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Issue Article

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MOLECULAR DOCKING STUDIES OF Cu(II), Zn(II), Co(II), Ni(II) COMPLEXES WITH ABSCISIC ACID AND MONOETHANOLAMINE

Abstract: *The protein-ligand binding studies of [Me(ABA)$_2$(MEA)] and [Me(ABA)$_2$(MEA)$_2$] (here, Me= Cu(II), Zn(II), Co(II), Ni(II); ABA= abscisic acid; MEA= monoethanolamine) complexes with AtTIR1 protein (PDB ID: 2P1O) have been carried out using CB-Dock2 server. The binding energies of coordination compounds to the target 2P1O protein are significantly improved compared to the ABA or MEA molecule. Zinc and copper coordination compounds with two ABA molecules and one MEA molecule interact with the protein more strongly than other compounds, forming an H-bond with the following amino acid residues ARG9, TYR298, ARG344 and ARG403.*

Key words: *Abscisic acid, monoethanolamine 2P1O, docking studies, PDB database.*

Language: *English*

Citation: Mengnorov, I., & Khujamshukurov, N. A. (2023). Molecular docking studies of Cu(II), Zn(II), Co(II), Ni(II) complexes with abscisic acid and monoethanolamine. *ISJ Theoretical & Applied Science, 05 (121)*, 601-606.

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Introduction

Phytohormones regulate the protective responses of plants against both biotic and abiotic stresses by means of synergistic or antagonistic actions referred to as signaling crosstalk. Plants adapt to or tolerate stress through production of specific hormones that are produced at very low concentrations. One of the classical and well-studied phytohormones is abscisic acid (ABA), the importance of which is highlighted by its various roles in development (such as seed dormancy, germination, and floral induction) and stress responses (such as drought, salinity, and pathogen infection) [1-5]. The molecular structure of ABA consists of a cyclohexene ring with a monomethyl group, a dimethyl group, a ketone group, a hydroxyl group and a hydrocarbon side chain conjugated to the carboxylic acid group (Fig. 1).

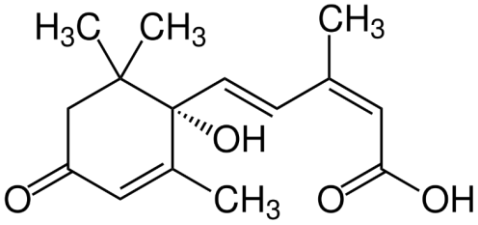


Fig. 1. Structure of ABA

Under stressful environmental conditions such as water shortage, high salinity and temperature extremes, the ABA content in plants rises significantly, stimulating stress-tolerance effects that help plants adapt and survive under these adverse conditions (Fig. 2.) [6].

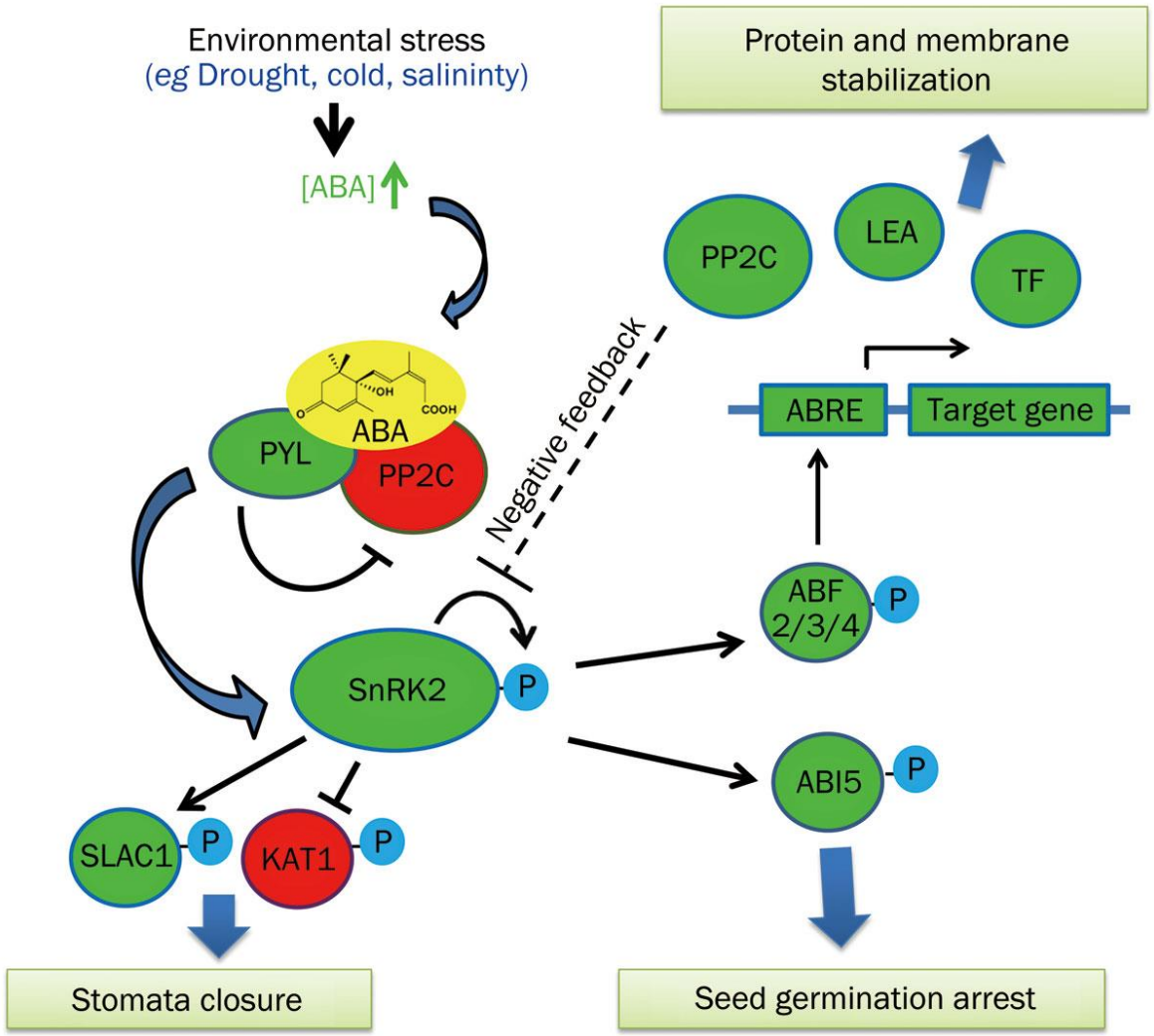


Fig. 2. ABA-mediated abiotic stress response

Under drought or osmotic stress conditions, ABA promotes stomatal closure, which prevents water loss through transpiration, and the accumulation of osmocompatible solutes to retain water [7,8]. The role of ABA as a negative regulator of plant growth has also been long established [9]. The activity of ABA in the induction and maintenance of seed dormancy is attributed to its potent effects on the inhibition of seed germination [10]. The inhibitory effects of ABA on germination and growth help plants withstand these stressful conditions and germinate only when the conditions are favorable for growth.

Moreover, ABA is not only involved in stress response, but also in plant growth by regulating the gene responsible for certain physiological processes ranging from stomatal opening to storage of proteins [11]. The receptors involved in ABA signaling were first discovered in Arabidopsis and it involves three major components- receptor PYR/PYL/RCAR (PYL-Pyrabactin resistance 1) protein family, positive regulator class III SNF-1-related protein kinase 2 (SnRK2) and negative regulator type 2C protein phosphatase (PP2C) [12]. PYR proteins are responsible for carrying out proper ABA signal transduction in Arabidopsis [13] and PP2Cs function as negative regulators in ABA-dependent pathways [14]. In this work, we theoretically studied the binding energy of metal complexes based on ABA and monoethanolamine (MEA) with proteins.

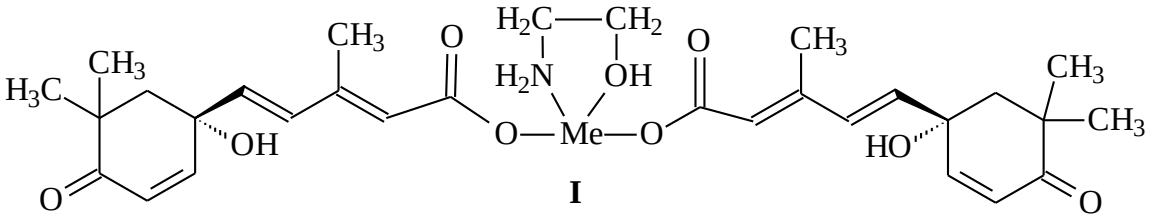
Materials and methods

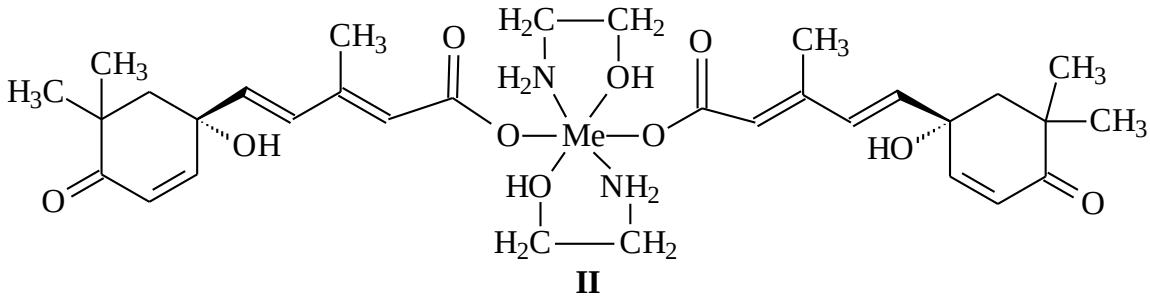
The geometry of ABA, MEA, and hypothetical coordination compounds was constructed using the Avogado software package [15]. Molecular docking studies have been carried out by CB-Dock2 server [16]. The target protein of AtTIR1 (PDB ID: 2P1O) was downloaded from PDB database [17].

Results and discussion

ABA is a plant hormone that regulates numerous aspects of plant growth, development, and stress responses. Molecular docking studies with the CB-Dock2 server were carried out to find new plant regulators. Hypothetical structures (Scheme 1) of coordination compounds based on MEA, ABA and metal ions (Cu(II), Zn(II), Co(II), Ni(II)) are constructed taking into account the fact that coordination compounds are more active than ligand molecules.

The protein-ligand binding of $[Me(ABA)_2(MEA)]$ and $[Me(ABA)_2(MEA)_2]$ (here, Me= Cu(II), Zn(II), Co(II), Ni(II); ABA= abscisic acid; MEA= monoethanolamine) complexes with AtTIR1 protein (PDB ID: 2P1O) was studied on the CB-Dock server. The results obtained are presented in table 1. It was found that the binding energy of ABA molecule with 2R1O protein is -5.7 kcal/mol and it forms H-bond only with GLU141 and ASP167 amino acid residues (Fig. 3). It was found that significant changes in binding energies occur in metal complexes. For example, the binding energy of the $[Zn(ABA)_2(MEA)]$ complex with metallic zinc is -9.7 kcal/mol, and it was found that the resulting complex has an H-bond with amino acid residues ARG9, TYR298 , ARG344 and ARG403 (Fig. 4).





Scheme 1. The structure of hypothetic coordination compounds. Me – Cu(II), Zn(II), Co(II), Ni(II).

Table 1. Binding energies of hypothetic structures to 2P1O

Compounds	Binding energy, kcal/mol	Contact residues with H-bond
$[Cu(ABA)_2(MEA)_1]$	-7.5	ARG9, TYR11, ASP167
$[Zn(ABA)_2(MEA)_1]$	-9.7	ARG9, TYR298, ARG344, ARG403
$[Co(ABA)_2(MEA)_1]$	-9.3	ARG9, TYR298, ARG344
$[Ni(ABA)_2(MEA)_1]$	-9.7	ARG9, TYR298, ARG344, ARG403
$[Cu(ABA)_2(MEA)_2]$	-7.1	-
$[Zn(ABA)_2(MEA)_2]$	-9.9	ARG9, ASP81, ARG344, ARG403
$[Co(ABA)_2(MEA)_2]$	-9.6	ARG9, ASN83, TYR298
$[Ni(ABA)_2(MEA)_2]$	-8.2	ARG9, ASN83
ABA	-5.7	GLU141, ASP167
MEA	-2.7	CYS140, GLU141

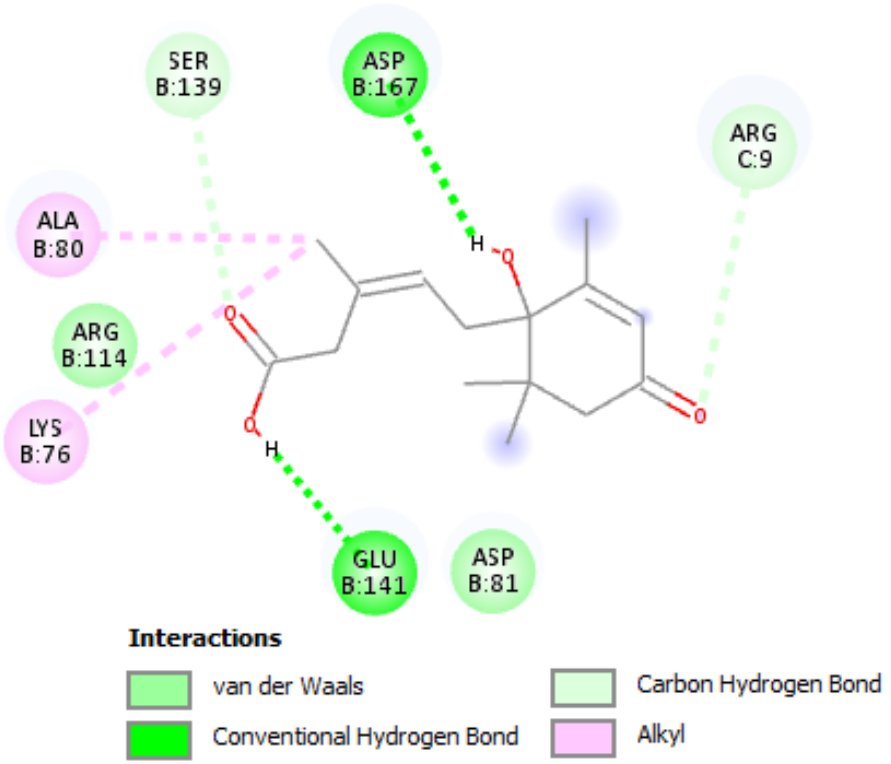


Fig. 3. Contact residues in the active site of the protein in 2P1O-ABA complex docked by CB-Dock2 server

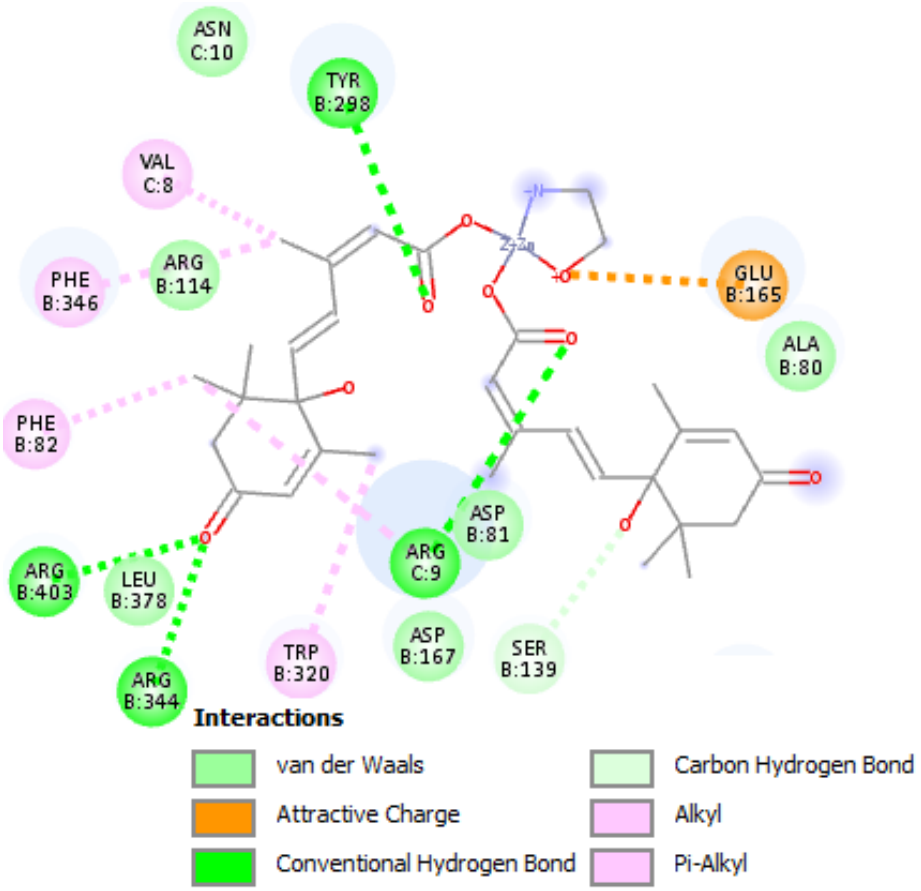


Fig. 4. Contact residues in the active site of the protein in 2P1O-Zn(ABA)$_2$(MEA)$_1$ complex docked by CB-Dock2 server

In addition, GLU165 is involved in the charge-charge interaction, enhancing the compound-protein interaction in the complex. A similar effect takes place in the $[Ni(ABA)_2(MEA)]$ coordination compound. There are no drastic changes in the interaction of type $[Me(ABA)_2(MEA)_2]$ compounds with proteins compared to type $[Me(ABA)_2(MEA)_2]$ compounds.

Conclusion

As a result of theoretical studies, it was established that the $[Zn(ABA)_2(MEA)]$ and $[Ni(ABA)_2(MEA)]$ complexes can have higher growth properties compared to the ABA compounds. This work may encourage chemists to synthesize coordination compounds $[Zn(ABA)_2(MEA)]$ or $[Ni(ABA)_2(MEA)]$ by reacting ABA with zinc or nickel salts.

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Issue Article

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ANALYSIS BESET WITH MODERN SITUATION AND TRENDS IN INDUSTRIAL DEVELOPMENT OF TAJIKISTAN REPUBLIC

Abstract: *The article dwells on the issue of theoretical foundations of industrial system development of Tajikistan Republic. It is noted that as a result of economic reformation of in the country`s sectors, a number of organizations and enterprises have undergone significant changes; the author`s definitions of the notion of industrial policy as well. It is concluded that there are real prerequisites for innovative development of industry in Tajikistan Republic, in addition, the existing industrial potential of the country possessing indicators for joint ventures creation taking into account the attraction of foreign and home capital makes it possible to establish close relations with home scientific institutions and to use their creative potential.*

Key words: *national economy, industrial policy, competitiveness of industrial products, industrial system, investments.*

Language: *Russian*

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АНАЛИЗ СОВРЕМЕННОЙ СИТУАЦИИ И ТЕНДЕНЦИЙ РАЗВИТИЯ ПРОМЫШЛЕННОСТИ РЕСПУБЛИКИ ТАДЖИКИСТАН

Аннотация: *В статье рассматривается вопрос о теоретических основах развития индустриальной системы Республики Таджикистан. Отмечено, что в результате реформирования экономики в отраслях страны ряд организаций и предприятий претерпели значительные изменения; также авторские определения понятия промышленной политики. Делается вывод о наличии реальных предпосылок для инновационного развития промышленности Республики Таджикистан, кроме того, имеющийся промышленный потенциал страны, обладающий показателями создания совместных предприятий с учетом привлечения иностранного и отечественного капитала, позволяет наладить тесные связи с отечественными научными учреждениями и использовать их творческий потенциал.*

Ключевые слова: *национальная экономика, промышленная политика, конкурентоспособность промышленной продукции, промышленная система, инвестиции.*

Введение

УДК – 338.1

Социально-экономическое развитие Республики Таджикистан тесно связано с уровнем развития промышленной системы страны и объективно отражает долю отраслей в обеспечение повышения применения инновационных технологий. В 2020 г. в структуре общего производства страны долю промышленной продукции представляли 293 вида продукции, куда в основном входили добыча золота, серебра, свинца, алюминия, угля, драгоценных металлов, выращивание хлопка, производство цемента, кирпича, асбеста, шифера, лекарств, мясной продукции и др. В целом, согласно официальным данным, объем

производства промышленной продукции по сравнению с 2019 годом увеличился на 9,7%.

Для оценки потенциала промышленной системы РТ необходимо провести сопоставительный регионально-структурный анализ промышленных отраслей, что позволит определить тенденции развития промышленности [1].

Необходимо отметить, что в наши дни в стране созданы условия для информационного обеспечения оценки промышленной системы, а также всей экономики. Так, в системе национальных счетов (СНС) налажен учет ВВП и ВРП, что позволяет осуществить сопоставительный анализ развития экономики страны и отраслей промышленности (таблица 1).

Таблица 1. Изменение производственной структуры ВВП РТ и доля ВРП в ней

	2010	2012	2014	2016	2018	2019	2020	2020 / 2010, %
I	**24707,1**	**36163,1**	**45606,6**	**54790,3**	**71059,2**	**79109,8**	**82543,0**	3,3 мар.
II	106,5	107,5	106,7	106,93	107,6	107,4	104,5	-
III	3285,8	4579,2	5523,7	6336,3	7870,2	8580,1	8788,9	2,6 мар.
IV	750,4	961,5	1119,3	808,7	860,0	900,3	851,5	113,5
V	**22308,9**	**32784,7**	**40836,2**	**49921,1**	**61368,4**	**68691,3**	**73870,5**	**3,3 мар.**
VI	90,3	90,7	89,5	91,6	89,1	88,8	89,5	-

Примечание: I – ВВП в действующих ценах соответствующих лет, млн сомони; II – темпы роста ВВП в процентах по сравнению с прошлым годом; III – ВВП на душу населения, сомони; IV – в долларах США; V – Валовой региональный продукт; VI – Доля ВРП в общем объеме ВВП, в %.

Составлено автором по источнику: *Таджикистан: 30 лет государственной независимости. Статистический сборник. – Душанбе: Агентство по статистике при Президенте РТ, 2021. – С. 335.*

В последние годы темпы роста основных экономических показателей в РТ значительно ускоряются. Как видно из данных таблицы 1, в рассматриваемый период ВВП республики (в 2020 г.) увеличился в 3,3 раза по сравнению с 2010 г. Одновременно доля ВРП в ВВП тоже увеличилась в 3,3 раза. Однако темпы роста по сравнению с прошлым годом снизились на 2,4%. В 2010 году доля ВВП на душу населения составила 3285,8 сомони, в 2020 году данный показатель увеличился в 2,6 раза. Необходимо отметить, что, хотя увеличение ВВП в иностранной валюте (доллары США) в анализируемый период составило 13,5%, темпы роста в 2020 году снизились по сравнению с 2019 и 2018 гг., что является следствием повышения банковского курса иностранной валюты. В 2010 г. доля ВРП в общем объеме ВВП составила 90,3%, в 2020 году этот показатель уменьшился на 0,8% и составил 89,5%.

Необходимо более глубоко проанализировать долю промышленности как ключевой отрасли в формировании основных показателей экономики страны.

Таблица 2. Доля ВПП (%) в объеме ВВП и ВРП в РТ (в действующих ценах соответствующих лет, млн сомони)

Показатели	2010	2015	2016	2018	2019	2020	2020 / 2010, %
ВВП	24707,1	50977,8	54790,3	71059,2	79109,8	82543	3,3 мар.
ВПП	11344	12196	15090	23894	27613	30890	2,7 мар
Доля ВПП в общем объеме ВПП, %	45,91	23,92	27,54	33,63	34,90	37,42	81,5
ВРП	22308,9	43745,9	49921,1	61368,4	68691,3	73870,5	3,3 мар.
Доля ВПП в общем объеме ВРП, %	50,8	27,9	30,2	38,9	40,2	41,8	82,2

Рассчитано автором по источникам: *Таджикистан: 30 лет государственной независимости // Статистический сборник. – Душанбе: Агентство по статистике при Президенте РТ, 2021. – С.335, 354-405; Промышленность Республики Таджикистан: 30 лет государственной независимости // Статистический сборник. – Душанбе: Агентство по статистике при Президенте РТ, 2021. –С.9.*

Как видно из данных таб. 2, значительна доля валового промышленного продукта в формировании основных показателей социально-экономического роста. В 2020 г. его доля в объеме

ВВП составила 37,42%, а в объеме ВРП – 41,8%. Хотя в росте данного показателя и его доли в 2020 г. по сравнению с 2010 г. наблюдается снижение в объеме ВВП на 18,5%, а в объеме ВРП – 17,8%, однако начиная с 2015 г. наблюдается увеличение, которое составило в 2020 г. 13,9%. Это свидетельствует о снижении производства в отдельных регионах страны и о неэффективном применении существующих законов. Одновременно это свидетельствует о необходимости реконструкции существующих механизмов поощрении и поддержки развития промышленных отраслей всех регионов страны, а также о необходимости проведения реформы государственного управления с целью налаживания более гармоничного взаимодействия между центром и регионами.

Промышленная политика занимает особое место в экономической политике республики. В современный период развития экономики обеспечение развития промышленной системы является одной из важнейших проблем. Как отмечается в Национальном стратегии развития РТ на период до 2030 г., в связи с мерами экономического развития и сценарием индустриального развития, «на таком уровне доля промышленности в структуре ВВП до конца предусматриваемого периода увеличится в 1,8 раза (в период 2021-2025 годов – до 16%, и в 2026-2030 годах – до 20-20,5%). По данному сценарию объем промышленного производства по сравнению с 2015 годом увеличится в 5,1 раза, в том числе в добывающей промышленности – в 6,4 раза, в перерабатывающей промышленности – в 5,5 раза, в производстве и распределении электроэнергии, газа и воды – в 2,2 раза» [4, с.19-20].

Как было отмечено, ВПП является одним из показателей, влияющих на экономическое развитие. Валовой промышленный продукт – это часть общественной продукции, показывающий в денежном выражении общий результат деятельности промышленного производства всех промышленных предприятий в определенный период времени (таблица 3).

Таблица 3. Динамика объема промышленной продукции в РТ и в ее регионах (в ценах соответствующих лет, млн сомони)

Годы	2015	2016	2017	2018	2019	2020	2020 / 2015, мар.
Республика Таджикистан	12196	15090	20029	23894	27613	30890	2,5
Доля в общем объеме, %	100	100	100	100	100	100	-
ГБАО	111,8	128,8	193,4	238,3	249,3	228,8	2,04
Доля в общем объеме, %	0,9	0,9	1,0	1,0	0,9	0,7	-
Согдийская область	4894,2	7078,5	10066,4	11498,4	13053,6	15573,2	3,1
Доля в общем объеме, %	40,1	46,9	50,3	48,1	47,3	50,4	-
Хатлонская область	4621,2	5047,7	6753,1	7294	8661,1	8998,3	1,9
Доля в общем объеме, %	37,9	33,5	33,7	30,5	31,4	29,1	-
г. Душанбе	1350,7	1461,8	1659	2664,9	2753,4	2800,6	2,07
Доля в общем объеме, %	11,1	9,7	8,3	11,2	10,0	9,1	-
РРП	1218,1	1373,2	1357,1	2198,5	2895,6	3289,4	2,7
Доля в общем объеме, %	10,0	9,1	6,8	9,2	10,5	10,6	-

Рассчитано автором по источнику: *Промышленность Республики Таджикистан: 30 лет государственной независимости // Статистический сборник. – Душанбе: Агентство по статистике при Президенте РТ, 2021. – С.9.*

Данные таб. 3 свидетельствуют, что промышленность в РТ имеет тенденцию к росту и в целом рост в 2020 году по сравнению с 2015 годом составил 2,5 раза. Необходимо отметить, что в 2015-2020 гг. в региональном плане тенденция к росту промышленности больше всего наблюдается в Согдийской области (3,1 раза). По данному показателю РРП занимают второе место (2,7 раза). Темпы роста ВПП в г. Душанбе и в ГБАО составили более чем в два раза. В Хатлонской области темпы роста составили почти два раза [1, с.9].

Для Республики Таджикистан характерно неравномерное географическое расположение промышленных отраслей. Так, до проведения социально-экономических реформ электроэнергетическая промышленность по большей части была расположена в регионах РРП и г. Душанбе, определенная часть – в Хатлонской и Согдийской областях, и минимальная часть – в ГБАО. В переходный для экономики период, после вхождения г. Нурека в Хатлонскую область, в отраслевом расположении промышленности произошли изменения. Также необходимо отметить, что в республике до 2016 года, и особенно в г. Душанбе, из-за отсутствия природного газа и топлива было прекращено производство тепловой и электроэнергии [5, с.73].

Однако, независимо от этого, на современном этапе в производстве промышленной продукции в РТ наблюдается рост, и на этой основе после 2015-2016 гг. увеличивается производство электроэнергии, воды, газа и тепловой энергии (табл.4).

Таблица 4. Динамика объема производства промышленной продукции в РТ (в ценах соответствующих лет, млн сомони)

Годы	2015	2016	2017	2018	2019	2020	2020/2015, маротиба
вся промышленность:	**12196**	**15090**	**20029**	**23894**	**27613**	**30890**	**2,5**
Производство и распределение электроэнергии, воды, газа и тепла	**2549**	**2718**	**3729**	**5688**	**6808**	**7527**	**2,9**
Добывающая промышленность	**1641**	**3004**	**4524**	**4686**	**4853**	**4309**	**2,6**
В том числе: Добыча энергетических материалов	203	222	298	331	377	429	2,1
Добыча неэнергетических материалов	1438	2782	4226	4355	4476	3880	2,6
Обрабатывающая промышленность	**8006**	**9368**	**11776**	**13520**	**15952**	**19054**	**2,3**
В том числе: Производство пищевых продуктов, включая напитки и табака	3482	3690	4304	4900	5399	7089	2,03
Текстильное и швейное производство	1292	1520	2354	2479	2636	2870	2,2
Производство кожи, изделий из кожи и производство обуви	41	49	57	63	71	91	2,2
Обработка древесины и производство изделий из дерева	77	103	119	138	148	142	1,8
Целлюлозно-бумажное производство, издательская и полиграфическая деятельность	143	115	142	241	260	182	1,2
Производство нефтепродуктов	52	62	79	105	127	87	1,6
Химическое производство	86	95	107	147	154	182	2,1
Производство резиновых и пластмассовых изделий	61	85	157	200	265	291	4,7
Производство прочих неметаллических минеральных продуктов	1201	1655	2091	2298	2593	2713	2,2
Металлургическое производство и производство готовых металлических изделий	1450	1850	2187	2708	3874	4978	3,4
Машиностроение;	93	114	142	203	308	291	3,1
Прочие отрасли экономики	28	30	37	38	117	138	4,9

Рассчитано автором по источникам: Таджикистан: 30 лет государственной независимости // Статистический сборник. – Душанбе: Агентство по статистике при Президенте РТ, 2021.С.-393-397; Промышленность РТ: 30 лет государственной независимости // Статистический сборник. – Душанбе: Агентство по статистике при Президенте РТ, 2021. – С.18-19.

Из данных табл.4 следует, что темпы роста объема промышленной продукции в добывающей отрасли в период 2015-2020 гг. в целом составили 2,6 раза, в том числе в добыче энергетических материалов – в 2,1 раза, в добыче неэнергетических материалов – в 2,6 раза. Однако необходимо отметить, что показатель по энергетическим материалам в 2020 году по сравнению с 2019 годом снизился на 11,2%, а по добыче неэнергетических материалов – на 13,3%. В обрабатывающей промышленности показатели 2015-2020 гг. показывают тенденцию к росту. В рассматриваемый период производство пищевых продуктов, текстильных изделий, изделий из кожи, продукции химического производства увеличилось более чем в 2 раза. Производство неметаллических минеральных продуктов, изделий металлургического производства и готовых металлических изделий и продукции машиностроения увеличилось больше чем в 3 раза. В 2015-2020 гг. производство резиновых и пластмассовых изделий увеличилось в 4,7 раза. Темпы роста по сравнению с 2019 годом составили 9,8%. В 2,3 раза увеличилась обработка древесины и производство изделий из дерева. Это прежде всего связано с вводом в эксплуатацию предприятий по обработке пластмассы в

Согдийской области и в г. Душанбе в последние три года.

В Республике Таджикистан промышленность в целом складывается из добывающей и обрабатывающей промышленности, производства электроэнергии, газа и воды. Добывающая промышленность связана с добычей минералов, угля, энергетических и неэнергетических материалов. Обрабатывающая промышленность включает сектор переработки и производства новой продукции (таб.5).

Таблица 5. Динамика стуктуры отраслей промышленности РТ (в период 2015-2020 гг, %)

Годы	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2020 / 2015, %**
вся промышленность	**100**	**100**	**100**	**100**	**100**	**100**	**100,0**
Производство и распределение электроэнергии, воды, газа и тепла	**20,9**	**18**	**18,8**	**23,8**	**24,6**	**24,4**	**116,7**
Добывающая промышленность	**13,5**	**19,9**	**22,6**	**19,6**	**17,6**	**13,9**	**103,0**
Добыча энергетических материалов	1,7	1,5	1,5	1,4	1,4	1,4	82,4
Добыча неэнергетических материалов	11,8	18,4	21,1	18,2	16,2	12,5	105,9
Обрабатывающая промышленность	**65,6**	**62,1**	**58,6**	**56,6**	**57,8**	**61,7**	**94,1**
Производство пищевых продуктов, включая напитки и табака	28,5	24,4	21,4	20,5	19,6	22,9	80,4
Текстильное и швейное производство	10,6	10,1	11,8	10,4	9,5	9,3	87,7
Производство кожи, изделий из кожи и производство обуви	0,3	0,3	0,3	0,3	0,3	0,3	100,0
Обработка древесины и производство изделий из дерева	0,6	0,7	0,6	0,6	0,5	0,5	83,3
Целлюлозно-бумажное производство	1,2	0,8	0,7	1	0,9	0,6	50,0
Производство нефтепродуктов	0,4	0,4	0,4	0,4	0,5	0,3	75,0
Химическое производство	0,7	0,6	0,5	0,6	0,6	0,6	85,7
Производство резиновых и пластмассовых изделий	0,5	0,6	0,8	0,8	1	1	200,0
Производство прочих неметаллических минеральных продуктов	9,8	11	10,4	9,6	9,4	8,8	89,8
Металлургическое производство и производство готовых металлических изделий	11,9	12,3	10,9	11,3	14	16,1	135,3
Машиностроение	0,8	0,8	0,7	0,9	1,1	0,9	112,5
Прочие отрасли экономики.	0,2	0,2	0,2	0,2	0,4	0,4	200,0

***Составлено автором по источнику*:** Промышленность РТ: 30 лет государственной независимости // Статистический сборник. – Душанбе: Агентство по статистике при Президенте РТ, 2021. – с. 20-21

По данным таблицы 5 можно говорить об относительном увеличении производства в промышленных отраслях в период 2015-2020 гг. Однако здесь уверенное первенство сохраняется за производством и распределением тепловой и электроэнергии.

В части увеличения численности промышленных предприятий страны необходимо отметить, что она еще не достигла уровня 1991 года. Однако темпы роста в период 2012-2020 годов свидетельствуют об уверенном увеличении количества промышленных предприятий (таблица 6).

Таблица 6. Количество промышленных предприятий в РТ по отраслям промышленности, единиц

Периоды	**2012**	**2014**	**2015**	**2017**	**2019**	**2020**	**2020/2012, %**
вся промышленность	1586	2164	2310	1999	2164	2283	143,9
В том числе: Добывающая промышленность	109	154	214	229	250	264	2,4 раз
По отношении к общему, %	6,9	7,1	9,3	11,5	11,6	11,6	-
Обрабатывающая промышленность	1448	1980	2071	1732	1746	1846	127,5
По отношении к общему, %	91,3	91,5	89,7	86,6	80,7	80,9	-

Производство и распределение электроэнергии, воды, газа и тепла	29	28	30	38	168	173	5,9 раз
По отношении к общему, %	1,8	1,3	1,3	1,9	7,8	7,6	-

***Составлено автором по источникам*:** Таджикистан: 30 лет государственной независимости // Статистический сборник. – Душанбе: Агентство по статистике при Президенте РТ, 2021.-С.397; Промышленность РТ: 30 лет государственной независимости // Статистический сборник. – Душанбе: Агентство по статистике при Президенте РТ, 2021. – с. 24-25

Как видно из таблицы 6, за период 2012-2020 годов количество промышленных пердприятий в целом увеличилось на 43,9%, в том числе в 2,4 раза увеличилось количество предприятий добывающей промышленности, которые составляют 11,6% от общего количества предприятий. В 2012-2020 годах количество предприятий обрабатывающей промышленности увеличилось на 27,5% и составило 80,9% от общего количества предприятий. Увеличение предприятий, занятых производством и распределением тепловой и электроэнергии, составило 5,9 раза. В 2020 г. они составили 7,6% от общего количества промышленных предприятий страны.

В целом, по данным Министерства промышленности и новых технологий РТ, в 2020 году в стране введены в эксплуатацию 83 промышленных предприятия, в том числе 34 – в Согдийской области, 21 – в Хатлонской области, 13 предприятий – в РРП, 13 предприятий – в г. Душанбе, и 2 предприятия – в ГБАО. На этих предприятиях создано 1,1 тыс. рабочих мест. Из 83 предприятий 29 функционируют в пищевой промышленности, 17 – в легкой промышленности, 13 – в машиностроении, 17 производят строительные материалы [6].

Необходимо отметить, что только за январь-сентябрь 2021 г. в РТ сданы в эксплуатацию 229 новых предприятий и цехов. В целом эти предприятия произвели продукцию более чем на 363 млн сомони. По статистическим данным Министерства промышленности и новых технологий РТ, в 2021 году наша страна заняла первое место среди стран СНГ по увеличению численности предприятий промышленности. В 2021 г. Выпуск промышленной продукции увеличился по сравнению с 2020 годом на 20% и составил 3,4 млрд долларов США.

Как видно из приведенных министерством данных: "... в 2021 году в республике объем промышленной продукции увеличился почти на 23%. Данный показатель – самый высокий среди стран СНГ. Согласно данным Статистического комитета стран СНГ, показатель Российской Федерации – 5%, Узбекистана – 3,5%, Казахстана – 3%, Киргизии – 0,2%. Республика Таджикистан достигла значительных успехов в добывающей промышленности, где увеличение объема производства продукции составило 32%. На 20% увеличилось производство электроэнергии и продовольствия. В 2021 году РТ экспортировала за рубеж 270 тыс. т очищенной руды, 1,2 млн т цемента и более 100 тыс. т хлопка. По сравнению с 2020 г. объем горнорудного производства увеличился на 60%. Предприятия отрасли выпустили продукции почти на 1 млрд американских долларов, что на 400 млн американских долларов больше, чем в прошлом году. На 11% увеличился объем производства пищевых продуктов" [7; 8; 9 10].

Вывод

Таким образом, в РТ существуют реальные предпосылки для инновационного развития промышленности, кроме того, существующий промышленный потенциал страны, обладающий показателями для создания совместных предприятий с учетом привлечения зарубежного и отечественного капитала, дает возможность наладить тесную связь с отечественными научными институтами и использовать их творческий потенциал.

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Issue Article

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LEONTIEV'S ECOLOGICAL AND ECONOMIC BALANCE MODEL IN THE SYSTEM OF COMPUTER MATHEMATICS

***Abstract**: In the last decade, advances in computer technology have made it possible to study ecological systems with many species interacting with each other in a variety of ways. Taking into account the development of the modern direction in mathematics – computer mathematics, the possibility of studying ecosystems at a higher quality level increases. The article discusses the modeling of the Leontiev balance model in the Maple system, which makes it possible to conduct research, avoiding routine calculations, calculation complexity, and reduces time costs.*

***Key words**: quantity of products, matrix, volume of costs, volume of pollutants, Leontiev model.*

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ЭКОЛОГО-ЭКОНОМИЧЕСКАЯ БАЛАНСОВАЯ МОДЕЛЬ ЛЕОНТЬЕВА В СИСТЕМЕ КОМПЬЮТЕРНОЙ МАТЕМАТИКИ

***Аннотация**: В последнее десятилетие успехи вычислительной техники позволяют изучать экологические системы с множеством видов, взаимодействующих друг с другом самым различным образом. Принимая во внимание, развитие современного направления в математике – компьютерной математики повышается возможность исследования экосистем на более качественном уровне. В статье рассматривается моделирование балансовой модели Леонтьева в системе Maple, что создает возможность проводить исследования, избегая рутинные выкладки, сложности вычисления, и сокращает временные затраты.*

***Ключевые слова**: количество продукции, матрица, объем затрат, объем загрязняющих веществ, модель Леонтьева.*

Введение

При решении проблем взаимодействия природы и общества наиболее распространенной моделью является эколого-экономическая модели. Построение моделей основано на использовании методов линейной алгебры и систем, описываемых дифференциальными уравнениями. Многоуровневая модель взаимодействия экологических и экономических систем включает блоки:

1) межотраслевого баланса;
2) динамики природных ресурсов;
3) принятия управленческих решений.

Главной целью (решением) этой модели является устранение проблемных ситуаций, связанных с принятием решений, эффективных с точки зрения сегодняшнего дня, но не эффективных для будущего. Модели этого типа обладают достаточной сложностью. Модели могут состоять, как из систем линейных алгебраических уравнений (СЛАУ) , так и включать системы уравнений в интегральной и дифференциальной форме. Рассмотрим структуру и методы блока

межотраслевого баланса (МОБ), который представлен многоотраслевой моделью Леонтьева в виде СЛАУ[1].

Межотраслевой баланс — метод анализа взаимосвязей между различными секторами экономической системы. Это означает, что каждый сектор выступает одновременно производителем и потребителем. Кроме полезного продукта по каждому сектору экономики происходит образование и выбросы загрязняющих веществ в окружающую среду. Количество загрязняющих веществ можно представить через удельные величины, например, приходящиеся на единицу выпуска каждого вида продукции.

Цель балансового анализа: определение количества продукции, произведенной каждым сектором для того, чтобы удовлетворить все потребности экономической системы в его продукции и, при этом, не нарушить установленных норм выбросов загрязняющих веществ в окружающую среду[2].

Для анализа составляется таблица межотраслевого баланса. Числа в строках таблицы, показывают, как распределяется произведенная продукция каждого сектора. Последний элемент строки представляет объем произведенной сектором продукции (общий выпуск). Данные в столбцах показывают, какую продукцию потребляет каждый сектор в процессе производства. Последнее число в столбце – это суммарные затраты сектора. Если объем затрат каждого сектора (сумма элементов в столбце таблицы) равен объему произведенной продукции (сумма элементов в соответствующей строке), то модель является замкнутой [1]-[3]. Для детального рассмотрения, рассмотрим упрощенную модель межотраслевого баланса. Пусть данная модель состоит из 3-х секторов — сельского хозяйства, промышленности и домашнего хозяйств. В качестве единицы измерения объемов товаров и услуг каждого сектора выберем их стоимость.

Таблица 1.1 Таблица межотраслевого баланса для простейшей эколого-экономической модели региона

	Сельское хозяйство	Промышленность	Домашние хозяйства	Общий выпуск
Сельское хозяйство	b_{11}	b_{12}	b_{13}	$\sum_{j=1}^{n} b_{1j}$
Промышленность	b_{21}	b_{22}	b_{23}	$\sum_{j=1}^{n} b_{2j}$
Домашние хозяйства	b_{31}	b_{32}	b_{33}	$\sum_{j=1}^{n} b_{3j}$
Затраты	$\sum_{i=1}^{n} b_{i1}$	$\sum_{i=1}^{n} b_{i2}$	$\sum_{i=1}^{n} b_{i3}$	

Таблицы межотраслевого баланса описывают потоки товаров и услуг между секторами экономики в течение фиксированного промежутка времени, например в течение квартала, полугодия или года. Такие данные, сохраняемые в таблицах, естественно описывать и анализировать в терминах матричной алгебры.

Для замкнутой экономической системы баланс между общим выпуском и затратами каждого сектора можно описать равенствами:

$$\sum_{j=1}^{n} b_{kj} = \sum_{i=1}^{n} b_{ik}, \qquad (1)$$

где b_{kj} - количество товаров и услуг k-го сектора экономики, потребляемого в j-м секторе; b_{jk} - количество товаров и услуг i-го сектора экономики, потребляемого в k-м секторе. Матрицей межотраслевого баланса (матрицей Леонтьева) называется матрица вида:

$$B = \begin{pmatrix} b_{11} & b_{12} & \dots & b_{1n} \\ b_{21} & b_{22} & \dots & b_{2n} \\ \dots & \dots & \dots & \dots \\ b_{m1} & b_{n2} & \dots & b_{nn} \end{pmatrix}. \qquad (2)$$

На практике экономика региона представляет собой открытую систему межотраслевых связей, в которой вся произведенная продукция (совокупный продукт) разделяется на две части: одна часть продукции (промежуточный продукт) идет на потребление в производящих секторах, а другая ее часть (конечный продукт) потребляется вне сферы материального производства — в секторе конечного спроса. При этом потребление в секторе конечного спроса может меняться. Для открытой системы межотраслевой баланс будет иметь вид:

$$x_i = \sum_{j=1}^{n} b_{ij} + y_i = \sum_{j=1}^{n} a_{ij} x_i + y_i \ , \quad i = \overline{1,n} \qquad (3)$$

или

$$x_i - \sum_{j=1}^{n} a_{ij} x_i = y_i , \ i = \overline{1,n} . \qquad (4)$$

СЛАУ (4) запишем в матричном виде:

$$X \cdot (E - A) = Y \ , \qquad (5)$$

в развернутом виде:

$$\begin{cases} (1-a_{11})x_1 - a_{12}x_2 ... - a_{1n}x_n = y_1 \\ -a_{21}x_1 + (1-a_{22})x_2 + ... - a_{2n}x_n = y_2 \\ ..... \\ -a_{n1}x_1 - a_{n2}x_2 - ... + (1-a_{nn})x_n = y_n \end{cases} \qquad (6)$$

В (5) E - единичная матрица, $X = x_i$ - объем выпуска i-го сектора(объем товаров и услуг, произведенных в одном из n производящих секторов), $i = \overline{1,n}$; $Y = y_i$ - конечный продукт i-го сектора(объем продукции i-го сектора, потребляемой в секторе конечного спроса) ; $A = a_{ij} = \frac{b_{ij}}{x_j}$ - количество продукции i-го сектора, которое расходуется при производстве единицы продукции j-го сектора(коэффициенты прямых затрат); b_{ij} - объем товаров и услуг i-го сектора, потребляемых в j-м секторе.

Система (6) описывает структуру связей и означает, что в сектор конечного спроса от каждого производственного сектора поступает та часть произведенной продукции, которая остается после того, как обеспечены потребности производящих секторов[4].

Предположим, что в течение некоторого промежутка времени коэффициенты прямых затрат a_{ij} остаются постоянными, а конечный спрос изменяется. Это означает, что существует линейная связь между выпуском и затратами и изменение выпуска хотя бы в одном секторе экономики влечет за собой пропорциональное изменение затрат всех производящих секторов. Коэффициентами пропорциональности этой связи являются элементы структурной матрицы. То есть в линейной модели «затраты – выпуск» соотношения баланса описывают связь неизвестного выпуска с заданным спросом. Эти соотношения позволяют определить, каким должен быть совокупный выпуск в каждом секторе, чтобы удовлетворить изменившиеся потребности общества[5].

В системе с заданной структурной матрицей A спрос Y всегда удовлетворяется, если существует вектор выпуска

$$X = (E - A)^{-1} Y \qquad (7)$$

все компоненты которого неотрицательны. Для этого необходимо выполнение условий Хаукинса-Саймона[4]:

$$1 - a_{11} > 0, \begin{vmatrix} 1-a_{11} & -a_{12} \\ -a_{21} & 1-a_{22} \end{vmatrix} > 0, ..., \begin{vmatrix} 1-a_{11} & -a_{12} & \cdots & -a_{1n} \\ -a_{21} & 1-a_{22} & \cdots & -a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ -a_{n1} & -a_{n2} & \cdots & 1-a_{nn} \end{vmatrix} > 0 \ . \qquad (8)$$

По условиям (8) все миноры детерминанта матрицы системы (6) должны быть положительными. Обозначим Z -общий объем загрязняющего вещества. Для расчета загрязнения окружающей среды каждым сектором и всеми одновременно необходимо дополнить систему уравнений (6) еще одним балансовым уравнением:

$$Z = c_1 x_1 + c_2 x_2 + ... + c_n x_n \ , \qquad (9)$$

где c_i -нормы выбросов загрязнителя на единицу продукции x_i [6].

Рассмотрим замкнутую модель эколого-экономической системы района, если заданы таблица межотраслевого баланса:

	Сельское хозяйство	Промышленность	Транспорт	Домашнее хозяйство
A	20	16	120	60
B	30	10	180	100
C	15	14	140	80

конечный спрос на продукцию:

Y	100
	150
	120

выбросы загрязняющего вещества на единицу продукции каждого сектора:

Z	0,04
	0,26
	0,34

Составим матрицу межотраслевого баланса, элементами которой являются числовые данные одноименной таблицы:

$$B = \begin{pmatrix} 50 & 16 & 120 & 60 \\ 30 & 10 & 180 & 100 \\ 15 & 14 & 140 & 80 \end{pmatrix}.$$

Вычислим общий выпуск каждой продукции, сложив элементы каждой строки:

$$\sum_{j=1}^{3} b_{1j} = 50+16+120+60 = 246;$$

$$\sum_{j=1}^{3} b_{2j} = 30+10+180+100 = 320;$$

$$\sum_{j=1}^{3} b_{3j} = 15+14+140+80 = 249.$$

Полученные данные, запишем в виде строчной матрицы:

$$X = (246 \quad 320 \quad 249).$$

Общее количество выбросов загрязняющих веществ Z_1 получим, умножив матрицу X на матрицу, элементами которой являются численные данные выбросов веществ :

$$Z_1 = X \cdot Z = (246 \quad 320 \quad 249) \cdot \begin{pmatrix} 0{,}04 \\ 0{,}26 \\ 0{,}34 \end{pmatrix} = 246 \cdot 0{,}04 + 320 \cdot 0{,}26 + 249 \cdot 0{,}34 = 177{,}70.$$

Вычислим структурную матрицу коэффициентов затрат, обозначив ее A. Для этого составим матрицу производственных секторов $X1$, элементами которой являются значения матрицы межотраслевого баланса без столбца значений домашнего хозяйства:

$$X1 = \begin{pmatrix} 50 & 16 & 120 \\ 30 & 10 & 180 \\ 15 & 14 & 140 \end{pmatrix}.$$

Составим матрицу удельного выпуска $X2$, которая является диагональной, а элементы главной диагонали равны значениям $x2_{1j} = \frac{1}{x_{1j}}$, $j = \overline{1,3}$ строчной матрицы X :

$$X2 = \begin{pmatrix} \frac{1}{246} & 0 & 0 \\ 0 & \frac{1}{320} & 0 \\ 0 & 0 & \frac{1}{249} \end{pmatrix}$$

Структурную матрицу коэффициентов прямых затрат, получаем, умножая матрицу $X1$ на матрицу $X2$:

$$A = X1 \cdot X2 = \begin{pmatrix} 50 & 16 & 120 \\ 30 & 10 & 180 \\ 15 & 14 & 140 \end{pmatrix} \cdot \begin{pmatrix} \frac{1}{246} & 0 & 0 \\ 0 & \frac{1}{320} & 0 \\ 0 & 0 & \frac{1}{249} \end{pmatrix} = \begin{pmatrix} \frac{25}{123} & \frac{1}{20} & \frac{40}{83} \\ \frac{5}{41} & \frac{1}{32} & \frac{60}{83} \\ \frac{5}{82} & \frac{7}{160} & \frac{140}{249} \end{pmatrix}.$$

Для того, чтобы осуществить расчет выпуска продукции для заданного конечного спроса, необходимо проверить условия Хаукинса-Саймона (8). Для этого составим матрицу $E - A$:

$$E - A = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} - \begin{pmatrix} \frac{25}{123} & \frac{1}{20} & \frac{40}{83} \\ \frac{5}{41} & \frac{1}{32} & \frac{60}{83} \\ \frac{5}{82} & \frac{7}{160} & \frac{140}{249} \end{pmatrix} = \begin{pmatrix} \frac{98}{123} & -\frac{1}{20} & -\frac{40}{83} \\ -\frac{5}{41} & \frac{31}{32} & -\frac{60}{83} \\ -\frac{5}{82} & -\frac{7}{160} & \frac{109}{249} \end{pmatrix},$$

затем вычислим диагональные миноры определителя матрицы $E - A$:

$$M_1 = \frac{98}{123};\ M_2 = \begin{vmatrix} \frac{98}{123} & -\frac{1}{20} \\ -\frac{5}{41} & \frac{31}{32} \end{vmatrix} = \frac{1507}{1968};\ M_3 = \begin{vmatrix} \frac{98}{123} & -\frac{1}{20} & -\frac{40}{83} \\ -\frac{5}{41} & \frac{31}{32} & -\frac{60}{83} \\ -\frac{5}{82} & -\frac{7}{160} & \frac{109}{249} \end{vmatrix} = \frac{135625}{490032}.$$

Как видно, все диагональные миноры структурной матрицы коэффициентов прямых затрат положительны, что говорит о выполнении условий (8). Следовательно, можно определить объем выпуска для заданного конечного спроса Y, который находится по формуле (7):

$$Ov = (E - A)^{-1} \cdot Y = \begin{pmatrix} \frac{384621}{271250} & \frac{105288}{678125} & \frac{246492}{135625} \\ \frac{9552}{27125} & \frac{156512}{135625} & \frac{62208}{27125} \\ \frac{126423}{542500} & \frac{92877}{678125} & \frac{375243}{135625} \end{pmatrix} \cdot \begin{pmatrix} 100 \\ 150 \\ 120 \end{pmatrix} = \begin{pmatrix} \frac{10393746}{27125} \\ \frac{2623104}{5425} \\ \frac{10194309}{27125} \end{pmatrix}.$$

Для вычисления матрицы Ov нужно предварительно вычислить обратную матрицу $(E - A)^{-1}$.

Вычислим для этого объема Ov суммарное количество выбросов загрязняющего вещества Z_2, умножив транспонированную матрицу Ov на матрицу Z - матрицу выбросов загрязняющих веществ:

$$Z_2 = (Ov)^T \cdot Z = \begin{pmatrix} \frac{10393746}{27125} & \frac{2623104}{5425} & \frac{10194309}{27125} \end{pmatrix} \cdot \begin{pmatrix} 0{,}04 \\ 0{,}26 \\ 0{,}34 \end{pmatrix} = 268{,}823.$$

Как видим, количество загрязняющих веществ при заданном спросе Y на продукцию увеличился.

Элементы 2-го столбца матрицы $(E-A)^{-1}$ указывают на изменения выпуска в производящих секторах при увеличении потребностей в промышленных товарах на единицу потребления промышленной продукции[7]. Учитывая это, произведем дополнительные вычисления. Например, вычислим материальные затраты при увеличении выпуска продукции (производимой промышленностью) на $4{,}5\%$. Для этого, умножим элемент, стоящий во второй строке столбца матрицы Ov на число $\frac{4{,}5}{100}$:

$$d = \frac{2623104}{5425} \cdot 0{,}045 = 21{,}758.$$

Следовательно, увеличится выпуск товаров и услуг: это вычисляется, умножив транспонированный 2-й столбец матрицы $(E-A)^{-1}$ на величину d :

$$Xy = \left(\frac{105288}{678125} \quad \frac{156512}{135625} \quad \frac{92877}{678125}\right) \cdot 21{,}758 = (3{,}3782 \quad 25{,}1093 \quad 2{,}9800).$$

Увеличение количества выбросов загрязняющих веществ составит при этом:

$$Z_3 = (3{,}3728 \quad 25{,}1093 \quad 2{,}9800) \cdot \begin{pmatrix} 0{,}04 \\ 0{,}26 \\ 0{,}34 \end{pmatrix} = 7{,}6767.$$

Проведем исследование модели межотраслевого баланса в системе Maple. Подключим специализированный пакет *Linalg*:

```
restart;
with(linalg);
```

Составляем матрицу межотраслевого баланса B, вводим данные матрицы выбросов загрязняющих веществ Z :

```
B:=matrix(3,4,[50,16,120,60,30,10,180,100,15,14,140,80]);
Z:=matrix(3,1,[0.04,0.26,0.34]);
```

$$B := \begin{bmatrix} 50 & 16 & 120 & 60 \\ 30 & 10 & 180 & 100 \\ 15 & 14 & 140 & 80 \end{bmatrix}$$

$$Z := \begin{bmatrix} 0.04 \\ 0.26 \\ 0.34 \end{bmatrix}$$

Для вычисления общего выпуска каждой продукции составим вектор общего выпуска[8]-[10]:

```
multiply(B,Matrix(4,1,[1$4]));
X:=convert(%,vector);
```

$$\begin{bmatrix} 246 \\ 320 \\ 249 \end{bmatrix}$$

$$X := [\,246\,,\,320\,,\,249\,]$$

Количество выбросов загрязняющих веществ Z_1 при заданных данных получаем, умножив матрицу X на матрицу, элементами которой являются численные данные выбросов веществ, используя команду *multiply* :

```
Z1:=multiply(X,Z);
```

$$Z1 := [\,177.70\,]$$

Произведем расчеты количества выбросов загрязняющих веществ Z_2 при заданных данных спроса на продукцию Y. Вычислим структурную матрицу коэффициентов затрат, как описана выше :

```
X1:=submatrix(B,1..3,1..3);
X2:=diag(seq(1/X[i],i=1..3));
A:=multiply(X1,X2);
```

$$X1 := \begin{bmatrix} 50 & 16 & 120 \\ 30 & 10 & 180 \\ 15 & 14 & 140 \end{bmatrix}$$

$$X2 := \begin{bmatrix} \frac{1}{246} & 0 & 0 \\ 0 & \frac{1}{320} & 0 \\ 0 & 0 & \frac{1}{249} \end{bmatrix}$$

$$A := \begin{bmatrix} \frac{25}{123} & \frac{1}{20} & \frac{40}{83} \\ \frac{5}{41} & \frac{1}{32} & \frac{60}{83} \\ \frac{5}{82} & \frac{7}{160} & \frac{140}{249} \end{bmatrix}$$

Проверим условия Хаукинса-Саймона (1.8), для чего составим матрицу $E - A$ [9]:

```
EA:=evalm(diag(1$3)-A);
M:=seq(det(submatrix(EA,1..i,1..i)),i=1..3);
if M[1]>0 and M[2]>0 and M[3]>0 then print (_Ysloviya_vipolnimi_);
else print (_Ysloviya_ne_vipolnimi_);
fi;
```

$$M := \frac{98}{123}, \frac{1507}{1968}, \frac{135625}{490032}$$

*_Ysloviya_vipolnimi_*

Объем выпуска для заданного конечного спроса Y вычисляем, используя формулу (7):

```
Y:=matrix(3,1,[100,150,120]);
Xx:=multiply(1/EA,Y);
```

$$Y := \begin{bmatrix} 100 \\ 150 \\ 120 \end{bmatrix}$$

$$Xx := \begin{bmatrix} \frac{10393746}{27125} \\ \frac{2623104}{5425} \\ \frac{10194309}{27125} \end{bmatrix}$$

При нахождении матрицы Xx, была вычислена обратная матрица $(E-A)^{-1}$. Суммарное количество выбросов загрязняющего вещества $Z2$ вычисляется при умножении транспонированной матрицы Xx на матрицу Z - матрицу выбросов загрязняющих веществ:

```
Z2:=multiply(transpose (Xx),Z);
```

$$Z2 := [268.8239668\ ]$$

Для вычисления количества выбросов загрязняющих веществ при увеличении потребностей в промышленных товаров, например на $4{,}5\%$, используем команды:

```
d:=Xx[2,1]*0.045;
Xn:=scalarmul(col(1/EA,2),d);
Z3:=multiply(Xn,Z);
```

$$d := 21.75846636$$

$$Xn := [3.378293686\ ,\ 25.10939050\ ,\ 2.980071639\ ]$$

$$Z3 := [7.676797634\ ]$$

Так как вычисления возможны при выполнении условий Хаукинса-Саймона запишем их внутри цикла:

```
if M[1]>0and M[2]>0 and M[3]>0 then print (_Ysloviya_vipolnimi_);
Y:=matrix(3,1,[100,150,120]);
Xx:=multiply(1/EA,Y);
      Z2:=multiply(transpose (Xx),Z);
      map(evalf,%,5);
d:=Xx[2,1]*0.045;
Xn:=scalarmul(col(1/EA,2),d);
Z3:=multiply(Xn,Z);
else print (_Ysloviya_ne_vipolnimi_);
fi;
```

Для автоматизированной программы вводятся числовые данные в начале программы:

```
b11:=50:b12:=16:b13:=120:b14:=60:b21:=30:b22:=10:b23:=180:b24:=100:
```

```
b31:=15:b32:=14:b33:=140:b34:=80:
z11:=0.04:z21:=0.26:z31:=0.34:
y11:=100:y21:=150:y31:=120:
B:=matrix(3,4,[b11,b12,b13,b14,b21,b22,b23,b24,b31,b32,b33,b34]);
Z:=matrix(3,1,[z11,z21,z31]);
Y:=matrix(3,1,[y11,y21,y31]);
```

Далее, программа идентична. Теперь изменяя данные, программа будет вычислять с новыми данными при этом изменения внутри программы не вносятся.

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Issue Article

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YASSAVI STUDIES IN UZBEKISTAN: HISTORY AND ANALYSIS

Abstract: *In the article, the scientific updates about Yassaviya's doctrine was studied, as the object of the article, the dissertations, articles and other materials researched during the years of independence were analyzed. Researching the study of Yassaviya Sufism, founded by Khoja Ahmed Yassavi, in our country is one of the urgent tasks of Yassavi studies. The results of the research can serve as an auxiliary guide to scientific researches in the future. In this regard, this article discusses Yassavi studies, the researches and innovations of Yassavi studies carried out in the years of independence were studied chronologically, and conclusions were given from the point of view of historiography and Islamic studies.*

Key words: *Islam, Khoja Ahmed Yassavi, Sufism, dissertations, articles.*

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Introduction

Among the Sufism teachings formed in Central Asia, the Yassawiya sect founded by Khwaja Ahmed Yassavi is known and famous and is considered one of the first sects that emerged in the region. In our country, 1993 was declared as the "Year of Ahmad Yassavi" [1:7] as a high respect for the scientific and educational heritage of Khoja Ahmad Yassavi, and the same year was also announced as the "Year of Yassavi" by the decision of UNESCO. Also, in 2016, the decision of the General Conference of UNESCO to celebrate the 850th anniversary of Ahmed Yassavi's death was announced. It is stated in many historical sources that Alloma Khoja Ahmed Yassavi lived between 1105-1166/67. After receiving his initial education in Turkestan, Yassavi came to Bukhara and received education from Khwaja Yusuf Hamadani, and for some time he was engaged in irshad (education and training) in Bukhara. Later, he moved to Turkestan and founded the Yassavi order and wrote poems - "Khikmat" in Turkish. Yassawi sect, like other schools of tariqats, has gone through its own stages of formation and development. The fundamental foundations of the tariqat were developed during the time of Khwaja Ahmed Yassawi, while the conceptual ideas were developed to a certain extent by later Yassawi sheikhs.

Review of literature on the subject. The scientific-enlightenment heritage of Khoja Ahmad Yassavi and the teaching of Yassaviism were also studied in Uzbekistan, and we can see the scientific research works of our mature scientists A. Fitrat, A. Sa'diy, E. Rustamov, B. Qasimov, I. Hakkulov, N. Hasanov. In particular, "Ahmed Yassavi" prepared for publication by I. Hakkulov in 1991. "Wisdoms" book, "Ahmed Yassavi" prepared for publication in 1992 by A. Abdushukurov. Devoni hikmat" book, A. Fitrat's 2-volume "Ahmad Yassavi. The book "Selected works" was published by B. Dostqoraev in 1994, and A. Sa'di's "Who was Ahmad Yassavi?" book and I. Haqkulov's book "Life of Ahmad Yassavi and the way of creativity" in 2001 [5:1].

Analysis and results.

The heritage and teachings of Khoja Ahmed Yassavi have been studied by eastern and western scholars, and since this study is not within the scope

of the research object of our article, we did not dwell on it.

The development of Yassavi studies in Uzbekistan mainly coincided with the years of independence, and during this period, many innovations related to the educational heritage of Khoja Ahmed Yassavi were introduced into science by Yassavi studies. Among them, Yassavi scholars discovered new manuscripts of a number of works written by Khoja Ahmad Yassavi, and wrote analytical texts. Among them are "Divoni hikmat", "Risola dar odobi tariqat", "Faqrnama", "Daftari avval", "Hikoyati me'raj", "Munojotnama", "Qissai No'man ibn Sabit", "Qiyamatnama", "Najotu-z-zakirin", "Tanbehu-z-zollin", "Tanzilu-s-salihin" works were also studied [3:322-328].

METHODS

Historicity, comparative analysis, gradualism, complex approach, and classification methods were used in the coverage of the article.

MAIN PART

According to some sources, the Yassavi sect spread among the nomads and Turkic peoples. But if we pay attention to the analysis of historical data, we can see that the Yasavi sect spread among the Persian-Tajik-speaking population in Central Asia, Turkey, the Caucasus and the Balkans. The services of the famous disciples of Khoja Ahmed Yassavi and his successors in later centuries are considered great in these campaigns. Among them, Mansur Ata, Said Ata, Suleiman Bakirghani (Hakim Ata), Sadr Ata, Sufi Mohammad Donishmand Zarnuqi, Baba Mochin, Zangi Ata, Amir Ali Hakim, Luqman Parranda, Imam Margazi, Hasan Bulg'ari Abdumalik Ata, Haji Bektash Vali, Taj Khoj , Uzun Hasan Ata, Sayyid Ata, Ismail Ata, Ishaq Khoja, Ayman Baba, Sheikh Ali Ata, Mawdud Baba, Badr Ata, Khalil Ata, Qusam Sheikh, Sheikh Khudoidad Vali [2:17] further improvement of Yassawiya sect, Central Asia and it is necessary to highlight the scientific and educational activities that are spreading around the world.

At this point, the book "Devoni Hikmat" played a big role in the spread of Yassaviism throughout the world, and our people have been reverently reading this book dedicated to wisdom for many centuries. In the book "Devoni Hikmat" we can see the idea of divine love, the true essence of Islamic Sharia, the Sunnah of our Prophet Muhammad, and through "Hikmat" we can see moral and educational appeals against the ignorance and ignorance of the people of Turkestan. Today, more than 20 identified copies of "Hikmat" are stored in the manuscript fund of the Oriental Studies Institute of the Russian Federation FA. In 2006, a book describing the manuscripts of "Devoni Hikmat" was published, in 2008, samples of the comparative text of Yassavi's Hikmat were published. In 2006, a manuscript catalog of Ahmad Yassavi's wisdom was also published [4:328].

Also, during the years of independence, the public was presented with the scientific news of the candidacy and doctor's dissertations on Yassawi doctrine. For example, I. Haqkulov's doctoral dissertation on the topic "Formation and development of Uzbek mystical poetry (ideology, followership, world of images)" [6:282] is devoted to the study of mystical sects and the development of Uzbek mystical poetry in Turkestan, as well as the leading characters and main poetic symbols of mystical poetry. Also, the term, concepts and essence of Sufism, the emergence of sects and Uzbek Sufism poetry, the heritage of Khoja Ahmad Yassavi and the language, meaning and image characteristics in "Devoni Hikmat", the tradition of followership in sects and poetry, the study of Sufism meaning and principles in Alisher Navoi's lyrics is a priority earned. This dissertation work is the first research work devoted to the philological research of the heritage of Khoja Ahmad Yassavi during the years of independence, and this scientific research of I. Haqkulov became a new stage in the direction of Yassavi studies during this period.

Unfortunately, during the communist regime, there was resistance to studying and researching the life and intellectual legacy of Khwaja Ahmed Yassavi. Research into Flatness in the 1970s also stalled as a result of the constraints of the authoritarian era. Publication of works was not allowed. After we gained independence, opportunities were given to literally study Yassavi's life and scientific and educational activities. In particular, "Hikmat", a masterpiece of the heritage of Khoja Ahmed Yassavi, began to be published in periodicals, and editions of "Devoni Hikmat" were presented to our people. In connection with the 1993 Yassavi year, various conferences, events and collections dedicated to the legacy of the scholar were published. Various articles on the life, work and religious-educational heritage of Khoja Ahmed Yassavi were presented to our people in mass media. The novel "The Last Journey of Yassavi" by Sa'dulla Siyoev was published in 1994. In the sister Republic of Kazakhstan, a university named after Yassavi was launched [7: 1].

Also, E.E. Karimov's "Sufiyskie tarikaty v Tsentralnoy Azii XII-XV vv." 07.00.02 on the topic [8:156] in his doctoral dissertation in historical sciences, which he defended in 1998, specializing in "Otechestvannaya istoriya", in conjunction with a comprehensive study of the emergence, formation and development stages of Central Asian Sufi orders, the Yassaviya order in Sufi teachings in the peoples of Central Asia scientifically studies its place. In M.M.Ismailov's dissertation entitled "Sheikh Khudoidad's "Bahr al-Ulum" is an important source for the history of Sufism in Central Asia (second half of the 18th century)" [9:157], the socio-political and cultural-spiritual life of Central Asia in the second half

of the 18th century process analysis is given. Also, the representative of the Yassawiya sect, Sheikh Khudoidad Vali, conducts research on the work "Bahr al-Ulum" and its sources, provides analyzes on the general content of the work, and presents the news of the Yassawiya sect from the point of view of source studies.

Researcher R. T. Shodiev's doctoral dissertation on the subject "Sufizm v dukhovnoy jizni narodov Sredney Azii (IX-XII vv.)" [10:2] in the history of philosophy, within the framework of Sufism, was the first to be successfully defended in the history of philosophy during the years of independence. is a research work. In the dissertation work, scientific research was conducted on the introduction and spread of Sufi teachings in Central Asia, the formation and development of Khojagan, Yassaviya, Kubroviya sects. Also, in the scientific work of J. O. Nematova, who conducted research in the field of philosophy, "Yassaviism and its place in the development of socio-philosophical thought" [11:133], the socio-historical reasons and spiritual foundations of the emergence of the Yassawism order, the spread of Sufism in the Turkestan region , the religious-philosophical content of the teaching, the rise of moral problems and the further development of the Yassaviite order and its influence on the spiritual life of the society are researched.

10.01.03 - Candidate's dissertation of N.D. Hasanov on the topic "Sultan Ahmad Hazini's "Javahirul Abror min Amvojil Bihar" and its scientific and historical value in Yassavi Studies" [12:154] - History of National Literature (History of Uzbek Literature) Life of Khoja Ahmad Yassavi and creativity, the emergence of Yassavit sect, the sources of Yassavit are analyzed. The harmony of Sultan Ahmed Hazini and Yassavi, the author of "Javahirul Abror min Amvojil Bihar" was studied. Also, the works "Devoni Hikmat" and "Javahirul Abror" and the illumination of mystical issues, shariat, tariqat, enlightenment and truth, guardianship, ageism, poverty, adab, zikr, khilavat, love, etc., are analyzed in them.

In 2017, the researcher continued his studies on Yassavism in a fundamental way and successfully defended his doctorate (DcS) thesis on the topic of "Sources on Yassavism and "Devoni Hikmat" [13:271]. In this scientific research, the state of legal studies in Uzbekistan, the research of legal studies in the East and the West is analyzed. Sources of Yassaviism, the historical period in which Khwaja Ahmad Yassavi lived, his biography and education, the emergence of the order, wisdom and wisdom and the continuation of this tradition, the idea and effects of Yassaviism, the idea of "Devoni Hikmat": content and language issues are researched.

Also, N. Hasanov on Yassaviism in "Yassavi studies in Turkey: a collection of interviews with Turkish scientists and Yassavi scholars on the topic of the life, work and sect of Kul Khoja Ahmed Yassavi" [14:56] Turkish professor Mahmud As'ad Joshon, Hasan Kamil Yilmaz, Najdat Yilmaz, Mustafa Uzun, Muhammad Sarhind Tayshiy, Mustafa Kara, Sulaymon Ulutog', Mustafa Tahrali publishes his scientific conversations with researchers-scientists in the form of a collection (pamphlet). gave a positive assessment. We can see the scientific results of N. Hasanov in Yassavi studies in the following monographs, pamphlets and collections.

In particular, "Khoja Ahmed Yassavi. "Divoni Hikmat" (newly discovered wisdom)" (preparer for publication) [15:176], "Sources on Yassawi and "Divoni Hikmat" (author)" [16:304], "Kul Khoja Ahmed Yassavi. He researched the heritage of Khoja Ahmad Yassavi as a preparer for publication in a collection of articles [17:536], and in scientific cooperation with his teachers, Yassavi scholar Haqkulov Ibrahim Chorievich, "Khoja Ahmad Yassavi. "Devoni hikmat" (preparer for publication)" [18:360] was published several times. "Khoja Ahmed Yassavi. "Umrung eldek otaro" (preparer for publication)" [19:400], "Khoja Ahmed Yassavi. He also publishes pamphlets such as "Don't tell others about your truth..." (wisdoms)" (publisher) [20:408]. Also "Khoja Ahmed Yassavi: life, work and traditions. (a collection of articles)", (preparer for publication) [21:334], co-authors: I.Ch. Hakkulov, A.A. Bektoshev, etc., were prepared in cooperation with philological scientists.

Yassavi scholar N.D. Hasanov presents articles, books, pamphlets and various materials in many foreign and local magazines dedicated to Ahmad Yassavi's life and activities to the general public.

CONCLUSION

In conclusion to our article, we must say that legal science was studied and researched in our country during the years of independence, and this process is still ongoing. However, the Yassawiya sect is a doctrine that has been formed and developed for a thousand years, and the scientific research conducted by a group of research scientists does not provide an opportunity to study the sect in detail. In this regard, if we focus on Yassavi Studies in Turkey, we can see that Turkish researchers have achieved many achievements. This opinion is confirmed by the large number of cases of referring to the sources of Turkish scientists in the research conducted by our local researchers.

Based on the results of the research, we can make the following suggestions regarding the perspective of Yassavishnosti in our country:

- It is necessary to establish a separate department or to announce grant projects in the Institutes of Language and Literature, History of the Academy of Sciences of the Republic of Uzbekistan in the field of legal studies;

• Translation into Uzbek of the results of the scientific research conducted by foreign researchers in the field of Orthopedics;

• Establishment of a department or center for researching the Yassavite order under the authority of the Office of Muslims of Uzbekistan;

• Organization of various contests, intellectual competitions and poetry evenings in order to promote Alloma's heritage;

• Introduction of the state scholarship named after Khoja Ahmed Yassavi;

• Establishment of Khoja Ahmed Yassavi international fund;

• Introduction of the state award named after Khoja Ahmed Yassavi;

• Organization of the club of legal scientists;

• Organization of an online platform for legal studies;

• Establishment of preferential tourist routes for pilgrimage tourism to the mausoleum of Khoja Ahmed Yassavi.

In today's era of globalization, studying, researching and directing our historical roots to the education of the younger generation is one of the most urgent tasks facing scientists, intellectuals and researchers. After all, the scientific-enlightenment heritage of Eastern scholars, including Khoja Ahmed Yassavi, is one of the pride and spiritual foundations of our nation.

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Issue Article

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THE ROLE OF SCIENTIFIC RESEARCH IN STUDYING THE HERITAGE OF SUFI SCIENTISTS

Abstract: *As a result of the reforms carried out in the years of independence, a number of renovations took place in the field of science. In particular, opportunities for studying Sufism in the field of philosophy have expanded. This article analyzed the scientific study of Sufism in the years of independence from the perspective of philosophical sciences.*

Key words: *Islam, Sufism, dissertations, philosophy, historiography, Islamic studies, source studies, scientific research.*

Language: *English*

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Introduction

In the process of restoration of our history and national values, a number of reforms were carried out in the direction of studying and conveying the heritage of Sufism to our people. Scientific research plays an important role in studying the heritage of Sufism, and scientific research, in turn, provides reliable information to the public. In this regard, it is necessary to emphasize the scientific research works carried out in the fields of Islamic studies, history, philosophy, philology, pedagogy. According to our analysis of the study of Sufism in the years of independence, the scientific research conducted in the field of philosophy is considered the most compared to other fields of science. We can explain the greatness of the contribution of the science of philosophy to the study of Sufism by the philosophical laws, the experience of the representatives of the field in using scientific research methods in the study of various ideologies, ideas and teachings, the breadth of rational and irrational thinking possibilities within the science, which gives the science of philosophy the opportunity to study Sufism on a large scale.

Within the scope of philosophy, researchers and scientists R. Shodiev, M. Jakbarov, F. Isomiddinov, J. Ne'matova, O. Sharipova, G. Navruzova, N. Safarova, S. Ismoilov, O. Safarboev, B. Namozov, A. .Samadov, N. Zaynobidinova, Kh. Rakhmatova, Kh. Samatov, M. Mamatov, Q. Rozmatzoda, J. Kholmo'minov, M. Norova, B. Namozov, Z. Isakov studied and presented their scientific conclusions to our people.

We can evaluate the main focus on researching the importance of ethical, mystical ideas and theories in scientific research works as an achievement of dissertations defended in the field of philosophy. Also, we can see that in the dissertations, the study of the concept of "perfect person", analysis and conclusions, development of suggestions and recommendations became a priority.

Doctoral dissertation on the subject of "Sufism v dukhovnoy jizni narodov Sredney Azii (IX-XII vv.)" [1:39] is the first research work successfully defended in this specialty within the framework of Sufism. R. T. Shodiev conducted research on the introduction and spread of Sufi teachings in Central Asia, the formation, development and mystical teachings of Khojagon, Yassaviya, Kubroviya sects. In the study of

M. Jakbarov, who prioritized the study of the concept of "perfect man" on the topic "Social ideal and the problem of the perfect man in the philosophical thought of Movarounahr of the 9th-12th centuries" [2:277], the spiritual and educational legacy left by scholars on human perfection a thousand years ago was analyzed. . In the research work of J. O. Ne'matova on the topic "Yassaviism and its role in the development of socio-philosophical thought" [3:133], the socio-historical reasons and spiritual foundations of the emergence of the Yassawism order, the spread of Sufism in the Turkestan region, the religious-philosophical content of the doctrine, moral problems the rise and further development of the Yassavaite order and its influence on the spiritual life of the society are researched.

The socio-economic and spiritual situation in Bukhara in the XII-XIII centuries, the life and work of Abdukholiq Gijduvani, the sect of Khojagons and the development of spiritual-theoretical and mystical thoughts in this period, ideas of man and humanity, the concept of science and faith, spiritual-moral purity and the idea of a perfect person. issues are covered in O. Sharipova's candidate's dissertation on "Ethical views in the mystical teachings of Khwaja Abdukholiq G'ijduvani" [4:160]. G. Navruzova, who is one of the leading scholars who has researched Sufism in the direction of philosophy, on the topic of "Naqshbandi Sufi Teachings and Perfect Human Education" [5:291], discusses the concept and essence of Sufism, the system of sects and Naqshbandi, Bahauddin Naqshband's life and Sufism. It has a great scientific value due to the research of its mystical views, views of existence in Naqshbandiyya doctrine, man and his levels of perfection, self-cultivation, the path of vigilance-harmony, "Khilvat" and "anjuman". In the research work of N. Safarova on the topic "The issue of spiritual and moral values in Khojagon's mystical teaching" [6:135], the conditions for the emergence of Khojagon's mystical teaching, its founder and major manifestations, as well as the mystical and philosophical worldview, attitude to science and enlightenment, ethics views are studied scientifically and analytically.

In his candidacy thesis on the topic "The role of Naqshbandi sect in the development of Sufism" [7:28], S.T. Ismailov studied the development of Sufism until the Naqshbandi period, the main sects in Turkestan, the spiritual-mystical roots and religious-philosophical foundations of Naqshbandi sect. Also, the life, religious-mystical heritage and sect of Bakhouddin Naqshband are highlighted, and the results of research on "Rashhas" and "Zikri Hafiya" in the Naqshbandi sect are presented. The practice of Naqshbandi and the way of harmonizing Sharia and Sufism, the impact on the socio-philosophical, religious-mystical and political life of the peoples of the region are also analyzed. At this point, it is necessary to emphasize that Ismailov Sobirjon Torabekovich's professional activity of combining scientific and practical life in the field of mystical ethics is also reflected in his pedagogic-teaching and mentoring activities at Gulistan State University. [8:1]

In the research work of O. Safarboev on the topic "Ideas of humanity and patriotism in the Sufi teachings of Najmuddin Kubro" [9:172], the theoretical and methodological problems of the study of the time, life, creativity and heritage of Sheikh Najmuddin Kubro are studied, in which the socio-political and social-political and spiritual-educational factors, philosophical analysis of the works of scholars, illumination of the human problem in his mystical views, analysis of the issue of human perfection in his works are given. Also, a number of issues such as the harmony of futuvvat and mystical ideas, the importance of humanitarian and patriotic ideas in raising a mature generation are studied in the teaching of Allama.

In the candidate thesis of B. Namozov on the topic "Philosophical foundations of the mystical views of Abu Bakr Kalabadi" [10:26], the life and mystical heritage of Abu Bakr Kalabadi, including the creation of the universe, existence, views on the Creator and man, thoughts on mystical knowledge, spiritual perfection and about the soul, the interpretation of divine love, the question of human will and religious tolerance, cultural and spiritual life in Movarounahr in the 9th-10th centuries are given priority in the research. A. Samadov [11:27] in his candidate's dissertation on the topic "Social-philosophical essence of the moral ideal and its importance in raising a mature generation" wrote the theoretical and methodological foundations of the moral ideal and its socio-philosophical system, Sufism philosophy and Eastern thinkers' views on the moral ideal, a mature generation carried out research on the principles of the formation and development of the moral ideal.

N. Zaynobidinova in her research work on "The issue of human spiritual perfection in Jalaluddin Rumi's mystical teachings" [12:29] sheds light on Jalaluddin Rumi's mystical views on spiritual existence and divine love. Also, the dialectic of contradictions between the body and the soul, love for man and being is one of the factors leading to perfection, and the way to curb it is also notable for the analysis of the philosophical and religious basis of views on human spiritual maturity. The main object of Kh. Rakhmatova's scientific research work on the topic "Social-philosophical views of Khoja Ahror Vali" [13:154] is the study of spiritual, moral, mystical ideas and theories of human development using many methods such as comparative, analytical, dialectic, and based on such comparative analyzes we can evaluate the carried out scientific research work as the achievement of dissertations defended in the field of philosophy.

The historical conditions and ideological conditions of the formation of the mystic worldview

in the candidate's thesis of H. Samatov on the topic "Spiritual heritage of Makhdumi Azam Kosani and its place in youth education" [14:125], dedicated to the study of the spiritual heritage of Makhdumi Azam Kosani and the social and moral place of this heritage in the process of globalization -the main principles of the ideological roots, scientific and spiritual heritage and worldview are explained. In the teachings of mystics, the question of existence, the views of scholars on knowing the universe and man are studied. Also, the mystic's ideas that the family is the spiritual and spiritual basis of the stability of the society, his ideas about spiritual alertness and responsibility, the perfect person and his upbringing are given. One of the scientific studies aimed at studying the historical-philosophical essence of Sufism is M. Mamatov's doctoral dissertation on the topic "Historical-philosophical essence of Sufism" [15:217]. also, the essence, characteristics of the foundations of the Sufi worldview, the classification of Sufism sects are highlighted. At the same time, the Sufis of Central Asia spoke about the renewal of Sufi teachings, their place in their development, and the need to use them in the current period. The relations and views of Central Asian thinkers to Sufism, the analysis of the dynamics of development of pantheism in Sufism are given. Modern sects and sharia, the idea of religious tolerance in Sufism and its place and role in the life of society, guarantees of freedom of conscience in Uzbekistan and issues of Sufism are also separately researched.

The biography and genealogy, creative activity and heritage of Khojamnazar Huvaido were studied in the doctor's thesis of Q. Rozmatzada on the topic "Ontological and epistemological concept in the mystical views of Khojamnazar Huvaido" [16:298]. In particular, the socio-philosophical essence of Naqshbandiyya ideas, the influence of Boborahim Mashrab's Sufi teachings and Huvaido's worldview, commonalities, differences and specific aspects in the Sufi views of Sufi Allahor and Khojamnazar Huvaido, Sufi views of Khojamnazar Huvaido and its important features, ontological and epistemological aspects of the Sufi and poet's Sufi views. The issue of concept, the followers of Khojamnazar Huvaido and the present period are also given relevant conclusions.

J. Kholmo'minov's candidate's dissertation on the topic "Mystical-mystical views of Maulana Abdurrahman Jami (based on the work "Sharhi Rubaiyot")" [17:153], the place of the work "Sharhi Rubaiyot" in Jami's philosophical-mystical heritage is separately researched. In particular, in clarifying the classification of Jami's mystical-mystical works, attention is paid to philosophical-mystical commentaries, works related to philosophical-mystical or mystical theory, works related to sect ethics or practical mysticism, works related to the history of Sufism, and to the research of manuscript copies of the work "Sharhi Rubaiyot" in Uzbekistan. In the philosophical-mystical analysis of the work "Sharhi Rubaiyot", the teachings of Jami and Ibn al-Arabi, the interpretation of the theory of wahdat ul-wujud, the enlightenment of God, and the transformation are covered in "Sharhi Rubaiyot". In the work "Sharhi Rubaiyot" the interpretation of Naqshbandi teachings, the position of Maulana Jami in the Naqshbandi order, the Naqshbandi interpretation of Ibn al-Arabi's views, and the mystical interpretation of the rules of the Naqshbandi walk are researched.

Also, J. Kholmo'minov's doctoral dissertation on the topic "Philosophy of Wahdat ul-Wujud and its influence on Naqshbandi doctrine (based on the views of Ibn-al-Arabi, Muhammad Porso and Abdurrahman Jami)" [18:64] Ibn al-Arabi's "Philosophy of Wahdat ul-Wujud" and pays special attention to the study of its place in the development of Islamic philosophical thought, and also presents its scientific conclusions by studying the attitude of the representatives of the Khojagon-Naqshbandiyya doctrine to the philosophy of Wahdat ul-Wujud. In the scientific work, Maulana Abdurrahman Jami's position as a theoretician of Naqshbandiyya doctrine is also revealed, and the combination of Naqshbandiyya doctrine and Wahdat ul-Wujud philosophy in Jami's views is also analyzed.

In the scientific work of M. Norova on the topic "The place of Sayfiddin Boharzi in the history of Sufism" [19:47], the great role of Sayfiddin Boharzi in the development of Kubroviya sect was studied. In particular, the place of Sufi views of Sayfiddin Boharzi in the development of mystical-philosophical thinking was studied separately. Also, the place and role of Saifiddin Boharzi in the development of philosophical views about the idea of the Perfect Man - one of the biggest topics in the Eastern nations - is revealed. B. Namozov's doctoral dissertation on the topic "Philosophical foundations of Muhammad Porso's mystical teaching" [20:67] describes the socio-political situation in Movarounahr (XIV-XV centuries), the peculiarities of the cultural and spiritual environment of this period, and the conditions that influenced the formation of Muhammad Porso's mystical teaching and Research work was carried out on the doctrine of Naqshbandiyya, which people followed. The ontological issues of Muhammad Porso's mystical views are analyzed, and a number of conclusions on this issue are presented. Together with the analysis of ontological issues, the epistemological nature of Muhammad Porso is scientifically studied, and the issues of achieving perfection are discussed separately. In the dissertation, we studied the spiritual and moral significance of Muhammad Porso's mystical views, the difference between self-righteousness and self-righteousness, perfect personality education and purity of heart, religious tolerance, and the role of moral ideas in the life of the society.

In Z. Isaqova's doctoral dissertation on the topic "Irfan and its place in the development of Eastern philosophical thought (10th-13th centuries)" [21:72], the unique aspects of the development of the science of irfan in the Muslim East of the 13th century were studied, and the essence of the concept of irfan was revealed in the research. Also, in the theory of knowledge of medieval Muslim eastern philosophy, the rational and irrational methods of knowing about the essence of gnosis were comparatively studied, the analysis of scientific-philosophical and religious-mystical concepts in the Muslim eastern philosophy was scientifically studied, and attention was paid to the scientific justification of the dialectic of prophethood and guardianship. In his research on Sufism and Human Psyche: Succession and Trend of Modernity, the researcher also analyzed the gradual development of mysticism and human psyche.

CONCLUSION

As a conclusion, we can say that scientific research works within the field of philosophy and the breadth of their scope give positive impressions about the research conducted by philosophers. In most of the scientific research works carried out by philosophers, approaches to Sufism have been carried out in a wide range, on the basis of various research methods, and the scientific research works analyzed above also confirm this opinion. Studying the spiritual-enlightenment heritage of Sufism is one of the most urgent tasks for science today. In order to eliminate the many negative consequences of the transformation of pure human feelings, the increase of immorality, and globalization, the wisdom and teachings of Sufism, which embody noble ideas, are the spiritual guidance of the young generation. acquires positive importance in moral education. After all, relying on the legacy of our scholars is beneficial for the present and future of our generations.

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Issue Article

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FEATURES OF MANUFACTURING FIBER BRAGG GRATINGS

Abstract: *Features of manufacturing fiber Bragg gratings, which are sensors based on fiber Bragg gratings. The types of Bragg lattices are considered, i.e. straight homogeneous lattices, lattices with variable periods, lattices with a long period, oblique lattices.*

Key words: *Fiber Bragg gratings, reflection spectrum, sensors, period.*
Language: *English*
Citation: Karnakova, G. (2023). Features of manufacturing fiber bragg gratings. *ISJ Theoretical & Applied Science, 05 (121)*, 632-637.
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Introduction

UDC 681.7

One of the most commonly used fiber-optic sensors are sensors based on fiber-Bragg gratings. The gratings reflect a light signal, the spectral characteristic of which (wavelength) shifts along with the change in the measured parameter (temperature).

In the manufacture of gratings, an area with a periodic change in the refractive index is created inside the core, and this area is directly called the VBR. A fiber Bragg lattice is a section of an optical fiber in the core of which the refractive index periodically changes in the longitudinal direction], which is shown in Figure 1 [1].

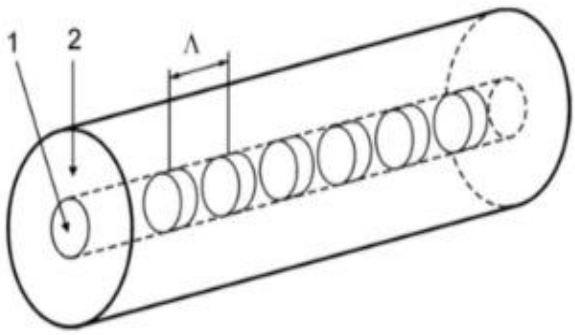

Figure 1. Fiber-bragg lattice where:
1- is the core, 2 - is the cloak,
λ - is the lattice period

The reflection spectrum of the fiber bragg lattice, depending on the wavelength, is shown in figure 2.

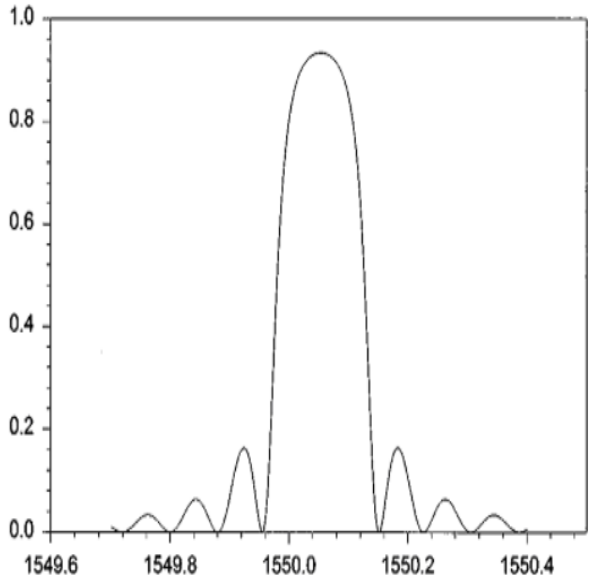

Figure 2. The reflection spectrum

Straight homogeneous gratings are a distributed bragg reflector formed in the light-carrying core of an optical fiber. straight homogeneous gratings have a narrow reflection spectrum, are used in fiber lasers, fiber-optic sensors, to stabilize and change the wavelength of lasers and laser diodes, etc. (fig.3).

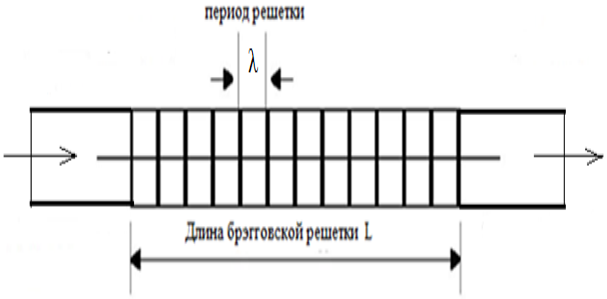

Figure 3. Structure of a straight homogeneous lattice

A chirped bragg lattice is called a bragg lattice, which has a period dependence along the direction of light propagation (chirp). Different wavelengths are reflected from the bbr at different depths having the corresponding period. the most common chirped bragg gratings with linear chirp. Thirped gratings are mainly used to compensate for dispersion [2]. The production of chirped bragg gratings (cbr) consists of the narrowing and bending of the optical fiber during recording and the linear stretching of the phase mask obtained when it is heated. phase masks with variable pitch are also used in the production of chirped bragg gratings. in lattices, chirp denotes an increase or decrease in the lattice period, and this change in the length of the period is most often linear. The cross-section of the structure formed on the fiber core is shown in figure 4.

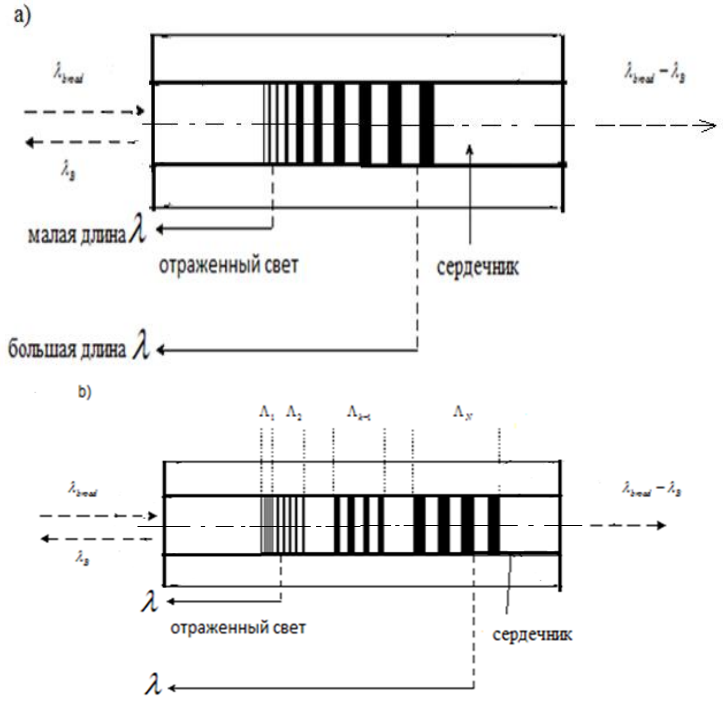

Figure 4. The structure of the chirped bragg lattice (cbr):
a) chirping of the bragg lattice,
b) cascade chirped lattice

The lattices shown in figure 4 can be obtained using fixed changes in the lattice period λ or by changing the refractive index in the core. Such a lattice can be used for different wavelengths. In chirped lattices, the frequency resonance is a linear function symmetric along the lattice [3]. Individual frequencies are reflected in different places of the grid. This results in different delay times. a temporary extension of the pulse is possible (figure 5).

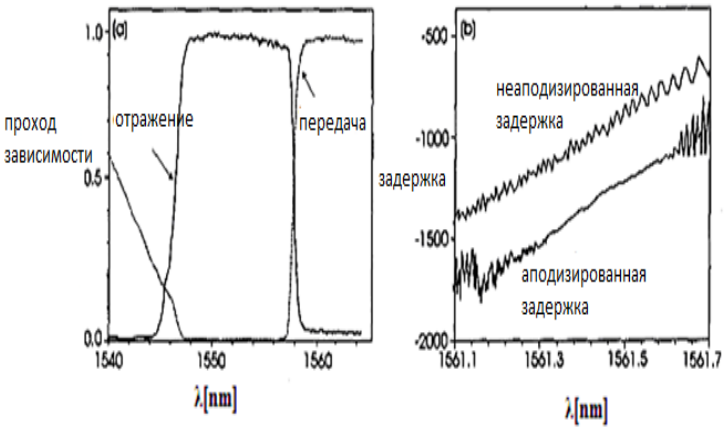

Figure 5. Characteristics of a typical bbr grating
a) transmission reflection profile,
b) apodized and non-apodized group delay

Lattices with a long period are a special type of bragg lattices with a period of microns. they combine the main mode with the upper layer modes propagating in the same direction.

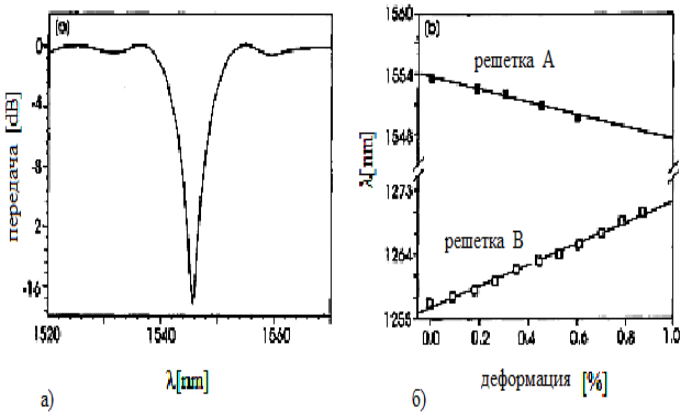

Figure 6. Characteristics of a lattice with a long period:
a) long-term transmission spectrum of the lattice,
b) the effect of deformation of two different gratings

In addition, fiber-optic amplifiers with light pumps are used in telecommunication systems [4]. They reduce the performance of the entire system by increasing the noise level by using wavelengths that have not been absorbed. This can be avoided by using chirped gratings that reject unoccupied wavelengths and leave only those that are really needed. this reduces the noise level. Such gratings can be used in the design of erbium optical amplifiers [5]. Chirped gratings are increasingly used as elements in telecommunication systems.

The technology of creating distributed fiber-optic phase interferometric sensors based on Bragg gratings requires recording arrays of gratings with specified reflection coefficients and spectrum width at half-height during the extraction of a fiber fiber [6].

It is known that type I Bragg fiber gratings can be recorded with almost any reflection coefficient and spectrum width at half-height, however, this requires the use of recording methods with a long exposure (10-20 min) [7], which cannot be done during the extraction of optical fiber. The use of type II gratings makes it possible to implement the technology of single-pulse recording of Bragg gratings with reflection coefficients up to 100% and the width of the reflection peak at half-height up to 1 nm [4]. However, type II gratings are characterized by a sharp dependence of the induced modulation of the refractive index in an optical fiber on the energy density in a laser pulse. This feature complicates obtaining a grating with the desired reflection coefficient, in addition, recording a type II grating into a fiber reduces the mechanical strength of the fiber fiber [8].

Therefore, in order to create a sensitive element of a fiber-optic FEED with the required ratio of the reflection coefficients of lattice pairs and a sufficient spectrum width at half-height, a method for obtaining chirped fiber Bragg gratings with a discretely varying period during optical fiber extraction was proposed and tested [4]. The main purpose of the work was to test the applicability of such gratings in distributed fiber-optic phase interferometric sensors. In order to achieve the goal of the work, experimental studies of the influence of various external influences on the spectral characteristics of Bragg gratings were carried out.

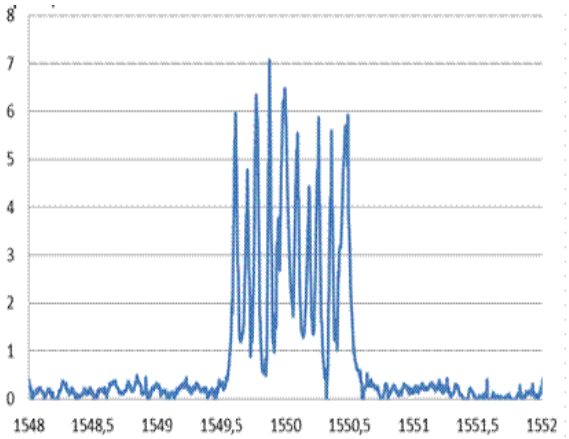

Figure 7. The spectrum of a fiber Bragg lattice with a discretely varying period

The effect of longitudinal mechanical stress. Using a device that creates a tension corresponding to a given value of the applied force and an optical spectrum analyzer, the effect of fiber tension on the displacement of the central wavelength was checked. The experiment was carried out at applied force values from 4 to 20 N. The limit values are determined by the technical characteristics and capabilities of the device. A step of 1 N is enough to determine the dependence. The light source and the spectroanalyzer were connected through a splitter to a grid, which, in turn, was located in the area of the light guide, to which a mechanical longitudinal voltage was applied using a specialized apparatus. Based on the results, graphs were constructed, dependencies were obtained.

The effect of temperature exposure. It is known that a noticeable degradation of gratings, the formation of which is due to the electrostriction mechanism, is observed already at 200-300 °C [4]. In addition, a change in temperature leads to a change in the wavelength of the Bragg resonance, which may interfere with the correct operation of interferometric sensors. Thus, the task of this experiment was to obtain the dependence of the shift of the Bragg resonance with an increase in temperature, as well as to determine the maximum operating temperatures of the sensor based on type I VBR with a discretely varying period.

To conduct the experiment, a circuit was assembled that included, in addition to a radiation source and a spectroanalyzer, a thermal chamber controlled by a thermostat and an optical power meter. VBR was heated in a thermal chamber to 370 °C, its spectrum was continuously monitored on an optical spectroanalyzer. Figure 2 clearly demonstrates the shift of the spectrum to the long-wavelength region with increasing temperature, as well as a strong decrease in the reflection coefficient at a temperature of the thermal chamber of more than 140 ° C. At a temperature of 280 °C, the spectrum of the grating practically became indistinguishable against the background of the noise of the optical circuit. A number of tests were carried out to determine the thermal stability of the grid. Several samples were successively kept in a thermal chamber for 3 hours and 20 minutes. at different temperatures. Degradation of the gratings was not observed at 100 and 120 °C.

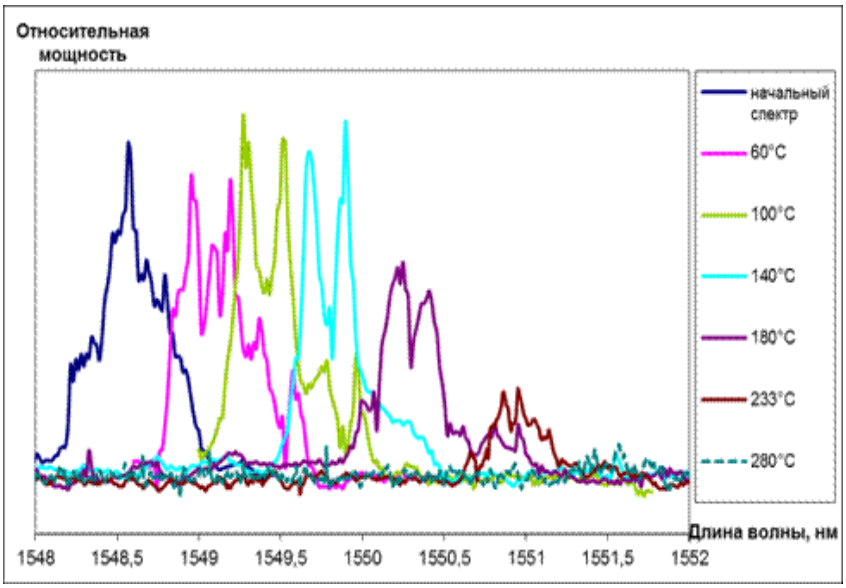

Figure 8. Dependence of the spectrum on temperature

The effect of winding. To study the effect of winding a fiber section with an induced lattice, rigging with different circles was used. The fiber section with the VBR was sequentially wound on diameters from 50 to 5 mm. The spectrogram was taken after winding on each dimeter. The flow of radiation energy between the axes of the birefringent light guide was recorded. At the same time, the spectral distance between the reflection peaks did not change, there were no displacements up to the winding of the light guide to diameters less than 10 mm. After conducting the experiment on relatively large circles, winding on smaller ones occurred with a small effort necessary to overcome the elastic properties of the optical fiber, as a result, a uniform 0.2 nm displacement was observed on the spectrogram, when winding on the smallest diameter, the displacement was 0.4 nm. The change in the localization of the peaks was associated with the applied tensile force, as a result of which the quartz glass was stretched and the displacement characteristic of mechanical stretching occurred. The experiment allowed us to establish that for fiber gratings with a length of 100 mm, winding even on small diameters does not significantly affect the reflection spectrum of the lattice.

Dependence on the state of the introduced

polarization. The dependence of the reflection coefficient of chirped fiber Bragg gratings with a discretely varying period on the state of polarization introduced into a birefringent light guide was investigated. To test this dependence, a scheme was assembled, the key elements of which are a polarization controller and an extinction meter. 5 test samples were alternately included in the scheme. The difference in reflected energy from different polarization states did not exceed 2 percent. The results obtained allow us to judge the independence of the VBR with a discretely varying period from the state of the introduced polarization.

In the course of the work, various factors influencing the spectral characteristics of chirped fiber Bragg gratings with a discretely varying period were investigated. The number of sections of a chirped VBR with a discretely varying period is theoretically calculated to obtain a quasi-continuous lattice reflection spectrum.

Experiments with the creation of longitudinal mechanical stress have been carried out. The dependence of the displacement of the Bragg resonance on the applied tensile force is obtained. Experiments on thermal effects were carried out. The dependences of the shift of the spectrum of chirped fiber Bragg gratings with a discretely varying period on temperature are obtained. Experiments were conducted to determine the temperature resistance of the tested samples. The dependence of the reflection coefficient of chirped fiber Bragg gratings with a discretely varying period on the state of polarization introduced into a birefringent light guide is investigated. Winding on various diameters is made. The spectra of gratings wound on circles of different sizes are analyzed.

The studied samples have a sufficient half-height spectrum and reflection coefficient for use in phase interferometric sensors. To obtain a quasi-continuous reflection spectrum of the chirped VBR, it is necessary to increase the number of lattice sectors, respectively reducing the angle of displacement of the interferometer mirrors when recording the diffraction structure. Depending on the reflectivity requirements, such a structure can be recorded with the same length or longer [9].

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Issue Article

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MODELING AND DEVELOPMENT OF AN ADVANCED CONTROL SYSTEM OF THE PROCESS OF AMMONIA SYNTHESIS

Abstract: *Recently a lot of attention is being given to the decision of research problems and constructions of parametric control systems by uncertain objects. The main objective of the proposed work is to form the development of methods and algorithms that allow to formulate and effectively solve the problems of constructing models and synthesizing control systems for technological processes in conditions of parametric uncertainty and their application in the construction of control systems for specific technological processes. The article deals with the problems of modeling and development of a system for improved control of technological processes of ammonia synthesis in conditions of parametric uncertainty. These developments allow solving various problems of system analysis, optimization and management, making it possible to reach a new level of control of technological production processes.*

Key words: *Uncertainty, computer model, modeling programs, mathematical model, advanced control systems, modernization, ammonia synthesis.*
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Scopus ASCC: *2611.*

Introduction

Currently, the most relevant is the solution of the optimal control problem, which is performed taking into account the uncertainty of the initial information. Uncertainty can be due to various reasons, including the inaccuracy of mathematical models. When solving problems of optimal operational control, one should also take into account possible deviations from the nominal values of a number of parameters that affect the process, but at the same time cannot be measured.

Systematic analysis of technical objects is complicated by the presence of uncertainties in physical, chemical, economic and technological information. Taking into account the uncertainty of information requires new approaches to methods of analysis, optimization and management of such systems. Modeling methods focused on the average values of the parameters, including those not fully defined, do not guarantee the optimality of the obtained solution and do not correspond to the constraints imposed on the process.

During the years of independence in our republic, special attention is paid to the automation and control of chemical-technological processes and industries. In this aspect, the creation of control systems for the ammonia synthesis process under conditions of parametric uncertainty, including perturbations in the composition of the feedstock, developed on the basis of the indicators of the technological process by building a dynamic model, developing algorithms and programs that implement automatic control systems for the modes of the ammonia synthesis column, as well as modernization and development of existing production facilities is one of the main tasks.

The development of control systems for technological processes of ammonia synthesis is a

rather difficult task, which can be found in the works of scientists [1-7]. This work continues research in this direction.

The analysis of the scientific and technical literature of recent years concerning research on the development of methods for the parametric identification and synthesis of control systems for technological objects indicates the achievement of significant theoretical and practical results in this field. There are and are developing various ways of building control systems that operate under conditions of a priori parametric uncertainty [8].

At the same time, the possibilities of interval methods in the problems of synthesis of mathematical models and control systems are not sufficiently appreciated in the literature [9]. This is due to the fact that so far no concepts and a constructive methodology have been developed for constructing models and process control systems under the conditions of interval-parametric uncertainty. Methods and algorithms for formalizing and synthesizing mathematical models of control objects, estimating parameters of technological control objects, and analyzing the stability of controlled systems under interval uncertainty have been insufficiently developed. Adaptive-interval methods and algorithms for the synthesis of control systems of technological objects with complete and simplified models of control objects also require their development. These circumstances are the reason for the difference between the theoretical and practically obtained characteristics of the estimates. Sometimes these differences become significant and are of fundamental importance for deciding whether to use the results of the work of interval estimation algorithms.

Thus, at present, the level of detail, the trade-off side between the complexity, accuracy and feasibility of mathematical models of technological processes and control systems, as well as the consideration of uncertainties, are mostly expressed by heuristic considerations of the designer based on experimental data, if any. Under these conditions, it is rather problematic to talk about how effective one or another interval method is used and whether the best options for the synthesis of models and control systems are selected. In connection with the aforementioned, the development of effective interval methods for parametric identification and synthesis of control systems for technological objects in conditions of uncertainty cannot yet be considered complete.

Within the framework of global research on the development of highly efficient systems for monitoring and control of technological processes of ammonia synthesis, a significant contribution was made by the leading research centers and higher educational institutions of the world: Osaka University and Tokyo Institute of Technology (Japan) Honeywell, Imperial College London (Great Britain), “SIMSCI-Simulation” and “University of California”, “Massachusetts Institute of Technology” (USA), “Siemens” (Germany), “Korea Advanced Institute of Science and Technology” (South Korea), Russian Chemical Technological University, Moscow Institute of Fine Chemical Technology, Kazan National Research University of Chemical Technology, St. Petersburg State Technological Institute (Russia), as well as such foreign scientists as B.D. Yudina, Yu.M. Ermolyeva, A. Charnes, W.W. Cooper, G. Symonds, I. Grossmann, L. Biegler, E. Pistikopoulos, B. Liu, G.L. Degtyareva, T.K. Sirazetdinova, G.M. Ostrovsky, N.N. Ziyatdinov, T.V., Lapteva, A.F. Egorov, S.I. Dvoretsky, D.S. Dvoretsky, V.A. Kholodnov, V.I. Elizarov, V.V. Kafarov and other researchers.

A significant contribution to the solution of scientific problems, modeling, analysis and control of the ammonia synthesis process under conditions of uncertainty in Uzbekistan was made by such scientists as academicians N.R. Yusupbekov, T.F.Bekmuradov, professors Sh.M. Gulyamov, D.P. Mukhitdinov, M. A. Ismailov, Sh.N. Nuritdinov, U. V. Mannanov and others.

However, in recent years, separation processes have become significantly more complicated, requiring the creation of control and optimization systems. At the same time, due attention is not paid to the creation of highly efficient control systems based on complete dynamic models of technological processes that fully describe the relationship between the process variables.

Considerable attention is currently being paid to the problems of setting analysis, optimization and control problems for various applied areas, as well as the development of methods for their solution. However, the existing solution methods either require large computational costs or are developed for a narrow class of problems.

In Uzbekistan and abroad, in the design, modeling and analysis of chemical technological systems (CTS), specialized software is widely used - simulation programs, such as: Aspen Plus, Aspen Dynamics, Aspen HYSYS, Honeywell UniSim, ChemCAD etc. These software products allow you to create CTS models with a high-fidelity, however, in a number of cases, their functionality limits their areas of application, in particular, there are no opportunities for solving optimization problems under uncertainty. Also, there are no standard tools for describing kinetic dependencies of a special kind when simulating reaction processes.

Methodology

In the practice of designing systems for automatic and automated control of technological objects, quite often a situation occurs when the real values of individual parameters of control objects are unknown and there are no statistical descriptions of them.

Uncertainties in the parameters may appear due to various reasons:

- using simplified models that approximate a real physical process;
- incomplete estimation and identification of unknown variables;
- the presence of non-stationary coefficients in the equations of the mathematical model of the object.

In addition, the accuracy of the description of control objects can be affected, for example, by such technological factors as equipment defects, vibrations, uneven running, changes in operating modes, errors in measuring instruments, inaccuracy of scales. Operational features, such as aging and wear of equipment items, fluctuations in temperature, humidity, pressure and other external influences, can also lead to a deviation of real characteristics from nominal values. In all the cases listed above, the nature of the variations of the unknown parameters of the control systems can be considered undefined, since their changes are subject only to a priori restrictions. To solve problems of managing objects with uncertain parameters, they usually involve minimax methods, methods of stochastic control, fuzzy logic, invariance, and adaptive control. The use of a particular approach depends on the type of uncertainties and requirements for the structure and quality of management systems.

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Theoretical and practical approaches to the formalization and use of high-quality information under conditions of uncertainty are being developed to select optimal management solutions for complex systems. For dynamic systems in conditions of uncertainty, specialized estimation methods are also developed in the problems of identification and filtering. At the same time, both already developed methods of game theory and new methods related to information processing and interval analysis are also widely used.

Each of the above mathematical methods is focused on certain classes of mathematical models:

- probabilistic models;
- range;
- linguistic;
- models allowing to obtain ellipsoidal estimates of the reachability regions of phase coordinates;
- multimode models of dynamic control systems;
- interval models; mathematical models that combine both interval parameters and probabilistic characteristics.

For a more complete description of the properties of control objects in mathematical models of dynamic systems and quality criteria for the operation of closed circuits, it is also advisable to take into account the uncertainty contained in the model parameters. In addition, the adequacy of the description of the mathematical model of a dynamic system in some cases is achieved only by taking into account uncertain parameters. Often, uncertainty is an integral part of a formalized mathematical model of a controlled dynamic system.

In this paper, we will stick to the point of view that if the exact numerical value of a certain parameter is unknown (for example, measured or specified with an error), then such parameters will be considered as belonging to certain numerical intervals with known boundaries. The numerical value of this parameter will be determined by the interval - a bounded set on the number line. We will speak of a mathematical model containing indefinite parameters as an interval-indefinite model or as a mathematical model that is under conditions of interval uncertainty. The presence of interval-indeterminate parameters (interval numbers) in a mathematical model makes it difficult to apply the known methods of analysis and synthesis of control systems for dynamic objects. Therefore, the further development of interval versions of the methods for analyzing and synthesizing dynamic systems with interval uncertainty seems very relevant.

In practice, the solution of the control problem is sought according to a certain mathematical model, the

accuracy of which is conditional. Various models can describe uncertainty in the values of the parameters:

1. Probabilistic (stochastic) model. It is used when an uncertainty factor can be attributed to a probabilistic, random nature. Random factors are described as probabilistic if probability density is given.
2. Statistical model. It is used when an object model is determined from the results of selective experiments under conditions of random noise and errors. In the statistical description of uncertainty factors, instead of the true moments, only estimates are obtained, the accuracy of which is determined by the experimental design, the number of experiments, interference dispersion, estimation method, etc. Thus, it is obvious that all the difficulties associated with operating with estimates of random parameters, stand up here in full.
3. Fuzzy (blurred) model. To describe the uncertainty factor in this situation, use the methods of the theory of fuzzy sets, the main provisions of which and decision-making methods are set forth. Currently, methods for solving such problems are poorly developed.
4. Interval model. Used when the range of possible parameter values is known. Interval analysis is used as a mathematical tool for solving a problem, the use of which for solving control problems became especially noticeable in the last century [10].

Experimental results.

The creation of a modern automated control system using industrial controllers allows not only increasing the economic efficiency of the enterprise, but also makes it possible to reach a new level of production process management.

In some cases, the modernization of the control system using the latest digital computer technology is, unfortunately, limited only to replacing obsolete automation tools, while not all the features and functions that modern microprocessor technology has are realized. In addition, in most cases, the control methods and methods remain the same as they were before the modernization, which ultimately cannot lead to the best management of complex technological objects, characterized, for example, by the mutual influence between adjustable parameters, the presence of disturbances, unsteadiness of dynamic characteristics objects, etc.

The paper discusses the problems of developing a system for advanced process control of ammonia synthesis. In our country and neighboring countries, there are more than thirty enterprises using the same type of ammonia synthesis reactor. This reactor is interesting, first, because it is a multidimensional control object, which is characterized by four inputs, four outputs and a significant number of disturbing influences. This, in turn, causes a number of difficulties in creating a control system and at the same time allows us to identify new ways to solve these problems.

One of the technological stages of ammonia production is the catalytic synthesis of ammonia in the column. The most important adjustable parameter is the temperature in the catalyst zone [11]. Temperature control is quite a difficult task, since the existing mathematical models are difficult to implement due to the complexity of the physicochemical dependencies. In addition, all parameters of the ammonia synthesis column vary over time.

As a research object, this work initially considered a typical chemical-technological system for the ammonia synthesis section. This chemical-technological system (CTS) was considered both separately and together with the section for the release of ammonia from purge gas. The process of producing anhydrous liquefied ammonia consists of the following stages:

- purification of the converted gas from carbon monoxide with liquid nitrogen - production of nitric mixture;
- compression of a mixture of nitric;
- synthesis of ammonia followed by cooling and condensation of ammonia gas to produce liquid ammonia;
- compression of process nitrogen;
- compression of carbon monoxide fraction and ammonia gas.

The technological scheme of the synthesis section is shown in fig. 1.

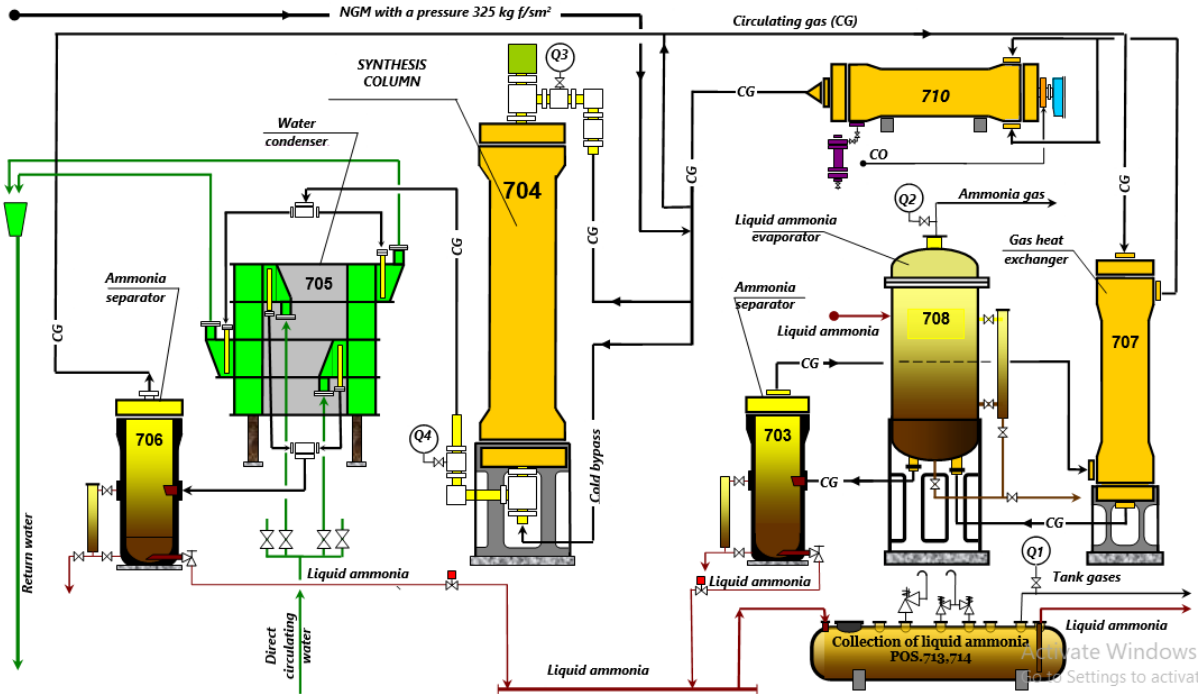

Fig. 1. Technological scheme of ammonia synthesis section.

According to the technological regulations [12], the nitrogen-hydrogen mixture (NGM) necessary for the ammonia synthesis process is obtained by cleaning the converted gas from carbon monoxide, argon, methane with liquid nitrogen.

Compressed gas compressors (pos. 710) up to a pressure of not more than 325 kg f/sm^2 (31.88 MPa) and nitrogen-hydrogen mixture is supplied to the units of synthesis of ammonia.

The process of ammonia synthesis from hydrogen and nitrogen takes place in the synthesis columns of units № 7, 8, 9 (pos. 704) on an iron catalyst at a temperature not exceeding 540 ^{0}C and a pressure not exceeding 325 kg f/sm^2.

In order to achieve the maximum performance of the reaction volume of the synthesis column, it is necessary to condense ammonia (pos. 705) most fully and separate (pos. 703,706) it from the gas mixture. NGM is cooled.

In this case, part of the ammonia goes into a liquid state and is removed from the system, the remaining gas returns to the cycle and joins the fresh gas (pos. 707,708).

The lower the temperature of NGM, the more ammonia from it condenses, and accordingly less remains in the gas. The residual volume fraction of ammonia in the gas mixture (circulating gas) at a pressure of 300 kgf/cm2, depending on temperature.

The maximum possible decrease in the temperature of the gas mixture and the improvement of the liquid ammonia separation conditions allows reducing the ammonia content at the synthesis column inlet and increasing the productivity of the column. The amount of ammonia formed corresponds to the difference of its content in the gas leaving the column and entering the column [13].

In this study, an advanced process control system for ammonia synthesis was developed and the following results were obtained (Table 1).

Table 1. Comparison table of technological indicators for the option of modernization with an advanced control system.

Parameters (technological indicators)	Before modernization	Traditional modernization	Modernization with advanced control system
Production, tons per day	1350	1800	1890
Primary reforming			
The temperature of the mixture of raw materials, ^{o}C	510	537	438
Outlet temperature, ^{o}C	820	810	706

Steam / Carbon	3.5	3.0	2.7
Secondary Reform			
T air, ºC	468	480	453
Methane yield, mol %	0.32	0.27	1.72
T at the exit, ºC	1002	972	885
Synthesis circuit			
CH_4 in feed gas, mol %	0.83	0.97	not
Inertness in gas, mol %	1.15	1.27	0.19
Pressure in the circuit, kg/cm^2 (excess.)	210	181	178

Conclusion

To achieve this goal the following tasks were solved:

- analysis of approaches to solving problems of building models and process control systems in conditions of uncertainty;
- formalization of the tasks of analysis and optimal control of the object under study in the context of parametric uncertainty of the initial information.
- development of the concept and methodology for constructing models and process control systems in the conditions of interval-parametric uncertainty;
- development of methods and algorithms for estimating the parameters and state of technological control objects;
- development and practical implementation of software and algorithmic support systems for solving problems of identification and synthesis of control actions under the conditions of interval uncertainty of the initial information;
- practical testing of the developed methods and computational schemes for the synthesis of process control systems based on the developed algorithms and software [10].

The main conclusions from the results of testing and trial operation of advanced process control systems are as follows [14].

Thanks to the control of the installation using advanced process control systems, it was possible to:

- increases the productivity of the reforming system by 25-30%;
- more optimal use of high potential heat;
- with parallel execution, the pressure drop is reduced;
- can be used to increase productivity, with an increase of up to 50%, as well as reduce energy consumption;
- best suited when major deficiencies are identified in areas of the furnaces and synthesis loop;
- use of excess air in a secondary reformer;
- softening the conditions in the primary reforming unit - extending the life of the pipes;
- a new stage of cryogenic treatment;
- new parallel process air compressor;
- increased CO_2 production;
- the use of pure dry synthesis gas allows achieving optimal conditions for increasing the productivity of the synthesis circuit and prolonging the life of the synthesis catalyst.

Solving these problems allows us to develop constructive methods, algorithms and computer models for parametric identification and synthesis of control systems for technological objects, contributing to an increase in the efficiency of functioning of control systems for technological objects of various functional purposes [15-18].

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Issue Article

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THE HISTORY OF THE SHAHI ZINDA ENSEMBLE AND THE HISTORICAL AND ARCHITECTURAL CHARACTERISTICS OF THE STRUCTURES IN THE COMPLEX

Abstract: *This article will talk about the architectural complex - Shahi Zinda, which is of great importance not only in Muslim, but also in the entire world history, its formation, architectural structures that are part of the complex, and its significance and role in the present day. The historiography of Uzbekistan also extensively highlights the role of the Shahi Zinda complex, which occupies an important place in the history of world civilization, in the development of Muslim urban planning in Central Asia.*

Key words: *Shahi Zinda complex, world civilization, Central Asia, architectural characteristics, structures in the complex.*

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Introduction

Samarkand is one of the most ancient cities in Central Asia and the world as a whole. According to archaeological excavations, the history of Samarkand dates back to the VIII century BC. The name of the city is of Turkic origin and means "a large rich settlement". For many years, Samarkand has been the largest center of cultural, commercial, and political life in Asia.

The ensemble of mausoleums of the Samarkand nobility Shahi Zinda is an architectural monument of the Middle Ages. The best medieval masters of India, Khorezm, Iran erected a unique necropolis.

On the slope of the settlement of Afrosiab there is an ancient necropolis consisting of 20 structures. It is an architectural and historical ensemble that embodies the 25th century history of Samarkand. The basis of the memorial complex of Shihi Zadeh is the tomb of Kussama ibn Sama, one of the first righteous men of Islam, popularly called the "living king".[10, p.77]

Shakhi-Zinda is the place of burial of royal nobility. However, the main mausoleum where the necropolis begins is considered to be the imaginary grave of the cousin of the Prophet Muhammad – Kusama ibn-Abbas. He was called “Shakhi-Zinda”. He was one of the believers who preached Islam in this province, and later this complex became an important pilgrimage site, revered among the people as a shrine. According to a legend, he came with a sermon to Samarkand in 610, where he spent 13 years and he was beheaded by Zoroastrians during prayer.

Kusama ibn-Abbas’s burial is a purpose of the visit to Samarkand for many adherents of religious or spiritual tourism

The decoration of the tombstone is made of tiled colored marble slabs, quotes from the Koran are inscribed in golden script. Fourteen mausoleums have survived to this day, the oldest of them is the tomb of Qusam ibn Abbas. However, the last structure erected in 1435 by Ulugbek was the portal, which serves as the central entrance to the necropolis. Also among all the buildings you can see one of the most magnificent mausoleums. It was built by one of Sahibkiran's sisters, Turkan What, for her daughter. Decorated with

unique ganch carvings, with a majolica-covered portal and decorated with vines, it was built in 1372. [2, p.7]

A necklace of masterpieces can rightfully be called the amazingly picturesque Shahi Zinda memorial complex, among the early monuments of which, running up to the fortress wall of Afrasiab, there are related to the history of pre-Mongolian Samarkand. But the main bright inflorescence, full of light and harmony, is the "fruits of the architects" of the era of Amir Timur and his grandson Ulugbek. The ensemble got its name "Shahi-Zinda" - "The Living King" - from the burial complex in which the cousin of the Prophet Qusam ibn Abbas, who died in battles with infidels, was buried.

This is the oldest architectural monument in Samarkand, its appearance dates back to the middle of the XI century, over the grave of the cousin of the Prophet Muhammad, Kusam ibn Abbas mausoleum, served as the core of the ensemble - the necropolis of Shahi-Zinda. It was a large urban religious and cult center not only for medieval Samarkand, but also for the whole of Central Asia, the pilgrimage to which at one time replaced the Hajj to Mecca. The area of the ensemble is 200x40m. As the excavations in the IX-X centuries have shown, this southern part of the territory of Afrasiab was inhabited and built up with residential mud houses. A fragment of a unique carved wooden frieze has been preserved from the mosque located among them (located on the territory of the modern Qusam ibn Abbas complex).

In the XIV - XV centuries, the popular "shrine" was turned into a country family necropolis of the Timurids. In the XVI - XIX centuries, with the change of the ruling dynasty and the transfer of the capital to Bukhara, no more ceremonial tombs were built in the ensemble. The buildings that appeared in these centuries did not significantly change its artistic appearance. [11, p.45]

A brilliant page in the history of architecture of Samarkand and Shakhi-Zinda are mausoleums built during the reign of Amir Temur, Mirzo Ulugbek and other Temurids. Shahi-Zinda today is one of the best architectural ensembles of Central Asia, a monument of great historical, cultural and artistic value. This memorial complex, the necropolis, is called by art critics "picturesque", "frozen music", "full of harmony and light", a genuine hymn to human labor.

The ensemble was studied by famous scientists - V.V. Bartold, V.L. Vyatkin, M.E. Masson, V.A. Shishkin, calligrapher Abu Said Makhdoom, artist G.N. Nikitin, art historian I.F. Borodina and many others. The contribution of folk restorers Akram Umarov, Mirhamid Yunusov, Shafi Isakov, Anar Kuliyev and others who revived the creation of architects of ancient eras is noble. [1, p.29]

The oldest core of the ensemble is the Qusam Ibn Abbas Complex, which was rebuilt many times, was recreated under Amir Temur and supplemented with new elements, until the XIX century. The door leading to the complex was made by master Yusuf Shirazi in 1404-1405. This is a beautiful work of art of carvings on elm with non-preserved ivory inlay. Above the entrance is a large mosaic quadrangular panel with the inscription: "The Prophet said ... "Al-Qusam-ibn-al-Abbas most of all people look like me in appearance and character." Behind the door is a minaret of the XI century. The lining of the base of the minaret is made with a set of shaped polished bricks typical of that period.

The complex consists of several rooms: a ziarathana (intended for performing a ziyarat - a rite of worship), a gurkhon (tomb), a chillahon (for holding a 40-day fast), a tugkhon (for storing cult equipment). Behind a wooden lattice in Gurkhon there is a tombstone - evidence of the high art of Central Asian ceramists. The dome of ziarathana was re - erected in 1334-1335 . In the same century, the walls were painted, the lower part of which was lined with hexagonal ceramic tiles. [6, p.81]

Next to the complex of Qusam ibn Abbas, passing through the upper chartak, there is a "Northern" Courtyard. In the first half of the XIV century, when the ensemble consisted mainly of surviving buildings of the XI-XII centuries, chartak and two mausoleums were built, which greatly determined the further development of the ensemble's composition; the Mausoleum of Khoja Ahmad, built in the 40s of the XIV century, which bounded the necropolis from the north; An unknown Mausoleum of 1361 (with east).

More than six centuries separate these structures from our time. Each of them gives an idea of the art of the masters of the middle of the XIV century. Both mausoleums are portal-domed buildings. The portals are decorated with a solid cover of tiles. Many details are distinguished by virtuoso execution (eight-pointed rosettes on the portal of the mausoleum of 1361 or a geometric ornament of seven- and octahedrons on the portal of the mausoleum of Khoja Ahmad). The facing of the mausoleums is made of carved watered terracotta. Along with this, painted majolica is also used in the decoration of the facade of the mausoleum of Khoja Ahmad. The name of the Samarkand master Fakhri Ali has been preserved on the entrance portal. As a result of the restoration work in 1962 under the guidance of the renowned master restorer Mirhamid Yunusov, the portal was re-laid with the strengthening of the preserved cladding. [3, p.18]

On the western side, the "northern courtyard" closes the Tuman-Aka - Temur's wife Complex, built in the late XIV - early XV centuries (completed in 1405), the architecture and decor of which differed significantly from previous mausoleums. The portal facing is dominated by a carved set mosaic. The name of the master calligrapher from Tabriz, Sheikh Mohammed ibn Haji Bandgir at-Tugrai Tabrizi, has been preserved on the portal. Unlike the mausoleums of the blue style (1361 and Khoja Ahmad), the

Tuman-aka mausoleum has a much wider color palette: blue, light blue, black, yellow, white, purple. The multicolored facade is contrasted with the design of the mausoleum inside. The artistic idea based on the contrast of the bright mosaic panel and wall paintings in the interior of the mausoleum is remarkable. In some panels, small landscapes were introduced - trees, shrubs, flowers with murmuring streams, in a word, the untouched silence of paradise. And the cup of the dome resembles the firmament in the form of golden stars scattered on a blue background. The tuman-aka mausoleum is distinguished by its extraordinary slimness. Its room is almost two times smaller than in all previous mausoleums, and the height is one and a half times more.

If you look at the southern path of the ensemble, then a narrow street of a medieval city comes to mind. This impression is not accidental, since the ensemble appeared within the boundaries of a residential, densely built-up urban quarter. Therefore, there is a reflection of the historically established topography of the area. The composition of the ensemble is designed to continuously change impressions as you move from the entrance portal to the Qusam ibn Abbas complex and back. First, a wide panorama of the entrance group opens, then a deep perspective of the road in the middle part and, finally, the isolated space of the courtyard. [1, p.34]

The historical, cultural and artistic value of the ensemble lies in the fact that Shahi-Zinda gives an idea of the development of architecture and monumental structures, monumental and decorative art over several centuries. The ensemble was a creative laboratory for the search for new designs of architectural composition, decor. It captures the stylistic features of local architectural schools before the Timur era and the school that developed under Temur, based on the creative techniques of local and foreign masters. Created in the distant past, these architectural structures still glorify the true creators - thousands of unknown masters.

Conclusion

In conclusion, it should be noted that the issue of providing reliable and scientifically based information to future generations about such architectural monuments as Shahi Zinda, their rich history and contributing to the study of the history of our country remains relevant. Using the example of the Shahi Zinda memorial complex, the role of Central Asia as an integral part of the history of Uzbekistan was studied, the presentation of ancient writings in it on the basis of historical research. The historical, cultural and artistic value of the ensemble lies in the fact that Shahi-Zinda gives an idea of the development of architecture and monumental structures, monumental and decorative art over several centuries. The ensemble was a creative laboratory for the search for new designs of architectural composition, decor. It captures the stylistic features of local architectural schools before the Timur era and the school that developed under Temur, based on the creative techniques of local and foreign masters. Created in the distant past, these architectural structures still glorify the true creators - thousands of unknown masters. In Muslim culture, the most impressive is architectural culture: it captures the history of Islam. Arches, domes, columns, carved doors, panels with quotations from the Koran are mandatory elements of Muslim culture. The combination of different styles in architecture was embodied in the Shahi Zinda Memorial complex.

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