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ESTIMATION OF THE INFLUENCE OF SKEWING AND NONCOAXIALITY OF THE BEARING RINGS ON THE AXIS VIBRATIONS OF THE SPINDLE OF A METAL-CUTTING MACHINE

Abstract: *The article notes that as a result of the processes of mechanical processing, heat treatment and assembly of parts included in the machine spindle assembly, in the latter occur deviations in the location of their responsible base surfaces . Are given the obtained analytical dependences, which make it possible to determine the modulus and phase of the angles of mutual misalignment of the rolling surfaces of the outer and inner rings of the bearings of each of the supports. Calculations based on the obtained dependences showed that the axis of rotation is curved, and the geometric axis of the spindle describes a closed shape around the axis of rotation. Based on theoretical studies and computer modeling of the spindle assembly, conclusions are drawn about the influence of the misalignment of the outer rings of bearings and the deviation from the alignment of the inner rings of bearings on the runout of the spindle axis, the displacement of the center of rotation and the runout of the working end of the spindle.*

Key words: *spindle assembly, spindle rotation, skew angles, deviation from alignment, modeling, changing the position of the center of rotation.*

Language: *Russian*

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ОЦЕНКА ВЛИЯНИЯ ПЕРЕКОСА И СООСНОСТИ КОЛЕЦ ПОДШИПНИКОВ НА БИЕНИЕ ШПИНДЕЛЯ МЕТАЛЛОРЕЖУЩЕГО СТАНКА

Аннотация: *В статье отмечается, что в результате процессов механической обработки, термической обработки и процесса сборки деталей входящих в узел шпинделя станка в последнем возникают отклонения расположения ответственных их базовых поверхностей. Приведены полученные аналитические зависимости, позволяющие определять модуль и фазу углов взаимного перекоса поверхностей качения наружных и внутренних колец подшипников каждой из опор. Расчёты по полученным зависимостям показали, что ось вращения является криволинейной, а геометрическая ось шпинделя описывает вокруг оси вращения замкнутую фигуру. На основании теоретических исследований и проведенного компьютерного моделирование работы шпиндельного узла сделаны выводы о влиянии перекоса*

наружных колец подшипников и отклонения от соосности внутренних колец подшипников на биение оси шпинделя, смещение центра вращения и величину биения рабочего конца шпинделя.

Ключевые слова: *шпиндельный узел, вращение шпинделя, углы перекоса, отклонение от соосности, моделирование, изменение положения центра вращения.*

Введение

УДК 539.374

Развитие машиностроительной отрасли требует гарантирования точности механической обработки, обеспечение производительности процесса, сокращение затрат времени и средств на переналадку оборудования при переходе на производство нового изделия. Одним из основных узлов, оказывающих непосредственное и существенное влияние на точность и производительность станка, является шпиндельный узел. Он является ответственным элементом формообразующей системы и, в зависимости типа оборудования, несет заготовку или инструмент, обеспечивает главное движение резания при обработке. [1-5 и др.].

В результате как механической, так и термической обработки элементов шпиндельного узла, как правило, возникают отклонения расположения ответственных базовых поверхностей деталей узла, такие как: отклонения от соосности посадочных поверхностей, параллельности плоскостей, перпендикулярности осей к торцовым поверхностям и др. [6-9 и др.]. На перечисленные отклонения дополнительно накладываются погрешности, возникающие в процессе сборки узла [1, 3, 7 и др.].

Методы и результаты исследования

Весь этот комплекс погрешностей определяет положение поверхностей качения наружных и внутренних колец подшипников в опорах шпинделя А и В (рис . 1).

Углы α_A и α_B перекоса поверхности качения наружных колец, а также углы β_A и β_B перекоса поверхностей качения внутренних колец подшипника определяются относительно общей оси этих поверхностей соответственно в опорах А и В. Как правило, имеет место взаимный перекос наружных и внутренних колец в опорах А и В на углы Θ_A и Θ_B соответственно. В общем случае все указанные углы лежат в разных плоскостях, взаимное положение которых будем характеризовать угловой координатой ν. Так, например, угол между плоскостями перекоса одноименных колец опор А и В будем обозначать через ν_α (для наружных) и ν_β (для внутренних колец). Пространственное положение наружных колец после сборки не изменяется, ориентация же внутренних колец зависит от угла поворота шпинделя φ. Поэтому углы взаимного перекоса наружных и внутренних колец в каждой опоре также зависят от угловой координаты φ.

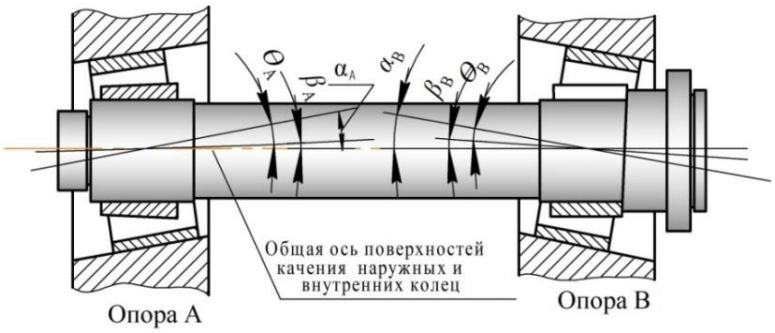

Рисунок 1 – Положение поверхностей качения наружных и внутренних колец подшипников в опорах шпинделя до момента силового замыкания.

В результате теоретических исследований получены аналитические зависимости, определяющие модуль и фазу углов взаимного перекоса поверхностей качения наружных и внутренних колец подшипников каждой из опор.

$$\Theta_A = \sqrt{\alpha_A^2 + \beta_A^2 - 2\alpha_A\beta_A \cdot \cos\varphi};$$

$$\nu_A = -\arcsin\left|\frac{\beta_A}{\Theta_A} \cdot \sin\varphi\right|, \qquad (1)$$

$$\Theta_B = \sqrt{\alpha_B^2 + \beta_B^2 - 2\alpha_B\beta_B - \cos\left[\varphi - (\nu_\alpha - \nu_\beta)\right]}, \qquad (2)$$

$$\nu_B = \nu_\alpha - \arcsin\left|\frac{\beta_B}{\Theta_B} \cdot \sin\left[\varphi - (\nu_\alpha - \nu_\beta)\right]\right|, \qquad (3)$$

где ν_α, ν_β – фазы вектора Θ_A и Θ_B соответственно.

Таким образом, отклонения от соосности поверхностей качения наружных и внутренних колец подшипников не остаются постоянными, а изменяются (по модулю и фазе) при повороте шпинделя по определенному закону. Рассмотренные выше углы определяют взаимное положение колец подшипников в опорах до

момента силового замыкания, поэтому тела качения на рис. 1 не показаны.

При сборке взаимный перекос колец в опорах создает контактные усилия N_A и N_B, в результате чего возникают реактивные моменты M_A и M_B (см. рис.2).

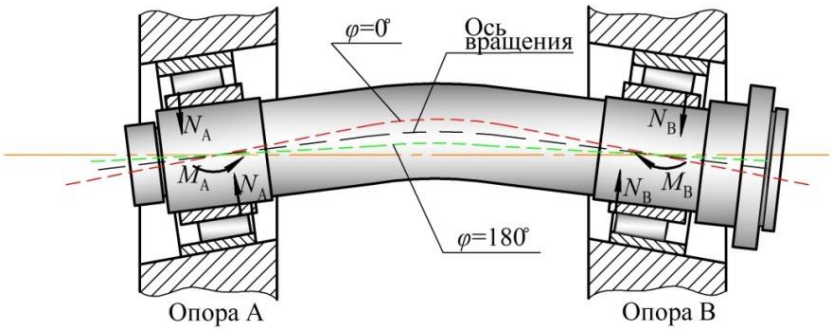

Рисунок 2 – Положение поверхностей качения наружных и внутренних колец подшипников в опорах шпинделя при возникновении реактивных моментов.

Очевидно, что фаза и модуль реактивного момента в каждой опоре зависят от того, в какой плоскости будет максимальный угол Θ и к:акова величина этого угла при произвольном угловом положении шпинделя φ. Поэтому изгиб шпинделя под действием реактивных моментов будет также изменяться при по вороте шпинделя как по величине, так и по фазе.

Положение геометрического центра сечения шпинделя в результате его изгиба можно определить, используя принцип суперпозиции, векторным сложением смещений, возникающих при изгибе шпинделя от раздельного действия реактивных моментов M_A и M_B. В соответствии с этим в расчётных схемах шпиндель представлен в виде балки на двух опорах, нагруженных реактивными моментами M_A и M_B, которые учитывают влияние угловой жёсткости двурядных роликовых и подшипников опор при наличии в них взаимного перекоса поверхностей качения наружных и внутренних колец (см. рис. 3,*а*).

Для определения реактивных моментов было получено следующее выражение [9-11]

$$M = \frac{\Theta}{t + \frac{L}{3EJ}}, \qquad (4)$$

где t – угловая податливость опор; L – расстояние между опорами шпинделя; J – момент инерции сечения шпинделя.

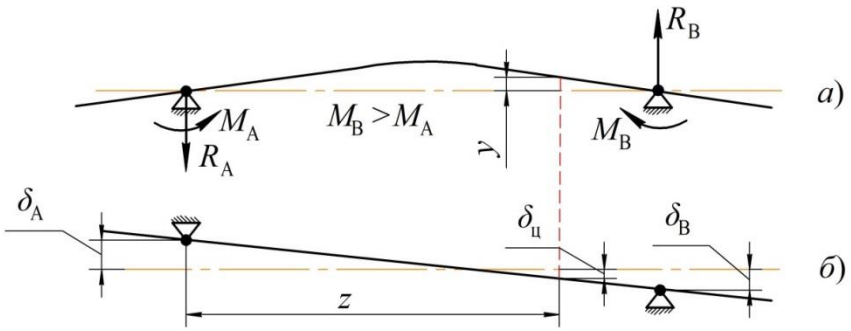

Рисунок 3 – Расчётная схема шпинделя: *а* – в виде балки на двух опорах; *б* – упругие деформации элементов шпиндельного узла, опоры которого имеют отклонения от соосности.

Были приняты следующие допущения: поверхности качения колец подшипников и тела качения не имеют отклонения формы и размеров; влияние упорного подшипника не учитываются, податливость опор шпинделя изотропна; корпус шпиндельного узла является абсолютно жестким, а шпиндель и его опоры – упруго податливые; шпиндель по ширине подшипника абсолютно жесткий; момент инерции J сечения шпинделя по всей его длине неизменный; соотношение основных размеров шпинделя допускает применение теории плоского изгиба.

Усилия R_A и R_B в опорах, которые являются следствием действия реактивных моментов на M_A и M_B, вызывают смещение шпинделя в упруго-податливых опорах. Они всегда расположены в одной плоскости, равны по величине и противоположны по направлению (см. рис. 3, *а, б*).

В результате упругих деформаций шпинделя и смещения его опор в каждом сечении шпинделя

центр его вращения смещается относительно номинального положения на величину $\delta_{ц}$, а геометрический центр этого сечения описывает относительно центра вращения окружность радиусом r_{δ}. Зависимости для определения указанных величин в любом сечении по длине шпинделя можно представить как:

$$\delta_{ц} = \sqrt{y_{ц}^2 + \delta_{Rц}^2 - 2y_{ц}\delta_{Rц} \cdot \cos\left(\nu_{уц} - \nu_{\delta Rц}\right)}; \quad (5)$$

$$r_{\delta} = \sqrt{r_{y}^2 + r_{\delta R}^2 + 2r_{y} \cdot r_{\delta R} \cdot \cos\left(\nu_{уц} - \nu_{\delta Rц}\right)}; \quad (6)$$

$$\nu_{\delta ц} = \nu_{уц} - \arcsin\left|\frac{\delta_{Rц}}{\delta_{ц}} \cdot \sin\left(\nu_{уц} - \nu_{\delta Rц}\right)\right|; \quad (7)$$

где $y_{ц}$ и $\delta_{Rц}$ – величина смещения центра вращения сечения в результате упругой деформации шпинделя и смещения его опор соответственно; r_{y} и $r_{\delta R}$ – радиусы окружностей которые описывает геометрический центр сечения относительно центра вращения, обусловленные упругой деформацией шпинделя и смещением его опор соответственно; $\nu_{уц}$, $\nu_{\delta Rц}$, $\nu_{\delta ц}$ – фазы, определяющие угловое положение центров вращения $y_{ц}$, $\delta_{Rц}$ и $\delta_{ц}$ соответственно.

Для определения величин, входящих в формулы (5…7), были получены аналитические зависимости, анализ которых показал, что положение центра вращения ($\delta_{ц}$, $\nu_{\delta ц}$) любого сечения шпинделя определяется параметрами перекоса α_{A}, α_{B} и ν_{β} наружных колец. Радиус окружности r_{δ} зависит только от параметров перекоса β_{A}, β_{B} и ν_{β} внутренних колец.

Расчёты по приведенным зависимостям (5…7) показали, что ось вращения в общем случае является криволинейной (рис. 4). При этом геометрическая ось шпинделя, являясь также криволинейной, описывает вокруг оси вращения замкнутую фигуру.

Для подтверждения результатов теоретических исследований было проведено моделирование работы шпиндельного узла станка в CAE-системе «ANSYS» с макросами блочной структуры на макроязыке APDL, содержащими набор команд, которые обеспечивают построение и корректировку модели узла шпинделя на основе использования твердотельной геометрии, объемных конечных элементов и учет масс-инерционных характеристик [12-16]. Каждый подшипник узла моделировался набором точечных пружин, равномерно расположенных по диметру посадочной поверхности шпинделя [15, 17].

При моделировании была предусмотрена возможность линейного и углового смещений опор шпинделя, а также отклонение от соосности внутренних колец подшипников (перекос на шейках шпинделя). В семи сечениях по длине шпинделя устанавливались контрольные точки расположенные под углом 90° относительно друг друга (точки 1, 2 установлены слева от опоры А, точки 3,4 справа от опоры А на расстоянии 0,17L, точки 5,6 на 0,34L, точки 7,8 на 0,5L, точки 9, 10 на 0,67L, точки 11, 12 на 0,84L и точки 13, 14 в сечении, расположенном справа от опоры В на расстоянии 0,25 L, где L – длина шпинделя). Контрольные точки с четными номерами располагались в плоскости перекоса опор. На рисунке 5 приведены три последовательно полученные характеристики исследуемого узла.

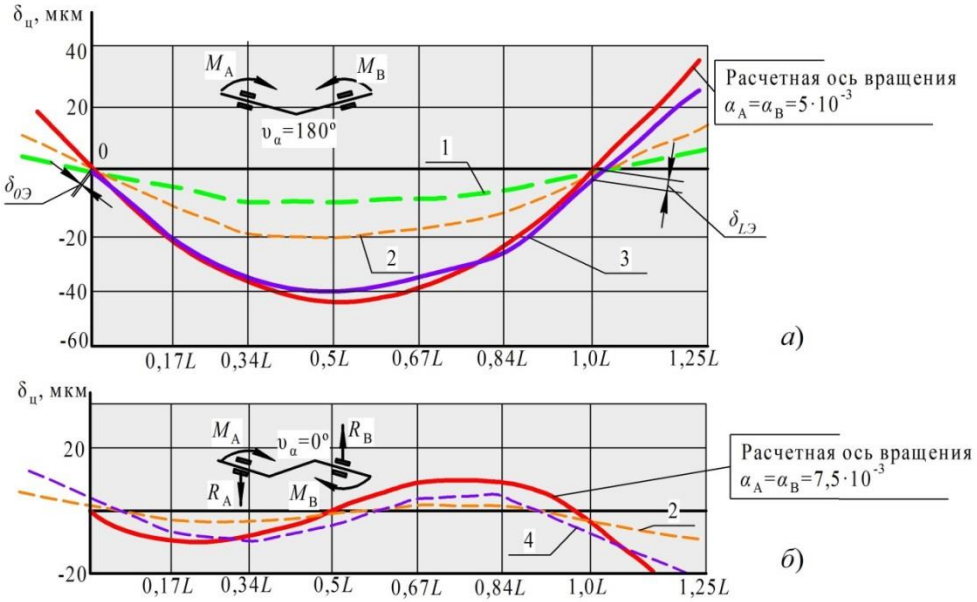

Рисунок 4 – Влияние углов перекоса наружных колец подшипников на смещение центров вращения сечений шпинделя: 1- $\alpha_{A} = \alpha_{B} = 10^{-3}$ рад, 2- $\alpha_{A} = \alpha_{B} = 2{,}5\times10^{-3}$ рад, 3 – $\alpha_{A} = \alpha_{B} = 5\times10^{-3}$ рад, 4 – $\alpha_{A} = \alpha_{B} = 7{,}5\times10^{-3}$ рад.

Первая (I) – при вращении шпинделя, у которого все кольца подшипников установлены с максимальной степенью соосности. В этом случае данные во всех контрольных точках практически не изменяются. Это говорит о том, что геометрическая ось и ось вращения совпадают и являются прямолинейными.

Вторая (II) – вращение шпинделя при перекосе внутренних колец подшипников на угол $\beta_A = \beta_B = 2{,}5\times10^{-3}$ рад. Ось вращения осталась прямолинейной и не изменила своего пространственного положения.

Третья (III) – вращение шпинделя при перекосе наружных колец подшипников на угол $\alpha_A=\alpha_B=5\times10^{-3}$ рад.. В этом случае, наряду с биением, в каждом сечении наблюдается изменение положения центра вращения на различную величину, что говорит о криволинейности оси вращения. Положение центра вращения в различных сечениях на показано пунктирной линией. Наибольшая величина смещения центра вращения $\delta_ц$ имеет место на рабочем конце шпинделя (точка 14) и в его средней части (точки 6, 8, 10). Следует отметить, что смещение центра вращения произошло только в плоскости перекоса опор, так как изменилось положение синусоид датчиков, расположенных в плоскости перекоса. При этом важно отметить, что перекос наружных колец не оказывает существенного влияния на величину биения.

Из рисунка 5 следует, что чем больше угол перекоса наружных колец подшипников, тем значительнее отклонение от прямолинейности оси вращения шпинделя. При этом следует отметить, что расчетные и полученные в результате моделирования параметры оси вращения имеют хорошую сходимость. Ось вращения на модели в отличие от расчётной имеет смещения в $\delta_{0Э}$ и $\delta_{LЭ}$ в опорах, наличие которых говорит о том, что в опорах возникли усилия R_A и R_B, тогда как согласно идеальной расчетной схеме при $\alpha_A=\alpha_B$ и $M_A=M_B$ они должны быть равны нулю. Появление усилий в опорах, вызывающих смещения в указанных направлениях очевидно, связано с тем, что угловая податливость опоры В больше, чем опоры А. Это подтверждается тем, что линейная податливость опоры В выше, так как при одинаковых усилиях ($R_A= R_B$) $\delta_{0Э}>\delta_{LЭ}$.

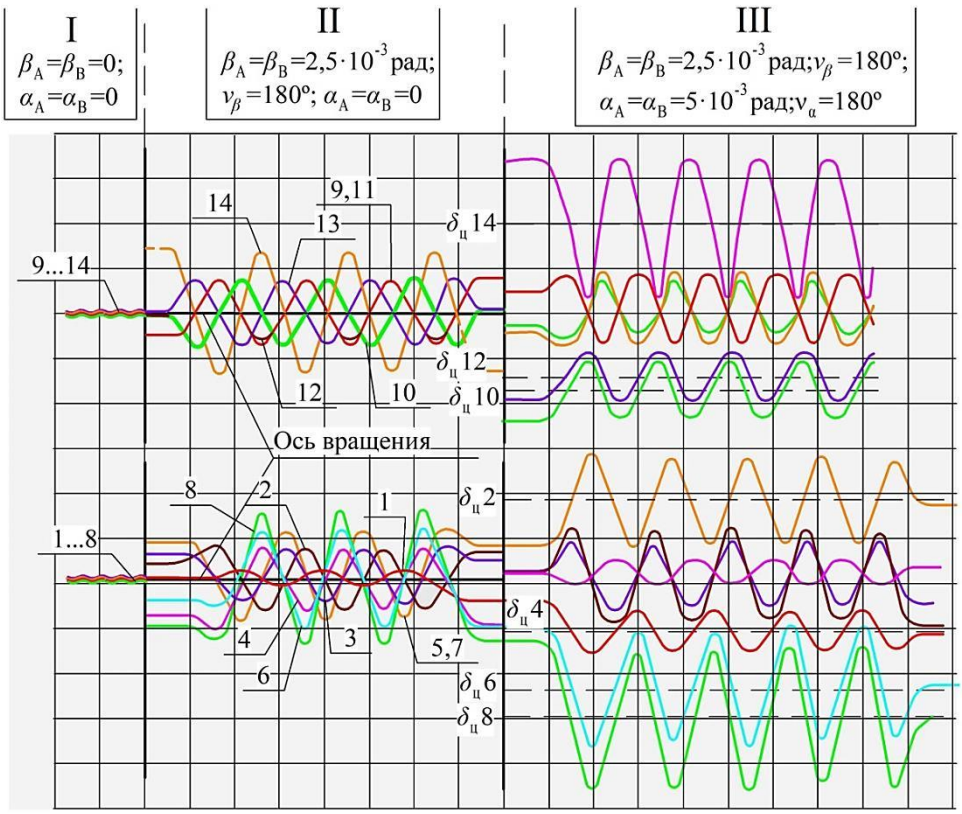

Рисунок 5 – Изменение положений геометрических центров и центров вращений сечений шпинделя.

Отклонение оси вращения от прямолинейности зависит не только от величины перекоса наружных колец подшипников, но и от угла ν_α. Если оба кольца повернуты в одном направлении (ν_α=0), то при прочих равных

условиях смещение центров вращения во всех сечениях будет меньше (см. рис. 4, *б*).

Отклонения от соосности внутренних колец подшипников опор являются причиной возникновения существенных биений (величина биения $\approx 2r_\delta$) рабочего конца шпинделя (рис. 6). Из графика видно, что при одной и той же величине отклонения от соосности обеспечение при сборке ν_β=0 вместо ν_β=180° позволяет более чем в 2 раза уменьшить биение рабочего конца шпинделя.

В шпиндельном узле, не имеющем на холостом ходу погрешностей по точности вращения при действии эксплуатационного усилия могут возникать отклонения формы или взаимного положения оси вращения и геометрической оси шпинделя. Поэтому при изготовлении шпиндельных узлов в зависимости от их назначения можно идти двумя путями:

– для шпиндельных узлов, работающих с незначительными эксплуатационными усилиями необходимо обеспечивать при изготовлении минимальные отклонения от соосности колец подшипников;

– для шпиндельных узлов с высокими эксплуатационными нагрузками на стадии изготовления необходимо целенаправленно формировать отклонения от соосности колец подшипников по модулю и фазе таким образом, чтобы в наибольшей степени компенсировать влияние эксплуатационных усилий.

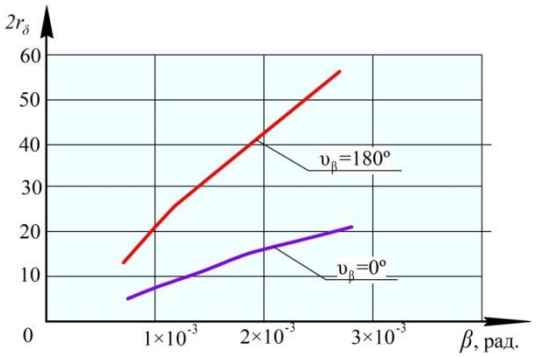

Рисунок 6 – Влияние углов перекоса внутренних колец подшипников на биение рабочего конца шпинделя.

Следует отметить, что при неподвижной плоскости действия эксплуатационной нагрузки (например, у токарного ставка) ось вращения совпадает с криволинейной геометрической осью шпинделя. В случае, когда вектор эксплуатационного усилия изменяет пространственное положение при вращении шпинделя (расточной станок), формируется криволинейная геометрическая ось, которая описывает вокруг прямолинейной оси вращения замкнутую фигуру.

Очевидно, что компенсацию действия эксплуатационного усилия можно считать идеальной только тогда, когда геометрическая ось и ось вращения становятся прямолинейными и совпадают друг с другом по всей длине шпинделя ($\delta_ц$=0, 2δ=0). Установлено, что при неподвижной плоскости действия эксплуатационного усилия компенсацию рационально производить путем перекоса наружных колец в плоскости этого усилия в соотношении α_B=2α_A, при этом ν_β=180°. В случае, когда плоскость действия эксплуатационного усилия связана с вращающимся шпинделем, уменьшение радиуса траектории движения геометрического центра вокруг центра вращения следует производить путем перекоса внутренних колец подшипников в соотношении β_B=βα_A, при этом ν_β=180°.

Выводы.

Полученные результаты позволяют сделать следующие выводы.

– Перекос наружных колец подшипников не вызывает биения шпинделя.

– Перекос наружных колец подшипников вызывает смещение центра вращения рабочего конца шпинделя. Для уменьшения этого смещения необходимо обеспечивать разворот обоих колец в одном направлении. За счет этого смещение центра вращения может быть уменьшено более чем в 2 раза по сравнению с вариантом, когда кольца развернуты в разные стороны (при неизменной величине отклонения от соосности).

– Биение рабочего конца шпинделя зависит от отклонения от соосности внутренних колец подшипниковых опор. При изменении отклонения от соосности внутренних колец от 1×10^{-3} до 4×10^{-3} рад биение может увеличиться с 19 до 68 мкм.

– При неизменной величине отклонения от соосности внутренних колец биение может быть уменьшено в 2,5 раза, если при изготовлении обеспечивается перекос внутренних колец в одном направлении.

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THE IMPACT OF THE TAX BURDEN ON THE ACTIVITIES OF TAXPAYERS

Abstract: *This article scientifically examines the theoretical basis of the impact of the tax burden on the activities of taxpayers. There, it discusses the concept of tax burden, optimization of tax burden, the impact of tax burden on the economy, its normative levels, the need to calculate the tax burden in the economy, methods of calculating the tax burden at the macro level, methods of calculating the tax burden at the micro level. In addition, the author studied the main directions of determining the level of the tax burden, the directions of the methodology for assessing the tax burden on legal entities and the impact of the tax burden on the legal entities and individual's activities.*

Key words: *taxes, tax system, tax burden, tax burden optimization, value added, sales revenue, Laffer curve, gross domestic product, taxpayers.*

Language: *English*

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Introduction

Among the problems of the tax system, the problem of the tax burden occupies a central place. It reflects the final assessment of the tax policy and system of a particular state. It's an effective indicator of the country's tax reform and plays an important role in the economy.

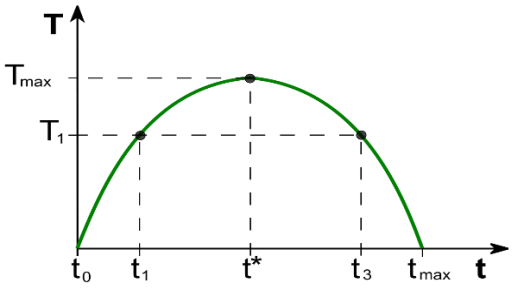
A prudent tax system that meets the needs of the state for financial resources does not negatively affect the production and entrepreneurial activities of taxpayers, but rather has a positive impact on finding effective ways of doing business. Therefore, the taxpayer's tax burden indicator will be sufficient to assess the quality of the country's tax system [5].

The tax burden represents a set of indicators of the country's tax system. A certain percentage of the income of individual business entities or other taxpayers is paid to the state in the form of taxes or other payments.

URGENCY

In "An Inquiry into the Nature and Causes of the Wealth of Nations", A.Smith focused on the relationship between the level of the tax burden and the state budget. "The state gains more from lowering the tax burden than from imposing hard-to-collect taxes. The remaining funds may remain as additional income that will be taxed to the treasury in the future. At the same time, the additional costs of the state related to penalties and mandatory payments will be reduced, and taxpayers will be able to make these payments more easily [1, 2].

American economist Arthur Laffer has proven that economic and government revenues grow as a result of tax cuts. This is called the Laffer curve.



T – the amount of taxes, t – the interest rate, %

Pic.1. Laffer curve

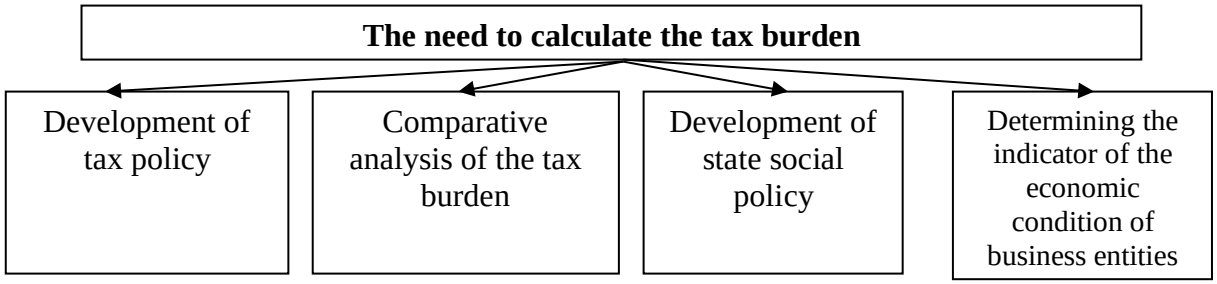
If t = 0, the state will have no tax revenue. If t = 100%, the result will be the same again for the state, because all the income of producers will be taken to the budget. There will be no interest in production. In all other cases of the tax rate, the state has a certain amount of income (0 <t <100%). When the tax rate is t °, tax revenues reach a maximum (T0 = Tmax). The conclusion is that reaching a certain level of the tax interest rate increases tax revenues, while a further increase in it, on the contrary, reduces tax revenues. The impact of economic entities on the dynamics of the tax rate is not felt immediately, but after some time. The Laffer curve shows that government revenue growth is objectively related to lower tax rates [3, 4].

THEORETICAL APPROCHES

In the XVIII-XIX centuries, foreign scholars analyzed the proportion between the budget and national income, the size of taxation of economic entities and citizens. The tax burden indicator and its impact on the economy was first pointed out in the 18th century. In this regard, F. Justi (1705-1771) studied at the macro level the relationship between the tax burden and the national income of the state. At the same time, he argued that the country's budget should be 1/6 of national income [6].

K.Gok justified the proportions between state budget expenditures and revenues and national income. He clearly believed that the tax burden, which was real for the country and was real at different stages of economic development, could not be a single, universal and at the same time optimal indicator [7].

Based on the above considerations, we can say that it is not possible to determine the tax burden indicator accurately and optimally for the same country or taxpayers, it can only be determined empirically. Because there is no other way to determine. There is no single methodology for specifying the tax burden for a particular country. The interest in the tax burden indicator in the economy, both theoretically and practically, is not in vain. The need to calculate the tax burden for each country can be schematically expressed as follows:



Pic. 2. The need to calculate the tax burden

ANALYTICAL PART

Based on the picture above, we can substantiate the role and importance of the tax burden indicator as follows.

Firstly, the calculation and determination of the tax burden is necessary for each state to develop a tax policy. By abolishing old taxes and introducing new taxes, setting tax rates and tax breaks, the state will not put pressure on the economy. From a macroeconomic point of view, the state used to determine the revenue side of the budget, the tax base and the impact of taxes on the economy through the tax burden.

Secondly, the tax burden indicator is necessary for a comparative analysis of the state with the tax burden and tax indicators of various other states. It is necessary for the location of production in the country, the distribution of investment and the movement of capital. This data also used for comparative analysis within the country and across regions.

The tax burden is an overall indicator of the role that taxes play in society. In many countries, the tax burden at the macroeconomic level is calculated relative to the total amount of taxes and levies on GDP [5]. It is as follows:

$$TB = \frac{T + P}{GDP} \times 100\%$$

There: **TB** – tax burden; **T** – tax; **P** - payments; **GDP** – gross domestic product.

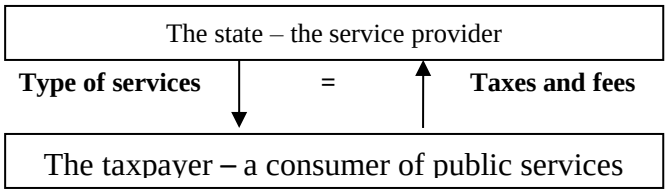
It should be noted that the role of taxes in the life of the state and society depends on geographical and climatic factors. Because these factors affect the development of the national economy and the ability to distinguish and compare with the economy of other countries.

Table 1. The average tax burden in European countries [8]

Countries	Tax burden according to GDP, %
Germany	42,9
Belgium	46,4
Denmark	52,8
France	46,3
Italy	42,9
The Netherlands	44,8
Austria	45,5
Sweden	54,2
United Kingdom	33,9
Spain	35,5

The table shows that the tax burden is high in countries with socially oriented market economies. In other words, the tax burden to one degree or another is manifested as a means of return to the state. This is because the level of social orientation of public policy emerges as an important factor in the dynamic development of the economy by the state.

Thirdly, tax burden indicators affect a state's social policy. The state develops its social policy based on the results of this indicator. Plans spending on defense, security services, education, medicine, science and training. That is, the state provides various services to the population. Due to this, the taxpayer collects taxes from the population and legal entities. The essence of the problem here is to determine the optimal level of tax amount, because the taxpayer wants to receive social services in the amount of taxes paid to the state.



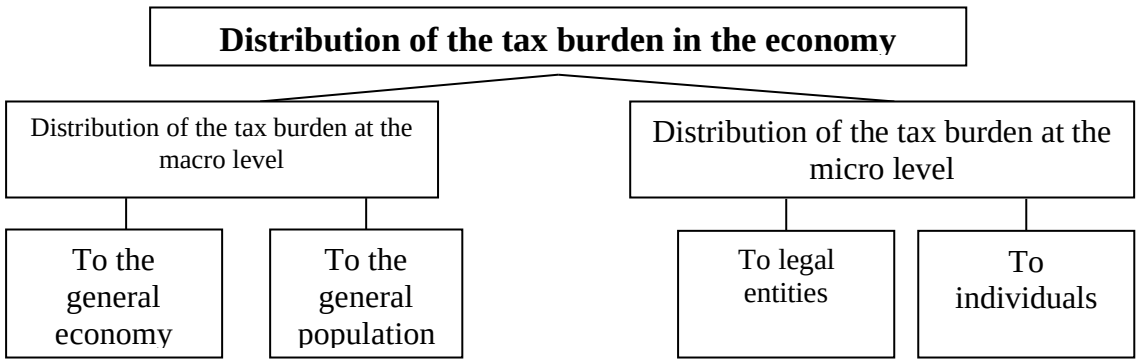
Pic. 3. The relationship between the state and taxpayers

Based on this, the state determines the tax burden and returns these funds to taxpayers through various services. We can see this even more clearly in the diagram below. Paying attention to the basics of taxation, elaborating it carefully, correctly determining the terms and amount of payment leads to the establishment of a fair tax burden.

Fourthly, tax burden indicators are used to determine the economic activity of economic entities. It is this indicator that determines the direction of investment in production. The tax burden is a great help in solving such issues as the development and reduction of production, regulation of the economy, the solution of production problems by industries, the creation of new jobs, the normalization of consumption and savings processes, the direction of investment.

Theoretically, the determination of the tax burden in the economy is carried out in two directions. That is, it is determined at the macro and micro levels.

At the macro level, the tax burden can be divided into two, that is, the tax burden on the whole economy and the population as a whole. This figure is general and is defined as the share of taxes and fees in relation to GDP, as mentioned above.



Pic. 4. Main directions of the determining the level of the tax burden

Macro-level refers to the tax system of the whole country, in other words, the state's intervention in the economy, its tax pressure. In this case, the tax burden is distributed to enterprises, industries and sectors. Also, the macro-level tax burden is insignificant for each of the legal entities and individuals. Because they pay taxes and fees to the budget and extra-budgetary funds from their own income [9].

When we analyze the structure of state budget revenues in the developed countries of the world, the main taxes in the GDP, ie income taxes, play a key role. The share of indirect taxes is low. In the Republic of Uzbekistan, we can see the opposite. This is because in the context of the transition to market relations, indirect taxes perform a more fiscal function and are necessary for the state. This view is also valid from the point of view of manufacturers. However, the main part of the tax burden is gradually falling on the population. Because the final consumers of products (works, services) are individuals. The real payer of indirect taxes is also the consumer of goods (works, services). From this we can say that individuals also pay taxes and indirect taxes that they pay. There are also some types of taxes paid by legal entities that are included in the cost of the product. Taxes included in the cost of production are also borne by individuals. Therefore, these indicators should be taken into account when calculating the tax burden on individuals.

World experience shows that as a result of increasing the tax burden on taxpayers (increasing the tax burden and raising tax rates, removing tax benefits, etc.) initially increases tax revenues, and when it reaches a maximum, these indicators begin to decline. As a result, budget revenues are declining and a certain proportion of taxpayers are in decline or production is declining, while the rest of the taxpayers are illegally evading taxes. The result is a shadow economy [10].

Todays, when making changes to the tax legislation, many countries are on the way to removing benefits and deductions, trying to introduce new fees. However, this leads to a sharp decline in income and taxable capital.

The world experience in taxation shows that taking more taxpayers 'income as tax leads to a decrease in investment in the economy. If the tax rate reaches 40 percent of income, it will have a negative impact on business development and expansion of production.

In other words, an effective tax system should meet the needs of the state by receiving 1/3 of the income. At the same time, the exact indicator of the tax burden is manifested differently in different countries at the macro and micro levels. It is primarily a matter of obligations between the state and taxpayers. The level of the tax burden depends on the budget expenditures for the provision of medical, educational, communal and other services to the population of the state. In Sweden, for example, the population donates 50 percent of their income to the state treasury, which does not negatively affect production efficiency. This is not surprising, as the state has been extensively protecting taxpayers economically and socially.

CONCLUSION

Each country determines the tax burden based on its different national characteristics and production. There are tens of thousands of operating enterprises with different characteristics in each country. Each of them has different options in paying taxes. Therefore, in the comparative analysis of the tax burden at the national level and in the calculation of the tax burden at the macro level, it is expedient to calculate the ratio of taxes and fees to GDP.

In summary, tax burden indicators are a key factor in the development of tax, investment and social policy of the state. Including:

- The tax burden in the country's economy is the result of state tax policy, which reflects the qualitative characteristics of any tax system. At the same time, the level of taxes levied determined, on the one hand, by the efficiency of social production, and, on the other hand, by the amount of the state's need for financial resources. Therefore, reducing the weight of the tax burden is primarily associated with reducing government spending;

- The state based on the indicator of the tax burden in the development of its social policy, which serves as the main source for it;

- The results of research show that there is no clear methodology for calculating the tax burden on businesses. It should be based on several methods to calculate and analyze it.

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ON THE ACTION OF A MOVING PRESSURE WAVE ON A VISCOELASTIC CYLINDRICAL SHELL INTERACTING WITH AN IDEAL LIQUID

Abstract: *In this paper, we present statements, develop methods for solving and obtain numerical results for new problems of stationary deformation of infinitely long viscoelastic cylindrical shells on a deformable base when a non-axisymmetric wave of normal pressure moves along the axis of the shell with up to a resonant velocity. The solution methods are based on the joint application of the integral Fourier transform (or the method of fundamental solutions) with respect to the axial coordinate and the decomposition of all the given n desired quantities into Fourier series with respect to the angular coordinate. An efficient algorithm for the joint calculation of integrals and Fourier series is developed and implemented on a computer. The mixed shell is estimated as a function of the pressure wave velocity and the viscosity of the materials.*

Key words: *pressure waves, cylindrical shell, viscoelasticity, resonant velocity, Fourier transform, deformable base.*

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Introductions

Natural oscillations and propagation of free waves in cylindrical shells interacting with a liquid have been studied by many authors, in particular in [1,2]. In this case, axisymmetric and non-axisymmetric problems were considered, and various models for the liquid and shell were used. The question of the action of a moving pressure wave on a cylindrical shell filled or surrounded by a liquid is less studied, and only axisymmetric loading was considered [3,4]. In this paper, using the integral transformation with respect to the axial coordinate and the Fourier series with respect to the angle, the solution of the problem of motion along an infinitely long cylindrical shell interacting with an ideal compressible fluid of normal pressure, arbitrary in length and circumference, but unchanged in time, is obtained. The speed of movement of the load is constant and, in the subsection, it is considered in the case when it is less than the speed of sound in a liquid. The liquid fills the cavity

2. Problem statement and basic equations

Consider the action of a non-axisymmetric moving pressure wave on a viscoelastic cylindrical shell interacting with an ideal compressible fluid The equations of motion of a viscoelastic cylindrical shell and an ideal fluid are introduced in the coordinate system r, θ, z [5].

The equations of motion of the bearing layers (shells) in displacements, in symbolic vector-matrix form, are written in the form

$$L_{ij}\vec{U}_k - \int_0^t L_{ij}R_{E\kappa}(t-\tau)\vec{U}_k(\vec{r},\tau)\,d\tau = \frac{(1-\nu_{0\kappa}{}^2)}{G_{0\kappa}h_{0\kappa}}\vec{q}_\kappa + +\rho_{0\kappa}\frac{(1-\nu_{0\kappa}{}^2)}{G_{0\kappa}}\frac{\partial^2\vec{U}_k}{\partial t^2}. \quad (k=1,2) \qquad (1)$$

Here, the index $k=1$ refers to the inner carrier layer, and $k=2$-to the outer layer, U_k is the displacement vector of the points of the middle surface of the bearing layer, and for Timoshenko-type shells the dimension of the vector U_k.

$$\left(U_{1k}=u_k;\ U_{2k}=\vartheta_k;\ U_{3k}=w_k;\ U_{4k}=\psi_{xk};\ U_{5k}=\psi_{yk}\right)$$

Here, respectively, axial, circumferential and normal displacements are also added the angles of rotation of the normal to the middle surface in the axial and circumferential directions: P_k is the vector of loads on the shell, the dimension of which also depends on the chosen theory of shells. L_{ij} is a matrix of differential operators of the theory of shells, including in problems of dynamics and time differentiation (terms with damping and inertial terms in expanded form). If, when writing the equations of motion of the bearing layers, shear deformations and inertia of rotation (Timoshenko -type shell) are taken into account, then the differential operators have the form

$$L_{11}=\frac{\partial^2}{\partial z^2}+\frac{1-\nu_k}{2a_k^2}\frac{\partial^2}{\partial\theta^2}--\rho_k\frac{1-\nu_k}{2G_{k0}}\frac{\partial^2}{\partial t^2};\ L_{12}=L_{21}=\frac{1+\nu_k}{2a_k}\frac{\partial^2}{\partial z\partial\theta};$$

$$L_{13}=L_{31}=\frac{\nu_k}{a_k}\frac{\partial}{\partial z};\ L_{14}=L_{15}=0;$$

$$L_{22}=\frac{1-\nu_k}{2a_k^2}\frac{\partial^2}{\partial z^2}+\frac{1}{a_k^2}\frac{\partial^2}{\partial\theta^2}-\rho_k\frac{1-\nu_k}{2G_{k0}}\frac{\partial^2}{\partial t^2};\ L_{23}=\frac{1}{a_k^2}\left[1+\frac{(1-\nu_k)k_0^2}{2}\right]\frac{\partial}{\partial\theta};$$

$$L_{25}=\frac{(1-\nu_k)k_0^2}{2a_k},\ L_{32}=\frac{1}{a_k^2}\frac{\partial}{\partial\theta};$$

$$L_{33}=-\frac{1-\nu_k}{2}k_0^2\left(\frac{\partial^2}{\partial z^2 k}+\frac{1}{a_k^2}\frac{\partial^2}{\partial\theta^2}\right)+\frac{1}{a_k^2}+\rho_k\frac{1-\nu_k}{2G_{k0}}\frac{\partial^2}{\partial t^2}; \qquad (2)$$

$$L_{34}=\frac{(1-\nu_k)}{2a_k}k_0^2\frac{\partial}{\partial z};\ L_{35}=-\frac{(1-\nu_k)}{2a_k}k_0^2\frac{\partial}{\partial\theta};\ L_{41}=L_{42}=0;$$

$$L_{43}=-6k_0^2\frac{1-\nu_k}{h_k^2}\frac{\partial}{\partial z};\ L_{45}=L_{54}=\frac{1+\nu_k}{2a_k}\frac{\partial^2}{\partial z\partial\theta};$$

$$L_{44}=\frac{\partial^2}{\partial x^2}+\frac{1-\nu_k}{2a_k^2}\frac{\partial^2}{\partial\theta^2}-6k_0^2\frac{1-\nu_k}{h_k^2}-\rho_k\frac{1-\nu_k}{2G_k}\frac{\partial^2}{\partial t^2};$$

$$L_{51}=L_{52}=0;L_{53}=-6k_0^2\frac{1-\nu_k}{a_kh_k^2}\frac{\partial}{\partial\theta};$$

$$L_{55}=\frac{1-\nu_k}{2}\frac{\partial^2}{\partial z^2}+\frac{1}{a_k^2}\frac{\partial^2}{\partial\theta^2}-6k_0^2\frac{1-\nu_k}{h_k^2}-\rho_k\frac{1-\nu_k}{2G_{k0}}\frac{\partial^2}{\partial t^2};$$

$$\lambda_{0s}=\frac{2\nu_sG_{s0}}{1-2\nu_s};\ \mu_{0s}=G_{s0}.$$

Here k_0^2-is the Timoshenko coefficient; h_k,a_k - thickness and radius of the middle surface of the bearing layer; nu ν_k-Poisson's ratio; $R_{E\kappa}(t-\tau)$ relaxation core; G_{k0}- instant modulus of elasticity.

The components of the load vector, respectively, has the form

$$\{P_{1k},P_{2k},P_{3k}\}=-\frac{1-\nu_k}{2G_{k0}h_k}\{p_{zk}\pm q_{zk},p_{\theta k}\pm q_{\theta k},p_{rk}\pm q_{rk}\}$$

$$P_{4k}=-\frac{3(1-\nu_k)}{G_{k0}h_k^2}(p_{zk}\pm q_{zk});\ P_{5k}=-\frac{3(1-\nu_k)}{G_kh_k^2}(p_{\theta k}\pm q_{\theta k}); \qquad (3)$$

where the minus sign corresponds to the inner shell, and the plus sign to the outer shell: q_{zk},$q_{\theta k}$, q_{rk} are the reaction components from the filler side: p_{zk}, $p_{\theta k}$,p_{rk}- intensity of the given load in the corresponding direction.

In the problem of free wave propagation, the components of a given load, $\psi(t)$ are taken to be zero. We accept the integral terms in (1) small. Then the function $\phi(t)=\psi(t)e^{-i\omega_Rt}$, where is a slowly varying function of time, $\omega_R-$is real constant. Further, applying the freezing procedure [6,7], we replace relations (1) with approximate ones of the form

$$\bar{L}_{il}^k\vec{U}_k=\frac{(1-\nu_{0\kappa})}{G_{0\kappa}h_{0\kappa}}\vec{q}_\kappa+\rho_{0\kappa}\frac{\left(1-\nu_{ok^2}\right)}{G_{0\kappa}}\frac{\partial^2\vec{U}_k}{\partial t^2}. \qquad (4)$$

Here $\bar{L}_{il}^k[\varphi(t)]=L_{ij}^k\left(1-(R_{ij}^k\delta_{ij})^{-1}\right)[\varphi(t)]$, δ_{ij}-Kronecker symbols, $R_{ij}^k(R_{11}^k=R_{22}^k=R_{33}^k==\overline{G}_k[\varphi(t)])$ is the third order diagonal matrix for the Kirchhoff - Love conjecture, and the fifth order for the Timoshenko conjecture. The system of differential equations (4) is solved under boundary conditions. The non-axisymmetric motion of a Timoshenko-type shell is described by equations (1), and (4) and in the components of the load vector only the term [8] $p_{3k}=-\frac{1-\nu_k}{2G_kh_k}(q_{rk}\mp p_{rk})$, the motion of an ideal compressible fluid is described by the wave equation

$$\frac{\partial^2\varphi}{\partial r^2}+\frac{1}{r}\frac{\partial\varphi}{\partial r}+\frac{1}{r^2}\frac{\partial^2\varphi}{\partial\theta^2}+\frac{\partial^2\varphi}{\partial x^2}=\frac{1}{c_1^2}\frac{\partial^2\varphi}{\partial t^2}. \qquad (5)$$

where φ - potential of fluid velocities; c_1- acoustic speed of sound in liquid; ρ_0- density of liquid.

The problem is reduced to the joint integration of equations (1), (4), and (5) when the boundary

conditions of impermeability of the shell and rigid wall are satisfied

$$\frac{d\varphi}{dr}\mathrm{I}_{r=a} = \frac{\partial w_k}{\partial t}; \frac{d\varphi}{dr} I_{r=b} = 0. \quad (6)$$

in this case, the pressure entering into (3) from the liquid side is expressed through the velocity potential by the formula

$$q_{rk} = -\rho_0 \frac{\partial \varphi}{\partial t} I_{r=a}. \quad (7)$$

Considering the steady-state process, we pass in the equations of motion of the shell and fluid to the coordinate system.

3.Methods of solution

When considering the establishing process, the Galilean transformation is applied [9]

$$\eta = (x - ct)/H, \quad (8)$$

where c- is the speed of movement of the load, H is some characteristic value in the problem under consideration, which has the dimension of length *(H = a)*. We apply the Fourier transform according to η [10]:

$$\varphi^{(0)}(\zeta) = \int_{-\infty}^{\infty} \varphi(\eta)\, e^{-i\zeta\eta} d\eta; \quad \varphi(\eta) = \int_{-\infty}^{\infty} \varphi^{(0)}(\zeta)\varphi(\eta)\, e^{i\zeta\eta} d\zeta. \quad (9)$$

Here ζ -is the Fourier transform parameter.

In the image space, the solution of the transformed equations is sought in the form of Fourier series in the angular coordinate θ . Assuming that the transformants of a given normal load and fluid pressure are expandable in Fourier series in θ

$$\left\{u_k^{(0)}, w_k^{(0)}, \psi_{xk}^{(0)}, p_{rk}^{(0)}, q_{rk}^{(0)}\right\} = \sum_{n=0}^{\infty} \left\{u_{nk}^{(0)}, w_{nk}^{(0)}, \psi_{xnk}^{(0)}, p_{rnk}^{(0)}, q_{rnk}^{(0)}\right\} \cos(n\theta);$$
$$\left\{v_k^{(0)}, \psi_{yk}^{(0)}\right\} = \sum_{n=1}^{\infty} \left\{v_{nk}^{(0)}, \psi_{ynk}^{(0)}\right\} \sin(n\theta), \quad (10)$$

where n- is the number of harmonics along the angular coordinate.

Substituting (10) into the transformed equations of motion of the shell, we obtain a system of algebraic equations for the Fourier coefficients of the transformants of the displacements of the middle surface. In this system, the unknown are the expansion coefficients of the liquid pressure, which should be expressed through the coefficients of normal displacement

$$\frac{\partial^2 \varphi_n^{(0)}}{\partial r_*^2} + \frac{1}{r_*}\frac{\partial \varphi_n^{(0)}}{\partial r_*} - \left[\frac{n^2}{r_*^2} + [1 - M^2]\zeta^2\right]\varphi_n^{(0)} = 0$$

shell. Representing the transformant of the velocity potential in the form (10) and substituting it into the transformed equation (1), we arrive at the equation

$$\frac{\partial^2 \varphi_n^{(0)}}{\partial r_*^2} + \frac{1}{r_*}\frac{\partial \varphi_n^{(0)}}{\partial r_*} - \left[\frac{n^2}{r_*^2} + [1 - M^2]\zeta^2\right]\varphi_n^{(0)} = 0, \quad (11)$$

where $M = \frac{c}{c_1}$ is the Mach number, c_1 is the acoustic speed of sound in the fluid. The solution to equation (11) in the subsonic regime of motion $c < c_1$ has the form [11]:

$$\varphi_n^{(0)} = A_n(\xi) K_n(\beta\xi r_*) + B_n(\xi) I_n(\beta\xi r_*),$$

where $\beta = \sqrt{1 - M^2}$.

Substituting (11) into (2), (3), we find the relationship between the liquid reaction and the normal displacement of the shell:

$$q_{r.nk}^0 = \rho_0 c^2 k \xi^2 f_k(\xi, n, c) \frac{w_{nk}^0}{h_k}, \quad (12)$$

where for $c < c_1$

$$f_k(\xi, n, c) = \frac{ns_4 - \beta\xi\varepsilon - (ns_2 + \beta\xi\varepsilon s_3)s_5}{(n + \beta\xi s_1)(ns_4 - \beta\xi\varepsilon) - (ns_2 + \beta\xi\varepsilon s_3)(ns_5 - \beta\xi s_6)}; \quad (13)$$

$$s_1 = \frac{I_{n+1}(\beta\xi)}{I_n(\beta\xi)}; \quad s_2 = \frac{I_n(\beta\xi\varepsilon)}{I_n(\beta\xi)};$$
$$s_3 = \frac{I_{n+1}(\beta\xi\varepsilon)}{I_n(\beta\xi)}; \quad s_4 = \frac{I_n(\beta\xi\varepsilon)}{I_{n+1}(\beta\xi\varepsilon)};$$
$$s_5 = \frac{K_n(\beta\xi)}{K_{n+1}(\beta\xi\varepsilon)}; \quad s_6 = \frac{K_{n+1}(\beta\xi\varepsilon)}{K_{n+1}(\beta\xi\varepsilon)},$$

where $\varepsilon = b/a$, $I_{n+1}(\beta\xi)$ and $K_n(\beta\xi)$- modification of the Bessel function of the 1st and 2nd kind, $f_k(\xi, n, c)$- for k = 1, 2, it differs in meaning with opposite signs.

If the shell is completely filled with liquid, then formula (13) takes the form

$$f_k(\xi, n, c) = \delta_k(n + \beta\xi s_1)^{-1}, \delta_k = \{\kappa = 1, \delta_1 = 1; \kappa = 2, \delta_1 = -1\}. \quad (14)$$

Substituting the found relation (12) into the system of algebraic equations for determining the expansion coefficients of the transformants of the displacements of the shell, we find

$$\left\{u_{nk}^{(0)}, v_{nk}^{(0)}, w_{nk}^{(0)}, \psi_{xnk}^{(0)}, \psi_{ynk}^{(0)}\right\} = -\frac{1 - v_k}{2G_k k^2} p_{z,nk} \frac{\{\Delta_{1k}, \Delta_{2k}, \Delta_{3k}, \Delta_{4k}, \Delta_{5k}\}}{\Gamma_{E1} \det_n \|a_{\bar{k}l}\|}, (\bar{k}, l = 1, \ldots, 5) \quad (15)$$

Determinant elements $\det_n \|a_{kl}\|$ calculated by the formulas

$$a_{11k} = -\left(1 - \frac{1 - v_k}{3} c_{0k}^2\right)\xi^2 - \frac{1 - v_k}{3} n^2;$$
$$a_{12k} = -a_{21k} = a_{45k} = -a_{54k} = i\xi \frac{1 + v_k}{2} n;$$
$$a_{13k} = a_{31k} = i\xi v_k;$$

$$a_{22k} = -\frac{1-v_k}{2}\left(1-\frac{2}{3}c_{0k}^2\right)\xi^2 - n^2; a23k = -2+1+vkk0k22n; a_{25k} = k^{-1};\ a_{32k} = n\ ; a_{33k} = 1 + k_{0k}^2\frac{1-v_k}{2}(n^2+\xi^2) - \frac{1-v_k}{3}c_{0k}^2\xi^2\left[1+\frac{\rho_{0k}^*}{k}f_k(\xi,n,c)\right]; \quad (16)$$

$$a_{34k} = -i\xi k_{0k}^2\frac{1-v_k}{2k};\quad a_{35k} = -k_{0k}^2\frac{1-v_k}{2k}\frac{n}{k};$$

$$a_{43k} = 12a_{34k};\quad a_{44k} = a_{11k} - 6(1-v_k)\frac{k_{0k}^2}{k^2};$$

$$a_{53k} = -12a_{35k};\quad a_{55k} = a_{22k} - 6(1-v)\frac{k_{0k}^2}{k^2};$$

$$a_{14k} = a_{15k} = a_{24k} = a_{41k} = a_{12k} = a_{51k} = a_{52k} = 0;$$

$$\rho_{0k}^* = \frac{\rho_0}{\rho_k};\quad c_{0k} = c(^{\frac{3\rho_k}{2G_k}}$$

$$\Gamma_{E1} = 1 - \Gamma_{E1}^C(\omega_R) - i\Gamma_{E1}^S(\omega_R),$$

$$\Gamma_E^c(\omega_R) = \int_0^\infty R_E(\tau)\cos\,\omega_R\tau\,d\tau;\ \Gamma_E^S(\omega_R) = \int_0^\infty R_E(\tau)\sin\omega_R\tau\,d\tau,$$

Where $R_E(\tau)$- the core of relaxation

Determinants $\Delta_{jk}(j=1,\ldots,5)$ are obtained from $\det_n\|a_{kl}\|$ by replacing the j-th column with elements{0,0,1,0,0}.

Substituting (15) into formula (12), we find the Fourier coefficients of the transformants of fluid pressure

Substituting (15) into formula (12), we find the Fourier coefficients of the transformants of fluid pressure

$$q_{r,nk}^0 = -\frac{1-v}{3}\frac{\rho_{0k}^* c_0^2}{k}\xi^2 f_k(\xi,n,c)\frac{\Delta_{3k}}{\Gamma_{E1}\det_n\|a_{kl}\|}p_{r.nk}^0 \quad (17)$$

For the bending moment and shear force in the shell, we obtain

$$M_{x,nk}^0 = -\frac{h_k a}{12}p_{r,nk}^0\frac{i\xi\Delta_{4k}n\nu_k\Delta_{5k}}{\Gamma_{E1}\det_n\|a_{\bar{k}l}\|}; \quad (18)$$

$$Q_{x,nk}^0 = \frac{(1-\nu_k)k_{0k}^5}{2k}ap_{r,nk}^0\frac{i\xi\Delta_{4k}n\nu_k\Delta_{5k}}{\Gamma_{E1}\det_n\|a_{\bar{k}l}\|}. \quad (19)$$

Now let's look at some examples. The final solution is obtained by substituting (15) - (19) in the Fourier series and applying the inverse Fourier transform. As an example, it is considered when the liquid is between a shell of radius b and a coaxial rigid cylindrical wall of radius *a*

External loads are taken in the form [12

$$p_r(\eta,\theta) = p_2\exp(a\eta)H(-\eta)\sum_{k=1}^{l}(\theta-\theta_k), \quad (20)$$

H(x)-Heaviside functions. In this case

$$p_{r,nk}^0 = \frac{p_2 a_{nk}}{a-i\xi}. \quad (21)$$

Here a_n are the Fourier coefficients of the function $\sum_{k=1}^{l}(\theta-\theta_k)$ If you accept $p_2 = 2\pi p_1/l$. Where $p_1 -$ intensity of moving loads, $q^* = q_r/p_1$

$$w_1^* = \frac{wG_1\Gamma_{E1}}{p_1 a} - -\frac{1-v_1}{kl}\sum_{n=0}^{\infty}\left\{\int_{-\infty}^{\infty}\frac{\Delta_{31}[a\cos(\xi\eta)-\xi\sin(\xi\eta)]}{\Gamma_{E1}(a^2+\xi^2)\det\|a_{\bar{k}l}\|}d\zeta\right\}\times a_n\cos(n\theta); \quad (22)$$

$$q^* = -\frac{2(1-v)p_{01}^* c_0^2}{3kl}\sum_{n=0}^{\infty}\left\{\int_{-\infty}^{\infty}\frac{f(\xi,n,c)\xi^2\Delta_{31}[a\cos(\xi\eta)-\xi\sin(\xi\eta)]}{\Gamma_{E1}(a^2+\xi^2)\det\|a_{\bar{k}l}\|}d\zeta\right\}\times\times a_n\cos(n\theta). \quad (23)$$

Similarly, using (22) and (23), one can write the formulas for *Mx*, *Qx*. The calculation of the nonconforming integrals (22) and (23) uses the following algorithm based on the Romberg method [13,14]

4. Calculation algorithm

The value w_1^\ast and q^\ast of (22) and (23) is calculated on a computer as follows. All numeric parameters required for calculations are set. To calculate the integral (22) under the improper integral function is denoted by $\chi_1(r_0,\Omega,t) = \frac{\Delta_{31}[a\cos(\xi\eta)-\xi\sin(\xi\eta)]}{(a^2+\xi^2)\Gamma_{E1}\det\|a_{\bar{k}l}\|}$ The following elementary transformations are performed on this function

$$\chi_1(r_0,\Omega,t) = \left(\Delta_1(r_0,)/\Omega(\Delta_2\Delta_3+\Delta_4\Delta_5)\right)e^{i\,\Omega\,t} \quad (24)$$

you can numerically integrate it by writing it as

$$\chi_1(r_0,\Omega,t) = x_1(r_0,\Omega,t) - i\,x_2(r_0,\Omega,t). \quad (25)$$

The incident pulse w_1^\ast is described by the expression

$$w_1^*(\Omega,t) = f_1(\Omega,t) - i\,f_2(\Omega,t),$$

Where $f_1(\Omega,t)$, $f_2(\Omega,t)$ real functions. Using Euler's formula for $\ell xp(i\Omega t)$, dividing into real and imaginary (25) parts, after some transformations we get

$$w_1^* = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}[x_1(\Omega,t) - ix_2(\Omega,t)]d\Omega \quad (26)$$

Dividing the integral (16) into two terms

$$w_1^* = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{0}[x_1(\Omega,t) - ix_2(\Omega,t)]d\Omega + \frac{1}{\sqrt{2\pi}}\int_0^{\infty}[x_1(\Omega,t) - ix_2(\Omega,t)]d\Omega \quad (27)$$

and replacing the Ω variable in the first integral with -Ω, we have

$$w_1^* = \frac{1}{\sqrt{2\pi}}\int_0^{\infty}[x_1(\Omega,t) - x_1(-\Omega,t)] - i[x_2(\Omega,t) - x_2(-\Omega,t)]d\Omega\ . \quad (28)$$

Since (28) is the inverse Fourier transform and contains a real value in the left part [13], the relation is vale

$$x_1(\Omega,t) = -x_1(-\Omega,t)\ ; x_2(\Omega,t) = -x_2(-\Omega,t). \quad (29)$$

- Given it, from (29) we finally obtain

$$w_1^* = \frac{\sqrt{2}}{\pi}\int_{\omega_a}^{\omega_b}[x_1(\Omega,t) + i\,x_2(\Omega,t)]d\Omega. \quad (30)$$

the integral using the Romberg method, you have to repeatedly calculate the integrand. The inverse Fourier transform for some image, the original of which is known in advance, showed that with the integration step length of 0.01, the error of the procedure does not exceed 0.3-0.5%. For a system without damping, the first resonant velocity must first be determined by constructing dispersion curves for a different number of waves in the circumferential direction.

5. Numerical results.

Calculations are carried out for a steel shell interacting with a water layer.

The following parameter values were assumed:

$$k = \sqrt{2/3}, k = 0.005, \in = 0.45, \nu_1 = 0.25, a = 1.0, \rho_0^* = 0.13, c_0 = 0.1, M = 1.66.$$

Table 1

l	θ										
	0	$\frac{\pi}{10l}$	$\frac{\pi}{5l}$	$\frac{3\pi}{10l}$	$\frac{2\pi}{5l}$	$\frac{\pi}{2l}$	$\frac{3\pi}{5l}$	$\frac{7\pi}{10l}$	$\frac{4\pi}{5l}$	$\frac{9\pi}{10l}$	$\frac{\pi}{l}$
2	-9,96	-7,64	3,53	-3,43	1,92	-1,63	0,41	0,019	-1,00	1,12	-1,54
4	-6,12	-6,19	-3,04	-0,39	1,29	0,08	-1,47	-0,61	1,21	-0,11	-1,70
6	-4,75	-4,18	-2,91	-1,72	-0,92	-0,31	0,25	0,47	0,04	-0,74	-1,13
8	-2,95	-2,44	-2,74	-1,78	-1,03	-0,59	-0,53	-0,42	-0,21	-0,02	-0,07

As an example of a viscoelastic material, we take the three parametric relaxation kernels: $R_\lambda(t) = R_\mu(t) = Ae^{-\beta t} / t^{1-\alpha}, \nu = 0.25,$ $\mathbf{A = 0,048}$; $\boldsymbol{\beta = 0,05}$; $\boldsymbol{\alpha = 0,1}$. All results are obtained in dimensionless parameters. In the table.1.the distribution over the angular coordinate of the liquid pressure on the shell $\mathbf{q}^*$ in the cross section $\boldsymbol{\eta = 0.5}$ for a different number of self-balanced forces is given.

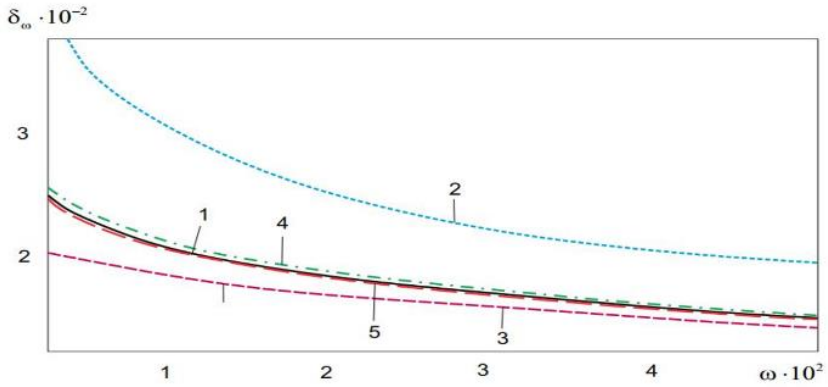

Figure 1. The change in the imaginary part of the radial displacement as a function of the velocity at different viscosity parametrizes. A=0.01, 2. A=0.005, 3. A=0.02, 4. A=0.015. 5. A=0.017

The table shows that the greatest fluid pressure is at $\boldsymbol{\theta = 0^0}$. With increasing angles of pressure, the moving load exerted on the shell fits. The change in the imaginary part $0 \le \theta \le \pi / l$ of the radial displacement depending on the speed, the moving pressure at different viscosity parameters is shown in Figure 1. It can be seen that the mixed shells decrease exponentially with increasing speed.

6. Conclusion

1. A mathematical formulation and methods for solving the problem are proposed, when a driving fluid with a constant velocity is between a viscoelastic shell and a coaxial rigid cylindrical wall.

2. An algorithm has been developed for calculating improper integrals with high accuracy.

3. Taking into account the viscous properties of the shell does not increase the interleaving to 12-16%. The mixed and force factories of the shell smoothly decrease with increasing fluid velocity.

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QR – Issue QR – Article

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ON THE IMPORTANCE OF DEVELOPING FINANCIAL LITERACY AMONG PRIMARY SCHOOL PUPILS

Abstract: *This article discusses the need to introduce the concept of "economic literacy" into primary school education, the relevance of this problem in the country, as well as the approaches of scientists in the study of this topic and the conditions for the formation of primary concepts of economic literacy.*

Key words: *economic literacy, economic knowledge, primary school, economic training, pedagogical issue, attitudes, knowledge, skills, financial education, financial behavior.*

Language: *English*

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Introduction

At the current stage of development of the Republic of Uzbekistan, the objectives of the country's transition to a democratic State governed by the rule of law and from a planned to a market economy are determined. This process has necessitated changes in the content of the education system. One of the most important problems is the question of the literacy of students in the economic, legal and information fields, which corresponds to the new stage of the development of society. In view of the intensive development of the economy, competition and an increase in the number of qualified personnel, it is planned to strengthen the role of disciplines that ensure the successful socialization of students, in particular the economy. With the changing structure of the Uzbek economy, accompanied by the emergence of private property, major changes are taking place in the demands placed by employers on potential workers, particularly in the area of economic knowledge. On April 13, President Shavkat Mirziyoyev signed the decree «On measures for further development of the capital market», informs UzA. According to the decree, the program «Financial and Investment Literacy» has been adopted, it is also planned to introduce the course «Financial Literacy» as a subject for pupils of general education schools and students of non-economic higher education institutions. There are plans to develop a financial management training methodology for this discipline and to hold financial literacy competitions [7].

Various aspects of this pedagogical problem are solved in the studies of philosophers, sociologists, economists, educators and psychologists.

The main part

The concept of «economic literacy» is a defined level of economic knowledge, skills and experience of economic activity, reflected by the logic of the content of initial vocational training, and ensuring entry into working life, rational decision-making, Serving as a basis for the continuous improvement of his economic knowledge and the economic qualities of his personality; Economic literacy: a level of functional literacy in the economic field that involves the attainment of standard objectives in the productive, consumer and social spheres through applied knowledge;

The combination of conditions under which economic reforms are being implemented in Uzbekistan has a significant impact on the process of adaptation of primary school pupils in society. The resulting socio-pedagogical problems call for the development of pedagogical tools to shape the modern

economic literacy of primary school pupils. Scientific research in this area covers various aspects of economic training: professional self-determination of the individual, socio-psychological security, functional literacy, economic education, entrepreneurship.

An important component of functional literacy is, in our view, economic literacy, which is a means of developing the basic concepts of means.

In analyzing economic training as a pedagogical issue, we have come to the conclusion that there have been significant changes in attitudes towards understanding economic literacy, and these changes are objective. We have come to the conclusion that the resulting economic literacy, as it stands today, will help primary-school students to understand economic processes more readily available in high school.

In a theoretical study, we have come to the conclusion that economic literacy is the level at which economic knowledge, skills and economic experience are defined, as reflected in the logic of the content of initial vocational training, and ensuring entry into the labor market, rational decision-making, the basis for continuous improvement of economic knowledge and the economic qualities of the individual.

Economic literacy is the level of functional literacy in the economic field, which implies the attainment of standard tasks in the productive, consumer and social spheres based on applied knowledge.

An analysis of the organization and state of modern economic preparation of students has shown that the system of preparation of students for life and work is currently in the stage of reform, both in terms of organization and content.

An analysis of the pedagogical literature has shown that the various branches of science view the process of developing the economic literacy of future participants in a high-technology society as an integral part of the general preparation of adolescents, taking into account:

- the educational requirements of society;
- the possibilities of modern pedagogy;
- the psychological development of adolescents;
- use of educational motivation to develop students' economic literacy.

O.E. Kushina's work emphasizes that pupils must have learned many components of financial literacy (attitudes, knowledge, skills) by the time they reach the age of 14. Consequently, the author identified several levels of financial and economic literacy among schoolchildren and defined a system of age-appropriate criteria.

Criteria for assessing the knowledge and skills of children of primary school age, which characterize the preparatory phase for the development of financial and economic literacy:

The ability to observe reason and generalize information about objects and economic phenomena and regularities;

Initial knowledge of the economic conditions in which people live and run a household;

Basic knowledge of the fundamentals of business and entrepreneurship;

The value of the world around them;

A tolerant attitude towards people of different income levels, professions, ethnicities, etc. is adopted.

Criteria for assessing the level of financial and economic literacy among secondary school-age children, reflecting knowledge of the principles of financial and economic behavior in society, as well as basic financial and economic knowledge:

Learning interest, critical thinking about the development of the economy as a whole;

- understanding of civil liability;

Existence of a system of values in the field of interpersonal relations in the classroom, in the family and in civic activities;

Initial knowledge of various economic and financial activities.

Criteria for assessing the level of financial and economic literacy of older children, demonstrating systemic knowledge

- economic and financial literacy and skills;
- basic level skills;
- basic knowledge of various economic and financial activities.

The ability to comprehend and systematize information on economic processes, to generate ideas and to apply the knowledge acquired to solving problems in economic and social activities, in the family and domestic sphere and in social relations; counteract antisocial behavior [3, 14-25].

School conditions are the basis for financial literacy, according to many scholars, but opinions differ.

A. Grohmann and R. Kouwenberg described foreign research experiences and identified two main channels for financial literacy in junior high school:

1. The family has the greatest influence on the child in this matter. It is the parents who push for the right financial decision to establish acceptable financial behaviour in their children. In addition, parents with higher education encourage children to study money, savings, personal budget, etc.

2. Schools have an indirect impact on a child's financial literacy, as schooling helps a child to acquire the tools to carry out financial activities, namely, numeracy skills, practice-oriented tasks, that will help the child make the right financial decisions in the future [2, 114-133].

L.U. Ryzhanovskaya believes that the main sources of financial literacy are science, education and the institutional environment.

The role of science in this issue is vast and involves the development of a system interlocking

notions of a new subject area - financial, based on a clearly defined purpose of financial education, including the study of finance (money) and the stereotyping of successful financial behavior [5, 151-158].

The foundation of financial literacy in primary school is considered the most appropriate for learning, behaviour and attitudes. It is at this stage that the development of cognitive processes and personal qualities is taking place, thus contributing to the development of the foundations of financial literacy, which continues throughout a person's life. According to E.E. Stupina, the following personal characteristics determine the success of the financial literacy of junior schoolchildren:

1. Economic training and education.
2. Moral and economic personality

(honesty, responsibility, thrift, hard work, selflessness).

3. Availability of socio-economic experience [6].

Asimova L.B. provides a classification of classes in financial literacy:

1. Depending on the different psycho-pedagogical stages of study material by students:

- Lessons on new material;
- Lessons for the consolidation of knowledge and skills;
- Lessons to be learned;
- A lesson in student monitoring, evaluation and correction;
- Combined lessons.

2. Depending on the teaching methods used in the course:

- Lessons - lectures;
- Lessons - seminars;
- Lessons – workshops [1, 71].

Extra-curricular activities have also great potential in creating conditions for the development of many areas of the student's personality. The objectives, tasks, content and forms of extra-curricular activities include a wide range of independent work. Structured extra-curricular activities include teaching, education and development methods that encourage students to learn their knowledge and skills on their own, and to engage in more informal interaction with educators, which leads to the disappearance of formal attitudes and the development of students' internal capacities [4].

Conclusion

In conclusion, financial literacy is an important component of modern human life, which implies not only impeccable knowledge of the theory of finance, but also practical skills in its use. A person who is financially literate is able to manage the money properly and to draw up the financial plan necessary to achieve the goals set. Financial literacy involves knowledge about money (products and services). This justifies the relevance of discussions about the concept of «financial literacy» on the part of domestic and foreign researchers.

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MAHMUD KASHGARI'S «DEVONU LUG'OTIT TURK» AND MODERN UZBEK LANGUAGE

Abstract: *The article describes the phenomena as narrowing, expansion and change of meaning in the lexicon of the Uzbek language on the basis of lexemes used in Mahmud Kashgari's "Devonu lug'otit turk".*

Key words: *lexeme, narrowing of meaning, expansion of meaning, change of meaning.*
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Introduction

There are such works that even after years, centuries, millennia will attract the attention of scientists with their value and significance. Through such valuable sources, it is possible to gain important insights into the history, ethnic structure, culture of the nation, and also to find out facts about the language used, and to study them in comparison with the present. Among such works, Mahmud Kashgari's encyclopedic dictionary "Devonu lug'otit turk" is a source of pride for us, Uzbeks, as well as for all Turkic peoples.

Although this unique written monument with a history of ten centuries has been widely studied by world linguists, it has not lost its significance and value, and a broader study of the linguistic features of this masterpiece is one of the important issues of modern linguistics. It is one of the urgent tasks of Uzbek linguists to take the lead in this regard and to draw important conclusions about the history of Turkic languages and the ancient Turkic language through their research.

The main part

During the years of independence, a number of areas of scientific research of the Uzbek language have developed. A comprehensive study of the history of our language, which has its roots in ancient times, is one of the works in this direction. One of the tasks to be performed today is a comprehensive and in-depth scientific study of the historical development of the Turkic languages, in particular the Uzbek language, with the help of rich factual materials reflected in manuscript sources. After all, the most reliable source in the study of the history of language is the written monuments that have come down to us.

Functional, semantic and stylistic analysis of the lexical layer used in the work "Devonu lug'otit turk" allows to obtain important information about the rich possibilities of expression of the early Uzbek language [8.102] "Devon" as an encyclopedic dictionary is one of the sources that functioned as a base for the development of linguistics. The fact that the author laid the foundations of areal linguistics, drew a linguistic map of the Turkic peoples, explained more than nine thousand lexemes in use at that time, and highlighted the peculiarities of dialects are clear evidence of his work as a mature linguist.

Perhaps for this reason, Mahmud Kashgari is recognized by Uzbeks, Uyghurs, Kyrgyzs, and all Turkic peoples in general as a representative of their ethnic group, nation [1], and they repeatedly refer to this rare work of the encyclopedic scholar. Re-study of “Devon” will be the basis for discovering new aspects of this unique work, acquainting the general public with such a masterpiece, and revealing the facts of the history of language. In this sense, our research serves to draw conclusions not only on the history of

Turkic languages, but also on the history of Turkic peoples and nations, to introduce the rich cultural heritage of Turkic peoples to the world community by comparing the semantic features of noun lexemes in this work with modern Uzbek.

Changes in the life of a society at different times are reflected, first of all, in its lexical layer. As a result, some words in languages may become obsolete, or replaced with new ones. “Language is always in motion, it is always changing. All layers of language (phonetic, lexical, morphological, syntactic) expand and improve over the years. As a result of the development of society, new concepts can be added to language in the form of new linguistic units. Or units that have been used for years may become obsolete over time. This is a natural indicator, a feature of language ”[9.55]. By studying such semantic changes, it is possible to draw important conclusions about the history of languages, to obtain interesting information.

M. Mirtojiyev considers the following as a logical-semantic phenomenon that creates the semantic development of the word 1) expression, i.e. the expansion and narrowing of meaning; 2) the emergence of derivative meaning; 3) processes such as euphemism and dysphemism [6.6]. In this article, we analyze the lexemes that were used in the Old Turkic language and underwent various semantic changes in the modern Uzbek language on the basis of Mahmud Kashgari's Devonu lug'otit turk.

Some words used in the ancient Turkic language have undergone some semantic changes in the modern Uzbek language. In this case, the meanings of some words have been narrowed, some have been expanded, and some have been used in the opposite sense.

The expansion and narrowing of lexical meaning occurs for extralinguistic reasoning in the scope of only one lexical meaning [6.112]. In “Devon”, the word *jiɜim* is interpreted as "the young of everything." Hence, the word was first used in the Old Turkic language to refer to things other than man as well. It is used in modern Uzbek only for human beings. Apparently, when the word *jiɜim* is taken in relation to the eleventh century, it is now used only in reference to man, and its meaning was narrowed. But at the same time, there has been an expansion in the semantics of this word applied to man. In the "Thesaurus of the Uzbek language" the word means the following: "physically grown man", "in general, a young man ", in a figurative sense, "a man, a brave man, a bold man", "a girl's lover", "a man belonging to a military gang, a group", "referring to a person younger than himself" [10.266-267].

It is natural for words to undergo semantic changes during language development. Obsolescence of words, semantic expansion or narrowing of meanings are observed in almost all languages. For example, in English, the word *deer* was used for any wild animal in ancient times, but today the meaning of the word has narrowed to only “deer”, which means a type of animal.

The narrowing of the meaning between the noun lexemes used in “Devon” can also be seen in the example of the word *кэјік*. ... The meanings of the lexeme *кэјік* in the “Drevnetyurkskiy slovar” are “a member of ungulates belonging to the deer” and “a wild animal in general” [2. 294]. The following passage confirms that the word *кэјік* is also used in the “Oltin yoruq” (“Golden Light”) to mean "wild animal": *барс ирбиз арслан бöрида улаты йавлақ кэйиклäр – барс, қоплон, арслон, бўри ва бошқа ёввойи ҳайвонлар.*

Mahmud Kashgari's work also gives the meaning of this lexeme "everything that is actually wild." But unlike “Drevnetyurkskiy solvar”, Koshghari further limits the scope of application of this lexeme, i.e. it is emphasized that it is not applied to any wild animal, but the ones that can be eaten: deer, argali.

So, we can see from this that by the eleventh century, there has been a narrowing in the meaning of the lexeme. However, it is also acknowledged that the word is used to mean "deer" [3.213] and "mountain goat". It should be noted that the “wild” semantics in the lexeme semema was the basis for its application to objects other than animals. In Devon, it is said that *кэјік сöгўт* is a "wild tree" and is explained as follows: "Everything is of two kinds: domestic and wild." The wild is called *кэјік*”[5.114].

It is also shown that the lexeme *кэјік*, combined with the word *кіши* (man) (*кэјік кіши*), means "a one-legged animal in the form of a man believed to live in water." This is a mythological view and is associated with totemism. So, the lexeme *кэјік* which in ancient times was used for "animal, beast", "wild animal", "deer, argali that can be eaten", "deer", "mountain goat", "everything that is wild", "one-legged animal in the form of a man believed to live in water" is used in modern Uzbek literary language only in the sense of “the common name of a large group of mammals, such as deer, etc.” [10.364].

In modern Uzbek, this lexeme is also present in the compound word *kiyiko’t*. Kiyikot is “an annual and perennial fragrant medicinal plant belonging to the mint family” [10. 364].

In the 11th century manuscripts, the word *jïлқï* was used for all four-legged animals [5. 25]. Later, as a result of the differentiation of the concept it expressed, the word was used only in the sense of "horse" and "herd of horses", that is, in relation to one species of animal, which means, its lexical meaning narrowed. In Yusuf Khas Hajib's “Qutadgu Bilig”, the word is also used to mean "animal."

The word "*қïсïр* " was used in the 11th century to mean "barren" and "young horse" in the book "Devonu lug'otit turk". In modern Uzbek, the word means only "barren."

In the ancient Turkic language, the word *эрўк* was used as a common name for fruits, such as peaches, apricots, plums, and to distinguish these fruits, various words were used to denote them: أُرُكْэрўк - a common name for peaches, apricots, plums; they differ from each other in one quality: تُلُكْ أُرُكْ *mўlўг эрўк* "peach"; أُرُكْ سَرِغ *сарiғ эрўк* "apricot"; *қара эрўк* "plum" [3.65]. In modern Uzbek, each fruit has its own name, the word *эрўк* is used in the form of "o'rik" and serves to denote a type of fruit tree and its fruit.

The word "*алқїш* " is an example of words that have narrowed meanings in modern Uzbek. This word was first used in the Turkish language أَلْقِشْ алқїш in the meanings such as "to applaud, praise; to pray; congratulations; remembering one's good qualities. We even see that it has the meaning of "salawat, salutation to the prophet": يَلاوَجْقا أَلْقِشْ بِرْكِلْ *Jалавачқа алқїш бэрғil* ("Bless the prophet [applaud him])" [3.84]. In modern Uzbek, the meaning of the word is narrowed, and it is used in two senses: "words of goodwill, praise, supplication" and "applause that mean satisfaction". The meaning of the word "salutation to the Prophet" is now obsolete.

It is possible to observe the narrowing of the meaning in the *амач*: the word اَمَچْ амач II in ancient times meant "hammer, yoke; farming tools "[3.55], while it now means "the simplest of the oldest wooden or iron tools with metal teeth, plowed with the addition of a vehicle ".

Another example of such a lexeme is the word *кäсäк* in "Devon". The word كسَكْ *кäсäк* is defined by Kashgari as "a part of a thing" [3.263], which refers to a part of anything. For example, *бiр кэсäк этмäк* is a piece of bread.

There is also the word *kesak* in modern Uzbek, but this word is interpreted in Thesaurus of the Uzbek language as "a piece of dried clay" [10.355]. Hence, the meaning of the word *кесак*, used in the ancient Turkic language to mean a piece of anything, narrowed down and was used only in reference to a piece of clay. In the Tashkent dialect, this word is used together with the word *қанд* (sugar) (*бир кесак қанд* – a lump of sugar).

"In the narrowing of the lexical meaning, certain parts of the referent it expresses are differentiated and called by another name. As a result, the word becomes narrower in the lexical sense. For example, in the time of M. Kashghari, all fibers were called *юнг* (wool). Later, cotton fiber was expressed by the word *ип* (yarn), and cocoon fiber by the word *ипак* (silk). The word *юнг* now refers to the fiber that is extracted from the skin of an animal, i.e. the word yung has narrowed in the lexical sense. Differentiation of fibers according to their nature is extralinguistic. It is reflected in the lexical meaning of the word. Accordingly, the narrowing of lexical meaning is called extralinguistic [6.113]. Hence, the narrowing of the meaning of a lexeme in the gradual development of languages is also a common feature peculiar to several languages.

There are also some words that were used in ancient times in the form of adjectives, and later became nouns, in the sense of which the phenomenon of narrowing can also be observed. For example, the word *эркäк*. In ancient times, the word اِرْكَكْ *эркäк* was also used to mean "the male of any animal or bird", and the rooster, that is, the male of the hen, was distinguished as the *эркäк тақағу*, and the female as the *тїшї тақағу* [3.92]. The word تَقَاغو *тақағу* is a gender-specific word meaning "hen" and is used equally for both roosters and hens [3.234]. In modern Uzbek, the word *эркак* refers to a group of nouns and means "a man; male ".

In the 11th century, the word *köl* meant "pool," "lake," "accumulated water; pond "and" sea "[5. 91], and during language development the word also underwent semantic differentiation: "specially dug depth, which serves to store water" is called *hovuz*; "a natural body of water that is filled (covered with water) on land, with a closed perimeter and depth" is called *ko'l*; "the part of the ocean that is connected to land or splits on land, the part of the ocean that is separated by land or islands and peninsulas" is called dengiz. In ancient times, the word " *суw*" was used instead of the words *дарё, денгиз* (river,sea): For example, *Эmil суwї ақа мурур* [3.67]. According to Mahmud Kashgari, *Эmil* is the name of a river in the Kipchak lands. It flows into the Bulgar [Caspian] Sea. It also has a tributary that flows into Russian lands. According to I. Kormushin, Этil is present Volga River or the Volga River flows through the Kama River [3.67]. Thus, in the modern Uzbek language, the word *кўл*, as mentioned above, has only one meaning, that is, "a natural body of water filled with land (covered with water), with a closed perimeter and depth". In "Devon", the word *тэңiз*, meaning "sea" [5,240]. The word *кöл* is also used in a figurative sense to refer to the adults of the snow leopards as part of the *кöл ёркiн*. It means "a man of many minds, like a full lake." During the development of language, this meaning also disappeared from consumption.

In linguistics, the occurrence of a shift in the size of a lexeme from a narrow meaning to a broad meaning is called an expansion of meaning. In Devon, the word " قِشْلاغ *қїшлағ*" means "wintering place" [3.308], and the word " *jajлағ* " means "summer place" [5.34]. The word *jajлағ* also means "pasture". The lexeme originally meant "meadow at the top of a mountain," and in the ancient Turkic language, the word *jaj* meant "summer," and the word *jajлағ* meant "a place to live in summer." The Turks, who were mainly engaged in cattle-breeding, moved to those places in the summer to graze their cattle in the meadows at the top of the mountain. In the winter, they moved from *jajлағ* to *қїшлағ*. In modern Uzbek, the word *яйлов* (pasture) means not only "cattle pasture at the top of the mountain", but also "cattle

pasture in general". Such areas can be at the top of a mountain, in the steppes, or even in the lowlands. As mentioned above, in Devon, the word "قِشْلاغ қïшлағ" means "wintering place". Explaining this lexeme, Mahmud Kashgari also gives extensive information about the fact that it is located in the southern part of the mountain, where there is a lot of grass, little snow, and the crop grows well [3.308]. This means that the area was located on the south side, where there was little snow, which led the people of that time to spend the winter in such places. In modern Uzbek, the word means "a place, territory where the population is mainly engaged in agricultural activities."

Or in "Devon", the word تَغارْ *mағар* is interpreted to mean "a sack in which wheat and other things are placed" [3.276]. In modern Uzbek, the meaning of the word has changed, meaning "a large deep round vessel used for kneading dough, laundry and other purposes."

Nowadays, the word *ўғил* (son) is used only in reference to a human child. In ancient times, it was used to mean "the child of any living thing." For example, *Эр оғлї муңазмас, їт оғлї кўläрмäс* - "A puppy does not always suffer, he gets rid of it by some means, just as a puppy cannot always lie on its back like a horse [4.56]; *Муш оғлї* is a kitten [4.16].

Conclusion

In summary, the study of changes in the semantic structure of words plays an important theoretical and practical role in illuminating the semantic development of lexemes in use in modern Uzbek literary language.

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QR – Issue QR – Article

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THE ROLE OF PSYCHOLOGICAL TOOLS IN THE DEPICTION OF NATIONAL CHARACTER (BASED ON ISAJON SULTAN'S NOVELS «ETERNAL WANDERER», «FREE»)

Abstract*: The article analyzes the issues of national character in the novels of the famous writer Isajon Sultan, the role of psychological means in creating the image of national color, their types, the discovery of the character of the heroes through internal and external monologue.*

Key words*: facial expressions, illusions, national character, national color, psychological means, modern romance, psychological image, internal and external monologue.*

Language*: English*

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Introduction

The definition of "character, which is formed and manifested in human behavior, under the influence of the inner world," is a relatively complete description of the nature of character. It takes into account the psychological characteristics of the person.

Reflecting on essays, stories and narratives, literary critic M. Kochkarova said, “In the discovery of the human psyche in modern Uzbek prose, our writers use a variety of psychological imagery, including dreams, memories, internal and external monologues, dialogues, polylogues, The author's statement, landscape, psychological image, facial expressions and gestures of the heroes, illusions, hallucinations, twin images are widely used, all of which require our researchers to study with a new perspective [8, 173]. It is true that it is important to look at and analyze a modern story (and works of all genres in general) in a new light. However, from the sources cited by the researcher as a means of psychological imagery, hallucinations are actually a condition that occurs in the mind of a mentally ill person, and its use in a work of art is not very justified. In addition to the tools presented by the researcher as a psychological image, it is necessary to include portraits, interiors, chronotope, motifs. Because we have seen in the analysis that these tools are also an important psychological tool in the analysis of the character of the character.

The main part

Isajon Sultan's novels focus on the relationship between children and parents in creating a national character. For example, based on the author's two most famous novels, "Eternal Wanderer" and "Free", the relationship between father and son is discussed separately. In the novel "Eternal Wanderer", a piece called "Generation" attracts the attention of every reader. "You said you would come in the summer if you could. For now, I’m looking forward to summer. If you have a chance when you come, I will pour out to you what I am thinking in my heart… If I am making a mistake, if you show me the right way with the blessings of fatherhood and coaching, if my thoughts are acceptable I look forward to receiving your blessing if you give me a white blessing ” [3, 51]. In the passage, the character of the Uzbek children through the psychological state of the son, that is, before doing something or going to work every day in the early morning, of course, to get a blessing from his parents, parental consent is above all It is from this

character that the wise saying, "Father is pleased, God is pleased," which permeates the whole body of the Uzbek people, comes from this character. In our country, it is not polite to climb on the roof of a house where parents live and talk to them out loud. Such notions are more clearly described in the author's novel "Free". Excerpts from Mashrab's "Repentance is Unacceptable" say that even the repentance of a person who does not please his father will not be accepted..

If you fight with religious faith, you will succeed in this path.

Thirty-three thousand rooms, if you will.

When Jesus comes down from heaven, he prays for you

If your murshid is Hizr, he cannot be a leader,

Unless your father agrees, your repentance will not be accepted.

In this novel, the national character of the Uzbek people, such as parental consent and respect for them, is reflected in a unique way through the dialogic, monologue speech of the protagonists of the novel, through psychological means. For example, in the psychological world of Ozod, the protagonist of the novel on the same subject, "… But they say that your mother's honor is a hundred times greater than your father's? Why is it that when a father is at the forefront of everything, the mother is given more respect? Yes, it's really weird: when a child is told to "honor your mother," the mother is told to "obey your husband," and when the son grows up one day and becomes a father, he looks at his mother. When a girl witnesses the return of her honor from her husband, she sees in her child the opposite of the respect she showed to her master when she got married" [4, 53] the national colors of our people are not found in any other nation. Each person is reflected in his inner world, psychological views and thoughts based on his mentality.

"On the day of my blessing, the earth and the sky resounded. I was told:

"She is the owner. The owner of both is God!"

"O woman! Obey your Lord as you obey your Lord"

"Both of you worship Him!"

In fact, such blessings never come from outside when the blessing is recited, when a woman is psychologically entrusted with a young man who deems her permission worthy, and realizes that she can be happy with him, voices like the one above come from the inner, spiritual world of man. "…do you know who the engaged girl is?

In the future, the engaged girl's father, mother, tribe and relatives will be husband.. The world will be a better place! The well-being will be the same - God will take the woman's well-being from the owner" [4, 91-94] In the novel "Free" such concepts as blessing, marriage, family are also approached from the point of view of our national character. How great these concepts are, and to distort or betray them, is radically condemned. It is deeply ingrained in the psychological world of the protagonists. The blessing of marriage in the name of Allah is also sacred, and the appearance of bread, which we Uzbeks consider a supreme blessing, serves to further strengthen this process.

Our national colors are always reflected in the works of art. In particular, in the author's novel "Free",… But I am often criticized. Put the table in a clean place, he says, stupid. He says that if you get a nail, it will bury you on the doorstep, and when the goats come, it will grow and block your way. He says to open the gate in the morning when the star is gone, and there will be food" [4, 43] At first glance, such concepts as animism and fetishism, such traditions, seem to be meaningless from a real point of view, deeply ingrained in the psychological consciousness of our people. It should be noted that such views are unique to our people.

"My children went to work in the fields in the morning, and they are still dying," he said. I said they could bake bread and eat it hot. Tired, is the labor of the earth easy?

"Yes, you're right," he said. "My men have come, I've boiled the soup, and they're waiting for their father." I don't want you to drink until your father comes" [4, 10] it is a common custom in our country for a newborn child not to reach for the table from an early age, even if the utensils are separate, and for the little ones to reach out before the big one in the house starts eating. This is how every Uzbek child is brought up.

In the analyzed novel "Free" the psychophysiological and artistic means of speech, which are a factor and the basis for the formation of national character, can be classified as follows:

Table 1.

With details	Dream, wind, bird, tulip, lion, owl, jug, humo bird, salt desert, tortoise scorpion
According to the subjective structure of the novel	Characters (parent and child, father and son), characters (couple, grandfather and grandson, engaged youth, wind), narrator participation
According to the construction of the fable	conversation, event, behavior, mood, the inner world of images and their perfection [8, 137]

According to the composition of the work	nature (weather events, volcano, salt desert, mountain), human (Ozod, Dilorom, Eran, mother, father, child, neighboring women…), society
According to the protagonists	dialogue, internal and external monologue, polylogue, nonlinear means
According to the names chosen for the protagonists	Ozod, Oydin, Dilorom, Eran

In the analysis, we looked at aspects of national character, such as patience, adaptability, obedience to adults, pride, and honor. Through the characters of the father in the novel, the author portrays the character of a man who sacrifices himself for the future of his children, the happiness of his family, always busy with the worries of his children, and the mother portrays a patient, loyal, passionate woman for her family. The image of freedom is characterized by self-awareness, perfection, courage and enthusiasm, which are characteristic of real Uzbek guys, who are not afraid of any difficulties in achieving their goals.

In the creation of a national character in the work of art, such issues as self-awareness, understanding of the meaning of life, changing one's destiny, one's struggle with one's own world and psychological world are at the forefront. The above idea is proved by the fact that in the novel Ozod achieves his goal and finds both the humo bird and the tulip.

Conclusion

In modern Uzbek prose, ie in Isajon Sultan's novels, the role of artistic speech and psychological means in creating a national character is growing. The writers perfectly revealed the psyche of the characters through internal and external monologue, dialogue, polylogue, author's statement, landscape, psychological image, mimicry of the heroes, portrait, interior, chronotope, motif.

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QR – Issue QR – Article

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THE PRAGMATICS OF THE PROSODIC MEANS

Abstract: *The article is devoted to the matters of the pragmatic functions of the prosodic means, the functional features of the intonation. The study of prosodic means in the speech acts helps to reveal the communicative types of the sentences. The results of the conducted experiment were thoroughly discussed. The essence of pragmaphonetic analyses in Uzbek linguistics was shown.*

Key words: *pragmatics, prosodic means, intonation, speech acts, locutive act, illocutive act.*
Language: *English*
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Introduction

The study of prosodic means in the world linguistics has a long history. The initial views on the prosodic means in the world linguistics have shaped in recitation of the sacred books as Indian Vedas and Muslim Koran.

The scientific theory of prosodics have initially been observed in the works of A.M.Peshkovskiy, G.A.Glison, N.S.Trubetskoy, A.M.Sherbak, A.A.Reformatskiy, L.R.Zinder. The theory of intonation has been developed by V.A.Artyomov, T.M.Nikolaeva, M.I.Matusevich, M.V.Panov, N.M.Cheremisina, N.D.Svetozarova, T.A.Brizgunova, A.M.Antipova, L.A.Kanter. Nowadays the interest to the experimental-phonetic studies is enormous. The following scientists as A.S.Shagidevich, O.Y.Burashnikova, L.N.Sibilyova, A.K.Derkach can also be included into list of the researches. The research works of I.Y.Galochkina, D.L.Lentsa, Y.V.Solovyova, G.Kundrotas and Z.M.Bazarbaeva are distinguished by study the pragmatic features of segmental and suprasegmental units.

The first views of the prosodic means in the Uzbek language are linked with the name of A.Ghulomov. The study of prosodic means through the experimental phonetic methods began in the 60ss of the XX century. One should mention the experimental studies by S.Otamirzaeva, D.Niyozova, A.Mahkmudov, Kh.Yuldosheva, M.Yusupova and N.Khaitmetov related to the matters of prosodic means. The matters of intonation on the bases of the experimental research are also elucidatedin "Phonetics of Uzbek language" by M.Mirtojiev.

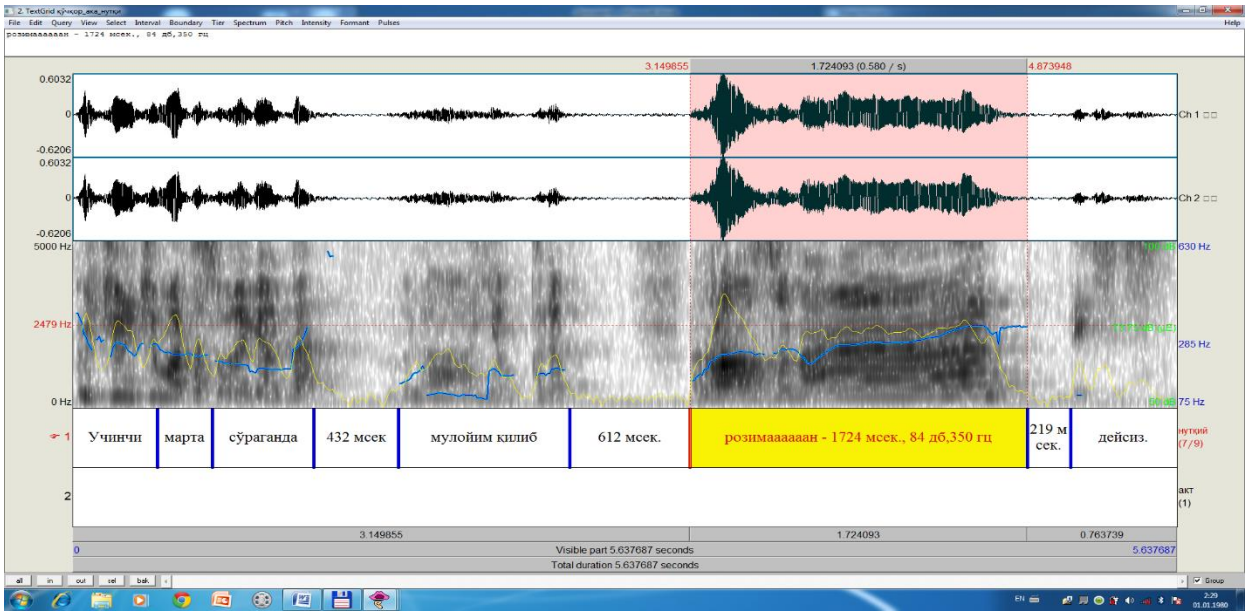
In 80-90ss of the XX century A.Nurmonov, N.Makhmudov were engaged in the study of the issues of pragmatics in Uzbek linguistics. The Uzbek pragmalinguistics was founded at the beginning of the 21st century. The scientific inferences by M.Khakimov, S.Safarov, S.Boymirzaeva, M.Kurbonova have been the theoretical bases for the recent work. However, the study of prosodic means in the communicative process in the Uzbek language has not been thoroughly studied. Thus, the aim of the recent paper is to analyze the prosodic means in pragmatic aspect.

The main part

The pragmatics defines the attitude of the speakers to the objects, events, situations of the outer world. This attitude is defined by forms of the pragmatic imaginations. In the result of the semiotic system influence on the language the notion of the relationship in the system of the linguistic units is formed. The essence of the relationship is defined in the means of the speech acts and intonation forms. The notion of pragmatics and its essence are defined by the existence of the speech acts and the different semantic

structures; thus forming the bases of the interlocution system. The speech acts serve to fill the essence defined by the notion of pragmatics.

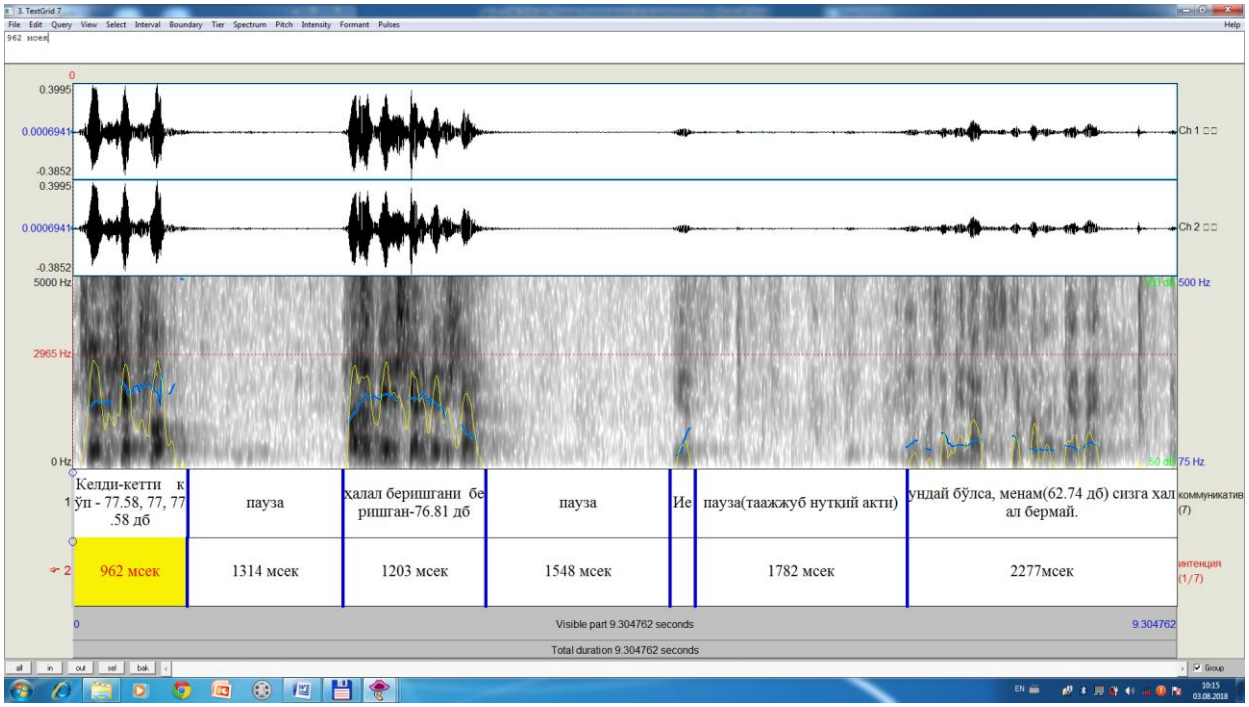
In the works devoted to the matters of pragmalinguistics the locutive, illocutive and perclocutive types of the speech are distinguished[3; 5]. The matter of the speech acts are distinguished by concerning the structure of the speech events in the system of the language and speech. The speech acts are considered to be the components of the communicative units in the syntactic layer. Therefore, the propositional structure of the utterances in the analyses and research of the speech acts play an important role. The proposition is the information expressed by the utterance; its semantic structure is seen in the imperative, interrogative and declarative sentences. The intonation is regarded as the means expressing the speech act and, as usual, according to the aim of the sentence serves to distinguish the types of them. The classification of the types of the speech acts can be understood through analyses of their features. Mainly, locutive act (from English "locution" – to direct the pronunciation to the aim[6]) is related to the phonetic articulation stage of the speech the speakers pronounce through the pronunciation of the language units as the sounds, syllables, word and sentences. Therefore the locutive acts are related to the phonetic prosodic layer and are considered to be the primary process of forming the speech. While pronouncing the segmental means the phonation, melodics, tone, the intensiveness of the sounds, tempo and pause are considered. The pronunciation of the segmental units according to the communicative aim of the interlocutors, the speech situation and context is called locutive act. In the sentence *Учинчи марта сўраганда, мулойим қилиб, розимаааан дейсиз* ("Iron wife") robot by the name Alomat is being taught, which is peculiar to the locutive act. The pronounciation related to the locutive act is seen in the diagram. The intensive pitch *розимаааан* is observed here. It shows that the logical stress falls on word *розимаааан*, which shows the communicative aim of the speaker.



Picture 1.

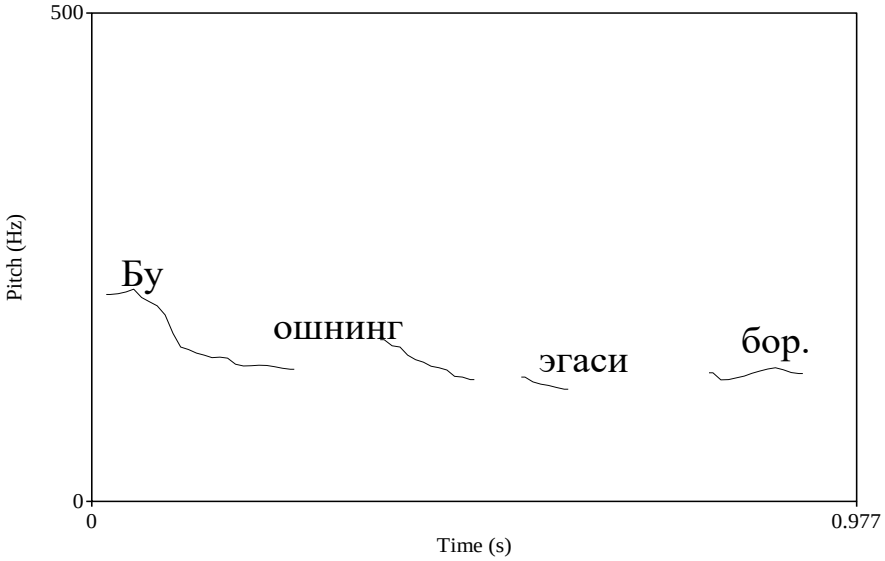
The special place has been given to the illocutive act in the structure of the speech acts. The illocutive acts in the speech process (from English illocutionary –denotes the communicative aim in the process of the pronunciation [6]) serves to denote the communicative aim, a purpose of the speakers. The illocutive act is considered one of the main information showing the aim of the communicator and is expressed by the intonation.

The communicative intention is seen in the intensive component of the intonation of the speech act. – *Келди-кетти кўп, ҳалал беришгани беришган.* The degree of the strength is equal to 77.58 db, 77 db, 77, 58 db, the stress on the syllables *келди-кетти* forms the speech act in the word *ҳайдаш.*



Picture 2.

The different speech acts are formed through the melodics in the structure of the speech. The components of the intonation fulfill the pragmatic function in order to denote the speech acts in the speech. As it is known, the sentences are divided into declarative, interrogative and imperative types, the speech acts are formed according to them. For example, in the declarative sentence *Бу ошнинг эгаси бор* the declarative act is shown, in the interrogative sentence *Бу йигит ким?* the interrogative act is shown. In forming the speech acts falling and rising tones of the melodic action have a significant place as the primary component of the intonation.



Picture 3.

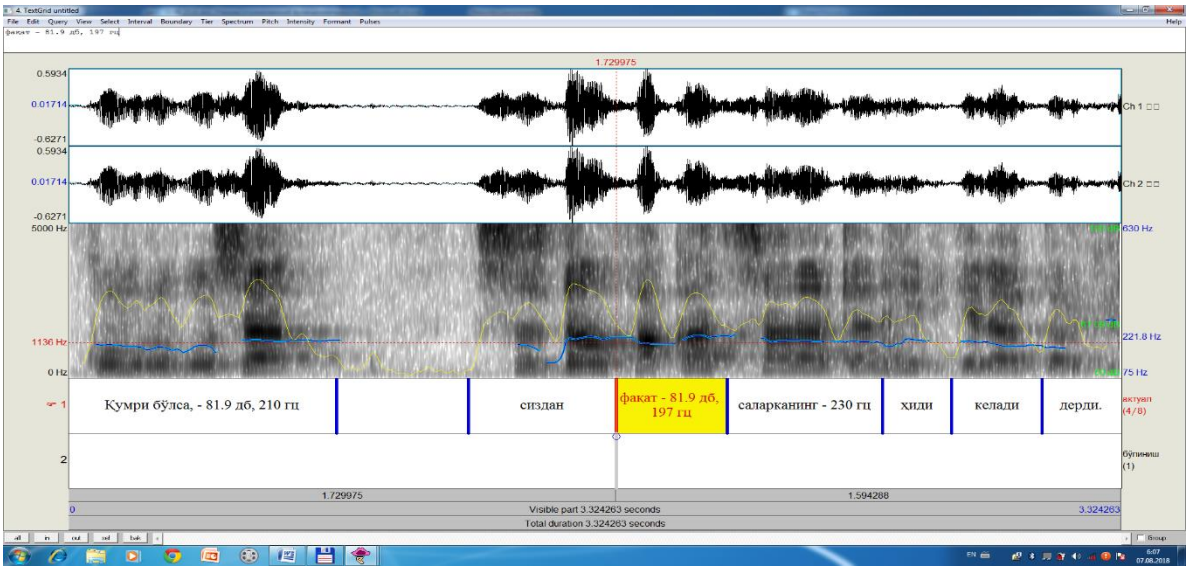
There are two views on the intonation and the actual division of the sentences. Mainly, “the intonation is the main means in the actual division of the sentences in the communicative speech. It rises at the melodic effect, falls at the nuclear of the expression[4; 1]”. The intonation is linked with the theory of the actual division of the sentences, the melodics is considered to be the main component of

the intonation in forming the bases and nuclear of the expression.

The second view is related to the theory of L.R.Zinder on the intonation and the actual division of the sentences. It is stated that the intensiveness fulfils the main task in the actual division of the sentences according to the logical stress. Mainly, the syllable with logical stress is regarded rheme[2]. The intensiveness in the actual division of the sentences is considered the main component forming the theme and rheme.

In the sentence *Қумри бўлса, сиздан фақат саларканинг ҳиди келади, дерди* the intensive action falls on *фақат*, which has a logical stress and the acoustic quantity is equal to 81.9 db. As we know, the part with the logical stress forms the logical presupposition on the bases of the existing proposition in the sentence. The logical stress on the word *фақат* points to the next part *саларканинг ҳиди*. This gives the contrasting information *саларканинг ҳиди*.

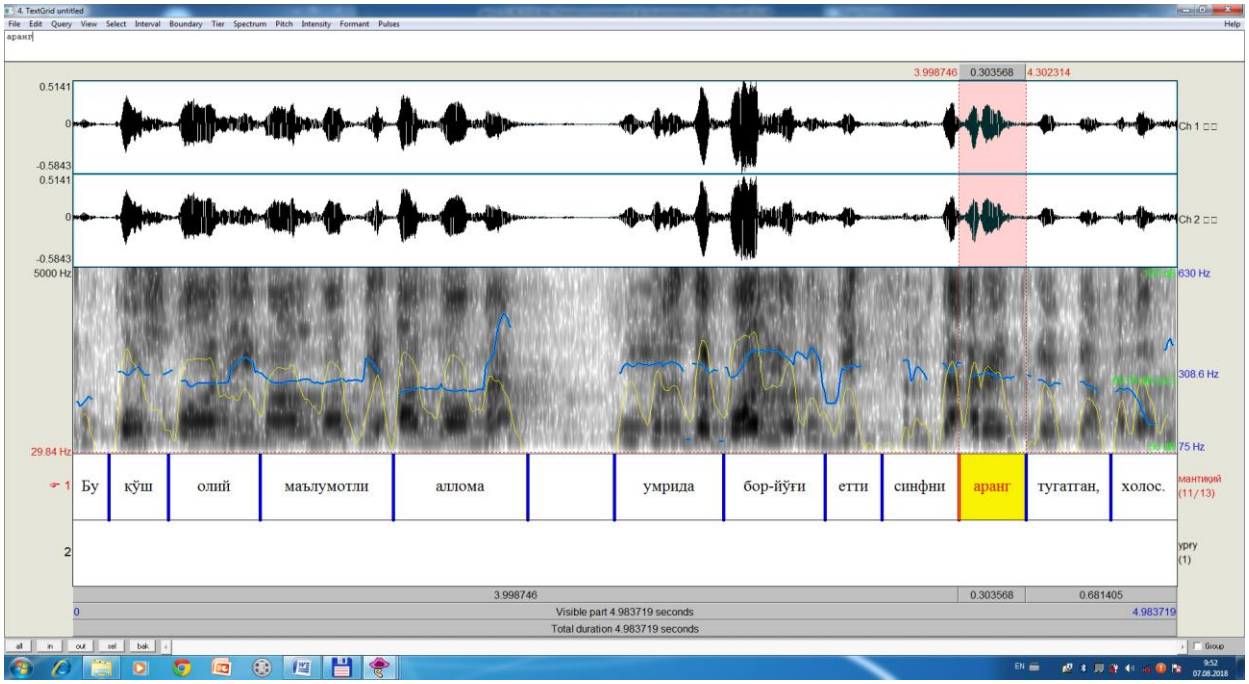
According to the experimental phonetic research the intonation is linked with the actual division of the sentence and the intensive action denotes the logical stress in the sentence. It is seen that the intensive action of the stress forms the intensive pitch at 81.9 db.



Picture 4.

The diagram shows the expression said by Adolat *Бу қўш олий маълумотли аллома умрида бор-йўғи етти синфни аранг тугатган, холос (Uyghun*,, “Parvona”*)* the action of the frequency of the main voice’ tone is given.

Бу қўш олий маълумотли аллома is theme, the melodic pitch is equal to 491.5 hz. In the sentence *Умрида бор-йўғи етти синфни аранг тугатган, холос*– the rheme is shown in the falling tone.



Picture 5.

In the actual division of the sentence the part *умрида бор-йўғи етти синфни аранг тугатган*, *холос* is considered the rheme, the intensive pitch *бор-йўғи* is tantamount to 82.59 db. The part *Бор-йўғи бу аллома етти синфни аранг тугатган* on the bases of the proposition *олий маълумотли бўлиш тугул*, *ҳатто ўрта маълумотга ҳам эга эмас* forms the presupposition.

It is known from the abovementioned, that the intonation plays an important role in the actual division of the sentence in the oral speech. In order to differentiate the theme and rheme in the sentence the intensive action of the stress fulfils the task of the main criterion. The logical stress in the sentence falls on one of the parts of the rheme by stating the components of the rheme and expressing the unknown information is shown by the special stress. The experimental phonopragmatic observations have shown that the views of L.R.Zinder on the intonation and the actual division of the sentences have been scientifically substantiated.

Conclusion

The semantic structures shown in the actual division of the sentences are distinguished by the intonation functions. These functions of the intonation are completely and partially reflected in its components. The component of the intensiveness of the stress fulfills the function of separation in the actual division of the sentences. These two semantic structures are seen through the intensive peaks in the intensive action of the stress. The degree of the intensiveness in the rheme is higher than the norm. The intensive degree of the stress in the thematic part can be adjusted to the normal range. The stated views indicate that the intensiveness of the stress has a significant role in the actual division of the sentence.

The intonation is the main means expressing the speech acts in the communicative speech. The components of the intonation as the melodics, stress, pause, tempo and timbre have their own functions in forming the speech acts.

The logical stress is one of the parts of the propositional structure in the stressed parts of the sentences. The semantic structures in the actual division of the sentences are distinguished by the functions of intonation.

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QR – Issue QR – Article

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METHODS OF CALCULATING THE TAX BURDEN ON LEGAL ENTITIES AND DIRECTIONS FOR IMPROVEMENT

Abstract: *This article is a scientific study of the improvement of the methodology for calculating the tax burden on legal entities, which describes the various methods, directions of calculation of the tax burden on legal entities today, the pros and cons of the methods used in practice. It is also scientifically based on the method of determining the tax burden of legal entities by calculating the ratio of value added in the calculation of the tax burden, as well as the expediency of calculating the net and total tax burden of legal entities by studying all foreign and domestic methods of calculating the tax burden.*

Key words: *tax burden, tax burden optimization, tax burden calculation methods, value added, sales revenue, indirect taxes, net tax burden, total tax burden.*

Language: *English*

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Introduction

There are various directions in the scientific literature on determining the tax burden of legal entities. Their calculation allows to determine the extent to which legal entities and the economy operate under the influence of the tax burden. Based on the methods of calculating this tax burden, we can determine the extent to which changes in the number, rates, benefits of taxes affect the activities of legal entities.

It is necessary to determine the average level of the tax burden on the sectors of the national economy. It provides an opportunity for effective development and a steady flow of revenues to the budget. Once the limits of the tax burden on the sectors of the national economy are determined, it is possible to create an optimal model of the tax burden on the sectors of the economy, mathematical models that determine the impact of taxes on economic growth [1, 2].

URGENCY

In tax theory, it has been found that indirect taxes affect the amount of the tax burden. Analyzes have shown that indirect taxes have such characteristics that their source can be easily changed.

The enterprise that pays the tax includes it in the price of goods, works, services, so that they are imposed on consumers. However, the enterprise can raise the price of the product only as long as the solvency of demand increases.

If the price, including the tax, is too high, demand will fall, some buyers will switch to products from other manufacturers, and others will switch to consuming other products that replace products.

THEORETICAL APPROCHES

Professor M.Almardonov proposes distinguishing between absolute and relative tax burden. According to the author, the absolute tax burden is the absolute amount of tax liabilities of economic entities, representing the burden of tax and social insurance contributions in enterprises, which are transferred to the budget and extra-budgetary funds. The relative tax burden is considered as the ratio of the absolute amount to the newly created value [7]. It is as follows:

$$Dn = \frac{T + SF}{NCV} \times 100$$

Dn – relative tax burden on the business entity.
T – taxes;
SF – social fees;
NCV - newly created value.

This formula determines the ratio of all tax payments and social needs of the legal entity to the newly created value, which determines the relative tax burden of the legal entity.

According to Professor K.Yahyoev's description of the tax burden, "The tax burden is taken in relation to profit or total income. The share of all taxes and levies paid in the country's GDP is also a tax burden" [8]. It is clear from this definition that the author views the tax burden as the ratio of all taxes and fees paid at the micro level to income or profit. This poses considerable difficulties in calculating and determining the tax burden. Because if the tax burden on profit is calculated, its level will increase significantly. When calculated in relation to income, the tax burden decreases. This causes considerable inconvenience in planning budget revenues.

Professor T.Tashmurodov, in his textbook "Explanatory Dictionary of Taxes", describes the tax burden as follows: "The tax burden is the ratio of the sum of all taxes and fees paid by a business entity or citizen to income" [9]. This definition also complicates the mechanism for calculating the tax burden. Because here the income is taken as the basis for calculating the tax burden. This causes inconvenience in calculating the tax burden of legal entities.

Professor B.Isroilov in his monograph "Tax accounting and analysis: problems and their solutions" describes the tax burden as follows: "Tax burden is the ratio of the sum of all taxes and fees paid by a business entity or citizen to the state, local budget and various funds in the prescribed manner to the volume of work, income or other tax object of the payer" [10]. Even in this definition, the essence of the tax burden is not widely explained. This is because the ratio of total taxes and fees paid is called the ratio of taxpayers to workload, income, or object of taxation. Here are three objects that do not look like each other. These cannot be a sufficient basis for calculating the tax burden.

ANALYTICAL PART

In calculating the tax burden on legal entities and determining the impact of taxes on their activities, the tax burden is calculated in the following directions:

Direction 1. Under this direction, the weight of the tax burden is defined as the ratio of the total amount of taxes and fees paid to the proceeds from the sale of the product. While this indicator shows the share of taxes and fees in sales revenue, it does not fully reflect the impact of taxes and fees on the financial and economic activities of enterprises, as it does not take into account the types and composition of taxes in total revenue from sales. In order to conduct a qualitative economic analysis, in our view, an indicator that links the tax burden with the financial activity of enterprises will be necessary.

Direction 2. Based on this direction, the source of tax and its payment is compared with each other. The weight of the tax burden is determined for each tax group depending on its source. This direction contradicts the generally accepted view that taxes included in cost are more beneficial to the enterprise because they reduce profits and thus reduce the amount of income tax. Along with the decline in corporate profits, it also leads to a decrease in tax revenues to the budget.

In this direction the tax burden can be determined as follows:

$$TBi = [(I-C-P)/(I-C)] * 100\%$$

or

$$TBi = [(I-C-P)/P] * 100\%$$

There:
TBi – tax burden indicator;
I – income;
C – costs of goods sold, excluding taxes;
P – net profit remaining at the disposal of the enterprise after tax deduction.

In this method, the total amount of taxes paid indicates how much of the profits remaining at the disposal of the enterprise went to taxes and fees.

Indirect taxes are not taken into account in this direction, as they do not affect the profits of the enterprise.

Therefore, in order to retain consumers, the company will have to reduce profits by the amount of taxes and fees without changing prices.

Indirect taxes affect the prices of products and thus affect demand. The weight of indirect taxes is imposed on sellers and consumers depending on the nature of demand. If the demand for a product is flexible, most of the indirect taxes fall on the seller, because as soon as he raises the price he loses his buyer, if the demand is inelastic, the seller can impose the main part of the tax on the consumer, because the amount of demand is almost independent [3, 4].

It will be very difficult to put this theory into practice. Because it is very difficult to determine the impact of indirect taxes. Therefore, it is possible to determine the effect of indirect taxes on a particular product only through such a line

Direction 3. Based on this direction, the tax burden can be defined as the share of value added taxes and fees. Under this direction, value added is considered a source of income and, in turn, a source of tax payment. Thus, according to this direction, the

tax is compared with its source of payment. This indicator makes it possible to show the average amount of tax burden for different types of production, thus providing a comparison of the tax burden in different economic systems.

By applying this direction, the share of value added taxes can be determined depending on the type of production and profitability

It is possible to determine the development potential of the enterprise depending on the amount of value added that remains at the disposal of the enterprise after payment of taxes.

The main disadvantage of this direction is that it does not include taxes on the use of the following subsoil resources, excise taxes, property, use of water resources.

Direction 4. Based on this direction, it is necessary to differentiate the absolute and relative tax burden. However, in our opinion, it is not enough to determine the tax burden based on the revenue from the sale of products in enterprises.

Absolute tax burden is the amount of taxes and insurance premiums transferred to the budget and extra-budgetary funds, the absolute amount of tax liabilities of economic entities. This indicator represents the actual tax payments to the budget and compulsory insurance contributions to extra-budgetary funds, as well as dependents on these payments. In calculating the amount of the absolute tax burden, income tax from individuals and payments to the pension fund are not taken into account, because its payers are individuals, and enterprises collect this tax and transfer it to the budget.

Insurance premiums paid by business entities to extra-budgetary funds are recognized as mandatory payments and should be taken into account when calculating the tax burden, as their nature is similar to that of taxes.

The strength of this approach is that it can be used to compare the tax burden on specific enterprises, as well as for private entrepreneurs, regardless of their industry. On the downside, it is not possible to plan for changes in economic activity depending on the number of taxes, their rate, and preferences.

Direction 5. According to this direction, the indicator of the tax burden is related to taxes and other mandatory payments, the structure of taxes in the enterprise, the mechanism of taxation. The tax burden is calculated based on the following equation:

T=TP:SP*100%,

There: **ST** – taxe payments; **SP** – the source of payment.

The total amount of taxes includes all taxes paid, VAT, excise tax, personal income tax, contributions to extra-budgetary funds, etc.

This direction takes into account the characteristics of a particular enterprise, ie the value added also includes material costs, depreciation, shares of labor costs and personal income tax.

The above five directions have their own pros and cons. For a complete and comprehensive analysis of the tax burden, an indicator is needed in which the tax burden should be related to the development model of the enterprise. The third line meets this condition. The strength of this approach is that it is recommended that the tax burden be calculated using the given equation. In this equation, the total amount of the tax burden can be determined by changing each of the variables. This equation takes into account the tax rate, the stock of production, labor and material capacity, and the level of profitability of production.

However, when conducting an analysis to achieve maximum effect in determining the tax burden on enterprises, and to determine the impact of changes in the tax burden on the economic activity of the enterprise, the third and fifth directions should be used. The data obtained should be supplemented by an analysis of changes in demand for the enterprise's products as prices change, which in turn helps to determine the severity of the indirect taxes levied on the consumer [5, 6].

The current state of calculation of the tax burden on legal entities in our country today is calculated on the basis of the methodology provided by the Ministry of Finance and the State Tax Committee of the Republic of Uzbekistan. According to it, taxes and fees are calculated in relation to the volume of sales of the business entity. It is as follows:

$$TB = \frac{\text{Taxes and fees}}{\text{Revenue from product sales}} \text{ x } 100\ \%$$

There: **TB** – tax burden on legal entities.

The calculation of the tax burden in this method significantly reduces the tax burden on legal entities, and as a result, the activities of these entities are underestimated, causing a number of economic difficulties. That is, based on the data of government agencies involved in this area, the state develops a budget program and acts on it. As a result, the state may aggravate the tax burden on legal entities. This, of course, can only have a negative impact on the macroeconomic situation.

In our opinion, when calculating the tax burden on legal entities, it is expedient to determine the ratio of all taxes, fees and deductions paid by the legal entity to the state budget by the value added of the legal entity. Then the real level of the tax burden will appear and there will be no negative impact on either the state budget or the legal entity.

Having studied the above definitions and analyzed the instructions of the Ministry of Finance and the State Tax Committee of the Republic of Uzbekistan on the calculation of the tax burden on legal entities, we can say that there is no single methodological basis for calculating the tax burden on

legal entities. This situation further requires research on the calculation of the tax burden of legal entities.

Studying the opinion of foreign and domestic scholars on the calculation of the tax burden of legal entities and all the methods in this regard, we can state the following:

- When calculating the tax burden of legal entities, it is necessary to determine the sum of all taxes and fees they pay by the ratio of the newly created value;
- When calculating the tax burden of legal entities, it is expedient to calculate the net and total tax burden. Here, the net tax burden represents the burden of all taxes, budgetary and extra-budgetary contributions paid by the legal entity, while the total tax burden represents the burden of legal entities' contributions to taxes, budgetary and extra-budgetary funds, and taxes and fees levied on workers.

CONCLUSION

Some economic literature does not take into account the personal income tax and social payments paid to them in the process of calculating the tax burden of economic entities. This seems right at first glance. However, it should be noted that the income of an individual and his tax, as well as the source of creation of social contributions for him, is also the value added of the legal entity. In fact, personal income tax should be taken into account when calculating the tax burden on the employee, the citizen. At present, individuals working in legal entities in our country also make a number of social payments to the budget with income tax. Although these payments seem to be paid by individuals, the burden falls on legal entities.

As a result of our research, we have been able to draw the following conclusions:

- The results of the study showed that there is no single decision in the calculation of the tax burden on legal entities, which requires further research in the future;
- In our opinion, the tax burden of legal entities can be understood as the ratio of all taxes, fees and deductions paid by a legal entity to the state budget to the value added of the legal entity;
- The results of the analysis showed that it is necessary to make changes to the mechanism of calculating the tax burden in our country today. At the same time, the calculation of the tax burden on the newly created value of legal entities provides an opportunity to accurately assess their activities;
- When calculating the tax burden of legal entities, it is expedient to calculate the net and total tax burden. Here, the net tax burden represents the burden of all taxes paid by the legal entity, contributions to the budget and extra-budgetary funds, while the total tax burden represents the burden of legal entities' contributions to taxes, budget and extra-budgetary funds and taxes and fees withheld from workers.

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INFLUENCE OF Al (Mn Fe) Si DISPERSOIDS WITH DIFFERENT SIZES AND NUMERICAL DENSITY ON THE MICROSTRUCTURE AND MECHANICAL PROPERTIES OF EXTRUDED ALLOYS OF THE AA6XXX Al-Mg-Si SERIES WITH DIFFERENT Mn CONTENT

Abstract: *The effect of Al (MnFe) Si dispersoids with different sizes and numerical density on the evolution of the microstructure and mechanical properties of extruded AA6082 alloys with different Mn contents at ambient temperature and elevated temperature under T5 conditions has been investigated. Compared to the low density of coarse dispersoids formed by conventional homogenization, the density of fine dispersoids formed by new low temperature homogenization was more effective in increasing the material's resistance to plastic deformation during extrusion. Al.*

Key words: *Extrusion of Al-Mg-Si, AA6082 alloy, Microstructure of Al (MnFe) Si dispersoids, Mechanical properties, Solid solution, artificial and natural aging, Microstructure of alloys, alloyed, Dispersoids, extruded.*

Language: *Russian*

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ВЛИЯНИЕ ДИСПЕРСОИДОВ Al(Mn Fe) Si С РАЗЛИЧНЫМИ РАЗМЕРАМИ И ЧИСЛОВОЙ ПЛОТНОСТЬЮ НА МИКРОСТРУКТУРУ И МЕХАНИЧЕСКИЕ СВОЙСТВА ЭКСТРУДИРОВАННЫХ СПЛАВОВ СЕРИИ AA6xxx Al-Mg-Si С РАЗЛИЧНЫМ СОДЕРЖАНИЕМ Mn

Аннотация: *Исследовано влияние дисперсоидов Al(MnFe)Si с различными размерами и числовой плотностью на эволюцию микроструктуры и механических свойств экструдированных сплавов AA6082 с различным содержанием Mn при температуре окружающей среды и повышенной температуре в условиях T5. По сравнению с низкой плотностью грубых дисперсоидов, образующихся при обычной гомогенизации, высокая плотность тонких дисперсоидов, образующихся при новой низкотемпературной гомогенизации, была более эффективной в повышении устойчивости материала к пластической деформации при экструзии, что приводило к растворению большего количества составляющих частиц Mg_2Si в матрице α - Al.*

Ключевые слова: *Экструзия сплава Al-Mg-Si, Микроструктура дисперсоидов Al(MnFe)Si, Механические свойства, Твердый раствор, искусственное и естественное старение, Микроструктура сплавов, легированные, Дисперсоиды, экструдированые.*

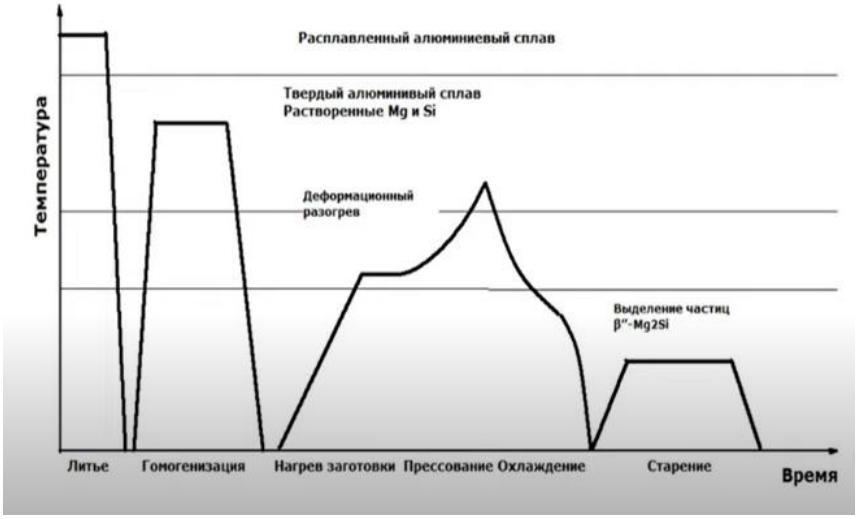
Введение

Термическая обработка алюминиевых сплавов

Термическую обработку алюминиевых профилей применяют для модификации свойств алюминиевых сплавов, из которых они сделаны,

путем изменения их микроструктуры. Основными упрочняющими механизмами в алюминиевых сплавах являются упрочнение за счет легирования твердого раствора и упрочнение за счет выделений вторичных фаз. Как правило, один из этих механизмов в сплаве является доминирующим.

Рисунок 1. Твердый раствор алюминиевых сплавов.



Твердый раствор получают нагревом алюминиевого сплава, при котором все имеющиеся в нем фазы растворяются с образованием одной гомогенной фазы – алюминия с растворенными в нем легирующими элементами. С повышением температуры растворимость элементов увеличивается, со снижением температуры – снижается. Механизм упрочнения заключается в том, что при достаточно быстром охлаждении алюминиевого сплава растворенные элементы остаются в атомной решетке алюминия и искажают, упруго деформируют ее. Эта искаженная атомная решетка затрудняет движение дислокаций и, следовательно, пластическую деформацию сплава и тем самым повышает его механическую прочность.

Старение алюминиевых сплавов.

Алюминиевые сплавы, которые упрочняются старением, содержат определенное количество растворимых легирующих элементов, например, некоторых комбинаций из меди, магния, кремния, марганца и цинка. При соответствующей термической обработке эти растворенные атомы соединяются в виде очень малых частиц, которые выделяются внутри зерен алюминиевого сплава. Этот процесс и называют старением, так он происходит «сам собой» при комнатной температуре. Для ускорения и достижения большей эффективности упрочнения алюминиевого сплава старение проводят при повышенной температуре, скажем, 200 °C.

Закалка алюминиевых профилей на прессе.

Закалка на прессе является весьма экономически выгодной технологией термической обработки алюминиевых профилей по сравнению с закалкой с отдельного нагрева. При закалке на прессе охлаждение алюминиевых профилей проводят от температуры, с которой они выходят из матрицы. Необходимое условие для закалки на прессе – интервал температур нагрева алюминиевого сплава под закалку должен совпадать с интервалом температур алюминиевых профилей на выходе из пресса. Это, в принципе, выполняется только для «мягких» и «полутвердых» алюминиевых сплавов – технического алюминия, алюминиевых сплавов серий 3xxx и 6xxx, Упрочняющей фазой для сплавов серии 6xxx является соединение Mg_2Si.

Закалка на прессе сплавов АД31, 6060, 6063 и AA6082.

Все алюминиевые сплавы серии 6xxx могут получать закалку непосредственно на прессе. Для фиксирования растворенных фаз в твердом растворе алюминия необходимо охлаждение алюминиевых профилей на выходе из пресса со скоростью не ниже некоторой критической скорости. Эта скорость зависит от химического состава алюминиевого сплава. Обычно усиленного охлаждения вентиляторами бывает достаточно для большинства алюминиевых профилей, однако иногда бывает необходимым и охлаждение их водой или смесью воздуха и воды. Успешная закалка алюминиевых сплавов серии 6xxx зависит от толщины профиля, а также от типа

сплава и его химического состава. В случае чрезмерно массивных алюминиевых профилей, например, из сплава АД33 (6061) и относительно медленной скорости прессования материал на выходе из матрицы может не достигать интервала температур, необходимого для закалки и часть частиц Mg_2Si останется не растворенной. Поэтому при последующем воздушном, или даже водяном, охлаждении профилей их полной закалки не получится. В таких случаях применяют отдельный нагрев под закалку в специальных печах – обычно вертикальных с последующим охлаждением в вертикальных баках с водой. После закалки алюминиевых профилей производят их растяжение на 1,5 – 3 % для правки и снятия остаточных напряжений.

Старение алюминиевых профилей: искусственное и естественное

Заключительной операцией термической обработки алюминиевых профилей является старение, естественное или искусственное. Естественное старение происходит само собой в течение некоторого времени, разного для различных алюминиевых сплавов – от нескольких недель до нескольких месяцев. Искусственное старение производят в специальных печах старения. Типичные режимы термической обработки для некоторых алюминиевых сплавов 6ххх приведены в таблице 1.

Таблица 1. Типичные режимы термической обработки для некоторых сплавов серии 6ххх.

Сплав		Температура нагрева под закалку, °С	Искусственное старение	
EN 573	ГОСТ 4784		Температура°С	Выдержка,ч
6005	---	530	175	8
6061	АД33	530	175	8
6063	АД31	530	175	8
6066	---	530	175	8
6262	---	540	175	12

Благодаря высокому соотношению прочности и веса, хорошей формуемости и отличной коррозионной стойкости сплавы Al-Mg-Si AA6082 широко используются в качестве конструкционных материалов в транспортной и строительной промышленности [1]. Сочетание (а) наноразмерных прекурсоров Mg_2Si, образующихся при искусственном старении, и (б) волокнистой зернистой структуры, полученной при горячей деформации за счет образования дисперсностей при гомогенизации, обеспечивает относительно высокую прочность сплавам AA6082 семейства Al-Mg-Si 6ххх [2]. Сплавы AA6082 подходят для высоконапряженных применений с рабочими температурами, как правило, не превышающими 150 °C. Однако при более высоких температурах прочность AA6082 сплавов существенно уменьшается благодаря быстрому огрубление β"/β′- MgSi выпадает в осадок [3].

В общепринятой промышленной практике гомогенизацию перед экструдированием проводят при относительно высокой температуре, обычно при 550 ° C для сплавов AA6082, что приводит к образованию грубых дисперсоидов Al(FeMn)Si (диаметром~200 нм) в матрице α - Al [4,5]. Попытки усиления дисперсионного упрочняющего эффекта в различных сплавах на основе Al были предметом многочисленных исследований, так как эти дисперсоиды (1) устойчивы к огрублению при температурах до 400 ° C и (2) сравнительно дешевле наноразмерных триалюминиды, легированные Sc, Zr или Er. Введение твердотельного осаждения мелкодисперсных и плотных дисперсоидов улучшает высокотемпературные механические свойства алюминиевых сплавов [6-7]. Дисперсоиды могут эффективно замедлять рекристаллизацию как при горячей деформации, так и при постдеформационном отжиге

Сплавы AA6082 преимущественно обрабатываются экструзионными операциями для изготовления алюминиевых конструкционных элементов. Пиковая температура во время экструзии обычно может достигать 550 ° C, при которой происходит активное укрупнение дисперсоидов. Кроме того, неизвестно влияние содержания Mn и связанных с ним дисперсоидов на эволюцию микроструктуры при экструзии, а также на осаждение преципитатов β"/β′-MgSi при обработке старением. Возможность включения тонких и плотных дисперсоидов в дополнение к осадкам β"/β′ в матрицу α-Al сплавов AA6082 может повысить ее механическую реакцию на тепловое воздействие; это новый и экономически эффективный подход к повышению высокотемпературных механических свойств алюминиевых конструкций в процессе эксплуатации. Целью данного исследования было изучение влияния изменяющегося содержания Mn и связанных с ним дисперсоидов на микроструктурную эволюцию при экструзии и старении, а также на механические свойства

сплавов AA6082 при окружающей среде и повышенных температурах.

2. Экспериментальные процедуры.

2.1. Материалы и предварительная экструзионная термообработка.

Литые заготовки постоянного тока (диаметром 100 мм) из четырех вариантов сплавов типа AA6082 были предоставлены заводом «БЕНКАМ» г.Наваи. Химические составы, проанализированные методом оптической эмиссионной спектроскопии, приведены в таблице 2. Среднее расстояние между вторичными дендритными плечами в центре и среднем радиусе всех литых заготовок было измерено равным ~17 μm, что свидетельствует о хорошей воспроизводимости температурного профиля при отливке постоянным током.

Таблица 2. Химический состав литого сплава AA 6082 (мас.%)

Сплавы	*Mg*	*Si*	*Mn*	*Fe*	*Ti*
0 Mn	*0,83*	*1,01*	*000*	*0,22*	*0,016*
0,5% Mn	*0,84*	*1,01*	*0,50*	*0,23*	*0,016*
0,7% Mn	*0,84*	*1,02*	*0,72*	*0,23*	*0,015*
1 % Mn	*0,81*	*1,02*	*1,00*	*0,24*	*0,015*

По результатам первоначальных испытаний литые заготовки подвергали термообработке при 400 ° C в течение 5 ч для индуцирования образования большого количества дисперсоидов Al(FeMn)Si в матрице α-Al. Четыре варианта сплава подвергались термообработке при 400 ° C в течение 5 ч и далее именуются сплавами 0Mn, 0,5 Mn(L), 0,7 Mn(L) и 1Mn(L) соответственно (см. Таблицу 3).

Таблица 3. Термическая обработка различных сплавов перед экструзией.

Сплавы	Термически обработки.	Коды сплавов.
0 Mn	400 C/час.	0,5 Mn
0,5%Mn		0,5 Mn (L)
0,7%Mn		0,7 Mn (L)
1 % Mn		1,0 Mn (L)
0,5%Mn	500 C/час.	0,5 Mn (H)

Некоторые заготовки, содержащие 0,5% Mn, были также подвергают обычной промышленной гомогенизации при 550 °C в течение 5 ч (далее именуемый сплавом 0,5 Mn(H)) для сравнения упрочняющего эффекта дисперсоидов с различными размерами и числовыми плотностями. Скорость нагрева для обеих термических обработок была установлена на уровне 100 °C/ч.

2.2. Экструзионная и постэктрузионная термообработка.

Термообработанные заготовки экструдировали последовательными стадиями предварительного нагрева, экструзии и закалки. Пули предварительно нагревали до 500 °C с помощью индукционного нагрева в течение ~5 мин. и быстро переносили на пресс. Заготовки экструдировали со скоростью тарана 10 мм/с для получения круглых прутков диаметром 17,8 мм. Температуру экструзионных стержней на выходе из пресса измеряли вручную с помощью термопары типа K. Чтобы сохранить микроструктуру при экструзии, стержни закаляли на водяной ванне. Образцы экструдированных стержней выдерживали при температуре 180 ° C в течение 5 ч для закалки T5. Кроме того, некоторые из обработанных T5 образцов были дополнительно подвергнуты воздействию при 300° C в течение 100 ч для определения прочности при повышенной температуре [5, 8].

2.3. Характеристика материала.

Микроструктура сплавов была охарактеризована с помощью оптической микроскопии (ОМ), сканирующей электронной микроскопии (СЭМ), оснащенной дифракцией обратного рассеяния электронов, и просвечивающей электронной микроскопии (ПЭМ). Шлифование и полирование образцов проводили по стандартной металлографической

методике. Заключительную стадию полировки обрабатывали 0,05 µm коллоидной суспензией кремнезема. Образцы литых заготовок для металлографических исследований были разрезаны по среднему радиусу. Для характеристики микроструктуры экструдированных стержней образцы секционировали таким образом, чтобы плоскость обзора поддерживалась параллельной направлению экструзии и проходила через центр стержня. Сканирование EBSD экструдированных сплавов, обладающих некристаллизованной и рекристаллизованной зернистой структурой, проводилось с шагом 0,5 и 5 µm соответственно. Запуски сканирование для каждого условия были уверены, что коэффициент индексации составляет не менее 85%. Тонкая фольга TEM была подготовлена с использованием следующих этапов: (i) пробивка образца диаметром 3 мм, (ii) истончение дискообразного образца до ~ 50 µm путем шлифования и полировки и (iii) электрохимическая полировка образца двухструйным электрополировщиком при 20 В постоянного тока с использованием раствора 67% метанола и 33% HNO_3 при ~ 20-30 °C. Наблюдения за осадками и дисперсоидами в матрице α-Al проводились с помощью просвечивающего электронного микроскопа (ПЭМ) вблизи оси зоны [001] состояния пучка g200 (работающего при 200 кВ). Объемную долю дисперсоидов Al(FeMn)Si, fd, оценивали по следующему уравнению [9]:

$$f_d = A_d \frac{\overline{KD}}{\overline{KD}+t}(1 - A_{DFZ}) \qquad (1)$$

где D - эквивалентный диаметр дисперсоида, t - толщина фольги ПЭМ, Ad-процентная площадь дисперсоидов из изображений ПЭМ, A_{DFZ}-процентная площадь свободных зон дисперсоидов из изображений ОМ; K - средний коэффициент формы дисперсоидов, принимаемый в данном исследовании равным 0,45. Численная плотность дисперсоидов Al(Fe Mn)Si оценивается по ссылке [3]:

$$N_v = \frac{N}{A\,(\overline{D}+t)} \qquad (2)$$

где Nv представляет собой количество дисперсоидов внутри изображения, а A - площадь изображения. Числовая плотность преципитатов β".

$$N_v = \frac{3N_t}{A(t+l)} \qquad (3)$$

где: Nt - количество игл β", ориентированных вдоль направления луча; l - средняя длина игл β", t-толщина фольги ПЭМ. Для количественной оценки преципитатов и дисперсоидов было использовано по меньшей мере шесть ПЭМ-микрофотографий, полученных из различных областей матрицы α-Al. Были проведены испытания на микротвердость по Виккерсу при нагрузке 100 г и времени выдержки 20 с. Механические свойства T5 характеризовались проведением испытания на предел текучести при сжатии (YS) при комнатной температуре. Для исследования прочности сплавов AA6082 - T5 при повышенных температурах были проведены испытания на предел текучести при сжатии как при 20, так и при 300 °C на образцах после длительного термического воздействия (300°C/100 ч). Все испытания на предел текучести при сжатии проводились с помощью термомеханического имитатора,на образцах длиной 15 мм и диаметром 10 мм. Скорость деформации во время испытания устанавливали на уровне 10-3 с—1 для достижения общей деформации 0,2. Для испытаний при 300 °C образцы предварительно нагревали до температуры испытания со скоростью 2 °C/c и выдерживали в течение 3 мин перед нагрузкой сжатием. Для получения воспроизводимых результатов в испытаниях на растяжение и сжатие было испытано не менее трех образцов в каждом состоянии.

3. Результаты и обсуждение.

3.1. Образование дисперсоидов Al(Fe Mn)Si и их влияние на эволюцию микроструктуры при экструзии:

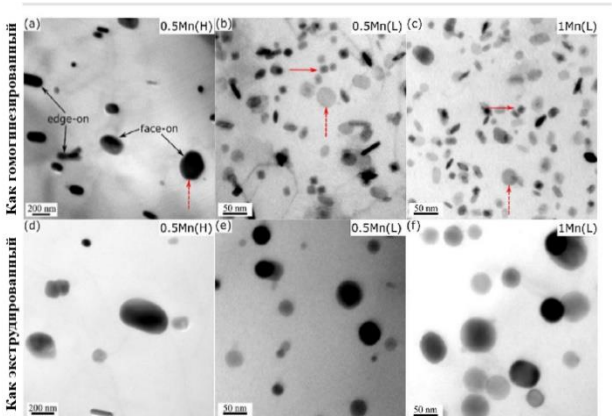
На рис. 1a показаны дисперсоиды Al(FeMn)Si в матрице α-Al сплава 0,5 Mn(H) перед экструзией, который подвергался промышленному процессу гомогенизации при 550 ° C в течение 5 ч. Согласно литературным данным [9], дисперсоиды имеют в основном тромбоцитарную форму и имеют средний эквивалентный диаметр (D) 156 нм (табл. 4).

Напротив, микроструктуры сплавов 0,5Mn (L) и 1Mn (L) перед экструзией, которые были подвергнуты термообработке при 400 ° C в течение 5 ч, характеризовались гораздо более мелкими (D ~ 25 нм) и более плотными диспергаторами Al (FeMn) Si (см. рис. 1b, c и таблицу 3). Дисперсоиды в этих сплавах представлены преимущественно пластинками (пунктирные стрелки) или кубоидами (сплошные стрелки).ПЭМ-изображение сплава 0,7Mn (L) здесь не показано, поскольку оно показывает характеристики дисперсоидов, аналогичные характеристикам сплавов 0,5Mn (L) и 1Mn (L). На изображениях ПЭМ на рис. 1d, e и f показаны дисперсоиды Al (FeMn) Si в сплавах 0,5Mn (H), 0,5Mn (L) и 1Mn (L) после экструзии, соответственно.

Таблица 4. Количественные результаты ТЭМ дисперсоидов в экспериментальных сплавах.

Сплавы	Гомогенный состояние			Экструдированное состояние		
	D, nm	$N_v, \mu m^{-3}$	f_d, %	D, nm	$N_v, \mu m^{-3}$	f_d, %
0Mn	*a*	*a*	*a*	*a*	*a*	*a*
0.5 Mn(H)	156.8(±41)	4.3(±3)	0.66(±0.2)	187.5(±52)	3.7(±3)	0.70(±0.2)
0.5 Mn(L)	25.3(±2.6)	971.5(±112)	0.65(±0.1)	40.3(±2.5)	316.5(±46)	0.64(±0.1)
0.7 Mn(L)	25.1(±2.5)	1318.4(±96)	0.85(±0.1)	40.2(±2.3)	415.4(±36)	0.88(±0.1)
1 Mn (L)	25.2(±2.7)	1383.1(±121)	0.94(±0.1)	40.2(±2.5)	418.3(±34)	0.93(±0.1)

Дисперсоиды в сплаве 0,5Mn (H) остаются значительно крупными (D ~ 187 нм) (см. Рис. 1d и таблицу 3). Числовая плотность Nv и объемная доля fd дисперсоидов Al (FeMn) Si в сплаве 0,5Mn (H) оказались равными ~ 4 мм - 3 и 0,70% соответственно. Хотя аналогичная объемная доля дисперсоидов Al (FeMn) Si обнаружена в сплаве 0,5Mn (L), их численная плотность остается намного выше, чем в сплаве 0,5Mn (H) (~ 317 мм-3 против ~ 4 мм-3). 3 соответственно). Nv и fd дисперсоидов были сравнительно выше в сплаве 0,7Mn (L), чем в сплаве 0,5Mn (L), однако Nv и fd сплава дисперсоиды в сплавах 0,7Mn (L) и 1Mn (L) были аналогичными,примерно 416 мм — 3 и 0,90% соответственно (см. таблицу 3). Примечательно, что дисперсоиды укрупнялись во время экструзии, поскольку их средний эквивалентный диаметр увеличивался От ~ 25 нм до экструзии (см. Рис. 1b и c) до ~ 40 нм после экструзии (см. Рис. 1e и f, а также таблицу 3), дисперсоиды Al (FeMn) Si становятся весьма чувствительными к укрупнению при температурах выше 450 °C.



На рис. 1. Светлое поле ПЭМ -изображения, показывающие Си дисперсоиды если смотреть вдоль [001] Al зоне оси B (A, D) 0,5 мм(ч), (б, е) 0,5 мм(L) и (C, Ф) 1 млн(л) сплавов до (A, Б, B) и после (D, E, F) прессования. Сплошные и пунктирные стрелки указывают на кубовидные и тромбоцитарные дисперсоиды соответственно. Дисперсоиды, расположенные ребрами и широкими поверхностями (почти) перпендикулярно направлению обзора, обозначаются соответственно ребром и лицевой стороной. Обратите внимание, что микрофотографии из сплава 0,5 Mn(H) представляют собой гораздо большую площад матрицы α-Al по сравнению с микрофотографиями из сплавов 0,5 Mn(L) и 1 Mn(L).

Хотя время выдержки дисперсоидов при высокой температуре, выше 500 °C, во время экструзии было весьма ограничено из-за индукционного нагрева и относительно высокой скорости поршня (10 мм / с), дисперсоиды все еще испытывали умеренное укрупнение (Таблица 3). Действительно, диффузия растворенного вещества происходит намного быстрее во время высокотемпературной экструзии из-за пластической деформации материала, которая ускоряет укрупнение дисперсоидов Al (FeMn) Si из-за высокой плотности дислокаций. Кроме того, во время экструзии дисперсоиды претерпели морфологические изменения.

Дисперсоиды пластинчатой и кубовидной формы, наблюдаемые в условиях гомогенизации (рис. 1a, b и c), стали более округлыми после экструзии, что сделало дисперсоиды более овальными или, в меньшей степени, сферическими по форме (рис. 1d). , д и e). Механизмы, лежащие в основе этих морфологических изменений, станут предметом будущих исследований.

На рис. 2 показаны карты обратной полярности (ОП) в центре экструдированных стержней в плоскости, параллельной направлению экструзии. В сплаве 0Mn зерна кажутся равноосными, и большинство из них не имеют субструктуры; эквивалентный диаметр зерен ~ 220 мм (рис. 2a).

Это указывает на то, что при экструзии основного сплава произошла полная рекристаллизация [10]. Напротив, зерна во всех сплавах, содержащих Mn, являются волокнистыми и выровнены по направлению экструзии (рис. 2b, c и d). Это означает, что дисперсоиды из-за их пиннинга Зенера эффективно замедляют или ингибируют рекристаллизацию во время экструзии во всех Mn-содержащих сплавах [11].

Сплав 0.5Mn (H) содержал небольшую часть рекристаллизованных зерен (рис. 2б). Однако наличие границ субзерен (угол разориентации от 2° до 15°) в удлиненных зернах предполагает, что динамическое восстановление в основном происходило во время экструзии сплава 0,5Mn (H) [12]. С другой стороны, зеренная структура сплавов с мелкими и плотными дисперсоидами (0,5Mn (L), 0,7Mn (L) и 1Mn (L)) была восстановлена лишь частично и содержала в основном волокнистые и неперекристаллизованные зерна.

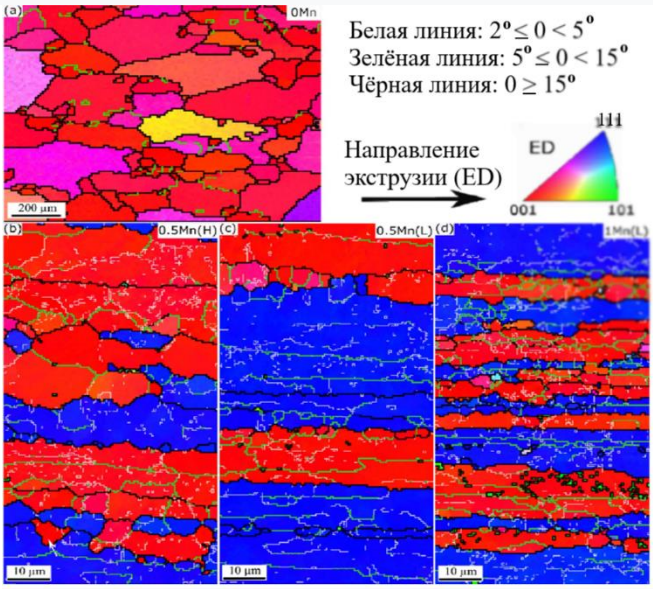


Рис. 2. Карты ОПР (обратный полюсный рисунок), на которых показаны структуры зерен после экструдирования в центре экструдированных стержней из (a) 0Mn, (b) 0,5Mn (H), (c) 0,5Mn (L) и (г) сплавы 1Mn (L) в плоскости, параллельной направлению экструзии (ED). Пунктирными стрелками на рис. 2б показаны рекристаллизованные зерна. Обратите внимание, что карты показывают кристаллографическую ориентацию зерен вдоль ED, а карта из сплава 0Mn представляет гораздо большую площадь по сравнению с таковыми из сплавов 0,5Mn (H), 0,5Mn (L) и 1Mn (L).

Что касается ориентации зерен, то карты *ОПР* показывают, что большинство зерен в сплаве 0Mn демонстрируют компонент текстуры <001> Al || ED (рис. 2a), которая является типичной текстурой рекристаллизации, наблюдаемой в осесимметрично деформированных материалах ОДМ [13]. В сплавах с марганцем, имеющих неперекристаллизованную структуру зерен, зерна ориентированы вдоль оси экструзии в Направление <111> или <001> (рис. 2b, c и d). Это подтверждает, что осесимметричная деформация, которая произошла во время экструзии, привела к развитию двухволоконной текстуры, состоящей из волокон <111> и <001> [10,14].

Чтобы выявить влияние мелких и плотных дисперсоидов на текстуру и зернистую структуру, были получены карты IPF поперечных сечений экструдированных стержней (рис. 3); измеренные доли площади текстур волокна <111> и <001>, а также средний эквивалентный диаметр зерен в поперечном сечении представлены в таблице 4. Соотношение между текстурами волокна <111> и <001> равно единице в сплава 0,5Mn (H), тогда как текстура волокна <111> более улучшена, чем

текстура волокна <001> в 0,5Mn (L) и 1Mn (L), составляющие примерно 70–72% зерен (Таблица 4).

Кроме того, средний эквивалентный диаметр зерен в сплавах 0,5Mn (L) и 1 (Mn (L) заметно уменьшен по сравнению с тем, который наблюдается в сплаве 0,5Mn (H) (Таблица 4). Различия в текстуре и структуре зерен наблюдаемые в сплавах 0,5Mn (L) и 1 (Mn (L) по сравнению со сплавом 0,5Mn (H), вероятно, связаны с повышенным сопротивлением материала пластической деформации во время экструзии из-за присутствия в нем более мелких и более плотных дисперсоидов). первые сплавы [10].

Для получения наилучших механических свойств важно растворить большую часть частиц Mg_2Si в алюминиевой матрице во время экструзии для последующего старения T5 [29]. Микроструктуры сплавов после экструдирования, показанные на рис. 4, показывают присутствие небольшого количества нерастворенных частиц Mg_2Si во всех сплавах, подтверждая эффективность термомеханического процесса во время экструзии в растворении большинства частиц Mg_2Si в α-Al. матрица.

Долю площади нерастворенных частиц Mg_2Si измеряли для всех сплавов и результаты приведены в таблице 5. Больше нерастворенных частиц Mg_2Si было обнаружено в сплавах 0Mn и 0,5Mn (H) (~ 0,28%) по сравнению со сплавами 0,5Mn (L), 0,7Mn (L) и 1Mn (L) (~ 0,18%), что также подтверждается более низкой электропроводностью сплавов 0Mn и 0,5Mn (H)

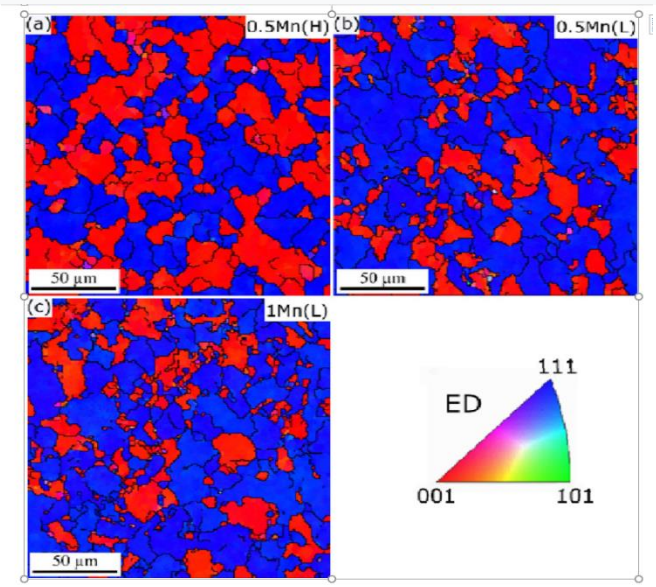


Рис. 3. ОПР (обратный полюсный рисунок), на которых показаны структуры зерен после экструдирования в центре экструдированных стержней из (a) 0,5Mn (H), (b) 0,5Mn (L) и (c) 1Mn (L).) сплавы. Обратите внимание, что изображения снимаются с плоскостей, перпендикулярных направлению экструзии.

Таблица 4. Доля площади волокон <111> и <001> и средний эквивалентный диаметр зерен, полученные из карт EBSD на рис. 3.

Сплавы	Доля площади волокон <111>,%	Доля площади волокон <001>,	Среднее экв. диаметр зерен, мм
0.5Mn(H)	50	50	10.9
0.5Mn(L)	72	28	8.5
1Mn(L)	70	30	7.3

Анализ параметров процесса экструзии, таких как температура на выходе стержней и максимальное приложенное давление, показывает, что максимальные давления, достигаемые в сплавах с мелкими дисперсоидами, разумно выше, чем у сплавов 0Mn и 0,5Mn (H) с или без грубых дисперсоидов.Это подтверждает, что мелкие и плотные дисперсоиды увеличивают устойчивость материала к пластической деформации, которая, в свою очередь, вызывает повышение температуры во время экструзии.

Комбинация более высокой степени пластической деформации и большего повышения температуры, вызванного мелкими и плотными дисперсоидами, вызвали растворение относительно большего количества составляющих частиц Mg_2Si в матрице.

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STATE OF CHARGE ESTIMATION OF HIGH-POWER LITHIUM-ION BATTERIES WITH IMPROVED EQUIVALENT CIRCUIT MODELING AND ADAPTIVE EXTENDED KALMAN FILTERING ALGORITHM

Abstract: *This paper focuses on the accurate estimation of the state of charge of lithium-ion batteries through the establishment of an equivalent model, experimentation, simulation, and the use of an adaptive extended Kalman filtering algorithm. Several models have been used in the creation of the high-power lithium-ion battery and as it is difficult to estimate the state of charge of the lithium-ion battery accurately numerous methods and techniques are employed. A Thevenin equivalent circuit model is designed to include two resistor-capacitors in series for easy parameterization and estimation of the state of charge of the battery. An experimental approach is adopted and data from the open-circuit voltage and the hybrid pulse power characteristic tests are used for parameterization. The battery is modeled and simulated in Simulink/MATLAB with inputs from the results and calculations from the experimental data. An improved adaptive extended Kalman filtering algorithm was used to accurately estimate the state of charge. The main idea of using the improved adaptive algorithm is to update the statistical noise covariance parameters and to improve the estimation performance and accuracy. This reduced the interference of system noise*

effectively and minimized estimation error to the smallest value. An extended Kalman filtering algorithm was employed alongside the adaptive extended Kalman filtering algorithm to verify the effectiveness of the adaptive algorithm. Results and computations from the experiment and simulation are compared and the results show that the improved adaptive extend Kalman filtering algorithm has good convergence speed, is more stable, and has a high precision of accuracy in the estimation of the state of charge. The maximum estimation error realized with the use of the extended Kalman filtering algorithm was 4.97%, and the maximum estimation error based on the use of the improved adaptive extended Kalman filtering algorithm was 1.85%. The results, therefore, show that the adaptive algorithm adopted in this paper can be used efficiently and effectively for the accurate state of charge estimation of the high-power lithium-ion battery.

***Key words**: high-power lithium-ion batteries; battery management system; Thevenin equivalent circuit model; state of charge; adaptive extended Kalman filtering algorithm.*

***Language**: English*

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Introduction

Currently, lithium-ion batteries are perhaps the most important new energy source in the 21st century, and research in the area of improving and enhancing the performance of the technology through various techniques and methods is key to unearthing greater potential. The key to improving, controlling, monitoring, and managing the lithium-ion battery is the battery management system (BMS) [1], and the estimation of the state of charge (SOC), state of health (SOH), state of power (SOP), and other battery parameters is a very important research field that ensures the safety and reliability of electronic devices that use these batteries as a source of power. Research on the improvement of the function, reliability, and performance of lithium-ion battery technology is important and any breakthrough in the area would go a long way to improve upon the technology [2]. The BMS is responsible for measuring the states of the battery accurately and also ensure safe operation and prolong the battery life [3]. An improved Thevenin equivalent circuit model was proposed, designed, and implemented through experimentation and simulation. The model was achieved by adding an extra RC branch to the Thevenin model, making it a second-order resistor-capacitor. The 2RC Thevenin model has better accuracy, stability, robustness, and is very effective for SOC estimation [4]. This model was used to study and record parameters and estimate relationships between voltage, current, SOC, and the charging/discharging characteristics.

Research concerning battery management systems (BMS) from a global perspective includes those which display an entire BMS design adopting a distributed structure to reach better scalability and portability [5]. Different approaches to designing a BMS depend on the functionalities desired for the specific application, but most of them focus on key functions such as SOC estimation [6] and the balancing process [7]. The improvement is towards the design of intelligent BMS's for electric and hybrid electric vehicles [8], and artificial intelligence applied for the battery state estimation [9]. SOC estimation has therefore drawn the attention of many researchers, and many different methods have been proposed [10, 11]. The OCV method, a full charge detector/dynamic load observer, and the CC method with robust extended Kalman filtering algorithm (REKF) are combined in [12]. It is difficult to determine the specific approach when such methods are used, however, based on the classification made in [12, 13], two categories; direct and indirect methods, and several subcategories that summarize trends in SOC estimation are mentioned and aligned appropriately.

Battery models are used to study the relationship between the external characteristics and the internal states of a battery by establishing a mathematical model. Models in a discrete-time state-space form are also used for SOC estimation [14, 15]. Current literature makes mention of the use of equivalent circuit models (ECMs) as being widely used as a foundation for model-based estimation and control [16]. Generally, equivalent circuit models including the Rint model, the Thevenin model, the RC model, and the partnership for a new generation of vehicle (PNGV) model [17] are selected. The first-order RC, second-order RC, and third-order RC are all employed to accurately model the battery [18, 19]. Among them, the Thevenin model is widely used, but not accurate enough since all of its elements can change, depending on the condition and state of the battery.

According to [20, 21], to maximize parameter identification, new designs are being developed using charging/discharging, and [22, 23] combined SOC estimation methods as a means of estimating SOC in the presence of unknown or time-varying battery parameters. Research in the area either assumes an accurate SOC/OCV relationship or seeks to impose approximations such as OCV being piece-wise linear with SOC [24] or constant during discharging [25]. According to [11, 26], RC parameters are determined through analyzing the transients in a battery voltage

response under certain excitations such as constant or pulse current experiments. The voltage source in an ECM typically represents the battery's open-circuit voltage, which depends on the SOC [27]. A relationship between SOC and OCV can be identified by charging or discharging the battery using a small current [28]. Parameter identification based on current-voltage data is addressed in [21], by a method that reduces the problem of solving a set of high-order polynomial equations into solving several linear equations and a single-variable polynomial equation. A Thevenin ECM is used in [14] for every single cell in an array of more than 90 series-connected cells, to identify the internal resistance of each cell. In [29] a Thevenin model using two different branches for charge and discharge is connected in series n times to represent n cells in a series. According to [30, 31], there are three different ECMs of lithium-ion batteries widely adopted because of their excellent dynamic performance and postulates that the second-order ECM is the most accurate and has the best dynamic performance, but it is also the most complex. The Thevenin model and second-order ECM were used for SOC estimation and compared with three other enhanced ECMs in [14, 32] and the difference between these models is the way the SOC equations are calculated. The parameters of the second-order ECM can be calculated with different datasets depending on the purpose, like in [33]. In [34], a comparison between continuous-time and discrete-time equations of the second-order ECM is made and concludes that discrete-time identification methods are less robust due to undesired sensitivity issues in the transformation of discrete domain parameters.

According to [35], SOC can be directly calculated by the transformation of model equations with the deployment of a simple Thevenin ECM. In [36], a Thevenin ECM is used to obtain the OCV, and then, a linear fitting of a portion of the OCV–SOC curve is used to obtain the SOC. A similar process is used in [37] to obtain the SOC with a simple ECM that considers just a voltage source and an internal resistance. A Kalman filter (KF) is introduced in [38] to extract an OCV value in a noisy environment, and then to estimate SOC based on the OCV–SOC mapping. In addition to models, there are different types of closed-loop methods for SOC estimations, such as direct feedback [13], extended Kalman Filters [39], unscented Kalman Filters (UKF) [40, 41], and neural network [42, 43]. These methods are used to further improve the accuracy of the SOC estimation since they can recursively estimate the uncertainty of system state estimations and adapt Kalman gain to achieve optimal estimation in the next time step of the iteration process. It is common to find a combination of CC or OCV methods with the KF method like in [44, 45] and as proposed in [46, 47], the EKF method is also used in combination with CC and/or OCV. Another common improvement to the Kalman filtering algorithm for SOC estimation is the unscented Kalman filtering algorithm, which is used in [48, 49] to improve estimation accuracy. A UKF algorithm is implemented in [50] to estimate SOC using an improved ECM with a resistance and a capacitor correction factor. This was done to first, measure the effect of different current rates and the SOC estimation on the battery internal resistance, and secondly to identify the impact of different current rates and temperatures on the battery's capacity [51]. The works presented in [52, 53] use a multi-model approach that adopts a bank of EKFs to estimate the SOC of the battery. A robust extended Kalman filtering algorithm is implemented in [54] to be more robust to uncertainties in the system, and measurement equations, and noise covariances. A SOC estimation approach that uses an improvement in the measurement noise treatment is proposed in [55] and, by correcting the covariance matrix error in the depicted EKF, establishes an adaptive Kalman filtering algorithm that can reduce the estimation error. To deal with the variation of battery parameters due to temperature changes [56], an online approach is proposed for SOC estimation and parameter updating using a dual square root UKF based on unit spherical unscented transform.

To obtain a more accurate and reliable SOC, an improved Thevenin equivalent model is proposed and its parameters are identified. Experimental data results and simulated results are compared and analyzed to further appreciate the effectiveness of the improved adaptive extended Kalman filtering (AEKF) algorithm used. The use of the AEKF algorithm in this research is to accurately and diligently estimate the SOC and eliminate or reduce errors by updating the noise covariance matrix. The use of this adaptive extended Kalman filtering algorithm is an innovation in this work coupled with the 2RC Thevenin equivalent model for successful implementation and SOC estimation. According to the results realized, it is worth noting that, the SOC estimation using the AEKF algorithm is more accurate and reliable comparatively than the EKF algorithm. This paper is organized in sections as follows; The mathematical analysis is conducted in section 2, experimental analysis in section 3, and the last section is section 4 which coves conclusion and further research plan.

2. Mathematical Analysis

The basic concepts of SOC estimation, battery modeling, and the Kalman filtering algorithm are first introduced in this section. The improved Thevenin equivalent model including the 2RC's added as well as the description of corresponding parameters to be identified through experimentation are presented, the EKF and the improved AEKF algorithms are introduced in detail to emphasize the improvement in the SOC estimation accuracy.

2.1 The structure of the improved 2RC Thevenin equivalent model

An appropriate equivalent circuit model established and described, and the input, output, and state variables are determined. The modeling and simulation are done in Simulink/MATLAB and the parameters identified from the experimental data are used for real-time correction of variables like the internal resistor, capacitors, and current. Simulations are carried out and the results are verified to make sure the proposed method works perfectly for the accurate estimation of the SOC of the battery. The state of charge of the high-power lithium-ion battery is defined as the remaining capacity of the battery and is written mathematically as, the ratio of remaining capacity to the maximum available capacity and expressed as shown in Eq. (1).

$$SOC_t = \frac{Q_t}{Q_0} \times 100\% \tag{1}$$

Where Q_t is the residual capacity of the battery at time t and Q_0 is the rated capacity. The value of SOC is the ratio between the current residual capacity and the capacity in the fully charged state when the battery is fully static at a certain time.

2.1.1 Electrical circuit model

The improved Thevenin equivalent circuit model is suggested for experimental and simulation purposes to model the behaviour of the high-power lithium-ion battery. The dynamic system of the Thevenin model describes the fixed parameters as variables that vary with the state of charge and temperature, enabling a more accurate description of the performance of the battery. This method was adopted because the topology generally proposes a tradeoff between battery cell computational requirements and the approximation of voltage precision. The model is as shown in (figure 1).

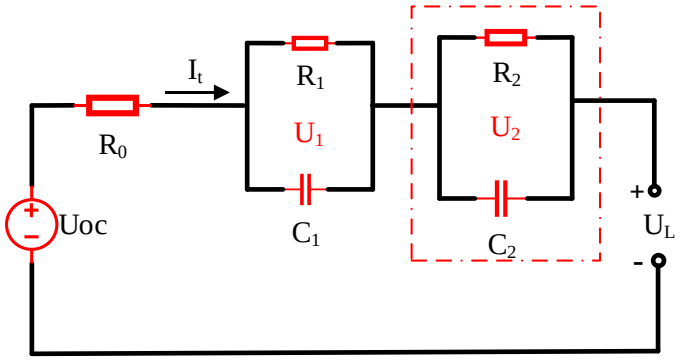


Figure 1: The 2RC Thevenin Equivalent Circuit Model

Where *Uoc* is the Open-Circuit Voltage, R_0 is the ohmic resistance of the battery, I_t is the charge/discharge current flowing from the voltage source and U_L represents the terminal voltage of the battery. R_1 and R_2 denote the electrochemical polarization resistance and concentration polarization resistance, respectively. C_1 and C_2 denote the electrochemical polarization capacitance and concentration polarization capacitance respectively.

2.1.2 State-space description

The state-space representation is a mathematical model of a physical system as a set of input, output, and state variables related to the first-order differential equations or difference equations. Concerning (figure 1) and the application of Kirchhoff's law, Eq. (2) is obtained and written as:

$$\begin{cases} U_L = U_{oc}(SOC) - i(t)R_0 - U_1 - U_2 \\ \dfrac{dU_1}{dt} = -\dfrac{U_1}{R_1C_1} + \dfrac{i}{C_1} \\ \dfrac{dU_2}{dt} = -\dfrac{U_2}{R_2C_2} + \dfrac{i}{C_2} \end{cases} \tag{2}$$

Where *[SOC, U_1, U_2]* is selected as the state variables which need to be realized and after discretization of Eq. (2) and considering the definition of SOC as stated earlier, its state space equation can be written as shown in Eq. (3)

$$\begin{cases} \begin{bmatrix} SOC_{k+1} \\ U_{1,k+1} \\ U_{2,k+1} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1-T/\tau_1 & 0 \\ 0 & 0 & 1-T/\tau_2 \end{bmatrix} \\ U_{L,k+1} = U_{oc}(SOC, k+1) - U_1 - U_2 - IR_0 \end{cases} \tag{3}$$

In the above equation, parameters that the model needs to identify include ohmic internal resistance *Ro*, open circuit voltage *Uoc*, polarization internal resistance R_1, R_2, and polarization capacitor C_1 and C_2

which will lead to identifying U_1 and U_2.

2.2 Iterative calculation algorithms

2.2.1 Extended Kalman filtering

The extended Kalman filter algorithm is used for predicting the future state of a system based on a previous state. Kalman filter is a linear unbiased recursive filter, which is constantly "predicted and corrected" in the calculation process. Whenever new data is observed, new predicted values can be calculated at any time, which is very convenient for real-time processing. Due to the discharge rate, temperature, and complex internal chemical reaction, the battery presents a nonlinear state. Based on Kalman, the Jacobian matrix is obtained by using the Taylor formula for linearization, and the extended Kalman filter algorithm is obtained. The extended Kalman filter consists of two equations; state equations and observation equations, which include *A, B, C*, and *D* matrices that can be realized using Ro, R_1, R_2, C_1, and C_2. x_k is the system state matrix that captures the system dynamics and one of the matrix values represents SOC. The input of the system is u_k which is a control variable matrix that is known or can be measured. w_k, is the noise of the system state equation. Eq.. (4) shows the state equation and the observation equation.

$$\begin{cases} X_k = AX_{k-1} + BI_{L,k-1} + w_k \\ U_{L,k} = CX_k + DI_{L,k-1} + v_k \end{cases} \quad (4)$$

Where, x_k represents the system state variable at time k, y_k is the system observed variable at time k, u_k is the system input which is used as the control variable; A_k is the transfer matrix of state x from k-1 to k, and B_k is the input matrix. C_k is the measurement matrix, D_k is the feedforward matrix; ω_k is the noise of the system state equation. Kalman filter algorithm is used for state prediction and estimation. Kalman filter is mainly composed of five equations, which can be divided into the prediction stage and correction stage. The recursive relationship between the estimated value of state and covariance in the prediction stage (Time Update): is shown in Eq. (5).

$$\begin{cases} \hat{X}_k^- = \hat{X}_{k-1} + BI_{L,k-1} + w_k \\ \hat{P}_{k|k-1}^- = A\hat{P}_{k-1}A^T + Q_w \end{cases} \quad (5)$$

According to the model, the last moment of the state estimate of *k-1*, X_{k-1} and its covariance matrix P_{k-1} directly calculates the forecast of this moment, X_k^- and its covariance matrix $P_{k|k-1}$. Q_w is the covariance matrix of process noise w_k. The estimated values of Kalman gain are calculated as shown in Eq. (6).

$$K_k = \hat{P}_{k|k-1}^- C^T \left(C\hat{P}_{k|k-1}^- C^T + v_k \right) \quad (6)$$

The state correction stage is then performed for further computations to arrive at an appropriate equation that can be used to effectively make sure the appropriate parameters are identified. This can be achieved as shown in Eq. (7).

$$\begin{cases} \hat{X}_k = \hat{X}_k^- + K_t \left(U_{L,k} - C\hat{X}_k^- \right) \\ \hat{P}_{k|k-1} = \hat{P}_{k|k-1}^- - K_t C\hat{P}_{k|k-1}^- \end{cases} \quad (7)$$

The moment of state estimation x_k and $P_{k|k-1}$ is realized after this and the Kalman filter algorithm is completed in one iteration, and an iterative estimation is carried out for each observation, with good real-time performance.

2.2.2 Adaptive extended Kalman filtering algorithm

Currently, the SOC estimation method is mainly based on the equivalent model combined with the Kalman filter algorithm and its extended algorithm as well as fuzzy logic and neural network-related algorithms. The Kalman filter (KF) algorithm is one of the most widely used intelligent algorithms, and it is usually used in practical situations, such as path planning, target tracking, and SOC estimation of lithium-ion batteries. The basic principle of the algorithm is to take the minimum mean square error as the best estimation criterion, and by establishing a state equation and an observation equation model, a state-space model of signals and noise is used to introduce the relationship between the state variables and the observed variables. Time estimates and observations of the current time, update the estimates of the state variables. The Kalman filter is a mathematical function that provides estimating states with iterative steps, in a way to minimize the mean squared error. This technique has been providing performance efficiency in the field of parameter estimation and state transition. The improved Thevenin equivalent circuit model of the lithium-ion battery can be simplified as shown in Eq. (8).

$$\begin{cases} x_{k+1} = f(x_k, u_k) + w_k \ldots\ldots = \mathrm{A}_k x_k + \mathrm{B}_k u_k + w_k \\ y_k = h(x_k, u_k) + v_k \ldots\ldots = C_k x_k + \mathrm{D}_k u_k + v_k \end{cases} \quad (8)$$

The functions f (*) and h (*) are nonlinear equations and the first equation is the state equation, where x_k is the n-dimensional system state vector at time point k, and v is the n-dimensional system noise vector. The function f (x_k, u_k) is a non-linear state transition function. The second equation is an observation equation, where y is an observation vector, and v is a multi-dimensional system interference vector at time point k. The function h (x_k, u_k) is a non-linear measurement function. The above function can be explored by using the Tailor method on the prior estimation point x_k of the state x_{k+1}. The higher-order components of the process can be ignored, and linear approximations of off (*) and h (*) can be used as shown in Eq. (9).

$$\begin{cases} f(x_k,u_k) \approx f(x_{k|k-1},u_k) + \left.\dfrac{\partial f(x_k,u_k)}{\partial x_k}\right|_{x_k=x_{k|k-1}} (x_k - x_{k|k-1}) \\ h(x_k,u_k) \approx h(x_{k|k-1},u_k) + \left.\dfrac{\partial h(x_k,u_k)}{\partial x_k}\right|_{x_k=x_{k|k-1}} (x_k - x_{k|k-1}) \end{cases} \quad (9)$$

The estimation process of the Kalman filter algorithm includes a time update and measurement update. The time update process is also known as the forecast process. It is a one-step prediction of the current state variable and provides a prior estimation process for the next moment. The measurement update process is the process of feeding back observations and correcting deviations. The EKF algorithm equations are as follows.

1. The filter initial conditions given in terms of the one-step prediction means the first state prediction has the same statistics as the initial condition of the system. The initial condition of the filter equation is given as:

$$x_0 = E(x), P_0 = \mathrm{Var}(x) \quad (10)$$

2. When EKF is used to estimate the SOC of the lithium-ion battery, the SOC is a component of the state vector, the current is used as control quantity in the input parameters and the output is terminal voltage. The state vector estimation time update is given as:

$$x_{k|k-1} = f(x_{k-1},u_{k-1}) \quad (11)$$

3. The state covariance time update process predicts the current state variables by updating them and providing a prior estimate of the next time. State covariance update time update is given as:

$$P_{k|k-1} = FP_{k-1}F^T + Q_k \quad (12)$$

4. The Kalman gain is the relative weight given to the measurements and current state estimate and can be manipulated to achieve a particular performance. The calculation of the Kalman gain coefficient is given as:

$$K_k = P_{k|k-1}H^T(HP_{k|k-1}H^T + R_k) \quad (13)$$

5. The measurement update process, also known as the correction process, is a process of feedback on the observed values and the correction of the deviation. The state vector measurement update is given as:

$$x_k = x_{k|k-1} + K_k(y_k - h(x_{k|k-1},u_k)) \quad (14)$$

6. The state covariance matrix consists of the variances associated with each of the state estimates obtained and the correlation between the errors in the state estimates. The update state covariance matrix is given as:

$$P_k = (I - K_kH)P_{k|k-1} \quad (15)$$

In the above equations, $x_{k|k-1}$is the direct time estimate at time k, x_{k-1} is the optimal estimate state value at the last moment. P_k is the covariance update of x_k, Q_k is the covariance of process noise w, K_k is the Kalman gain coefficient. R_k is the covariance of observation noise v. Since the covariance matrix P_k is decomposed, at least it is guaranteed that P_k is always non-negative definite, which can overcome the filter divergence caused by the limited word length of the computer. Sage-Husa algorithm adaptively updates the noise variables by comparing the final and initial estimated values. The estimator-related quantities are calculated as shown in Eq. (16).

$$\begin{cases} \tilde{y}_k = y_k - h(x_k,u_k) - R_{k-1} \\ Q_k = \dfrac{1}{k}\sum_{i=0}^{k-1}\left(K_k\tilde{y}_k\tilde{y}_k^TK_k^T + P_k - FP_{k|k-1}F^T\right) \\ R_k = \dfrac{1}{k}\sum_{i=0}^{k-1}\left(\tilde{y}_k\tilde{y}_k^T - HP_{k/k-1}H^T\right) \end{cases} \quad (16)$$

To make the estimation of noise more accurate and to avoid the influence of the observed value on the estimated value, this paper considers the noise at the previous moment and the current moment at the same time. In practice, the smaller the value of b, the smaller the impact at the previous moment; if the value of b is small, the estimated noise will oscillate, so it can be determined according to the specific situation. Then the calculation of the noise matrix is as shown in Eq. (17).

$$\begin{cases} Q_k = (1-d_{k-1})Q_{k-1} + d_{k-1}\left(K_k\tilde{y}_k\tilde{y}_k^TK_k^T + P_k - FP_{k/k-1}F^T\right) \\ R_k = (1-d_{k-1})R_{k-1} + d_{k-1}\left(\tilde{y}_k\tilde{y}_k^T - HP_{k/k-1}H^T\right) \end{cases} \quad (17)$$

2.2.3 Iterative calculation process

After obtaining the main parameters in the 2RC Thevenin equivalent circuit model, the state space equation is obtained using the relationship between

voltage and current as shown in Eq. (18).

$$\begin{cases} E(t) = U_L + R_1 I(t) + u(t) \\ I(t) = \dfrac{u(t)}{R_2} + C\dfrac{du}{dt} \\ SOC(t) = SOC(t_0) - \dfrac{1}{Q_0}\int_{t_0}^{t} \eta i(t)dt \end{cases} \quad (18)$$

The three equations above are combined and discretized to obtain the state equation needed to perform further calculations leading to the conversion of non-discretized parameters into discretized ones as shown in Eq. (19).

$$\begin{cases} x(k|k-1) = A_k x(k-1) + B_k i_{k-1} + w_k \\ A_k = \begin{pmatrix} 1 & 0 \\ 0 & e^{-t/\tau} \end{pmatrix} \\ B_k = \begin{pmatrix} -\dfrac{t}{Q_0} \\ R_2(1-e^{-t/\tau}) \end{pmatrix} \end{cases} \quad (19)$$

It is important to also consider the observation equation for further successful computation and attainment of accurate results. The next thing to do therefore is the observation equation which is shown in Eq. (20).

$$y_k = h(x_{k-1}, i_{k-1}) + v_k = U_{oc} - R_1 i_k - u_k + v_k \quad (20)$$

The parameters of the battery are initially non-linear variables and have to be linearized. After linearization, using the first-order Taylor series with the values of A_k, B_k, and C_k, the formulas are obtained as shown in Eq. (21).

$$\begin{cases} \hat{A}_k = \begin{pmatrix} 1 & 0 \\ 0 & e^{-t/\tau} \end{pmatrix} \\ \hat{B}_k = \begin{pmatrix} -\dfrac{t}{Q_0} \\ R_2(1-e^{-t/\tau}) \end{pmatrix} \\ C_k = \left(\dfrac{\partial u_{oc}}{\partial s_{oc}}, -1\right) \end{cases} \quad (21)$$

In performing the mathematical calculation for the algorithm, there are a few steps to follow to achieve this. The first step is known as the state prediction stage. The predicted value at time k is calculated as shown in Eq. (22).

$$x(k|k-1) = A_{k-1}x(k-1) + B_{k-1}i_{k-1} \quad (22)$$

The second step in this calculation is the prediction of the covariance matrix. This is done by calculating the estimation error of *x(k|k-1),* the covariance matrix of the corresponding *x(k|k-1)* is obtained as shown in Eq. (23).

$$P(k \mid k-1) = A_{k-1}\hat{P}_{k-1}A_{k-1}^T + Q_k \quad (23)$$

The Kalman gain is calculated in the third step to further improve the computation and arrive at the value for a specific time. The Kalman gain at time k is obtained as shown in Eq. (24).

$$K_k = P_k C_k^T (C_k P_k C_k^T + R_k)^{-1} \quad (24)$$

The fourth step is the update of the status. The optimal estimated value of the existing state is estimated from the real-time measured/obtained open-circuit voltage value Uoc(k) as shown in Eq. (25).

$$\hat{X}_k = x(k|k-1) + K_k\left[U_{oc}(k) - C_k * x(k|k-1)\right] \quad (25)$$

In the fifth step, the noise covariance is updated. The noise covariance is updated according to the Kalman gain. This helps to avoid errors or at least minimize them and leads to accurate estimation. The noise covariance of the previous moment is shown in Eq. (26).

$$\hat{P}_k = (1 - K_k C_k)P_k \quad (26)$$

In the calculation, the five steps are continually cycled in a loop, and the estimated state is continuously updated so that the estimated value is closer to the true value during the update process. The basic iterative calculation process for SOC is as shown in (figure 2).

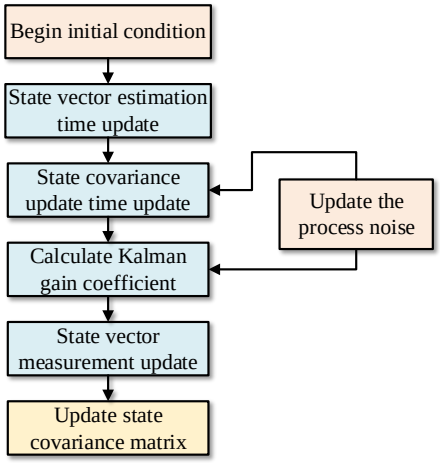


Figure 2: The SOC estimation process using the AEKF algorithm

2.3 Model building and Realization

2.3.1 Simulink/MATLAB Simulation model

After obtaining the required circuit model parameters, the simulation model of the lithium-ion battery is established in Simulink/MATLAB. The simulation model has mainly composed of the SOC calculation module, the circuit parameter updating module, and the terminal output voltage calculation module. The SOC calculation module is based on the extended Kalman filtering algorithm and the Improved Adaptive extended Kalman filtering algorithm. SOC values are obtained through the use of the codes for calculations based on the algorithms and to prevent the battery from overcharge and over-discharge. In this work, the influence of temperature change on the output voltage of the lithium-ion battery is ignored. For the time-domain ordinary differential equation of the 2RC Thevenin equivalent circuit, the corresponding voltage response equation is solved and discretization as it is required before modeling to obtain the discretization state-space equation of the model. The logical structure of the circuit model is shown in (figure 3).

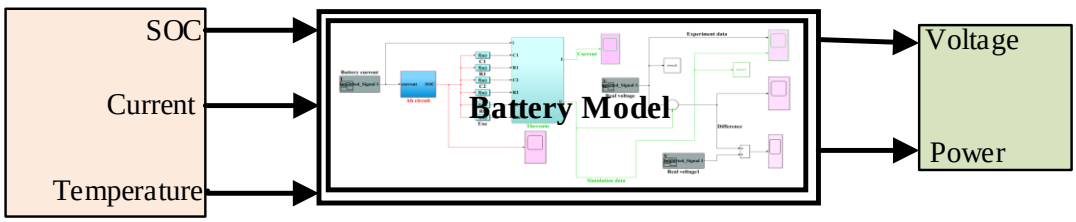


Figure 3: Logical structure of the circuit model

In the battery management system, both current and terminal voltage are input, as the battery simulation model is to verify the accuracy of the parameter settings in the model, the current is input and terminal voltage is the output. The simulation module can be built and the second-order RC internal circuit is the core part of the whole module, and the circuit structure is directly used to build the module, including an ohmic internal resistance, two RC parallel structures, a controllable voltage source, and controllable current source, voltage, and current sensor, and input and output interface, as shown in (figure 4).

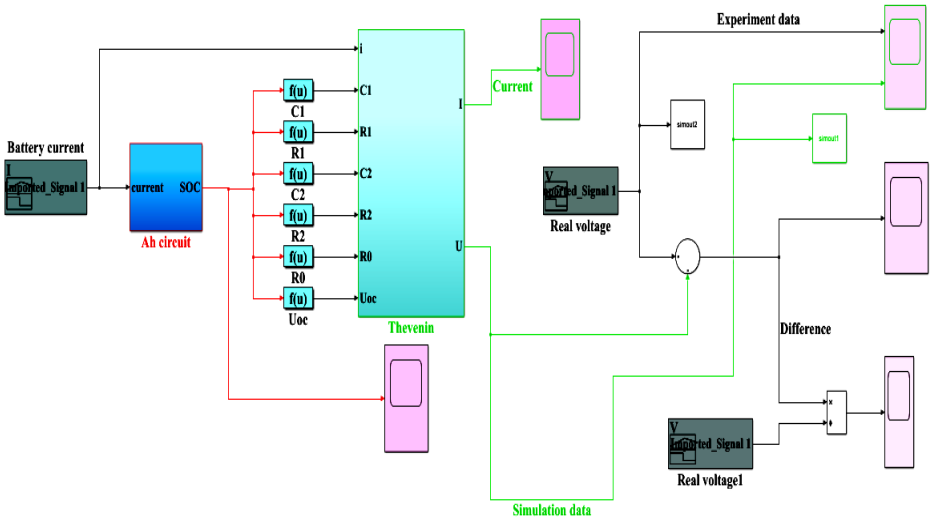


Figure 4: The Simulation Model of the 2RC Thevenin equivalent model

(Figure 5) shows the internal component of the model in (figure 4) representing the proposed 2RC Thevenin equivalent circuit model. The necessary inputs and outputs are labeled and other components are duly presented in the figure based on the proposed model.

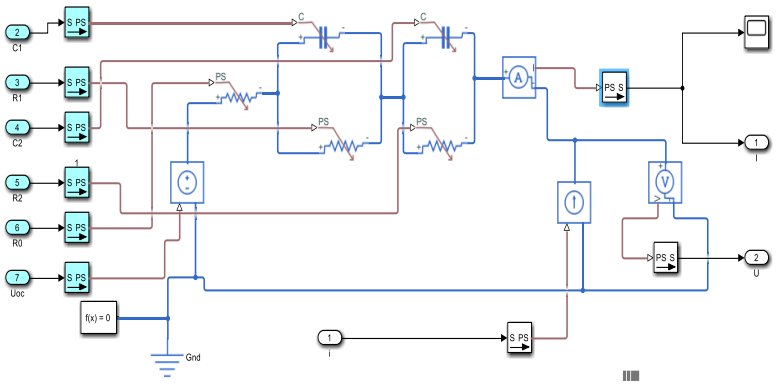


Figure 5: The internal circuit of the 2RC Thevenin equivalent model

Controllable voltage source and controllable current source are the signal interface in SIMULINK, which can turn the signal into a material port. Convert the external input voltage source into a voltage and current source that the circuit can connect to. Voltage sensors and current sensors are also signal transducers, converting physical interfaces into signal interfaces. The extended Kalman filtering algorithm and the Adaptive extended Kalman filtering algorithm are coded into the simulation model and the complete diagram is shown in (figure 6).

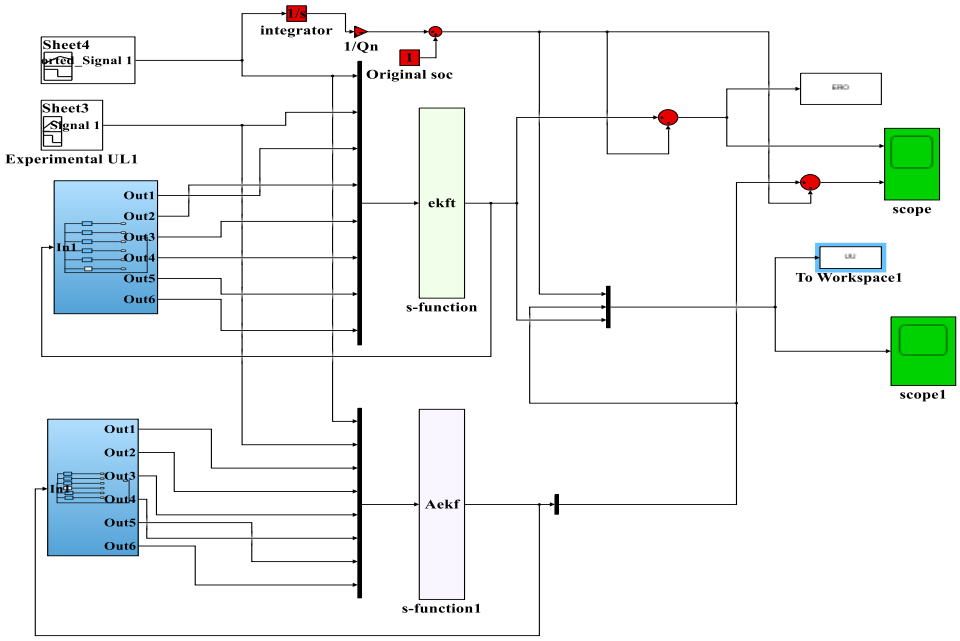


Figure 6: Integration of algorithms into the simulation diagram

3. Experimental Analysis

3.1 Test platform construction

The GTK 3.7V 40Ah high-power lithium-ion battery was used for this experiment with a rated capacity of 40 Ampere hour (Ah), a charge cut-off voltage of 4.2V, and a discharge cut-off voltage of 2.75V. The test equipment is the sub-source BTS 750-200-100-4, with a maximum charge-discharge power of 750W, a maximum voltage of 200V, and a maximum current of 100A. The basic properties of the battery are shown in table 1.

Table 1: Basic technical parameters of the battery

Factor	Specification
Size: length * width * height/ mm	148×27×92
Rated voltage/V	3.7
Maximum load current /A	5C
Rated capacity/Ah	40
Charge cut-off voltage/V	4.2
Discharge cutoff voltage/V	2.75

Setting up the experiment requires the connection of the battery to the test machine which is also connected to a computer. A specific terminal is chosen from the 16 available, and connect to the battery for the experiment to commence. The software on the computer is then programmed to follow a logical algorithm to accomplish the task.

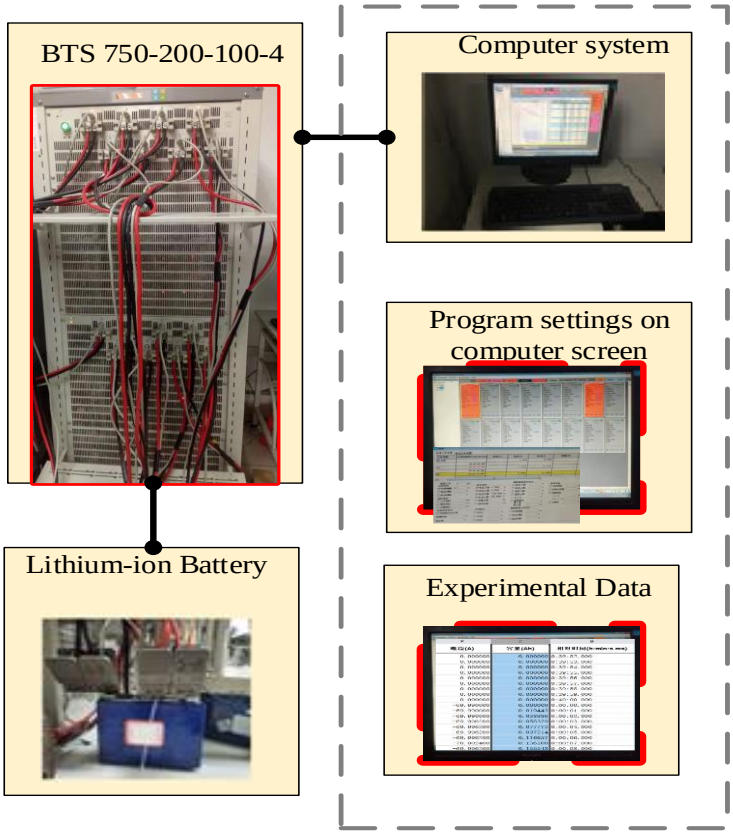


Figure 7: Experimental Setup

3.2 Results, verification, and comparison

3.2.1 Parameter identification and extraction

The Open-Circuit Voltage test:

The open-circuit voltage (OCV) of the battery is the stable voltage value of the battery when the battery is left in the open circuit condition. The test was performed on the Lithium-ion battery to acquire data for parameter identification. Using the Ampere hour (Ah) method, the real capacity of the battery is determined and used in the programming during the experiment. After charging the battery, the battery terminal voltage will gradually decline to a stable value when it is left in the open circuit condition and after discharge, the battery terminal voltage will gradually rise to a stable value when the load is removed. The electromotive force of the battery is equal to the open-circuit voltage of the battery. The battery electromotive force is one of the metrics used to measure the amount of energy stored in the battery. The relationship between the battery OCV and the battery SOC can be attained through this experiment. There are a few ways to obtain the open-circuit voltage of a battery and include the stationary method, also known as the direct method which is relatively more accurate.

The program that controls the experiment which resides on a computer connected to the battery testing machine (BTS 750-200-100-4) is then set to follow conditions to obtain a flow chart of the processes involved in the experiment. The test consists of simple steps and follows a logical sequence with a loop that ensures continuity and data capture at relevant SOC points. The first step is the capacity test that calibrates the capacity of the battery and the subsequent steps capture the OCV of the battery at specific SOC points.

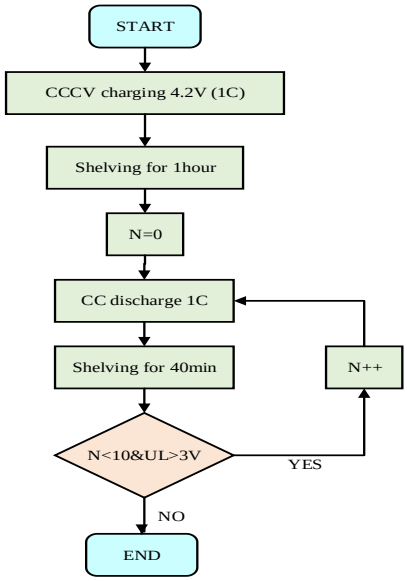


Figure 8: OCV experiment process

In the test, the measured voltages at the end of each standby stage are regarded as the final open-circuit voltage. All the values of the open-circuit voltages at different SOC's are measured and recorded. Table 2 shows the OCV data obtained at the various levels of SOC. These values were extracted and used for the curve fitting that reveals the relationship between OCV and SOC and further used to obtain the polynomial equation for further calculations.

Table 2: Values from the SOC/OCV test

SOC	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
OCV	4.1914	4.0628	3.9521	3.8529	3.7602	3.6852	3.6393	3.6188	3.5645	3.4886

The OCV/SOC values were imported and using the curve fitting tool, a relationship was realized through the use of a polynomial fitting. The variation of OCV with SOC obtained through the experimental method is shown in (figure 9).

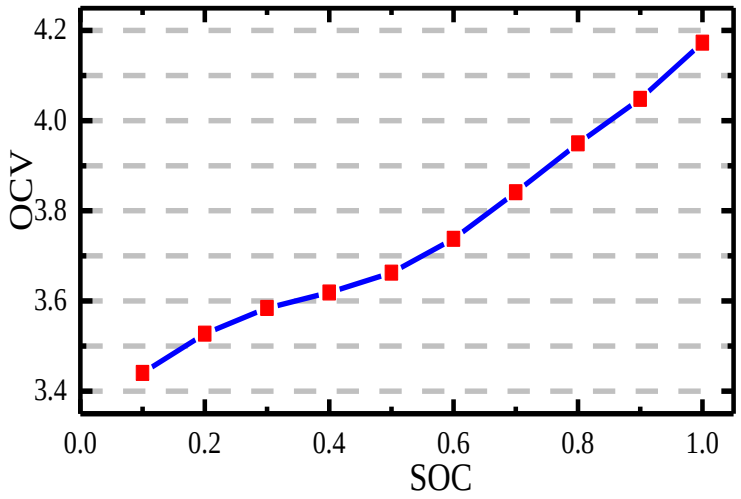


Figure 9: OCV/SOC Curve fitting

The capacity and Hybrid Pulse Power Characterization (HPPC) Test:

The experiment is performed as a method for parameter identification of the Thevenin model and then data from the test conducted is analyzed and used in equations to calculate the parameters. Taking the GTK 3.7V 40Ah high-power lithium-ion battery as the research object, the battery test equipment was is BTS750-200-100-4. The HPPC experiment was conducted on the lithium-ion battery according to the "American Freedom CAR battery experiment manual". The single HPPC working step was to take 1C (current 40A) constant current 10s, shelve for 40s, and 1C (current 40A) constant current charge 10s, and then shelve. The Capacity and HPPC experiments performed on the high-power lithium-ion battery were conducted according to the following steps.

1. The battery is fully charged using a constant current of 1C followed by a constant voltage of 4.2V. Then, the battery is discharged with a constant current to its discharge cut-off voltage of 2.75V. The experiment is repeated three (3) times for the difference between the discharge capacity of each measurement not to exceed 2%, and then the measured capacity is deemed to be the actual capacity of the battery.
2. The battery is left in the open-circuit condition to rest for 40 minutes to achieve electrochemical and heat equilibrium. After performing step (1) on the lithium-ion battery, SOC = 1.
3. Discharge the experimental battery at a constant current of 1C for 10s, leave it for 40s, and charge at 1C for 10s, then leave it.
4. Discharge the battery with a current value of 40A for 6 minutes to decrease the battery SOC to the next SOC point and leave it for 30 minutes.
5. Repeat steps (3) (4) 9 times to obtain the complete data for the test.

The HPPC test is carried out using simple steps in order to obtain the necessary values needed for parameterization and further computation as far as the research is concerned. The experimental process of the HPPC test can be seen in (figure 10).

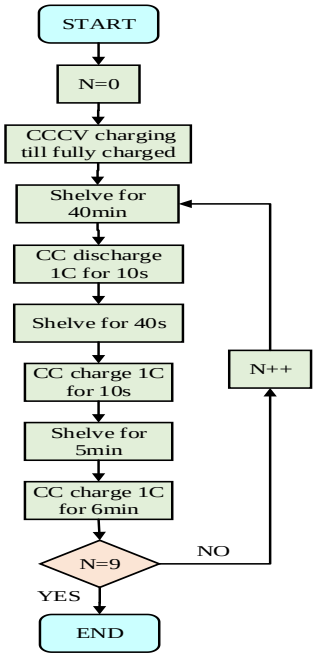


Figure 10: HPPC test process

Through parameter identification, the functional relations of resistance, capacitance, voltage, and SOC were obtained. Then, the circuit module was built in Simulink/MATLAB. The module contains other submodules that assist in the processing, calculation, and optimization of the interface for better simulation. The EKF and the improved AEKF algorithms were incorporated in this module as well. The parameters identified in the experiment and subsequent use in SOC estimation are compared with the results from the simulated. This can be obtained by simulating the construction and the design of function to operate on is completed. Through direct comparison of the curves, the error in parameter identification can be observed and manipulated by changing the value of parameter input, and the optimal simulation model can be obtained by modifying the functions.

The experimental results from the OCV and HPPC tests are used as the basis for parameterization. The test was conducted at 0.1 SOC intervals from 1.0 to 0.1. When a current *I* is loaded, a voltage rise or drop appears when there is a pulse charge or discharge and this can be used to calculate the parameters. (Figure 11) shows the test data for SOC at 0.9.

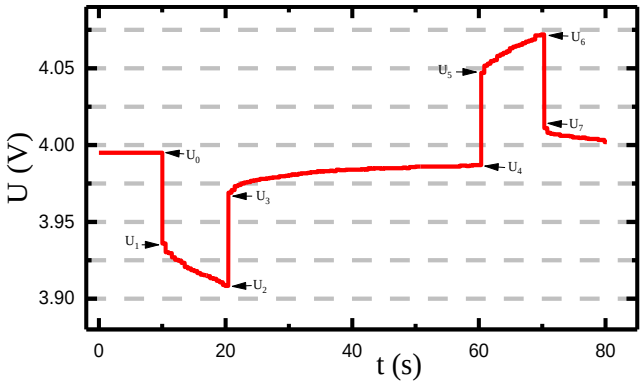


Figure 11: Voltage curve for a specific SOC

The labels U_0 to U_7 represent values for various segments of the curve corresponding to the battery during the experiment. U_0-U_3 and U_4-U_7 show the discharge characteristics and charging characteristics of the battery respectively.

1. The U_0-U_1 segment shows the ohmic internal resistance Ro, which depicts the rapid drop of the voltage at the moment of discharge of the battery.
2. U_1-U_2 shows the steady drop in terminal voltage due to the polarization capacitor which is due to the polarization effect of the battery as it is being charged. This polarized capacitor is the zero-state response of the 2RC series loop.
3. U_2-U_3 shows the resting of the battery and the disappearance of the load current, the ohmic voltage disappears, and the rapid rise of the terminal voltage.
4. U_3-U_4 shows the steady rise of the terminal voltage as the polarization capacitance discharges through the polarization resistance, forming a zero-input response of the 2RC series loop.

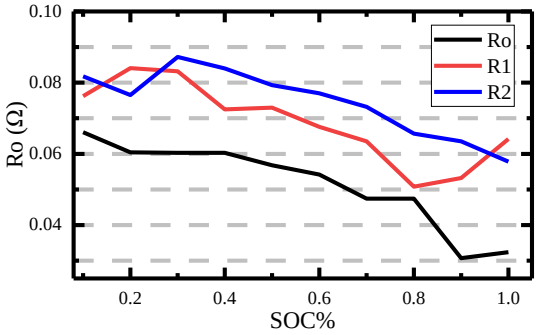
The opposition to the flow of the current offered by the battery itself resulting in the generation of heat is measured in Ohms. Based on the voltage drop from U_0 to U_1 for each of the SOC's, the ohmic resistance R_0 can be deduced. The value of (R_1, R_2, C_1, C_2) as seen in the Thevenin equivalent circuit diagram is to make it stable and achieve possible desired outcomes. Whenever the potential of an electrode is forced away from its value at the open-circuit, R_1 is calculated. This causes current to flow through electrochemical reactions that occur at the electrode surface. The value of R_1 can be determined using the voltage response of the battery cell to a discharging current pulse and voltage and can be calculated using the difference in voltage (U) over the current *I*. The build-up of solutes on the membrane surface due to convective-diffusive transport in the boundary layer which can be linked to R_2 can be determined and calculated using the difference in voltage (U) over the current *I*. A capacitor is formed when two conducting plates are separated by a non-conducting media called the dielectric. The value of the capacitance depends on the size of the plates, the distance between the plates, and the properties of the dielectric. The part of the polarization of the battery resulting from changes in the electrolyte concentration due to the passage of current through the electrode C_2 is determined.

With these equations, the information can be used to derive values of the parameters. This data can then be simulated in Simulink MATLAB for verification and validity of the values and the modeling of the 2RC Thevenin equivalent circuit. Table 3, shows the data acquired after the calculations.

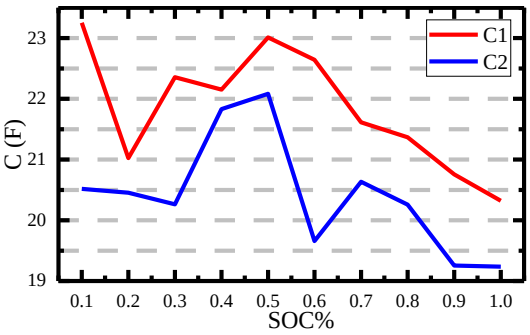
Table 3. The model Parameter calculation result

SOC	OCV/V	*Ro*/mΩ	R_1/mΩ	R_2/mΩ	$C_1/10^3$ F	$C_2/10^3$ F
1.0	4.1914	0.0324	0.0642	0.0578	20.3215	19.2359
0.9	4.0628	0.0307	0.0532	0.0635	20.7558	19.2560
0.8	3.9521	0.0474	0.0508	0.0657	21.3673	20.2565
0.7	3.8529	0.0474	0.0635	0.0732	21.6135	20.6354
0.6	3.7602	0.0542	0.0676	0.0770	22.6417	19.6580
0.5	3.6852	0.0568	0.0730	0.0793	23.0131	22.0827
0.4	3.6393	0.0603	0.0725	0.0840	22.1528	21.8318
0.3	3.6188	0.0603	0.0832	0.0872	22.3564	20.2624
0.2	3.5645	0.0604	0.0841	0.0765	21.0251	20.4528
0.1	3.4886	0.0661	0.0762	0.0818	23.2540	20.5187

The values of the internal Ohmic resistance R_0, the electrochemical polarization resistance R_1, and concentration polarization resistance R_2 calculated from the proposed 2RC Thevenin equivalent circuit are compared in (figure 12(a)). The values of the electrochemical polarization capacitance C_1 and the concentration polarization capacitance C_2 calculated from the 2RC Thevenin equivalent circuit are compared in (figure 12(b)).



(a) Resistance identification result



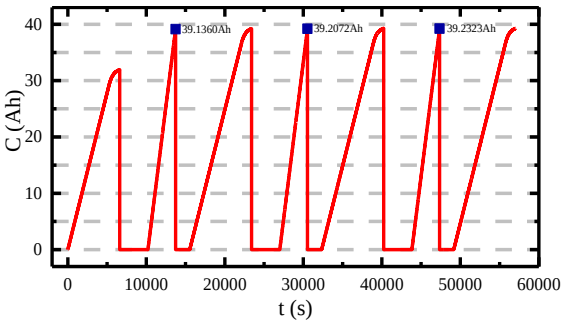
(b) Capacitance identification result

Figure 12: comparison of the identified parameters

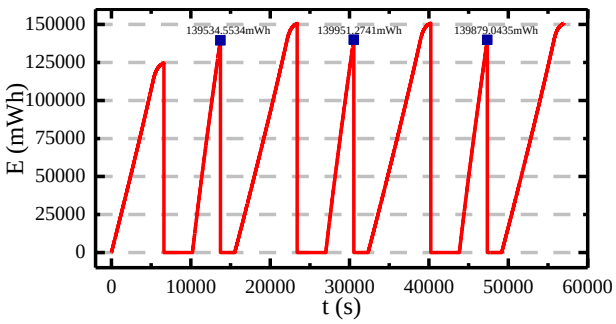
According to the result, it can be observed from (figure 12(a)) that, the internal resistance R_0 decreases steadily as state-of-charge increases. The electrochemical polarization resistance R_1 first increases and then decreases with an increasing SOC and then increases again as SOC approaches the highest point. The concentration polarization resistance R_2 first decreases then increases sharply and gently decreases as SOC increases. From (figure 12(b)), the results show the variation in the curves of the two capacitances are somewhat similar and seem to be fluctuating as SOC increases and finally decreases when SOC is above 0.7 till it reaches the highest point.

3.2.2 Capacity test result

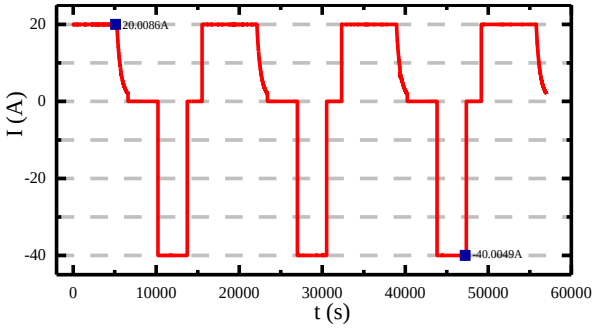
The capacity experiment was conducted for calibration of the capacity, current, energy, and voltage of the battery. According to the capacity experiment, these various parameters can be deduced and compared with the information provided by the manufacturer to compare and see if the experiment was successful or not. (Figure 13(a)) is the Capacity variation curve with time and it can be deduced from the figure that the Capacity of the battery is approximately 40Ah. Three maximum values obtained in the experiment are 39.1360Ah, 39.2072Ah, and 39.2323Ah.



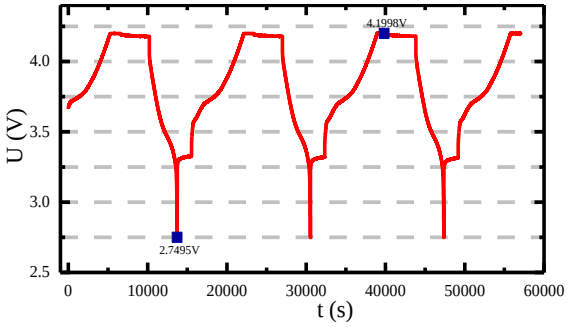
(a) Capacity variation curve



(b) Energy variation curve



(c) Current variation curve



(d) Voltage variation curve

Figure 13: capacity test results

(Figure 13(b)) shows the energy variation curve and displays three maximum energy values obtained in the experiment as 139.534Wh, 139.951Wh, and 139.879Wh. The energy of the battery is therefore approximately 140Wh. The energy variation curve fluctuates in the whole process since its main purpose is to charge the lithium-ion battery when the constant-current charge-discharge interval is carried out. (Figure 13(c)) shows the current variation curve of the capacity test and displays the maximum and minimum current values obtained in the experiment as 20.0086A, and -40.0049A respectively. (Figure 13(d)) shows the voltage variation curve and displays the maximum and minimum values obtained in the experiment as 4.1998V which is approximately the maximum voltage of the battery stated as 4.2V and 2.7495V approximately 2.75V stated earlier as the minimum voltage of the battery.

The comparison of the current and voltage curves from the experiment and how the variation is depicted to achieve the capacity of the battery. The current flow and the voltage can be seen and analyzed from (figure 14).

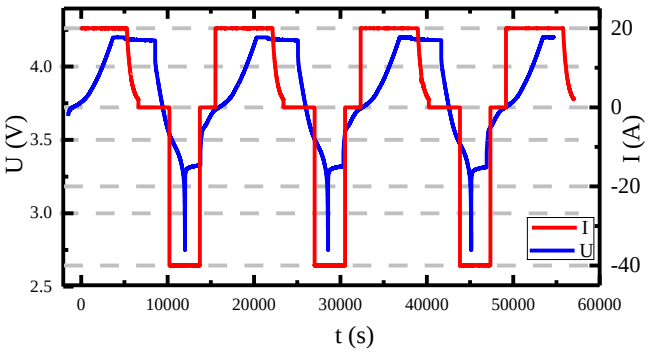
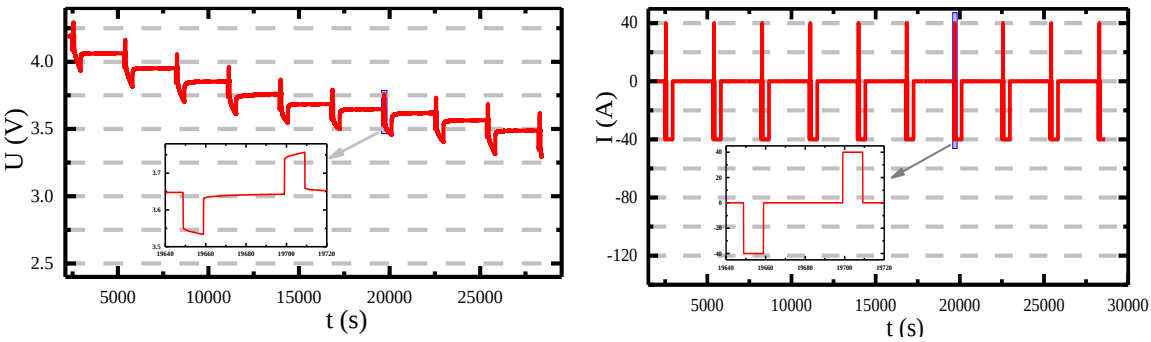


Figure 14:Voltage/Current discharge variation curve

3.2.3 HPPC test results

The result from the HPPC test was used to identify each OCV at specific SOC points. The voltage curve is also useful in the identification of battery parameters. (Figure 15(a)) and (b) shows the schematic diagram of the HPPC terminal voltage and current curves with time respectively and illustrates the mechanism of the HPPC experiment throughout the test. The figure also emphasizes one of the SOC points for reference and shows the single charge and discharge variation in the experiment.



(a) Voltage variation curve **(b) Current variation curve**

Figure 15: HPPC test result

From the result, it can be observed that as the number of cycles increases, the battery terminal voltage assumes a downward trend. The current variation reveals that, as the number of cycles increases, the discharge current increases. (Figure 16) shows the comparison of the voltage and current curves from the HPPC experiment and the variation with time. The overlaying curves shown in the figure depict the real or actual occurrence with the battery at specific times.

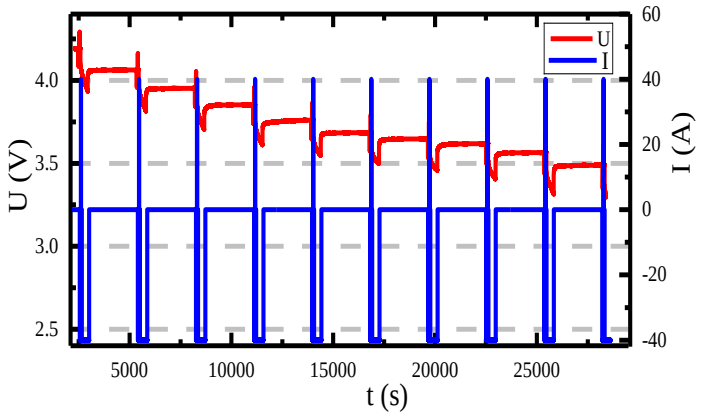


Figure 16: Voltage/Current discharge variation curve

3.2.4 SOC estimation result

The experimental results and parameterization did then used for SOC estimation. (Figure 17) shows the estimation depicting a downward slope with time as SOC reduces from 1 to 0.1. The result shows a gradual decrease and fluctuating trend which is because there is a process of alternating charge and discharge during the experiment with the discharge time longer than the charging time.

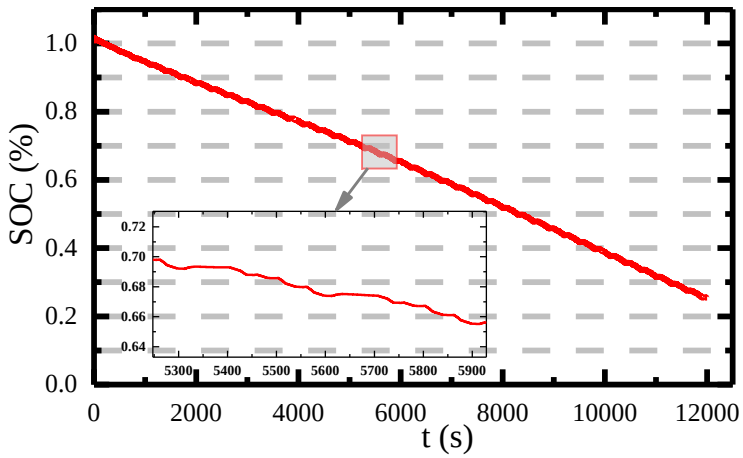


Figure 17: SOC variation curve

3.3 Verification of research results

3.3.1 Voltage characteristics

The 2RC Thevenin equivalent circuit model is established through parameterization with the HPPC experimental results. To verify the validity of the SOC estimated values in the simulation, the results are compared with and the results from the HPPC experiment and the computations done thereafter. The value of current (*I*) in the experimental data obtained by the test equipment is taken as the input condition, and the simulation terminal voltage is obtained through the simulation model and the experimental terminal voltages are compared to obtain the results as shown in (figure 18).

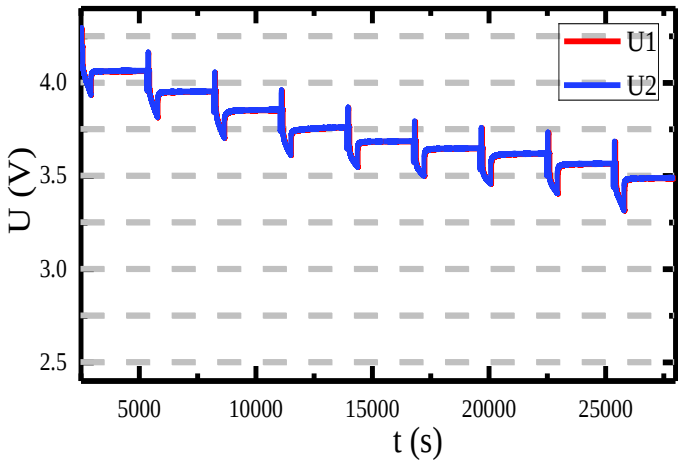
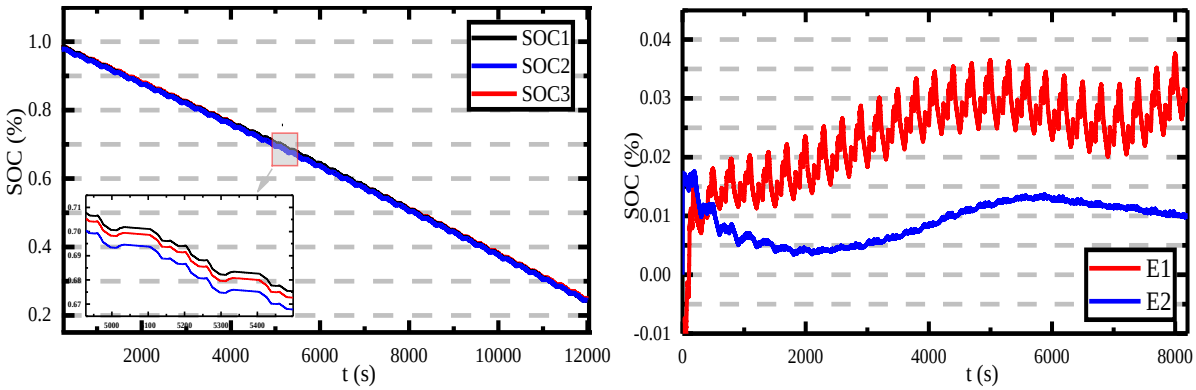


Figure 18: Comparison of voltage variation curves

Where U1 is the change curve of real terminal voltage data obtained through the HPPC test while U2 is the output terminal voltage curve obtained through the simulation model. The figure shows the variation trend of both the experiment and simulation curves is similar to that of the actual test curve. This means that the results can be verified and authenticated as appropriate for use in any calculation toward the accurate estimation of SOC.

3.3.2 Comparison and Verification of SOC estimation result

To illustrate the adaptability and performance of the improved adaptive Kalman filtering algorithm, for SOC estimation, Beijing Bus Dynamic Stress Test (BBDST) working condition experiment was designed and the effectiveness of the algorithm for accurate SOC estimation was compared with the extended Kalman filtering algorithm. SOC estimation results from the proposed model and the use of the two algorithms; the extended Kalman filtering algorithm and the adaptive extended Kalman filtering algorithm are then compared to assess and verify the validity and efficient performance of the model and algorithms implemented. The three methods are compared as shown in (figure 19). It can be observed from the figure that the three methods all follow the same trend and have a good convergence. The same figure also shows the difference in error margin comparing the use of the EKF and the AEKF estimation curves with that of the true SOC curve.



(a). comparison of SOC estimation curves **(b). SOC estimation Error**

Figure 19: SOC variation curves for three different methods

(Figure 19(a)) is the result of SOC estimation for three different methods. SOC1 is the true SOC value, and SOC2 is the SOC estimate using the extended Kalman algorithm and SOC3 is the SOC estimation using the adaptive extended Kalman filter. (Figure 19(b)) is the error curve obtained through the difference in SOC values of the two algorithms. The error of SOC estimation using the extended Kalman is around 4.97%, and the error of SOC estimation using the improved adaptive extended Kalman algorithm is less than 1.85% and has a strong correction function.

In recent years, researchers have proposed some new estimation methods to help correct the errors with especially the traditional SOC estimation methods. The use of these improved and adaptive methods would reduce the estimation errors as much as possible and improve the estimation accuracy. In the actual battery management system, the methods to estimate the SOC of the battery are all traditional, and most of these new methods are only in the theoretical

research or simulation stage.

4. Conclusions and Further Research Plan

In the quest to improve the accuracy and reliability of the lithium-ion battery state of charge estimation in this study, the 2RC Thevenin model was established and the parameters were obtained. This model was used due to its advantages of low error, long-term testing, and accounting for polarization effects and transient analysis for power battery charging and discharging. The steps used in the experiment were simple and convenient, and the algorithm complexity, very moderate making the experimental results obtained accurate and appropriate for parameterization. The maximum relative errors of the 2RC Thevenin equivalent models using both algorithms were all less than 4.97%, which can generally satisfy the precision requirements for practical engineering calculation, such as algorithms based on ECM for advanced BMSs. The choice of an adaptive law for the process noise covariance matrix shows an improvement in estimation performances. In terms of maximum estimation error, the EKF result was 4.97%, while with AEKF this range reduced up to 1.85%. The extended Kalman filter algorithm used effectively reduces the influence of nonlinear equations and successfully realizes the SOC estimation of the battery. The improved adaptive extended Kalman filter algorithm for SOC estimation used in this work can effectively and accurately estimate the battery SOC and has high precision compared to the extended Kalman algorithm. The results are of great instructional significance to the application in practical control systems for the equivalent circuit modeling of batteries. The improved adaptive extended Kalman filter algorithm has good convergence speed, higher estimation accuracy, and stability and is appropriate and convenient for SOC estimation. Therefore, for stringent applications such as automotive and high-power demanding devices, the second-order RC model could be the preferred choice, and the use of an adaptive algorithm for SOC estimation would be better for accurate and timely information.

For further and future research, it is important to perform several experiments to acquire necessary experimental data for analysis. It is also important to use several methods and techniques in the estimation of SOC. The use of algorithms is also an important aspect of research in this direction because it helps to improve the accuracy of SOC estimation. These algorithms have been improved over the years and more improvement and research leading to the establishment of more effective and efficient algorithms must be promoted to better the function of Battery management systems for estimations.

Acknowledgments

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QR – Issue QR – Article

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INTERFERENCE, TYPES, STRUCTURE, CONTENTS AND THEIR MEANINGS

Abstract*: The article deals with the interference, structure, meanings and contents of the word philology. The structure, branches and explanations in the formation of speech of the student s in the contacting English-Uzbek languages.*

The problem of language interference being a process which regards the mastering of a second language, appeared as result of transference of speech skills from one contact language into another (from the native language into the second one), has concerned researchers for decades.

Interference, once appeared in linguistics, when a foreign language began to be taught in different schools, educational establishments, later. Every teacher knows that English language in Europe began to develop earlier at the beginning of its middle formation. At that time England began to export its goods of human usage life style.

Key words*: Philology, linguistics, grammar, formation, structure, branches, contents, meanings.*

Language*: English*

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Introduction

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In the process of teaching and learning English there are important terms in linguistics. Their meanings, usages and their roles are grate in the formation of speech, understanding and mastering English. Of course, the students before learning any foreign language they have to understand the terms , their meaning which are being taught as language phenomena.

Further the first language –mother tongue (L1) and the target Language (L2) will be used in learning language2-target language, students (pupils) have previous language 1 experiences. According to L.B. Sherba learners of a target language and can masterly operate with them.

These experiences are two types. Mother longue experience and mental experiences. Mother tongue experiences can be seen in language learning processes. What are they? First students before learning a target language have mother tongue experiences. Their experiences in language 1 will be used while learning the target language. The first language- Language 1 has its phonological, morphological, grammatical and syntactical specifics. Every of them has a firm knowledge print in their brains. They always are ready to be used by the learners.

In learning language 2-target language the learners use mother tongue in the life style. the ways of expressing of feelings, thoughts and mental outlooks. These factors are also influence for learning a target language.

So, the learners meet (with) some difficulties. They are phonological, lexical, grammatical and called as interferences. These interferences may be ша two types. They are inter-lingual and intra-lingual. Intra-lingual interference may occur in any case of usage language phenomena. They may be called as phonological, lexical and grammatical in linguistics.

In the social and moral interference the learners may meet in expressing their feelings and thoughts in a target language. Any nation any person while expressing their thoughts use their historical, traditional, cultural, educational and national experiences. While expressing feelings and thoughts the learners have to be more attentive. Because, moral way of life plays more important role in acting and behaving in the real life style.

Academician L.B. Sherba was right because any learner has at his disposal ready outlooks knowledge in various subjects in surrounding world. Yet, it may be any kind of activity, thought, behave, play, talk, spending time, sightseeing, eating, living and other cultural, moral feelings and activities. They all influence in understanding each-other by the representatives of the two language speakers.

If to take into consideration language interferences in this case it should be taken only language phenomena. Any language is analyzed in the following four levels. They are phonological, morphological, lexical and grammatical.

In phonological level the sound system of the two languages L1and L2. professor S.Ph.Shatilov wrote: The sound system of the comparing languages- L1 and L2 can be described in the following way:

a. 1) similar sound;
b. 2) half (partially similar);
c. 3) quite different sounds.

He is right with his personal outlook knowledge and understanding, on the one hand. On the second hand, the analyses may be different by different scholars- scientists. Inside the phonological system one can find differences even in similar sounds. Describing this associate professor Kh. M. Makhmatkulov gives the following explanation and examples: **Similar sounds** as [k], [n], [m], [l], [b], [g], [d], [z], [o], [p], [s] and some other sounds.

But these sounds in English and Turkic languages are considered to be similar, in pronouncing some of these sounds are differences. For example, the sound [l] has different pronunciation types in the following words: We may call them [l]1, [l]2, [l] [3 .

L [l] 1	L [l] 2	[l] 3
Tall	let	language
Ball	lend	lasso
Hall	lesson	lamb
Fall	love	lamp
Call	live	lips

B. Half –similar sounds. They are - [r], [t], [v], [f] , etc. which sound half- similar in pronunciation, but in pronouncing some words with them, there can be heard and understood that there one feels the differences **.**

C. Quite different sounds- The following sounds as [w], [O], [o]. pronunciation of these sounds need special attention. The organs of speech work quite different.

The analyses of these sounds and the pronunciation show that their difficulties in pronouncing need from teachers special ways of showing how to pronounce them in order to be able to pronounce perfectly. Teachers have to show, to train their pronunciation with the help of different technical and nontechnical aids, pictures, visual aids and other didactic mater

In order to eliminate language interference, first of all teachers must make clear what are the the language phenomena and language levels. Professors Haymovich and Chakhayan put questions: what is phoneme?-the smallest distinctive unit. What is morpheme?-the smallest meaningful unit. What is a word?- the smallest naming unit. What is a sentence?- the smallest communication unit.

If to analyze language units, there are different language interferences. The teachers tasks are to find the sources of their appearances and to differentiate them and to look ford of their elimination of these interferences.

At the beginning of this article it was given the term philology and its inter privation. What is “philology”?- the study of language; especially, the study of how languages and words develop. Definition: the study of literature and of disciplines relevant to literature or to language as used in literature.

2. a: linguistics; especially; historical and comparative linguistics; b: the study of human speech especially as the vehicle of literature and as a field of study that sheds light on cultural history. Philology (from Latin) love of literature; from Greek- philologos- found of learning and literature from phil+logos; word speech- legend.

In conclusion it can be said that any term in linguistics has its meanings and contents. The teachers have to use them and give their meanings in a correct way in order the teachers may understand any term and their usage in language speech.

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QR – Issue QR – Article

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NEW APPROACH IN TEACHING COLLOID CHEMISTRY

Abstract: *This article is devoted to the consideration of such issues as: the quality of education, the process of forming a credit-modular system in higher educational institutions, teaching colloidal chemistry.*

The rating system for assessing the performance of teachers is becoming a necessary requirement in increasing the efficiency of each university. The quality of education in modern conditions is determined by factors characteristic of many educational institutions: there is a gradual targeting from industry to information content; education and science are designed to make up for the high quality of education.

Key words: *quality of education, formation, scientific character, rating system, colloidal chemistry, credit-modular system, modern conditions.*

Language: *Russian*

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НОВЫЙ ПОДХОД В ПРЕПОДАВАНИИ КОЛЛОИДНОЙ ХИМИИ

Аннотация: *Данная статья посвящена рассмотрению таких вопросов, как: качество образования, процесс формирования кредитно-модульной системы в высших учебных заведениях, преподавание коллоидной химии.*

Рейтинговая система оценивания результатов работы преподавателей становится необходимым требованием в повышении эффективности работы каждого вуза. Качество образования в современных условиях обуславливается факторами, характерными для многих образовательных заведений: происходит постепенное нацеливание от промышленности к информативности; образование и наука призваны восполнить высоким качеством обучения.

Ключевые слова: *качество образования, формирование, научность, кредитно-модульная система, коллоидная химия, современные условия.*

Введение

УДК 371.321

В нынешнее время система высшего профессионального образования претерпевает новый этап образовательной модели подготовки преподавателей, в которой квалификация является одной из важнейших задач.

Качество образования в современных условиях обуславливается факторами, характерными для многих образовательных заведений: происходит постепенное нацеливание от промышленности к информативности; образование и наука призваны восполнить высоким качеством человеческого капитала недостаток капитала финансового; в современном обществе быстро осуществляется как накопление научных данных, так и их устаревание.

К одним из основных элементов формирования системы качества подготовки кадров в вузах относятся следующие:

Научность, профессиональная ориентированность, системность и комплексность, сочетание современных подходов в управлении - все эти понятия являются определяющими. Новшество, которое претерпевает сегодня высшая школа, в полной мере затронуло каждого преподавателя. Это

переосмысливание преподавания в вузах и внедрение новых образовательных технологий, все больше внедряется в процесс обучения и дистанционное обучение, активизация инновационной деятельности.

На сегодняшний день все больше требований к педагогическим ВУЗам с целью повышения рейтинга в сфере образования, характеризующих лучшие вузы мира. Повысившиеся требования к высшей школе продиктованы необходимостью встроить высшее образование в мировое образовательное пространство. Все больше требований к преподавателям вузов. К таковым относят индексы цитируемости в публикациях, объемы финансирования научных проектов, участвующих в конкурсах, получение патентов на изобретения, а также инновационная деятельность в преподавании [1]

Рейтинговая система оценивания результатов работы преподавателей становится необходимым требованием в повышении эффективности работы каждого вуза [2].

В основу рейтинговой системы вуза могут быть положены как уже названные критерии (публикационная активность преподавателя, его эффективность в подготовке научных кадров, участие в научных конференциях), так и методическая состоятельность преподавателя (разработка новых образовательных программ, рабочих программ модулей и дисциплин, карт компетенций, создание курсов для электронного и дистанционного обучения, написание учебников) [3,4]. Включены в рейтинговую таблицу и разделы, посвященные инновационной деятельности преподавателя. [5,6,7]

Результаты научной деятельности учитывают количество цитирований работ преподавателя за последние пять лет. При балльной оценке научных публикаций принимается во внимание не только уровень публикаций (статьи, учтенные системами Web of Science, Scopus, труды, изданные в центральной и зарубежной печати или университетском издательстве, публикации в журналах из перечня ВАК), но и импакт−фактор научного журнала, в котором опубликована статья [8]. Необходимо учесть, что в университетах страны есть немало способов стимулирования преподавателей, имеющих высокий рейтинговый балл. Это приоритетность командировочного финансирования, возможности длительных научных стажировок и др. [8].

Такие явления как мониторинг, планирование и управление, т.е. совокупность различных мероприятий, процессов, а также документов, направленных на создание, в первую очередь у коллектива вуза, уверенности в том, что результаты, касающиеся качества образования будут получены. Важно добавить, что качество образования повышается, благодаря следующим целям:

1. подотчетность и прозрачность деятельности вузов;
2. повышение качества образования в экономическом, социальном и культурном понимании, а значит- повышение конкурентоспособности высших учебных заведений;
3. сопоставимость программ на национальном и международном уровне;

Данный перечень является необходимым условием для обеспечения качества образования в вузах.

Это, в свою очередь, связано с разработкой и эффективным использованием различных электронных технологий, что позволит изменить всю систему информационного, программно−методического обеспечения образовательного процесса (поиск справочного материала, осуществление оценивания, обработка результатов оценивания и др.). Вместе с тем, электронную систему качества образования можно создать только при условии четкого определения целей и задач оценивания качества образовательного процесса в вузе.

Благодаря анализу деятельности образовательного заведения и достигнутым результатам предлагаемой модели совершенствования деятельности вуза система качества обучения в вузе нацелена на поддержание высококачественного и конкурентоспособного уровня высшего образования. К таковым относят: качество планово−организационное обеспечение, преподавание, внедрение инновационных технологий обучения и т.д. Выполнение новых подходов в образовательном процессе вуза служит его стабильному развитию, поддержанию результативности инновационной деятельности в области подготовки конкурентоспособных и компетентных кадров [9,10].

Система качества образования коллоидной химии в вузе может быть охарактеризована по нескольким признакам, как:

– социальная и личностная;
– динамическая;
– открытая (взаимодействие с внешней средой);
– целенаправленная;
– развивающаяся;
– ценностно−ориентированная (ценность профессиональной деятельности).

Эффективность внутренней системы оценивания качества образовательного процесса в вузе во многом определяется уровнем научно−преподавательского состава, его готовностью к внедрению педагогических

инноваций в обучении, воспитании и развитии будущих специалистов [9].

Таким образом, уровень развития и внедрения информационных технологий, многогранное обучение позволяют управлять качеством образовательного процесса. В нынешнее время содержание образования в высшем учебном заведении должно предоставлять:

-высокий уровень культуры личности - общей и профессиональной;

- слияние в национальную и мировую культуру.

Готовность вуза к созданию инновационных условий обучения будущих специалистов-химиков означает совокупную готовность к научно−исследовательской работе, информационно−аналитической и информационно−технической деятельности, включая систему оценки качества.

Новые технологии в обучении коллоидной химии и систематическое использование развивающих упражнений является эффективным средством активизации учебной деятельности студентов, положительно влияющим на повышение качества знаний, умений и навыков студентов, развитие умственной деятельности. При подготовке будущих учителей необходимо снабжать их умением использовать развивающие упражнения и задачи и, конечно, научить их составлять подобные задания, развивающие у студентов химическое и логическое мышление, наблюдательность в ходе эксперимента, а также использовать свои полученные знания за время обучения в высшем учебном заведении в своей профессиональной деятельности.

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INVESTIGATION OF STABILITY CONDITIONS FOR STATIONARY ROTATION OF A SPHERICAL GYROSCOPE ROTOR

***Abstract**: In this paper, we study the stability conditions of stationary rotations of a conducting absolutely rigid body (gyroscope rotor) during the spin of a non-contact gyroscope in a resistive medium in the case of fast gyroscope rotations, when the kinetic energy of the rotor is high compared to the moment of resistance and the active torque.*

***Key words**: absolute solid, regular precession, high-frequency magnetic field, non-contact gyroscope, gyroscope rotor, kinetic energy, moment of resistance, polarizability coefficient, ellipsoid of inertia, nutation angle.*

***Language**: Russian*

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***Scopus ASCC**: 2200.*

ИССЛЕДОВАНИЕ УСЛОВИЙ УСТОЙЧИВОСТИ СТАЦИОНАРНЫХ ВРАЩЕНИЙ РОТОРА ГИРОСКОПА СФЕРИЧЕСКОЙ ФОРМЫ

***Аннотация**: В работе исследуется условия устойчивости стационарных вращении проводящего абсолютно твердого тела (ротора гироскопа) сферической формы при раскрутке неконтактного гироскопа в сопротивляющейся среде в случае быстрых вращений гироскопа, когда кинетическая энергия ротора велика по сравнению с моментом сопротивления и активным вращающим моментом.*

***Ключевые слова**: абсолютно твердое тело, регулярная прецессия, высокочастотное магнитное поле, неконтактный гироскоп, ротор гироскопа, кинетическая энергия, момент сопротивления, коэффициент поляризуемости, эллипсойд инерций, угол нутации.*

Введение

UDC 681.38(62-251)

В работе [8], ,был рассмотрен вопрос об устойчивости по отношению к переменным δ, L, ϑ найденных стационарных движений ротора неконтактного гироскопа, соответствующих особым точкам:

$Sin\vartheta_0 = 0, \quad L_0 = \frac{a\sqrt{2}\, e_1^1 I_3}{2n_3 - b\sqrt{2}e_1^1}$

$Cos\vartheta_0 = 0, \quad L_0 = \frac{a\sqrt{2}\,(e_3^1 + e_1^1) I_1}{4n_1 - b\sqrt{2}(e_3^1 + e_1^1)}$

$Sin^2\vartheta = A/B, \quad L_0 = -C/D$

где

$A = (4n_3(e_3^1 + e_1^1) - 2\, b\sqrt{2}e_3^1 e_1^1)I_1 - (8n_1 e_1^1 - 2\, b\sqrt{2}e_3^1 e_1^1)I_3,$

$B = b\sqrt{2}e_1^1(e_3^1 - e_1^1)(I_3 - I_1),$

$C = a\sqrt{2}(e_3^1 - e_1^1)I_1 I_3,$

$D = 4(n_3 I_1 - n_1 I_3) + b\sqrt{2}(e_3^1 I_3 - e_1^1 I_1),$

$a = \Gamma(0.5)\varepsilon_0/\sqrt{\pi}/\sqrt{\omega}, \quad$ b $= \Gamma(1.5)\varepsilon_0/\sqrt{\pi}/\omega^{3/2},$ Γ - гамма функция, $\varepsilon_0 = c/\sqrt{4\pi\lambda_0}\mu -$

малый параметр при решении соответствующей электродинамической задачи, ω - угловая скорость вращения вектора напряженности магнитного поля [2].

Предположим, что момент диссипативных сил является линейной функцией угловой скорости тела и в проекциях на оси трехгранника x имеет вид [4]

$$\bar{M}_x = -N\bar{\Omega}_x$$

где $N = diag\{n_1, n_2, n_3\}$ - диагональная матрица с положительными элементами, стоящими на главной диагонали, $\bar{\Omega}$ - угловая скорость твердого тела.

Введя параметр $\rho = e_3^1/e_1^1$ - отношение коэффициентов поляризуемости ротора,

$$N_1 = \frac{n_1}{b\sqrt{2}e_1^1}, \quad N_3 = \frac{n_3}{b\sqrt{2}e_1^1},$$

- нормированные коэффициенты сопротивления, характеризующие вязкость окружающей среды, были получены [10], соотношения (1), (2) и (3), отражающие условия устойчивости стационарных вращении и регулярной прецессии при раскрутке неконтактного гироскопа в сопротивляющейся среде в случае быстрых вращений гироскопа, когда кинетическая энергия ротора велика по сравнению с моментом сопротивления и активным вращающим моментом:

условия устойчивости стационарного вращения вокруг полярной оси

$$N_3 > \tfrac{1}{2}\ , \quad N_1 > \tfrac{\rho}{4} \qquad \tfrac{I_3}{I_1} > J_2(N) \qquad (1)$$

условия устойчивости стационарного вращения вокруг экваториальной оси

$$N_3 > \tfrac{1}{2}\ , \quad N_1 > \tfrac{\rho}{4} \qquad \tfrac{I_3}{I_1} > J_2(N) \qquad (2)$$

условия устойчивости регулярной прецессии при

$$0 < \rho < 1,\ N_3 > \tfrac{1}{2}\ , \quad N_1 > \tfrac{\rho+1}{4}\ , \quad \tfrac{N_1}{N_3} > \tfrac{\rho+1}{2},$$

и при

$$\rho > 1, \quad N_3 > \frac{1}{2}\ , \quad N_1 > \frac{\rho+1}{4}\ , \quad \frac{N_1}{N_3} < \frac{\rho+1}{2},$$

$$J_1(n) < I_3/I_1 < J_2(n) \qquad (3)$$

где

$$J_1(n) = \tfrac{(4N_3-1)(\rho+1)}{8N_1-(\rho+1)}, \quad J_2(n) = \tfrac{(2N_3)(\rho+1)-\rho}{4N_1-\rho}.$$

Эти соотношения удобно представить в безразмерном виде.

Введем параметр $\rho = e_3^1/e_1^1$ - отношение коэффициентов поляризуемости ротора,

$$N_1 = \frac{n_1}{b\sqrt{2}e_1^1}, \quad N_3 = \frac{n_3}{b\sqrt{2}e_1^1}$$

- нормированные коэффициенты сопротивления, характеризующие вязкость окружающей среды.

Тогда имеем:

условия устойчивости стационарного вращения вокруг полярной оси

$$N_3 > 0{,}5 \quad N_1 > 0{,}25\rho \quad I_3/I_1 > J_2(N) \qquad (4)$$

условия устойчивости стационарного вращения вокруг экваториальной оси

$$N_3 > 0{,}5\ ,\ \ N_1 > 0{,}25(\rho+1),$$
$$I_3/I_1 < J_1(N) \qquad (5)$$

условия устойчивости регулярной прецессии при $0 < \rho < 1,\ N_3 > 0{,}5,\ N_1 > 0{,}25(\rho+1),\ N_1/N_3 > (\rho+1)/2),$

и при $\rho > 1,\ N_3 > 0{,}5,\ N_1 > 0{,}25(\rho+1),\ N_1/N_3 < (\rho+1)/2),$

$$J_1(n) < I_3/I_1 < J_2(n) \qquad (6)$$

где

$$J_1(n) = \tfrac{(4N_3-1)(\rho+1)}{8N_1-(\rho+1)},$$
$$J_2(n) = ((2N_3)(\rho+1)-\rho)/(4N_1-\rho)$$

В качестве примера использования полученных условий, рассмотрим частный случай когда внешняя поверхность ротора представляет собой сферу и следовательно,

$$n_1 = n_2 = n_3 = n.$$

При этом неравенства (4), (5), (6) могут быть представлены в виде:

при $\rho > 2,\ x > \rho/4$ и $\rho < 2,\ x > 0.5\ \ I_3/I_1 > J_2(x)$

при $\rho < 1,\ x > 0.5$ и $\rho > 1, x > (\rho+1)/4 \quad I_3/I_1 < J_1(x) \qquad (7)$

при $\rho > 1, x > (\rho+1)/4$ и $\rho < 1,\ x > 0.5\ \ J_1(x) < I_3/I_1 < J_2(x)$

где $J_1(x) = \tfrac{(4x-1)(\rho+1)}{8x-(\rho+1)}$, $J_2(x) = \tfrac{(2x)(\rho+1)-\rho}{4x-\rho}$, $\rho = e_3^1/e_1^1$, $x = n/(b\sqrt{2}e_1^1)$ - безразмерные параметры.

Введем на плоскости прямоугольную систему координат с осями, по одной из которой будем откладывать значения x, а по другой отношение I_3/I_1 .

На этой плоскости графики зависимостей

$$I_3/I_1 = J_2(x) \text{ и } I_3/I_1 = J_1(x)$$

представляет собой в общем случае гиперболы. Их взаимное расположение полностью характеризует области устойчивости найденных частных решений.

Рассмотрим следующие возможные случаи.

Пусть тензор поляризуемости шаровой, т.е. $\rho = 1$. В этом случае

$I_3/I_1 = J_2(x) = 1$ (рис.1).

Областями устойчивости будут две бесконечные полосы:

$$-1 < I_3/I_1 < 2 \qquad (8)$$

- отвечает устойчивому вращению вокруг полярной оси;

$$-0 < I_3/I_1 < 1 \qquad (9)$$

– устойчивому вращению вокруг экваториальной оси. Здесь учтено неравенство $I_3/I_1 < 2$, которому должно удовлетворять реальное тело.

Таким образом, при $\rho = 1$ тело со сплюснутым эллипсоидом инерции устойчиво вращается вокруг полярной оси, регулярная прецессия не существует, а тело с вытянутым эллипсоидом инерции устойчиво вращается вокруг экваториальной оси.

Пусть теперь тензор поляризуемости не шаровой, т.е. $\rho \neq 1$. В этом случае $J_1(x)$ и $J_2(x)$ имеют общую горизонтальную асимптоту

$$P = (\rho + 1)/2 \text{ , при } x \to \infty.$$

На рисунках 2 – 4 показано расположение областей устойчивости в зависимости от величин параметра ρ.

Область обозначенная (8), отвечает устойчивому вращению вокруг полярной оси, через (9) обозначена область устойчивости вращений тела вокруг экваториальной оси, заштрихованная область соответствует устойчивой регулярной прецессии. Области устойчивости попарно не пересекаются.

В случае $\rho > 3$, кривые $J_1(x)$ и $J_2(x)$ всюду лежат выше горизонтальной асимптоты $P > 2$. В случае, когда неравенства (7) не выполнены, существует неустойчивая регулярная прецессия, и тело выходит либо на режим вращения вокруг полярной оси, либо на режим вращения вокруг экваториальной оси (в зависимости от начальных условий).

В случае устойчивой регулярной прецессии, угол нутации ϑ находится из равенства

$$Sin^2\vartheta = \frac{(4x(\rho+1) - 2\rho)I_1 - (8x - 2\rho)I_3}{(\rho - 1)(I_3 - I_1)}$$

Как видно из этого равенства, в зависимости от параметров ρ, x угол нутации ϑ может принимать разные значения.

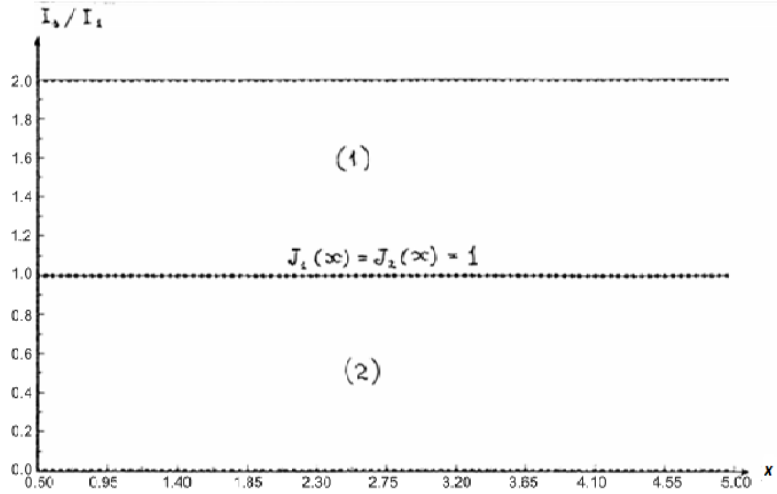

Рис.1 Область устойчивости при $\rho = 1$

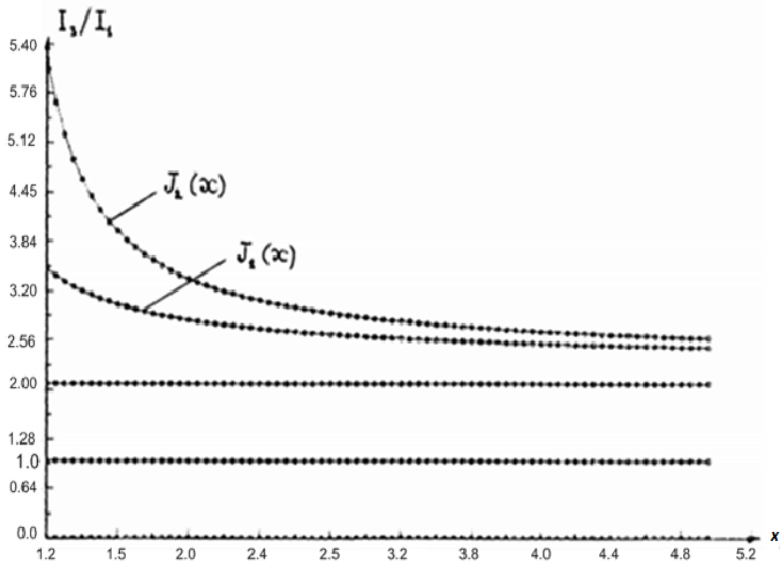

Рис.2 Графики изменения $J_1(x)$ и $J_2(x)$ при $\rho > 3$ $(\rho = 3.2)$

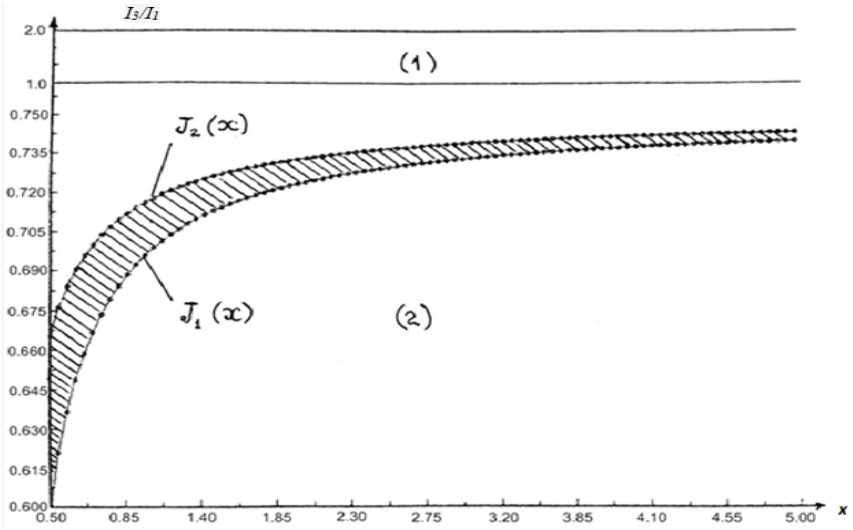

Рис.3 Область устойчивости при $0 < \rho < 1$ $(\rho = 0.6)$

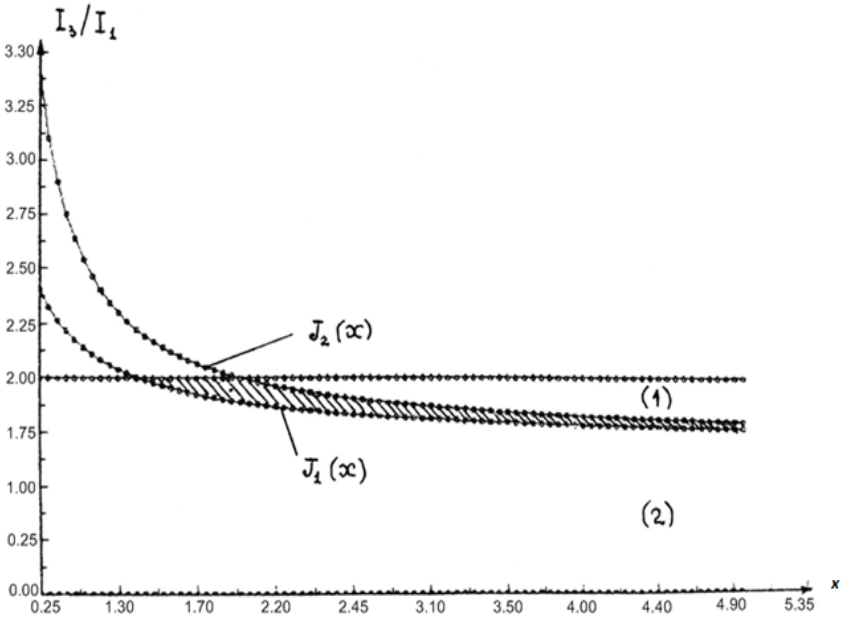

Рис.4 Область устойчивости при $1 < \rho < 3$ $(\rho = 2.4)$

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DEVELOPMENT TRENDS OF THE CEMENT INDUSTRY IN UZBEKISTAN

Abstract: *The article provides an overview and analysis of the cement industry in Uzbekistan. The authors analyzed the volume of construction work, the volume of production and sales of cement products on the exchange, as well as the target parameters of the production of cement products in 2019-2025. The advantages and disadvantages of each production technology are presented in detail. The authors reviewed the existing and projected cement manufacturing enterprises in Uzbekistan.*

Key words: *cement industry, technologies, dry production technology, wet production technology, clinker.*

Language: *English*

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Introduction

In order to further improve the construction industry, form mechanisms for the consistent development of architecture and construction institutions, ensure the efficiency of the public administration system, progressive implementation in the field of digital technologies; the President's decree approved the Strategy for modernization, accelerated and innovative development of the construction industry of the Republic of Uzbekistan in 2021-2025 [1].

Analyzing the above indicators, one can see that there is a stably positive dynamics of growth in construction volumes and similarly repeated rates of GDP growth, but with a slightly different amplitude. As a result of the pandemic, at the end of 2020, GDP growth amounted to 101.6%, while the volume of construction work increased by 109.1% compared to the previous year.

The republic is also carrying out large-scale work to further deepen structural reforms in the construction materials industry, aimed at ensuring sustainable growth rates of production and export of competitive products, as well as modernization, technical and technological renewal of enterprises.

Methods.

The achieved level of cement production of about 9000 thousand tons per year (as of 2018) is not able to meet market needs (Table 3). As shown in Table 1, the volume of construction work is growing every year, over 20 years from 388 billion Uzbek soums in 2000 to 65,154.6 billion Uzbek soums in 2020, which indicates significant economic growth in the industry.

Table 1. The volume of construction work in the Republic of Uzbekistan (in billion soums)

Years	2000	2004	2008	2012	2016	2020
Construction work volumes	388,4	1121,9	3575,9	11753,9	29413,9	65154,6

Source: State Statistics Committee of the Republic of Uzbekistan

In order to optimize the volume of supplies, stable and rhythmic satisfaction of the needs of the sectors of the economy of the republic in cement, including the implementation of the most important nationwide development and modernization programs and large investment projects, the Cabinet of Ministers of the Republic of Uzbekistan annually approves the balance of production and consumption of cement.

In order to create favorable conditions for the accelerated development and diversification of the industry, attracting investments in the processing of local mineral raw materials and increasing the export of construction materials, the government approved the forecast parameters for expanding the raw material base of the construction industry. Based on geological exploration, production and processing of local raw materials in 2019-2025 and Target parameters for the production of construction materials in 2019-2025, taking into account the diversification and expansion of the range of products, it is envisaged to increase the production of wallpaper by more than 47 times, aerated concrete blocks - 7 times, paint and varnish materials - 4 times, composite reinforcement rebar and basalt - 3 times and cement - 2 times [2].

Table 2. Target parameters for the production of cement products in 2019-2025, taking into account the diversification and expansion of the product range (in thousand tons)

The name of indicators	2018 (fact)	Forecast							
		2019	2020	2021	2022	2023	2024	2025	Dynamics, in 2025 by 2018 (%)
Cement, including high quality and special types based on energy saving technologies	9 080	10 984	13 400	16 400	19 100	19 500	19 900	20 260	223,1

Source: Resolution of the President of the Republic of Uzbekistan PP-4335 of 23.05.2019 "On additional measures for the accelerated development of the construction materials industry."

These target parameters were developed by the government taking into account the increasing demand for construction products. According to the Resolution, it is planned to systematically increase the volume of cement production in the country by more than 2 times. The production plan was at the level of 10,984 thousand tons of cement in 2019, and in fact, 10,549.8 thousand tons of cement were produced in the republic (Table 2), which indicates that the planned volumes were not fulfilled due to the temporary suspension of cement production at the end of 2020 at Kuvasaycement JSC and Akhangarantsement JSC, due to the decrease in gas pressure supplied to cement producers.

Table 3. Indicators on production volumes, sales and price indices of cement in Uzbekistan for 2016-2019

	2016	2017	2018	2019
Cement production in Uzbekistan (thousand tons)	8645,9	9132,2	9080,4	10549,8
Sale of cement at the commodity and raw materials exchange of Uzbekistan (mln. Soums)	2435307,3	2330384,6	5546717,0	4839813,1
Price index (December to December of the previous year; percentage)	135,7	122,1	97,9	119,9

Source: State Statistics Committee of the Republic of Uzbekistan

All large cement enterprises of the republic are included in the register of monopolists, and the value of their products is declared. For the construction of facilities financed from centralized sources, cement is supplied at the declared price, and for other consumers, cement is sold through exchange trading at free (market) prices.

Results and Discussion.

Cement industry in Uzbekistan

Currently, there are 12 cement plants in Uzbekistan with a total annual capacity of more than 9.0 million tons, including large ones - JSC Kizilkumcement, in Navoi region, production capacity - 3,500 thousand tons), JSC Akhangarancement (Akhangaran region, 1740 thousand tons), JSC Bekabadcement (Bekabad region, 1250 thousand tons), JSC Kuvasaycement (city of Kuvasay, 1080 thousand tons), Jizzakh cement plant (city of Jizzak, 1000 thousand tons of gray cement or 450 thousand tons of white cement), - and small cement production with a total capacity of 640 thousand tons per year (Table 4) [6].

Table 4. Design capacity of enterprises for cement, thousand tons

Plants in operation		**Plants under design and construction**	
Company*	**Capacity**	**Company***	**Capacity**
JSC “Kizilkumcement”	3 500	“Titan Cement” LLC	221
JSC “Akhangarancement”	1 740	JV “Shanfeng Bridge of Friendship”	1 200
JSC “Bekabadcement”	1 250	“Yaypanshifer LLC.”	100
JSC “Kuvasaycement”	1 080	“Gallaorolcement” Subsidiary	100
“Jizzakh cement plant”	1 000	JSC “Sherobod Cement Plant”	1 500
“JV Fergana Cement” LLC	120	JV ‘Surkhancementinvest”	360
‘Turon Eco Cement Group” LLC	100	**Total**	**3 531**
“Farhadshifer” LLC	100		
“Everest Metal Favotir” LLC	100		
“Kezar” LLC	60		
JV “Sing lida” LLC	100		
“Buyuk” Private Enterprise	60		
Total	**9 210**		
Overall		**12 482**	

** All operating, designed and constructed enterprises are full-cycle factories.*

The capacity utilization of cement plants of the republic is close to 100%. It should be noted that on the newly introduced technological lines of Bekabadcement JSC and the Jizzakh cement plant, the efforts of the specialists of these enterprises have achieved the design indicators of cement production in a short period of operation. Similar results were achieved by the collectives of small enterprises JV Fergana Cement LLC, Turon Eco Cement Group LLC and Farhadshifer LLC.

Along with the increase in the volume of cement production, much attention is paid to expanding the range of products and their quality. All large cement enterprises have implemented a quality management system, received international certificates ISO 9001: 2000 and ISO 9001: 2015. Small enterprises have also begun work in this direction.

In 2020-2021, the association plans to launch another 10 new cement plants. These factories will be built in the Republic of Karakalpakstan, Jizzakh, Kashkadarya, Surkhandarya, Tashkent, Andijan, Fergana and Namangan regions.

In recent years, large-scale work has been carried out to reform the sector, improve the efficiency and potential of enterprises. From a critical point of view, the activity of each enterprise is analyzed, on a systematic basis, work is underway to reduce the cost of production by improving the quality and production of energy-saving, innovative construction materials. The enterprises use digital technologies, automated processes dangerous to human life. Special attention

is paid to the development of new directions in the production of construction materials and the attraction of foreign investors into this process, the development of new types of products and the attraction of innovations [5].

In the CIS countries and in Uzbekistan, in particular, cement plants use predominantly the "wet" method, at the same time, almost all foreign manufacturers of the binder work according to the "dry technology".

In a number of Western European countries and Japan, due to the high fuel consumption, the wet method is completely absent, all 100% of the cement is produced using an economical dry method. In the USA, Canada, many countries, the dry method prevails, according to which 60-80% of factories work. In the CIS countries, only about 15% of the total volume of cement production is carried out by the dry method, and the rest is carried out by the wet method.

Conclusions

Construction, as part of the economy, is involved in the creation and modernization of fixed assets for all other sectors of the economy, and thus is a key fund-forming industry. Cement is a semi-finished product from the group of construction materials and occupies the most important direction in the development of the construction industry. The cement production process itself is capital intensive and energy intensive.

Thus, the creation of advanced technologies with minimal expenditure of material and energy resources is one of the main tasks of the construction industry, which includes the production of building materials and products.

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QR – Issue QR – Article

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PUBLIC EDUCATION IN UZBEKISTAN HISTORY OF FORMATION

Abstract: *The article analyzes scientific-historical analysis of the existing problems in the system of public education in Uzbekistan and the implementation of reforms and measures taken in the framework of the National Program for Personnel Training in 1997-2009, using archival documents and scientific sources.*

Key words: *National program, education, youth, reforms, teachers, material and technical base, textbooks.*
Language: *English*
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Introduction

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Our independence required the restoration and further enrichment of our rich and great spirituality and national values, the formation of a national education system, the achievement of world standards on the basis of its harmonization with the requirements of the time. Because the strengthening of our independence, the development of reforms in all areas was closely linked with the field of spirituality and education. For the first time in the history of education in the country, since the adoption of the Law "On Education" (1992) [1, p. 12-14.], a lot of positive work has been done to develop the system of education and training. The adoption of a new law "On Education" and the National Training Program (1997) showed that the education sector in the country has reached a new level and the reforms in this area have begun to deepen. An important link in the education system of the Republic of Uzbekistan In the process of its development, the school education system has gone through the following stages from the last years of the former Soviet regime to the present day:

- The strengthening of command and control in public education and its impact on the educational process in schools (1980-1990) [2, p. 127-135.];
- The beginning of educational reforms in the first years of independence, the development of secondary schools and the first changes in the education system (1991-1996) [3, p. 79-84.];
- The new law "On Education" and the National Training Program and the National Program for the development of school education on the basis of further deepening the reforms of education (1997-2009).

The administrative-command style of the ruling party and the government of the former regime and the domination of individual ideology served the extreme politicization of education, hindering the national and cultural development of the people, the study and promotion of their historical heritage. The education of Soviet schools in Uzbekistan was also politicized, and national educational standards were limited. All these politicizations and restrictions have had a negative impact on the development of public education in the republic. The struggle to establish "communist regimes" in schools has, in fact, undermined the upbringing of the younger generation. In 1984, the ruling party and the Soviet government tried to regain their position by carrying out school reform. However, these reforms were mixed with their "reconstruction" policies. The experience and results of the ongoing school reform in Uzbekistan show that the measures set out in the reform are insufficient,

attempts are being made to implement them in the old style, the improvement of the public education system is slow, conservatism, formalism and pursuit of interest prevail in educational institutions.

The independence of the republic allowed the formation of a new system of national schools, the liberation of the educational process from politicization and ideology. A vivid example of this was the adoption of the Law on Education on July 2, 1992. Under this law, reforms in the education system began. Research, creativity and initiatives on the new organization of education have expanded. The state has begun to take measures to strengthen the material and educational base of schools, to provide them with teaching staff, to pay attention to nationalism in school education, to bring school education closer to world standards on the basis of studying the experience of developed countries.

In the early period of educational reform, the educational process in the public education system was improved and enriched with a number of new pedagogical technologies and methods of practice. Despite the specific economic difficulties of the transition period, the material and technical base of public education has also been strengthened.

Due to the special attention of our state, in order to bring up the younger generation physically healthy, spiritually harmoniously developed, to identify and encourage their talents, the funds "Mahalla", "Soglom avlod uchun", "Ulugbek", "Umid", "Forum of Culture and Arts of Uzbekistan" and the Kamolat Youth Social Movement was established and began to work effectively in cooperation with educational institutions.

The government of the republic has also paid special attention to raising the prestige and prestige of teachers and coaches in society, as well as their material and spiritual encouragement. October 1 was designated Teachers and Coaches' Day. In addition, during the transition to a market economy, more than a dozen decrees and decisions were adopted on social protection of teachers, improving their living conditions and financial situation. [4, p. 36-39.]

Although reforms have been launched in the country's education system and a number of measures have been taken, there are still some shortcomings in this regard. The educational, material, technical and information base of schools remained weak, and they were not provided with sufficient new quality teaching and scientific literature and didactic materials. The partially changing education system and the work being done to train qualified specialists did not meet the requirements of democratic changes in society and the emerging market economy. The problems of ensuring continuity and continuity of education were also unresolved. It is these problems that have set the state and the government the task of further deepening the reforms in the education system.

In this regard, on August 29, 1997, a new Law on Education and the National Training Program were adopted. The National Training Program has set tasks to further deepen educational reforms in the country, justified the stages of implementation of the program. Based on the program, a National Model of training has been developed. [5, p. 22-28.]

Indeed, the National Program has served as an important step in deepening the education reforms launched in our country. The tasks of the National Training Program have been gradually implemented, in the first stage the content and components of the education system have been updated, and the training and retraining of teachers has been organized in accordance with modern requirements. Also, state educational standards, curricula for updated education, textbooks, manuals will be developed, which will determine the necessary requirements for a high level of training, qualifications, quality of cultural and spiritual level. A rating system of assessment in educational institutions and a system for monitoring the quality of training and the need for them has been developed. In the second stage, the strengthening of the material and technical and information base of educational institutions was continued, the educational process was provided with high quality educational literature and advanced pedagogical technologies. At this stage, students moved on to differentiated education according to their abilities and capabilities.

Educational institutions have been provided with specially trained qualified teaching staff, and a healthy competitive environment has been created in their activities. However, in the deepening of education programs based on the National Program, it became clear that a number of problems, especially in the development of school education, could not be fully resolved. This was mainly reflected in the construction and renovation of schools, training and technical base, information resources, and the orientation of students to secondary special and vocational education in connection with the transition to 9 years of education. Decree of the President of the Republic of Uzbekistan dated May 21, 2004 "On the State National Program for the Development of School Education for 2004-2009" [6, p. 98-106.] and the Cabinet of Ministers of July 9, 2004 "On measures to implement the State National Program for the Development of School Education for 2004-2009" [7, p. 111-118.] have played an important role in overcoming the existing problems. The tasks of the third stage of the National Program (post-2005) and the experience gained in the field of education in the implementation of the above-mentioned decrees and decisions were analyzed and summarized, the system of training was further improved in accordance with the country's development prospects. Attention is paid to further strengthening the material and technical, personnel and information bases of educational

institutions, the provision of the educational process with new teaching materials, advanced pedagogical technologies.

The education of young people has also played an important role in the process of deepening educational reforms on the basis of the program. In order to prevent some negative situations among young people, the teaching of social sciences and humanities in secondary schools of the country began to be carried out in harmony with the national idea. It is also important to include in the curriculum such subjects as "Ethics", "History of world religions", "The idea of national independence and the foundations of spirituality", "The idea of national independence: basic concepts and principles" and to keep pace with the times training also began to yield results.

The effective use of students' free time outside the classroom was carried out in accordance with the national idea and national values. The results of these efforts are reflected in the achievements of students in the national and world Olympics and competitions, and in the involvement of our youth in maintaining peace in the country. Thus, due to the constant care of our government for the development of school education, providing the younger generation with national education and skills in line with world standards, educating them in the spirit of devotion to the motherland and its people, the current image of education has changed radically. It has become an education system that reflects the national and spiritual spirit and aspirations of the country, which is boldly advancing along the path of development, and competes with world education.

In this regard, based on the results of research, the following proposals and recommendations to further deepen educational reform, based on the importance of educational reforms in the spiritual, educational, political and economic development of the implementation of the tasks of the National Training Program. expedient:

1. As a result of the deepening of educational reforms, most secondary schools, especially urban schools, are located in modern, well-equipped buildings, their material and technical base is strengthened, fully equipped with information technology, but a number of problems in rural schools are not fully resolved. The adoption and implementation of the tasks in it can also serve to make radical changes in the content of education in rural areas and to achieve a higher level of education of rural youth;

2. In this regard, the ministry, which is still responsible for the upbringing of the younger generation, employs staff in various organizations and centers, putting the interests of the people above their own interests, caring for the country's youth as their sons and daughters, caring for their future, noble, pure. It is desirable to provide under the supervision of the general public, local authorities, financial control departments in each region to provide conscientious, enlightened people, construction and repair of secondary schools, equipping them with modern equipment and strengthening the material and technical base. Such measures can not only prevent the development and eradication of certain non-legal conditions that negatively affect the effectiveness of education reforms, but can also play an important role in the complete elimination of these shortcomings;

3. Taking into account the fact that teachers are the main responsibility for the education of students, the government should continue to take care of their financial situation, improve their living standards, pay them taxes, electricity, gas, utilities, land in rural areas. further improvement of their good deeds will serve to increase the interest and responsibility of teachers in their work;

4. Given that the image of modern heroes in fiction, film, radio and television has not yet been professionally developed, works of art, films, national series and films that cover the honorable and hard work of research, creative, selfless school teachers in film, radio and television. performance can also serve to increase the activity of all educators, their love for their profession and further increase their prestige in society;

5. Make changes in the work of existing clubs on the effective use of students' free time, in addition to the activities of such clubs as volunteers, information, debate, economists, ecologists, thinkers, computer scientists, teachers and students. improvement is also of great importance in leading to a further expansion of the ranks of young people who can meet today's requirements.

6. Further enhancing the role of the community in improving the learning, recreation and family conditions of students, further strengthening family-school-neighborhood cooperation is a spiritual necessity of today. Because through national education, along with school, the family and the community play an important role in the development of such qualities as self-awareness, patriotism, national consciousness, morality in young people.

The implementation of these recommendations in our lives, first of all, to further strengthen the position of the system of secondary schools in the world at the level of world educational standards, the full implementation of our national model in practice, full integration of education and training, the activities of secondary schools in the country. to adapt to broad reforms in a coordinated manner, and most importantly, to expedite the elimination of some of the existing shortcomings in school education and upbringing and to further improve school education.

After all, the formation of high spiritual qualities in the youth of our society, their upbringing in the spirit of our rich cultural and spiritual heritage, respect for our millennial history, universal values, love for

the Motherland, devotion to the ideas of independence is a decisive factor in all reforms in our country.

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KARAKALPAK-AZERBAIJANI CULTURAL AND LITERARY RELATIONS (On the example of scientific research of Professor Nizami Mamedov Tagisoy)

Abstract: *This work examines the works of the famous Azerbaijani scientist - literary critic, Turkologist working in the field of Karakalpak-Azerbaijani cultural and literary ties Nizami Mamedov Tagisoy. A prominent Turkic scholar, working in this field for more than 20 years, conducts important research in the study of the Karakalpak folklore, epic, classical literature of the 19th - 20th centuries and on modern Karakalpak literature. Peru N. Mamedov Tagisoy owns dozens of articles, translations of Karakalpak folk tales, translation of poems, shezhire and the poem "Bozatau" by Azhiniyaz into Azerbaijani. Two textbooks on Karakalpak social, cultural and literary life have been prepared for the humanitarian faculties of Azerbaijani universities, he maintains systematic ties with Karakalpak literary scholars, opposes and reviews the research of Karakalpak scientists, thus playing the most active role in the development and formation of Azerbaijani-Karakalpak cultural, folklore and literary connections. Based on this, we made the works of a scientist devoted to these relations as the object of our work.*

Key words: *Azerbaijan, Karakalpaks, people, folklore, culture, literature, Turkic languages, science, scientist, history, tradition, fairy tale, epic, motive, plot, mentality, poet, work, ethnogenesis, hero, image.*

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КАРАКАЛПАКСКО-АЗЕРБАЙДЖАНСКИЕ КУЛЬТУРНО-ЛИТЕРАТУРНЫЕ СВЯЗИ (На примере научных исследований профессора Низами Мамедова Тагисоя)

Аннотация: *В данной работе изучаются труды известного азербайджанского учёного – литературоведа, тюрколога, работающего в области каракалпакско-азербайджанских культурно-литературных связей Низами Мамедова Тагисоя. Крупный учёный-тюрколог, более 20 лет работая в этой области, проводит важные исследования в части изучения каракалпакского фольклора, эпоса, классической литературы XIX – XX веков и по современной каракалпакской литературе. Перу Н.Мамедова Тагисоя принадлежат десятки статей, переводы каракалпакских народных сказок, перевод стихов, шежире и поэмы «Бозатау» Ажинияза на азербайджанский язык. Для гуманитарных факультетов азербайджанских университетов подготовлены два учебника по каракалпакской общественной, культурной и литературной жизни, он поддерживает систематические связи с каракалпакскими учёными-литературоведами, оппонирует и рецензирует исследования каракалпакских учёных, играя тем самым самую активную роль в развитии и формировании азербайджанско-каракалпакских культурных, фольклорных и литературных связей. Исходя из этого, мы объектом своей работы сделали труды учёного, посвящённых этим отношениям.*

Ключевые слова: *Азербайджан, каракалпаки, народ, фольклор, культура, литература, тюркские языки, наука, ученый, история, традиция, сказка, эпос, мотив, сюжет, менталитет, поэт, произведение, этногенез, герой, образ.*

Введение

Азербайджанцы, туркмены, гагаузы, анатолийские тюрки, каракалпаки, казахи, киргизы, карачаевцы, малкары, ногайцы, узбеки, татары, кумыки и другие тюркские народы – все они из одних этнических корней. Эти народы были разделены по разным историческим причинам и живут в разных регионах. Несмотря на то, что сегодня они живут отдельно, их язык, культура и традиции достаточно похожи друг другу. Это мы хорошо видим и чувствуем в фольклоре и литературе этих народов. Например, Мехсети Гянджеви, Хагани Ширвани, Низами Гянджеви, Мирза Шафи Вазех, Мирза Фатали Ахундзаде, Сеид Азим Ширвани, Мирза Алекпер Сабир, Джалил Мамедкулизаде, Гусейн Джавид и имена других поэтов известны и популярны не только в Азербайджане, но и у многих тюркских народов. А каракалпакские бахши-жырау, поэты, такие как Соппаслы Сыпыра жырау, Жийен Жырау, Кунходжа, Ажинияз, Бердах, Отеш, Омар, Гулмурат, Кулмурат и многие другие также играют важную роль в культуре родственных народов. Несмотря на то, что их творчество популяризируется благодаря изысканиям многих учёных, исследующих эти литературные связи между тюркскими народами, тем не менее в этой части стоят глубокого внимания труды азербайджанского ученого, доктора филологических наук, профессора Низами Мамедова Тагисоя, исследующего в своих трудах эти взаимоотношения. Своей научной деятельностью Низами Мамедов Тагисой вносит большой вклад в ознакомление народов других стран с каракалпакской художественной литературой и устном народным творчеством. Так, например, в 2006 году в издательстве «Мутарджим» столицы Азербайджана – в городе Баку вышла в свет книга ученого-переводоведа “Qaraqalpaq xalq nagılları” (Каракалпакские народные сказки) [1], где он представил целый ряд каракалпакских народных сказок требовательным азербайджанским читателям. Эти сказки являются бесценными культурными образцами каракалпакского народа.

А в 2007 году в издательстве «Мутарджим» вышла в свет книга ученого «Каракалпакская литература» [2], в которой дано подробное описание истории происхождения каракалпакского народа, его культуры, этнографии, искусства, литературы и фольклора. Эта книга – итог многолетнего кропотливого труда профессора Низами Мамедова. На примере известных эпосов «Кырк кыз», «Шарьяр», народных сказок, песен, образцов классической художественной литературы, поэтических произведений Кунходжи, Ажинияза, Бердаха ученый говорит о сокровенной мечте каракалпаков – жить и трудиться в свободном и процветающем краю.

В 2015 году уже выходит в свет его новая книга «Qaraqalpaq ədəbiyyatı» [3] в доработанном и переработанном варианте, в которой профессор охватил фактически многие узловые проблемы истории каракалпаков, их эпическое творчество, фольклор, меткие слова и изречения, загадки, песни, обряды и верования, каракалпакское острословие и анекдоты, различные виды каракалпакских сказок, классическую каракалпакскую литературу, творческое своеобразие Жийена Жырау, Кунходжи, Ажинияза, Бердаха, Отеша, Омара, Кулмурата и др. В этой фундаментальной книге скрупулезному и детальному анализу подвергаются творческие особенности таких каракалпакских писателей XX в., как Омар-шаир, Сейфульгабит Мажитов, Аяпберген Мусаев, Аббаз Дабылов, Садык Нурумбетов, Абдираман Отепов, Мирзагали Дарибаев, Тилеуберген Жумамуратов и др.

Специальными портретными очерками представлены своеобразие творческой манеры Жолмурзы Аймурзаева, Ибрайыма Юсупова, Толыбая Кабулова, яркий, впечатляющий лик каракалпакских прозаиков Ахмета Шамуратова, Асана Бегимова, Тулепбергена Каипбергенова, а также представителей каракалпакской драматургии, основные этапы развития национального театра, роль азербайджанской драматургии и театра в становлении каракалпакского сценического искусства, творчество ведущих профессиональных драматургов, сыгравших большую роль в развитии каракалпакского театра, где, помимо отмеченного, изучаются и другие вопросы каракалпакской литературы.

В научных изысканиях Низами Мамедова Тагисоя со знанием дела нашли отражение особенности развития каракалпакской поэзии, становление национальной прозы, формирование каракалпакской драматургии, театра и искусства сценического воплощения драматургических образцов.

Важным вкладом учёного в каракалпакскую литературу мы считаем разработку проблем каракалпакской фольклористики и каракалпакского литературоведения, что показывает высокий уровень осведомлённости профессора Низами Тагисоя в данной области.

Несмотря на то, что каракалпакско-азербайджанские литературные связи имеют определённую историю, Низами Тагисой эти связи освещает в историко-хронологической последовательности, где особо выделяет роль драматургических произведений азербайджанских писателей – комедии У.Гаджибейли «Аршин мал алан» и драмы

М.С.Ордубади «Пятирублёвая невеста» и др., что даёт возможность сказать о роли азербайджанской драматургии и театра в становлении каракалпакского сценического искусства.

Вместе с этим, ученый в данном фундаментальном научном труде дает подробный анализ жанров, сюжетов и образов героев в художественных и лирических произведениях, живших и творивших в XX веке писателей и поэтов – А.Дабылова, Т.Кабулова, героев Узбекистана И.Юсупова и Т.Каипбергенова и многих других. Особое место в этом научном труде занимает исследование романа-трилогии Т.Каипбергенова «Дастан о каракалпаках», где ученый дает высокую оценку художественному мастерству писателя, своеобразию его стиля, умению несколькими яркими штрихами раскрыть образы героев трилогии. Руководитель лаборатории «Фольклорная экспедиция», профессор Бакинского славянского университета Рустам Камал дал высокую оценку этому научному труду Низами Мамедова и отметил важные особенности представленных всех жанров каракалпакской литературы и устного народного творчества [6, с. 3].

При исследовании фольклора и литературы нашего народа азербайджанский ученый условно разделил свой научный труд на следующие части – общая характеристика Каракалпакстана и каракалпакского народа, каракалпакские эпосы и другие жанры устного народного творчества, каракалпакская литература XVIII – XIX веков, каракалпакская литература XX века, современная каракалпакская литература, особенности развития каракалпакской драматургии и театра. В каждой части ученый, опираясь на конкретные аргументации, даёт соответствующую оценку произведениям устного творчества и литературы каракалпаков.

Низами Мамедов Тагисой как крупный учёный известен своими литературоведческими и тюркологическими исследованиями не только в Азербайджане, но и далеко за его пределами. Наряду с многочисленными работами, посвященных творчеству русских писателей – А.Блока, С.Есенина, К.Симонова, В.Луговского, А.Адалис, П.Антокольского, Н.Тихонова, С.Васильева, азербайджанских – С.Вургуна, Мир Джалала, И.Эфендиева, Эльчина, Ф.Коджи, К.Абдуллы, Э.Гусейнбейли, Р.Равана, Э.Ахмеда, К.Кюргырахлы, М.Демирчиоглу, В.Бахманли, А.Гасанли, Ф.Бабанлы, А.Халафли, Ш.Агаяра, Ю.Нагмекяра и мн. других, его изыскания в области литературной критики, в частности каракалпакской литературы заслуживают самой высокой оценки.

В 2015 году каракалпакская научно-литературная общественность отмечала важное событие по случаю издания 100-томника каракалпакского фольклора. 25 – 27 ноября того года по этому случаю в Нукусе проходила представительная Международная конференция. Среди почётных гостей этой конференции был и профессор Низами Мамедов Тагисой, выступивший с интересным докладом. Тогда же в пространном и красивом зале Каракалпакского драматического театра имени Бердаха была презентирована его книга «Qaraqalpaq ədəbiyyatı», что в значительной степени была одобрена каракалпакскими учёными-литературоведами. Выступая с речью на конференции, он сказал: «Эта книга «Каракалпакская литература». Она издана в Баку на азербайджанском языке. В настоящее время этот научно-исследовательский труд включен в учебную программу вузов Азербайджана и сегодня изучается наравне с другими гуманитарными дисциплинами. Я привез вам четыре-пять экземпляров этой книги и хочу подарить их вам. Такое взаимоуважение и взаимопроникновение духовных и национальных ценностей между нашими родственными народами, безусловно, служат укреплению дружбы и дальнейшему развитию культуры и искусства» [7, с. 3].

Профессор Низами Тагисой постоянно поддерживает научно-творческие связи с каракалпакскими учёными. Он систематически интересуется с новинками каракалпакской литературы.

В 2020 году в Баку в издательстве «Elm və təhsil» вышла в свет книга переводов «Hacıniyaz», в которой наряду с переводами нашего классика, имеется обширный материал по общему творческому пути Ажинияза [5]. Важным вкладом в азербайджано-каракалпакских литературных взаимосвязей следует считать и этот оригинальный источник. Эти переводы были совместно осуществлены с доктором философии по филологии, также работающей в области азербайджанско-каракалпакских взаимосвязей, сотрудницей Института фольклора Национальной Академии Наук Азербайджана дочерью Низами муаллима Шабнам Мамедовой одним из редакторов книги был автор этих строк. Весомость этих переводов в том, что к нему предпослано необходимая вступительная статья переводчиков под названием «Певец каракалпакской народной души – Ажинияз Косыбай улы» [4, с 4 – 33], в которой освещаются основные особенности поэтического своеобразия каракалпакского классика. В этой книге достаточно адекватно раскрывается художественный талант великого поэта. В ней представлены переводы 52-х стихотворений, шежире и поэмы «Бозатау». Кроме этого, книга оснащена фольклорно-этнографическими терминами, которыми так богата поэзия Ажинияза. Мы считаем, что переводы Ажинияза

на азербайджанский язык – важное культурное событие как в жизни азербайджанцев, так и каракалпаков, исторически связанных тесными генетическими узами.

Перу неутомимого учёного принадлежат книги и исследования как в области национального литературоведения, так и в частности изучения проблем тюркологической литературы. Помимо каракалпакской литературы и фольклора приоритетными в его творчестве являются проблемы азербайджанско-русских, узбекских, гагаузских, казахских, киргизских, карачаевских, ногайских, татарских, кумыкских, башкирских и т.д. взаимосвязей. Профессор Низами Мамедов Тагисой ученый все тюркского масштаба, детально изучающий литературу и фольклор каракалпаков, казахов, ногайцев, карачаевцев и других народов [7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; 25].

Заслуживают специального изучения такие книги автора как, впервые появившийся в Азербайджане по инициативе Низами Тагисоя и выпущенный в соавторстве другими азербайджанскими профессорами Рафиком Манафоглу и Рустамом Камалом «Толковый словарь переводческих терминов» [22; 23], а также обширное художественное творчество, нашедшее своё отражение в азербайджанских изданиях [26; 27; 28].

Как мы видим, научное творчество и его художественные искания своеобразные по форме и оригинальные по содержанию привлекут внимание и в дальнейшем не только азербайджанских и каракалпакских исследователей, но и учёных других республик и народов.

Из отмеченного следует, что Низами Мамедов Тагисой – талантливый исследователь многих тюркских литератур. Его статьи, материалы и книги отличаются своеобразным и тонким индивидуальным взглядом. Они достаточно интересны и полемичны. Другой важной особенностью исследований профессора Тагисоя является то, что он в одинаковой степени владеет русским и азербайджанским, а также многими тюркскими языками, что даёт его исследованиям и переводам характер оригинальности.

В настоящее время профессор Низами Мамедов Тагисой с большой ответственностью и усилием работает над проблемами каракалпакской и тюркских литератур, разрабатывает вопросы этногенеза, истории, культуры наших народов, ищет их точки соприкосновения в контексте сюжетов, мотивов, тем, героев, образов, чем насыщена богатая тюркская литературная традиция.

Желаем доктору филологических наук, профессору Низами Мамедову Тагисою новых творческих и научных успехов в исследовании проблем тюркологического литературоведения и решения многих вопросов как сближения в общем плане тюркских, так в частности азербайджанской и каракалпакской литератур.

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Scientific publication

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