özü isə maksimum əldə edilə bilən məqsədləri müəyyən etmək və onlara nail olmaq bacarığıdır. Bu, yalnız maksimum əldə edilə bilən məqsədlərin qoyulması müəssisənin bütün iyerarxiyası boyunca iki əks istiqamətdə - yuxarıdan aşağıya və aşağıdan yuxarıya getdikdə mümkündür. Həm təşkilatçılıq, həm də özünü-təşkilat prinsipləri haqqında qeys oluna bilər. Və təşkilatın əsas vəzifələrindən biri özünü-təşkilatı formalaşdırmaq və saxlamaqdır.

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OPTIMIZING PRODUCTION MANAGEMENT: STRATEGIES FOR EFFICIENCY AND QUALITY

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DOI: [10.5281/zenodo.11188955](https://doi.org/10.5281/zenodo.11188955)**Abstract**

In the dynamic landscape of modern manufacturing, optimizing production management stands as a critical imperative for organizations striving to remain competitive. This article delves into the intricacies of production management, focusing on strategies tailored to enhance both efficiency and quality. Through a comprehensive examination of industry best practices and innovative methodologies, the article explores how the integration of advanced technologies, such as automation and data analytics, can revolutionize traditional production paradigms. Furthermore, it delves into the importance of fostering a culture of continuous improvement and employee empowerment to drive operational excellence. By synthesizing insights from diverse sectors and real-world case studies, this article offers actionable guidance for production managers seeking to navigate the complexities of today's manufacturing landscape and achieve sustainable success.

Keywords: production, efficiency, manufacture, enterprise, quality.

Introduction

In today's dynamic business landscape, the mantra of success for any manufacturing enterprise reverberates around two key pillars: efficiency and quality. As industries evolve and consumer demands become increasingly nuanced, the pressure mounts on production managers to navigate a complex web of challenges while ensuring seamless operations and top-notch product standards. Enter the realm of production management, where the orchestration of resources, processes, and personnel holds the key to unlocking operational excellence.

This article delves into the heart of production management, exploring a myriad of strategies tailored to enhance efficiency and uphold uncompromising quality standards. From harnessing cutting-edge technologies to fostering a culture of continuous improvement, the quest for optimization encompasses multifaceted approaches that resonate with the core ethos of modern manufacturing. Join us as we embark on a journey through the realm of production management, uncovering actionable insights, best practices, and innovative solutions designed to propel your organization towards unparalleled efficiency and excellence [1].

In an era defined by rapid technological advancements and ever-evolving market dynamics, the landscape of production management is undergoing a profound transformation. Gone are the days of traditional, siloed approaches; instead, forward-thinking enterprises are embracing a holistic perspective that integrates digital innovations with time-honored principles of operational excellence. At the heart of this paradigm shift lies the pursuit of efficiency – the relentless quest to minimize waste, optimize resource utilization, and streamline workflows. Yet, efficiency alone is not sufficient to guarantee success; in an era where consumer expectations soar to unprecedented heights, the imperative to deliver uncompromising quality looms large. Hence, the synthesis of efficiency and quality emerges

as the cornerstone of effective production management, underpinning every facet of organizational performance.

Through this exploration, we aim to dissect the anatomy of successful production management, offering a roadmap that empowers leaders to navigate the complexities of the modern manufacturing landscape with confidence and clarity. From the adoption of agile methodologies to the embrace of data-driven decision-making, the strategies elucidated herein represent a tapestry of proven tactics and innovative approaches, meticulously woven to foster operational excellence and drive sustainable growth. Join us as we embark on a voyage of discovery, unraveling the intricacies of production management and illuminating the path towards a future where efficiency and quality converge to redefine the boundaries of possibility [2].

In the fast-paced world of manufacturing, optimizing production management stands as a beacon of competitiveness and sustainability. Efficiency and quality serve as the bedrock upon which successful production operations are built. In today's hyper-competitive landscape, where markets evolve swiftly and consumer expectations continue to escalate, mastering the intricacies of production management is no longer an option—it's a necessity for survival and growth.

Efficiency and quality are not merely buzzwords; they represent the essence of operational excellence. Efficiency encompasses the judicious use of resources, streamlined processes, and swift execution, while quality denotes the ability to meet or exceed customer expectations consistently. Balancing these two elements requires a nuanced approach, integrating strategies that enhance productivity without compromising on product integrity. In this comprehensive guide, we delve deep into the realm of production management, unraveling a plethora of strategies meticulously crafted to optimize efficiency and quality. From the adoption of lean manufacturing principles to the integration of cutting-

edge technologies and the cultivation of a culture of continuous improvement, we explore the multifaceted landscape of production management, offering actionable insights and practical advice for organizations striving to stay ahead of the curve.

Lean Manufacturing: Streamlining Processes for Enhanced Efficiency and Quality

At the heart of efficient production management lies the philosophy of lean manufacturing. Originating from the Toyota Production System, lean principles advocate for the elimination of waste across all facets of production. Waste, in this context, refers to any activity that does not add value to the end product, be it excess inventory, unnecessary motion, overproduction, defects, or underutilized talent. One of the foundational concepts of lean manufacturing is value stream mapping—a systematic approach to identifying and visualizing every step in the production process, from raw materials to finished goods. By meticulously analyzing value streams, organizations can pinpoint inefficiencies, identify bottlenecks, and devise targeted interventions to streamline workflows and optimize resource utilization. Furthermore, the 5S methodology—sort, set in order, shine, standardize, and sustain—provides a framework for organizing the workplace, minimizing clutter, and fostering a culture of cleanliness and orderliness. By standardizing processes and ensuring workplace discipline, organizations can create an environment conducive to productivity and quality.

Just-in-Time (JIT) production is another cornerstone of lean manufacturing, emphasizing the timely delivery of materials and components to the production line, thereby minimizing inventory costs and reducing lead times. By synchronizing production with customer demand, organizations can eliminate excess inventory, lower carrying costs, and respond swiftly to market fluctuations [3].

Lean manufacturing is a powerful methodology aimed at streamlining processes to enhance efficiency and quality within manufacturing operations. Originating from the Toyota Production System (TPS) in the 1950s, lean principles have since been adopted by organizations worldwide, revolutionizing the way products are made and improving overall business performance. At its core, lean manufacturing is centered around the elimination of waste, which refers to any activity that does not add value from the customer's perspective. This waste can manifest in various forms, including excess inventory, unnecessary motion, overproduction, defects, waiting time, and underutilized talent. By identifying and eliminating these inefficiencies, lean manufacturing strives to create a leaner, more agile, and more responsive production system. One of the foundational concepts of lean manufacturing is value stream mapping (VSM), a visual tool used to analyze and optimize the flow of materials and information throughout the production process. By mapping out every step in the value stream—from raw materials to finished products—organizations can identify bottlenecks, redundancies, and opportunities for improvement. This enables them to design a more streamlined and efficient production flow, reducing lead times,

minimizing inventory levels, and increasing overall throughput.

Additionally, lean manufacturing emphasizes the importance of continuous improvement, known as *kaizen*, which encourages employees at all levels of the organization to identify and implement small, incremental changes to improve processes and eliminate waste. This culture of continuous improvement fosters innovation, empowers employees, and ensures that the organization remains adaptable and responsive to changing market conditions [4].

Furthermore, lean manufacturing promotes the concept of standardized work, which involves documenting and optimizing the best practices for performing tasks within the production process. By standardizing work processes and procedures, organizations can ensure consistency, reduce variability, and improve overall quality. In summary, lean manufacturing offers a comprehensive framework for streamlining processes, reducing waste, and enhancing efficiency and quality within manufacturing operations. By embracing lean principles and methodologies, organizations can achieve significant improvements in productivity, cost-effectiveness, and customer satisfaction, positioning themselves for long-term success in today's competitive marketplace.

Integration of Advanced Technologies: Driving Efficiency and Enhancing Quality

In an era defined by technological innovation, the integration of advanced technologies has emerged as a game-changer in production management. Automation, robotics, artificial intelligence (AI), and the Internet of Things (IoT) are revolutionizing manufacturing processes, enabling organizations to achieve unprecedented levels of efficiency and quality.

Automation plays a pivotal role in streamlining repetitive tasks, reducing human error, and increasing throughput. Automated assembly lines, robotic arms, and automated material handling systems can significantly boost productivity while ensuring consistency and precision in product assembly. Moreover, AI-powered predictive analytics are transforming the landscape of maintenance management, enabling organizations to anticipate equipment failures before they occur. By analyzing sensor data and historical performance metrics, AI algorithms can identify patterns indicative of impending failures, allowing maintenance teams to take proactive measures to prevent unplanned downtime and minimize disruptions to production.

Data-driven decision-making is another hallmark of modern production management, leveraging the vast amounts of data generated by production processes to inform strategic decision-making. By harnessing advanced analytics tools, organizations can gain valuable insights into production performance, identify areas for improvement, and optimize processes to enhance efficiency and quality continually [5].

Integrating advanced technologies is crucial for driving efficiency and enhancing quality in today's competitive business landscape. Here's a comprehensive approach on how organizations can effectively integrate advanced technologies to achieve these goals:

1. Assessment of Current Processes:

Identify Pain Points: Conduct a thorough assessment of existing processes to identify inefficiencies and areas where quality can be improved.

Understand Requirements: Understand the specific needs and requirements of your organization to tailor technology integration accordingly.

2. Strategic Planning:

Alignment with Objectives: Ensure that the integration of advanced technologies aligns with the organization's strategic objectives and long-term vision.

Prioritize Investments: Prioritize technologies that offer the highest potential for improving efficiency and quality while maximizing return on investment.

3. Selection of Technologies:

Automation and Robotics: Implement automation and robotics solutions to streamline repetitive tasks and reduce errors, thereby enhancing efficiency and quality.

AI and Machine Learning: Utilize AI and machine learning algorithms to analyze data, optimize processes, and predict potential quality issues before they occur.

IoT and Sensors: Deploy IoT devices and sensors to monitor equipment performance, track production processes in real-time, and ensure adherence to quality standards.

Advanced Analytics: Leverage advanced analytics tools to gain actionable insights from data, identify trends, and make data-driven decisions to improve quality and efficiency.

4. Integration and Connectivity:

Interoperability: Ensure seamless integration and interoperability of different technologies and systems to enable smooth data flow and communication across the organization.

Cloud Computing: Embrace cloud-based solutions to facilitate accessibility, scalability, and collaboration while reducing infrastructure costs [6].

5. Employee Training and Upskilling:

Training Programs: Provide comprehensive training programs to equip employees with the skills and knowledge needed to effectively utilize advanced technologies.

Encourage Adoption: Foster a culture of continuous learning and experimentation to encourage employees to embrace new technologies and drive innovation.

6. Quality Assurance and Control:

Real-Time Monitoring: Implement real-time monitoring systems to track quality metrics and detect deviations from standards promptly.

Quality Management Software: Deploy quality management software to standardize processes, automate workflows, and ensure compliance with quality standards and regulations.

7. Continuous Improvement:

Feedback Mechanisms: Establish feedback mechanisms to gather insights from employees and customers for ongoing improvement of processes and products.

Iterative Approach: Adopt an iterative approach to technology integration, continuously refining and optimizing processes based on feedback and performance data.

8. Data Security and Privacy:

Security Measures: Implement robust cybersecurity measures to protect sensitive data and ensure compliance with privacy regulations.

Ethical Use: Ensure ethical use of data and technology, adhering to principles of transparency, accountability, and fairness.

9. Supplier and Partner Collaboration:

Collaborative Relationships: Foster collaboration with technology suppliers and partners to stay updated on the latest advancements and best practices.

Co-Innovation: Explore opportunities for co-innovation and co-development of customized solutions to address specific business needs [7].

10. Continuous Evaluation and Adaptation:

Performance Metrics: Define key performance indicators (KPIs) to measure the impact of technology integration on efficiency and quality.

Iterative Improvement: Continuously evaluate the performance of integrated technologies and processes, making adjustments as needed to optimize outcomes.

By following these steps and integrating advanced technologies strategically, organizations can drive significant improvements in efficiency, quality, and competitiveness, ultimately leading to sustained growth and success.

Cultivation of a Culture of Continuous Improvement: Empowering Employees for Success

While technology undoubtedly plays a crucial role in optimizing production management, true transformation requires more than just technological solutions—it demands a cultural shift within the organization. Cultivating a culture of continuous improvement is essential for fostering innovation, empowering employees, and driving sustainable improvements in efficiency and quality. At its core, a culture of continuous improvement encourages employees at all levels of the organization to actively participate in problem-solving, share ideas for improvement, and take ownership of their work. By fostering a sense of ownership and accountability, organizations can tap into the collective wisdom of their workforce, unlocking untapped potential and driving meaningful change. Moreover, employee training and development play a vital role in equipping workers with the skills and knowledge needed to excel in their roles. By investing in employee training programs, organizations can empower their workforce to adapt to changing technologies, embrace new methodologies, and drive continuous improvement initiatives [8].

Furthermore, effective communication and collaboration are essential for fostering a culture of continuous improvement. By facilitating open communication channels and encouraging cross-functional collaboration, organizations can break down silos, promote knowledge sharing, and leverage the diverse perspectives of their workforce to drive innovation and improvement.

Conclusion:

In conclusion, optimizing production management is a multifaceted endeavor that demands a holistic approach. By embracing lean manufacturing principles, integrating advanced technologies, and cultivating a culture of continuous improvement, organizations can

unlock new levels of efficiency and quality in their production operations. In an increasingly competitive marketplace, mastering these strategies is essential for staying ahead of the curve, delivering value to customers, and ensuring long-term success and profitability. Through the implementation of various strategies discussed in this article, such as lean manufacturing, automation, supply chain integration, and continuous improvement methodologies, companies can enhance their operational efficiency, minimize waste, and meet evolving customer demands.

By adopting a holistic approach that encompasses technology, process optimization, and employee empowerment, businesses can streamline their production processes, reduce costs, and improve overall quality. Moreover, fostering a culture of innovation and adaptability enables organizations to respond swiftly to market changes and stay ahead of the curve.

While the journey towards optimized production management may present challenges, the rewards in terms of increased productivity, enhanced customer satisfaction, and sustainable growth are substantial. Embracing these strategies not only positions companies for success in the present but also equips them to navigate future disruptions and thrive in an ever-evolving marketplace. Ultimately, by prioritizing efficiency and quality in production management, businesses can unlock their full potential, drive profitability, and establish themselves as industry leaders in the global market.

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CHARACTERISTICS AND ANALYSIS OF FACTORS AFFECTING BUSINESS

Israilov B.*doctor of economics, professor*DOI: [10.5281/zenodo.11188959](https://doi.org/10.5281/zenodo.11188959)**Abstract**

The effectiveness of the system of relations between the state and business entities is a positive factor of the socio-economic situation in the country. No matter how optimal the state policy is for creating the necessary conditions for business entities, any economic policy will not be effective if the business entity does not organize its activities properly. In the article, the authors studied the issue of internal and external factors affecting the activity of business entities and expressed their attitudes.

Keywords: state, business, business entity, state economic policy, efficiency, factors, analysis, result.

INTRODUCTION. The Sustainable Development Goals (SDGs) program of the United Nations recommends that the poor, rich and middle-developed countries of the world focus their activities on improving the well-being of the population and ensuring the protection of our planet. Efforts to eradicate poverty require increasing economic activity in order to increase economic growth and address a

number of challenges, such as education, health, social protection and employment. For this, it is planned to double the share of production in the gross domestic product (GDP), for which countries will spend approximately 1.051 billion US dollars annually [1].

It is known that the main source of income of the budget is tax revenue (Tab.1).

1- Table

The share of tax revenues in the budget revenues of states, %

T / r	Countries	Share of tax revenues in the state budget, %
1.	USA	95.5
2.	Great Britain	90.0
3.	Belarus	90.0
4.	Bulgaria	45.0
5.	Germany	89.0
6.	Italy	80.0
7.	Russia	90.0
8.	Czechia	68.5
9.	Kazakhstan	83.0
10.	Kyrgyzstan	68.0
11.	Uzbekistan	94.0

Source: Prepared by the author based on information from <https://ru.wikipedia.org/wiki>.

Taxes are formed due to the redistribution of income of business entities in the order and norms established by the legislation.

Research methodology. Methods such as logical thinking, analysis, synthesis, comparison and grouping are used in order to conduct research on the topic and justify the results.

Analysis of literature on the topic. O.D.Yevseyev [2], I.I.Mazur, V.D.Shapiro [3], M.Robson, M.Ullakh [4], A.G.Rindin, G.A.Shamayev [5], M.Hammer, J.Champi [6] about organizations of business entities and their specific features, J.H.Martin [7], M. Porter, V. Millar [8], A V Radchenko [9] were studied in the works of scientists.

IIMazur and VDS Shapiro give opinions that the business process is a systematic closed process, M.Robson, M.Ullakhlar work system, M.Hammer, J.Champilar the stages of activity and its results, A.V. Radchenko gives the opinion that the organization's activities are aimed at making a profit.

The role of taxes in the formation of state revenues and theoretical issues of regulating tax relations A. Temur [10], A. Smith [11], D. Ricardo [12] were studied in classic works.

Problems of tax administration improvement, Sh.Toshmatov [13], T.Malikov [14], B.Israilov [15], B.Tashmurodova [16], N.Khaydarov [17], B.Ibragimov [18] it has also been studied in the research of Uzbek scientists.

The first group of analyzed authors focused only on the business process in their work. The second group of scholars describes their views on taxes and their role in the formation of the state budget and tax administration. In the studies, the specific characteristics of business entities and the need to support them were not sufficiently evaluated in the works of scientists. Analyzing the work of scientists, it is possible to observe the tendency to prioritize the interests of the state in the study of business and state relations.

In the framework of the article, we focused on the analysis of the role of factors related to business development due to the fact that the importance of business subjects in the life of the state and society is of great importance in the conditions of market relations.

Analysis and results. There are many factors affecting business activity, and they can be divided into economic, political, legal and technological factors. In order for a businessman or manager to ensure the

effectiveness of his activities, it is necessary to study and analyze each factor that affects the business result. Because management requires choosing the most

convenient option for business. Factors that affect the efficiency of business results are grouped into internal and external factors (Figure 1).

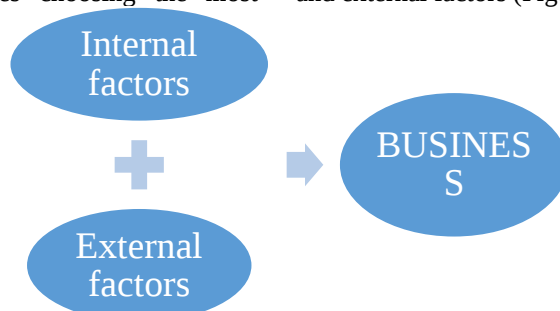


Figure 1. A group of factors affecting business results.

Internal factors affecting the business result are factors that occur in the subject and can be eliminated by his efforts. These factors are interrelated and are typical for any business entity. Such factors are an increase (decrease) in the amount of profit ; increase (decrease) in production volume ; increase (deterioration) of product quality ; increase (increase) in product cost p a ; affects the increase (decrease) in

the volume of product sales. The negative impact of these factors depends on the efforts of business entity managers to eliminate or reduce them. Scientifically correct organization of activities and constant efforts to solve problems can prevent the negative impact of these factors on business results. It is appropriate to study and analyze the composition of these factors into the following groups (Figure 2).

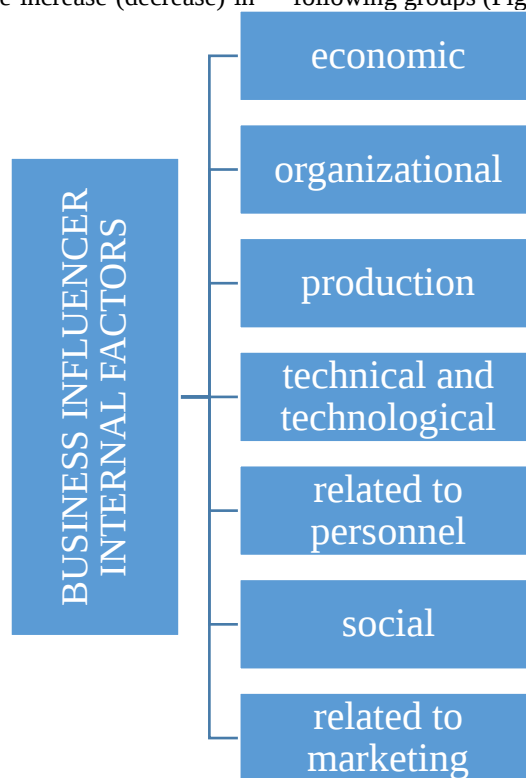


Figure 2. Classification of factors affecting business results i.

This group of factors affecting business activity:

- factors related to production;
- divided into factors not related to production.

The category of factors related to production includes the state of fixed assets, technologies, labor and financial resources. Factors unrelated to production are social issues of labor organization, personnel supply, and environmental protection.

Also, internal factors related to production are divided into extensive and intensive factors. Extensive factors are related to the increase in the level of quantity, in this case, the number of employees, the

number of equipment, and the amount of financial resources are additionally involved. Under the influence of intensive factors, a high result is achieved due to the level of productivity.

There are several views of scientists regarding the composition of factors influencing business activity and their interrelation [19-22]. It is not unbiased to consider the analysis of factors recommended by scientists.

The cultural level of entrepreneurial activity of business structures is reflected in their relations with the state, clients and competing business entities. The

final result of the business depends on compliance with the rules of ethics and culture of its organization. Business culture is part of the system of internal factors affecting the result of its activity. Therefore, it is necessary to study this issue.

Bankruptcy and inefficiency of business entities in today's consumer market is characterized by non-observance of the rules of business culture.

By culture, we usually mean dressing well, speaking well, being quiet and not talking loudly.

Organizational culture is a system of shared values, symbols, beliefs, and collective behaviors that motivate a team's actions to achieve goals.

Business culture in business entities is not a process that is formed in a day, two days or a week or month. It is the norms of ethics generally recognized by business structural structures, their members and accepted by the community in a certain period of time.

The organizational culture of a business entity is formed on the basis of the area where its purpose is located, the beliefs, views and corporate ethics of the main members of the team, and strict norms, principles, trust and values that are the basis of relations and interactions in the internal and external environment (Figure 3).

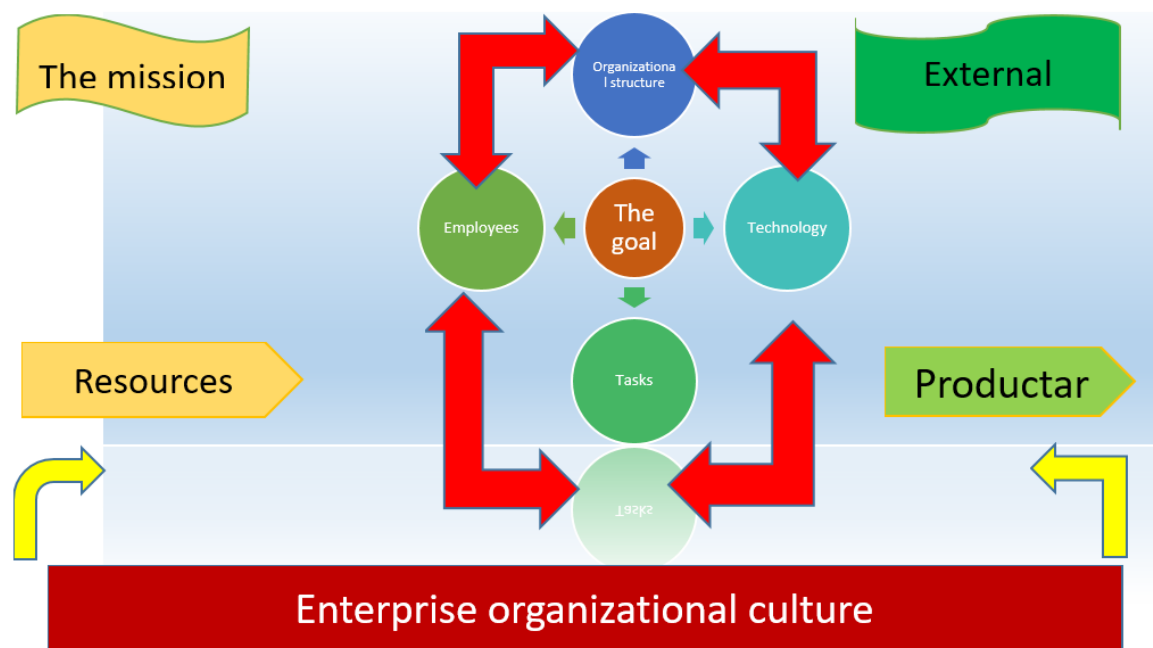


Figure 3. The environment for the formation of organizational culture of a business entity ¹.

Is manifested in the attitude of employees to each other, tasks and solving their personal life issues, as well as the approach of the business entity to these events and incidents.

Business organizational structures, their partners work based on these generally recognized rules in problematic situations that arise during their activities.

Adherence to these standards is mandatory for all employees and partners who recognize them.

The organizational culture of a business entity cannot be forced on employees. Organizational culture works well when it is consciously recognized by employees. Researchers believe that it is necessary to study the formation and change of organizational culture in business organizations in connection with the processes of organizational life stages.

The culture of a business entity begins to form from the time when the idea of its organization appears. During this period, the organizational culture is like a baby and requires more attention from those around it. During this period, the author has a high risk of making a mistake due to the height of his desire to put his idea into practice. At this stage of organizational culture, the ability of the head of the business entity to take risks

and the characteristics of valuing the opinion of others are important.

The second stage of the business entity's organizational culture occurs when its office architecture and team organization are not formed. This phase will consist of hardship, economic hardship and struggle for survival. Overcoming economic failure is the result of the organizational culture and cohesion of the business entity, and failure is a test and a lesson for future challenges.

After overcoming economic helplessness and failures, the next stage of growth of the organizational culture of the business entity begins. In the eyes of the market participants, the enterprise is not afraid of economic difficulties and temporary failures, but finds a positive solution with the unity of the team, and builds respect and trust in the business entity among customers. At this stage, the honest and responsible operation of the business entity determines its future. Because every mistake made at this stage causes doubts about the trust that has arisen in relation to the business entity. At this stage of the business entity's organizational culture, the relationship between the team and the management has not fully found its place.

¹ ACCA. "Invedeniye v finans y i upravleniye biznesom" (IFB). Textbook. Upravlenchesky uchet (Accountant and business). 2 KAPLAN PUBLISHING. 2019. Prepared on the basis of.

Therefore, employees try to assign responsibility to the leader, and the leader to the employees.

In modern business organizations, managers pay attention to empowering employees and increasing their responsibility in decision-making. At the growth stage of the organizational culture, the relationship between the business entity and the external environment can be harmful. Therefore, the business entity has to make many risks and mistakes at this stage.

The next stage of formation of organizational culture in a business entity is called "youth stage" in many literatures. At this stage, the business entity has to go through a long and painful period. The business entity transfers its powers to the employees and causes the renewal of the organizational structure. The success of this stage depends on the professionalism of the head of the business entity, and due to the measures taken by the head, a high degree of harmony and harmony is ensured in the business entity.

Effective completion of the youth stage brings the organizational culture of the business entity to the "flowering stage". This stage is the stage that ensures the interconnection of knowledge, goals, opportunities and means of achieving them. If the business entity does not rest on the success achieved at this stage, seeks to attract new forces and new opportunities, and always strives for renewal, its flowering stage will last. Otherwise, a stabilization phase occurs.

The "sustainability phase" begins when a business loses its cool, drunk from its heyday. At this stage, the allocation of funds for scientific research by the business entity is reduced and a simple development path is chosen. A business entity is limited to past successes, does not seek to innovate, and as a result, development stops.

The "Blooming" and "Stability" stages define the middle age of a business entity. During this period, documents are created that reinforce the slogans and culture of the business entity. At these stages, the business entity finds its place in society and the market.

After the "stage of stability", the stage of aristocratism in the life of a business entity begins. The specific features of this stage are manifested in the decrease in the allocation of funds for scientific research and the increasing attention to the issues of control and insurance and improvement. The image of the organization is represented by behavior, behavior and dress code. New innovations are not supported, as a result, employees act to survive, not the business entity. These circumstances mean that a new stage will occur in the business entity.

The new stage of the life process of a business entity is "initial bureaucracy". At this stage, the leader blames the employees for the failure of the business entity. Unemployment grows, the number of permanent employees decreases, employees are constantly renewed, and the management does not change. In the business entity, the number of cases of blaming each other increases, no one finds fault with himself. These situations complicate the life processes of the business entity and cause it to move to the last stage.

The last stage of the life cycle of a business entity is the stage of "bureaucracy and completion". At this

stage, the team loses trust in each other. Activity information is hidden by employees. The management does not pay attention to the negative impact of such situations on the business result. As a result, the values of the business organization are completely undermined, and these situations cause the business entity to go bankrupt or split up.

As a result of the analysis of the essence of the stages of the life process of a business entity, it is necessary to form an organizational culture and to constantly update it based on the development of society. Such an approach guarantees the long-term and stable operation of the business organization.

The specific characteristics of the organizational culture of a business entity are manifested in the following cases.

1. The employee's knowledge of his place in the business entity.

2. Accessibility and communication language.

3. These situations are expressed in written, verbal and non-verbal forms of communication, "right to call" and public relations.

4. Conversations can be carried out in such forms as abviate, gestures, slang, depending on the characteristics of regions and industries.

5. Appearance, dress and behavior at work.

6. Habits, eating and drinking, traditions. Namely, Employee meal plan, bringing from home, using buffet cafe service, eating out, group meals. Eating habits of managers, department heads and employees.

7. Attitude and use of working time.

8. System of relations between team members. That is, the formation of a system of relations based on age, gender, status, scientific potential, knowledge, experience, level. Level of communication formality, availability of employee support and dispute resolution procedures.

9. Values in a business entity. What is possible and what is not possible. Valuable things in the business entity for employees.

8. Attitude to the behavior of employees.

10. What is employee trust aimed at? That is, employees trust the leader, the existence of a justice system. Relationships with team members, colleagues and clients.

11. The system of increasing the qualification and knowledge of the employee.

12. The possibility to increase one's knowledge and experience, the existence of conditions to support it.

13. Work ethic and incentive system. Creation of working conditions, proper distribution of duties.

In most business entities, the employee's internal culture and knowledge of his place are valued. In some business entities, the employee's disclosure of his mood is encouraged. But some employees work best when they work alone. In a business entity, employees who achieve a better positive result in cooperation can also be the majority.

While employees are considered the main factor in shaping the organizational culture of a business entity,

organizational culture is created and shaped by managers and leaders.

The deterioration of the organizational culture of a business entity can also occur as a result of the actions of managers and leaders. The existence of the following situations in which a business entity has arisen as a result of the actions of managers and leaders can cause the decline of the organizational culture of a business entity:

- dissatisfaction of employees in the position of management;
- inability of managers to form the basic values of the workplace;

- absence of specific "slang" and "folklore" in the business entity;
- use of intimidation methods in labor orientation;
- how to motivate individual employees.

Formation of an organizational culture, which deals with these situations and ensures the solution of priority tasks and career growth, protects the business entity from decline.

External factors affecting business activity and its result are factors independent of the entity (Figure 4).

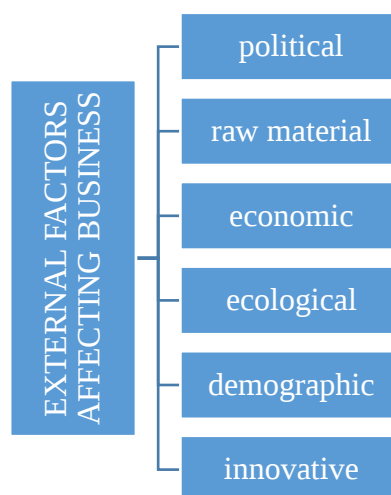


Figure 4. General classification of external factors affecting business results

These factors directly and indirectly affect the business result. This group of factors consists of a number of factors, each of which affects the business result. Therefore, it is appropriate to classify their

content accordingly for analysis. For example, the general structure of the economic factors included in this group can be seen in the diagram below (Fig. 5).

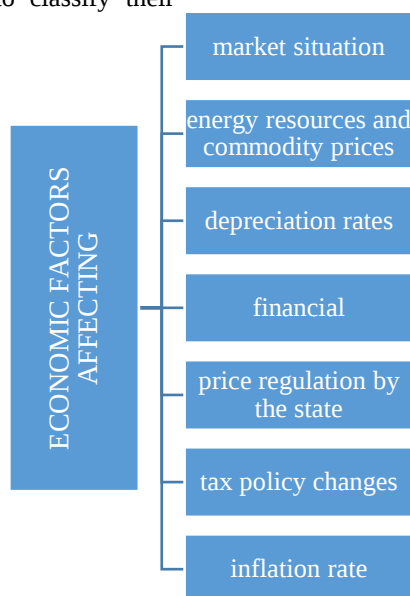


Figure 5. Classification of the composition of the group of economic factors affecting business.

We believe that the impact of these factors on business results should be determined using economic analysis methods and SVOT analysis. The influence of factors is calculated based on the methods recommended by scientists. Timely delivery of necessary and important information for management is one of the main tasks of the analysis. Appropriate

management decisions are made based on the impact of each factor on the current and past business results.

Conclusions and suggestions. In addition, there are factors of a private nature that affect business activity. When starting a business and running it, it is appropriate for a businessman to analyze the impact of additional ecological, ethical and demographic factors

on the business result along with the main factors. A factor that usually seems insignificant to us can have a more positive or negative impact on the business result.

The political environment in a country can affect business activities in various ways. This situation leads to increased risk and loss. Therefore, political factors affect the results of business activities, as well as the policies of the government and local authorities. Therefore, when organizing his activities, a businessman needs to analyze the local and international political situation and, based on the results of the analysis, find ways of cooperation for his business.

Changes in public policy can also cover economic, legal and social spheres. For example, the state may change tax rates and bases based on the political views of the ruling party, or give tax payers benefits and preferences. Therefore, a businessman should not forget in making every decision that political decisions in society can affect the economic, legal, social, cultural environments and technological development processes.

Using these recommendations will extend the life of the business and ensure capital efficiency.

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PECULIARITIES OF THE COMPANY'S STRATEGIC MANAGEMENT OF HUMAN RESOURCES IN GEORGIA

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Abstract

In this article, based on the latest literary sources, such an actual issue of management theory and practice as the peculiarities of the company's strategic management of human resources in Georgia is studied.

The role of strategic management of human resources on the effective functioning of companies is analyzed based on the data obtained as a result of the research of companies. Factors affecting/obstructing the strategic management of companies have been identified. The role of human resource management specialists in the success of companies and their importance from the employees' point of view are evaluated and analyzed.

Companies with a strategic human resources management plan and those without a strategic management plan are compared and the practices in them are analyzed according to organizational functions, which ultimately determine the human resources management policy in the companies.

Keywords: human resources, strategic management of human resources, intellectual capital, strategic thinking, recruiting, outsourcing, senior HR specialist, HR consultant, HR administrator.

Introduction

Today, the strategic management of human resources is a global challenge and, in this regard, Georgia is no exception.

In the conditions of modern increased competition, companies face the necessity of strategic management of human resources. Any company, in turn, tries to be competitive in the market and have a well-organized work culture. At the same time, the heads of the companies try to create effective systems of employee motivation in order to successfully operate the business. However, there are factors, and their action prevents the implementation of activities related to strategic management and creates a barrier to the effective functioning of the business.

In this regard, if we compare today's competitiveness of companies with 10-15 years ago, we will find a significant difference. In particular, we will see that the importance of factors such as technology, finance, production process, etc. has significantly decreased and, on the contrary, the role of human resources and capital has increased. Thus, the study of the problem of strategic management of the company's human resources is very necessary and contemporary.

Research methodology

In order to study the mentioned problem in detail, research was carried out in 30 companies operating in Georgia (large, medium, small). One human resource (HR) specialist or a person working in this direction from each company was involved in the research, who places the HR function in the company. The research questions were related to the activities of HR services as well as their involvement in the strategic work process of the organization.

The purpose of the research was to study the strategic management of human resources as a factor of the company's effectiveness. To achieve the set goal, the following tasks were defined: study of the company's human resources management policy; revealing the relationship between the strategy of human resources

management and the strategy of the organization; research on the role of human resource management managers in companies and their impact on business results; identifying the hindering factors and challenges in the company's human resources management process; determining the influence of the strategic human resource management plan on the rate of employee turnover.

Based on the research objectives, strategic human resource management was defined as a long-term development approach to human resource management (HRM) through the implementation of HR programs aimed at solving business issues and directly involved in ensuring long-term business goals.

Research results

As a result of the conducted research, the existing barriers were identified, which prevent human resources management specialists from performing HR functions.

It has been established that in today's competitive environment, it is difficult for an organization to succeed without a well-developed strategic plan that focuses on both short and long-term visions of the organization. A business with only a short-term vision is doomed to failure. This forces companies to have a competitive strategy, which means that the execution of planned activities is effective (Armstrong, 2017). Strategic thinking requires managers to take a long-term view of the business and the competitive environment together (Daft, 2010). In general, strategy ensures effective achievement of business results.

Having a strategy is equally important for large, medium and small companies. Of all surveyed companies, small (the average annual number of employees does not exceed 50 employees) - 15%, medium (the average annual number of employees varies from 50 to 250 people) - 52%, large (the average annual number of employees exceeds 249 people) - 33%.

Most of them (65%) have a strategic development plan according to individual departments/divisions. This fact confirms that most companies analyze the importance of strategy. However, 35% of companies do

not have a strategic plan by department/division at all. In such a case, it can be said that the work of the companies has a chaotic character. If we take into account the fact that within the scope of the research, companies of this type were distinguished by a large number of employees, the personnel management takes on an even more chaotic appearance. Therefore, we can say that today, the idea of the need to have a strategic human resources plan in the management of companies is still in its infancy.

In order to ensure the high effectiveness of the strategy, it is necessary that the information is clearly and comprehensibly delivered to each person who can influence the business results during the implementation of the strategy. Such a relationship helps to rationally deliver the strategy to the parties involved in the management process and creates the basis for the successful implementation of business plans. In this regard, the role of human resource management managers (SHRM) is particularly important in the process of forming business strategies. This means that SHRM has acquired vital importance and has become an important factor in business development.

According to the research, the HR manager is most often involved in the implementation of organizational strategies (70%) and focuses on strategic results (70%). In 63% of cases, he participates in the creation and development of the organizational strategy. In some cases, the HR manager is more involved in the development of business goals (33%) and the creation of organizational strategy (10%). However, in no case only 13% do not participate in the creation of organizational strategy.

As already mentioned, the existence of a strategy is important not only at the general business level, but also at the level of individual departments and divisions, which will be consistent with the general strategy of the company. In this regard, it is important for companies to have a well-formed human resources development strategy and plan.

Today, small and medium-sized enterprises focus more on human resource development than before, because due to sudden changes, human resources have become a strategic factor that affects the success of companies. Indeed, employees' intellectual capital, knowledge and competence determine the success or failure of a business in a dynamic environment (Ceranec & Popovic, 2010).

Consequently, HRM issues have become relevant for business for several reasons: first, because HRM is considered a top priority; second, HRM is of particular interest because human resources play a vital role in building sustainable competitive advantage; third, especially in small companies, the workforce plays an essential role (Bamberger, Biron, & Mashoulam, 2014).

Therefore, the existence of the HR institution becomes crucial in the formulation of the human resource management policy. The majority of surveyed companies (80%) have a strategic human resources plan. Only 20% of surveyed companies do not have a strategic plan. Along with the strategy of individual departments, there is also a strategy of human resources management. More specifically, 92% of large companies

surveyed have a strategic HR plan, which is not surprising, as large companies have to make great efforts to maintain their positions in a competitive environment.

Comparing large and small companies, we can say that the office space, the different amount of employees and the level of production in a small company are small. Accordingly, the HR department is also similar. Being an HR specialist in a small company means taking on more roles than human resource management (Johnson, 2017). Large- and medium-sized companies are not inferior to small-sized companies by having a strategic HR plan. In the case of 83% of the surveyed small companies, the existence of a strategic HR plan was observed.

According to 85% of the respondents, HR is represented in their company as a department/department/specialist. The companies where the HR institute exists in some form are mostly medium or large sized companies. Working as an HR specialist in a large company means managing human resources, gaining experience and creating a corporate culture. However, managing a large number of personnel is associated with certain challenges and requires a creative approach from the manager.

As for the second part, in 15% of companies (mainly medium and small businesses) HR functions are distributed to one or more people who perform personnel management functions in combination. In practice, these responsibilities are largely distributed to administrative managers who are more likely to perform operational tasks than strategic ones. Moreover, they are less involved in the process of making strategic decisions.

Based on the above, we can conclude that in large companies, due to the large number of employees, there is a need for their complex management, which leads to the existence of HR as a separate unit.

The most effective way for HR to communicate strategic initiatives to employees is to discuss the same department's strategy in the context of the company's strategy. It is important for HR to actively participate in the development and implementation of both human resources and business strategy. If he is not involved in the formation of business initiatives and aligning strategies with them, then he will not be able to make strategic contributions and participate in initiatives related to business development.

Respondents who indicated that their companies have an HR function in some form, 70% of them have a strategic HR plan. This fact may also be explained by the fact that human resources management services are often managed by certified HR professionals, therefore, their theoretical and practical knowledge in the mentioned field is quite high, and experience itself determines that managers often consider human resources management as one of the strategic directions and the whole Efforts are being made in personnel development. From this we can conclude that the presence of the HR service in the company has a significant impact on the formation and development of the strategic HR plan.

It is established that the concept of strategic management of human resources implies compliance of HR

strategy with business strategy. Otherwise, it turns out that these two strategic directions develop in an unstructured and chaotic manner. The human resources management manager, along with the employee management and development functions, performs a number of duties. This is expressed in the formulation of business plans and goals, creation of organizational strategy and strategic mapping.

The research revealed the main directions in which the human resource management service is most often involved. According to the respondents, HR is most often involved in the creation of the full cycle of the organizational strategy - from planning to implementation. The service is involved in the implementation of the organizational strategy and focuses on strategic results, equally 70% - 70%, and in 63% of cases it participates in the creation of the organizational strategy and the development of business goals.

It should also be noted that the existence of HR does not mean that the process of managing employees is complete and includes all levels of management in terms of attracting, selecting, hiring, preparing job descriptions, developing and maintaining personnel.

The majority of respondents - 40% state that the human resources management process in their companies is perfect. In particular, 92.5% focus on recruitment and selection, 70% on motivation, 58% on training and development, and 55% on retention. However, when asked which specific functions they do not perform, a minority said they are sometimes not involved in the development of compensation and performance management and retention programs. In contrast, HR management in 35% of companies does not cover all areas of strategic management. Among them, they never engage in work/life program development, talent management, and success planning programs.

To perfect human resource management, managers play different roles in companies. In this regard, especially large companies, where several HRs work in different directions, are particularly outstanding. Unlike small companies, where one or at most two people manage several functions at the same time. In addition, HR roles in large organizations are divided according to the complexity of the activities to be performed and the level of responsibilities.

For example, let's consider the personnel employed in HR in managerial and non-managerial positions in the company. The perception of high-level human resource management managers is more general and strategic, while for middle and low-level human resource management managers, the priority is to communicate directly with people, help and support employees. HR managers coordinate and plan HR activities unlike HR executives. This allows them to engage employees in recruitment, benefits programs, training, labor disputes and other administrative needs.

Nowadays, companies are experiencing increasing growth and human resource management services are no exception in this regard. The role of human resources management consultants is also growing in companies with a special speed. They may specialize in various areas of HR, including benefits programs, employee initiatives and reward programs, changes in

company culture after mergers and acquisitions, employee motivation, retirement planning, recruiting, or other factors that companies address when outsourcing.

In addition, HR employees in companies work as recruiters, selection specialists, as well as in the direction of trainings and career development. For example, those who are experienced in building and developing relationships with people work as recruiters. However, their role also differs depending on the position. For example, executive recruiters delegate tasks to senior recruiters in finding and filling job opportunities. Those who possess both theoretical and practical knowledge of human management issues, work in training and development, etc.

The role of HR administrator is also quite relevant. This includes daily routine office work - preparation of orders, labor contracts, sometimes participates in the recruitment process. When researching the role of human resource management managers, the activities to be performed were combined into three main groups: senior HR specialist, HR advisor, HR administrator. The meanings of the proposed categories/roles were explained to the respondents in advance. 55% of the surveyed respondents perform the function of senior HR in the company. The advisor function - 15% and the administrative function - only 10%.

According to these data, it is confirmed that the traditional approach to human resource management is gradually undergoing a transformation to a strategic approach. Which is definitely a positive fact, although it must be noted that human resource management managers in companies do not work only in the direction of strategic planning. In fact, they combine administrative activities with the work of strategic content due to the shortage of personnel in the company.

The presence of a strategic approach in a company does not mean that the human resources and capital management process is perfect. A deficiency in management may be related to employee relations, motivational system creation, salary rates and less opportunities for development and encouraging employee initiative.

All of the above actually represent a barrier to the perfection of the processes. However, companies sometimes think that they are doing their job exceptionally well, communicating with their employees and ensuring that their employees' lifestyles are improved. However, this kind of perception often does not coincide with the real wishes and opinions of the employees. HR plays an especially important role in this matter. Initiatives, decisions on employee incentives, creation of a pleasant working environment belong to HR to a significant extent. However, HR performs a number of operational and strategic roles that are not only related to human resource management. For the past 20 years, the function of HR has been to provide administrative support to strategic services. In some companies, HR has to constantly prove that it plays a vital role for the organization.

Conclusion

In conclusion, from the results of the conducted research, it is clear that today's transformational business environment implies the existence of challenges in

human resources management. Despite the fact that HR services have acquired a strategic role in organizations in recent years, they still face a number of barriers in the work process in the face of rapid changes. The process of change is never-ending, therefore, HR management services need to perform additional activities in order to immediately respond to the changes and to respond appropriately to it.

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ELECTRICAL ENGINEERING

РЕЗУЛЬТАТИ ВИЗНАЧЕННЯ ВЛИВУ ВОЛОГОВМІСТУ НА ПОТІК РЕЧОВИНИ В М'ЯСІ ПІД КОМБІНОВАНОЮ ДІЄЮ ТЕПЛОВОГО ПОТОКУ І ЕЛЕКТРИЧНОГО СТРУМУ

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RESULTS OF DETERMINING THE INFLUENCE OF MOISTURE CONTENT ON THE FLOW OF SUBSTANCES IN MEAT UNDER THE COMBINED ACTION OF HEAT FLOW AND ELECTRIC CURRENT

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Анотація

У статті досліджено закономірності виникнення потоку речовини в м'ясі свинини під впливом електричного струму, теплового потоку від нагрівача та їх комбінованої дії. Встановлено, що вологовміст м'яса має істотний і нелінійний вплив на об'єм речовини, що переноситься в м'ясі під впливом електричного струму та теплового потоку. Запропоновані аналітичні залежності для визначення кількісних параметрів з урахуванням вологовмісту, площі та товщини м'яса, різниці потенціалів, величини теплового потоку та прикладеного надлишкового тиску.

Abstract

The article investigates the patterns of substance flow occurrence in pork meat under the influence of electric current, heat flow from a heater, and their combined action. It has been established that the moisture content of the meat has a significant and nonlinear impact on the volume of substances transferred in the meat under the influence of electric current and heat flow. Analytical dependencies are proposed to determine quantitative parameters taking into account moisture content, meat area and thickness, potential difference, heat flow magnitude, and applied excess pressure.

Ключові слова: електричний струм, тепловий потік, вологовміст, м'ясо свинини, потік речовини.

Keywords: electric current, heat flow, moisture content, pork meat, substance flow.

Постановка проблеми

Жарення виробів із м'яса на нагрівальній поверхні є одним із розповсюджених процесів теплового оброблення в харчовій промисловості. Процес жарення натуральних виробів з м'яса є ресурсовитратним (втрати маси готового продукту сягають 35%) і енерговитратним (питома витрата теплоти сягає 1300 кДж/кг). Енергетична ефективність процесу жарення невисока, оскільки використовується висока температура поверхонь жарення (423...473 К) з коефіцієнтом використання площі 0,5...0,7. Використання двостороннього підведення теплоти під час процесу кондуктивного жарення значно інтенсифікує сам процес і призводить до значного підвищення виходу готового продукту [1]. Вдосконалення процесу і апаратів кондуктивного жарення м'яса, в т.ч. і за двостороннього підведення теплоти на основі глибокого розуміння процесів, які протікають в ньому, є актуальним завданням.

Аналіз останніх досліджень

Перенос теплоти в м'ясі під час жарення основним способом здійснюється внаслідок виникнення в ньому теплового потоку від розігрітої поверхні нагрівання [2]. На ефективність процесу жарення м'яса впливає величина теплового потоку, а також величина викликаного ним потоку маси речовини [3-5]. Виникнення потоку речовини під час кондуктивного і фритюрного жарення досліджувалося авторами [3-5, 6].

Одним із напрямків підвищення енергетичної і ресурсної ефективності процесу кондуктивного жарення м'яса є використання фізичних і електрофізичних методів впливу на сировину в процесі жарення [7], насамперед тиску і електричного струму.

Початковий період процесу двостороннього жарення під дією електричного струму і теплового потоку від електричного нагрівача характеризується теплопередачею через парові прошарки в поверхневому шарі м'яса [8, 9]. Коефіцієнт теплопередачі через парові прошарки залежить від питомої потужності поверхонь жарення та коефіцієнту теплопровідності м'яса. Збільшення коефіцієнту теплопередачі в цей період лише збільшенням коефіцієнту теплопровідності м'яса шляхом фізичного або електрофізичного впливу не призведе до значної інтенсифікації процесу жарення, оскільки інтенсивне відведення теплоти вглиб м'яса повинне забезпечуватися відповідним підведенням теплоти ззовні, тобто інтенсифікацією тепловіддачі до м'яса від пари в парових прошарках. На величину коефіціє-

нта тепловіддачі під час конденсації пари в менісках капілярів впливає її питомий об'єм, а відповідно, і кількість самої пари у парових прошарках. Відповідно до цього, для забезпечення такої кількості пари в поверхневих шарах необхідне виникнення в м'ясі потоку рідини, достатнього для утворення такої кількості пари в наслідок фазового перетворення. Виникнення в м'ясі свинини потоку рідини під дією електричного струму досліджувалося в роботі [10], яловичини – в роботі [11]. Встановлено, що величина потоку речовини прямопропорційно залежить від площі м'яса і електродів, напруги електричного струму та нелінійно залежить від товщини м'яса. В роботі [12] досліджувалося виникнення потоку речовини в м'ясі свинини під комбінованою дією електричного струму та теплового потоку від нагрівальної поверхні. Встановлено, що величина потоку речовини прямопропорційно залежить від величини теплового потоку і нелінійно залежить від товщини м'яса. Крім того, встановлено, що за комбінованої дії теплового потоку і постійного електричного струму напругою 27 В протягом 2 с потоки речовини від теплового потоку і від електричного струму накладаються один на одного. Вплив вологовмісту м'яса на виникнення в ньому потоку речовини, а також на величину ефективного кінетичного коефіцієнту процесу переносу речовини в м'ясі під комбінованою дією електричного струму і теплового потоку від електронагрівача не досліджувалося.

Мета роботи: дослідження впливу вологовмісту м'яса на величину потоку речовини в м'ясі свинини під комбінованою дією електричного струму і теплового потоку від електронагрівача.

Для досліджень була використана експериментальна установка на основі модернізованого пристрою Перрена [13], наведена на рис. 1.

Установка складається зі скляного циліндру 5, до якого знизу за допомогою термолука герметично приклеєно електрод у вигляді мідної пластини. До цієї пластини за допомогою перфорованого електрода 3 і притискного кільця 4 щільно притискається дослідний зразок з м'яса свинини, після чого в циліндр заливається дистильована вода 6. Циліндр 5 закривається пробкою 7, через яку виведено трубку 8 з мірним капіляром 9. На електроди подається випрямлений струм (з пульсацією) напругою 27 В (обґрунтування величини напруги наведено в роботі [10]) від електричного трансформатора 10 з діодним містком 11.

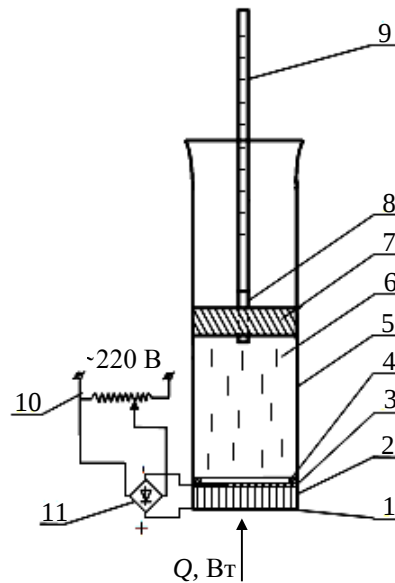


Рис. 1. Принципова схема установки для дослідження впливу вологовмісту м'яса свинини на виникнення в ньому потоку речовини під комбінованою дією теплового потоку від електронагрівача і електричного струму:

1 – герметичний електрод у вигляді мідної пластини; 2 – дослідний зразок із м'яса свинини;
3 – перфорований електрод; 4 – притискне кільце; 5 – скляний циліндр;
6 – дистильована вода; 7 – пробка; 8 – трубка; 9 – мірний капіляр; 10 – ЛАТР; 11 – діодний місток

Для виникнення в м'ясі теплового потоку був використаний плоский нагрівальний елемент із температурою поверхні 423 К та тепловим потоком від нього $Q = 18...72$ Вт, який щільно притискався до герметичного електроду у вигляді мідної пластини 1. Обґрунтування впливу величини теплового потоку наведено в роботі [12]. Тепловий потік $Q = 18...72$ Вт забезпечувався постійним фазовим регулятором напруги на семісторі ВТА16-600В.

За початок відліку процесів переносу речовини в дослідженнях було обрано момент повного закипання води й початку інтенсивного пароутворення біля мідної пластини 1, що фіксувалося візуально. В дослідженні виникнення потоку речовини під дією електричного струму подавали напругу на електроди. В дослідженнях комбінованого впливу теплового потоку та електричного струму на виникнення потоку речовини після моменту повного закипання води й початку інтенсивного пароутворення біля мідної пластини під дією теплового потоку від нагрівача вмикали подачу напруги на електроди. Об'єм води в мірному капілярі 9 фіксувався за допомогою відеозйомки на камеру мобільного телефону Realme 9 Pro+ із частотою 25 кадрів/с. Після цього за допомогою демоверсії програми Free Video to JPG Converter здійснювалася розкадровка відео в формат JPG для подальшої обробки результатів.

Для дослідження виготовлялися зразки м'яса із найдовшого м'язу від трьох тварин (віком 8, 10 і 12 місяців).

Тривалість комбінованої дії електричного струму та теплового потоку від нагрівача на дослідні зразки фіксувалася за допомогою електронного секундоміра «Select Stop Watch».

Для визначення початкового вологовмісту м'яса зразок зважували на аналітичних вагах, після чого висушували його до рівноважного вологовмісту w_p за ISO 1442:2005 в сушильній шафі [14]. Помилка! Джерело посилання не знайдено. Висушений тестер зважували на аналітичних вагах. Значення вологовмісту розраховували за формулою (без врахування маси чаші, піску і скляної палички):

$$w = \frac{m_1 - m_2}{m_1} \cdot 100\%;$$

де m_1 – маса тестера до висушування; m_2 – маса тестера після висушування.

Початковий вологовміст найдовшого м'язу від самої тварини віком 8 міс. становив 73,1%, від тварини віком 10 міс. – 72,8%, від самої старшої – 72,1%. Як видно з цих даних, вологовміст м'язової тканини залежить і від віку тварини.

В дослідженнях використовувалися дослідні зразки, виготовлені з найдовших м'язів тварин зазначеного віку. Найдовші м'язи розрізалися впоперек волокон на шматки товщиною 0,01 м. Загостреним краєм скляного циліндра 5 вирізалися дослідні зразки площею $10,17 \cdot 10^{-4} \text{ м}^2$.

Результати досліджень та обговорення

Спочатку проводили дослідження впливу вологовмісту дослідних зразків на виникнення потоку речовини в м'ясі свинини під дією електричного струму. Вихідними параметрами дослідження були: напруга постійного електричного струму (з пульсацією) на електродах $U = 27$ В; площа дослідного зразка $S_m = 10,17 \cdot 10^{-4} \text{ м}^2$; товщина дослідного зразка $\delta_m = 0,01$ м; коефіцієнт пропорційності, який враховує співвідношення поміж площею контакту перфорованого електроду та площею зразка м'яса

$k_s = 0,438$, надлишковий тиск $p = 2320$ Па, граничний тиск для дослідного зразка $p_{гр} = 10400$ Па. Результати досліджень наведені в табл. 1. та рис. 2.

Таблиця 1

Результати визначення впливу вологовмісту м'яса свинини на виникнення в ньому потоку речовини під дією електричного струму

Вологовміст м'яса, w ,	Об'єм перенесеної речовини, $V_p \cdot 10^6$, m^3 , за $U = 27$, В, $S_M = 10,17 \cdot 10^{-4}$, m^2 , $\delta_M = 0,01$, м і тривалості впливу τ , с					
	0,5	1	2	3	4	5
0,731	0,0559	0,1119	0,2237	0,3356	0,4475	0,5593
0,728	0,0552	0,1103	0,2207	0,3310	0,4413	0,5517
0,721	0,0534	0,1068	0,2137	0,3205	0,4273	0,5342

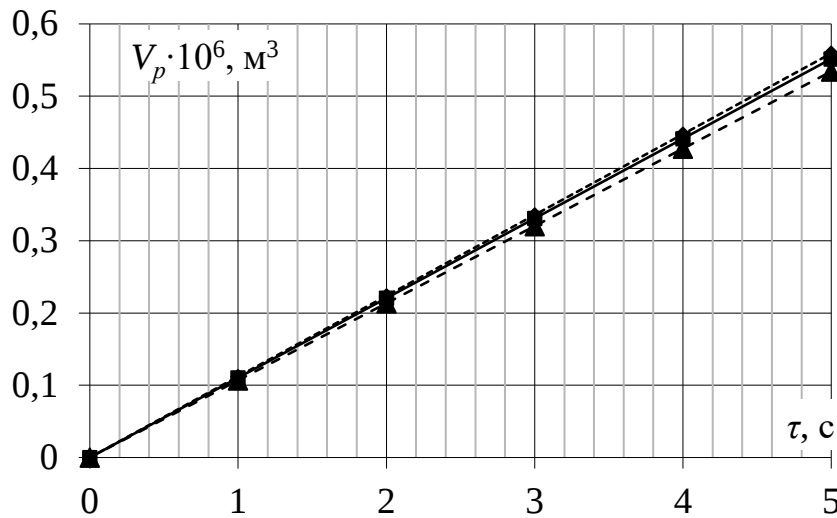


Рис. 2. Кінетика об'єму речовини, перенесеної в м'ясі свинини під дією електричного струму за напруги $U = 27$, В, площі зразка $S_M = 10,17 \cdot 10^{-4}$, m^2 , його товщини $\delta_M = 0,01$, м, величини прикладеного надлишкового тиску $p = 2320$ Па, протягом $\tau = 0,5 \dots 5,0$ с і вологовмісту $\blacklozenge$ – 0,731, $\blacksquare$ – 0,728 та $\blacktriangle$ – 0,721 кг/кг.

Як видно з табл. 1 та рис. 2 протягом 5 с в межах одного вологовмісту кінетика об'єму речовини, перенесеної в м'ясі під дією електричного струму має прямопропорційний вигляд. З наведених даних видно, що вологовміст м'яса істотно і нелінійно впливає на об'єм речовини, що переноситься в м'ясі під дією електричного струму.

З роботи [10] таку залежність об'єму речовини, що переноситься в м'ясі свинини під дією електричного струму від напруги, площі контакту перфорованого електроду з м'ясом, товщини дослідного зразку та його площі, тиску і тривалості впливу для вологовмісту $w = 0,731$ можна представити у вигляді:

$$V_p = k_e \cdot k_s \cdot U \cdot S_M \cdot \delta_M^{-0,731} \cdot \frac{(p_{гр} - p)}{p_{гр}} \cdot \tau, m^3;$$

для вологовмісту $w = 0,728$

$$V_p = k_e \cdot k_s \cdot U \cdot S_M \cdot \delta_M^{-0,728} \cdot \frac{(p_{гр} - p)}{p_{гр}} \cdot \tau, m^3;$$

для вологовмісту $w = 0,721$

$$V_p = k_e \cdot k_s \cdot U \cdot S_M \cdot \delta_M^{-0,721} \cdot \frac{(p_{гр} - p)}{p_{гр}} \cdot \tau, m^3.$$

$$J_{pe}^V = \frac{V_{pe}}{S_M \cdot \tau} = k_e \cdot k_s \cdot U \cdot \delta_M^{-w} \cdot \frac{(p_{гр} - p)}{p_{гр}}, m^3/(m^2 \cdot c); \quad (2)$$

або

$$J_{pe}^G = \frac{V_{pe} \cdot \rho_M}{S_M \cdot \tau} = k_e \cdot k_s \cdot U \cdot \delta_M^{-w} \cdot \frac{(p_{гр} - p)}{p_{гр}} \cdot \rho_M, kg/(m^2 \cdot c); \quad (3)$$

де ρ_M – густина м'яса, кг/м³.

Наведені залежності з достовірністю 95% описують отримані результати експерименту.

Очевидно, що показник степені товщини дослідного зразку відповідає значенню вологовмісту дослідного зразку, що дає змогу сформулювати теоретичну кінетику об'єму речовини, що переноситься в м'ясі свинини під дією електричного струму, в наступному вигляді

$$V_p = k_e \cdot U \cdot S_M \cdot \delta_M^{-w} \cdot \frac{(p_{гр} - p)}{p_{гр}} \cdot \tau, m^3; \quad (1)$$

де k_e – ефективний кінетичний коефіцієнт процесу переносу речовини в м'ясі під дією електричного струму, $m^{1+w}/(c \cdot B)$. В даному експерименті $k_e = 0,4132 \cdot 10^{-6} m^{1+w}/(c \cdot B)$.

Потік речовини J_p , що переноситься через одиницю площі S_M м'яса в одиницю часу τ в даному діапазоні параметрів залежить від напруги електричного струму U , товщини м'яса δ_M , вологовмісту w та величини прикладеного тиску p :

Вихідними параметрами для дослідження впливу вологовмісту дослідних зразків на виникнення потоку речовини в м'ясі свинини під дією теплового потоку від електронагрівача були: тепловий потік від електронагрівача $Q = 92$ Вт; площа дослідного зразка $S_M = 10,17 \cdot 10^{-4}$ м²; товщина дослідного зразка $\delta_M = 0,01$ м; надлишковий тиск $p = 2320$ Па, граничний тиск для дослідного зразка $p_{гр}$

= 10400 Па. Результати досліджень наведені в табл. 2 і рис. 3.

Як видно з табл. 2 та рис. 3 протягом 5 с в межах одного вологовмісту кінетика об'єму речовини, перенесеної в м'ясі під дією теплового потоку від електронагрівача має прямопропорційний вигляд. З наведених даних видно, що вологовміст м'яса істотно і нелінійно впливає на об'єм речовини, що переноситься в м'ясі під дією теплового потоку від електронагрівача.

Таблиця 2

Результати визначення впливу вологовмісту м'яса свинини на виникнення в ньому потоку речовини під теплового потоку від електронагрівача

Вологовміст м'яса, w ,	Об'єм перенесеної речовини, $V_p \cdot 10^6$, м ³ , за $Q = 92$, Вт, $S_M = 10,17 \cdot 10^{-4}$, м ² , $\delta_M = 0,01$, м і тривалості впливу τ , с					
	0,5	1	2	3	4	5
0,731	0,01457	0,02914	0,05828	0,08742	0,11655	0,14569
0,728	0,01477	0,02954	0,05909	0,08863	0,11818	0,14772
0,721	0,01526	0,03051	0,06102	0,09154	0,12205	0,15256

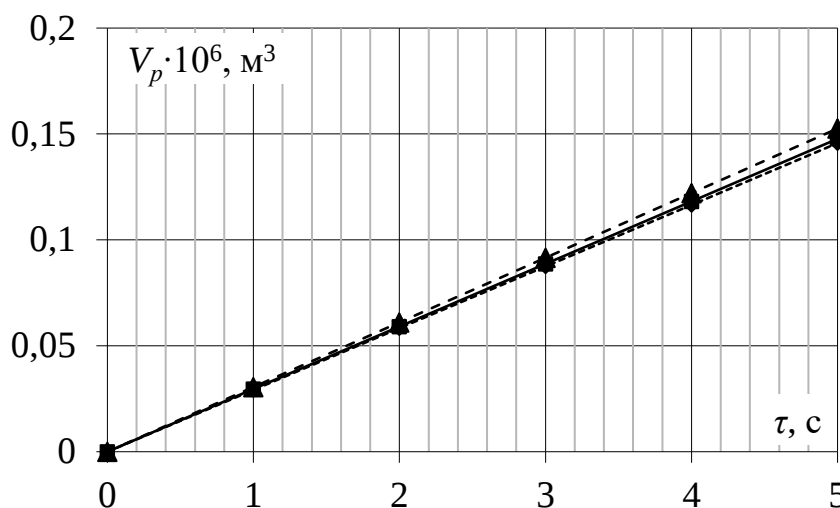


Рис. 3. Кінетика об'єму речовини, перенесеної в м'ясі свинини під дією теплового потоку від електронагрівача $Q = 92$, Вт, за площі зразка $S_M = 10,17 \cdot 10^{-4}$, м², його товщини $\delta_M = 0,01$, м, величини прикладеного надлишкового тиску $p = 2320$ Па, протягом $\tau = 0,5 \dots 5,0$ с і вологовмісту $\blacklozenge$ – 0,731, $\blacksquare$ – 0,728 та $\blacktriangle$ – 0,721 кг/кг.

З роботи [12] таку залежність об'єму речовини, що переноситься в м'ясі свинини під дією теплового потоку від електронагрівача від величини теплового потоку, товщини дослідного зразка та його площі, тиску і тривалості впливу для вологовмісту $w = 0,731$ можна представити у вигляді

$$V_p = k_T \cdot Q \cdot S_M \cdot \delta_M^{-(1-0,731)} \cdot \frac{(p_{гр}-p)}{p_{гр}} \cdot \tau, \text{ м}^3;$$

для вологовмісту $w = 0,728$

$$V_p = k_T \cdot Q \cdot S_M \cdot \delta_M^{-(1-0,728)} \cdot \frac{(p_{гр}-p)}{p_{гр}} \cdot \tau, \text{ м}^3;$$

для вологовмісту $w = 0,721$

$$V_p = k_T \cdot Q \cdot S_M \cdot \delta_M^{-(1-0,721)} \cdot \frac{(p_{гр}-p)}{p_{гр}} \cdot \tau, \text{ м}^3;$$

Очевидно, що показник степені товщини дослідного зразка відповідає значенню вологовмісту дослідного зразка, що дає змогу сформулювати теоретичну кінетику об'єму речовини, що переноситься в м'ясі свинини під дією теплового потоку від електронагрівача, в наступному вигляді

$$V_p = k_T \cdot Q \cdot S_M \cdot \delta_M^{-(1-w)} \cdot \frac{(p_{гр}-p)}{p_{гр}} \cdot \tau, \text{ м}^3; \quad (4)$$

де k_T – ефективний кінетичний коефіцієнт процесу переносу речовини в м'ясі під впливом теплового потоку, м^(2-w)/(с·Вт); для даного випадку за вертикального вектору переносу маси $k_T = 0,11614 \cdot 10^{-6}$ м^(2-w)/(с·Вт).

Потік речовини J_{p_T} , що переноситься через одиницю площі S_M м'яса за одиницю часу τ у даному діапазоні параметрів залежить від величини теплового потоку від нагрівача Q , товщини δ_M , вологовмісту дослідного зразка w і величини прикладеного надлишкового тиску p

$$J_{p_T}^V = \frac{V_{p_T}}{S_M \cdot \tau} = k_T \cdot Q \cdot \delta_M^{-(1-w)} \cdot \frac{(p_{гр}-p)}{p_{гр}}, \text{ м/с}, \quad (5)$$

або

$$J_{p_T}^G = \frac{V_{p_T} \cdot \rho_M}{S_M \cdot \tau} = k_T \cdot Q \cdot \delta_M^{-(1-w)} \cdot \frac{(p_{гр}-p)}{p_{гр}} \cdot \rho_M, \text{ кг/(м}^2 \cdot \text{с)}. \quad (6)$$

Дослідження впливу вологовмісту дослідних зразків на виникнення потоку речовини в м'ясі свинини під комбінованою дією теплового потоку від

електронагрівача й електричного струму здійснювалось за наступних вихідних параметрів: напруга постійного електричного струму (з пульсацією) на електродах $U = 27$ В; тепловий потік від електронагрівача $Q = 92$ Вт; площа дослідного зразка $S_M = 10,17 \cdot 10^{-4}$ м²; товщина дослідного зразка $\delta_M = 0,01$ м; коефіцієнт пропорційності, який враховує співвідношення поміж площею контакту перфорованого електроду та площею зразка м'яса $k_S = 0,438$, надлишковий тиск $p = 2320$ Па, граничний тиск для дослідного зразка $p_{гр} = 10400$ Па. Результати досліджень наведені в табл. 3. та рис. 4.

Як видно з табл. 3 та рис. 4 під час комбінованого впливу теплового потоку від електронагрівача

й електричного струму на дослідний зразок з м'яса свинини, в межах одного вологовмісту, об'єм перенесеної речовини в дослідних зразках накладається один на одного та має лінійну залежність тільки впродовж перших 0...2 с. Після 2 с комбінованої дії потоки речовини від дії електричного струму та теплового потоку від електронагрівача перестають накладатися один на одного, що цілком співпадає з даними наведеними в роботі [12], та залежить від зневоднення шару м'яса біля мідної пластини (герметичного електроду). З наведених даних видно, що під час комбінованого впливу теплового потоку й електричного струму вологовміст м'яса також має істотний і нелінійний вплив на об'єм речовини, що переноситься в м'ясі.

Таблиця 3

Результати визначення впливу вологовмісту м'яса свинини на виникнення в ньому потоку речовини під теплового потоку від електронагрівача й електричного струму

Вологовміст м'яса, w ,	Об'єм перенесеної речовини, $V_p \cdot 10^6$, м ³ , за $U = 27$ В; $Q = 92$, Вт, $S_M = 10,17 \cdot 10^{-4}$, м ² , $\delta_M = 0,01$, м і тривалості впливу τ , с					
	0,5	1	2	3	4	5
0,731	0,0705	0,1410	0,2820	0,3746	0,4562	0,5166
0,728	0,0699	0,1399	0,2797	0,3716	0,4525	0,5125
0,721	0,0687	0,1373	0,2747	0,3649	0,4443	0,5032

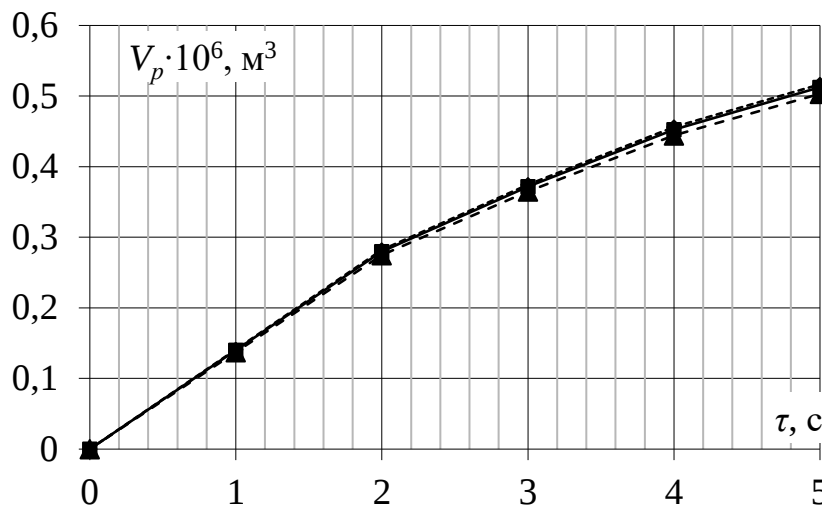


Рис. 4. Кінетика об'єму речовини, перенесеної в м'ясі свинини під дією теплового потоку від електронагрівача $Q = 92$, Вт й електричного струму за напруги $U = 27$ В, за площі зразка $S_M = 10,17 \cdot 10^{-4}$, м², його товщини $\delta_M = 0,01$, м, величини прикладеного надлишкового тиску $p = 2320$ Па, протягом $\tau = 0,5 \dots 5,0$ с і вологовмісту $\blacklozenge$ – 0,731, $\blacksquare$ – 0,728 та $\blacktriangle$ – 0,721 кг/кг.

Це дає підстави сформулювати теоретичну кінетику перенесеного в м'ясі під час комбінованої дії теплового потоку й електричного струму об'єму речовини в інтервалі тривалості впливу 0...2 с в наступному вигляді

$$\begin{aligned}
 V_p &= V_{p_t} + V_{p_e} = k_t \cdot Q \cdot S_M \cdot \delta_M^{-(1-w)} \cdot \frac{(p_{гр} - p)}{p_{гр}} \cdot \tau + k_e \cdot k_S \cdot U \cdot S_M \cdot \delta_M^{-w} \cdot \frac{(p_{гр} - p)}{p_{гр}} \cdot \tau = \\
 &= (k_t \cdot Q \cdot \delta_M^{-(1-w)} + k_e \cdot k_S \cdot U \cdot \delta_M^{-w}) \cdot S_M \cdot \frac{(p_{гр} - p)}{p_{гр}} \cdot \tau, \text{ м}^3,
 \end{aligned} \quad (7)$$

Відповідно до (7), потік речовини J_p , що виникає під комбінованим впливом теплового потоку від нагрівача й електричного струму в інтервалі тривалості впливу 0...2 с буде дорівнювати

$$J_p^V = \frac{V_p}{S_M \cdot \tau} = (k_t \cdot Q \cdot \delta_M^{-(1-w)} + k_e \cdot k_S \cdot U \cdot \delta_M^{-w}) \cdot \frac{(p_{гр} - p)}{p_{гр}}, \text{ м/с}, \quad (8)$$

або

$$J_p^G = \frac{V_p \cdot \rho_M}{S_M \cdot \tau} = (k_t \cdot Q \cdot \delta_M^{-(1-w)} + k_e \cdot k_S \cdot U \cdot \delta_M^{-w}) \times$$

$$\times \frac{(p_{\text{гр}} - p)}{p_{\text{гр}}} \cdot \rho_m, \text{ кг}/(\text{м}^2 \cdot \text{с}). \quad (9)$$

Таким чином, отримані дані підтверджують що об'єм перенесеної речовини та величина потоку речовини в м'ясі свинини, під комбінованою дією теплового потоку від нагрівача й електричного струму, досягають свого максимуму при тривалості спільного впливу протягом 2 с, що підтверджує обґрунтування частоти електричного струму 0,5 Гц під час двостороннього жарення виробів з м'яса свинини під дією електричного струму процес та обладнання реалізації якого описані в роботі [15].

Висновки. В ході проведених досліджень встановлені кількісні параметри перенесення речовини в м'ясі свинини під окремим впливом електричного струму й теплового потоку від нагрівача та їх комбінованою дією. Вперше встановлено, що вологовміст м'яса істотно і нелінійно впливає на виникнення в ньому потоку речовини. Запропоновано закономірності виникнення потоку речовини в м'ясі свинини під дією електричного струму та теплового потоку від нагрівача з урахуванням вологовмісту м'яса та величини прикладеного надлишкового тиску. Підтверджено, що максимальний ефект комбінованого впливу електричного струму та теплового потоку на процеси перенесення речовини в м'ясі спостерігається при тривалості 0...2,0 с, коли дія обох факторів накладається одна на одну, а залежність має лінійний характер.

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HISTORY OF ART

THE RHYTHM OF HUMANITY: HOW MUSIC SHAPES CULTURE AND SOCIETY

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Abstract

"The Rhythm of Humanity: How Music Shapes Culture and Society" delves into the profound influence of music on human civilization, exploring its role as a dynamic force in shaping cultural identity, social cohesion, and historical narratives. This article examines the multifaceted ways in which music transcends mere entertainment to become a mirror reflecting the values, beliefs, and aspirations of societies throughout history.

Drawing from diverse cultural contexts and historical periods, the article traces the evolution of music's impact on shaping collective identity and fostering a sense of belonging within communities. From ancient rituals to modern-day pop culture phenomena, music has served as a powerful tool for expressing emotions, transmitting knowledge, and mobilizing social movements.

Moreover, the article highlights the interconnectedness of music with other forms of artistic expression, such as literature, visual arts, and dance, underscoring its role as a catalyst for cultural innovation and exchange. Through case studies and theoretical frameworks, it explores how music functions as a language of resistance, resilience, and revolution, challenging dominant narratives and amplifying marginalized voices.

Ultimately, "The Rhythm of Humanity" illuminates the transformative potential of music as a unifying force that transcends geographical, linguistic, and ideological boundaries, fostering empathy, understanding, and solidarity among diverse peoples. By recognizing the profound impact of music on culture and society, we gain deeper insights into the human experience and the intricate tapestry of our shared heritage.

Keywords: Music, culture, society, identity, influence, social cohesion

Introduction:

In the vast tapestry of human existence, few phenomena possess the transcendent power to resonate across time, space, and culture quite like music. From the haunting melodies of ancient rituals to the pulsating rhythms of contemporary global beats, music has woven itself intricately into the fabric of human civilization, shaping our identities, narratives, and social dynamics in profound ways. In "The Rhythm of Humanity: How Music Shapes Culture and Society," we embark on a journey to explore the multifaceted role of music as a transformative force that transcends the boundaries of language, geography, and ideology.

Music is not merely a form of entertainment; it is a universal language that speaks to the depths of the human soul, evoking emotions, memories, and aspirations that are shared across generations and continents. It serves as a powerful medium for expressing cultural identity, transmitting knowledge, and forging bonds of solidarity within communities. Through its melodies, harmonies, and lyrics, music reflects the values, beliefs, and struggles of societies throughout history, serving as a mirror that reflects the collective consciousness of humanity.

As we delve into the intricate interplay between music, culture, and society, we will uncover how music functions as a catalyst for social change, a beacon of hope in times of adversity, and a vehicle for cross-cultural dialogue and understanding. From the vibrant rhythms of indigenous ceremonies to the anthems of social movements, music has played a pivotal role in shaping historical narratives and mobilizing collective action.

Through a combination of historical analysis, cultural critique, and interdisciplinary perspectives, this article seeks to illuminate the transformative potential of music as a unifying force that transcends differences and fosters connections among diverse peoples. By recognizing the profound impact of music on culture and society, we gain deeper insights into the human experience and the rich tapestry of our shared heritage. Join us on a journey through the melodies and rhythms that echo the heartbeat of humanity, as we explore the enduring legacy of music as a dynamic force in shaping our world [1].

In the grand symphony of human existence, few elements resonate as deeply and universally as music. From the beating drums of ancient rituals to the electric guitar solos of modern rock concerts, music permeates every facet of human culture and society. It serves as a conduit for expression, a catalyst for change, and a mirror reflecting the collective identity of communities worldwide. In this article, we embark on a journey to explore the profound influence of music on shaping culture and society, examining its role as a dynamic force that transcends boundaries and connects humanity in ways both tangible and intangible.

The Cultural Identity of Music:

Music is intricately woven into the fabric of cultural identity, serving as a sonic tapestry that captures the essence of a people's history, beliefs, and values. Whether it's the haunting melodies of traditional folk songs or the pulsating rhythms of indigenous dances, music embodies the soul of a culture, transmitting knowledge and preserving heritage from one generation to the next. Through music, communities affirm their sense of belonging and celebrate the richness of

their cultural diversity. The cultural identity of music is a rich tapestry that reflects the unique heritage, traditions, and values of communities around the world. Music serves as a powerful medium through which cultural narratives are expressed, preserved, and transmitted from one generation to the next. Across diverse cultures and regions, music plays a central role in defining and affirming cultural identity [2].

One of the most profound aspects of music's role in cultural identity is its ability to encapsulate the essence of a people's history and experiences. Traditional folk songs, for example, often recount stories of triumph, struggle, love, and loss, providing a window into the collective memory of a community. These songs are passed down through oral tradition, serving as a link to the past and a reminder of cultural continuity. Moreover, music embodies the values and beliefs of a culture, serving as a vehicle for expressing spiritual, social, and political ideals. In many indigenous cultures, music is deeply intertwined with ceremonial practices and rituals, serving as a means of connecting with ancestors, spirits, and the natural world. Similarly, religious music plays a vital role in expressing devotion and reverence, shaping the spiritual identity of communities [3].

In addition to its ceremonial and spiritual functions, music also reflects the social dynamics and diversity within a culture. Different musical genres and styles often emerge within specific social contexts, reflecting the experiences and perspectives of different social groups. For example, the blues music of African American communities in the United States emerged as a response to the hardships of slavery and segregation, expressing themes of resilience, survival, and hope. Furthermore, music serves as a marker of cultural identity, distinguishing one community from another through distinct musical traditions and practices. Whether it's the intricate rhythms of West African drumming, the soulful melodies of Indian classical music, or the high-energy beats of Brazilian samba, each culture's music reflects its unique sonic palette and aesthetic sensibilities.

Overall, the cultural identity of music is a testament to the richness and diversity of human expression. Across cultures and continents, music serves as a universal language that transcends linguistic and ideological barriers, forging connections and fostering understanding among people from all walks of life. By celebrating and preserving musical traditions, we honor the unique heritage and identity of communities around the world [4].

Social Cohesion and Collective Experience:

Beyond its role in preserving cultural traditions, music plays a vital role in fostering social cohesion and collective experience. From communal singing during religious ceremonies to the electrifying energy of a stadium concert, music has the power to unite individuals across diverse backgrounds, forging bonds of solidarity and shared emotion. In moments of joy, sorrow, or celebration, music serves as a universal language that transcends barriers of language and ideology, bringing people together in harmony. Social cohesion and collective experience are integral aspects of human interaction, and music plays a profound role in fostering

unity and shared emotions within societies. Through communal musical experiences, individuals come together to celebrate, mourn, express solidarity, and forge bonds that transcend differences [5].

One of the most striking ways in which music fosters social cohesion is through communal performances and rituals. Whether it's a village gathering, a religious ceremony, or a neighborhood block party, music often serves as the catalyst for bringing people together in shared spaces. The act of singing, dancing, or playing music in unison creates a sense of belonging and togetherness, reinforcing social bonds and strengthening community ties.

Moreover, music has the power to evoke deep emotional responses and create a sense of collective experience among participants. In moments of joy, music amplifies feelings of celebration and camaraderie, uniting individuals in shared expressions of happiness and exuberance. Conversely, in times of sorrow or hardship, music provides solace and comfort, serving as a source of empathy and support for those who are grieving or struggling [6].

In addition to its role in fostering social cohesion within communities, music also has the power to bridge divides and promote inclusivity among diverse groups. Musical collaborations and cross-cultural exchanges bring people from different backgrounds together, fostering mutual understanding and appreciation. Through music, individuals have the opportunity to connect with others who may have different experiences, beliefs, or perspectives, transcending barriers of language, ethnicity, and ideology. Furthermore, music can serve as a catalyst for social change and collective action. Throughout history, music has been a powerful tool for expressing dissent, raising awareness about social issues, and mobilizing movements for justice and equality. Protest songs, anthems, and musical performances have galvanized communities to unite in pursuit of common goals, inspiring solidarity and resilience in the face of adversity [7].

In conclusion, social cohesion and collective experience are fundamental aspects of human society, and music serves as a dynamic force that enhances these dynamics. Through communal performances, emotional resonance, cross-cultural exchange, and activism, music fosters unity, empathy, and solidarity among individuals and communities. By embracing the power of music to connect and inspire, we can create more inclusive and harmonious societies where all voices are heard and valued.

The Transformative Power of Music:

Throughout history, music has been a driving force behind social change and political movements. From the protest songs of the Civil Rights era to the anthems of the LGBTQ+ rights movement, music has served as a voice for the marginalized and a call to action for justice. Through its lyrics, melodies, and rhythms, music has the power to challenge dominant narratives, inspire activism, and amplify the voices of those who have been silenced. The transformative power of music is profound and far-reaching, touching every aspect of human experience and society. Music has the remarkable ability to evoke emotions, inspire

action, and shape the course of history. From personal healing to social change, music serves as a catalyst for transformation on multiple levels. One of the most striking aspects of music's transformative power is its ability to heal and provide solace in times of emotional distress. Whether it's through the soothing melodies of classical music, the cathartic release of rock and roll, or the rhythmic beats of hip-hop, music has a therapeutic effect on the mind, body, and soul. Studies have shown that listening to music can reduce stress, alleviate anxiety, and elevate mood, offering a form of emotional support and resilience in the face of adversity [8].

Moreover, music has the capacity to transcend cultural, linguistic, and ideological boundaries, fostering empathy, understanding, and connection among diverse groups of people. Through shared musical experiences, individuals from different backgrounds come together to celebrate their common humanity, bridging divides and promoting inclusivity. Musical collaborations and cross-cultural exchanges provide opportunities for dialogue and mutual exchange, challenging stereotypes and fostering a sense of global citizenship. Beyond its role in personal healing and cross-cultural understanding, music has been a driving force behind social change and political activism throughout history. From the protest songs of the Civil Rights era to the anti-war anthems of the 1960s, music has provided a voice for the marginalized and a platform for advocacy. Artists have used their music to raise awareness about social issues, mobilize communities, and inspire movements for justice and equality [9].

Furthermore, music has the power to shape cultural narratives and challenge dominant ideologies, offering alternative perspectives and amplifying marginalized voices. Through its lyrics, melodies, and rhythms, music provides a platform for storytelling, preserving oral traditions, and documenting the lived experiences of communities. In this way, music becomes a tool for reclaiming cultural identity and asserting agency in the face of oppression.

In conclusion, the transformative power of music is undeniable, influencing individuals, communities, and societies in profound ways. Whether it's through personal healing, cross-cultural exchange, or social activism, music has the capacity to inspire, unite, and empower us to create a more just, compassionate, and harmonious world. By harnessing the power of music to connect and transform, we can unlock its full potential to shape the course of human history [10].

Cross-Cultural Dialogue and Exchange:

In an increasingly interconnected world, music serves as a bridge that spans continents and cultures, facilitating cross-cultural dialogue and exchange. From the fusion of musical styles in jazz and hip-hop to the global reach of pop music icons, music transcends geographical boundaries to create a shared language of creativity and collaboration. Through cultural exchange, music fosters mutual understanding and appreciation, enriching the tapestry of human experience. Cross-cultural dialogue and exchange facilitated by music serve as crucial avenues for fostering understanding, appreciation, and collaboration among diverse communities around the world. Music transcends

linguistic and cultural barriers, providing a universal language through which individuals can connect, communicate, and share experiences.

One of the most significant ways in which music promotes cross-cultural dialogue is through its ability to facilitate cultural exchange and mutual appreciation. Through exposure to different musical traditions, genres, and styles, individuals gain insights into the diverse cultural practices and values of other communities. This exposure fosters empathy, respect, and curiosity about the experiences of others, breaking down stereotypes and fostering a sense of global interconnectedness [11].

Furthermore, music serves as a bridge that connects people from different cultural backgrounds, facilitating interactions and relationships that transcend geographical boundaries. Musical collaborations between artists from diverse cultural backgrounds provide opportunities for creative exchange and innovation, blending musical traditions and styles to create new forms of expression. These collaborations not only enrich the artistic landscape but also promote cultural understanding and appreciation among audiences worldwide. Moreover, music festivals, concerts, and cultural events serve as platforms for cross-cultural dialogue and exchange, bringing together people from different parts of the world to celebrate their shared love of music. These gatherings provide opportunities for artists and audiences to interact, learn from one another, and forge meaningful connections that transcend cultural differences. In this way, music becomes a catalyst for building bridges of understanding and friendship among diverse communities.

In addition to fostering interpersonal connections, music also plays a crucial role in promoting intercultural understanding at the societal level. Through the dissemination of music recordings, performances, and educational programs, individuals have access to a wealth of cultural resources that broaden their perspectives and deepen their appreciation for cultural diversity. This exposure encourages cultural curiosity and empathy, leading to greater tolerance and respect for differences. In conclusion, cross-cultural dialogue and exchange facilitated by music are essential for promoting understanding, empathy, and cooperation in an increasingly interconnected world. By embracing the diversity of musical traditions and engaging in meaningful interactions with people from different cultural backgrounds, we can cultivate a more inclusive and harmonious global community. Through the universal language of music, we can build bridges that transcend borders and unite us in our shared humanity [12].

Conclusion

In conclusion, "The Rhythm of Humanity: How Music Shapes Culture and Society" has provided a compelling exploration of the profound impact of music on the human experience. Throughout history, music has transcended barriers of language, geography, and ideology to serve as a powerful force in shaping cultural identities, fostering social cohesion, and mobilizing collective action. From ancient rituals to contemporary global movements, music has played a central

role in expressing emotions, transmitting knowledge, and forging connections among diverse peoples.

As we reflect on the diverse manifestations of music across cultures and time periods, we recognize its transformative potential as a universal language that speaks to the depths of the human soul. Through its melodies, harmonies, and rhythms, music serves as a mirror reflecting the values, beliefs, and aspirations of societies, while also challenging dominant narratives and amplifying marginalized voices.

Moreover, our exploration has underscored the interconnectedness of music with other forms of artistic expression, highlighting its role as a catalyst for cultural innovation and exchange. By recognizing the significance of music in shaping historical narratives and fostering cross-cultural dialogue, we gain deeper insights into the complexities of the human experience and the rich tapestry of our shared heritage. As we look to the future, it is essential to continue nurturing and celebrating the diversity of musical traditions, recognizing the power of music to bridge divides and inspire positive change in our increasingly interconnected world. By embracing the rhythm of humanity, we can harness the transformative potential of music to create a more inclusive, empathetic, and harmonious society for generations to come.

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MATERIALS SCIENCE AND MECHANICS OF MACHINES

INCREASING THE FATIGUE STRENGTH OF MACHINE PARTS USING SURFACE ENGINEERING METHODS

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Abstract

The purpose of the work is to increase fatigue resistance and durability of machine parts due to various methods of surface action. To solve it, studies of the effect on the surface condition of various variants of combined methods of mechanical processing, cementation and surface plastic deformation, as well as a modern method of bombarding the surface layer with low-energy ions were carried out. It was established that after grinding the surface before cementation, and not after, it increases by 41% endurance limit (σ_{-1}) of 20X2H4A steel, as compressive stresses during cementation reduce the effect of harmful tensile stresses that occur during grinding. An even greater increase in σ_{-1} is achieved after final blasting due to additional compressive stresses and significant surface smoothing during surface plastic deformation - slandering. The high efficiency of ion bombardment of the surface of 40X and 65Г steels is shown, under the influence of which the grains in the thin surface layer are very finely ground (from 50 μm to 600 nm), a developed substructure is formed, defects are "healed", and the surface roughness is significantly reduced.

These changes in the state of the surface contributed to resistance to fatigue failure and a significant increase in the durability of the products.

Keywords: mechanical processing, shot peening, ion bombardment, surface roughness, substructure, cyclic durability.

Introduction

As you know, any external impact on the material of a part occurs through its surface and most destructive processes begin in the surface layers. The service life of machines is largely determined by the quality of the surface of machine parts. The surface condition significantly affects the volumetric mechanical properties of products, and, first of all, resistance to fatigue failure, since a fatigue crack usually initiates from the surface or in surface layers.

Due to the increasing complexity of modern structures, operating modes, and the intensification of work processes of mechanisms and machines, the ability of parts to resist fatigue failure is of particular importance. It should be emphasized that fatigue develops at stress levels significantly below the yield strength of the material (even before the first signs of plastic deformation appear) and leads to a decrease in service life. This is confirmed by statistics - more than 80% of failures of machine parts occur due to destruction due to the development of fatigue processes [1]. Fatigue damage is local, not accompanied by any visible effects and is therefore especially dangerous. Therefore, solving the issue of increasing fatigue strength is relevant.

Analysis of publications.

One of the important features of the functioning of machine parts and mechanisms is the presence of a significant number of stress concentrators, which have a significant impact on the performance parameters of products [2]. In this regard, it is necessary to provide

for the possibility of "technological compensation" for the presence of concentrators in order to minimize their negative impact on the reliability of the product during operation under conditions of shifting power loads. These problems are solved by surface engineering methods.

The quality of the surface is determined by the microgeometry of irregularities, the sign of stresses, chemical composition, grain size, and structural changes that occur during the processing of parts [3,4]. One of the main indicators of fatigue strength - the endurance limit - strongly depends on the quality of the surface layer, the presence of microcracks in it, and their size. Since, under repeated force stresses, the onset of fracture is associated with the formation of a surface crack, it is quite obvious that as the surface roughness decreases, the fatigue resistance increases. Thus, according to work [4], the endurance limit of samples made of low-strength steel, the surface of which was not treated after rolling, is 70% of the endurance limit of finely polished samples. For high-strength steel, which is more sensitive to local stresses, this ratio is significantly lower and amounts to only 35%. Reducing the depth of depressions and micro-roughnesses, which are stress concentrators and cause the appearance of fatigue cracks, leads to increased fatigue life.

To increase the fatigue strength of a wide range of machine parts, surface plastic deformation (SPD) is widely used. The authors [5] have convincingly shown

that SPD using a striker tool for parts made of normalized steel 40X leads to an increase in the level of compressive macrostresses by more than 6 times. At the same time, durability increases by ~ 5 times.

With such types of hardening surface treatment as carburization and nitriding, significant compressive stresses arise on the surface, preventing the initiation of fatigue cracks. The work [6] notes that in parts after carburization (with subsequent hardening and low tempering), depending on the carbon concentration in the hardened layer, the value of these stresses reaches 300–400 MPa, and after nitriding they increase to 700–800 MPa. As a result, the endurance limit increases by 1.3–1.5 times, respectively.

Modern and effective methods of processing the surface layer, which radically change its structural-stress state and microgeometry, include ultrasonic impact treatment (UIT), frictional hardening, and ion-plasma technologies (CIB method). Using these surface modification methods, the improvement in the fatigue characteristics of the material can accordingly be explained by the submicro- and nanostructuring of a thin surface layer, an increase in the density of defects in the crystal structure and the creation of compressive stresses.

The authors of [7] note that after ultrasonic impact treatment (UIT) of Cr3 steel, the formation of a subgrain structure in the surface layer and the appearance of compressive macrostresses led to an increase in the endurance limit by 50%, and the durability increased by an order of magnitude.

The performance of machine parts under cyclic loads is significantly influenced by technological methods of surface hardening using highly concentrated energy sources. The source [8] states that frictional hardening of the surface prevents the further development of existing cracks and the formation of new ones. On the surface of the metal (carbon, structural steels and cast irons) a hardened layer 0.1–0.4 mm thick with a nanocrystalline structure, surface roughness $R_a = 0.4–0.63 \mu\text{m}$ is formed, which has increased fatigue and corrosion-fatigue strength. The durability of parts after friction hardening of the surface increases to 50%. The authors of work [9] came to a similar conclusion, stating that after friction treatment, due to the formation of a specific structurally stressed state of the metal, characterized by an increased dislocation density, refined grain, and the presence of residual compressive stresses, the fatigue strength of steels 45, 40 X and Y8A both in air and in a corrosive environment (3% aqueous NaCl solution). The increase in durability is 1.3–1.6 times in air and 3.4–6.5 times in a corrosive environment.

The influence of nanostructured surface layers on increasing cyclic durability became the subject of research in works [10–13]. The authors of [10–12] point to a significant increase in fatigue strength after the formation of a nanocrystalline layer on the surface as a result of ion bombardment. At the same time, the results of [13] indicate that ion bombardment, while providing a nanostructure to the surface of steel products, leads to only a very slight increase in the endurance limit σ_{-1}

($\sim 5\%$). Such controversial findings require further research in this innovative direction, arouse considerable interest and are certainly relevant. The development of provisions on the possibility of healing discontinuities that arise in the metal during cyclic loading is also an important aspect in solving the problem of increasing the durability of products.

Purpose and objectives of the study

The purpose of this work is to increase fatigue resistance and increase the durability of machine parts by modifying the surface.

The objectives of the research are to study the influence of the surface condition after various processing methods (mechanical in combination with chemical-thermal, ion bombardment) on fatigue strength, which will make it possible to predict the durability of products.

Material and research methods

Case-hardened steel 20X2H4A, upgradeable steel 40X, spring steel 65Г were studied.

Different methods of surface treatment were chosen for the study: carburizing, mechanical processing (grinding and polishing), shot peening (SPD) and ion bombardment.

Shot blasting of gear teeth was carried out in a pneumatic chamber according to the following mode: air pressure 5 atm, shot with a diameter of 0.6–0.8 mm, distance from the nozzle 200 mm, processing time 5 minutes. The surface roughness and profile were determined using a TR200 profilometer according to the ISO 4287-1997 standard. The measurement error for R_a did not exceed 10%.

Fatigue tests were performed on a MUI-6000 machine using a symmetrical bending with rotation scheme. The test base was 10^7 loading cycles. The test samples had a working part shortened due to the transition sections, which made it possible to reduce warping (no more than 0.05 mm) and increase rigidity. In order to obtain reliable results for each state of the material, at least 10 samples were subject to testing.

The treatment of fatigue samples with low-energy ($<3 \text{ keV}$) titanium ions was carried out on a Bulat-3t installation in an argon atmosphere, at a pressure of 0.133 Pa, a current of 95–100 A, and a voltage of 900–1100 V. Treatment time was 1.5 min. Selection of parameterson bombardment (IB) mode prevented sample heating. To ensure uniform surface treatment, the samples were rotated using a planetary mechanism.

In order to obtain the distribution of components and their identification in the surface layers of samples treated with ion bombardment, micro-X-ray spectral analysis was used. The stressed state of the surface layer was determined using a DRON-3 diffractometer.

Research results

The influence of various types of mechanical processing on the endurance limit and durability of products made of case-hardened steels

Case-hardened steel 20X2H4A, which is widely used for large critical parts, in particular heavily loaded gears operating under high alternating stresses and friction conditions.

Carburization mode: temperature 930°C, holding for 10 hours, cooling to 820°C, quenching in oil, low

tempering 180-200°C, effective layer thickness 1.3 – 1.5 mm. After cementation, a high-strength, brittle surface state is realized, for which roughness indicators are especially important, since even minor irregularities are stress concentrators and their relaxation occurs not due to local plastic deformations, but due to the occurrence of microcracks. Taking these provisions into account, the surface of the samples for testing for fatigue strength was processed according to three options:

1. Turning with an allowance for grinding to a depth of 0.2 mm per side, cementation + hardening + low tempering, grinding to a depth of 0.2 mm.

2. Turning, grinding, chemical-thermal treatment, polishing to nominal size.

3. Turning, grinding, chemical-thermal treatment, polishing, shot blasting.

Option 1 corresponds to the gear manufacturing technology commonly used in practice. But, as is

known, during the grinding process, residual tensile stresses and structural heterogeneity are created in the surface layer after carburization due to phase transformations.

Option 2 eliminates the harmful effects of residual stresses from grinding, since it was carried out before carburization. In option 3, the goal was to assess the effect of surface plastic deformation.

Fig. 1 shows the surface profiles of the samples after the indicated processing options.

As can be seen, after grinding (Fig. 1, a) the surface profile is characterized by deep protrusions and depressions. Mechanical polishing leads to a significant deep protrusions and depressions. Mechanical polishing leads to a significant smoothing of the protrusions and a significant reduction in surface roughness (Fig. 1, b). Shot treatment due to work hardening slightly worsens the surface roughness (Fig. 1, c).

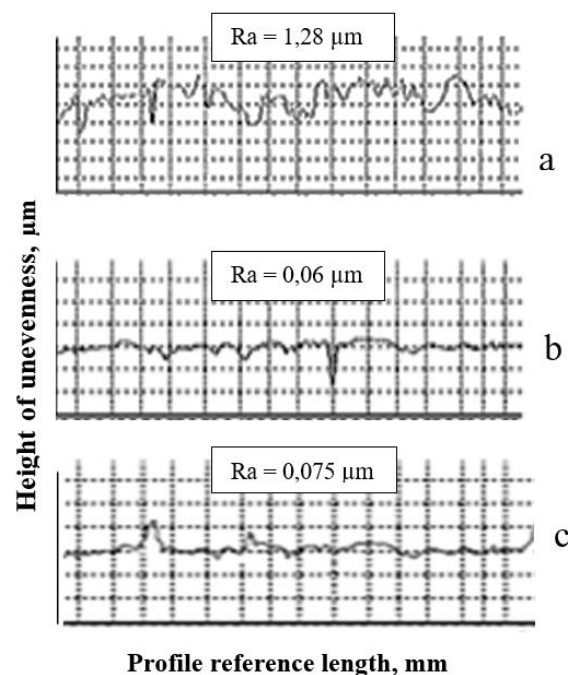


Fig.1 Profiles and surface roughness of samples after different processing options:
a – grinding; b – polishing; c – shot blasting.

Based on the test results, fatigue curves were constructed (Fig. 2.)

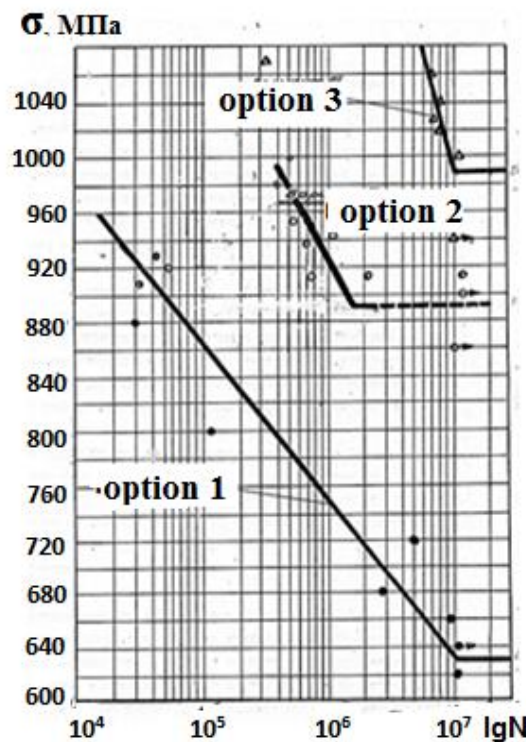


Fig.2 Fatigue curves of specimens made of steel 20X2H4A after various types of surface treatment

Table 1 shows the values of the endurance limits of samples obtained after various options for their surface treatment.

Table 1

Values of endurance limits of tested sample variants

No option	Endurance limit σ_{-1} , MPA	Increase in endurance limit, %
1	630	100*
2	890	141
3	990	157

*Option 1 is accepted as 100%

The appearance of the curves in Fig. 2 indicates that grinding before carburization and polishing after (processing option 2) led to a significant decrease in surface roughness (Fig. 1, b) and an increase in the limit endurance by 41%. The durability of the samples under overloads has also increased noticeably. This is indicated by the fact that the left inclined branch of the curve of option 2 is located significantly more to the right than the section of the inclined branch of the curve of option 1 at the same stress level.

Shot blasting of the surface increased the endurance limit by another 16% (up to 57%) and increased durability further (option 3, Fig. 2). This fact can be explained by the appearance of internal residual compressive stresses recorded by us (about 550 MPa), as well as the almost complete destruction of the structural heterogeneity of the surface in the process of plastic deformation during shot peening. In addition, as is known, during surface plastic deformation, positive changes in the intragranular structure occur (crushing of blocks, increase in dislocation density), which contributes to surface hardening. The resulting depressions from the shot (diameter 0.8 mm), although they increase its roughness, but due to their rounded shape and small penetration into the very hard martensitic structure of the surface after chemical

treatment, are not significant stress concentrators - sources of fatigue crack development.

The tests carried out showed the effectiveness of not only the final surface plastic deformation, but also the grinding of samples before carburization. In addition, the use of option 2, where possible, reduces the surface treatment process.

Ion bombardment as one of the modern methods for increasing the cyclic durability of products

The experiments were performed on samples made of steels 40X and 65Г. These steels were chosen for practical reasons. 40X steel is used to make axles, connecting rods, gears, shafts, that is, parts that are used under repeated cyclic loads. Steel 65Г is spring-steel, and one of the main requirements for these products is high fatigue strength.

The surface condition of 40X steel samples after ion bombardment (IB) is illustrated in Fig. 3.

Before bombardment, the average grain size corresponded to 50 μm , and after IB, a developed substructure with a grain size of 600-800 nm and wide grain boundaries (Fig. 3). The formed cellular dislocation substructure (Fig. 4, b), characterized by a low dislocation density in the cell body and significant misorientation.

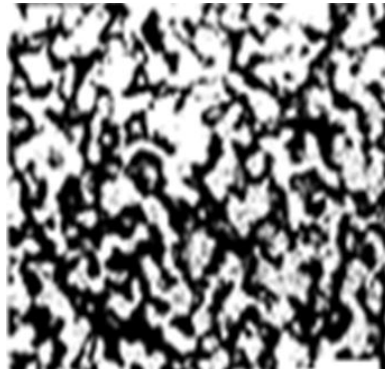


Fig. 3 Sample made of steel 40X (hardening + high tempering) after IB;
× 15000.



a *b*
Fig. 4 Substructure of steel before (a) and after (b) IB; × 15000.

Using the method of micro-X-ray spectral analysis, a chemical deposit on the surface with a method for identifying titanium was identified, which could be consumed during the bombardment and fall into power. The results showed that the hardness of

titanium on the surface is only 0.35% (Fig. 5, a). Titanium is present in the surrounding spots, which is confirmed by a diffraction pattern and elemental analysis of one of them (Fig. 5, b).

Інформація		
Напруження (кВ) 20.0		
Сума % 100.0		
Елемент	Інт.	С %
Fe K	34605	98.74
Mn K	252	0.72
Ti K	815	0.35
Si K	342	0.18

a

Інформація		
Напруження (кВ) 20.0		
Сума % 100.0		
Елемент	Інт.	С, %
Ti K	4710	97.03
Fe K	647	2.75
Si K	347	0.17

b

Fig. 5 Chemical and elemental composition of the surface of the sample(a) and composition of titanium drops (b) after IB.

Drops of titanium fall into areas of surface irregularities and discontinuities (pores, cavities, microcracks), “heal” them (Fig. 6) and reduce the number of stress concentrators.

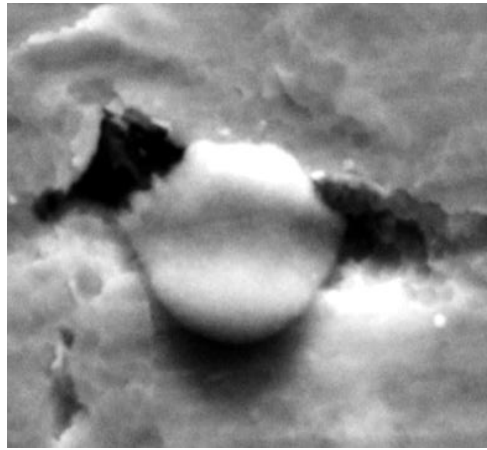


Fig. 6 A drop of Ti that flogged into a recess on the surface during IS; $\times 10000$

However, despite the presence of a droplet phase of titanium and a developed substructure, the roughness after IB decreases very significantly (Fig. 7), which indicates a shallow depth of the surface relief.

Similar structural changes occurred in steel 65Г (hardening. + medium tempering) after IB.

Reduction of roughness, “healing of surface defects, significant grain refinement and the presence of a developed substructure in the surface layer could not but affect the durability of products.

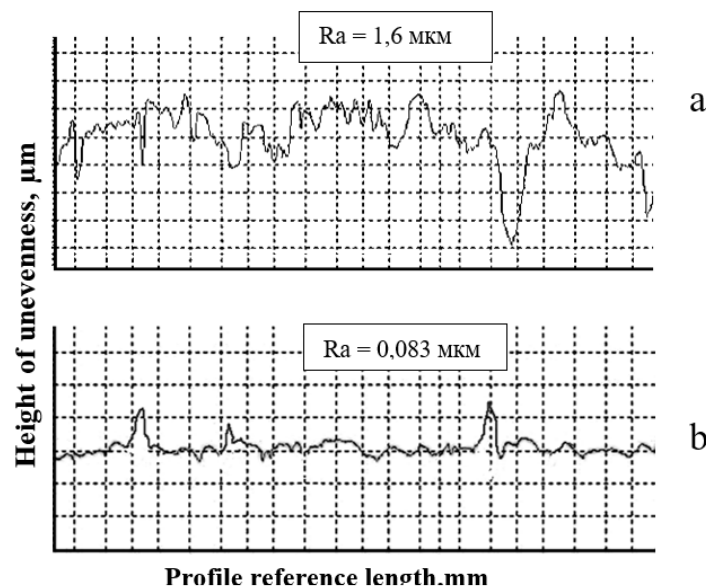


Fig. 7 Surface roughness sample made of 40X steel:
a – before IB, b – after IB

The results of cyclic durability tests are shown in Table 2. As can be seen from the table, at a stress of 380 MPa, a sample made of 40X steel without IB failed after 297,600 cycles, and after IB it withstood 1,000,000 cycles without destruction. An increase in stress to 430 MPa (by 14%) led to destruction, but at the same time the durability increased by ~ 1.5 times. An even greater increase in cyclic durability is recorded for samples made of 60G steel: without IB they failed after 937,440 cycles at a stress of 380 MPa. After IB,

even with an increase in stress by 44% - up to 550 MPa (the maximum for the diameter of the tested samples), they withstood more than 1 million cycles without destruction.

Thus, it has been convincingly shown that surface treatment using one of the modern methods - bombardment with low-energy ions - significantly increases the fatigue resistance of products under cyclic loads.

Table 2

Impact of information security on cyclic durability

Material and processing	Stress magnitude, MPa	Number of cycles before failure	Test result
Steel 40X, original	380	297600	collapsed
Steel 40X, original + IB	380	1000000	didn't collapse
Steel 40X, original + IB	430	453840	collapsed
Steel 65, original	380	937440	collapsed
Steel 65, original+ IB	550	1116000	didn't collapse

Conclusions

1. Research has shown that grinding the surface before carburization (and not after) increases the endurance limit of high-strength steel 20X2H4A with a brittle martensitic structure after hardening by 40%.

2. Subsequent fine polishing and shot peening of the cemented layer further increases the resistance to fatigue failure due to a significant reduction in surface roughness and the creation of favorable compressive stresses.

3. The greatest effect of increasing the cyclic durability of products was recorded after bombarding a thin surface layer with low-energy ions and is achieved by significant grain refinement, the formation of a developed substructure, an increase in dislocation density, and "healing" of surface defects, which are local stress concentrators and potential sources of microcrack formation.

4. When addressing issues of technological support and improving the quality of machine parts operating under cyclic loading conditions, one should choose processing processes that will ensure the characteristics of the surface layer, guaranteeing the durability of the product.

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MATHEMATICS

AN EFFICIENT METHOD FOR THE NUMERICAL SOLUTION OF FOURTH ORDER INITIAL VALUE PROBLEMS

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Abstract

In this paper, we propose an efficient numerical method to solve fourth order initial value problems. Analysis proves that the proposed method have at least quadratic convergence. Numerical results confirm the accuracy and efficiency of the proposed method.

Keywords: Initial Value Problems, Taylor series, Maximum Absolute Error, Approximation, Lipschitz condition.

1. Introduction

An efficient method for solving second order initial value problems has been proposed by P. K. Pandey and Archana Yadav in [6] and for third order initial value problems by the authors in [5].

In this paper, we study an effective numerical technique based on Taylor series approximation to solve fourth order initial value problems (IVPs) of the following type:

$$u^{IV} = f(x, u, u', u'', u'''), a \leq x \leq b, \quad (1.1)$$

subject to the initial conditions

$$u(a) = \alpha_0, u'(a) = \alpha_1, u''(a) = \alpha_2, u'''(a) = \alpha_3 \quad (1.2)$$

where the function f is continuous in $[a, b] \times \mathbb{R} \times \mathbb{R} \times \mathbb{R} \times \mathbb{R}$.

We assume that f satisfies a Lipschitz condition in a convex domain D of $[a, b] \times \mathbb{R} \times \mathbb{R} \times \mathbb{R} \times \mathbb{R}$ so that above problem 1.1 with 1.2 possesses a unique solution [1, 2, 3].

To find an approximation to the solution of the above problem, we discretize the domain $[a, b]$ into N equal subintervals each of size $h = \frac{b-a}{N}$:

$$a = x_0 < x_1 < x_2 < \dots < x_{N-1} < x_N = b \quad (1.3)$$

where the nodes are given by $x_i = a + ih, i = 0, 1, \dots, N$.

We denote by $u(x)$, the true solution of the above problem in $[a, b]$ and by u_i, u'_i, u''_i, u'''_i the approximations to the true solution and its derivatives $u(x_i), u'(x_i), u''(x_i), u'''(x_i)$ respectively in

this order for each $i = 0, 1, \dots, N$. We also denote f_i for the approximate value of $f(x_i, u(x_i), u'(x_i), u''(x_i), u'''(x_i))$.

This article is arranged in the following order. In section 2, we derive the method and discuss its convergence. In section 3, we illustrate the method with examples.

2. The Derivation of the Scheme and Convergence Analysis

Choose and fix a real number a :

$a \neq -1$.

We define the scheme:

$$\begin{aligned} \overline{u_{i+1}} &= u_i + hu'_i + \frac{h^2}{2}u''_i + \frac{h^3}{6}u'''_i + c_1h^4u_i^{IV} + c_2h^5u_i^V \\ \overline{u'_{i+1}} &= u'_i + hu''_i + \frac{h^2}{2}u'''_i + \frac{h^3}{6}u_i^{IV} + c_1h^4u_i^V \\ \overline{u''_{i+1}} &= u''_i + hu'''_i + \frac{h^2}{2}u_i^{IV} + c_1h^3u_i^V \\ \overline{u'''_{i+1}} &= u'''_i + hu_i^{IV} + c_1h^2u_i^V \end{aligned} \quad (2.1)$$

We find $a_0, b_0, c_0, d_0, c_1, c_2$ so that

$$u_{i+1} = a_0(\overline{u_{i+1}} + au_i) + b_0h(\overline{u'_{i+1}} + au'_i) + c_0h^2(\overline{u''_{i+1}} + au''_i) + d_0h^3(\overline{u'''_{i+1}} + au'''_i)$$

Using Taylor series on the left hand side

$$u_{i+1} = u_i + hu'_i + \frac{h^2}{2}u''_i + \frac{h^3}{3!}u'''_i + \frac{h^4}{4!}u_i^{IV} + \frac{h^5}{5!}u_i^V + O(h^6)$$

$$\begin{aligned}
&= a_0 \left(u_i + hu'_i + \frac{h^2}{2} u''_i + \frac{h^3}{6} u'''_i + c_1 h^4 u_i^{IV} + c_2 h^5 u_i^V + au_i \right) \\
&\quad + b_0 h \left(u'_i + hu''_i + \frac{h^2}{2} u'''_i + \frac{h^3}{6} u_i^{IV} + c_1 h^4 u_i^V + au'_i \right) \\
&\quad + c_0 h^2 \left(u''_i + hu'''_i + \frac{h^2}{2} u_i^{IV} + c_1 h^3 u_i^V + au''_i \right) \\
&\quad + d_0 h^3 (u'''_i + hu_i^{IV} + c_1 h^2 u_i^V + au'''_i)
\end{aligned} \tag{2.2}$$

Truncating the series and equating the corresponding coefficients of $u_i, hu'_i, h^2 u''_i, h^3 u'''_i, h^4 u_i^{IV}, h^5 u_i^V$ on both the sides, we get

$$\begin{aligned}
1 &= a_0(1+a) \\
1 &= a_0 + b_0(1+a) \\
\frac{1}{2} &= \frac{a_0}{2} + b_0 + c_0(1+a) \\
\frac{1}{6} &= \frac{a_0}{6} + \frac{b_0}{2} + c_0 + d_0(1+a) \\
\frac{1}{24} &= a_0 c_1 + \frac{b_0}{6} + \frac{c_0}{2} + d_0 \\
\frac{1}{120} &= a_0 c_2 + b_0 c_1 + c_0 c_1 + d_0 c_1
\end{aligned} \tag{2.3}$$

Solving these, we get

$$\begin{aligned}
a_0 &= \frac{1}{(1+a)} \\
b_0 &= \frac{\frac{1}{a}}{(1+a)^2} \\
c_0 &= \frac{\frac{1}{a(a-1)}}{2(1+a)^3} \\
d_0 &= \frac{a(a^2 - 4a + 1)}{6(1+a)^4} \\
c_1 &= \frac{a^4 - 10a^3 + 14a^2 + 2a + 1}{24(1+a)^3} \\
c_2 &= -\frac{22a^7 - 251a^6 + 97a^5 + 125a^4 + 100a^3 - 23a^2 - 11a - 3}{360(1+a)^6}
\end{aligned} \tag{2.4}$$

We also get the expressions for the first, second and third derivatives:

$$\begin{aligned}
u'_{i+1} &= \left(\frac{\overline{u_{i+1}} - u_i}{24c_2 h} \right) + \left(\frac{24c_2 - 1}{24c_2} \right) u'_i + \left(\frac{48c_2 - 1}{48c_2} \right) hu''_i + \left(\frac{72c_2 - 1}{144c_2} \right) h^2 u'''_i + \left(\frac{4c_2 - c_1}{24c_2} \right) h^3 u_i^{IV} \\
u''_{i+1} &= \left(\frac{\overline{u'_{i+1}} - u'_i}{6c_1 h} \right) + \left(\frac{6c_1 - 1}{6c_1} \right) u''_i + \left(\frac{12c_1 - 1}{12c_1} \right) hu'''_i + \left(\frac{18c_1 - 1}{36c_1} \right) h^2 u_i^{IV} \\
u'''_{i+1} &= \left(\frac{\overline{u''_{i+1}} - u''_i}{2c_1 h} \right) + \left(\frac{2c_1 - 1}{2c_1} \right) u'''_i + \left(\frac{4c_1 - 1}{4c_1} \right) hu_i^{IV}
\end{aligned}$$

where $u_i^{IV} = f_i$.

If R_i denotes the remainder in the approximation at node i , then from above discussion we have

$$R_i = O(h^6).$$

Therefore, the accuracy of the above method is at least quadratic.

3. Numerical Illustrations

The following six problems illustrate the performance of our method. We compute the maximum absolute errors MAE, MAED1, MAED2 in the true solutions, its first and second derivatives $u(x), u'(x), u''(x)$, namely:

$$\begin{aligned}
\text{MAE} &= \max_{1 \leq i \leq N} |u(x_i) - u_i| \\
\text{MAED1} &= \max_{1 \leq i \leq N} |u'(x_i) - u'_i| \\
\text{MAED2} &= \max_{1 \leq i \leq N} |u''(x_i) - u''_i| \\
\text{MAED3} &= \max_{1 \leq i \leq N} |u'''(x_i) - u'''_i|
\end{aligned}$$

All the computations were performed on Ubuntu 20.04.4 LTS linux operating system with IDLE 3.8.10 running Python version 3.8.10 on Intel Core[®] i5-9400 CPU @ 2.90GHz $\times$ 6 PC.

Example 1. Consider the fourth-order initial value problem:

$$u^{IV} = 12(u')^2 + 12uu'', 0 \leq x \leq 1$$

with the initial conditions:

$$u(0) = 1, u'(0) = -2, u''(0) = 6, u'''(0) = -24$$

with the exact solution

$$u(x) = \frac{1}{(1+x)^2}.$$

The output for $a = \frac{1}{2}$ is given below:

N	MAE	MAED1	MAED2	MAED3
256	0.00023970950451382422	0.0008648216360307992	0.00225840468932087	0.0037021091015531082
512	5.982651015087881e-05	0.00021575277277591232	0.0005632412917198626	0.0009233724670376642
1024	1.494378507291283e-05	5.388065621514393e-05	0.00014063586914719872	0.00023054351628482017
2048	3.7342291691055962e-06	1.3463768216648297e-05	3.5140921894327715e-05	5.760422733958048e-05

Example 2. Consider the fourth-order initial value problem:

$$u^{IV} = -u' - 4e^{-x}, 0 \leq x \leq 1$$

with the initial conditions:

$$u(0) = 0, u'(0) = 1, u''(0) = -2, u'''(0) = 3$$

with the exact solution

$$u(x) = xe^{-x}.$$

The output for $a = \frac{2}{5}$ is given below:

N	MAE	MAED1	MAED2	MAED3
256	5.07782070557905e-07	1.9225837056791274e-06	5.241934204647247e-06	8.475958695464136e-06
512	1.2714545172265446e-07	4.810618334961402e-07	1.3107540829948583e-06	2.1174836130066765e-06
1024	3.173316220905775e-08	1.2019330018038228e-07	3.277544385338338e-07	5.292859011074569e-07
2048	7.888418029899924e-09	2.99736465765539e-08	8.182726823902087e-08	1.321730801473464e-07

Example 3. Consider the fourth-order initial value problem:

$$u^{IV} = -4 \cos x + u, 0 \leq x \leq 1$$

with the initial conditions:

$$u(0) = 0, u'(0) = 0, u''(0) = 2, u'''(0) = 0$$

with the exact solution

$$u(x) = x \sin x.$$

The output for $a = \frac{1}{2}$ is given below:

N	MAE	MAED1	MAED2	MAED3
256	6.059861937801614e-07	2.3726911722032895e-06	6.807556253068947e-06	1.2082855353146016e-05
512	1.5178042078733966e-07	5.939416483080606e-07	1.702995872043811e-06	3.019631480416507e-06
1024	3.801529435687456e-08	1.4862909636370603e-07	4.259044633914133e-07	7.547607223656883e-07
2048	9.50230039098443e-09	3.7099023408870835e-08	1.0634909525242264e-07	1.8851668448505166e-07

Example 4. Consider the fourth-order initial value problem:

$$u^{IV} = 24u^5, 0 \leq x \leq 1$$

with the initial conditions:

$$u(0) = 1, u'(0) = -1, u''(0) = 2, u'''(0) = -6$$

with the exact solution

$$u(x) = \frac{1}{1+x}.$$

The output for $a = \frac{1}{2}$ is given below:

N	MAE	MAED1	MAED2	MAED3
256	3.12434808869555e-05	0.00010626888116294086	0.00024724704317630186	0.0003021831752841875
512	7.799656273788091e-06	2.6515978590990752e-05	6.166201796634074e-05	7.532371792307035e-05
1024	1.9483945974396732e-06	6.622357080932062e-06	1.5396774960679815e-05	1.88032057674703e-05
2048	4.867235900429812e-07	1.6544980299126877e-06	3.846811710089826e-06	4.697267051378962e-06

Example 5. Consider the fourth-order initial value problem:

$$u^{IV} = -4e^x \sin x, 0 \leq x \leq 1$$

with the initial conditions:

$$u(0) = 0, u'(0) = 1, u''(0) = 2, u'''(0) = 2$$

with the exact solution

$$u(x) = e^x \sin x.$$

The output for $a = \frac{1}{2}$ is given below:

N	MAE	MAED1	MAED2	MAED3
256	9.99910898968892e-07	4.130361320520137e-06	1.2933133346493264e-05	2.7246045575912703e-05
512	2.505632772376032e-07	1.0346073273659329e-06	3.237528902300113e-06	6.81208237440778e-06
1024	6.2869359496176e-08	2.5931127334288817e-07	8.098177088911029e-07	1.7027831056282139e-06
2048	1.570052088339935e-08	6.487729509174756e-08	2.0249710130926246e-07	4.257019761144676e-07

Example 6. Consider the fourth-order initial value problem:

$$u^{IV} = 4e^x(3 + 2x) + u, 0 \leq x \leq 1$$

with the initial conditions:

$$u(0) = 0, u'(0) = 0, u''(0) = 2, u'''(0) = 6$$

with the exact solution

$$u(x) = x^2 e^x.$$

The output for $a = \frac{1}{2}$ is given below:

N	MAE	MAED1	MAED2	MAED3
256	4.287940488012509e-06	1.859161943329468e-05	6.367776486371213e-05	0.0001640355317604758
512	1.0749753238670223e-06	4.658764012788197e-06	1.595006763821516e-05	4.1036406344119314e-05
1024	2.6924900131675145e-07	1.166706365296477e-06	3.9914350757896955e-06	1.026271385740074e-05
2048	6.733705149031266e-08	2.917741479535607e-07	9.98234828131217e-07	2.5661813722877014e-06

Example 7. Consider the fourth-order initial value problem:

$$u^{IV} = u - 8x \cos x - 12 \sin x, 0 \leq x \leq 1$$

with the initial conditions:

$$u(0) = 0, u'(0) = -1, u''(0) = 0, u'''(0) = 7$$

with the exact solution

$$u(x) = (x^2 - 1) \sin x.$$

The output for $a = \frac{1}{2}$ is given below:

N	MAE	MAED1	MAED2	MAED3
256	8.668500844586244e-07	0.9960709314811149	1.6641355185864626e-05	4.7245480606195045e-05
512	2.1775315399446997e-07	0.9980411616543208	4.171866886171216e-06	1.1821233000253173e-05
1024	5.4437395932624075e-08	0.9990220080755576	1.0444202032111605e-06	2.9565572439160803e-06
2048	1.361527236406552e-08	0.9995113612579783	2.613367224846286e-07	7.395293688539084e-07

4. Conclusion

In this paper we have proposed a numerical method to solve fourth order initial value problems having at least quadratic convergence. We have given the derivation for the proposed scheme and estimated the error involved. We have also given several numerical examples which confirms our claim.

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NORMAL AND PATHOLOGICAL PHYSIOLOGY

INTRODUCTION OF *T-786C* ENDOTHELIAL NO-SYNTASE FOR INTERRUPTIONS AND DEVELOPMENT OF RHEUMATOID ARTHRITIS

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Abstract

Rheumatoid arthritis is a systemic autoimmune disease characterized by a chronic course, causing erosive and destructive changes in the joints and involving the internal organs and systems of the body in the pathogenesis.

The etiology of rheumatoid arthritis is still not fully understood, but both genetic and environmental factors contribute to the development of the disease. Several genetic features have been linked to rheumatoid arthritis, as have several environmental factors, such as cigarette smoke, dust exposure, and the microbiome. Other environmental factors, as well as hormonal influences, may explain the higher risk of developing this disease in women.

Keywords: rheumatoid arthritis, *T-786C* of endothelial NO-synthase, *T*-allele and *C*-allele of the *eNOS* gene, patterns of inheritance of rheumatoid arthritis.

Introduction. Patients with rheumatoid arthritis (RA) have a higher risk of mortality compared to the general population. Despite the reduction of this indicator after the improvement of the treatment strategy and the deepening of knowledge about the course of the disease, studies during the last 50 years have consistently observed the risk of mortality in patients with RA 1.5 times higher than in the general population [7].

The pathogenesis of RA is based on autoimmune inflammation with an unknown primary antigen, which can be viruses, bacteria or even hypothermia, which causes T-lymphocyte immunodeficiency and leads to uncontrolled synthesis by B-lymphocytes of antibodies directed to the synovial membrane of the affected joint, which are immunoglobulins G, A, M. They combine with the antigen in a complex antigen, which independently damage the synovial membrane or undergo phagocytosis in the synovial fluid. After being absorbed by phagocytes, they activate lysosomal enzymes that, after exiting, damage the synovial tissues of the joint, starting a nonspecific inflammation [5, 13].

As a result of damage to the synovial membrane of the joint, fragments of proteins are formed, which the body perceives as foreign objects, as a result of which antibodies are produced, closing the vicious circle [18, 16].

A key role in the pathogenesis of RA is played by genetic factors in interaction with the environment and the individual's lifestyle, they play an important role in changing gene expression and the clinical realization of

inherited or acquired pathology, including multifactorial. That is why the study of genetic mutations and their association with a certain pathology is becoming important today not only from a scientific point of view, but also for practical health care [1, 2].

Despite a number of studies establishing the role of the above genetic factors in the occurrence of certain vascular, infectious and autoimmune diseases, as well as RA [9, 12], individual immunological mechanisms of the development of RA remain unstudied and require detailed targeted research. Also, information on the role of the *T-786C* polymorphism of the *eNOS* gene promoter in the formation of RA in the available sources of literature is limited, and the available data are contradictory and relate to individual nosologies and their pathogenetic links [20].

In this regard, it was considered necessary to study the frequencies of alleles and genotypes of the *T-786C* polymorphism of the *eNOS* gene in patients with RA and their association with the severity of the course of RA.

Material and methods. The clinical diagnosis of RA was verified according to the criteria of the American College of Rheumatology and the European Antirheumatic League (ACR/EULAR 2010) [3].

To study the *T-786C* polymorphism of the *eNOS* gene promoter, 2 groups of patients were selected: a control group, $n=20$ and an experimental group (RA patients, $n=60$).

Genomic DNA for molecular genetic research was isolated from peripheral blood using the commercial

test system "innuPREP Blood DNA Mini Kit" (Analytik Jena, Germany) using centrifugal filters.

To determine polymorphic variants of the *eNOS* gene (*T-786C*) (rs2070744) [4], modified protocols with oligonucleotide primers using the PCR method

and subsequent analysis of restriction fragment length polymorphism (RFLP) were used. The studied regions of the genes were amplified using specific primers ("Metabion", Germany), indicated in the table. 1.

Table 1

Oligonucleotide primers		
Gene (polymorphism)	Primer sequence (5' – 3')	The size of the amplified DNK region
<i>eNOS</i> (<i>T-786C</i>)	TGGAGAGTGCTGGTGTACCCA - forward GCCTCCACCCCCACCCTGTC - reverse	180 p.n.

Specific fragments of the *eNOS* gene (*T-786C*) were amplified using the commercial DreamTaq Green PCR Master Mix (2x) kit (Thermo Scientific, USA) (Table 2).

Table 2

Composition of amplification mixtures		
A fragment of a gene	Reagents	Number
<i>eNOS</i> (<i>T-786C</i>)	DreamTaq Green PCR Master Mix	25 µl
	Primer F	100 pmol (1 µl)
	Primer R	100 pmol (1 µl)
	DEPC-treated Water	18 µl
	DNK	5 µl
The total volume of the mixture		50µl

Amplification products of DNA fragments of the *eNOS* gene (*T-786C*) were subjected to hydrolytic cleavage with the MspI FastDigest restriction endonuclease (Thermo Scientific, USA). The state of the restriction fragments was analyzed in a 4% agarose gel (agarose from Cleaver Scientific, Great Britain) with the addition of ethidium bromide and further visualization using a transilluminator. The resulting image was processed in the Vitran program.

Statistical processing was carried out using Microsoft Office Excel® 2010™, IBM SPSS Statistics® 23.0 applications.

The difference in the distribution of genotypes of the *T-786C* polymorphism of the *eNOS* gene in the control group and patients for the conformity of the distribution of genotypes to the Hardy-Weinberg law was tested using the χ^2 test with 2 degrees of freedom, and in the control group - using the χ^2 test with 1 degree of freedom, without using Yeats corrections.

Criteria for the inclusion of patients in the study: the age of patients over 18 years old, the diagnosis of RA according to the ACR/EULAR 2010 criteria, the duration of the disease is at least 6 months, with a low, moderate and high degree of activity according to DAS28; signed informed consent of the patient to participate in the study.

Criteria for excluding patients from the study: the patient's age is younger than 18 years, pregnancy or lactation, acute coronary syndrome, acute cerebrovascular accident, acute heart failure, chronic heart failure of classes II-IV according to NYHA, the presence of mental disorders, malignant neoplasms and infectious diseases in the stage exacerbation or unstable remission, alcohol and drug addiction.

Research results and discussion.

The study of genetic mutations and their association in patients with RA is gaining importance today, as

it remains one of the unsolved medical and social problems.

Considerable attention is paid to the study of *NO* metabolism, which is a mediator of synovial fluid cell apoptosis in the pathogenesis of RA [10]. In patients with RA, *NO* contributes to the body's immune defense, acting as an immunoregulator, which is caused by the action of cytokines that stimulate the synthesis of *NO* [19, 6]. As the disease progresses, the concentration of *NO* increases, which causes its cytotoxic effect and complicates the course of RA [11].

Among the 453 allelic variants of the *eNOS* gene (according to the NCBI database), one of the most studied is the *T-786C* polymorphism of the *eNOS* gene, which is located on the 7th chromosome (7q 35-36), consists of 26 exons and encodes an mRNA of 4052 nucleotides [17]. The *T-786C* polymorphism in the promoter region is associated with a decrease in *eNOS* expression [14], which leads to endothelial dysfunction [8].

As a result of the above, endothelial dysfunction and systemic inflammation occur, which are important pathological processes in RA and lead to the progression of the underlying disease.

In our study, the relative frequencies of the *T*-allele and *C*-allele of the *eNOS* gene in patients with RA and in the control group (Table 3) probably did not differ. However, the *T*-allele occurred more often in the experimental group than the *C*-allele (by 35.0%; $\chi^2=29.40$, $p<0.001$), without a statistically significant difference in the control. In general, among the 160 isolated alleles in the examined population, the *T*-allele dominated over the *C*-allele (by 30.0%, $\chi^2=28.80$, $p<0.001$).

Table 3

Frequencies of T-786C alleles of the eNOS gene polymorphism (rs 2070744)
in patients with rheumatoid arthritis

Research groups, n alleles	T alleles, n (%)	C alleles, n (%)	OR [95% CI]	χ^2
Research group, n=120	81 (67,5)	39 (32,5)	4,31 [2,51-7,40]	$\chi^2=29,40$ p<0,001
Control group, n=40	23 (57,5)	17 (42,5)	1,83 [0,74-4,44]	$\chi^2=1,80$ p>0,05
OR [95% CI]	1,54 [0,74-3,20]	0,65 [0,31-1,36]	-	-
χ^2 p	$\chi^2=1,32$; p>0,05		-	-
In general, n=160	104 (65,0)	56 (35,0)	3,44 [2,18-5,46]	$\chi^2=28,80$ p<0,001

Note. OR - Odds ratio, n (%) is the absolute (relative) number of alleles.

The distribution of genotypes in the healthy group does not correspond to the Hardy-Weinberg law with a probable excess of heterozygosity ($F=-0.33$; $\chi^2=4.49$; $p=0.034$), which, however, overlapped with the normal

distribution in the experimental group and generally formed a normal population equilibrium without a probable difference between the expected on the actual heterozygosity (Table 4).

Table 4

Indicators of heterozygosity of the T-786C polymorphism of the eNOS gene (rs 2070744)
in patients with rheumatoid arthritis

Группы	Alleles, n (%)		P_T	P_C	H_O	H_E	F	χ^2	P
	T	C							
Research group, n=120	81 (67,5)	39 (32,5)	0,67	0,33	0,38	0,44	0,13	<1,0	>0,05
Control group, n=40	23 (57,5)	17 (42,5)	0,57	0,43	0,65	0,49	-0,33	4,49	0,034
In general, n=160	104 (65,0)	56 (35,0)	0,65	0,35	0,45	0,45	0,01	<1,0	>0,05

Notes: 1. P_T is the relative frequency of the T allele; P_C is the relative frequency of the C allele. 2. H_O – actual heterozygosity; H_E – expected heterozygosity; F is the inbreeding coefficient. 3. χ^2 p is a criterion for the validity of the "null" hypothesis between actual and expected heterozygosity. 4. n (%) is the absolute number (percentage) of observations.

Frequencies of T-786C genotypes of the eNOS gene polymorphism in patients with RA are shown in table. 5. The analysis proved a probable superiority of the relative frequency of TC of the polymorphic variant in the control group over that in patients (by 26.67%, $\chi^2=4.31$, $p=0.038$). Also, the TC genotype dominated over the CC genotype both in the group of patients and in the control: by 25.0% ($\chi^2=14.52$, $p<0.001$) and 55.0% ($\chi^2=16.13$, $p<0.001$) respectively. Among pa-

tients with RA, carriers of TT alleles occurred more often than those with the CC variant (by 35.0%, $\chi^2=23.84$, $p<0.001$). And among practically healthy individuals, the relative frequency of TC carriers prevailed over that with a favorable TT variant (by 40.0%, $\chi^2=7.11$, $p=0.008$).

The probability of the model according to the Akaike information criterion (AIC) is 16.01 (OR=9.0; 95% CI=4.40-18.41; $\chi^2=40.0$; $p<0.001$).

Table 5

Frequencies of T-786C genotypes of the eNOS gene polymorphism in patients with rheumatoid arthritis

№	Genotypes of the eNOS gene	Research groups, n=80		OR [95% CI]	χ^2 p
		RA, n=60 (%)	Control, n=20 (%)		
1	TT- genotypes, n=34	29 (48,33)	5 (25,0)	2,81 [0,91-8,70]	$\chi^2=3,34$ p=0,067
2	TC- genotypes, n=36	23 (38,33)	13 (65,0)	2,99 [1,04-8,59]	$\chi^2=4,31$ p=0,038
3	CC- genotypes, n=10	8 (13,33)	2 (10,0)	1,38 [0,27-7,14]	$\chi^2<1,0$ p>0,05
OR [95% CI] TT- genotypes against TC; χ^2 p		1,59 [0,73-3,45] $\chi^2=1,38$ p>0,05	0,15 [0,03-0,64] $\chi^2=7,11$ p=0,008	-	-
OR [95% CI] TT- genotypes against CC; χ^2 p		13,14 [4,34-39,75] $\chi^2=23,84$ p<0,001	6,25 [0,61-63,54] $\chi^2<1,0$ p>0,05	-	-
OR [95% CI] TC- genotypes against CC; χ^2 p		8,27 [2,65-25,79] $\chi^2=14,52$ p<0,001	42,25 [5,15-148,9] $\chi^2=16,13$ p<0,001	-	-
The probability of the co-dominant model of the higher education system [95% CI] χ^2 ; p		9,0 [4,40-18,41] $\chi^2=40,0$; p<0,001		-	-

Note. OR – odds ratio; 95% CI is a 95% confidence interval.

Racial and population analysis (Table 6) showed that the frequency of the CC genotype of the eNOS gene in the population of the Bukovyna region examined by us (10.0% - in the control, 13.33% - in the experimental group) does not reliably differ from that of Caucasian populations and individual populations of the equatorial race, including by allelic distribution

($P_T = 0.57-0.68$ and $P_C = 0.32-0.43$ versus $P_T = 0.50-1.0$ and $P_C = 0.33-0.59$; $p>0.05$), indicating high heterogeneity and racial non-specificity. At the same time, the frequency of the T-allele in our studies is slightly lower, and the frequency of the C-allele is higher than those for Asian populations ($P_T = 1.0$; $p<0.05$ and $P_C = 0$) [15, 18].

Table 6

Racial and population differences in frequencies of genotypes, T-786C alleles of the eNOS gene polymorphism

Races, populations	TT- genotypes	TC- genotypes, %	CC - genotypes, %	T-алель	C-алель
The results we received (Bukovyna)	0,25-0,48	0,38-0,65	0,10-0,13	0,57-0,68	0,32-0,43
Equatorial race (African Americans)	0,39-1,0	0,17-0,50	0-0,10	0,50-1,0	0,08-0,50
European race (Caucasians)	0,13-1,0	0-0,56	0-0,30	0,41-1,0	0,33-0,59
Asian race	0,97-1,0	0-0,43	0-0,012	1,0	0

Conclusion. Therefore, this gene in a homozygous state is found in 12.5% of the examined residents of Bukovyna: in 13.33% of patients with RA, and in 10.0% of healthy people, respectively ($p>0.05$). According to the allelic distribution of the T-786C polymorphism of the eNOS gene in the population in general, the T-allele dominates over the C-allele (65.0% vs. 35.0%; $\chi^2=28.80$; $p<0.001$): in patients with RA – by 35.0% [OR=4.31, 95%CI=2.51-7.40, $p<0.001$], in the control - by 15.0% ($p>0.05$) with a probable excess of heterozygosity ($F=0.33$; $\chi^2=4.49$; $p=0.034$). The TT genotype of the eNOS gene occurs in 48.33% of patients with RA. The frequency of the C-allele of the eNOS gene in the population of the Bukovyna region examined by us probably does not differ from that for Caucasians and certain populations of the equatorial

race ($P_T = 0.57-0.68$ and $P_C = 0.32-0.43$ vs. $P_T = 0.50-1.0$ and $P_C = 0.33-0.59$; $p>0.05$), indicating high heterogeneity and racial non-specificity.

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CULTURE OF SPEECH AND LISTENING IN THE PROCESS OF BUSINESS COMMUNICATION**Pashayeva P.***Ph.D. in pedagogy, associate professor*DOI: [10.5281/zenodo.11189028](https://doi.org/10.5281/zenodo.11189028)**Abstract**

Communicative problems cause more and more people's interest. This is a necessary part of the professional competence of specialists in all spheres of activity. A modern specialist must possess knowledge in the field of business and academic communication in order to understand communication partners, establish relationships with them, conduct business talks, negotiations and master the basics of public speaking.

The purpose of teaching the subject "Business and academic communication in the Azerbaijani language" is the formation of students' oral and written business and academic communication skills. To provide knowledge in the field of theory and practice of business and academic communication, based on the most effective methods and forms of business communication, the formation and development of communicative competence, which will allow students to carry out their professional activities in the future, is considered one of the main goals of this subject. Concrete words, grammatical constructions, etc. d. for each message. Such types of speech activity as speaking, writing, listening and reading are the basis of the speech process.

Keywords: communication, oral and written speech, business and academic communication.

The process of speaking or talking means that a person joins the system of mutual social relations in a specific case. However, what distinguishes these two subjects from each other is that the thoughts that dominate the inner existence of the listener at the moment of communication, since the relationship to the subject of the speech is in the form of internal speech, can be fully protected from external influences and remains under the control of the subject. Therefore, there is a direct connection between the concepts of listening and inner speech. At the same time, among the means of verbal communication (speaking, listening, reading and writing), it is important to understand that listening is in an active position, that there are active and passive forms of listening, that communication culture consists of normative, communicative, and ethical components.

As a result of teaching the subject of business and academic communication, students get extensive information about the components of communication culture, the observance of conversational standards and the principle of communication expediency, the activity form of conversation, the fact that listening is a type of communication, the forms of listening, and the improvement of listening skills.[3, 11]

Communication problems are causing more and more interest among people. This is a necessary part of the professional competence of specialists in all fields of activity. A modern specialist should have knowledge in the field of business and academic communication in order to understand the communication partners, establish a relationship with them, conduct business conversations, negotiations and master the basics of mass speech. Specific words, grammatical constructions, etc. for each communication. should be There are types of speech activity, such as speaking, writing, listening and reading, which are the basis of the speech process. The main feature of literary language is standardization. A norm is a uniform, generally accepted use of language elements, rules of use in a certain period. Norms are not invented by scientists, they are supported by the regular

processes and events that occur in the language, the experience of speaking. The main sources of the norm include the works of writers, the language of the media, generally accepted contemporary usage, and the scientific research of linguists.

Norms help preserve the integrity and understanding of the literary language, protect it from the influx of dialect speech, social jargon, and foreign languages. Language norms are changing. This is an objective process that does not depend on the will and desire of individual individuals. According to researchers, this process has intensified in recent decades due to social changes. In the critical period, the logo sphere, that is, the field of speech culture, changes significantly, and this, in turn, shows changes in the social consciousness of the language collective. There are options within the literary norm. This objective norm variation is generally associated with language development.

In the process of literary language development, there are changes towards dialects and other functional types of language. As a rule, norms of written speech are formed earlier than oral expression. Currently, there is a tendency for the convergence of written and oral speech. [5, 62-63]

A language event is considered normative if it is characterized by the following features:

- 1) compliance with the structure of the language;
- 2) mass and regular reproduction in the process of communication;
- 3) public approval and recognition. [2, 87]

Both spontaneous and conscious processes take place in the formation of the speech norm. Spontaneity is associated with the mass and regular use of a certain language norm among native language speakers. Language and discourse are processes of "legitimization" or codification of spontaneous language norms that are consciously dominated by grammars and dictionaries. Coding, etc., fixation of events that develop in the process of social experience, is carried out by philologists. What has been mentioned shows the necessity of following the principle of communication expediency in

speech, therefore, the style of speech should be in accordance with the conditions and goals of communication. Knowing the standards of speech and following the principle of appropriateness of communication is the basis of communication culture. Communication culture consists of three: normative, communicative, ethical components, and the main criteria are: 1. Communicative expediency. It is not enough to speak or write correctly, it is important to be aware of the stylistics of words and expressions in order to be able to use them in appropriate communicative situations. 2. Accuracy of statement. Here, two aspects are considered: a) accuracy in the process of reflecting reality and b) accuracy in expressing ideas in one word. The first aspect is related to the authenticity of the speech (true or false). In the second aspect, the following shortcomings are possible: lack of concreteness, confusion. 3. Sequence of presentation. The statement should reflect the logic of reality, the logic of thought and should be characterized by the logic of speech expression. Logical thinking should reflect the facts and relationships of reality (cause-effect, difference-similarity, etc.). The violation of the logic of speech expression is also manifested in the wrong division of the written text into paragraphs. 4. Communicative aesthetics. This is manifested in the rejection by the literary language of means of expression that insult the honor and dignity of a person. 5. Compatibility. The relevance of certain language means depends on the context, situation, and psychological characteristics of the interlocutor's personality. The saying "They don't talk about the rope in the hanged man's house" reflects the essence of this principle very well. [3, 115]

Listening is one of the forms of human activity, like the process of speaking. Hearing and listening cannot be equated. We note that we hear a lot even when we don't want to. If numerous sounds are included in this series, we can say that a person lives in the world of sounds in the true sense. But since the ear is constantly exposed to external sounds, a unique adaptation process takes place. More precisely, the effect of "inaudibility" is created in the vortex of sounds. If every sound (speech) that we care about acts as a source of information for us, it encourages us to listen.

Listening is a conscious activity of a person. This effort comes from the need for information of a person, who is a social being, or from the desire of reality to influence events and processes. Also, the attitude of the parties to each other is reflected in the hearing (agreement, inner feeling of sympathy, disgust, etc.).

Whether we like it or not, listening is a vital necessity. Science has proven that three-quarters of human communication is speaking and listening. It should be noted that among the means of verbal communication (speaking, listening, reading and writing), listening is in the active position.

The famous philosopher Leibniz writes that "... I am ready to travel twenty miles to listen to my worst enemy, if only I can learn something from him." [6, 10]

It is true that listening is important for learning, but it is not essential. For example, any information can be learned by reading from a newspaper (magazine,

book) page or by observing an event live (while watching a football game in a stadium). This suggests that other means than listening can be important as a means of understanding. However, there are spheres of human activity in which it is impossible to do without lively conversation. If there is a conversation, then there is also an addressee (listener).

In many cases, communication is compared in a two-way way. Since solving any problem requires mutual effort, the listening party should also play its role. Sometimes it is assumed that the listening party is passive. In fact, this misconception contradicts the culture of listening. Because even when a person "takes water in his mouth" and remains silent, his attitude towards the subject of the speech should not be considered equal to zero. It is possible that by using non-verbal means, the listener confirms what was said, expresses his agreement and displeasure with gestures.

The process of speaking or talking means that a person joins the system of mutual social relations in a specific case. However, what distinguishes these two subjects from each other is that the thoughts that dominate the inner being of the listener at the moment of communication, and the relationship to the subject of the speech is in the form of internal speech, can be completely protected from external influences. Therefore, there is a direct connection between the concepts of listening and inner speech. [2, 94-95]

Among the numerous forms of listening in recent times, there is talk of male or female listening forms. There are gender characteristics and mentality factors in this style of approach. It must be admitted that the positive qualities of women in the listening process are higher than those of men. It turns out that a subtle creature is also more sensitive. This sensitivity is observed by women's preference for empathic listening. Empathetic listening is also important in defining women's social roles (educator, doctor, psychologist, etc.).

In the history of Azerbaijani diplomacy, it is possible to find the names of female diplomats even in the Middle Ages. Sara Khatun, the mother of Aggoyunlu ruler Uzun Hasan, and his wife Daspina Khatun were famous for their negotiation skills. In later times, the Azerbaijani woman impressed even the Europeans with her skill.

The French traveler, ethnographer and writer Alexandre Dumas (father Dumas) skillfully wrote about his meeting and negotiations with Khursudbanu Natanvan, the khan's daughter in Baku, that there was a very strict discipline in this family. Children learn to speak in the presence of adults. The lady of the house was a real noble. It is true that women have not been given much space in the diplomatic arena. Observations of the present day allow us to confirm that the activity of women in the spheres of foreign relations and diplomacy is strengthening. The recent increase in the number of women among the ambassadors confirms that such predictions are in line with reality.

It is difficult to evaluate the speech process, which is a complex psychophysiological phenomenon, without listening. It is believed that men are attentive only for 15-20 seconds. In the following moments, they internally look for a moment to intervene on the subject

of the speech. This means that men tend to listen reflexively. Therefore, men have some difficulty in communicating with women. However, since the listening style is the same when a man talks to a man, abnormal elements that do not meet ethical requirements are not observed. The same is true when a woman interacts with a woman. Observations show that men interrupt women twice as often. Undoubtedly, this is a very bad and unethical habit. [8, 25]

Thus, listening should also be explained by the concept of space and the relations between the parties at this time. Communication between the speaker and the listener at a certain distance should be in accordance with ethical criteria. As a result of teaching the subject of business and academic communication, students get extensive information about the components of communication culture, the observance of speech standards and the principle of communication expediency, the activity form of speech, the fact that listening is a type of communication, the forms of listening, and the improvement of listening skills. At the same time, they learn that listening is in an active position among the means of verbal communication (speaking, listening, reading and writing), but also the existence of active

and passive forms of listening, and that communication culture consists of normative, communicative, and ethical components.

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LEADERSHIP QUALITIES OF STUDENTS: THEORETICAL ANALYSIS

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DOI: [10.5281/zenodo.11189037](https://doi.org/10.5281/zenodo.11189037)**Abstract**

Based on an analysis of scientific research, the author identifies the following leadership qualities that need to be developed in a future teacher in the process of professional training at a university: professional: organizational and managerial qualities, effective communication, cooperation and the ability to work in a team, tolerance, adaptability, innovation; personal: self-confidence, responsibility, discipline, activity and initiative, empathy, desire for self-development and self-improvement.

Keywords: leadership, leader, leadership qualities, future teachers, classification of leadership qualities, educational process at a university, professional and personal leadership qualities.

Reform processes that permeate modern society in all spheres of activity provoke the emergence of new trends, trends in the training of future specialists, including future teachers. Globalization, informatization and digitalization contribute to the optimization of the educational process on the one hand, but on the other hand, the teacher ceases to be the dominant source of information, losing his leading position in the labor market. That is why training a competitive teacher with leadership qualities and capable of creating an innovative educational product is one of the priorities of modern higher education.

The problem of leadership qualities is being actively studied abroad, and the main scientists (W. Bennis, R. Dilts, E. Dearing, A. Lawton, B. Nanus, D. Russell, E. Rose, etc.) include personal and professional ones.

W. Bennis, B. Nanus identify the following leadership qualities: guiding vision (clear understanding of professional and personal goals); inner passion (the desire to take advantage of the opportunities that are presented); integrity of personality; loyalty to one's principles; desire and ability to learn from and work with others; curiosity; willingness to take risks and experiments [1].

According to R. Dilts, D. Russell, leadership qualities should include: communication (the ability to build effective interaction with people); systems thinking (allows the leader to identify and understand the problem space in which he and his colleagues work); strategic thinking (allows you to think through the path along which you need to move towards the intended goal [2].

A. Lawton, E. Rose, N. Huber identify foresight and the ability to see priorities as the most important leadership qualities. In addition, effective communication and the ability to build interpersonal relationships are also priorities for a leader [3; 4]. In turn, A.V. Avdeeva presents the following leadership qualities as components of leadership competence:

- intellectual (manifested in readiness to perform professional tasks, in the ability to generate ideas and move away from standard solutions),
- organizational (expressed in the ability to make decisions independently, voluntarily take responsibility for solving a group problem),

- performance (including readiness to perform long-term work with high efficiency, the ability to find a non-standard solution and adequately evaluate the results achieved);

- socio-communicative (including the ability to lead people, the ability to smooth out conflicts when solving complex problems in a group and find a common language with different people) [5].

L.D. Kuznetsova, V.V. Manikhin, A.S. Ognev talk about leadership competencies, which are based on the following qualities:

- desire for achievement and self-development,
- creativity,
- ability to inspire others;
- managerial qualities, namely: the ability to set goals, forecast, make decisions, and effectively control;
- ability to act in situations of uncertainty;
- social responsibility [6].

In turn, N.A. Kryukova divides the leadership qualities of future specialists into basic and additional. The scientist includes the following in the first category:

- the ability to motivate, inspire people, take care of the team (team) and give it a vision of a common mission;

- the ability to interact in a team, listen to its decisions, and develop it;

- the ability to understand people's psychology, resolve conflicts, find mutual understanding and inspire trust. As we see, we are talking about organizational and communicative competencies. Additional qualities of a leader N.A. Kryukova include:

- research competencies (the ability to conduct scientific analysis to obtain a discovery or other new result);

- intellectual competencies (the ability to think analytically, compare facts, build logical chains to solve a problem);

- information competencies (the ability to find and systematize the data necessary to solve a problem) [7, p. 20-22].

A.V. Evdokimov complements this list with such qualities as ambition and a high level of energy. According to the scientist, a leader is honest with himself and others, confident in himself and his goals [8].

In the work of N.V. Prikhodko we find the following list of personal leadership qualities: communication skills, organizational skills, increased activity, moderate emotionality, pronounced innovation, business and moral qualities.

In the works of foreign researchers we also find a similar list of leadership qualities: motivation to act, organizational skills, effective communication, empathy and emotional intelligence [9; 10; 11].

In the works of E.V. Andrienko characterizes the leadership qualities of an individual taking into account the specifics of pedagogical activity. Thus, the scientist identifies two groups of teacher leadership qualities: communicative (sociability, focus on others, tendency to cooperate, empathy, tact, patience, emotional stability, flexibility in learning new roles, artistry) and professional (high intellectual flexibility, criticality and quick thinking, ability to improvise, self-criticism, independence, initiative and others).

Based on the works of E.V. Andrienko, T.P. Pitina identifies the following groups of teacher-leader qualities:

- organizational (organization, responsibility, ability to integrate group efforts);
- communicative (sociability, flexibility, influence);
- personal (activity, responsibility, independence). The scientist specifies that: “a high level of development of organizational skills helps the teacher to effectively organize the activities of each student and the activities of the group as a whole. The formation of communicative qualities allows the teacher to productively develop interpersonal relationships with students and regulate relationships between students, their parents, and colleagues. Stable and positively oriented personal qualities, such as determination, confidence, responsibility, activity, contribute to the professional self-improvement and personal development of the teacher” [12].

E.I. Prikhodchenko classifies the leadership qualities of future specialists into three groups:

- general management (professional competence, practical thinking, communication, organizational abilities, hard work, willpower, healthy lifestyle, stress resistance, collectivism);
- actual leadership (charismatic, creativity, initiative, empathy, morality);
- specific – characteristic of a certain area [13, p. 54-55].

M.I. Gubanova, G.V. Uglyanitsa identifies two groups of leadership qualities of future teachers: professional business and personal.

Professional and business qualities, according to the scientist, contribute to the organization of joint activities of all participants in the educational process and characterize the instrumental norm of leadership, since this includes the entire range of qualities that reflect the attitude towards one's profession (activity, determination, perseverance, responsibility, creativity, organization, competence, high intellectual flexibility, criticality and quick thinking, independence, initiative, etc.).

In turn, the effectiveness of communication among participants in the educational process depends

on the formation of personal leadership qualities. Such qualities express the expressive norm of leadership, and they include personality qualities that express a person's attitude towards other people (kindness, sociability, goodwill, fairness, empathy, attentiveness, responsiveness, love for children, sympathy, tact, patience, self-criticism, sincerity, emotional stability, flexibility in learning new roles, demandingness, etc.) [14, p. 45].

Deeply explores the leadership qualities of students – future specialists – A.V. Avdeev, dividing such qualities into four blocks:

- intellectual: willingness to take responsibility, the ability to generate ideas (creativity), the ability to practically assess the situation; understanding the innovative needs of the economy and the characteristics of future professional activities; mastery of basic techniques and means of influencing the team; ability to use modern means of obtaining, storing, processing and presenting information; use information reasonably and expediently, pay attention to the main thing when organizing work on joint projects;

- organizational: the ability to make decisions independently, take responsibility for solving a group problem; effectively organize your own activities, organize productive personal contacts; have a psychological readiness to work in a team, the ability to find an individual approach to people;

- performance: readiness to perform long-term work with high efficiency; the ability to put forward ideas and outline ways to implement them; the ability to act purposefully, according to a clear algorithm of actions with a persistent desire to achieve the set goal; ability to implement decisions made and adequately evaluate achieved results; possession of basic means of solving professional problems and skills of rational information processing;

- social and communicative: the ability to lead people, the ability to resolve conflicts when resolving a group task and find a common language with different people, feel and understand the emotions of others; the ability to notice characteristic and subtle features of objects and phenomena [5].

Quite interesting, in our opinion, is the study by M.S. Ionova, N.V. Rezepova, where scientists prove the existence of a correlation between a student's social status in a group and his leadership position. Thus, the “stars” of the group were the undisputed leaders in all respects, while the “rejected” showed the least leadership qualities. In turn, scientists included communication and organizational qualities as leadership qualities [15].

We share the opinion of scientists regarding the need to develop all of the above-mentioned leadership qualities in future teachers, however, we note that it is difficult to form such a wide range of personal qualities at a high level during 4-5 years of study at a university. That is why, the most important task of modern science is to highlight such leadership qualities of future teachers that are directly related to the teacher's ability to form an initiative and active personality of the student, on the one hand, and, on the other hand, to be competitive in the modern labor market.

Based on a deep analysis of the phenomenon of “leadership” and the category of “leadership qualities,” as well as the list of such qualities among modern teachers, we can state that the most important leadership qualities of future teachers in today’s sociocultural situation include:

- professional: organizational and managerial qualities, effective communication, cooperation and ability to work in a team, tolerance, adaptability, innovation;
- personal: self-confidence, responsibility, discipline, activity and initiative, empathy, desire for self-development and self-improvement.

Thus, we understand the leadership qualities of future teachers as a stable set of personal qualities of a student, which allow him to be the initiator and organizer of various types of socially significant activities, obtain effective results from such activities, and strive for self-development and self-improvement. Based on an in-depth analysis of scientific literature, we identify the following leadership qualities of a future teacher: professional (organizational and managerial qualities, effective communication, cooperation and ability to work in a team, tolerance, adaptability, innovation) and personal (self-confidence, responsibility, discipline, activity and initiative, empathy, desire for self-development and self-improvement).

We see prospects for further research in the characteristics of the identified qualities and the search for ways to form them in the educational space of the university.

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FREEDOM AND SELF-SUFFICIENCY OF THE INDIVIDUAL IN THE FORMATION OF POSITIVE MORAL AUTONOMY

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Abstract

Strategic directions and basic provisions of education development are increasingly relying on the process of fostering moral consciousness, moral autonomy, and identity. The results of the study indicate the importance of self-knowledge, directing one's own efforts towards the development of qualities that will correspond to one's own ideas about ideals, life priorities, and meaningful life values.

Keywords: freedom, self-sufficiency of the individual, moral autonomy, moral identity.

The construct of moral identity is used to measure the extent to which moral values such as justice, fairness, compassion, honesty and caring are considered important to self-identity [4; 5; 6]. Hardy defines moral identity as the degree to which moral values are central to one's sense of self. In the context of youth political purpose and political engagement, moral identity is closely related to political identity, which can be understood as concern with social, political and governmental issues, as well as political participation (6). Political identity is determined by whether political activity is an important way of identifying oneself [1].

Adolescence and adulthood are marked by the development of moral identity and political participation. Foreign scholars have found that having a moral identity in late adolescence is a crucial factor in predicting a sustainable political goal, which is to engage in political activity. The results indicate that the development of moral identity significantly affects the formation of political goals in the transitional period of adulthood, and the role of NGOs in this regard cannot be overestimated.

Unfortunately, Ukraine does not conduct any such empirical studies. The issue of developing the value of moral autonomy in adolescents within the context of NGO is only considered theoretically, with a more philosophical approach than practical and pedagogical approaches.

From the philosophical point of view, our study is interested in the views of J.-P. Sartre's philosophy of freedom, based on the idea that man is nothing or freedom, and his life is a possibility, is particularly relevant. Freedom is not something that must be done, but rather a decision made by oneself. What a person chooses to be is a choice they make freely. The definition of goals and objectives is enough to give freedom to a person, regardless of their aspirations being manifested and realized. Freedom involves not only choosing one's own abilities, but also one's attitude towards a particular situation. Even someone who is a slave can decide how they feel about their situation. According to J.-P. Sartre, a person is "doomed to be free". The categorical imperative is to use your freedom and be who you are. Freedom as a value of meaning and life implies internal freedom of choice and a person's great responsibility for his or her choice, for his or her own life, for all of humanity.

The idea of freedom is a unifying concept for all peoples at all times, as stated by K. Jaspers, an existentialist philosopher. In his concept of world order, he gives a philosophical justification for this phenomenon. "The will to create a world order based on law does not have as its immediate goal freedom as such, but only political freedom, which opens up space in human existence for all the possibilities of true freedom" [3]. This, in his opinion, characterises: 1) overcoming external influences, overcoming one's own permissiveness; 2) gaining the meaning of life, realisation of rights, since the condition of freedom is maximum breadth, which is why the content of freedom in life is full of polarities and contradictions; 3) freedom is not a cause of itself, true freedom is aware of its limits, the freedom of an individual is connected with the freedom of all others; 4) freedom gives rise to alternatives; 5) freedom is characterised by movement and dialectic: "Such freedom arises only with the change of the individual. It cannot be created by institutions forcibly introduced into a community of people who have not changed; it is related to the nature of communication between people who are ready to change. Planning freedom is not possible, but those who work together to properly plan specific tasks can gain freedom [2].

It is this freedom that is a prerequisite for the formation of moral autonomy, and this aspect should be particularly emphasised by educators and social workers when creating and supporting the functioning of NGOs for teenagers.

The absence of fear or dependency on anyone or anything, envy, and the ability to overcome life's barriers is what determines self-sufficiency as the basis for autonomy. Self-sufficiency is not possible for individuals who avoid solving their own problems, are indecisive, or afraid. Self-sufficiency necessitates self-development and self-work. Those who work on themselves often experiment, make mistakes, and discover their own identity and meaning in life. Self-sufficiency is affected by all of these actions. Developing this quality, <unk>, can be achieved by ceasing to demand from others and taking responsibility for what is taking place. Self-sufficiency implies self-development, which we define as the process of a person's purposeful influence on himself or herself in order to develop or polish physical and moral qualities, essential forces, spiritual

sphere, activate abilities, inclinations and form the necessary skills for life, as well as self-realisation of new knowledge, skills and abilities [7]. Given the above, it can be argued that the basic principles of effective education of moral consciousness and moral autonomy of adolescents in the context of public organisations should be as follows:

- humanistic principle, which consists in recognising a person as the highest value, understanding the child, treating him or her kindly, trusting, accepting the child as he or she is, changing his or her behaviour through positive means;
- the individual principle affirms the uniqueness and originality of the inner world of each child, determines his/her self-concept, interests, needs in life;
- the principle of continuity characterises the process of education as continuous throughout a person's life;
- the principle of integrity consolidates the efforts of all educational entities into one system;
- the principle of continuity, which ensures the transfer from generation to generation of the experience of assimilating humanistic values that are the basis for the education and development of children's personalities;
- the principle of cultural relevance, according to which the education of the moral consciousness of a growing personality is carried out in accordance with the cultural conditions of society;
- the principle of natural correspondence, i.e. education of moral consciousness of older adolescents, taking into account their individual characteristics, temperament, qualities, inclinations, abilities, age, natural conditions, social environment, folk traditions, etc.;
- the principle of pedagogical competence, which consists in the appropriate use of pedagogical forms, methods, selection of content, pedagogical tact;
- the principle of stimulation is determined by the belief in the strengths and abilities of the child, his/her ability to achieve high results, and the motivation to self-organisation, self-education and self-improvement.

The creation of stable, historical formations that are objective is necessary for the formation and development of the children's movement. The creation of positive moral autonomy in the younger generation is greatly influenced by an institutional structure, reality, and active subject.

Conclusions. Thus, as a subject of the process of education of moral consciousness, an individual activates self-knowledge and directs his/her efforts towards himself/herself in order to develop those qualities that correspond to his/her own ideas about ideals, life priorities, goals, meaningful life values and requirements for himself/herself.

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EFFECTIVE USE OF INTEGRATION IN CONDUCTING LANGUAGE CLASSES

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*Ph.D. in pedagogy, associate professor*DOI: [10.5281/zenodo.11189054](https://doi.org/10.5281/zenodo.11189054)**Abstract**

As we know, the language is a whole system, and it is impossible to understand it at a complete and sufficient level without knowing the internal laws existing in this system, without taking into account the dialectical unity of language rules with each other. In the learning process, integration is built on the basis of comparison, and it is flawed to make concepts that have no similarities into an object of comparison.

Without knowing the lexical-grammatical signs of any linguistic concept, it is impossible to understand the nature of the relationship between them, and thus, to understand the necessary, objective relationships in the chain of linguistic phenomena.

Taking this aspect into account, Professor Hasan Baliyev wrote: "The teacher should provide the students with the most necessary knowledge about grammatical concepts and concepts, and also take care of their acquisition of the skills specified in the program for individual sections".

After the mastered concept is examined in integration with another one according to its main and additional features, their use in speech practice is realized. Degree, time, quantity signs are not possible without a grammatical object. In the research work, we have paid attention to the integrative teaching of linguistics sections, and we have investigated the possibilities of intra- and interdisciplinary integration in mastering language rules.

Keywords: grammatical concept, concepts, necessary knowledge, integration, speech practice.

Language rules, which are generally called "grammatical knowledge", have been widely discussed in scientific and pedagogical literature. In one sense, it has been suggested that learning the rules facilitates acquisition.

One of a number of content directions or lines intended to be implemented in the teaching of the Azerbaijani language is the integration of knowledge and skills on "Language rules".

By learning the rules of the language, students get acquainted with the phonetic, lexical and grammatical structure of the language, and have concrete, clear and simple concepts about them. The teaching of rules and interpretations in an integrated form enables the formation and development of correct language and speech skills of students, and helps to understand the most necessary linguistic concepts and concepts. [6, 88-89]

Integration is also an enabler of succession. If we pay attention to the new textbooks and teaching aids, it can be seen that many elements of traditional education have preserved themselves in the content of the Azerbaijani language course, in the system of its acquisition.

Although the new textbooks devote a lot of space to the practical, practical nature, the role of the language rule as a mediator has not been ignored.

Apart from the primary class, the theoretical knowledge of language rules mainly starts in class V, where the possibilities of in-text integration are widely used. If we pay attention to additional resources to the textbook, the integration is mainly based on the content, structure and analysis of the text, not on the language order.

It is possible to observe such a relationship in most of the standards. If we compare the new textbook with the old textbook, we can observe how the succession is expected and the innovations.

If we consider the intra-disciplinary communication system, we will see that intra-disciplinary communication

itself is based on intra-linguistic communication. This connection in language manifests itself as the unity and difference of language and thinking. Language as a system begins with phonetics (phonemes), and is completed in text syntax and speech. Experience also shows that words are learned in connection with sound.

Each process manifests itself in the activity before and after it. When a language fact does not connect to each other like a cogwheel, the system stops moving, speech, expression, law, method are incomplete. For example, mastering language rules is done in parallel with teaching sounds and letters. [2, 111]

In the process of teaching the first 3 sounds (a, n, t), the student gets acquainted with the rules of the language, and the following result is obtained:

- 1) recognizes these sounds and can pronounce them correctly;
- 2) is able to write and read words through those sounds;
- 3) can distinguish the sound and letter composition of the word;
- 4) can distinguish vowel and consonant sounds in the word with the help of signs;
- 5) understands dividing words into parts, that words consist of syllables;
- 6) Can form sentences by looking at pictures or using words;
- 7) understands that the number of syllables in a word corresponds to the number of vowels in it.

Entertaining games are provided in such an integrated way, speech sounds are presented simulating the sounds of animate and inanimate objects in nature. Learning achievements gained through the sounds and letters taught in grades V-XI can be systematized as follows:

1. Understands the difference between sound and letter.
2. Understands that words are formed from sounds.

3. Able to distinguish between vowel and consonant sounds.
4. Learns the syllabic structure of the word.
5. Understands the number of vowels in syllables and words.
6. He is able to ask questions about the word.
7. Gets acquainted with the types of grammatical meaning of the word, distinguishes the words denoting name, sign, number, action, recognizes the graphic sign.
8. Acquires the ability to construct a sentence.
9. Realizes that the suffixes -lar2 create the concept of quantity (plurality).
10. An initial idea about the root and suffix of the word is formed.
11. He is able to distinguish phrases and sentences, learns to express them orally and in writing.
12. Gets knowledge and experience about homonymy, synonymy and antonymy of words.
13. Gets acquainted with some pronunciation rules of words containing k, q consonants.
14. Acquires basic information about complex words. [2, 120-121]

During the teaching of the language rules to be learned, students learn those rules with new methods. Unlike traditional textbooks, tests on language rules are taught in new textbooks under logical headings such as "think and answer" and "true-false".

In the newly published textbooks, intra-disciplinary communication is mastered first in the integration of speech parts, then the constituent parts and structure of the word. Of course, it is impossible to talk about its composition and structure without words.

In fact, the foundation of phonetic education is laid during the literacy period, during which students are introduced to syllable sequences and events, even if they are primitive. Through subject mastery, they learn that the first habits related to literary pronunciation and writing are created by giving priority to studies and tasks based on the comparison of sound and letter composition. [3, 69]

The comparison of sound with words gives effective results, and in a kind of beginning, the foundation of the teaching of phonetics with orthography and

spelling is laid. By working on specific descriptions (e.g. filling in the blanks), students learn about the social nature of voice, its types, the role of voice in speech, etc. they gain initial familiarity with the issues.

Data on the teaching of language rules related to phonetics, orthography, and spelling are quite extensive in terms of both content standards and volume. Knowledge of those rules is strengthened through studies and tests.

By mobilizing integration opportunities, students' theoretical knowledge about sounds and letters is expanded and clarified. At the end of this lesson, students master the following about sounds and letters:

- 1) that words are formed from the combination of sounds;
- 2) sounds are divided into two groups, vowels and consonants;
- 3) that letters are signs of sounds in writing;
- 4) that the sound is heard, and the letter is visible by writing.

In the course of the lesson, students simultaneously strengthen their knowledge of the rules of spelling and pronunciation of words. [4, 25]

They clearly see that when pronouncing vowel sounds, the air flow does not encounter any obstacles in the oral cavity, while in consonants, on the contrary, the voice encounters various obstacles in the oral cavity.

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**ЖЫЛКЫ ТУКУМУНА КАРАТА БААЛУУЛУК МАМИЛЕ - АТА-БАБАЛАР САЛТЫ АРКЫЛУУ
КЫРГЫЗ ЖАШТАРЫН ТАРБИЯЛООНУН ФАКТОРУ КАТАРЫ (КЫРГЫЗ ЭЛИНИН
БААТЫРДЫК «МАНАС» ЭПОСУНУН МИСАЛЫНДА)**

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**VALUE ATTITUDE TO THE HORSE AS A FACTOR OF EDUCATION OF KYRGYZ YOUTH
BASED ON ANCESTRAL TRADITIONS (ON THE EXAMPLE OF THE KYRGYZ FOLK HEROIC
EPIC «MANAS»)**

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Аннотация

Сунушталган илимий макалада кыргыз элинин баатырдык «Манас» эпосунун мисалында кытай аскер баш командачысы Коңурбай менен жоопкерчиликтүү жекеме-жеке сайышка чыгаар алдында Манаска ылайыктуу күлүк тандоо маселеси менен байланыштуу суроо каралат.

Бул кармаш күтүүсүз жаралган, анткени, ага чейин баатырдын Аккуласы Ат чабышка коё берилген болчу. Мындай маанилүү иште Манас жардам берүүсүн өтүнүп, өзүнүн эң жакын чоросу, акылман Кошойго кайрылат жана ага ишеничин, анын билимине, тапкычтыгына, сынчылык дараметине чоң үмүт артканын билдирет.

Чынында, бир нече сунушталган тулпарлардын арасынан Кошой баатыр үчүн мыкты күлүк тандагандыгы кеп болот.

Бөлөк эпизоддо, кытай тектүү экенине карабастан, кийинчерээк Кан Манастын эң жакын жана ага берилген чоросу болуп калган Алмамбет, «Чоң казат» аталган ири окуяда чалгындоо операциясына жарамдуу болгон мыкты күлүктү тандай билип, өзүнүн бийик сапаттарын көрсөтөт.

Сөздүн мына ушул өңүтүндө, албетте, казак Каны Айдаркан өзүнүн баласы эр Көкчө менен короосундагы жылкыларды аралап жүрүшүп, андагы ар бир атка таасын жана мазмундуу мүнөздөмө беришкен жагдай белгилүү кызыгууну туудурбай койбойт.

Abstract

In this research article, based on case studies of the Kyrgyz folk heroic epic «Manas», we have analysed the issue of selecting a good warhorse for Manas in his upcoming responsible single combat with Konurbai, the commander-in-chief of the Chinese troops. In such an important matter, Manas turns to his close combat colleague, the wise Koshoi, saying that he believes him and hopes very much for his skill and knowledge. And indeed, out of several proposed horses, Koshoi managed to choose the best steed for the hero.

In another episode, despite his Chinese origin, Almambet, who later becomes one of the closest associates of Khan Manas, also demonstrates his best qualities in choosing the best horse for reconnaissance operations in such a major event as the «Great campaign». In this vein, there is a certain interest in the moment when the Kazakh Khan Aidarkan and his son, the hero Kokcho, give a detailed and meaningful description of each of the horses they have in their herd.

Ачкыч сөздөр: тарбия, салт, жылкы, баалуулук, баатырдык эпос, мурас, болочок муун.

Keywords: upbringing, tradition, horse, value, heroic epic, heritage, future generation.

Киришүү. Ата-бабалардын нарктуу да, нускалуу да салтына назар таштап, эчен-эчен кылымдардын кыйырын карыткан тарых-таржымалына сереп салып, сынчылык касиетке кандай маани бергенин боолголоого болот. Сынчылык, бул, алдыңкы кезекте адамдын акыл парасатынын, эсинин, адабинин, жүрүмүнүн, турум-турпатынын кандайлыгын баалоодон баштап, анын шык-дараметин, мүмкүнчүлүгүн, күч-кубатын, кайраттуулугун, жөндөмүн,

жарамдуулугун “таразалай” билген жөндөмдүүлүк болуп саналат. Жан-жаныбарларды мүнөздөөдө, сыпаттоодо жана баалоодо да аталган өнөр арбын колдонулган. Сынчылар, адатта, эч кимге байкатпай туруп эле кадыресе билип коюшкан. Бул өнөрдү улуу муундар жаш жеткинчектерге үйрөтүүнүн, мурастаонун камын көрүшкөн. Сынчылар эл ичинде өзгөчө урматталган жана кадырлуу болушкан. Эпосто баатырлардын, балбандардын минсе кубаты, жол жүрсө

колдоочусу болгон күлүктөрүнө карата колдонулган бул өнөрдүн баян-таржымалын иликтөө, албетте, белгилүү кызыгууну жаратпай койбойт.

Изилдөөнүн методдору. Коюлган теманын алкагында тиешелүү мазмунду ылгоо, окуп-үйрөнүү, талдоо, индукция, дедукция, салыштыруу, абстракташтыруу ж.б. ыкма-методдор колдонулду. Ошондой эле тексттердеги “себеп-натыйжа” байланыштарын иликтөө, табуу жана орнотуу иш-аракеттери жүргүзүлдү.

Негизги мазмуну. Коңурбай жекеме-жеке сайышка Манасты чакырып, Манас үчүн бул күтүүсүз болчу жана анын Аккуласы мурдараак Ат чабышка коё берилгендиктен, Кошой абасына кайрылып, ага күлүк тандап берүүсүн суранат. Оболу Калкамандын Кара аты сунушталат. Кошой бул күлүктүн Коңурбай менен сайышта чабалдык кыларын белгилейт. Андан соң эр Үрбүнүн тулпарын, Көкүлдүн Тору кашкасын сунушташкан учурда, адардын да бул чоң кармашта акырына дейре чыдабасын жүйөлөйт. Алмамбеттин Сараласын болсо, ал күлүгүн бере салып, Алмамбеттин жөө туруп калышын Манас туура көрбөйт. Кошойдун сынчылык касиетин төмөндөгү саптар айгинелейт:

Ат карады Кошой кан,
Карап турган канча жан
Абакениз эр Кошой
Аныктап көзүн салыптыр [1, 1567-б.].

Күлүктөрдү улам сындап, Алымсарыктын Жармандай аттуу тулпарын Манаска ылайык табат. Жармандайдын мыктылыгы мындайча сүрөттөлөт:

Акжолтой жайы дагы бар,
Ал кайраты ашкере
Азыр толгон чагы бар.
Мандайында багы бар,
Кулагында шамы бар,
Чуу укканда күчөгөн

Тулпарлык жайы дагы бар [1, 1568-б.].

Чоң Казат окуясында аскер башчы Алмамбет Бакбурчундун шаарына чалгынга баруу чечимине байланыштуу, анын чалгынга жарамдуу күлүк тандоо өнөрүнө сереп салып көрөлү. Эр Манас алгач чалгынга жарайт деп Калкамандын Кара атын сунуштайт. Ал аттын карый түшкөндүгүн жүйөөлөп, Алмамбет ал күлүктү макул көрбөйт. Анда Манас ошо замат Токотойдун Тору атын сунуштаганда аны да жактырбай, Ажыбайдын Күрөнүнүн ар тараптан мыктылыгын мүнөздөп (б.а. ар кандай абдан татаал, кыйчалыш кырдаалдарда адамга “канат болчу” жайын жүйөөлөп), Күрөң атты берүүсүн өтүнөт. Айлана-тегеректегилер Ажыбайдын Күрөнүнүн нак тулпарлыгын укканда, анчалыгын билбегендерине айран-таң болушкандары айтылат. “Аны уккан соң кан Манас” ошо замат Ырчы уул менен Боз уулду Ажыбайга аттантат [1, 1700-1701-бб.].

Алар Ажыбайга келишкенде, ал Алмамбеттин сынчылык касиетин жогору баалап, ага ыраазы болуп, Манас өзү атайын суратып жаткандан кийин “Эр кадырын эр билет, Эр билбесе не билет?” деген эл макалын айтып, нарктуу кепти эске салып,

Күрөң атты эки чоронун колуна карматып, урмат көрсөтүп аларды кайра аттантат [1, 1702-б.].

Айдаркандын үйүнө теги кытай эр Алмамбеттин келгенине аябай кубанышып, анын урматына “Баш куттуктоо” салтын өткөрүүнү чечишет. Айдаркан уулу эр Көкчө жана малайы менен үчөө 600 жылкыны аралай жүрүшүп, ар бир аттын кыял-жоругун мүнөздөшүп, сыпатташып, ар биринин баалуулугун белгилешкени, алардын эч бирин союшка ыраа көрүшпөй кыйналышкан учуру төмөнкүчө сүрөттөлөт:

Алты жүз экен жылкысы,
Ар кайсысын караса
Артыкча жакшы жылдызы:

Алардын жылкыларга берген сыпаттамалары суктандыарлык да, өрнөктүү да: “Арыктабай алты айга, Минип жүрсө түттү – деп”, “Ар бир бээсин чыгарат, Аябаган сүттүү – деп”, “Кулунун жакшы бакты – деп”, “Уйдан жоош жаныбар, Кыялы мага жакты – деп”, “Жана бирөөн дагы айтып, Бу табылбас мүлүк – деп”, “Тууганынын баарысы, Тулпарга чалыш күлүк – деп”, “Жана бирөөн дагы айтып, Карматат жоош колго – деп”, “Тууганынын баарысы, Тукуму менен жорго – деп”, ошентип:

Аталуу-бала ээрчишип
Аралап жүрдү жайма-жай,
Кандайын кармап соёрун
Кан Айдаркан, эр Көкчө
Экөө жүрүп биле албай [1, 1001-б.].

Төмөндө кытай аскер башчысы Коңурбайдын Алгара аттуу күлүгүнүн абдан мыктылыгы, б.а., бийиктиги алтымыш бакса дубалдан арыштап (секирип) аттап өткөнү жөнүндө кеп жүрөт. Ага чейин канчалаган көнүктүрүү, машыктыруу, иш-аракеттери болгондугу, тай чагынан баштап бир бакса дубалдан көптөгөн жолу арыштоого үйрөтүлгөндүгү, андан соң баксанын катмарларын улам бийиктетип барылгандыгы айтылат.

Бакса – сокмо дубалдын катмарлары. Бир катмардын бийиктиги аалым А. А. Байбосуновдун китебинде болжол менен 7 сантиметрге барабар болгон узундук айтылат [3, 25-б.].

Коңурбайдын Алгараны машыктырып үйрөткөнү:

Арам өлгөн Алгара ат
Алат кылган мурунтан,
Алтымыш бакса дубалдан
Арыштап чуркап кеткени.
Капкасын кара таш кылган,
Каран калган кара атты
Тай чагында маш кылган,
Бир бакса дубал өндүргөн,
Кайра-кайра чуркатып,
Миң аттатып көндүргөн,
Эртеңки күнү дагы да
Эки бакса өндүргөн,
Эки аттатып көндүргөн,
Үчүнчү күндө үч бакса,
Көнөт экен мал бакса,
Атырылтып октолткон,
Антип жүрүп каранды
Алтымыш бакса токтолткон [1, 1819-б.].

Ошентип отуруп, адам бүткүл дитин коюп, сабырдуулук менен мал жаныбарды үйрөтүүгө болорлугу насаатталып жатат. Алгара эчендеген жолу Коңурбайды согуш майданында капсаландуу абалдан же өлүмдөн куткарып кеткен.

Ата-бабаларыбыз жылкы тукумун кандай асырап, барктаганын билүү үчүн Кеңеш Жусупов Белек Солтоноевдин эмгегин эскерүүнү макул көрөт: “Кыргыздар жакшы атынын башын бийик жыгачтын башына илген. Сынчылар кишини жана атты гана сынап, башка малды сынабаган. Күлүк, чобур болорун кулун жана тай кезинде сынап билген. Үйдө олтуруп тыштан аттын баскан дабышынан күлүк болорун билген. Жоокерчиликте жалгыз жанын атына тапшырган. Кээ бир ат ээси уктап калса, суук кишинин элесин алса, ээсин чапчып, же тиштеп ойготкон. Аттын жаш же кары бээден туулгандыгын билген. Байгеге чапканда аттын чыгарын, байгеге илинерин жана каларын билген. Көбүнчө Бугу кыргызынан Найман, Жаныбек дегендер атка биринчи сынчы болуп, күлүктү 18 түргө, бүркүттү 65 түргө бөлгөн [4, 290-291-бб.].

Ошол Жаныбектин үлкөн сынчылык касиети тууралуу Асыкбек Оморов 1883-жылы Ысык-Көлдүн түндүгүндө Саяк манабы Ырысмендинин ашында Керкашка күлүктүн ат чабышта маарага биринчи болуп келишин, ошол эле жылдары казактарда бир чоң ат чабыш болуп, бир топ кишилердин күмөнсүрөгөнүнө карабай дал Жаныбек сындаган тулпардын чоң соорун коюлган баш байгени жеңип алышын баяндайт [7, 95-б.].

2010-жылы Америкада аттардын интеллектин жана эс тутумун изилдеген окумуштуулар жылкыга байланыштуу көптөгөн кызыктуу маалыматтарды аныкташкан: “Көрсө, аттар биздин сөздөрүбүздү биз ойлогондон да жакшы түшүнөт экен. Анан да алардын эс тутуму аябай өнүккөн болуп, адамдардын жасаган жакшы-жаман мамилесин өмүр бою унутпай, эсине сактап калышат. Ага мээрим менен өзгөчө мамиле кылган адамды эч качан унутпай, досундай жакшы көрүп калышат. Ал эми орой мамиле кылгандарды өмүр бою кечирбеген кекчил болушат. Мындан сырткары, аттар адамдын үнүнөн анын эмоциясын түшүнүшөт. Кожоюнунун үнүнөн анын кандай эмоционалдык абалда экендигин даана сезишет. Ошондуктан болсо керек, акыркы учурда медицинада ат менен дарылоо деген өзгөчө метод пайда болду”, - деп жазат Гулиза Акиева [2, 31-б.].

Бүгүнкү күндөрдө эпостогу мыкты күлүк буудандардын аттарын бөбөктөр, чүрпөлөр оюнчуктарына коюп алышып, кызуу, маашырланып ойногондорун, аларга айтылган улуулардын жылуу каалоолорун академик Азиз Салиев мындайча эскерет: “Азыркы күндө да балдар өзүлөрүнүн оюнчук аттарын “Тайтору”, “Аккула”, “Тайбуурул” деп аташат, “Манастай болуп чоңойгун”, “Айчүрөктөй сулуу бол!” деген каалоо-тилектерди угушат” [6, 210-б.].

Жогоруда баяндалгандардын негизинде төмөндөгү жыйынтыктарды чыгаруу мүмкүн.

Корутунду:

- кыргыздар байыртадан жылкы тукумун сындогоо жана баалоого чоң маани берген. Жылкыны канаты сымал, тумардай көргөн. Күлүк чыкчу атты саяпкерлер кулун чагынан тарта асыраган, таптаган, анын оор түйшүгүн чыдамкайлык менен көтөргөн. Жоокерчилик заманда жылкы баатырлардын, балбандардын жан шериги болгон. Мыкты тулпарлар эр азаматтарды майдан талаасында канчалаган абдан оор, калабалуу, коркунучтуу кырдаалдардан куткарып алып чыгып кеткени (маселен, Манас баатырдын Аккуласы) аңыз кепке айланган. Күлүктөр курч мелдештерде, таймаштарда жаанын “жебесиндей сызып, куштай учуп” алдыга озуп, жеңиштерге жеткирип, кыргыздардын намысына эчен курдай жараганын баалай билишибиз парз;

- күлүктүн аралыкты чаап өтүүсүн туюнтуучу өлчөм бирдиктери: “Тай чабым”, “Кунан чабым”, “Ат чабым” ж.б. аталыштары кыргыз элинин жашоо кечирүү мүнөзүнүн жылкы тукуму менен байланышынын тереңдигин жана ажырагыс биримдигин маалымдайт;

- ошол сынчылык касиетти, өнөрдү аздектеп, болочок урпактарга үйрөтүү милдеттерин чечүү иш-аракеттери – ата-бабалардын баскан жолун, калтырган изин, алардын таберик көөнө мурастарын урматтоону символдоштурат;

- жылкынын сырткы келбети, турум-турпаты кооз, көркөм, көзгө өзгөчө жылуу, сүйкүмдүү көрүнгөн, керемет жаныбар экендигин сезип-туюп, баалай билишибиз маанилүү.

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PHILOLOGY

A COMPARATIVE QUALITY ASSESSMENT OF CHATGPT MODELS AND HUMAN TRANSLATION OF SCIENTIFIC TEXTS

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Abstract

This paper aims to examine and compare translations of scientific texts from English to Russian performed by ChatGPT-3.5, ChatGPT-4, and human translators. The study conducts a comparative quality analysis of these translations and utilizes the neural-based machine translation evaluation metrics COMET-22 and BLEURT-20.

A key aspect of this paper is to identify errors, shedding the light on the strengths and limitations of both the deep learning based language models in order to better estimate their performance in comparison to human translation.

Using a mixed-method research approach, this study analyzed 30 scientific articles in English language assessing the efficiency of automated translation systems.

Keywords: AI (Artificial Intelligence), natural language processing (NLP), COMET-22, BLEURT-20 metrics, ChatGPT models, translation, human translation

Introduction. The development of world's technologies has seen remarkable progress in the natural language processing (NLP) and automatic evaluation metrics as well.

Lately advancements, in natural language processing (NLP) have been quite impressive leading to the creation of the language models such as ChatGPT. These deep learning-based models have demonstrated proficiency, in translation activities sparking a lot of enthusiasm among researchers. Particularly, in the area of machine translation, these models have shown tremendous promise.

Machine translation serves to connect people across languages enabling the exchange of information, in the scientific community. The accurate and swift translation of content, into languages plays a role in fostering cooperation enhancing cultural awareness and speeding up progress, in scientific fields.

With the increasing acknowledgment and usefulness of ChatGPT 4 in translation it is vital to subject this language model to evaluation and comparison with human translations. Understanding the strengths and weaknesses of ChatGPT 4 in handling content is essential for leveraging its capabilities ethically.

As AI language models reshape the translation landscape grasping their potentials and constraints becomes crucial for making informed decisions on integrating them into scientific workflows. AIs role in translating texts is highly valuable as it facilitates a streamlined and accessible global exchange of scientific knowledge.

The history of neural networks

The history of networks spans, over years and has experienced significant progress in both theoretical and practical domains. A neural network is a method in machine learning that processes inputs to forecast outputs. While they share similarities, with machine learning approaches they possess strengths.

Linear models are a core element of statistical machine translation. A potential translation x of a sentence is represented by a set of features $hi(x)$. Each feature is weighted by a parameter λi to obtain an overall score [1].

Neural networks are mathematical models that use learning algorithms inspired by the brain to process information. Since neural networks are used in computers, they are collectively called as "artificial neural networks" (ANNs) [2]. It consists of layers of interconnected nodes, known as neurons, organized in different layers, such as input, hidden, and output layers. Each neuron performs simple computations on its input data and passes the results to other neurons.

Neural networks modify linear models in two important ways. The first is the use of multiple layers. Instead of computing the output value directly from the input values, a hidden layer is introduced. It is called hidden, due to inputs and outputs in training instances, but not the mechanism that connects them — this use of the concept hidden is similar to its meaning in hidden Markov models [3].

Deep Learning

The progress of deep learning technology has unveiled revelations and advancements that have significantly propelled the realm of intelligence research. As time has passed the field has undergone changes that mirror the viewpoints and inputs from a range of researchers.

The advancement of deep learning technology has provided valuable insights and technological breakthroughs that have significantly shaped the field of artificial intelligence research.

The history of learning is commonly categorized into three stages; Cybernetics (1940s 1960s) Connectionism (1980s-1990s) and Deep Learning (from 2006 to the present) [4, 5].

Looking back at the emergence of cybernetics it was a period characterized by the exploration of networks. In 1943 Warren McCulloch and Walter Pitts introduced a model for networks establishing a foundation for future advancements. In the 1950s 1960s Frank Rosenblatt developed the Perceptron, a network designed to mimic human thought processes.

Interest in networks experienced a resurgence in the 1980s with the rise of connectionism. Notable progress during this era included the introduction of the backpropagation algorithm by Rumelhart, Hinton and Williams in 1986 enabling. Neural networks to learn from complex datasets. This period also witnessed the development of models and algorithms such, as Hopfield networks and Boltzmann machines contributing to both theoretical understanding and practical applications of neural networks.

The modern era of deep learning began in 2006 when Geoffrey Hinton demonstrated that pre-training layers of neural network one at a time could significantly improve the training processes for deep neural networks. This discovery, along with the increasing availability of large data sets and powerful GPU (Graphics Processing Units), led to major breakthroughs. By 2012, Alex Krizhevsky, Ilya Sutskever, and Geoffrey Hinton [6] made a landmark achievement with their AlexNet model, which drastically outperformed other competitors in the ImageNet competition, reducing the error rate by a substantial margin.

Since then, deep learning has seen exponential growth in interest and application, influencing multiple fields such as autonomous driving, natural language processing, and medical diagnosis. Organizations like OpenAI have been at the forefront, pushing the boundaries with models like GPT (Generative Pre-trained Transformer), which showcases the capabilities of deep

learning in understanding and generating human-like text. Additionally, the research organization OpenAI uses deep learning technology to build all generative models, leveraging large amounts of data to train AI systems to perform various tasks [7].

The field of translation has been remarkable advancement with systems like ChatGPT compared to traditional human translation efforts. These AI-driven tools leverage deep learning to interpret and generate text across different languages, achieving near-human or superior performance in terms of speed and scalability, though they may still face challenges with nuances and context-specific interpretations [8, 9, 10].

Metrics

Neural machine translation (NMT) utilizes Transformer-based deep learning, has advanced rapidly current years [11]. Unlike statistical machine translation, NMT uses neural network to generate more varied sentences. However, evaluating the quality of these translations is essential but challenging. Due to linguistic variability there is no single correct translation, making human evaluation subjective and inappropriate. Human and automated evaluation considered as main approaches to assessing the machine translation systems.

As we know human evaluation effective and considered the gold standard in natural language generation but also expensive and requires substantial human labor. Automated evaluations are more cost-effective and easy used for comparative analysis but have limitations.

Automated metrics are evolving to better mimic human assessment by incorporating advanced machine learning techniques, including those based on deep learning models like Transformers. These metrics generally fall into several categories: lexical-based, embedding-based, and supervised metrics.

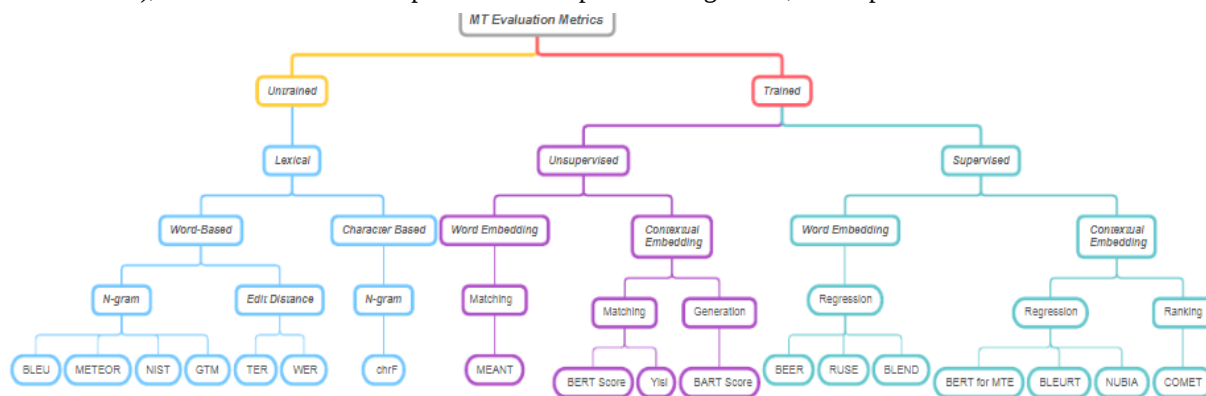


Figure 1. Taxonomy of automatic evaluation metrics.

The first well-known evaluation metric for machine translation, BLEU (Bilingual Evaluation Understudy) was introduced in 2002 [12]. BLEU was developed by researchers at IBM and quickly became a standard for evaluating the quality of text translated by machine translation systems. It compares the candidate translation of text to one or more reference translations, measuring the precision of matched sequences of word or phrases. BLEU was pioneering due to one of the first metrics provided a quantitative way to assess the qual-

ity of machine-translated text, allowing for more systematic and reproducible evaluation across different translation systems.

However, two decades later, according to the study 'The Results of WMT22 Metrics Shared Task: Stop Using BLEU – Neural Metrics Are Better and More Robust' (Figure 2) [13], it has been demonstrated that neural-based learned metrics are superior; traditional overlap metrics like BLEU, SPBLEU, or CHRF correlate poorly with human ratings.

The results also reveal that neural-based machine translation evaluation metrics are significantly better than non-neural metrics across different domains and chal-

lenges. In order to gather data on translation errors performed by ChatGPT-3.5, ChatGPT-4, and human translators, in the list shown below the COMET-22 and BLEURT-20 were selected.

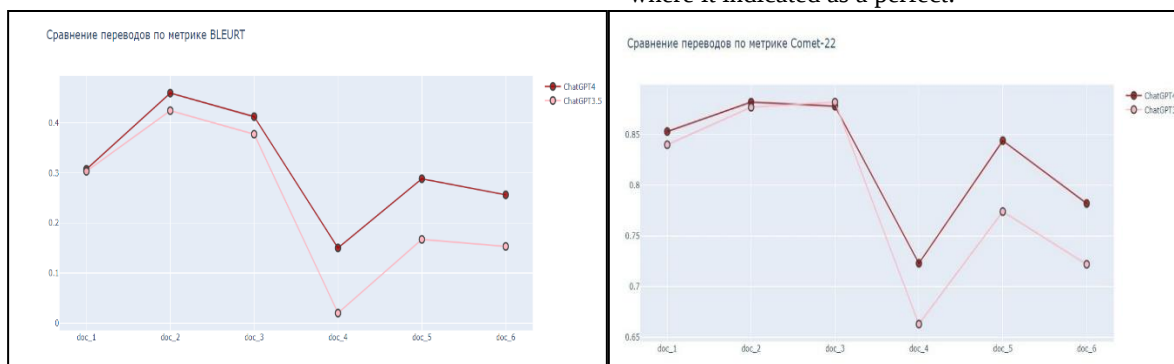
Metric	avg rank
METRICX XXL	1.20
COMET-22	1.32
UniTE	1.86
BLEURT-20	1.91
COMET-20	2.36
MATESE	2.57
COMETKiwi*	2.70
MS-COMET-22	2.84
UniTE-SRC*	3.03
YiSi-1	3.27
COMET-QE*	3.33
MATESE-QE*	3.85
MEE4	3.87
BERTSCORE	3.88
MS-COMET-QE-22*	4.06
chrF	4.70
F101SPBLEU	4.97
HWTSC-TEACHER-SIM*	5.17
BLEU	5.31
REUSE*	6.69

Figure 2.

Main Results

Using a mixed-method research approach, this study analyzed 30 scientific articles (each contain at least 650 words), sourced from the Acta Naturae journal. [14], These articles translated into Russian language using specific prompts for the ChatGPT-3.5 and ChatGPT-4 models and then compared with human translations. The resulted data (below graphics) were

analyzed using the COMET-22 and BLEURT-20 metrics [15, 16]. The results show that ChatGPT-4 model has improved its performance in translation field comparing with ChatGPT-3.5, which allow to conclude that there is an undoubted improvement in the quality of machine translation based on neural learning. Analyzing these models, which generated scores are roughly from 0-1, for human translation was taken 1 score, where it indicated as a perfect.



BLEURT-20	ChatGPT3.5	ChatGPT4
doc_1	0,303	0,307
doc_2	0,424	0,459
doc_3	0,377	0,412
doc_4	0,02	0,15
doc_5	0,167	0,288
doc_6	0,153	0,256

COMET-22	ChatGPT3.5	ChatGPT4
doc_1	0,840	0,853
doc_2	0,877	0,882
doc_3	0,882	0,878
doc_4	0,663	0,723
doc_5	0,774	0,844
doc_6	0,722	0,782

Many mistakes were found regarding (Doc. 4, 5, 6) for instance:

Original-The reconstruction of the genome of Prince Dmitry Alexandrovich indicates the contribution of three ancestral components to his origin:

Russian version-Реконструкция генома князя Дмитрия Александровича указывает на вклад трех родовых компонентов в его происхождение.

ChatGPT-4-Реконструкция генома князя Дмитрия Александровича указывает на вклад трех **предковых компонентов** в его происхождение.

ChatGPT-3.5- Реконструкция генома князя Дмитрия Александровича указывает на вклад трех **предковских** компонентов в его происхождение;

Original-The existence of a “blind spot” in the study of the genomes of the Medieval Russian

Russian Version: Существование «белого пятна» в изучении геномов древнерусской элиты

ChatGPT-3.5- Существование "темных пятен" в изучении геномов средневековой русской знати;

ChatGPT-4-Существование "слепого пятна" в изучении геномов средневековой русской знати

Original-The location of princely burial grounds is established by annalistic messages, synodics of the XVI–XVII centuries.

Russian Version-Местоположение княжеских погребений устанавливается по летописным сообщениям, синодикам XVI–XVII вв.

ChatGPT-3.5- Место княжеских захоронений устанавливается по **аннальным сообщениям**, синодикам XVI–XVII веков,

ChatGPT-4-Местоположение княжеских захоронений устанавливается по летописным сообщениям, синодикам XVI–XVII веков.

Statistical analysis shows that ChatGPT-4 model translates better in comparison with previous model (i.e) ChatGPT-3.5.

In general, ChatGPT-4 demonstrates high-quality translations in the meaning and choice of a word, in simple extended sentences, and complex sentences as well.

However, the primary errors identified in the comparison between human translated and machine-translated texts include incorrect translations and repetition, non-equivalent and misinterpreted idiomatic expressions. A professional translator, specializing in a specific field, can easily overcome with such difficulties.

Conclusion

In assessing the efficiency of automated translation systems against human translation capabilities, the performance of ChatGPT-4, as quantified by the COMET-22 metric achieves an accuracy of 88% and ChatGPT-3.5 achieves an accuracy of 87%. In the BLEURT-20 metric the performances of ChatGPT-4 and ChatGPT-3.5 models are 45% and 42% respectively.

It should be underlined, that COMET-22 neural fine-tuned metric is a more powerful metric, trained on a wider and more diverse dataset and focusing on the comprehensive semantic similarity between source text and translation. As a result, it is less sensitive to minor errors or deviations in translation. The indicators shown in the schemes above are higher, than those of BLEURT-20.

BLEURT-20 in its turn, is more appropriate for tasks where a high degree of linguistic knowledge and stylistic accuracy is required.

Through the progress in computational linguistics and machine learning, these innovative systems i.e. ChatGPT-3.5 and ChatGPT-4 can interpret and translate the complex nuances of language. However, it's important to remember that automated systems often struggle with idiomatic expressions, cultural references, and the deep context that typically demands human intuition and cultural knowledge. Consequently, while the 88% accuracy rate of ChatGPT-4 demonstrates strong general translation abilities, it also high-

lights the limitations where human oversight and intervention are still necessary in the translation process. We hope that performance of capabilities of neural machine translation systems will improve in the nearest future.

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GREAT MASTER OF TURKISH POETRY

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DOI: [10.5281/zenodo.11189077](https://doi.org/10.5281/zenodo.11189077)**Abstract**

Yunus Emre (1240-1320), who has a large "Divan" with a magical structure of words, consisting of stanzas, couplets, tajnis and quatrains, and a 362-verse masnavi called "Admonition", is a great master of poetry in the history of the literature of Turkic-speaking peoples.

The history of the written Turkish literary and artistic language has been on a wide development path since the 13th century with the creativity of Mevlana Jalaladdin Rumi, his son the poet Sultan Valad, and Yunus Emre, who wrote with the motto "a few words are the property of the land, many words are the burden of animals".

However, we must not forget the fact that Maulana Jalaluddin, who is considered the "prophet of love", and his son Sultan Valad wrote in Persian. Therefore, in the same century, Hasanoglu in Azerbaijan and Yunus Emre in Anatolia are considered the first professional creators of poetry examples written in their mother tongue. As can be seen from the pearls of words as elegant, harmonious and instructive as the examples of poetry in "Dade Gorgud", Yunus Emre wrote in such a simple and clear, sweet, instructive and bright language that his poems for the reader of a Turkic-speaking nation, it is as native as a mother's breath, pure and dear as a mother's breast.

That is why, for almost 800 years, Yunus Emre's poetry has preserved its existence as an impregnable, indestructible fortress of poetic words. The genius poet conquered hearts with his poetry and art, and the poet's belief that "there is no mountain higher than the heart" has been proven true by the trials of history.

Yunus Emre's love of life seems to have been fertilized by the genius of Nizami Ganjavi and Jalaladdin Rumi, and at the same time, he was the first example, the first resource, the first fountain of vitality in the path of inspired creativity of the wordsmiths who came after him, such as Nasimi, Khatai, Fuzuli, Karacaoglu, Ashiq Veysel, Ashiq Alasgar.

Keywords: Yunus Emre, history of poetic, literary and artistic language.

Yunus Emre considers the human love of life as an invincible force that keeps the world and the universe in order, he calls his sofa "the book of love" and says that "love is a fiery object that confuses minds and excites the seas."

Taking into account the address in the Gakh district of Azerbaijan, the existence of the tomb of an art conqueror in ten places clearly shows that Yunus Amre is the memory of the people as a whole, and his poetry is the memory of the native language.

Yunus Amre is the first prominent creator of old Anatolian Turkish in the second half of the 13th century and the first half of the 14th century. F.K. Timurtas wrote about this: "The Turkish nation found its own language and spirituality in the poetry of Yunus".[3, 8]

His book of poems called "Guldaste" opens with "Minajati Muhammad". In the eyes of Yunus Amra, Muhammad is the lord of the prophets, the pillar of religion... Sharia is the style of truth.

The poet considers God and his most enlightened servant Muhammad as the qibla of goodness, kindness, mercy and hope in the path of truth, and emphasizes that he is just and fair. Muhammad's greatness in mercy is described in the poem "God's Answer" with the verses "I will ask for the Ummah from me, I will not set your Ummah on fire, I will not make you angry, I will not leave you alone, I will forgive your Ummah", and the poet's astonishment and infinite joy in front of this greatness is described with the applause of "our sultan of a hundred thousand thanks".[1, 97]

With this belief, Yunus Amra unites the created and the created, equates the light of Muhammad in the human heart with the Sun, and stands at the same stage

as Hallaj Mansur, Fazlulla Naimi and Imaduddin Nasimi on the path of spreading Sufi teachings based on three levels: Sharia, sect and truth. He tries to spread this teaching not only in Anatolia, but also in all Asian countries.

In the poetry of Yunus, there is the integrity of the world, man and thought, there is a natural unity of a person's scientific, artistic, socio-philosophical, ethical, aesthetic and religious worldview, universal perfection and completeness of style. In his lyrics, people's life, customs and traditions, taste and psychology, belief in God, personal freedom, holy personalities, places and books in the history of Islamic religion, physical and spiritual beauty, universal feelings and thoughts are emblazoned with bright artistic colors.

Yunus Amre's poem is the most accurate mirror of the Turkish style of poetic expression and perfect artistic creativity. In him, the love of God and the love of the world flow like Oman.

Yunus Amre is a powerful wordsmith of his time, and he has his own poetic ideas and individual style concept about artistic creativity.

Jonah's poetry is a very instructive textbook of life, a source of moral advice. Unique literary personalities and masters of figurative words like Yunus Emre rarely grow up in life, they are born once in a hundred years. Because he understood this truth, he spoke about it in his poem. [1, 83]

Everyone who reads "Guldaste" as a researcher, purposefully and carefully, comes to the conclusion that Yunus Amre's poem is the greatness of the spirit of humanity in the history of Turkish language literature, the golden ratio of the art, which is more characteristic

for the weight of the syllables, the legal measure and order, the smooth flow of thoughts, the precise words.

It is the pinnacle of poetry that can be seen from all over the world with its structure, language richness and poetic fluency, wisdom and instructive capacity.

Yunus Amre is such a peak that neither the Moon sets nor the Sun goes out. That's why I don't want to say that he is immortal because of his love, "If I'm in love, I won't die anymore!" has a great moral right to say.

Thus, Yunus Emre illuminated the development path of Turkish-language folk poetry like the Sun and distributed gifts to Turkic-speaking villages in a large area from Anatolia to the Yenisei, from the Indian Ocean to the Balkan Peninsula, from the Carpathians to the Altai-Tian-Shan mountains. [1, 24]

Yunus Emre's poetry is easily absorbed by everyone, like pure mountain air, in a way that fully corresponds to the law of identity of the human thinking, especially the thinking of the Turkic peoples.

Everyone likes the native mother's lullaby, as if it calls the whole Islamic world to unity and unanimity.

There is such an example: "If there are five fingers, it is difficult to break them." The fingers on the hand are nothing individually, but when they are united,

they become a powerful fist." Therefore, Yunus Amre's poetry retains its ideological and artistic value even today.

In the following verses of the poet Mammad Aslan, who stands out for his creativity, language clarity and laconicity, poetic thought fluency, wisdom and instructiveness, the master of powerful words, who "holds the burden of poetry from the heart" like Yunus Amre, the hearts of poetry and art lovers are read and their infinite love is expressed.

Hello, old Yunus,
Hello, word fountain of the East!
Because of that face of hundreds of years
The voice of the Turk! [2, 113]

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PHYSICS

ИССЛЕДОВАНИЕ ЭЛЕКТРОПРОВОДНОСТИ И ДИЭЛЕКТРИЧЕСКИХ СВОЙСТВ ОТВЕРЖДЕННОЙ ПОЛИЭТИЛЕНАМИНОМ ОЛИГОСТИРОЛЬНОЙ ЭПОКСИДНОЙ СМОЛЫ С ПРИМЕСЮ ПОЛИГИДРОКИНОНА

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STUDY OF ELECTRICAL CONDUCTIVITY AND DIELECTRIC PROPERTIES OF POLYUETHYLENEAMINE CURED OLIGOSTYRENE EPOXY RESIN

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Аннотация

Полученные результаты показывают, что с введением в смолы-диэлектрики электрически активных центров, в частности, в олигостирольную эпоксидную смолу, примеси полигидрохинона, удастся получить материал с электропроводностью полупроводникового характера. При этом электропроводность и ее энергия активации проявляет зависимость от частоты подобно материалам с электропроводностью путем перескоков.

Abstract

The results obtained show that with introduction of electrically active centers into dielectric resins, in particular, into oligostyrene epoxy resin, polyhydroquinone impurities, it is possible to obtain a material with conductivity of a semiconductor nature. In this case the electrical conductivity and its activation energy exhibit frequency dependence similar to materials with electrical conductivity by jumping.

Ключевые слова: Эпоксидные смола, полигидрохинон, полупроводник, электропроводность, перескок.

Keywords: Epoxy resin, polyhydroquinone, semiconductor, electrical conductivity.

Применение синтетических смол часто ограничивается вследствие накопления в них в процессе эксплуатации электрического заряда. В некоторых случаях, с целью увеличения антистатичности, поверхность слоя смолы подвергают специальной химической обработке.

В данной работе мы приводим результаты исследований электрофизических свойств отвержденной полиэтиленполиамином (20 вес % от веса смолы) олигостирольной эпоксидной смолы, содержащей около 3 % химически связанного полигидрохинона. Фактический, рассмотренный состав является композитом. Введение в состав смолы примеси полупроводникового полимера—полигидрохинона в процессе синтеза позволила реализовать проводимость полупроводникового характера и тем самым достигнута высокая антистатичность материала. [3].

Как известно, в аморфных материалах, в частности, в халькогенидных стеклах, при наличии электрически активных центров перенос заряда в поле осуществляется преимущественно путем перескоков. По этому механизму проводимость является возрастающей функцией измерительной частоты [1,2]. Вероятность перескока электрона от центра к центру зависит от их энергетического положения и расстояния между ними.

Приложенное поле изменяет поляризацию центров, и электроны могут перескакивать преимущественно в одном направлении. Если электрон перескакивает лишь между ограниченным числом центров, то на постоянном токе не вносит вклад в проводимость. На переменном токе электроны, совершающие перескоки даже парой центров, в определенных условиях могут вносить вклад в проводимость.

Если в диэлектрик внести электрически активные центры достаточной концентрации, то материал будет обладать электропроводностью, сильно зависящей от температуры. К примеру, растворением в бензоле весьма малых количеств свободного радикала дифенилпикрилгидрозила ($10^{-3} + 10^{-1}$ моль/л) в [4,5] получена достаточно высокая электропроводность, зависящая от температуры по экспоненциальному закону. Необходимые для перескоковой проводимости условия нами осуществлены в олигостирольной эпоксидной смоле с примесью полигидрохинона, отвержденной полиэтиленполиамином в режиме ступенчатого увеличения температуры до 120°C. Об этом свидетельствуют специфические частотно-температурные зависимости электропроводности и эффективной диэлектрической проницаемости материала.

Образцы представляли собой пластинки с толщиной порядка 0.1 см и площадью 2 см². Электроды и охранный кольцо из серебра наносились в

вакууме путем термического напыления. Измерения проводились в вакууме $\approx 10^{-4}$ Торр в интервале температур $10 \div 110^\circ\text{C}$ и в диапазоне частот $10^2 \div 10^8$ Гц с помощью стандартных приборов для измерения диэлектрических параметров. Для измерений на постоянном токе использовался электрометри-

ческий усилитель У5-11 с дополнительным входным делителем напряжения. Исследование вольт-амперных характеристик в интервале напряжений $0 \div 150$ показывает, что в этих условиях соблюдается закон Ома, и контактными эффектами можно пренебречь.

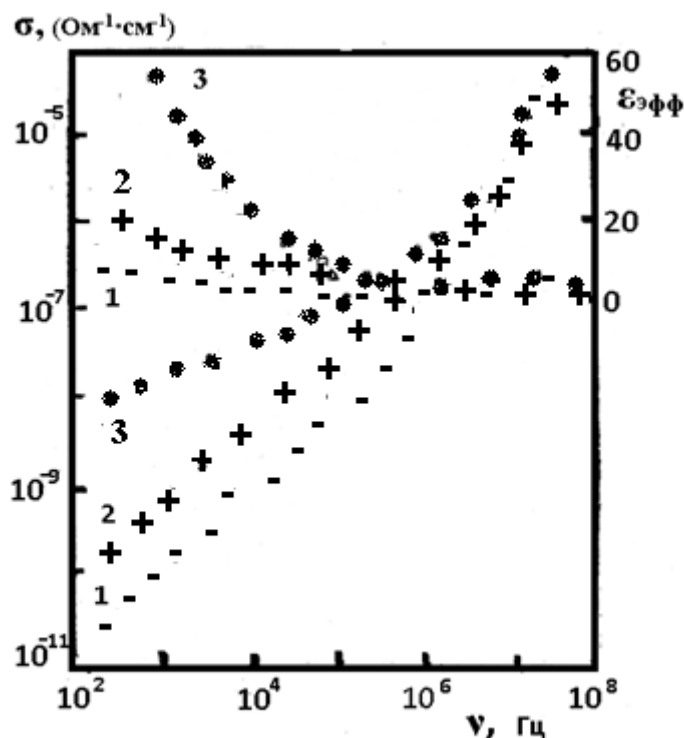


Рисунок 1.

Зависимость удельной электропроводности (1-3) и эффективной диэлектрической проницаемости (1 - 3) олигостирольной эпоксидной смолы от частоты для температур 20 (1,1), 52 (2,2) и 90°C (3, 3).

На рисунке 1 приведены частотные зависимости удельной электропроводности σ для трех температур. С ростом частоты проводимость возрастает и при $\nu = 6 \cdot 10^7$ Гц, σ превышает значение электропроводности на постоянном токе примерно на семь порядков. Зависимость σ от частоты описывается степенной зависимостью.

$$\sigma \sim \omega^{2-\alpha},$$

где $\alpha \geq 1$ в области низких частот, и $\alpha = 0$ вблизи верхней границы частотного диапазона. Квадратичная зависимость σ от ω ($\alpha=0$) в области частот $\nu > 10^7$ Гц неоднократно наблюдалась в стеклообразных полупроводниках[1]. По-видимому, та-

кая особенность частотной зависимости σ в аморфных материалах с прыжковой проводимостью является наиболее общей. Параметр α существенно зависит от температуры в области низких частот. В этой частотной области при температуре 20°C

$\alpha=1$, а потому $\sigma \sim \omega^1$, при 90°C α имеет большое значение ($\alpha=1.6$), и зависимость σ от ω слабая. На рис.1 приведена также частотная зависимость эффективной диэлектрической постоянной ($\epsilon_{\text{эфф}}$). Видно, что дисперсия $\epsilon_{\text{эфф}}$ обнаруживается в области низких частот, если температура образца достаточно высокая. Зависимости удельной электропроводности от температуры при разных частотах иллюстрированы на рис. 2.

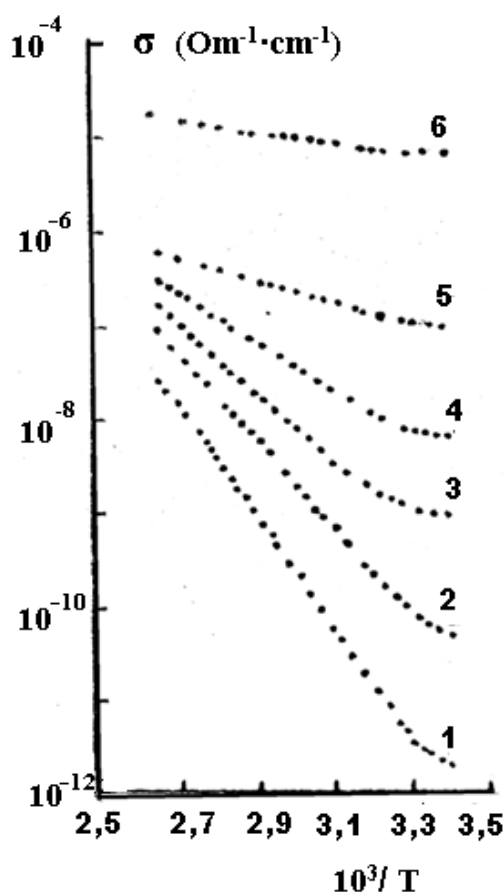


Рисунок 2. Температурные зависимости удельной электропроводности смолы на постоянном токе (1) и на частотах 10^3 Гц. (2); 10^4 Гц. (3); 10^5 Гц. (4); 10^6 Гц. (5) и $2 \cdot 10^7$ Гц. (6).

При $t > 30^\circ \text{C}$ эти зависимости описываются выражением

$$\sigma = \sigma_0 \exp\left(-\frac{\Delta E}{kT}\right),$$

где σ_0 – не зависящий от частоты множитель, k – постоянная Больцмана, ΔE – энергия активации электропроводности, которая на постоянном токе имеет значение $1,33 \text{ eV}$. В диапазоне частот $10^2 \div 10^6$ Гц с ростом частоты σ_0 и ΔE уменьшаются. На частотах $\nu > 10^6$ Гц величина $\Delta E = 0,1 \text{ eV}$, а σ_0 становится возрастающей функцией частоты. Подобная зависимость ΔE от частоты может быть результатом гетерогенности материала. Можно представить, что материал состоит из смеси непроводящих областей (смола-диэлектрик) и областей с проводимостью прыжкового характера. В области частот $\nu > 10^6$ Гц электронные процессы связаны лишь с “проводящими” областями.

Предположение об электрической гетерогенности материала подтверждается и результатами емкостных измерений. На низких частотах наблюдается значительная зависимость $\epsilon_{\text{эф}}$ от температуры, которая практически исчезает при измерении на высоких частотах. Что касается температурной зависимости σ при $\nu > 10^6$ Гц, то в этих условиях по-видимому, преобладающими являются электронов между парой ближайших центров и малое значение энергии активации ($\approx 0,1 \text{ eV}$) следует связать с термической активацией этого процесса.

Из полученных результатов следует, что с введением в смолы-диэлектрики электрически активных центров, в частности, в олигостирольную эпоксидную смолу, примеси полигидрохинона, удастся получить материал с электропроводностью полупроводникового характера. При этом электропроводность и ее энергия активации проявляет зависимость от частоты подобно материалам с электропроводностью путем перескоков.

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