Norwegian Journal of development of the International Science

№91 2022

NORWEGIAN JOURNAL OF DEVELOPMENT OF THE INTERNATIONAL SCIENCE

№91/2022

Norwegian Journal of development of the International Science

ISSN 3453-9875

It was established in November 2016 with support from the Norwegian Academy of Science.

DESCRIPTION

The Scientific journal "Norwegian Journal of development of the International Science" is issued 24 times a year and is a scientific publication on topical problems of science.

1000 copies

Norwegian Journal of development of the International Science

Iduns gate 4A, 0178, Oslo, Norway

email: publish@njd-iscience.com

site: http://www.njd-iscience.com

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THE EFFECT OF ADDITIVES ON THE PHYSICOCHEMICAL PROPERTIES OF OILS FOR GAS TURBINE ENGINES

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ВЛИЯНИЕ ПРИСАДОК НА ФИЗИКО-ХИМИЧЕСКИЕ СВОЙСТВА МАСЕЛ ДЛЯ ГАЗОТУРБИННЫХ ДВИГАТЕЛЕЙ

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https://doi.org/10.5281/zenodo.7032032

Abstract

Petroleum oils do not fully meet all the requirements of modern heat-stressed gas turbine engines in terms of thermal-oxidative stability, evaporation, operability at low temperatures and other operational and physico-chemical properties. Therefore, recently more and more attention has been paid to lubricants produced by synthetic methods. This topic is very relevant due to the fact that synthetic oils have a number of advantages over petroleum oils. In this regard, an urgent task is to improve the operational properties of ester oil compositions through the use of additives of national production. In total, 15 mixtures of esters national and foreign production were prepared, mixtures with the most acceptable properties were selected from them. To study the effect of additives on anti-wear properties, a compound ester mixture of DOS-T (dioctyl sebacinate thermostable) and DBS (dibutyl sebacinate) was selected in a ratio of 1:1. Additives of national production (ADTF, K-45, TEF-3) were added to it.

Comparing the data obtained, it can be concluded that the most acceptable for the selected mixture is an additive of national production of ADTP at a concentration 0.6% by weight.

Аннотация

Зачастую нефтяные масла не полностью удовлетворяют всем требованиям современных теплонапряженных газотурбинных двигателей по термоокислительной стабильности, испаряемости, работоспособности при низких температурах и по другим эксплуатационным и физико-химическим свойствам. Поэтому в последнее время все больше внимания уделяется смазочным материалам, получаемым синтетическими методами. Данная тема очень актуальна в связи с тем, что синтетические масла обладают рядом преимуществ по сравнению с нефтяными маслами. В связи с этим актуальной задачей является улучшение эксплуатационных свойств сложноэфирных композиций масла за счет применения присадок отечественного производства. Всего было приготовлено 15 смесей сложных эфиров отечественного и зарубежного производства, из них выбраны смеси с наиболее приемлемыми свойствами. Для изучения влияния присадок на противоизносные свойства была выбрана сложноэфирная смесь ДОС-Т (диоктилсебацинат термостабильный) и ДБС (дибутилсебацинат) в соотношении 1:1. К ней были добавлены присадки отечественного производства (АДТФ, К-45, ТЭФ-3).

Сопоставив полученные данные, можно сделать вывод, что наиболее приемлемой для выбранной смеси является присадка отечественного производства АДТФ в концентрации 0,6 % масс.

Keywords: Ester, tribological properties, antiwear additive, dioctyl adipate, pentaerythritic alcohol, dioctyl sebacate.

Ключевые слова: Сложный эфир, трибологические свойства, противоизносная присадка, диоктиладипинат, пентаэритритовый спирт, диоктилсебацинат.

Сложные эфиры являются перспективной основой для производства масел, применяемых для газотурбинных двигателей. Синтетические масла на основе сложных эфиров обладают рядом преимуществ по сравнению с нефтяными маслами, например, высокотемпературные и низкотемпературные свойства. Тем не менее, не все сложные эфиры обеспечивают требуемый комплекс физико-химических свойств. Исходя из этого, необходимо исследовать сложные эфиры различных структур, производимых из разных типов сырья.

В ходе эксперимента нами были исследованы четыре образца сложных эфиров отечественного производства и один образец зарубежного производства.

При анализе полученных данных сложных эфиров очевидно, что ни один из них не удовлетворяет полностью предъявляемым требованиям к маслам для газотурбинных двигателей. Некоторые показатели существенно отличаются, это связано с различной структурой эфиров. Такие эфиры как ДОС-Т (диоктилсебацинат термостабильный), ДБС (дибутилсебацинат) и ДОА (диоктиладипинат) имеют линейную структуру. У эфиров ПЭТ-Б (пентаэритритовый эфир – базовый) и Nycobase 5950 более разветвленная структура, в соответствии с этим у данных эфиров более высокая термоокислительная стабильность, устойчивость к износу [1,2].

Исходя из этого необходимо смешать чистые сложные эфиры между собой для получения смеси с показателями, которые будут удовлетворять требованиям, предъявляемым к маслам для газотурбинных двигателей. Концентрации смесей выбирались исходя из различного строения представленных сложных эфиров, а также по разнице полученных показателей. В таблицах 1 - 5 приведены показатели полученных смесей.

Таблица 1 – Физико-химические свойства сложных эфиров ДОС-Т и ДБС и их смесей в различных концентрациях

Свойства	Сложные эфиры и их смеси					Нормированное значение
	ДОС-Т	ДБС	25% масс. ДОС-Т/ 75% масс. ДБС	50 % масс. ДОС-Т / 50 % масс. ДБС	75% масс. ДОС-Т / 25 % масс. ДБС	
Плотность при 20 °С, кг/см^3	910	937	919	926	930	975-992
Температура застывания, °С	<-30	-12	<-30	<-30	<-30	Минус 60
Температура вспышки, определяемая в открытом тигле, °С	220	225	224	223	221	Не ниже 245
Критическая нагрузка, $Р_К$, кгс	47,5	50,0	50,0	50,0	47,5	Не менее 67
Диаметр пятна износа, $Д_и$, мм	1,40	1,10	1,31	1,19	1,16	Не более 0,6
Показатель преломления, n_D^{20}	1,4530	1,4409	1,4478	1,4451	1,4418	-
Кинематическая вязкость при 40°С, мм^2/с	39,0	6,2	26,0	18,0	11,0	Не более 35
Кинематическая вязкость при 100°С, мм^2/с	8,0	2,0	6,4	5,6	4,3	Не более 6,0

Наилучшими показателями обладает смесь с содержанием сложных эфиров 50 % масс. ДОС/ 50 % масс. ДБС. Диаметр пятна износа составляет 1,19 мм, в то время как смесь с содержанием сложных эфиров 25% масс. ДОС-Т/ 75% масс. ДБС, а также сложный эфир ДОС-Т уступают по данному показателю. Критическая нагрузка у данной смеси (50 кгс) выше, чем смеси с содержаниями сложных эфиров 75% масс. ДОС-Т/ 25% масс. ДБС и сложного эфира ДОС-Т. Температура застывания у всех смесей одинакова. Температура вспышки у смеси с содержанием сложных эфиров 50 % масс. ДОС/ 50 % масс. ДБС выше, чем у смеси 75% масс. ДОС-Т/ 25% масс. ДБС, но незначительно ниже, чем у смеси 25% масс. ДОС-Т/ 75% масс. ДБС.

Таблица 2 – Физико-химические свойства сложных эфиров ДОС-Т и ПЭТ-Б и смесей в различных концентрациях

Свойства	Чистые сложные эфиры и их смеси					Нормированное значение
	ДОС-Т	ПЭТ-Б	25% масс. ДОС-Т/ 75% масс. ПЭТ-Б	50 % масс. ДОС-Т / 50 % масс. ПЭТ-Б	75% масс. ДОС-Т / 25 % масс. ПЭТ-Б	
Плотность при 20 °С, кг/см^3	910	991	956	953	946	975-992
Температура застывания, °С	<-30	<-30	<-30	<-30	<-30	Минус 60
Температура вспышки, определяемая в открытом тигле, °С	220	258	235	242	215	Не ниже 245
Критическая нагрузка, $Р_К$, кгс	47,5	40,0	40,0	42,5	45,0	Не менее 67

Диаметр пятна износа, $Д_и$, мм	1,40	1,00	1,30	0,93	0,90	Не более 0,6
Показатель преломления, n_D^{20}	1,4530	1,4520	-	-	-	-
Кинематическая вязкость при 40°С, мм^2/с	39,0	23,4	15,4	11,2	8,5	Не более 35
Кинематическая вязкость при 100°С, мм^2/с	8,0	5,0	3,8	3,1	2,6	Не более 6,0

Лучшими показателями обладает смесь с содержанием сложных эфиров 50% масс. ДОС-Т/50% масс. ПЭТ-Б. У данной смеси выше критическая нагрузка (42,5кгс), чем у смеси с содержаниями ДОС-Т 25% масс. ПЭТ-Б 75% масс. и сложного эфира ПЭТ-Б, а также меньше диаметр пятна износа, чем у смеси 25% масс. ДОС-Т/ 75% масс. ПЭТ-Б и сложных эфиров ДОС-Т и ПЭТ-Б. При этом температура вспышки (242 °С) выше, чем у остальных смесей [1,3].

Таблица 3 – Физико-химические свойства смесей ДБС и ПЭТ-Б в различных концентрациях

Свойства	Сложные эфиры и их смеси					Нормиро-ванное значение
	ПЭТ-Б	ДБС	25 % масс. ПЭТ-Б/ 75% масс. ДБС	50 % масс. ПЭТ-Б / 50 % масс. ДБС	75% масс. ПЭТ / 25 % масс. ДБС	
Плотность при 20 °С, кг/см^3	991	937	951	964	979	975-992
Температура застывания, °С	<-30	-12	<-30	<-30	<-30	Минус 60
Температура вспышки, определяемая в открытом тигле, °С	258	225	233	237	250	Не ниже 245
Критическая нагрузка, $Р_К$, кгс	40,0	50,0	47,5	45,0	42,5	Не менее 67
Диаметр пятна износа, $Д_и$, мм	1,00	1,10	1,10	1,10	1,07	Не более 0,6
Показатель преломления, n_D^{20}	1,4520	1,4408	1,4430	1,4471	1,4493	-
Кинематическая вязкость при 40°С, мм^2/с	23,40	6,20	8,03	10,35	15,11	Не более 35
Кинематическая вязкость при 100°С, мм^2/с	5,02	2,00	2,40	2,88	3,76	Не более 6,0

Смесь с содержанием сложных эфиров 50% масс. ДБС / 50% масс. ПЭТ-Б обладает лучшими физико-химическими показателями. У данной смеси выше критическая нагрузка, чем у сложного эфира ПЭТ-Б и смеси с содержанием 75% масс. ПЭТ-Б / 25% масс. ДБС, а температура вспышки (237 °С) выше, чем у смеси с содержаниями 25% масс. ПЭТ-Б / 75% масс. ДБС и сложного эфира ДБС

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Таблица 4 – Физико-химические свойства смесей ДОА и ПЭТ-Б в различных концентрациях

Свойства	Чистые сложные эфиры и их смеси					Нормиро-ванное значение
	ДОА	ПЭТ-Б	25% масс. ДОА/ 75% масс. ПЭТ-Б	50 % масс. ДОА/ 50 % масс. ПЭТ-Б	75% масс. ДОА / 25 % масс. ПЭТ-Б	
Плотность при 20 °С, кг/см^3	930	991	969	952	943	975-992
Температура застывания, °С	<-30	<-30	<-30	<-30	<-30	Минус 60
Температура вспышки, определяемая в открытом тигле, °С	196	258	238	227	214	Не ниже 245
Критическая нагрузка, P_K, кгс	45,0	40,0	42,5	45,0	45,0	Не менее 67
Диаметр пятна износа, $Д_и$, мм	1,10	1,00	1,07	1,07	1,10	Не более 0,6
Показатель преломления, n_D^{20}	1,4461	1,4408	1,4506	1,4489	1,4475	-
Кинематическая вязкость при 40°С, мм^2/с	7,66	23,40	16,35	12,45	10,04	Не более 35
Кинематическая вязкость при 100°С, мм^2/с	2,32	5,20	3,97	3,30	2,83	Не более 6,0

Смесь с содержаниями сложных эфиров 50 % масс. ДОА / 50 % масс. ПЭТ-Б является наилучшей по своим физико-химическим показателям. У данной смеси выше критическая нагрузка (45 кгс), чем у смеси 25 % масс. ДОА / 75 % масс. ПЭТ-Б и сложного эфира ПЭТ-Б. Также меньше диаметр пятна износа (1,07 мм) и выше температура вспышки, чем у смеси 75% масс. ДОА / 25 % масс. ПЭТ-Б и сложного эфира ДОА.

Таблица 5 – Физико-химические свойства смесей ДБС и Nycobase 5950

Свойства	Чистые сложные эфиры и их смеси					Нормированное значение
	Nycobase 5950	ДБС	25% масс. NB 5950/ 75% масс. ДБС	50 % масс. NB 5950 / 50 % масс. ДБС	75% масс. NB 5950 / 25 % масс. ДБС	
Плотность при 20 °С, кг/см^3	992	937	950,8	965	978,1	975-992
Температура застывания, °С	<-30	-12	<-30	<-30	<-30	Минус 60
Температура вспышки, определяемая в открытом тигле, °С	256	185	232	241	250	Не ниже 245
Критическая нагрузка, P_K, кгс	53	50	50	53	53	Не менее 67
Диаметр пятна износа, $Д_и$, мм	0,70	1,10	1,0	0,85	0,76	Не более 0,6
Показатель преломления, n_D^{20}	1,4560	1,4409	1,4446	1,4482	1,4526	-
Кинематическая вязкость при 40°С, мм^2/с	22,50	6,20	7,20	10,18	18,90	Не более 35
Кинематическая вязкость при 100°С, мм^2/с	4,77	2,05	2,24	2,83	4,22	Не более 6,0

Исходя из полученных данных, можно сделать вывод, что наилучшей композицией является смесь с содержанием сложных эфиров 75% масс. Nycobase 5950 / 25 % масс. ДБС. Данная смесь имеет выше критическую нагрузку, диаметр пятна износа меньше (0,76 мм), а температуру вспышки больше, чем у остальных смесей и сложного эфира ДБС. Несмотря на то, что эта смесь является лучшей из всех рассмотренных выше, предпочтительнее выбрать отечественную смесь с содержанием

сложных эфиров 50 % масс. ДОС-Т/ 50 % масс. ДБС, так как разница между трибологическими свойствами невысокая, а отечественная смесь ниже по стоимости, более доступна и выгодна для исследований в рамках программы импортозамещения [4].

Следующим этапом нашей работы было – добавление к выбранной смеси противоизносных присадок, а именно АДТФ, К-45, ТЭФ-3. Нами была выбрана смесь с содержаниями сложных эфиров 50 % масс. ДОС-Т / 50 % масс. ДБС исходя из приемлемых физико-химических и эксплуатационных свойств данной смеси, низкой стоимости в сравнении с другими эфирами и смесями, недостаточной изученностью данных смесей и их физико-химических и эксплуатационных свойств.

При получении композиций сложных эфиров с добавлением отечественной присадки АДТФ производства ООО «ННП Квалитет» были получены результаты, представленные в Таблице 6.

Таблица 6 – Трибологические показатели композиций эфиров с присадкой АДТФ

Концентрация, % масс.	Критическая нагрузка Рк, кгс	Диаметр пятна износа Ди, мм
0,2	56	0,96
0,6	71	0,73
1,0	75	0,65

При получении композиций сложных эфиров с добавлением отечественной присадки К-45 производства ООО «ННП Квалитет» были получены результаты, представленные в Таблице 7.

Таблица 7 – Трибологические показатели композиции эфиров с присадкой К-45

Концентрация, % масс.	Критическая нагрузка Рк, кгс	Диаметр пятна износа Ди, мм
0,2	53	1,11
0,6	56	0,93
1,0	60	0,84

При получении композиций сложных эфиров с добавлением отечественной присадки ТЭФ - 3 производства ООО «ННП Квалитет» были получены результаты, представленные в Таблице 8.

Таблица 8 – Трибологические показатели композиции эфиров с присадкой ТЭФ - 3

Концентрация, % масс.	Критическая нагрузка Рк, кгс	Диаметр пятна износа Ди, мм
0,2	56	1,05
0,6	63	0,89
1,0	67	0,75

Анализируя все полученные значения, делаем вывод, что наиболее предпочтительной для выбранной смеси является присадка отечественного производства диалкилдитиофосфат АДТФ, так как более резкое изменение критической нагрузки и диаметра пятна износа наблюдается при добавлении данной присадки в концентрации 0,6 % масс. При заданной концентрации диаметр пятна износа сократился с 1,19 мм до 0,73 мм, а критическая нагрузка увеличилась с 50 кгс до 71 кгс, что является следствием высокой приемистости присадки АДТФ к смеси сложных эфиров 50 % масс. ДОС-Т / 50 % масс. ДБС. При концентрации 1,0 % масс. АДТФ изменения менее существенны, поэтому приемлемой концентрацией в данном случае будет присадка в концентрации 0,6 % масс [5].

При добавлении присадок К-45 и ТЭФ-3 также заметно улучшение трибологических свойств, но изменения менее значительны. С добавлением присадки К-45 в концентрации 1,0 % масс. критическая нагрузка увеличилась с 50 кгс до 60 кгс, а диметр пятна износа снизился с 1,19 мм до 0,84 мм, в то время как при добавлении АДТФ в меньшей концентрации 0,6 % масс. критическая нагрузка увеличилась до 71 кгс, а диаметр пятна износа также при меньшей концентрации снизился до 0,73 мм.

Присадка ТЭФ-3 имеет схожий состав с присадкой АДТФ, эти присадки являются беззольными, получают их на основе диалкилдитиофосфатов, но присадка АДТФ оказала большее влияние на трибологические свойства выбранной смеси. Критическая нагрузка при добавлении присадки ТЭФ-3 в концентрации 1,0 % масс. увеличилась с 50 кгс до 67 кгс, диаметр пятна износа изменился с 1,19 мм до 0,75 мм, в то время как при добавлении присадки АДТФ в меньшей концентрации трибологические показатели на порядок лучше.

Сравнивая выбранную смесь с маслом зарубежного производства AeroShell Turbine Oil 500 (Таблица 9), было выявлено, что полученная в ходе исследований смесь уступает зарубежной, но не

значительно, соответственно, она более конкурентоспособна в дальнейшем при изучении состава сложных эфиров, а также добавляемого пакета присадок.

Таблица 9– Сравнение трибологических свойств композиции сложных эфиров 50 % масс. ДОС-Т / 50 % масс. ДБС с AeroShell Turbine Oil 500

Масло	Критическая нагрузка $Р_к$, кгс	Диаметр пятна износа $Д_и$, мм
AeroShell Turbine Oil 500	94	0,40
Композиция 50 % масс. ДОС-Т / 50 % масс. ДБС	71	0,73

Таким образом, были исследованы физико-химические и эксплуатационные свойства созданных композиций сложноэфирных масел. По результатам сравнительных испытаний наиболее подходящей смесью для проведения дальнейшей работы стала смесь 50 % масс. ДОС-Т / 50 % масс. ДБС. На основе этой смеси было исследовано влияние трех присадок АДТФ, К-45, ТЭФ-3 на физико-химические свойства сложноэфирной смеси. Из полученных композиций была также выбрана одна – это композиция 50 % масс. ДОС-Т / 50 % масс. ДБС с присадкой АДТФ 0,6% масс. Сравнение данной композиции с зарубежным маслом AeroShell Turbine Oil 500, показало целесообразность изучения составов сложноэфирных масел для газотурбинных двигателей, так как по полученным результатам, было выявлено, что данные составы являются конкурентоспособными с аналогами отечественного и зарубежного производства [1,6].

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EARTH SCIENCES

APPLICATION FEATURES OF SINGLE-LIFT UNITS FOR DUAL COMPLETION OF FACILITIES OF MIDDLE AND LOWER CARBONIC STRATA

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Abstract
More efficient technologies should be introduced when developing mature fields to maintain the profitability of oil production. This article considers a unit for dual completion of several facilities, which makes it possible to develop strata, the individual exploitation of which is unprofitable. The considered unit also makes it possible to develop multilayer facilities in a single grid. Today there are many different types of dual completion units, the application of which depends on geological and physical characteristics of the facility and technical characteristics of the well. By design, dual completion units can be divided to single-lift and dual-lift units. The advantage of the dual-lift scheme is the ability to obtain direct information on the flow rate, water cut of the strata being developed and the bottom hole pressure of the upper stratum. During the application of the single-lift scheme, there is no possibility to directly determine the performance of each facility. The need to use single-lift schemes for dual completion is determined by the fact that small-diameter well technologies are actively used today. In a number of cases, when connecting the productive stratum with the implementation of single-lift dual completion, it was not possible to achieve an increase in the flow rate. The performed studies showed that the predicted oil flow rate was not achieved due to the decrease in productivity of the upper horizon and lack of bottom hole pressure control in the lower facility, as well as a requirement for the presence of differential pressure between the facilities for the correct work of equipment. One of the solutions to this problem is the introduction of more advanced units for dual completion.

Keywords: oil production technologies, dual completion, bottom hole pressure, dual completion single-lift unit, unit with dividing piston.

Mature fields development should be carried out using more efficient technologies that provide an acceptable level of profitability. Well operation is often hampered by the problem of simultaneous fluid production from several productive horizons having different filtration-volume properties, as well as different characteristics of stratum oil and energetic states [1-2, 8, 19].

The technology of dual completion makes it possible to develop several facilities simultaneously without waiting for depletion of the lower strata. This production method allows to develop layers the separate exploitation of which is unprofitable. It also makes it possible to develop multilayer deposits as a single grid [3-5, 14, 16].

To date, there are a large number of different layouts of equipment for dual completion [11, 12, 15]. The choice of unit type depends on geological and physical properties of strata, technical arrangement and well condition. The peculiarities of unit design and choice of technological scheme are influenced by gas-oil ratio, stratum temperature and pressure, presence of mechanical impurities, composition of produced fluid, diameter of production string. According to the operating method, the technology can be divided into two types: simultaneous separate extraction of fluid from each of the separated facilities (dual completion) and simultaneous separate injection of the agent. Dual completion units can be divided into single-lift and dual-lift schemes (Figure 1).

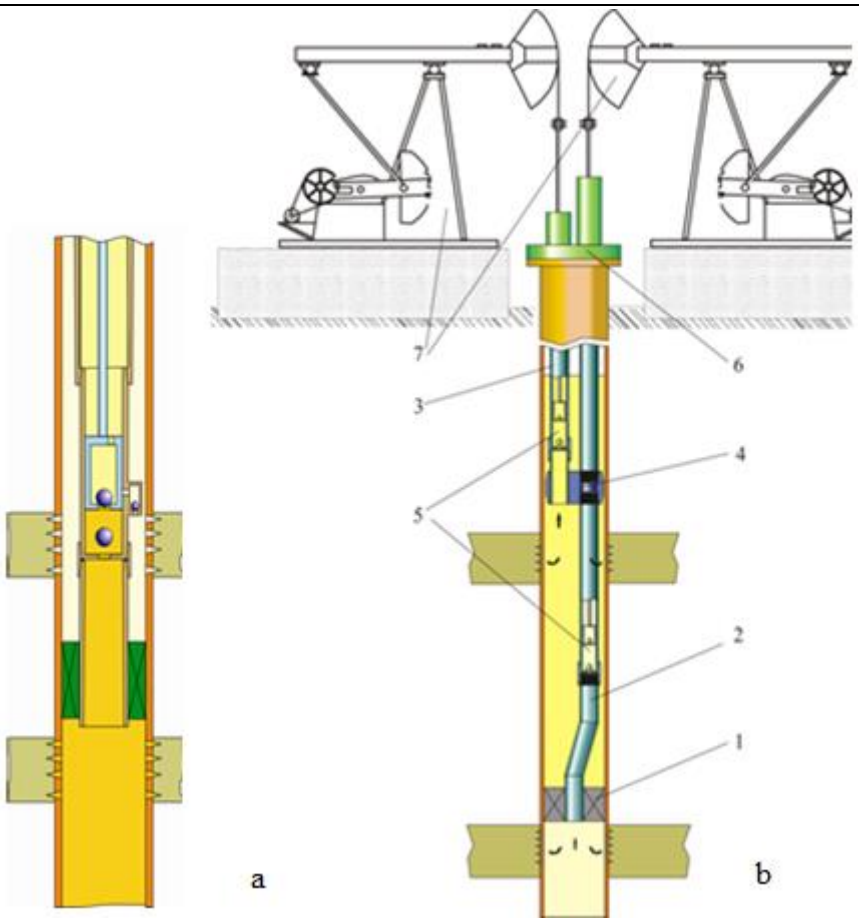

Figure 1- Design scheme of layouts for dual completion: a) single-lift; b) dual-lift

The dual-lift configuration consists of a dual outfit, a packer to decouple the facilities, an anchor connecting the two lifts and two rod-depth pumps, with a rocker or chain drive used as the surface drive. Advantages of dual-lift scheme are the possibility to obtain direct measurements of fluid flow rate, watercut of connected facilities and pressure at the bottom hole of the upper facility.

The single-lift configuration (Figure 2), unlike the dual-lift configuration, includes only one bottom hole sucker-rod pump, the facilities are separated by a packer, and fluid enters the pump through the main and side suction (auxiliary) valves that are connected with the stratum. The fluid from the area with lower bottom hole pressure enters through the main valve, while the fluid from the area with higher bottom hole pressure enters through the auxiliary valve.

In case of single-lift configuration, the production watercut and fluid flow rate cannot be determined directly [20]. However, it is possible to determine bottom hole pressure of the upper facility by the dynamic level. The load drop in the dynamogram (Figure 3) can be used to calculate the bottom hole pressure and the flow rate ratio. The plunger retooling can be used to leave one facility in operation, the top or the bottom one, depending on the location of the lateral suction valve.

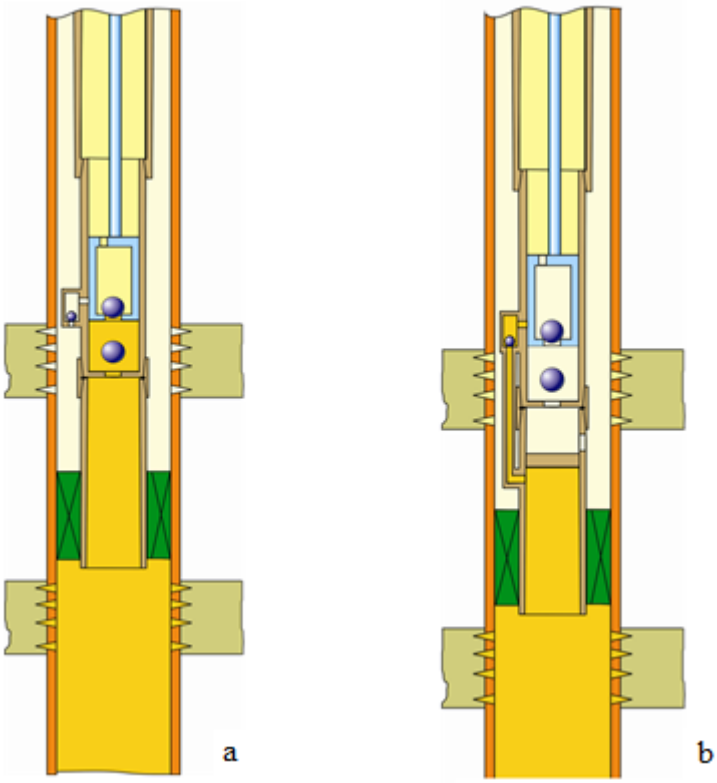

Figure 2- Schematic diagram of a classic single-lift unit

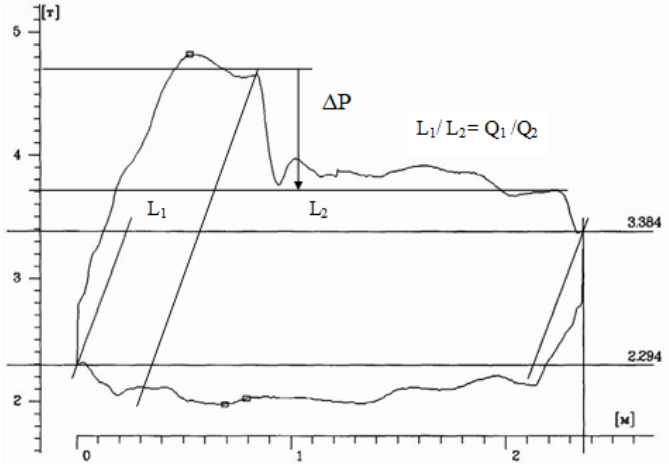

Figure 3- Dynamogram of the dual completion single-lift system

To date, the technology of drilling small diameter wells is widely used. Most of them are drilled in multi-layer fields [18]. In this regard, there is a necessity of using single-lift units for dual completion. Many wells currently use the classic dual completion single-lift units (Figure 2).

However, in a number of cases when connecting productive stratum with implementation of dual completion single-lift unit one could not reach the flow rate increment, in particular, when connecting Kizelovskiy horizon to Vereiskian one, oil flow rate increment was not obtained at several wells [6, 7, 9, 10].

The initial analysis showed that this problem is also relevant for other middle and lower carbonic strata. Compared were the average oil flow rates of wells by facility operating with single-lift dual completion and without dual completion. Figure 4 shows a graph comparing wells with and without dual completion and the number of wells involved in the calculation. The figure shows that the average flow rate of wells without dual completion is significantly higher than that of wells equipped with single-lift dual completion.

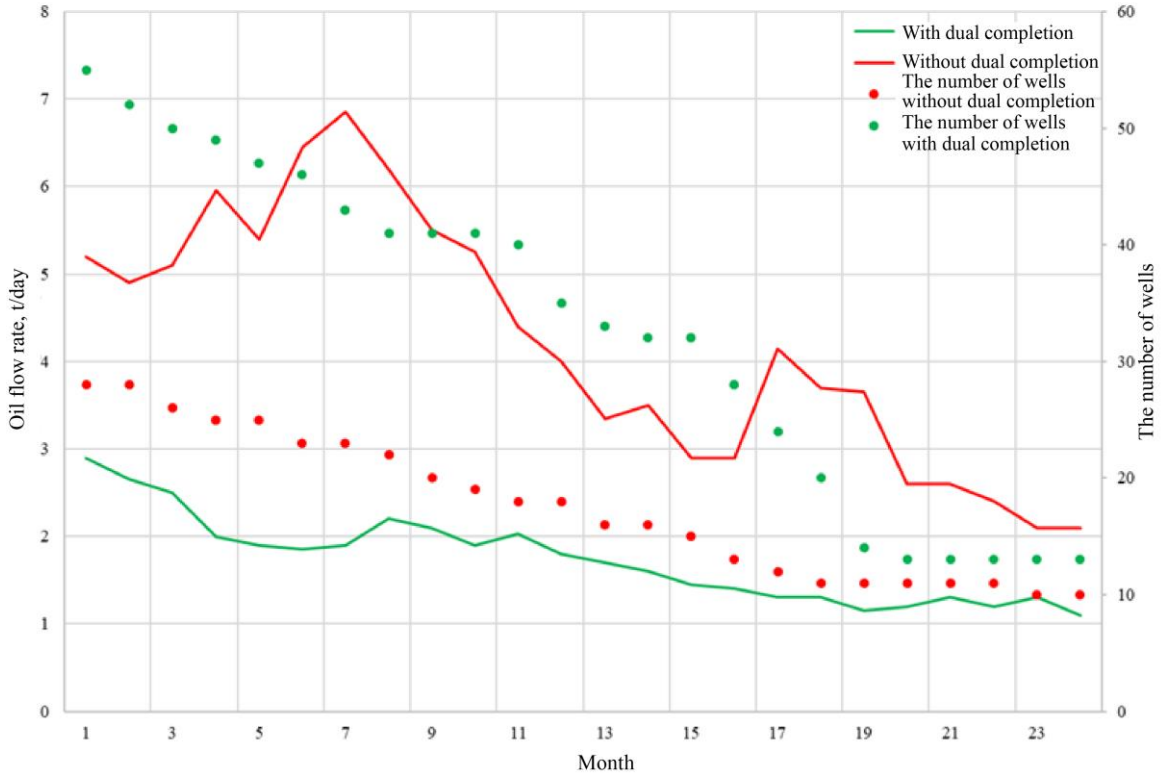

Figure 4-

Dynamics of well performance equipped with and without single-lift dual completion, Vereiskian horizon

The performed studies (dynamic level measurements, installation of a pressure gauge, retooling of the plunger, analysis of the dynamogram history) showed that the decrease in productivity of the Vereiskian horizon was due to a drop in the dynamic level below the stratum top, which resulted in pore collapse, whereas gas release in the bottom-hole zone reduced the phase permeability of oil. The planned flow rate for the Kizelovskiy horizon was not achieved since there was no bottom hole pressure control at the lower facility. The withdrawals from the facility decreased, dynamic level increased, but it was impossible to control these processes since the pressure measurements from the lower facility were not carried out. To control bottom hole pressure, it is necessary to lower a hydraulic smart controller into the well. At the same time, lowering of hydraulic smart controller for bottom hole pressure measurements in small diameter wells (d_{string}=102 mm) is complicated.

A major problem is that the classic single-lift unit works only when there is a bottom hole pressure difference between the exploited facilities. Given the loss in production rate and the results of all the work done, it can be concluded that the dual completion technology between the middle and lower carbonic strata needs to be changed.

The following alternative units for dual completion can be used to solve this problem:

- Dual completion unit with dividing piston and product mixing. The scheme is shown in Figure 5a.
- Dual completion unit with dividing piston and additional lifting (dual completion AL). The scheme is shown in Figure 5b.

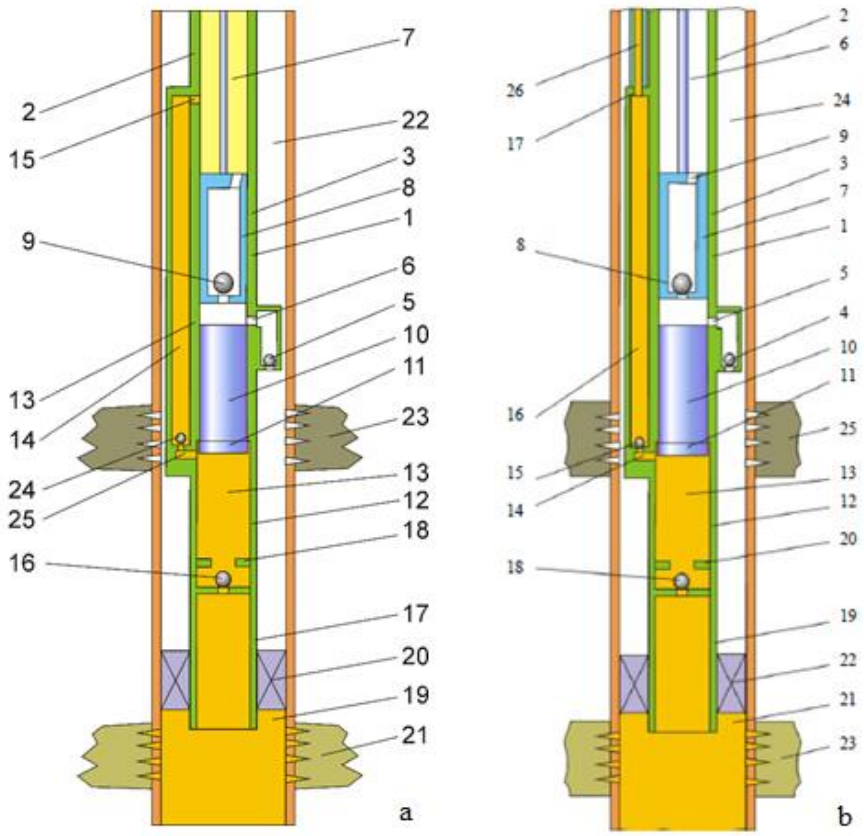

Figure 5 – Scheme of dual completion unit with dividing piston
a) With product mixing;
b) With separate lifting.

Figure 5 shows the dual completion unit with dividing piston. The advantage of this unit is that it works when there is no differential pressure between the facilities. The operating dynamogram of this unit can have a reverse step (Figure 6)**.** Figure 5b shows a similar unit, but with separate lifting. As the string of rods moves upwards the fluid from the lower facility moves to the extension and the lower part of the cylinder. Upon reaching the end of the lateral valve, the dividing piston stops and the fluid from the upper facility flows into the pump cylinder. When the plunger moves downward, the fluid of upper facility is displaced into hollow rods, the fluid from lower facility is displaced into tubing after the plunger reaches the dividing piston [13, 17].

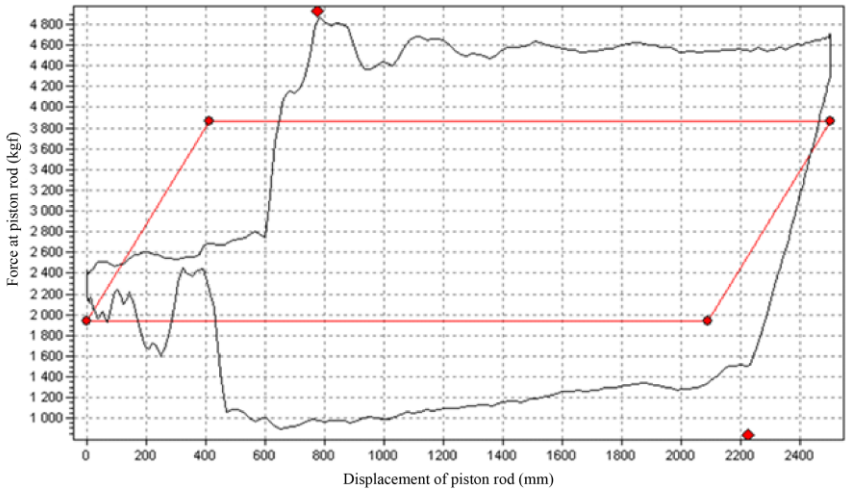

Figure 6 - Operating dynamogram of the dual completion single-lift system with dividing piston

To evaluate the effectiveness of the dual completion unit with dividing piston, it was put into practice in 10 wells of middle or lower carbonic strata. The dual completion unit with a dividing piston has shown higher efficiency compared to the classic single-lift unit. This primarily can be explained by the fact that the unit works effectively even without pressure differences between facilities.

One of the disadvantages of the dual completion unit with a dividing piston is that it can only be used in a production string with a diameter of 146 mm or more.

It is recommended to test this unit in simultaneous separate exploitation of middle and lower carbonic strata. However, in this case, the dual completion unit with dividing piston does not solve the problem of reducing the dynamic fluid level below the perforation interval. So, the following variants of exploitation of facilities of middle and lower carbonic strata are used:

- Operation of facilities by separate grid for maximum output;
- Operation of facilities as part of the existing technology with potential loss of production;
- Development of new technology to reduce production losses when working as part of dual completion.

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ECONOMIC SCIENCES

THE IMPACT OF THE CORONAVIRUS PANDEMIC ON THE EXCHANGE RATE OF THE RUSSIAN NATIONAL CURRENCY

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https://doi.org/10.5281/zenodo.7032100

Abstract
This article considers the impact of the coronavirus pandemic on the ruble exchange rate. In modern realities, the exchange rate, having a strong relationship with the main macroeconomic indicators, has a tangible impact on the country's economic system. The ruble exchange rate was analyzed using multiple linear regression (MLR) correlation analysis. The results have shown that the price of oil significantly affects the exchange rate. Moreover, other independent variables such as RTS Index and foreign investment in Federal loan bonds included in the model also have a distinguished effect on the ruble exchange rate.

Keywords: Exchange rate, Brent oil price, RTS index, Federal loan bonds

I. INTRODUCTION

On March 11, 2020, the World Health Organization announced the start of a pandemic of a new coronavirus infection of COVID-19, which has affected all countries of the world.

The pandemic has caused the largest global recession in 80 years, which was accompanied by large-scale isolation of the population. Global stock markets finally collapsed in March 2020, when major global indices fell by several percent. The general director of the World Health Organization, Tedros Ghebreyesus, expressed the hope that the coronavirus pandemic would be overcome in less than two years, therefore, by 2021 it will not be possible to finally "defeat" the coronavirus infection. In this regard, a wide range of opinions are expressed on the future dynamics of the ruble exchange rate, but the situation continues to be uncertain, since the pandemic process itself has so far undefinite characteristics, which is reflected in an increase in the degree of uncertainty of all economic and social processes. [1] The exchange rate is one of the most important macro-parameters of the open economy, therefore, the study of the actual dynamics of the ruble exchange rate and the identification of factors is affecting it in the specific conditions of the global pandemic remains highly relevant. [2]

The pandemic of coronavirus infection has significantly shaken the Russian economy. Since the beginning of 2020, the ruble's exchange rate against the dollar has grown by 16.52 rubles from 61.91 to 78.43 rubles [3] and almost reached a historical maximum in the history of the Russian Federation, including the event of 2014, called "Black Tuesday," when the ruble's exchange rate against the dollar in one day soared from 61 to 80 rubles. During the analyzed period, the price of oil also fell significantly: by $38.93 per barrel from 58.16 to $19.23.

In this research it will be determine the degree of influence of factors such as RTS Index, volume of Federal loan bonds owned by non-residents (in billion rubles); and oil prices Brent (the price is indicated in US dollars per barrel) on the exchange rate of the US dollar pair in Russian rubles.

II. LITERATURE REVIEW

The theory of exchange rate is a theoretical model of the determination and change of foreign price exchange rate of currency, also known as the theory of exchange rate determination. The central idea is that the exchange rate is determined by the supply and demand of foreign exchange. Western exchange rate theories are complicated and various schools, including traditional exchange rate theories and modern exchange rate theories. Some demonstrating exchange rate determination, and others explaining exchange rate changes. As a part of financial theory, exchange rate theory has developed from a subsidiary theory to an independent theory along with the process of exchange rate system from simple to complex. As the core topic of international financial theory research, exchange rate theory is an important part of international economic system. Its development runs through the whole history of modern western economic thought. It has always been a hot issue in western international economic research, and new theories emerge in endlessly. Exchange rate theory mainly includes the following two aspects: one is the determination of exchange rate. Under the floating exchange rate system, the volatile exchange rate not only affects the interests of micro subjects, but also relates to the internal and external balance of the national economy. The determination of exchange rate and the factors influencing the exchange rate change have become the hot issues of international financial scholars; the second is the exchange rate system. [4]

Consider factors that affect the exchange rate of the Russian national currency in modern realities. The factors affecting the ruble exchange rate can be divided into two main groups: internal and external factors. Internal factors of currency exchange rate formation include:

1) The Central Bank's key rate;
2) Unemployment rate;
3) Inflation rate;
4) RTS Index;
5) Federal loan bonds;
6) Balance of payments;
7) GNP of the country and industrial production index, etc. [2]

External factors affecting the ruble exchange rate include:

1) Oil prices. The profitable part of the country for more than half consists of profits provided by the export of raw materials, including oil. The prices of the raw materials from that make up Russian exports also have an impact.

2) The situation in the world economy. During the process of globalization, countries became interdependent, so news and changes in the world influence the national currency and the country directly.

3) Current sanctions. It did not stop working at a difficult time for the world economy.

4) Closing boundaries. The economy and industry are interethnic and interregional. [5]

However, in addition to these, there are many others factors affecting the growth of the ruble exchange rate.

The concept of the exchange rate is inseparable from the concept of the foreign exchange market. The currency market can be described as a certain centralized platform on which currency transactions are carried out, which are based on the fluctuation in the demand and supply of foreign currency for sale to the national currency and the subsequent formation of the exchange rate. The combination of world, national and regional markets, which differ in the volume, nature of foreign exchange transactions, as well as the list of currencies that are available for operations form a single global foreign exchange market. [6]

For the period of 2020, one can argue about the great dependence of the economic situation in the country on the foreign exchange market and, in particular, on the ruble exchange rate. The pandemic of coronavirus once again showed the dependence of the Russian economy on the fall in oil prices.

The difficult negotiations on the OPEC + deal, designed to reduce oil production, and for the Russian Federation to strengthen the ruble exchange rate and stabilize oil prices, at the moment do not provide a complete understanding for long-term planning of foreign exchange policy and the overall economic situation. [7]

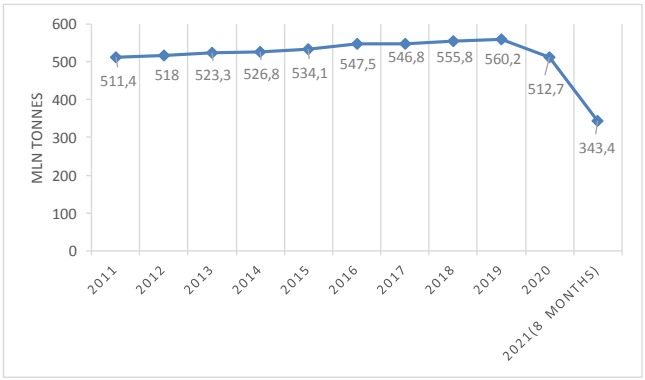

Fig. 1. Russia's oil production, million tonnes

From Fig. 1. it can be seen, Oil production in Russia in 2021. fell to a low of 343.4 million tons in the last ten years. [8]

The shock of the pandemic was exacerbated in March 2020 by a sharp drop in oil prices, as shown in figure 2, and the associated instability in financial markets.

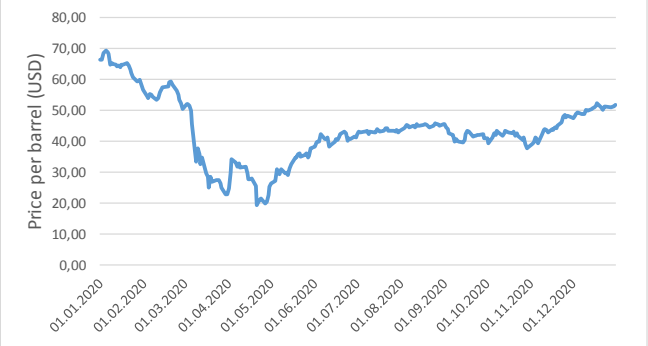

Fig. 2. Brent oil price dynamics, USD

The cost of a barrel of Brent crude oil is one of the main brands of oil traded on international oil exchanges, mainly on ICE (IntercontinentalExchange) [9].

The RTS index is a price, market capitalization-weighted composite index of the Russian stock market, which includes the most liquid shares of the largest and dynamically developing Russian issuers, whose economic activities belong to the main sectors of the economy. This index reflects the economic situation of the country. Accordingly, the RTS index either affects or is related to the exchange rate of the US dollar in rubles. [10]

Federal loan bonds are government debt obligations issued by the Ministry of Finance of Russia, denominated either in rubles or in foreign currency to attract funds, including non-residents of the Russian Federation.

In Russia, the share of demand for government securities in recent years is presented by non-residents, whose share in the domestic government market Russia's debt is high. Foreign investors are attracted by the high yield of federal loan bonds, which has a small chance of falling due to high rate of the Bank of Russia.

Given the fact that in Russia there are no restrictions on the movement of capital, such investors, with a decrease in the profitability of Federal loan bonds or an unnecessary change in the exchange rate of the ruble against the US dollar, foreign investors can withdraw invested funds from the market at any time. This can happen, for example, due to the introduction of additional packages sanctions that will impose restrictions on the purchase of Federal loan bonds by non-residents or other shocks of the foreign exchange market. Which will ultimately negatively affect the ruble exchange rate. [7]

III. RESEARCH METHODOLOGY

It will be analyzed the ruble exchange rate using multiple linear regression (MLR) correlation analysis.

MLR allows to answer questions that consider the role(s) that multiple independent variables play in accounting for variance in a single dependent variable.

The formula for a multiple linear regression is:

$$Y_i = a + b_1X_{1i} + b_2X_{2i} + \cdots + b_kX_{ki} + \varepsilon_i \quad (1)$$

where, for i=n observations:

Y_i - the predicted value of the dependent variable

a - a point estimate of free term

X_{1i},X_{2i}, X_{ki} - independent variable

b_1,b_2, b_k - the regression coefficient (the effect that increasing the value of the independent variable has on the predicted Y_i value)

ε_i - the model's error term [11]

With the help of it, it will be established the degree of influence of such factors as the RTS Index, the volume of Federal loan bonds owned by non-residents (in billion rubles); and Brent oil prices (price indicated in United States dollars per barrel) on the exchange rate of the US dollar pair in Russian rubles. This study used exchanged rate as main dependent variable.

The data are taken by average monthly values, except for foreign investments in Federal loan bonds, the value of which is indicated on the first day of the reporting month. Used data from the resource Investing.com[12], the website of the Moscow Exchange [13], the website of the Central Bank of Russia [14].

Table 1. Baseline Data For Average Monthly Values From January To May 2020

Month	Exchange rate USD/RUB	Brent oil prices (USD)	RTS Index (USD)	Federal loan bonds owned by non-residents (billion RUB)
Jan	61,8121	58,16	1517,07	2 870
Feb	63,9798	51,52	1299,69	3 014
Mar	78,442	23,74	1014,44	3 185
Apr	74,7635	19,23	1125,03	2 892
May	72,5003	36,44	1219,76	2 992
$R^2 = 0.981$				

We will analyze these indicators by multiple regression. The multiple regression equation is obtained:

$$Exchange\ rate\ USD/RUB = -44.2258 - 0.6286 Brent\ oil\ prices + 0.03079 RTS\ Index + 0.03353 Federal\ loan\ bounds\ owned\ by\ non\ residents \quad (2)$$

IV. EMPIRICAL ANALYSIS AND FINDINGS

Interpretation of multiple regression coefficients. The constant estimates the aggregated effect of other factors on the Exchange rate result and means that in the absence of independent variables would be -44.2258. The coefficient $b_1$indicates that with an increase of Brent oil prices by 1, Exchange rate USD/RUB decreases by 0.6286. The coefficient b_2 indicates that with an increase of RTS Index by 1, Exchange rate USD/RUB increases by 0.03079. The coefficient b_3 indicates that with an increase of Federal loan bonds owned by non-residents by 1, Exchange rate USD/RUB increases by 0.03353.

By conducting an analysis for multicollinearity (dependence between factors) by the Farrar-Glober method, with which the multicollinearity of all factors is tested and separately according to the criteria of Fisher and Student, it was revealed that all factors are multicollinear.

It will be funded the paired correlation coefficients, which shows a consistent change in the two features, reflecting the fact that the variability of one feature is in accordance with the variability of the other.

$$r_{xy} = \frac{\overline{x \cdot y} - \bar{x} \cdot \bar{y}}{s(x) \cdot s(y)} \quad (3)$$

where *x* are the values taken in the sample *X*, *y* are the values taken in the sample *Y*; $\bar{x}$ is the average value for *X*, $\bar{y}$ is the average value for *Y*

$$r_{yx_1} = \frac{2566.611 - 37.818 \cdot 70.3}{15.147 \cdot 6.373} = -0.953 \quad (4)$$

The values of the paired correlation coefficient indicate a very strong linear relationship between Brent oil prices and exchange rate of the USD/RUB.

$$r_{yx_2} = \frac{858809.208 - 1235.198 \cdot 70.3}{170.13 \cdot 6.373} = -0.945 \quad (5)$$

The coefficient indicates a very strong linear relationship between RTS Index and exchange rate of the USD/RUB.

$$r_{yx_3} = \frac{210642.111 - 2990.6 \cdot 70.3}{111.899 \cdot 6.373} = 0.567 \quad (6)$$

The coefficient indicates a moderate linear relationship between Federal loan bonds owned by non-residents and exchange rate of the USD/RUB.

$$r_{x_1x_2} = \frac{49071.601 - 1235.198 \cdot 37.818}{170.13 \cdot 15.147} = 0.915 \quad (7)$$

The values of the paired correlation coefficient indicate a very strong linear relationship between Brent oil prices and RTS Index.

$$r_{x_1x_3} = \frac{112490.804 - 2990.6 \cdot 37.818}{111.899 \cdot 15.147} = -0.359 \quad (8)$$

The values of the paired correlation coefficient indicate a weak linear relationship between Brent oil prices and Federal loan bonds owned by non-residents.

$$r_{x_2x_3} = \frac{3681071.328 - 2990.6 \cdot 1235.198}{111.899 \cdot 170.13} = -0.678 \quad (9)$$

The values of the paired correlation coefficient indicate a moderate linear relationship between RTS Index and Federal loan bonds owned by non-residents.

Calculated paired correlation coefficients that determine the tightness of the relationship between the two features, it was obtained that a change in the exchange rate of the US dollar in Russian rubles leads to a practical similar change in the price of oil BRENT and the RTS index, since the correlation coefficients are greater than 0.9. The average correlation shows the amount of RTS Index and Federal loan bonds owned by non-residents, which is approximately 0.7. A weak relationship, the correlation coefficient value is approximately 0.3, shows the volume of Federal loan bonds owned by non-residents and the price of BRENT oil.

It will be made a system of equations for finding β-coefficients:

$$-0.953 = \beta_1 + 0.915\,\beta_2 - 0.359\,\beta_3$$
$$-0.945 = 0.915\,\beta_1 + \beta_2 - 0.678\,\beta_3$$
$$0.567 = -0359\,\beta_1 - 0.678\,\beta_2 + \beta_3 \quad (10)$$

This system of linear equations is solved by the Gauss method: $\beta_1 = -1.494$; $\beta_2 = 0.822$; $\beta_3 = 0.589$.

It will be calculated a standardized regression equation, due to which it is possible to evaluate the influence of factors using β-coefficients.

The following standardized equation was obtained:

$$Exchange\ rate\ USD/RUB = -1.494 Brent\ oil\ prices + 0.822 RTS\ Index + 0.589 Federal\ loan\ bounds\ owned\ by\ non\ residents \quad (11)$$

Since all standardized β-coefficients are more than 0.5, they have a serious impact on the US dollar exchange rate in Russian rubles, the BRENT oil price has the largest weight of the coefficient.

V. CONCLUSIONS

This paper discusses the impact of the coronavirus pandemic on the exchange rate of the Russian national currency. Based on the literature review, the study has designed the correlation-regression equation, which shows the relationship and effect of independent variables on the value of the dependent variable.

Based on the results of the analysis, it can be concluded the following conclusions:

Since the beginning of 2020, exchange rate USD/RUB has grown significantly due to the declaration of a pandemic COVID-19 and the introduction of a number of restrictions on the economies of all countries.

The pandemic of coronavirus showed a huge dependence of the ruble exchange rate on the price of oil, which cannot inspire optimism, since this dependence greatly affects the economy of the Russian Federation.

The RTS index is strongly interconnected with indicators such as the ruble exchange rate and the price of oil and, accordingly, can be used both for analysis of the exchange rate and for analysis of the economy of the Russian Federation, as an indicator of the state of large domestic companies.

The volume of federal loan bonds owned by non-residents cannot be considered as an indicator of exchange rate change, but it is an indicator by which the behavior of foreign investors in case of exchange rate change can be judged.

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13. Materials of the website of the Moscow Exchange https://www.moex.com [Electronic Resource]

14. Materials of the website of the Central Bank of the Russian Federation. - https://cbr.ru/analytics/dkp/bal/ [Electronic Resource]

ECONOMIC ASPECTS OF PLACING KOSOVO-METOHIJA WINE ON THE INTERNATIONAL MARKET

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Abstract

Wine production in Kosovo and Metohija has a long, centuries-old tradition, but unlike some previous times where wine was produced in large economic systems, today wine is produced in small and medium-sized family and local wineries. Small private wineries are becoming the backbone of wine production. Kosovo and Metohija are part of the global market, which in recent years has been trying to become part of the wine quality management system. Wine quality management is achieved by implementing concepts related to the quality of wine systems through the International Organization for Standardization (ISO)[1] and Hazard Analysis Critical Control Point (HACCP)[2]. So, the concept of wine quality management is integrated from growing grapes in vineyards with the application of modern grape production technology with the application of ISO and HACCP standards in order to offer quality wine to the discerning market. Wineries in Kosovo and Metohija are not only based on the economic profitability of marketing wine to international markets, but also on quality.

Keywords: grapes, wine, wineries, export.

Methodological research

The aim of the work is to indicate the effects of growing vines and wine on an international level, while on a micro level the focus is on the area of Kosovo and Metohija. Several scientific methods were used in the work (method of generalization, comparison and classification, analytical and synthesis method). We obtained the necessary data from domestic professional literature dealing with this topic. Data from temporary institutions from Kosovo and Metohija as well as special publications from this area were used.

INTRODUCTION

The wine-growing region of Kosovo - Metohija includes two sub-regions: northern and southern. The northern subregion includes wines from the Istočki and Peč vineyards. The southern sub-region unites wine production from the Đakovo, Orahorački, Prizren, Suvorečka and Mališevo vineyards, with the largest being the Orahovačka vineyard. The vineyards are located at an altitude of 300 to 600 meters above sea level, on moderately steep to gentle slopes. Soil types such as loam and alluvial soil, humus-silicate soil and other types of soil prevail.

After 2000, the tradition of viticulture in the north of Kosmet was renewed with large plantations on the slopes of Kopaonik and Rogozna near Leposavić. Given the known political situation in Kosovo and Metohija, the wine industry is regulated by two laws: the Wine Law of the Republic of Serbia, which defines two wine regions (North Metohija and South Metohija) and the Kosovo Wine Law, which was passed by the temporary institutions of Kosovo after the unilateral declaration of independence in 2008. Pristina institutions define two regions (Dukađini region and Kosovo Plain region). Therefore, Serbs from Kosovo and Metohija harmonized their wine production with

[1] The International Organization for Standardization (ISO) defines a wide range of conditions related to quality management that are applicable to all products. Therefore, the ISO 9000 document defines quality as a preferred characteristic that a product must have, e.g. the product must be reliable, usable and repairable.

[2] HACCP is a system that can be used as a series of procedures to control processes and sensitive points in the food production chain, with the ultimate goal that the consumer consumes food, in a condition and in a way that will be safe for his health.

Serbian laws, while Albanian wineries are harmonized with Kosovo laws.

According to data provided by Serbian sources, the current area under vineyards in Kosovo and Metohija is around 3,220 hectares. The most common white grape varieties are: Smederevka (45% or 358 hectares), Italian Riesling (28% or 218 hectares), Chardonnay (13% or 106 hectares), Rhine Riesling (6% or 48% hectares), Župljanka (3% ie 26 hectares). Of the black grape varieties, the most represented are: Vranac (26% or 447 hectares), Prokupac (25% or 401 hectares), Gama (18% or 289 hectares), Pinot Noir (11% or 112 hectares).

Viticulture of Kosovo and Metohija

Picture 1.
downloaded from the site: http://www.test2.viewsource.biz/strana/25_regije/31_kosovo-i-metohija/ 16.08.2022.

According to the data of the Ministry of Agriculture, Forestry and Rural Development from Pristina, in the Green Report 2019, they present data that the total production in vineyards in 2018 increased significantly compared to 2017 to about 27,322 tons, where table grapes recorded an increase of 57 %, and vines for 83%. Therefore, vineyard production recorded a growth of 78%, and yields increased by 74%. "In 2017, yields were 4.8 tons per hectare, and in 2018, 8.4 tons per hectare." Vines record higher yields of table grapes compared to 2017 by 79%, and table grapes by 54%.[3]

In the 1990s, vineyards covered an area of 8.8 million hectares (in Europe, 69.3% of plantations), in the middle of the 2000s, 7.7 million hectares (58.4% in Europe), and in 2013 they were reduced to 6,9 million hectares.[4] It is estimated that the world area under vineyards occupies about 6.969 million hectares.

Wine production or the so-called of God's nectar in Kosovo and Metohija has a long tradition, so the wine sector can be a good example for cluster development, given that this segment is a rare example where exports are greater than imports. As is well known, one cluster helps create another.

[3] Publication Green Report 2019, Ministry of Agriculture, Forestry and Rural Development, Prishtina, p: 75.

[4] Denda, S., Denda, B., Production and commodity exchange of grapes and wine: situation in the world and in Serbia (Šumadija region), Agroeconomika, year 45, number 70, Novi Sad, 2016, UDC: 338. 48, p: 82 .

The authors from Kosovo and Metohija Ramaj V. and Rama H. in their work from 2015 point out that 4965 winegrowers are seriously engaged in the production of grapes on an area of 3170.27 hectares. Varieties for wine production are grown on an area of 2455.82 hectares, table grapes on an area of 712 hectares and grapes for drying on an area of 2.45 hectares. Also, the same authors state that in 2013, 7.7 million liters of wine were produced. According to data from the register of Temporary Institutions of Kosovo and Metohija (Kućі Y, 2019), vines are grown on 3,320 hectares in 18 municipalities.

The agricultural sector has a significant share in the economy of Kosovo and Metohija. The average rural household owns about 2.4 hectares, while only 10% of the population owns more than 5 hectares.[5] Therefore, the agricultural potential of Kosovo and Metohija is limited.

The largest exporters of wine in 2013 per ton:[6]

1. Italia 2016 t, 2. Spain 1831 t, 3. France 1515 t, 4. Chile 879 t, 5. Australia 711 t, 6. South Africa 605 t, 7. USA 414 t,8. Germany 400 t, 9. Argentina 322 t, 10. Portugal 306 t.

Country	2017.	2018.	2019.	2020.
Italia	4.250.000	5.480.000	4.750.000	4.910.000
France	3.641.900	4.920.000	4.220.000	4.660.000
Spain	3.248.000	4.490.000	3.370.000	4.070.000
USA	2.333.900	2.610.000	2.560.000	2.280.000
Australia	1.369.000	1.270.000	1.200.000	1.060.000
Argentina	1.182.100	1.450.000	1.300.000	1.080.000
China	1.163.600	930.000	780.000	660.000
South Africa	1.080.100	950.000	970.000	1.040.000
Chile	949.200	1.290.000	1.190.000	1.030.000
Germany	746.200	1.300.000	820.000	840.000
Portugal	673.700	610.000	650.000	640.000
Russia	631.200	430.000	460.000	440.000
Romania	431.700	510.000	380.000	360.000
Brazil	355.300	310.000	220.000	220.000
Hungary	318.000	360.000	270.000	240.000
New Zeland	285.100	300.000	300.000	330.000
Greece	255.000	220.000	200.000	200.000
Austria	248.600	280.000	250.000	270.000
Ukraine	187.200	100.000	100.000	100.000
Moldova	180.100	190.000	150.000	120.000
Bulgaria	108.000	110.000	90.000	90.000
Serbia	99.300			
Georgia	85.600			
Japan	79.600			
Switzerland	79.200	110.000	100.000	90.000
Peru	76.500			
Croatia	72.600	100.000	70.000	70.000
Uruguay	67.300	70.000	60.000	70.000
CzechRepublic	64.500	70.000	50.000	60.000
THE WORLD Total	24.800.000	29.400.000	25.800.000	26.000.000

Picture 2: Wine production in 2017 in liters.[7]

Export of wine from Kosovo and Metohija to other markets in the period from 2013-2018. year was:[8] 1. Croatia - 14,216,165 liters, 2. Serbia - 12,892,127 liters, 3. Albania - 5,934,046 liters, 4. Slovenia - 1,731,604 liters, 5. Switzerland - 1,120,394 liters, 6. Czech Republic - 1,126 .460 liters.

An important factor for successful wine export is creating effective marketing and branding. International support and investments contribute to the promotion of Kosovo wine. The EU office in Kosovo launched the project "Wine Route and Development of Wine Culture in the South of Kosovo" in 2011-2013, in which 269,371 euros were invested. Kosovo bottled

[5] Beilock, R., RETHINKING AGRICULTURE AND RURAL DEVELOPMENT IN KOSOVO, South-Eastern Europe Journal of Economics 2 (2005) 221-248.

[6] https://worldpopulationreview.com/country-rankings/wine-producing-countries

[7] https://worldpopulationreview.com/country-rankings/wine-producing-countries;

[8] https://www.statista.com/statistics/240638/wine-production-in-selected-countries-and-regions/

wine is most often sold on the domestic market or exported to the surrounding area or to CEFTA member countries. In order to increase the export of wine to international markets, certain conditions must be met, as well as the provision of internationally recognized certificates.

In 2021, Kosovo joined the Vranaec World Day program, because viticulture and wine production are developing at an incredible speed. Today, wines from Kosovo and Metohija are exported to Albania, Belgium, Bosnia and Herzegovina, the Czech Republic, Croatia, Japan, the Netherlands, China and the USA. There is an interesting data from the website Wine Searcher, which is one of the leading global wine search platforms, where it is stated that in the last five years there were "as many as 77" searches from North Korea for wine from Kosovo "Amselfelder Rosiere Lieblich, sweet wine from Metohija which costs around 4 euros per bottle. The Kosovo Ministry of Agriculture, Forestry and Rural Development, realizing the great importance of wine production, constituted the Department for Viticulture and Winemaking within the Ministry. Within the department, there are: viticulture sector, the wine sector and the sector for early detection of diseases and pests. This creates the conditions for quality monitoring, preparation of strategic plans for the development of winemaking. Also, the wine sector issues documents related to wine quality control and manages and organizes the process of organoleptic evaluation of wine.

Due to the excellent climatic conditions, black varieties are represented in three quarters of the vineyards, while white varieties make up a quarter. Of the black varieties, the most represented are Vranac (50.2%), Prokupac, Gamay, Black Burgundy, and of the white varieties Smederevka, Italian Riesling (Graševina), Chardonnay and White Prokupac. In 2020, wine production was 9.3 million liters, half of which remained for domestic consumption, and the largest export was recorded to the Republic of Croatia and the Republic of Serbia. According to the data presented by the Government of Temporary Institutions in Kosovo, in 2020, 24 million euros were allocated for agriculture, with an increase in subsidies per hectare from one thousand to two thousand euros and subsidies per liter of wine from 4 cents to 8 cents. It is also reported that in 2020, Kosovo and Metohija exported food products, alcoholic beverages and tobacco worth around 43.5 million euros.

Kosovo's vinice

There are many names, some call them chateaus and wine houses, some call them cellars, somewhere they are wineries and wine cellars, and in Kosovo and Metohija they are vineyards. Vineyards are specially built parts of houses intended exclusively for grape processing and wine storage. The most famous are the Hočan vineyards. According to historical data from the 12th century, Stefan Nemanja donated this area to the Hilandar monastery, since Velika Hoča reached its peak in the Middle Ages by building 24 churches and two monasteries. Back then, it was known that in this area the influence of the coastal climate, which penetrates the White Drina valley, has a beneficial effect on viticulture. This area has a large number of sunny days throughout the year at an average altitude of 400 meters, so it represents perfect conditions for growing vines. Many wineries such as "Dečanska", "Vinice Brkić", "Vinarije Đuričić", "Winarije Petrović", "Winarije Antić" produce top quality wines known as "Dečanska vina". Among the most famous wines are: the red wines "Rajska Bašta" and "Izbor srca" as well as the white wine "Postojbina" from the Antić Winery. At the Petrović Winery are "Metohija red wine", "Carsko red", white wine "Zavičaj". In the north of Kosovo and Metohija, the most famous wines are "Picus", "Parus", "Oriolus", "Upupa" and "Merula" from the Lakićević Winery.

Wine production as a new economic opportunity in Kosovo and Metohija

The contribution of the agricultural sector in the gross domestic product (GDP) is almost 14.1%,[9] while agricultural products account for 16% of total exports and the agricultural sector provides about 25 general jobs, mostly in the informal sector. 62% of the population of Kosovo lives in rural areas and the agricultural sector plays an important role in providing employment opportunities and generating income for citizens living in these areas.[10]

In recent years, wine producers from Velika Hoča have gathered business representatives from the north of Kosovo and Metohija in order to create additional opportunities for possible new ways of economic cooperation.

It is important to point out that viticulture represents an important branch of agriculture in Kosovo and Metohija. The areas under vineyards were drastically reduced until the last decade. There were many reasons for this. The most important reasons for such a situation are the high investment costs for establishing a vineyard. Average investment costs are from 20,000-25,000 euros for traditional technology that does not include modern technological systems such as irrigation, anti-hail networks, anti-frost system, etc. Lack of financial resources is the main reason why the area under vineyards is decreasing. The economic effectiveness of investing in vineyards is negative with the current input and output prices. With various government subsidies (for grape seedlings and vine stakes), the effectiveness results are positive values.[11] Therefore, stronger subsidies for investments affect the revitalization of viticulture in Kosovo and Metohija. The effectiveness of investments in viticulture is influenced by two factors, grape yields and sales price changes. The level of investment sensitivity is relatively high, because weather or market fluctuations can affect the reduction of the

[9] SAK 2012.

[10] Responses to the Feasibility Study Questionnaire. June 2012

[11] Vasiljević et al. INFLUENCE OF THE GOVERNMENTAL INVESTMENT SUBSIDIES ON DEVELOPMENT OF SERBIAN VITICULTURE, ECONOMIC THEMES (2017) 55(2): 179-198.

value of production and thus the effectiveness of investment in vineyards can be jeopardized.

Independent winegrowers offer grapes to wineries for a relatively low price of 15-25 cents depending on the grape variety (Retallack, 2010). The average price of a 750 ml bottle of wine in retail is 3.35 euros, and the lowest price of domestic wine is 2.86 euros, Pinot Noir 3.07 euros, Cabernet Sauvignon 3.82 euros, Merlot 3.59 euros and Chardonnay 3.43 euros.[12]

Conclusion

The production of grapes and wine represents a significant share in the agricultural activity of Kosovo and Metohija. The wine trade generates high incomes for traditional producers in Italy, France and Spain. Kosovo and Metohija is creating its place on the international market. The dominant position in the production and export of wine is held by small individual producers who find their way to regional markets with high-quality grape varieties. The synergy of wine production and tourism generates additional income. Therefore, there are conditions for the economic conditions of Kosovo-Metohija wine on the international market.

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MATHEMATICAL SCIENCES

UDC 517.951.2 .

THE DARBOUX PROBLEM FOR THE NONHOMOGENEOUS GENERALIZED EULER-POISSON-DARBOUX EQUATION

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https://doi.org/10.5281/zenodo.7032233

Abstract
In the article a Darboux problem is considered for a generalized nonhomogeneous Euler-Poisson-Darboux equation in the characteristic triangle. A solution of the problem was found using Riemann method. It was proved that the function defined by the found formula actually satisfies the equation and boundary conditions.

Keywords: Darboux problem , nonhomogeneous generalized Euler-Puasson-Darbouh equation, Riemann method, Riemann -Hadamard function.

Introduction

Many differential equations of hyperbolic type with two lines of degeneracy in characteristic coordinates reduce to an equation of the form

$$L(u)\equiv u_{\xi\eta}+\left(\frac{\alpha}{\eta+\xi}+\frac{\beta}{\eta-\xi}\right)u_{\xi}+\left(\frac{\alpha}{\eta+\xi}-\frac{\beta}{\eta-\xi}\right)u_{\eta}+\gamma u=f(\xi,\eta)\cdot \tag{1}$$

Here, α, β, γ are given real numbers.

In works [1-4] for equation (1) in case $f(\xi,\eta)=0$ with , $\alpha=\gamma=0$ in the characteristic triangle $\Delta=\{(\xi,\eta):0\le\xi<\eta\le 1\}$ nonlocal boundary value problems have been investigated . The solution of the Cauchy problem for the equation $L(u)\equiv 0$ for $\alpha\ge 0$, $\beta\in[0,1/2)$ was found by the Riemann method in [5], and in [6] it was found using the Erdelyi-Kober operator. In [7-8] for the equation $L(u)\equiv 0$ in case $0<\alpha,,\ \beta<1/2$, the Darboux and Cauchy-Goursat problems were studied. The solutions of these problems have been constructed explicitly by the Riemann method.

Formulation of the problem

Consider the equation (1) in the characteristic triangle Δ of the plane $\xi O\eta$ bounded by segments $\overline{OA}=\{(\xi,\eta):\eta=\xi,\quad 0\le\xi\le 1\}$, $\overline{CA}=\{(\xi,1):0\le\xi\le 1,\}$, $\overline{OC}=\{(0,\eta):0\le\eta\le 1\}$, where $0<\alpha,,\ \beta<1/2$, and $f(\xi,\eta)$ is a given function.

Darboux's problem. Find a solution $u(\xi,\eta)\in C(\bar{\Delta})$ to the equation (1) satisfying the conditions

$$u(\xi,\xi)=\tau(\xi),\ 0,,\ \xi,,\ 1, \tag{2}$$

$$u(0,\eta)=\psi(\eta),\ 0,,\ \eta,,\ 1, \tag{3}$$

where $\tau(\xi)$ and $\psi(\xi)$ are given continuous functions, such that $\psi(0)=\tau(0)$.

The Riemann–Hadamard function of the equation $L(u)=0$ for conditions (2) and (3) was constructed in [7]:

$$V(\xi,\eta;\xi_0,\eta_0,\gamma)=\begin{cases}R_1(\xi,\eta;\xi_0,\eta_0,\gamma), & npu\quad \eta_0>\xi,\\ R_4(\xi,\eta;\xi_0,\eta_0,\gamma), & npu\quad \eta_0<\xi,\end{cases} \tag{4}$$

$$R_1(\xi,\eta;\xi_0,\eta_0,\gamma)=\sigma_0\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}F_3(\beta,\alpha,1-\beta,1-\alpha;1+k;\sigma_2,\sigma_1), \tag{5}$$

$$R_4(\xi,\eta;\xi_0,\eta_0,\gamma)=\chi\left(\frac{\eta+\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{(\eta-\xi)^{2\beta}}{\left[(\xi_0-\xi)(\eta_0-\eta)\right]^{\beta}}\sigma_2^{2\beta-1}\times$$

$$\times\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{k!(\beta)_k}H_2\left(1-\beta-k,1-\beta,\alpha,1-\alpha;2-2\beta;\frac{1}{\sigma_2},-\sigma_1\right)\cdot \tag{6}$$

where $\chi=\Gamma(1-\beta)/\Gamma(\beta)\Gamma(2-2\beta)$, $\sigma_0=[(\eta+\xi)/(\eta_0+\xi_0)]^{\alpha}[(\eta-\xi)/(\eta_0-\xi_0)]^{\beta}\cdot$

$\sigma_1=(\xi-\xi_0)(\eta-\eta_0)/(\eta+\xi)(\eta_0+\xi_0)\cdot$ $\sigma_2=(\xi-\xi_0)(\eta-\eta_0)/(\eta-\xi)(\eta_0-\xi_0)$.

$\sigma_3 = -\gamma(\xi-\xi_0)(\eta-\eta_0)$, $(\beta)_k = \beta(\beta+1)....(\beta+k-1) = \Gamma(\beta+k)/\Gamma(\beta)$ is the symbol of Pochhammer, $\Gamma(z)$ is the Euler gamma function, H_2 and F_3 are, respectively, the two variables hypergeometric functions of Horn and Appel [9].

Derivation of the main formula

Function $V(\xi,\eta;\xi_0,\eta_0;\gamma)$ has the following properties:

1^0) it ξ_0,η_0 satisfies equation (1) at $f(\xi,\eta)=0$, and the adjoint equation in terms of variables ξ,η:

$$L^*(u) \equiv u_{\xi\eta} - \frac{\partial}{\partial\xi}\left[\left(\frac{\alpha}{\eta+\xi}+\frac{\beta}{\eta-\xi}\right)u\right] - \frac{\partial}{\partial\xi}\left[\left(\frac{\alpha}{\eta+\xi}-\frac{\beta}{\eta-\xi}\right)u\right] + \gamma u = 0;$$

2^0) $V_\xi - \left(\frac{\alpha}{\eta+\xi}-\frac{\beta}{\eta-\xi}\right)V = 0$ at $\eta=\eta_0$,

3^0) $V_\eta - \left(\frac{\alpha}{\eta+\xi}+\frac{\beta}{\eta-\xi}\right)V = 0$ at $\xi=\xi_0$;

4^0) $V(\xi_0,\eta_0;\xi_0,\eta_0;\gamma)=1$;

5^0) $\lim\limits_{\eta-\xi\to 0} V(\xi,\eta;\xi_0,\eta_0;\gamma)=0$;

6^0) $\lim\limits_{\eta-\xi\to 0}\left\{\left[V_\xi - \left(\frac{\alpha}{\eta+\xi}-\frac{\beta}{\eta-\xi}\right)V\right]\Big|_{\eta=\xi_0+\varepsilon} - \left[V_\xi - \left(\frac{\alpha}{\eta+\xi}-\frac{\beta}{\eta-\xi}\right)V\right]\Big|_{\eta=\xi_0-\varepsilon}\right\}=0$, $\varepsilon>0$.

Let be $u(\xi,\eta)$ a solution to the Darboux problem, and $P(\xi_0,\eta_0)$ be an arbitrary point of the domain $\Delta\cup CA$. Let 's find $u(\xi_0,\eta_0)$. In a triangle $O'A'D'$ bounded by l segments $O'A'$, $A'D'$, $O'D'$ lines , , , respectively $\eta=\xi+\varepsilon$, $\eta=\xi_0-\varepsilon$ and $\xi=0$ in a rectangle $D''A''C''C'$ bounded by segments $D''A''$, $C'C''$, $D''C'$, $A''C''$ of straight lines $\eta=\xi_0+\varepsilon$, $\eta=\eta_0$, $\xi=0$, $\xi=\xi_0-2\varepsilon$, respectively, the identity

$$VL(u) - uL^*(V) = M_\xi + N_\eta - Vf(\xi,\eta) \equiv 0, \tag{7}$$

where $M = Vu_\eta - uV_\eta + \left(\frac{2\alpha}{\eta+\xi}+\frac{2\beta}{\eta-\xi}\right)uV$, $N = Vu_\xi + uV_\xi - \left(\frac{2\alpha}{\eta+\xi}-\frac{2\beta}{\eta-\xi}\right)uV$.

We integrate identity (7) over the triangle $O'A'D'$ and quadrilateral $D''A''C''C'$. Then, passing to the limit at $\varepsilon\to 0$ and using the properties 1^0-6^0 of function $V(\xi,\eta;\xi_0,\eta_0;\gamma)$ and the boundary conditions (2), (3), we obtain

$$u(\xi_0,\eta_0) = \int_0^{\eta_0}\left[\psi'(\eta)+\frac{\alpha+\beta}{\eta}\psi(\eta)\right]V(0,\eta;\xi_0,\eta_0;\gamma)d\eta +$$

$$+(1+2\beta)\chi(\eta_0-\xi_0)^{1-2\beta}\int_0^{\xi_0}\left(\frac{2\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{\tau(\xi)}{\left[(\xi-\xi_0)(\xi-\eta_0)\right]^{1-\beta}}\times$$

$$\times\Xi_2(\alpha,1-\alpha,\beta;\sigma_1,\sigma_3)\Big|_{\xi=\eta}d\xi + \int_0^{\xi_0}d\xi\int_\xi^{\eta_0} f(\xi,\eta)V(\xi,\eta;\xi_0,\eta_0)d\eta\ , \tag{8}$$

where $\Xi_2(\alpha,1-\alpha,\beta;\sigma_1,\sigma_2) = \sum\limits_{m,n=0}^{\infty}\frac{(\alpha)_m(1-\alpha)_m}{(\beta)_{m+n}}\frac{\sigma_1^m\sigma_2^n}{n!m!}$ is the Humbert function [9] .

From the process of obtaining formula (8) it is clear that if there is a solution to the problem $\{(1),(2),(3)\}$, then this solution has the form (8). From (8) at $0<\alpha,\ \beta<1/2$, $f(\xi,\eta)=0$ follows the formula obtained in [7].

Let us study formula (8). The first and second terms were studied in [7]. Here we consider the third term.

Let us introduce the following notation:

$$F(\xi_0,\eta_0) = \int_0^{\xi_0}d\xi\int_\xi^{\eta_0} f(\xi,\eta)V(\xi_0,\eta_0;\xi,\eta;\gamma)d\eta. \tag{9}$$

Theorem. If the function $f(\xi,\eta)$ can be represented as

$$f(\xi,\eta) = (\eta-\xi)^{\delta-1} f_1(\xi,\eta),\ \delta>0,\ f_1(\xi,\eta)\in C(\bar{\Delta}), \tag{10}$$

then the function $F(\xi_0,\eta_0)$ in the domain Δ satisfies equation (1) and the boundary conditions

$$\lim_{\eta_0\to\xi_0} F(\xi_0,\eta_0)=0,\ 0\le\xi_0\le 1; \qquad F(\xi_0,\eta_0)\big|_{\xi_0=0}=0,\ 0\le\eta_0\le 1. \tag{11}$$

Proof. Taking equality (4) into account, we write (9) as

$$F(\xi_0,\eta_0)=\lim_{\varepsilon\to 0}\left[F_{1\varepsilon}(\xi_0,\eta_0)+F_{4\varepsilon}(\xi_0,\eta_0)\right], \tag{12}$$

where

$$F_{1\varepsilon}(\xi_0,\eta_0)=\int_0^{\xi_0-2\varepsilon}d\xi\int_{\xi_0+\varepsilon}^{\eta_0}f(\xi,\eta)R_1(\xi,\eta;\xi_0,\eta_0;\gamma)d\eta, \tag{13}$$

$$F_{4\varepsilon}(\xi_0,\eta_0)=\int_0^{\xi_0-2\varepsilon}d\xi\int_{\xi+\varepsilon}^{\xi_0-\varepsilon}f(\xi,\eta)R_4(\xi,\eta;\xi_0,\eta_0;\gamma)d\eta. \tag{14}$$

Now, using equalities (13) and (14), we find the derivatives of the function $F_{1\varepsilon}(\xi_0,\eta_0)$ and $F_{4\varepsilon}(\xi_0,\eta_0)$:

$$\frac{\partial F_{1\varepsilon}(\xi_0,\eta_0)}{\partial\xi_0}=\int_{\xi_0+\varepsilon}^{\eta_0}f(\xi_0-2\varepsilon,\eta)R_1(\xi_0-2\varepsilon,\eta;\xi_0,\eta_0;\gamma)d\eta-$$
$$-\int_0^{\xi_0-2\varepsilon}f(\xi,\xi_0+\varepsilon)R_1(\xi,\xi_0+\varepsilon;\xi_0,\eta_0;\gamma)d\xi+$$
$$+\int_0^{\xi_0-2\varepsilon}d\xi\int_{\xi_0+\varepsilon}^{\eta_0}f(\xi,\eta)\frac{\partial}{\partial\xi_0}R_1(\xi,\eta;\xi_0,\eta_0)d\eta.$$

$$\frac{\partial F_{1\varepsilon}(\xi_0,\eta_0)}{\partial\eta_0}=\int_0^{\xi_0-2\varepsilon}f(\xi,\eta_0)R_1(\xi,\eta_0;\xi_0,\eta_0;\gamma)d\xi+$$
$$+\int_0^{\xi_0-2\varepsilon}d\xi\int_{\xi_0+\varepsilon}^{\eta_0}f(\xi,\eta)\frac{\partial}{\partial\eta_0}R_1(\xi,\eta;\xi_0,\eta_0;\gamma)d\eta.$$

$$\frac{\partial^2 F_{1\varepsilon}(\xi_0,\eta_0)}{\partial\xi_0\partial\eta_0}=f(\xi_0-2\varepsilon,\eta_0)R_1(\xi_0-2\varepsilon,\eta_0;\xi_0,\eta_0;\gamma)+$$
$$+\int_{\xi_0+\varepsilon}^{\eta_0}f(\xi_0-2\varepsilon,\eta)\frac{\partial}{\partial\eta_0}R_1(\xi_0-2\varepsilon,\eta;\xi_0,\eta_0;\gamma)d\eta-$$
$$-\int_0^{\xi_0-2\varepsilon}f(\xi,\xi_0+\varepsilon)\frac{\partial}{\partial\eta_0}R_1(\xi,\xi_0+\varepsilon;\xi_0,\eta_0;\gamma)d\xi+$$
$$+\int_0^{\xi_0-2\varepsilon}f(\xi,\eta_0)\frac{\partial}{\partial\xi_0}R_1(\xi,\eta_0;\xi_0,\eta_0;\gamma)d\xi_0+$$
$$+\int_0^{\xi_0-2\varepsilon}d\xi\int_{\xi_0+\varepsilon}^{\eta_0}f(\xi,\eta)\frac{\partial^2}{\partial\xi_0\partial\eta_0}R_1(\xi,\eta;\xi_0,\eta_0;\gamma)d\eta.$$

$$\frac{\partial F_{4\varepsilon}(\xi_0,\eta_0)}{\partial\xi_0}=\int_0^{\xi_0-2\varepsilon}f(\xi,\xi_0-\varepsilon)R_4(\xi,\xi_0-\varepsilon;\xi_0,\eta_0;\gamma)d\xi+$$
$$+\int_0^{\xi_0-2\varepsilon}d\xi\int_{\xi+\varepsilon}^{\xi_0-\varepsilon}f(\xi,\eta)\frac{\partial}{\partial\xi_0}R_4(\xi,\eta;\xi_0,\eta_0;\gamma)d\eta.$$

$$\frac{\partial F_{4\varepsilon}(\xi_0,\eta_0)}{\partial\eta_0}=\int_0^{\xi_0-2\varepsilon}d\xi\int_{\xi+\varepsilon}^{\xi_0-\varepsilon}f(\xi,\eta)\frac{\partial}{\partial\eta_0}R_4(\xi,\eta;\xi_0,\eta_0;\gamma)d\eta.$$

$$\frac{\partial^2 F_{4\varepsilon}(\xi_0,\eta_0)}{\partial\xi_0\partial\eta_0}=\int_0^{\xi_0-2\varepsilon}f(\xi,\xi_0-\varepsilon)\frac{\partial}{\partial\eta_0}R_4(\xi,\xi_0-\varepsilon;\xi_0,\eta_0;\gamma)d\xi+$$
$$+\int_0^{\xi_0-2\varepsilon}d\xi\int_{\xi+\varepsilon}^{\xi_0-\varepsilon}f(\xi,\eta)\frac{\partial^2}{\partial\xi_0\partial\eta_0}R_4(\xi,\eta;\xi_0,\eta_0;\gamma)d\eta.$$

Let's make an expression $L\left[F_{1\varepsilon}(\xi_0,\eta_0)+F_{4\varepsilon}(\xi_0,\eta_0)\right]$:

$$L\left[F_{1\varepsilon}(\xi_0,\eta_0)+F_{4\varepsilon}(\xi_0,\eta_0)\right]=$$
$$=\int_0^{\xi_0-2\varepsilon}d\xi\int_{\xi_0+\varepsilon}^{\eta_0}f(\xi,\eta)\left[\frac{\partial^2}{\partial\xi_0\partial\eta_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)\frac{\partial}{\partial\xi_0}R_1+\right.$$
$$\left.+\left(\frac{\alpha}{\eta_0+\xi_0}-\frac{\beta}{\eta_0-\xi_0}\right)\frac{\partial}{\partial\eta_0}R_1+\gamma R_1\right]d\eta+$$
$$=\int_0^{\xi_0-2\varepsilon}d\xi\int_{\xi_0+\varepsilon}^{\eta_0}f(\xi,\eta)\left[\frac{\partial^2}{\partial\xi_0\partial\eta_0}R_4+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)\frac{\partial}{\partial\xi_0}R_4+\right.$$
$$\left.+\left(\frac{\alpha}{\eta_0+\xi_0}-\frac{\beta}{\eta_0-\xi_0}\right)\frac{\partial}{\partial\eta_0}R_4+\gamma R_4\right]d\eta+$$
$$+\int_0^{\xi_0-2\varepsilon}f(\xi,\eta)\left[\frac{\partial}{\partial\xi_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}-\frac{\beta}{\eta_0-\xi_0}\right)R_1\right]\Bigg|_{\eta=\eta_0}d\xi+$$
$$+\int_{\xi_0+\varepsilon}^{\eta_0}f(\xi,\eta)\left[\frac{\partial}{\partial\eta_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_1\right]\Bigg|_{\xi=\xi_0-2\varepsilon}d\eta+$$
$$+\int_0^{\xi_0-2\varepsilon}\left\{f(\xi,\eta)\left[\frac{\partial}{\partial\eta_0}R_4+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_4\right]\Bigg|_{\eta=\xi_0-\varepsilon}-\right.$$
$$\left.-f(\xi,\eta)\left[\frac{\partial}{\partial\eta_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_1\right]\Bigg|_{\eta=\xi_0+\varepsilon}\right\}+$$
$$+f(\xi_0-2\varepsilon,\eta_0)R_1(\xi_0-2\varepsilon,\eta_0;\xi_0,\eta_0;\gamma).\qquad(15)$$

Due to the properties of the functions R_1 and R_4, the integrands in the first two iterated integrals are equal to zero.

By expression [9]

$$F_3(\alpha,\alpha',\beta,\beta';x,y)=\sum_{n=0}^{+\infty}\frac{(\alpha')_n(\beta')_n}{(\gamma)_n n!}y^nF(\alpha,\beta,\gamma+n;x),$$

from the equality (5), we obtain

$$R_1(\xi,\eta;\xi_0,\eta_0;\gamma)=\sigma_0\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n n!}\sigma_1^nF(\beta,1-\beta,1+k+n;\sigma_2).\qquad(16)$$

It is easy to verify that

$$\frac{\partial}{\partial\xi_0}R_1=-\frac{\alpha}{\eta_0+\xi_0}R_1+\frac{\beta}{\eta_0-\xi_0}R_1+$$
$$+\sigma_0(\sigma_3)'_{\xi_0}\sum_{k=1}^{+\infty}\frac{\sigma_3^{k-1}}{k!(k-1)!}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n n!}\sigma_1^nF(\beta,1-\beta,1+k+n;\sigma_2)+$$
$$+\sigma_0(\sigma_1)'_{\xi_0}\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=1}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n\sigma_1^n}{(1+k)_n(n-1)!}F(\beta,1-\beta,1+k+n;\sigma_2)+$$
$$+\sigma_0(\sigma_2)'_{\xi_0}\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n n!}\sigma_1^n\frac{\beta(1-\beta)}{1+k+n}F(1+\beta,2-\beta,2+k+n;\sigma_2),$$
$$\frac{\partial}{\partial\eta_0}R_1=-\frac{\alpha}{\eta_0+\xi_0}R_1-\frac{\beta}{\eta_0-\xi_0}R_1+$$
$$+\sigma_0(\sigma_3)'_{\eta_0}\sum_{k=1}^{+\infty}\frac{\sigma_3^{k-1}}{k!(k-1)!}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n n!}\sigma_1^nF(\beta,1-\beta,1+k+n;\sigma_2)+$$
$$+\sigma_0(\sigma_1)'_{\eta_0}\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=1}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n\sigma_1^n}{(1+k)_n(n-1)!}F(\beta,1-\beta,1+k+n;\sigma_2)+$$

$$+\sigma_0(\sigma_2)'_{n_0}\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n\,n!}\sigma_1^n\frac{\beta(1-\beta)}{1+k+n}F(1+\beta,2-\beta,2+k+n;\sigma_2)\cdot$$

Then

$$\frac{\partial}{\partial\xi_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_1=$$
$$-\gamma(\eta-\eta_0)\sigma_0\sum_{k=1}^{+\infty}\frac{\sigma_3^{k-1}}{k!(k-1)!}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n\,n!}\sigma_1^nF(\beta,1-\beta,1+k+n;\sigma_2)+$$
$$+\frac{(\eta-\eta_0)(\eta_0+\xi)}{(\eta+\xi)(\eta_0+\xi_0)^2}\sigma_0\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=1}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n\sigma_1^n}{(1+k)_n(n-1)!}F(\beta,1-\beta,1+k+n;\sigma_2)+$$
$$+\frac{(\eta-\eta_0)(\xi-\eta_0)}{(\eta-\xi)(\eta_0-\xi_0)^2}\sigma_0\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n\,n!}\sigma_1^n\times$$
$$\times\frac{\beta(1-\beta)}{1+k+n}F(1+\beta,2-\beta,2+k+n;\sigma_2),\qquad(17)$$

$$\frac{\partial}{\partial\eta_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_1=$$
$$-\gamma(\xi-\xi_0)\sigma_0\sum_{k=1}^{+\infty}\frac{\sigma_3^{k-1}}{k!(k-1)!}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n\,n!}\sigma_1^nF(\beta,1-\beta,1+k+n;\sigma_2)+$$
$$+\frac{(\xi-\xi_0)(\eta+\xi_0)}{(\eta+\xi)(\eta_0+\xi_0)^2}\sigma_0\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=1}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n\sigma_1^n}{(1+k)_n(n-1)!}F(\beta,1-\beta,1+k+n;\sigma_2)+$$
$$+\frac{(\xi-\xi_0)(\xi_0-\eta)}{(\eta-\xi)(\eta_0-\xi_0)^2}\sigma_0\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n\,n!}\sigma_1^n\times$$
$$\times\frac{\beta(1-\beta)}{1+k+n}F(1+\beta,2-\beta,2+k+n;\sigma_2)\cdot\qquad(18)$$

Putting $\eta=\eta_0$ in (17), we get

$$\left[\frac{\partial}{\partial\xi_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}-\frac{\beta}{\eta_0-\xi_0}\right)R_1\right]\Bigg|_{\eta=\eta_0}=0\cdot$$

From (18), it easily follows that

$$\lim_{\varepsilon\to0}\left[\frac{\partial}{\partial\xi_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}-\frac{\beta}{\eta_0-\xi_0}\right)R_1\right]\Bigg|_{\xi=\xi_0-2\varepsilon}=0\cdot$$

Now consider the expression under the last integral in (15). Applying the formula [9]

$$F(a,b,c;x)=(1-x)^{c-a-b}F(c-a,c-b,c;x)\qquad(19)$$

to the function $F(1+\beta,2-\beta,2+k+n;\sigma_2)$ in equality (18), we get

$$\frac{\partial}{\partial\eta_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_1=$$
$$-\gamma(\xi-\xi_0)\sigma_0\sum_{k=1}^{+\infty}\frac{\sigma_3^{k-1}}{k!(k-1)!}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n\,n!}\sigma_1^nF(\beta,1-\beta,1+k+n;\sigma_2)+$$
$$+\frac{(\xi-\xi_0)(\eta+\xi_0)}{(\eta+\xi)(\eta_0+\xi_0)^2}\sigma_0\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=1}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n\sigma_1^n}{(1+k)_n(n-1)!}F(\beta,1-\beta,1+k+n;\sigma_2)+$$
$$+\frac{(\xi-\xi_0)(\xi_0-\eta)}{(\eta-\xi)(\eta_0-\xi_0)^2}\sigma_0\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(1+k)_n\,n!}\sigma_1^n\times$$
$$\times\frac{\beta(1-\beta)}{1+k+n}\left[\frac{(\eta-\xi_0)(\eta_0-\xi)}{(\eta-\xi)(\eta_0-\xi_0)}\right]^{k+n-1}F(1+k+n-\beta,k+n+\beta,2+k+n;\sigma_2)\cdot\qquad(20)$$

By formula [9]

$$H_2(\alpha,\beta,\gamma,\delta,\varepsilon;x,y)=\sum_{n=0}^{+\infty}\frac{(-1)^n(\gamma)_n(\delta)_n}{(1-\alpha)_n n!}y^n F(\alpha-n,\beta,\varepsilon;x),$$

from (6), we have

$$R_4(\xi,\eta;\xi_0,\eta_0)=\chi\left(\frac{\eta+\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{(\eta-\xi)^{2\beta}}{\left[(\xi_0-\xi)(\eta_0-\eta)\right]^{\beta}}\sigma_2^{2\beta-1}\sum_{k=0}^{+\infty}\frac{\sigma_3^n}{k!(\beta)_k}\times$$

$$\times\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{(\beta)_n n!}\sigma_1^n F\left(1-\beta-k-n,1-\beta,2-2\beta;\frac{1}{\sigma_2}\right). \tag{21}$$

And from the formula (21) it follows that

$$\frac{\partial R_4}{\partial\eta_0}=-\frac{\alpha}{\eta_0+\xi_0}R_4-\frac{\beta}{\eta_0-\eta}R_4+$$

$$+\chi\left(\frac{\eta+\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{(\eta-\xi)^{2\beta}(2\beta-1)}{\left[(\xi_0-\xi)(\eta_0-\eta)\right]^{\beta}}\sigma_2^{2\beta-2}(\sigma_2)'_{\eta_0}\sum_{k=0}^{+\infty}\frac{(\sigma_3)^k}{k!(\beta)_k}\times$$

$$\times\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{n!(\beta+k)_n}\sigma_1^n F\left(1-\beta-k-n,1-\beta,2-2\beta;\frac{1}{\sigma_2}\right)+$$

$$+\left[\gamma(\xi-\xi_0)\right]\chi\left(\frac{\eta+\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{(\eta-\xi)^{2\beta}}{\left[(\xi_0-\xi)(\eta_0-\eta)\right]^{\beta}}\sigma_2^{2\beta-1}\sum_{k=1}^{+\infty}\frac{(\sigma_3)^{k-1}}{(k-1)!(\beta)_k}\times$$

$$\times\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{n!(\beta+k)_n}\sigma_1^n F\left(1-\beta-k-n,1-\beta,2-2\beta;\frac{1}{\sigma_2}\right)+$$

$$+\chi(\sigma_1)'_{\eta_0}\left(\frac{\eta+\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{(\eta-\xi)^{2\beta}}{\left[(\xi_0-\xi)(\eta_0-\eta)\right]^{\beta}}\sigma_2^{2\beta-1}\sum_{k=0}^{+\infty}\frac{(\sigma_3)^k}{k!(\beta)_k}\times$$

$$\times\sum_{n=1}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{(n-1)!(\beta+k)_n}\sigma_1^{n-1}F\left(1-\beta-k-n,1-\beta,2-2\beta;\frac{1}{\sigma_2}\right)+$$

$$+\chi\left(\frac{1}{\sigma_2}\right)'_{\eta_0}\left(\frac{\eta+\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{(\eta-\xi)^{2\beta}}{\left[(\xi_0-\xi)(\eta_0-\eta)\right]^{\beta}}\sigma_2^{2\beta-1}\sum_{k=0}^{+\infty}\frac{(\sigma_3)^k}{k!(\beta)_k}\times$$

$$\times\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{n!(\beta+k)_n}\sigma_1^n\frac{1-\beta-k-n}{2}F\left(2-\beta-k-n,2-\beta,3-2\beta;\frac{1}{\sigma_2}\right).$$

Applying formula (19) to the function $F\left(2-\beta-k-n,2-\beta,3-2\beta;\frac{1}{\sigma_2}\right)$, from the latter equality, we obtain

$$\frac{\partial R_4}{\partial\eta_0}+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_4=\frac{\beta(\xi_0-\eta)}{(\eta_0-\eta)(\eta_0-\xi_0)}R_4+$$

$$+\frac{(\xi-\xi_0)(\xi_0-\eta)}{(\eta-\xi)(\eta-\xi_0)^2}\chi\left(\frac{\eta+\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{(\eta-\xi)^{2\beta}}{\left[(\xi_0-\xi)(\eta_0-\eta)\right]^{\beta}}\sigma_2^{2\beta-1}\sum_{k=0}^{+\infty}\frac{(\sigma_3)^k}{k!(\beta)_k}\times$$

$$\times\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{n!(\beta+k)_n}\sigma_1^n F\left(1-\beta-k-n,1-\beta,2-2\beta;\frac{1}{\sigma_2}\right)+$$

$$+\left[-\gamma(\xi-\xi_0)\right]\chi\left(\frac{\eta+\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{(\eta-\xi)^{2\beta}}{\left[(\xi_0-\xi)(\eta_0-\eta)\right]^{\beta}}\sigma_2^{2\beta-1}\sum_{k=1}^{+\infty}\frac{(\sigma_3)^{k-1}}{(k-1)!(\beta)_k}\times$$

$$\times\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{n!(\beta+k)_n}\sigma_1^n F\left(1-\beta-k-n,1-\beta,2-2\beta;\frac{1}{\sigma_2}\right)+$$

$$+\frac{(\xi-\xi_0)(\eta+\xi_0)}{(\eta+\xi)(\eta_0+\xi_0)^2}\chi\left(\frac{\eta+\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{(\eta-\xi)^{2\beta}}{\left[(\xi_0-\xi)(\eta_0-\eta)\right]^{\beta}}\sigma_2^{2\beta-1}\sum_{k=0}^{+\infty}\frac{(\sigma_3)^k}{k!(\beta)_k}\times$$

$$\times\sum_{n=1}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{(n-1)!(\beta+k)_n}\sigma_1^{n-1}F\left(1-\beta-k-n,1-\beta,2-2\beta;\frac{1}{\sigma_2}\right)+$$

$$+\frac{(\eta-\xi)(\eta-\xi_0)}{(\xi-\xi_0)(\eta-\eta_0)^2}\chi\left(\frac{\eta+\xi}{\eta_0+\xi_0}\right)^{\alpha}\frac{(\eta-\xi)^{2\beta}}{\left[(\xi_0-\xi)(\eta_0-\eta)\right]^{\beta}}\sigma_2^{2\beta-1}\times$$

$$\times\sum_{k=0}^{+\infty}\frac{(\sigma_3)^k}{k!(\beta)_k}\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{n!(\beta+k)_n}\sigma_1^n\frac{1-\beta-k-n}{2}\times$$

$$\times\left[\frac{(\eta-\xi_0)(\xi-\eta_0)}{(\xi-\xi_0)(\eta-\eta_0)}\right]^{k+n-1}F\left(1-\beta+k+n,1-\beta,3-2\beta;\frac{1}{\sigma_2}\right).\quad(22)$$

Then from (20) and (2 2), substituting $\eta=\xi_0+\varepsilon$ and $\eta=\xi_0-\varepsilon$ respectively, and then passing to the limit at $\varepsilon\to 0$ and taking into account the equality $F(a,b,c;1)=\Gamma(c)\Gamma(c-a-b)/\Gamma(c-a)\Gamma(c-b)$ [9], we get

$$\frac{\partial}{\partial\eta_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_1=\left(\frac{\xi_0+\xi}{\eta_0+\xi_0}\right)^{\alpha}\left(\frac{\xi_0-\xi}{\eta_0-\xi_0}\right)^{\beta}\left[-\gamma(\xi-\xi_0)\right]\times$$

$$\times\sum_{k=1}^{+\infty}\frac{\sigma_3^{k-1}}{k!(k-1)!}\sum_{n=0}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{n!(1+k)_n}\sigma_1^n\frac{\Gamma(k+n)}{\Gamma(1-\beta+k+n)\Gamma(k+n+\beta)}+$$

$$+\left(\frac{\xi_0+\xi}{\eta_0+\xi_0}\right)^{\alpha}\left(\frac{\xi_0-\xi}{\eta_0-\xi_0}\right)^{\beta}\left[\frac{2\xi_0(\xi-\xi_0)}{(\xi_0+\xi)(\eta_0+\xi_0)^2}\right]\times$$

$$\times\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=1}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{(n-1)!(1+k)_n}\sigma_1^{n-1}\frac{\Gamma(k+n)}{\Gamma(1-\beta+k+n)\Gamma(k+n+\beta)}+$$

$$+\frac{(\xi_0-\xi)}{(\eta_0-\xi_0)(\xi-\eta_0)}\left(\frac{\xi_0+\xi}{\eta_0+\xi_0}\right)^{\alpha}\left(\frac{\xi_0-\xi}{\eta_0-\xi_0}\right)^{\beta}\frac{\beta(1-\beta)}{\Gamma(1+\beta)\Gamma(2-\beta)}+$$

$$+\left(\frac{\xi_0+\xi}{\eta_0+\xi_0}\right)^{\alpha}\left(\frac{\xi_0-\xi}{\eta_0-\xi_0}\right)^{\beta}\sum_{k=1}^{+\infty}\frac{\sigma_3^k}{(k!)^2}\sum_{n=1}^{+\infty}\frac{(\alpha)_n(1-\alpha)_n}{n!(1+k)_n}\sigma_1^n\frac{\beta(1-\beta)}{1+k+m}\times$$

$$\times\lim_{\varepsilon\to 0}\frac{\varepsilon^{k+n}(\xi_0+\varepsilon-\xi)}{(\eta_0-\xi_0)(\xi-\eta_0)}\frac{\Gamma(2+k+n)\Gamma(1-k-n)}{\Gamma(1+\beta)\Gamma(2-\beta)}.\quad(23)$$

$$\frac{\partial}{\partial\eta_0}R_4+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_4=\left(\frac{\xi_0+\xi}{\eta_0+\xi_0}\right)^{\alpha}\left(\frac{\xi_0-\xi}{\eta_0-\xi_0}\right)^{\beta}\left[-\gamma(\xi-\xi_0)\right]\times$$

$$\times\sum_{k=1}^{+\infty}\frac{\sigma_3^{k-1}}{(\beta)_k(k-1)!}\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{(\beta+k)_n n!}\sigma_1^n\frac{\chi\Gamma(k+n)\Gamma(\beta)\Gamma(2-2\beta)}{\Gamma(1-\beta+k+n)\Gamma(\beta+k+n)\Gamma(1-\beta)}+$$

$$+\left(\frac{\xi_0+\xi}{\eta_0+\xi_0}\right)^{\alpha}\left(\frac{\xi_0-\xi}{\eta_0-\xi_0}\right)^{\beta}\frac{2\xi_0(\xi-\xi_0)}{(\xi_0+\xi)(\eta_0+\xi_0)^2}\times$$

$$\times\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{(\beta)_k k!}\sum_{n=1}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{(\beta+k)_n(n-1)!}\sigma_1^{n-1}\frac{\chi\Gamma(k+n)\Gamma(\beta)\Gamma(2-2\beta)}{\Gamma(1-\beta+k+n)\Gamma(\beta+k+n)\Gamma(1-\beta)}+$$

$$+\frac{\xi_0-\xi}{(\eta_0-\xi_0)(\xi-\eta_0)}\left(\frac{\xi_0+\xi}{\eta_0+\xi_0}\right)^{\alpha}\left(\frac{\xi_0-\xi}{\eta_0-\xi_0}\right)^{\beta}\frac{\chi(1-\beta)\Gamma(3-2\beta)}{2\Gamma(2-\beta)\Gamma(2-\beta)}+$$

$$+\left(\frac{\xi_0+\xi}{\eta_0+\xi_0}\right)^{\alpha}\left(\frac{\xi_0-\xi}{\eta_0-\xi_0}\right)^{\beta}\sum_{k=1}^{+\infty}\frac{\sigma_3^k}{k!(\beta)_k}\sum_{n=1}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{n!(\beta+k)_n}\sigma_1^n\times$$

$$\times\frac{1-\beta-k-n}{2}\lim_{\varepsilon\to 0}\frac{\varepsilon^{k+n}\left(\xi_0+\varepsilon-\xi\right)}{\left(\eta_0-\xi_0\right)\left(\xi-\eta_0\right)}\frac{\chi\Gamma\left(3-2\beta\right)\Gamma\left(1-k-n\right)}{\Gamma\left(2-\beta-k-n\right)\Gamma\left(2-\beta-k-n\right)}. \quad (24)$$

From these equalities, by virtue of the value of c , it follows that

$$\lim_{\varepsilon\to 0}\left\{\left[\frac{\partial}{\partial\eta_0}R_4+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_4\right]\Bigg|_{\eta=\xi_0-\varepsilon}-\right.$$

$$\left.-\left[\frac{\partial}{\partial\eta_0}R_1+\left(\frac{\alpha}{\eta_0+\xi_0}+\frac{\beta}{\eta_0-\xi_0}\right)R_1\right]\Bigg|_{\eta=\xi_0+\varepsilon}\right\}=0\cdot \quad (25)$$

If we take into account equality (10) , then due to equality (25), the limit at the $\varepsilon\to 0$ last integral in (15) is equal to zero.

Based on the above and the equality $R_1\left(\xi_0,\eta_0;\xi_0,\eta_0;\gamma\right)=1$, from (15) at $\varepsilon\to 0$, it follows that $L\left[F\left(\xi_0,\eta_0\right)\right]=f\left(\xi_0,\eta_0\right)$, i.e. the function $F\left(\xi_0,\eta_0\right)$satisfies equation (1).

Let us now prove that conditions (11) are satisfied. For this aim , we $F\left(\xi_0,\eta_0\right)$ rewrite the function in the form $F\left(\xi_0,\eta_0\right)=F_1\left(\xi_0,\eta_0\right)+F_4\left(\xi_0,\eta_0\right)$, where

$$F_1\left(\xi_0,\eta_0\right)=\int_0^{\xi_0}d\xi\int_{\xi_0}^{\eta_0}f\left(\xi,\eta\right)R_1\left(\xi,\eta;\xi_0,\eta_0;\gamma\right)d\eta,\ F_4\left(\xi_0,\eta_0\right)=\int_0^{\xi_0}d\xi\int_{\xi}^{\xi_0}f\left(\xi,\eta\right)R_4\left(\xi,\eta;\xi_0,\eta_0;\gamma\right)d\eta\cdot$$

Let 's consider the function $F_1\left(\xi_0,\eta_0\right)$ the first. Taking into account equality (16), we rewrite the function $F_1\left(\xi_0,\eta_0\right)$in the form

$$F_1\left(\xi_0,\eta_0\right)=\int_0^{\xi_0}d\xi\int_{\xi_0}^{\eta_0}f\left(\xi,\eta\right)R_1\left(\xi,\eta;\xi_0,\eta_0\right)d\eta=$$

$$=\left(\eta_0+\xi_0\right)^{-\alpha}\left(\eta_0-\xi_0\right)^{-\beta}\int_0^{\xi_0}d\xi\int_{\xi_0}^{\eta_0}f\left(\xi,\eta\right)\left(\eta+\xi\right)^{\alpha}\left(\eta-\xi\right)^{\beta}\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{\left(k!\right)^2}\times$$

$$\times\sum_{n=0}^{\infty}\frac{\left(\alpha\right)_n\left(1-\alpha\right)_n}{\left(1+k\right)_n n!}\sigma_1^n F\left(\beta,1-\beta,1+k+n;\sigma_2\right)d\eta\cdot$$

In the integral over ξ and η respectively perform the replacement $\xi=\xi_0 z$, $\eta=\eta_0-\left(\eta_0-\xi_0\right)t$:

$$F_1\left(\xi_0,\eta_0\right)=\left(\eta_0+\xi_0\right)^{-\alpha}\left(\eta_0-\xi_0\right)^{1-\beta}\xi_0\times$$

$$\times\int_0^1\left(\eta_0-\xi_0 z\right)^{\delta+\beta-1}\left(\eta_0+\xi_0 z\right)^{\alpha}dz\int_0^1 A_1\left(z,t,\xi_0,\eta_0\right)dt, \quad (26)$$

where

$$A_1\left(z,t,\xi_0,\eta_0\right)=\left[1-\frac{\eta_0-\xi_0}{\eta_0+\xi_0 z}t\right]^{\alpha}\left[1-\frac{\eta_0-\xi_0}{\eta_0-\xi_0 z}t\right]^{\beta+\delta-1}\times$$

$$\times f_1\left[\xi_0 z,\eta_0-\left(\eta_0-\xi_0\right)t\right]\times\sum_{k=0}^{+\infty}\frac{\left[\gamma\left(\xi_0 z-\xi_0\right)\left(\eta_0-\xi_0\right)t\right]^k}{\left(k!\right)^2}\times$$

$$\times\sum_{n=0}^{+\infty}\frac{\left(-1\right)^n\left(\alpha\right)_n\left(1-\alpha\right)_n}{\left(1+k\right)_n n!}\left[\frac{\left(\xi_0 z-\xi_0\right)\left(\eta_0-\xi_0\right)t}{\left(\eta_0+\xi_0 z-\left(\eta_0-\xi_0\right)t\right)\left(\eta_0+\xi_0\right)}\right]^n\times$$

$$\times F\left(\beta,\beta+k+n,1+k+n;-\frac{\left(\xi_0 z-\xi_0\right)t}{\eta_0-\xi_0 z-\left(\eta_0-\xi_0\right)t}\right).$$

This implies the validity of the following equalities:

$$\lim_{\eta_0\to\xi_0}A_1\left(z,t,\xi_0,\eta_0\right)=f_1\left(\xi_0 z,\eta_0\right)F\left(\beta,\beta,1;t\right), \quad (27)$$

$$A_1\left(z,t,0,\eta_0\right)=\left(1-t\right)^{\alpha+\beta+\delta-1}f_1\left(0,\eta_0-\eta_0 t\right). \quad (28)$$

Then, due to the uniform convergence of the series, it follows from equalities (26), (27), (28) that the conditions

$$\lim_{\eta_0\to\xi_0} F_1(\xi_0,\eta_0)=0, \qquad F_1(\xi_0,\eta_0)\big|_{\xi_0=0}=0. \tag{29}$$

Let's now consider the function $F_4(\xi_0,\eta_0)$. Taking into account equality (21), we rewrite the function $F_4(\xi_0,\eta_0)$ in the form

$$F_4(\xi_0,\eta_0)=\int_0^{\xi_0} d\xi \int_{\xi}^{\xi_0} f(\xi,\eta)R_4(\xi,\eta;\xi_0,\eta_0;\gamma)d\eta=\chi(\eta_0+\xi_0)^{-\alpha}(\eta_0-\xi_0)^{1-2\beta}\times$$

$$\times\int_0^{\xi_0}(\xi_0-\xi)^{\beta-1}d\xi\int_{\xi}^{\xi_0}(\eta-\xi)(\eta+\xi)^{\alpha}(\eta-\eta_0)^{\beta-1}f(\xi,\eta)\times$$

$$\times\sum_{k=0}^{+\infty}\frac{\sigma_3^k}{k!(\beta)_k}\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{(\beta+k)_n\,n!}(-\sigma_1)^n F\left(1-\beta-k-n,1-\beta,2-2\beta;\frac{1}{\sigma_2}\right)d\eta.$$

In integrals with respect to ξ and η replacing by $\xi=\xi_0 z$, $\eta=\xi_0-(\xi_0-\xi)t$, we have

$$F_4(\xi_0,\eta_0)=\chi(\eta_0+\xi_0)^{-\alpha}(\eta_0-\xi_0)^{1-2\beta}\xi_0^{\beta+\delta+1}\eta_0^{\beta-1}\times$$

$$\times\int_0^1(1-z)^{\beta+\varepsilon}\left(1-\frac{\xi_0}{\eta_0}z\right)^{\beta-1}dz\int_0^1 A_4(z,t,\xi_0,\eta_0)dt, \tag{30}$$

where

$$A_4(z,t,\xi_0,\eta_0)=\left[2z+(1-z)t\right]^{\alpha}t^{\delta}\left(1-\frac{\xi_0-\xi_0 z}{\eta_0-\xi_0 z}t\right)^{\beta-1}f_1\left[\xi_0 z,\xi_0-(\xi_0-\xi)t\right]\times$$

$$\times\sum_{k=0}^{+\infty}\frac{\left[\gamma(\xi_0 z-\xi_0)(\eta_0-\xi_0-(\xi_0 z-\xi_0)t)\right]^k}{k!(\beta)_k}\times$$

$$\times\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{(\beta+k)_n\,n!}\left[\frac{(\xi_0 z-\xi_0)(\eta_0-\xi_0-(\xi_0 z-\xi_0)t)}{(\xi_0+\xi_0 z-(\xi_0-\xi_0 z)t)(\eta_0+\xi_0)}\right]^n\times$$

$$\times F\left(1-\beta-k-n,1-\beta,2-2\beta;-\frac{(1-t)(\eta_0-\xi_0)}{(\eta_0-\xi_0+(\xi_0-\xi_0 z)t)}\right).$$

This implies the validity of the following equalities:

$$\lim_{\eta_0\to\xi_0}A_4(z,t,\xi_0,\eta_0)=\left[2z+(1-z)t\right]^{\alpha}t^{\delta}(1-t)^{\beta-1}f_1(\xi_0 z,\xi_0-(\xi_0-\xi_0 z)t)\times$$

$$\times\sum_{k=0}^{+\infty}\frac{\left[-\gamma(\xi_0 z-\xi_0)^2 t\right]^k}{k!(\beta)_k}\sum_{n=0}^{+\infty}\frac{(-1)^n(\alpha)_n(1-\alpha)_n}{(\beta+k)_n\,n!}\left[\frac{-(\xi_0 z-\xi_0)^2 t}{\xi_0(1+z-(1-z)t)(\eta_0+\xi_0)}\right]^n, \tag{31}$$

$$A_4(z,t,0,\eta_0)=\left[2z+(1-z)t\right]^{\alpha}t^{\delta}f_1(0,0)F(1-\beta,1-\beta,2-2\beta;1-t). \tag{32}$$

Then, due to the uniform convergence of the series, it follows from equalities (30), (31), (32) that the conditions

$$\lim_{\eta_0\to\xi_0}F_4(\xi_0,\eta_0)=0, \qquad F_4(\xi_0,\eta_0)\big|_{\xi_0=0}=0. \tag{33}$$

By virtue of $F(\xi_0,\eta_0)=F_1(\xi_0,\eta_0)+F_4(\xi_0,\eta_0)$, the equalities (29) and (33) imply that conditions (11) are satisfied.

Theorem has been completed.

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MEDICAL SCIENCES

STUDY OF THE ACTION OF SOME CHEMICAL AND NATURAL SUBSTANCES ON CANDIDA ALBICANS CULTURES

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https://doi.org/10.5281/zenodo.7032255

Abstract

In the present study, we followed for 96 hours the effectiveness of some chemical compounds proposed for the treatment of Candida albicans, more precisely: essential oils of: ginger, lemon, frankincense and neem, cedar, wormwood, Siberian cedar oil, magnesium oil, tincture of iodine 2 %, 2 solutions of sodium bicarbonate, apple cider, apple cider vinegar, iodized salt, citric acid as well as four solutions (samples) of 1M acetic acid.

Keywords: Candida albicans, culture medium, culture plates, Candida Spp., essential oil, tincture

Abbreviations: h- hour; ATCC – standard culture of Candida albicans; µl - microliters; ml-milliliters; PS – physiological serum; 1M – molar concentration (1 mol/L; where L = liter).

Introduction

Candida albicans is a single-celled fungus from the yeast group, which in healthy people can act as a saprophyte of the digestive tract. Candida tropicalis is less common. Contamination with the fungus can be done through direct contact with the patient or through shared objects (1). Recent studies carried out in Europe and the USA highlight the increase in the incidence of nosocomial fungal infections, with a worrying mortality rate, which can reach 40-70% of cases. Fungiemias due to various species of Candida are ranked 4th, in terms of incidence, in the list of systemic infections associated with medical care, after bacteremias with species from the genera Staphylococcus, Steptococcus, Enterococcus (2), (3).

Candida albicans is a commensal of the digestive tract and vagina. Depending on the location, it is classified into: cutaneous candidiasis; mucous candidiasis; nail candidiasis (candidal onychomycosis).

Cutaneous candidiasis affects in order of frequency: intertriginous regions, periorificial skin, fingers (4).

Candidal onychomycoses are nail lesions caused by nail infections with yeast fungi belonging to the genus Candida. The species most commonly found in nail parasites is Candida albicans. Other less frequently isolated species are Candida guilliermondi, Candida tropicalis, Candida zeylanoides, Candida krusei or Candida parapsilosis (5).

Factors favoring infection include prolonged antibiotic therapy, immunosuppressive therapy, diabetes, AIDS, use of contraceptives, antitrichomoniasis treatment (6). Candida infections can be superficial or invasive; superficial infections often affect the skin or mucous membranes and can be successfully treated with topical antifungal medications. However, invasive fungal infections are often life-threatening, probably due to ineffective diagnostic methods and inadequate initial antifungal therapies (7), (8).

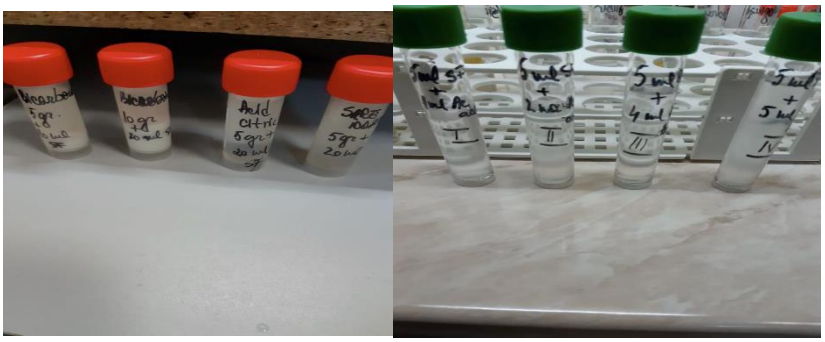
Invasive candidiasis is usually caused by dissemination of endogenous *Candida* species colonizing the patient's gastrointestinal tract. The risk for invasive candidiasis is higher during the early posttransplant period because of neutropenia, severe mucositis, and the presence of a central venous catheter (9).

MATERIAL AND METHOD

The study was conducted over 4 days between August 25 and 30, 2019 at the "Provita 2000 Medical Center" Clinic in Constanța. The purpose of the study was to investigate the action of some natural products on Candida Albicans colonies. For this, we used Sabouraud standard culture medium, on which we seeded samples of Candida albicans, from a standardized assortment, called ATCC. We introduced the plates to the thermostat, at the standard temperature of 37 ºC (10). In the present study, we carried out several experiments during 96 hours, using both natural products (essential oils, tinctures, etc.) and chemical products (sodium bicarbonate, citric acid, iodized salt), in order to be able to follow the action of the chemical compounds on Candida albicans cultures. The chemical compounds that were analyzed in the study were prepared in different dilutions. We then analyzed the size of the diameter of the zones of inhibition and lysis of the mycelial colonies at different time intervals (at 24 h, 48 h, 72 h (10) and at, 96 h).

Results

In this study, we investigated the action on candida of some essential oils: ginger, lemon, frankincense and neem, cedar, wormwood, magnesium oil, Siberian cedar oil, tincture of iodine 2 %, sodium bicarbonate solutions, apple cedar, of apple cider vinegar, citric acid, as well as four solutions of 1M acetic acid, over a period of 96 hours. In the first phase, I made the necessary dilutions, after which I added 2-3 colonies of Candida spp. I mixed and left them at the thermostat for about an hour. Later, from the emulsion obtained, I seeded on the Sabouroud plate and introduced the samples to the thermostat for 24 h, 48 h...96 h, reading the result for each case.



(a) *(b)*

Fig. 1.a. Preparation of sodium bicarbonate, citric acid and iodized salt solutions; 2.b. Preparation of 1M acetic acid solutions

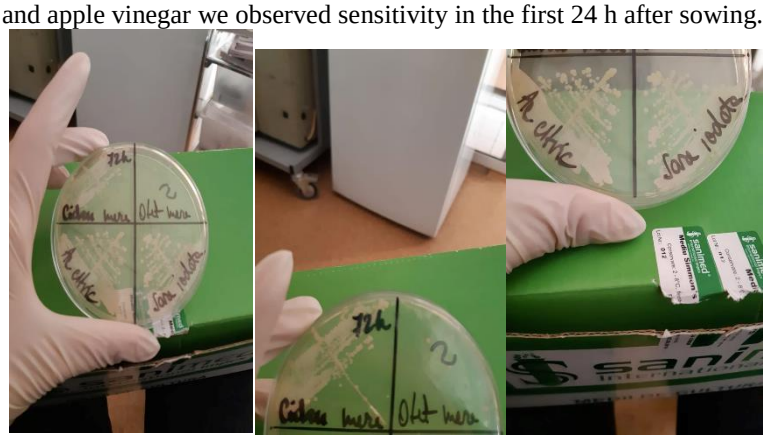
96 h experiment (4 days)

a. In the first experiment I used apple cider, apple vinegar, iodized salt and citric acid. To prepare the citric acid solution, I dissolved 5 g of the substance (citric acid) in 20 ml physiological serum. Apple cider and apple cider vinegar were used as they were commercially available. The iodized salt solution was prepared from 5 g of iodized salt and 20 ml of saline.

(a) *(b)*

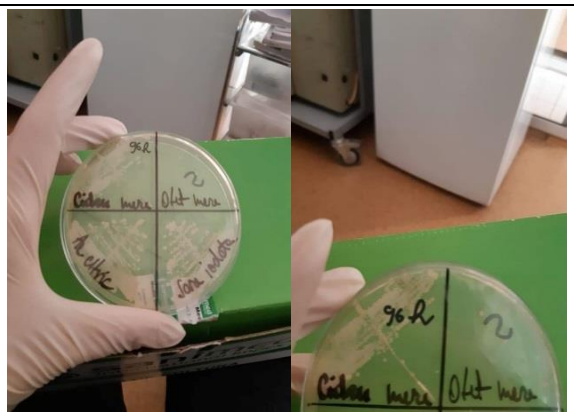
Fig 2. Culture plate seeded with Candida albicans and apple cider, apple vinegar, citric acid and iodized salt at 24 h (Fig 2.a) and 48 h (Fig. 2. B)

For apple cider and apple vinegar we observed sensitivity in the first 24 h after sowing.



(a) *(b)* *(c)*

Fig.3.a. Petri dish seeded with Candida albicans and apple cider, apple cider vinegar ig. 5 a and b), citric acid and iodized salt at 72 h (fig 3.a and b)



(a) (b)

Fig. 4.a. Petri dish seeded with Candida albicans and apple cider, apple vinegar, citric acid and iodized salt at 96 h (fig 4.a); Petri dish seeded with Candida albicans and apple cider, apple vinegar at 96 h (fig.4.b)

After 48 h, candida reappears in the case of the 4 substances used in the study; there is sensitivity to apple cider vinegar at 48 h and after, but not completely.

b. Sodium bicarbonate: 5 g/ 20 ml physiological serum, respectively 10 g/ 20 ml physiological serum. 2 % tincture of iodine was used in its native state.

(a) (b) (c)

Figure 5(a, b, c). Culture plate seeded with tincture of iodine (a, c) as well as sodium bicarbonate solutions at 24 h (a), 48 h (b), 72 h (c)

For sodium bicarbonate solutions no action appears against Candida albicans colonies in the first 4 days of incubation. The tincture of iodine proved very active on the Candida colonies during the 4 days.

(a) (b) (c)

Figure 6 (a, b, c). Petri plate seeded with Candida albicans with solutions of sodium bicarbonate (a, b) and tincture of iodine at 96 h (Fig 6.a, c)

c. Acetic acid 1M

For the experiment with acetic acid I prepared in the first phase 4 solutions/ samples of 1 M acetic acid (see table no. 1 and figure 1.b).

Table I. Composition of microbiologically analyzed acetic acid samples (used in the study)

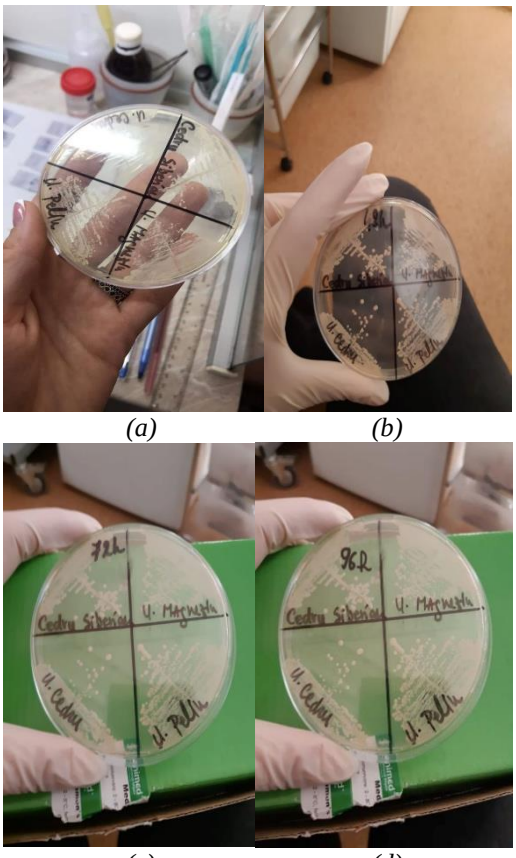
Crt no	Samples	Acetic acid 1M (ml)	Physiological serum (ml)	Volumetric ratio (Acetic acid/ PS)
1.	I	1	5	1/ 5
2.	II	2	5	2/5
3.	III	3	5	3/5
4.	IV	4	5	4/5

(a) *(b)* *(c)* *(d)*

Figure 7 (a, b, c, d). Culture plate seeded with Candida albicans on which the four solutions of 1M acetic acid were applied at 24 h (a, b), 48 h, 72 h (c) and 96 h (d), respectively

24 h after Candida seeding is observed a certain sensitivity for solutions / samples II, III and even IV of 1 M acetic acid, but not enough. The acetic acid used for the 48h, 72h and 96h, specifically samples III and IV has a degree of fungicidal action, but Candida albicans does not disappear permanently.

d. Siberian cedar oil (crude cold-extracted seed oil - for internal use), cedar essential oil, magnesium oil for massage (from Favisan), wormwood oil -200 µl oil /800 µl physiological serum



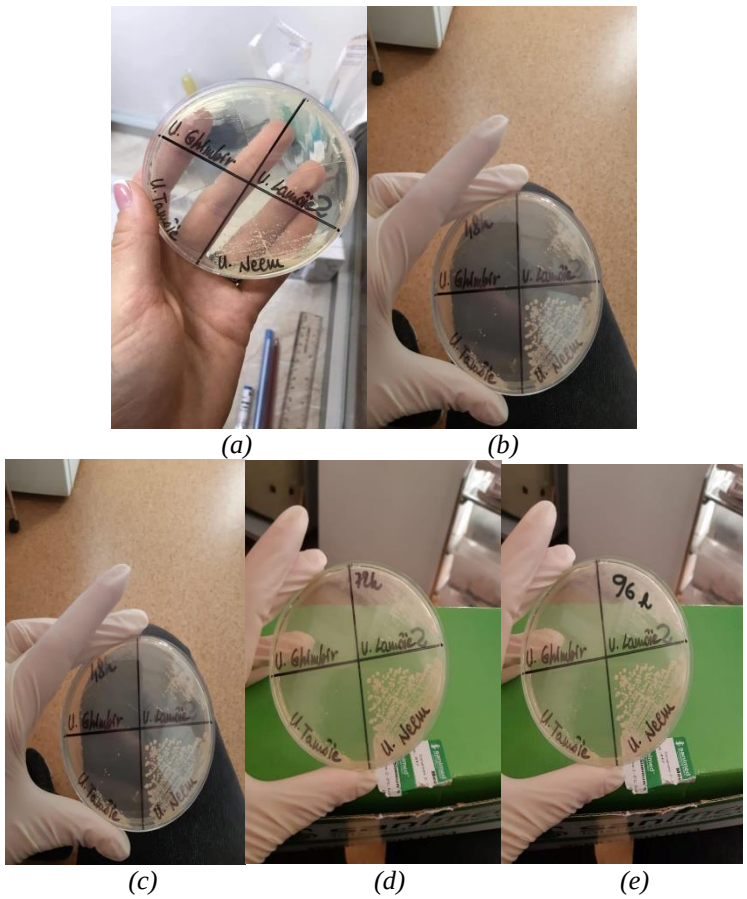
(a) *(b)*

(c) *(d)*

Figure 8(a, b, c, d) Culture plates seeded with Candida albicans on which oils of: Siberian cedar, cedar, magnesium and wormwood were applied in a concentration of 20% at 24, 48, 72 and 96 h

After 24 h, a degree of sensitivity occurs with cedar essential oil, unlike Siberian cedar oil for internal use. The four substances used in the experiment: Siberian cedar oil, cedar oil, wormwood oil and magnesium oil were inactive on Candida albicans, for the 4 days of the experimental study.

e. Ginger, lemon, frankincense and neem oil-200 ml oil/800 ml physiological serum



(a) (b) (c) (d) (e)

Figure 9 (a, b, c, d, e.) Culture plate seeded with Candida albicans on which ginger, lemon, frankincense and neem oils were applied in a concentration of 20% at 24 h (a), 48 h (b,c), 72 h (d), 96 h (e)

In the case of ginger, frankincense and lemon oils, a fungicidal action occurs in the first 24 hours. After 48 h, the action is maintained only with the ginger oil, a little with the lemon oil and a little with the frankincense oil. With ginger oil, candida did not reappear 72 h after sowing; also, with ginger essential oil, fungicidal action is also observed after 96 h, compared to neem oil, respectively, frankincense oil and lemon oil. Lemon oil and frankincense oil show a certain fungicidal action from the beginning, until the end of the 96 h; however, candida continued to re-emerge in a very small amount with these substances 2 days after seeding.

Discussions

The dilutions of 200 µl substance/800 µl physiological serum were made for the essential oils, and the iodine tincture applied had a concentration of 2%. Apple cider and apple vinegar were sampled as they were commercially available. Iodized salt, sodium bicarbonate and citric acid were used in solutions (in liquid state). For acetic acid CH3-COOH, 1 M, we made 4 different samples for the proposed study (see Table no.1). These substances were either in the form of tinctures, essential oils or other commercially available solutions. Over the solutions I added some colonies (2, 3) of Candida Spp. Apple cider and apple vinegar applied in their native state show fungicidal action in the first 24 h, compared to the iodized salt solution and the citric acid solution used in the study. With tincture of iodine, an obvious fungicidal action is observed against Candida albicans and less with apple cider vinegar after 4 days after inoculation with Candida albicans. The sodium bicarbonate solutions used did not show fungicidal action against Candida albicans; proved ineffective at the concentrations used. In contrast, iodine tincture maintained its antifungal effect for the 4 days.

After 24 h of seeding, some fungicidal action is observed in samples III and IV of acetic acid, but not sufficient to inhibit the Candida colonies completely. Ginger, frankincense and lemon oil show a degree of fungicidal action in the first 24 hours compared to neem oil, as well as 48 hours after inoculation with Candida albicans. Also, after 72 h and 96 h, sensitivity appears to ginger oil, frankincense and a little to lemon oil compared to neem oil, which was not effective against candida. It was observed that the four substances used in the experiment: Siberian cedar oil, cedar oil, wormwood oil and magnesium oil, were ineffective on Candida albicans, during the 4 days of the study, with the exception of cedar oil, which for 24 h showed fungicidal action against candida. Oil of lemon and frankincense showed some sensitivity from the beginning until

the completion of 96 h, but candida continued to recur with these substances at the concentrations used. Apple cider vinegar used in food can be a prophylactic, but also curative remedy in the treatment of Candida. Candida albicans shows sensitivity for the first 24 h to ginger, frankincense and lemon oils and even more, for the 96 h from seeding to ginger, for dilutions of 200 µl substance/800 µl physiological serum. For this reason, the mentioned substances can have prophylactic and curative indications for Candida albicans. Tincture of iodine proved its antifungal effect for the 96 h of research.

Bottom of Form

CONCLUSIONS

For apple cider vinegar, sensitivity of Candida colonies appears in the first 24 h compared to apple cider, iodized salt solution and citric acid. After 24 hours, a certain sensitivity of the Candida colonies to apple cider vinegar is observed, up to 96 hours of evaluation, but not completely; Candida reappears. The 2 sodium bicarbonate solutions we used in the study were found to be inactive in treating Candida. For the 4 days there is some sensitivity to samples III and IV of 1M acetic acid, but not enough to combat run. A higher concentration of acetic acid solutions; acetic acid which is commonly called vinegar could favorably influence the treatment of Candida albicans. A marked sensitivity of Candida colonies is observed for ginger oil and tincture of iodine, and a little for apple cider vinegar, after the 4 days of the study. Candida is totally sensitive to iodine tincture and ginger oil.

The results of the experiments reveal the fact that to treat mycoses of the skin and mucous membranes, we can use plant extracts (tinctures or oils) that can be applied locally. Thus, ginger oil is recommended, which showed a maximum fungicidal effect on Candida albicans colonies after 96 hours of incubation. The recommended concentration is 20%, in daily applications, until a total healing of the lesions.

Also, frankincense and lemon oil determine sensitivity of Candida colonies in the first 24 hours and, subsequently, to a lesser extent after 48 hours from seeding, up to 96 hours. We can consider that frankincense and lemon oil used in higher concentrations would give a good anifungic result or possibly by mixing them with other fungicidal substances. Lemon oil and frankincense oil can be used repeatedly/alternately with other antifungal substances.

Candida albicans is sensitive to apple cider vinegar, especially for the first 48 hours, and to a lesser extent thereafter. It could be used more often in food, with a prophylactic purpose. Iodine tincture and ginger oil showed their antifungal role in treating candida for the 4 days of the study.

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УДК: 618.2-06:616.9

RISK FACTORS FOR THE DEVELOPMENT OF PERINATAL INFECTIONS IN PREMATURE INFANTS

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ФАКТОРЫ РИСКА РАЗВИТИЯ ПЕРИНАТАЛЬНЫХ ИНФЕКЦИЙ У НЕДОНОШЕННЫХ ДЕТЕЙ

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https://doi.org/10.5281/zenodo.7032270

Abstract

Despite the optimization of antenatal protection and the improvement of modern diagnostic methods, specific infections of the perinatal period are the leading cause of neonatal mortality and morbidity. The purpose of the research is to assess the significance of risk factors for the development of perinatal infections in premature infants accrding to the results of cluster analysis

Materials and methods of research: This work is based on a comprehensive (anamnestic, clinical, paraclinical examinations and the results of enzyme immunoassay or/and polymerase chain reaction) examination of newborns with perinatal infections.

Results: A systematic research of factors predisposing to the development of perinatal infections using multifactorial mathematical cluster analysis with an assessment of parameters (31) in premature infants allowed identifying anamnestic and clinical features of the disease course. Cluster analysis by anamnestic, clinical and laboratory parameters revealed a relatively favorable cluster 1 and an unfavorable cluster 2. Premature infants with mono (CMVI) 69.1±3.1% and mixed infections (63.6±4.5%) belonged to cluster 2, which indicated the severity and generalization of the infectious process. The study of these results makes it possible to assess the prognosis of the outcome of the disease and thereby reduce the range of studies conducted, as well as serve as a basis for choosing the most effective drugs for immunocorrection.

Conclusion According to the research results, we have developed a method for predicting the disease, taking into account the cluster organization of the clinical status, which allows us to assess the condition of newborns that do not require specialized laboratory research methods.

Аннотация

Несмотря на оптимизацию антенатальной охраны, совершенствования современных методов диагностики, инфекции, специфичные для перинатального периода являются лидирующей причиной неонатальной смертности и заболеваемости.

Цель исследования: по результатам кластерного анализа провести оценку значимости факторов риска развития перинатальных инфекций у недоношенных детей.

Материалы и методы исследований: В основу настоящей работы положено комплексное (анамнестические, клинические, параклинические обследования и результаты иммуноферментного анализа или/и полимеразной цепной реакции) обследование новорожденных с перинатальными инфекциями. Результаты: Системное изучение факторов, предрасполагающих к развитию перинатальных инфекций с применением многофакторного математического кластерного анализа с оценкой параметров (31) у недоношенных детей позволило идентифицировать анамнестические и клинические особенности течения заболевания. Кластерный анализ по анамнестическим, клинико-лабораторным параметрам выявил относительно благоприятный кластер 1 и неблагоприятный кластер 2. Недоношенные с моно (ЦМВИ) 69,1±3,1% и микст-инфекциями (63,6±4,5%) относились ко 2 кластеру, что свидетельствовало о тяжести и генерализации инфекционного процесса. Изучение этих результатов позволяет оценить прогноз исхода заболевания и тем самым,

сократить спектр проводимых исследований, а также служить основой для выбора наиболее эффективных препаратов для иммунокоррекции.

Заключение На основании результатов собственных исследований разработан способ прогноза заболевания с учётом кластерной организации клинического статуса, позволяющий оценивать состояние новорожденных, не требующих специализированных лабораторных методов исследования.

Keywords: perinatal infections, premature newborns, cluster analysis.
Ключевые слова: перинатальные инфекции, недоношенные новорожденные, кластерный анализ.

Несмотря на антенатальную охрану, оптимизацию тактики ведения беременности, внедрения более современных и информативных методов диагностики внутриутробной инфекции, лечения и профилактики, инфекции специфичные для перинатального периода являются ведущей причиной неонатальной заболеваемости и смертности [1-4]. Частота встречаемости ВУИ колеблется от 6 до 53%, достигая 70 % среди недоношенных детей [5]. В этих условиях становится очевидной особая актуальность профилактики, своевременной ранней диагностики и эффективной терапии инфекционной патологии в период новорожденности [6,7].

Внутриутробные инфекции, являющиеся одной из основных причин рождения детей недоношенными, также определяют важность научных исследований проводимых в данном направлении [8].

Известно, что в патогенезе внутриутробных инфекций задействованы клинические, физиологические, иммунологические и генетические механизмы[9-13]. В связи с этим очевидной стала целесообразность выделения признаков перинатальных инфекций, установление которых позволило бы прогнозировать развитие болезни и эффективность лечения. Одним из оригинальных решений указанной задачи явилось применение кластерного анализа для разграничения клинических признаков перинатальных инфекцийу новорожденных детей.

Цель исследования: по результатам кластерного анализа провести оценку значимостифакторов риска развития перинатальных инфекций у недоношенных детей.

Материалы и методы исследований:В основу настоящей работы положено комплексное обследование новорожденных с перинатальными инфекциями. Работа выполнена в отделениях патологии доношенных и недоношенных новорожденных, анестезиологии, реанимации и интенсивной терапии НИИ Педиатрии имени К.Я.Фараджевой г.Баку (Азербайджанская Республика). Дизайн исследования включал два этапа и состоял из ретроспективных и проспективных методов исследования. На первом этапе проведен ретроспективный анализ медицинских карт 456 новорожденных с верифицированной внутриутробной инфекцией различной этиологии. В ходе данного исследования были получены данные о соматическом, акушерско-гинекологическом анамнезе женщин, особенностях течения данной беременности и родов. Проанализированы особенности течения заболевания, данные параклинических, инструментальных и иммунологических методов исследования у новорожденных детей по картам клинического, а на умерших детей — морфологического исследования, составленным на основе историй болезни новорожденных.

Второй этап включал системное изучение клинико- иммунологического состояния 278 новорожденных с перинатальными инфекциями.

Из всех наблюдаемых новорожденных, недоношенных со сроком гестации 27-37 недель было 433 (52,0 ±1,8%). Среди них со сроком гестации36-37 недель было 222 (51,3±2,4%), со сроком гестации 34-36 недель 127 (29,3±2,2%), со сроком гестации 31-34 недель 67 (15,5±1,7%), со сроком 31-27 недель 17 (3,9±0,9%) новорожденных. В зависимости от результатов комплексного обследования и учета этиологии заболевания недоношенные распределены на 3 группы: I группа - 220 новорожденных с внутриутробной цитомегаловирусной инфекцией; II группа- 118 новорожденных со смешанной инфекцией; III группа – 84 новорожденных с сепсисом. Контрольную группу составили 33 условноздоровых недоношенных.

Подтверждением диагноза перинатальной инфекции служил комплекс анамнестических, клинических, параклинических обследований и результаты специфических методов исследования (иммуноферментный анализ или/и полимеразная цепная реакция). Всем больным проведено УЗИ - исследование головного мозга, органов брюшной полости и сердца, рентгенография органов грудной клетки и брюшной полости. Для выполнения данной задачи использовался дисперсионный анализ ANOVA. Необходимо учитывать тот факт, что чем меньше значение внутригрупповой и больше значение межгрупповой дисперсии, уровень достоверности $p<0,05$, а критерий F высок, тем лучше признак характеризует принадлежность объектов к кластеру, тем достовернее кластеризация[14,15]. Вычисления проводились на электронной таблице EXCEL-2010 и SPSS-20.

Результаты и их обсуждения:

Объектом исследования послужили 351 недоношенный новорожденный. Для кластерного анализа популяции наблюдаемых новорожденных было использовано 31 параметров: пол ребенка, паритет беременности, аборты, выкидыш в анамнезе, смерть в антенатальном периоде, гинекологический анамнез, анемия, гестоз, экстрагенитальная патология, угроза выкидыша, смерть ребенка, оценка по шкале Апгар на 1 и 5 минуте, уровень гемоглобина, эритроцитов, лейкоцитов, СОЭ, общий билирубин, поражение центральной нервной системы (ЦНС), дыхательной системы, желудочно-кишечного тракта, мочеполовой системы, сердечно-сосудистой си-

стемы, полиорганная недостаточность, гипоксически-ишемическое поражение ЦНС (ГИПЦНС), гипоксически-геморрагическое поражениеЦНС (ГГПЦНС), инфекционное поражение ЦНС (ИПЦНС). Из перечисленных параметров 10 относились к материнским, 21-к характеристикам новорожденных (табл. 1).

Согласно данным, приведенным в таблице, такие параметры как паритет беременности, гинекологический анамнез, анемия, гестоз матерей, оценка по шкале Апгар на 1 и 5 минуте новорожденных при рождении, уровень гемоглобина, билирубина, поражение ЦНС, дыхательной системы, желудочно-кишечный тракт (ЖКТ), сердечно-сосудистая система (ССС), мочеполовая система (МПС), гипоксически-геморрагическое поражение (ГГПЦНС) вносили наибольший вклад в разделение новорожденных, поскольку имели уровень достоверности ниже 0,05. Новорожденные, которые имели данные показатели, мы отнесли ко 2 кластеру. Во 2 кластере преобладали женщины, имеющие наиболее часто повторные беременности (χ^2=9,99; p<0,001), гинекологические заболевания (χ^2=9,9; p<0,014), анемия (χ^2=8,1; p=0,057), гестозы (χ^2=6,77; p<0,001).

Обследуемые новорожденные были распределены на кластеры в зависимости от этиологии заболевания. Из220новорожденных с ЦМВИ к кластеру 1 относились 68 (30,9±3,1%), к кластеру 2- 152 (69,1±3,1%) новорожденных, из 118 новорожденных со смешанной инфекцией к кластеру 1 относились 43 (36,4±4,4%), к кластеру 2- 75(63,6±4,4%) новорожденных, из 95 новорожденных с сепсисом к кластеру 1 относились 52 (54,7±5,1%), к кластеру 2- 43 (45,3±5,1%) новорожденных. Контрольную группу составили 33 условно-здоровых недоношенных из них все 33 (100%) оказались вкластере 2.

Таблица 1. Кластерный анализ факторов риска развития перинатальных инфекций у недоношенных новорожденных

	Кластер		Ошибка		F	Знч.
	Средний квадрат	ст.св.	Среднийквадрат	ст.св.		
Пол	0,905	1	0,248	464	3,657	0,056
Гестационный возраст	1489,340	1	3,178	464	468,622	0,000
Возраст матери	94,122	1	31,037	464	3,033	0,082
Паритет родов	0,559	1	0,741	464	0,755	0,385
Двойня	2,996	1	0,364	464	8,234	0,004
Выкидыш	0,157	1	0,258	464	0,608	0,436
Гинекологический анамнез	9,990	1	1,649	464	6,059	0,014
Анемия	0,810	1	0,223	464	3,628	0,057
Гестоз	6,768	1	0,208	464	32,485	0,000
Экстрагенитальная патология	3,702	1	4,153	464	0,891	0,346
Угроза выкидыша	2,392	1	0,184	464	12,983	0,000
Смерть плода	3,428	1	0,100	464	34,138	0,000
Все тела	94145207,561	1	116101,765	464	810,885	0,000
Рост	5670,396	1	17,822	439	318,163	0,000
Окружность головы	684,237	1	3,036	330	225,395	0,000
Окружность груди	607,280	1	4,036	306	150,462	0,000
Апгар на 1 минуте	111,819	1	1,856	75	60,261	0,000
Апгар на 5 минуте	61,793	1	1,037	75	59,615	0,000
Гемоглобин	1363,030	1	874,858	428	1,558	0,213
Эритроциты	,336	1	1,662	395	0,202	0,653
Лейкоциты	237,441	1	49,272	406	4,819	0,029
С-реактивный белок	445,450	1	444,030	168	1,003	0,318
Поражение ЦНС	7,234	1	0,645	464	11,208	0,001
Дыхсистема	18,085	1	0,412	464	43,867	0,000
ЖКТ	2,680	1	0,675	464	3,973	0,047
МПС	3,138	1	0,384	464	8,166	0,004
ССС	0,285	1	0,522	464	0,547	0,460
Полиограннед	10,410	1	1,149	464	9,062	0,003
ГИП ЦНС	1,271	1	0,243	464	5,232	0,023
ГГП ЦНС	1,056	1	0,215	464	4,923	0,027
ИП ЦНС	0,137	1	0,131	464	1,049	0,306

Как видно наибольший процент новорожденных со смешанной и бактериальной инфекциями относятся к 2 неблагоприятному кластеру, что свидетельствует о тяжести и генерализации инфекционного процесса.

Во II группе обследованных матерей новорожденных с перинатальными инфекциями результативным признаком реализации инфекции явились высокий удельный вес гестоза II половины бере-

менности (χ^2=6,77; p<0,001), гинекологических заболеваний (χ^2=9,99; p=0,014), угроза выкидыша (χ^2=0,157; p<0,001), многоплодная беременность(χ^2=2,996; p<0,001), смерть плода в антенатальном периоде (χ^2=3,428; p<0,001). Изучение результативных признаков выявило низкие антропометрические параметры новорожденных: масса тела (p<0,001), рост (p<0,001), окружность головы (p<0,001), окружность груди (p<0,001). У детей с клиническими проявлениями перинатальной инфекции отмечается более низкий гестационный возраст (p<0,001), асфиксия при рождении по шкале Апгар на 1 минуте p<0,001), на 5 минуте (p<0,001), Проведенныйсравнительный анализ состояния детей позволил составить характеристики отдельных систем.У инфицированных новорожденных (кластер II) выявлены статистически значимые различия в частоте встречаемости гипоксически-ишемическое поражение ЦНС (χ^2=1,271; p=0,023), гипоксически-геморрагическое поражение ЦНС (χ^2=1,056; p=0,027), поражение дыхательной системы (χ^2=18,085; p<0,001), поражение ЖКТ (χ^2=2,860; p=0,047), мочеполовой системы (χ^2=3,138; p=0,004), полиорганная недостаточность (χ^2=10,410; p=0,003).

Анализ полученных данных выявил, что недоношенных 2 кластера с более отягощенным анамнезом матери и тяжелым неблагоприятным течением инфекционного процесса больше в группе новорожденных с ЦМВИ и неонатальным сепсисом. Следует отметить, что количествонедоношенных 2 кластера больше, чем доношенных.

Заключение

Исследование факторов, определяющих выделение кластеров клинического статуса, являются качественно новыми критериями оценки обследуемыхноворожденных.Полиморфность врожденных (внутриутробных) инфекций, общность патогенеза их развития определяют вариабельность клинической картины этих заболеваний, отсутствие патогномоничных симптомов, и как следствие, потребность в широком полиэтиологическом обследовании. На основе изучения факторов, предрасполагающих к развитию перинатальных инфекций, а также многофакторного математического кластерного анализа идентифицированы анамнестические и клинические особенности течения заболевания, что позволило всех наблюдаемых новорожденных разделить на 2 кластера. На основании результатов собственных исследований разработан способ прогноза заболевания с учётом кластерной организации клинического статуса, позволяющий оценивать состояние новорожденных, не требующих специализированных лабораторных методов исследования. Кластерный анализ по анамнестическим, клинико-лабораторным параметрам выявил относительно благоприятный кластер 1 и неблагоприятный кластер 2. Недоношенные с моно (ЦМВИ) 69,1±3,1% и микст-инфекциями (63,6±4,5%) относились ко 2 кластеру, что свидетельствовало о тяжести и генерализации инфекционного процесса.

Созданная с помощью многофакторных математических методов и кластерного анализа система информативных анамнестических, клинико-лабораторных и инструментальных критериев дает возможность прогнозированию и формированию групп риска по развитию перинатальных инфекций, а также служит основой для выбора наиболее эффективных препаратов для иммунокоррекции.

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PHYSICAL SCIENCES

DISPOSAL OF SPENT IONIZATION RADIATION SOURCES COBALT-60

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https://doi.org/10.5281/zenodo.7032324

Abstract
The article discusses the experience work of specialists of the consortium as part of the INP AS (Tashkent, Uzbekistan), JSC " JSC «Research Institute of Technical Physics and Automation»" and CJSC "Mounting Firm "Radiy" (Moscow, Russia) at utilization of 96 pieces of sources GIK-7-2 Co-60 of gamma installations of "RKhM-gamma-20" and "Issledovatel", including 2 emergency sources Co-60, their burial in specialization point for radioactive waste. Also, the experience of specialists in the elimination of emergency situation with recharge a highly active source of GIK 8-4 Co-60 for radiation gamma therapy from emergency holder with crack to a new holder from depleted uranium. The reason for the appearance of a crack on the body of the Co-60 source holder is discussed.

Keywords: radionuclide Co-60, emergancy situation, gamma-installation, ionization radiation source holder, deplated uranium, radioactive waste.

1. Introduction

Radiation technologies in scientific research, irradiation of materials and foods, gamma therapy in oncology is based on use gamma-radiation of closed source of ionizing radiation with radionuclide Co-60, which has a half-life of 5.2714 years and very hard energy of gamma radiation (1.732 and 1.3325 MeV). Sealed sources GIK 8-4 and GIK 7-2 Co-60 belong to dangerous radioactive sources of category 1 [1] and if safety rules are not observed or their protection is not reliable, they can cause irreparable harm to human health and the consequences can be fatal.

There are 16 large medical institutions in Uzbekistan with devices for radiation gamma therapy with Co-60 sources for oncological dispensaries, as well as a gamma installation with GIK-7-4 sources at the INP AN in Tashkent and a gamma installation GUBE-6000 of the Veterinary Research Institute with GIK- 7-2 in Samarkand region. Currently, the actual tasks are the utilization of expired Co-60 sources, and the related training of personnel to work with Co-60 sources, the development of technologies, special instruments and equipment used for their disposal. To work with high-level sources of Co-60, a consortium was created consisting of specialists from JSC "NIITFA", CJSC "MF" Radiy "and the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan, the purpose of which is to utilize sources of ionizing radiation Co-60 GIK 8-4 and GIK 7-2 and eliminate emergencies with them.

The article is aimed at presenting the experience of the consortium in the elimination of accidents with high-level sources of Co-60, as well as their disposal.

2. Materials and methods

Gamma-installations «RKhM-γ-20» and «Issledovatel» of JSC «Foton» were designed to conduct radiation research in the field of solid state physics, radiobiology, medicine and production and technological processes for gamma irradiation of semiconductor products. The assigned life of Co-60 sources has expired six times, however, the total activity of 96 pcs. sources of Co-60 GIC 7-2 in both gamma installations was 2.056 ·1013 Bq (555.4 Ci).

To discharge Co-60 sources from gamma-ray plants, a reusable transport packaging kit UKT-1V-26-12 with a rechargeable container KTB-250-12 was used (Fig. 1).

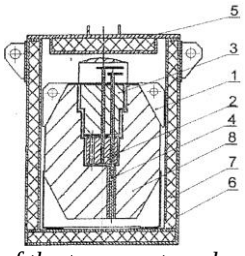


Fig. 1. Scheme of the transport packaging kit UKT1V-26-12: 1 - KTB-250-12 rechargeable container; 5 - cover of the protective container; 2 - drum; 6 - body of protective packaging; 3 - cork;7 - thermal protection.

In Table 1 are shown specifications of the UKT1V-26-12 packaging kit.

Table 1. Technical characteristics of the packaging kit UKT1V-26-12.

Facing	Steel type X18H10T
Protection	lead
Maximum container dimensions	diameter – 680 mm, height – 860 mm
Nest dimensions	diameter - 14 mm, height – 105 mm
Weight, kg	2320
Number of working channels	12
Permission loading sources Co-60	up to 25 kCi

Installations "RKhM-γ-20" and "Issledovatel" are lead containers, in the center of which there are working chambers located around the circumference with tubular cassettes ("squirrel wheel"), each of which could accommodate up to 6 GIK 7-2 sources Co-60 with dimensions: Ø=11.2 mm, h=81.5 mm. Fig. 2 shows the structural diagram of the "Issledovatel" gamma installation [2].

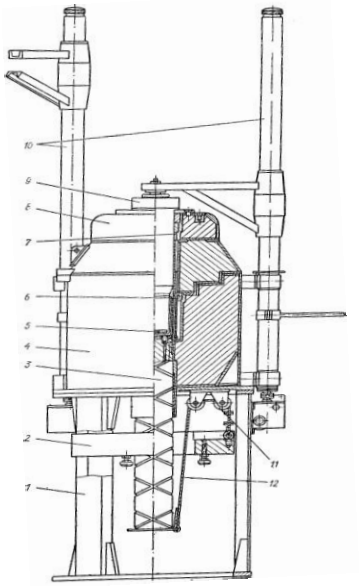
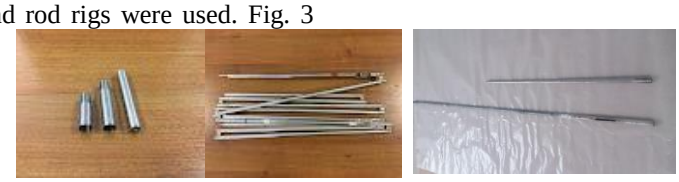


Fig. 2. Structural scheme of the "Issledovatel" gamma-installation: 1 - bed; 2 - counterweight; 3 - stock; lead container (radiation head); 5 - work table; 6 - cylindrical irradiator; 7-beam shutter; 8-shutter body; 9-cork; 10-lift mechanism;11 - blocks; 12- cables.

For the removal of GIK 7-2 Co-60 sources from the «RKhM-γ-20» and «Issledovatel» gamma-installations, standard collets and rod rigs were used. Fig. 3 shows a general view of the collets, rods and non-standard tools for removing 2 emergency Co-60 sources.



a *b* *c*

Fig. 3. Photo view of the collet (a), rod (b) and developed a new non-standard tools (c) for the removing 2 emergency Co-60 sources.

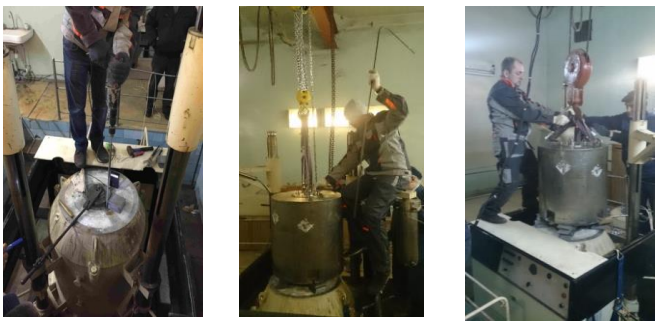
Non-standard tools are hollow tubes with pointed ends that attach to a drill and do the job of removing the epoxy around the Co-60 source.

The specialists with DPG-03 thermo luminescent dosimeters and «Rados Rad-60» (Radiation Safety Associates Inc.) dosimeters were provided. Dosimetric control of the exposure dose rate by dosimetric device IdentyFINDER R400 (USA) was carried out. The radiation-hazardous work of the personnel was carried out under constant dosimetric monitoring of the radiation level in compliance with sanitary standards and radiation safety requirements (SanPiN # 0193-06) [3].

3. Results and discussion

The consortium performed work on the radiation-safe mode of unloading 96 sources of Co-60 GIK 7-2, including 2 emergency sources from the gamma-ray installation "Issledovatel", they were transported by special vehicles during 4 times (total 560 km) from JSC "Photon" (Tashkent city) to the Republican State Enterprise for the Disposal of Radioactive Waste (settlement Aydarali, Tashkent region) accompanied by a police convoy and were buried in the storage of spent radioactive sources. An emergency situation is present when discharging from a gamma plant 2 emergency sources of Co-60, which are present in the hardened epoxy

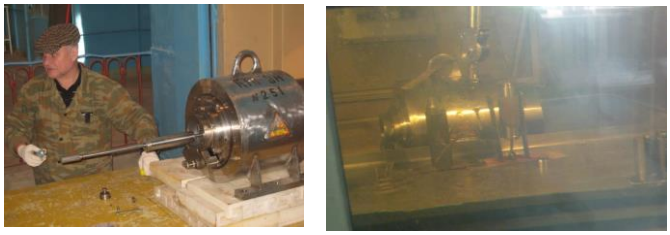
resin. In this emergency situation, standard equipment could not be used, so a non-standard tools was developed. Fig. 4 shows the use a non-standard tool for removing emergency sources 2 that were in the hardened epoxy resin and specially designed tools were used to destroy the epoxy resin (a).



a *b* *c*

Fig. 4. Destruction of epoxy resin (a), removal of emergency Co-60 sources from the «Issledovatel» gamma-installation (b), dismantling of the KTB-250-12 recharge container with Co-60 sources (c).

Another joint work of the consortium was the elimination of an accident with Co-60 radiation ionization source in an emergency holder of a gamma therapeutic remote apparatus in the Namangan Regional Oncological Dispensary, where the emergency situation arose due to a jamming in a transport and reloading container of the KTP-5M type of a clip with radioactive cobalt-60 of the GIK 8-4 type with an activity of 3750 Ci. The holder together with the source could not be removed from the rechargeable container using standard technology, which required the return of Co-60 to the manufacturer from the Russian Federation. Emergency situation by the personnel using special equipment with remote manipulators in a protective box of Republican central isotope laboratory was resolved. In the protective box, the holder with the Co-60 source was removed through the inlet channel using remote manipulators, the source was transferred to a new holder, which was then placed in the KTP-5M container in accordance with the flow chart (Fig 5).



a *b*

Fig. 5. Preparatory work with recharge container KTP-5M (a) and recharging of the Co-60 source from the emergency holder into a new holder in protective box (b).

The dosimetrically measurements on Radiagem-2000 radiometer and gamma spectrometric measurements immersion liquid on DSA-1000 digital multichannel spectrum analyzer with Genie-2000 software (Canberra, USA) were carried out.

The exposure dose rate (EDR) on the surface of the recharge container KTP-5M was 10.8 μSv/h, while the EDR in the working room was 0.25 μSv/h. After removing the Co-60 source from holder, a visual inspection of the holder body showed the presence of two longitudinal cracks on its surface, as a result of which the holder body swelled and increased by 0.94 mm in diameter, which led to a problem with its removal through the outlet channel of the container for recharging. Fig. 6 shows crack on the body of source holder.

Fig. 6. Crack on the body of the source holder.

However, a crack in the body of the holder did not lead to a violation of the tightness of the Co-60 source itself, the tightness of which was checked by the immersion method [4]. The gamma spectrometric analysis data of immersion liquid was showed that the Co-60 source is sealed because activity of immersion liquid is ≤185 Bk [5]. The method of dry and wet smears of radioactive contamination on the body of the holder was not detected.

Often there are emergencies with containers containing an alloy of depleted uranium (radiation heads of gamma flaw detectors, protective and transport containers).

Fig. 7 shows a depleted uranium container (a) containing a source of Co-60 for disposal and a depleted uranium plug fully wedged into the container body due to expansion (b).

a *b*

Fig. 7. Depleted uranium container (a) containing a source of Co-60 and a plug of depleted uranium that was completely wedged into the body of the container during expansion (b).

The emergency situation could be eliminated and the container lid with radiation ionization source of Co-60 opened only by repeatedly exposing the plug to alternating low temperature with liquid nitrogen (-196 ^{0}C) and high flame temperature with a gas burner (+500 ^{0}C).

When analyzing the cause of a crack in the depleted uranium holder body or jamming of the depleted uranium container cap, it was concluded that in the presence of oxygen, water vapor can be adsorbed on the walls of the holder with depleted uranium, which reacts violently with uranium with the release of hydrogen, which reacts with uranium to form pyroform uranium hydride [6]. As a result, the lid of the depleted uranium container swells or a crack occurs in the body of the container.

The ongoing chemical reactions can be represented by the following equation:

$$7U + 6H_2O = 3UO_2 + 4UH_3 + Q \uparrow \quad (1)$$

As is known, the density of depleted uranium is 19 g/cm³, therefore, with the complete oxidation of uranium due to oxygen and moisture from the air, a two-fold increase in the volume of the holder is possible. The cause of corrosion in the body of the holder is the thermodynamic instability of the metallic state of depleted uranium. It should be note that the IAEA classifies depleted uranium as category II nuclear material and defines the levels of physical protection during storage and transportation [7], which means that precautions must be observed when handling depleted uranium products.

4. Conclusions

In the total 96 pieces of exhausted Co-60 sources from the «RhM-γ-20» and «Issledovatel» gamma-installations at the appointed time and in compliance with radiation safety were discharged and utilizated as radioactive waste. Non-standard emergency with the removal of two emergency sources of Co-60 from the gamma installation successfully was completed [8]. The IAEA news reported on the successful completion of the international project [9].

The highly active source Co-60 GIK 8-4 from the emergency holder into a new holder of the gamma therapeutic installation was recharged. Replacement of the depleted uranium holder with a new one guarantees its further performance for 15 years.

The results of many years of work with depleted uranium products have shown that hydrolysis corrosion is observed in majority depleted uranium products used for radiation protection against gamma radiation (radiation head of gamma flaw detectors, transport packaging containers and protective containers for high radioactive closed radiation ionizing sources).

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TECHNICAL SCIENCES

ACCOUNT FOR THE INFLUENCE OF THE ECCENTRICITY OF CYLINDRICAL INSTALLATIONS FOR MEASURING THERMAL CONDUCTIVITY OF SUBSTANCES

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https://doi.org/10.5281/zenodo.7032332

Abstract
In cylindrical measuring devices for determining thermal conductivity, the heat flow and the temperature difference between coaxial endless cylindrical surfaces are considered. The technique for calculating the thermal conductivity for this case has long been worked out. In this work, the influence of the eccentricity of the working cylindrical surfaces of devices is theoretically determined when calculating the thermal conductivity. Approximate equations are found for calculating the thermal conductivity of liquids and gases.

Keywords: heat transfer, thermal conductivity, cylindrical calorimeter, eccentricity

When designing new technological processes, the correct selection of materials for the manufacture of equipment is necessary. These devices should be as hardy as possible, and the processes should be efficient. Data on the thermal conductivity of substances are needed to calculate the heat transfer processes taking place in these devices.

There are many experimental methods for determining thermal conductivities, both stationary and non-stationary [1, p. 19-72]. Non-stationary methods have a number of advantages and therefore are more often used [2, p. 347-355; 3, p. 12-22]. Depending on the shapes of the working surfaces, cylindrical, spherical and flat bicalorimeters are distinguished [1, p. 77-81].

For accurate calculations of thermal conductivity by these methods, it is necessary to take into account many errors in the eccentricity of the measuring cylinders. Eccentricity greatly affects the result of calculations.

Let us determine the exact solution of the problem of the influence of eccentricity for eccentric cylinders. Let's consider the differential heat equation [4, p. 30]

$$\frac{\partial^2 t}{\partial x^2}+\frac{\partial^2 t}{\partial y^2}=0 \qquad (1)$$

When solving equation (1), we use the method of sources (superposition principle), in which the temperature field is found by adding the temperature fields created by individual heat sources.

Two symmetrically located sources A and B excite a joint temperature field (Fig.1). For the case of infinite cylinders, the temperature difference is determined by the following expression:

$$\theta=\frac{Q}{2\pi\lambda}\ln\frac{r''}{r'} \qquad (2)$$

For a point m on the first cylindrical surface, we can write:

$$\left.\begin{aligned}\frac{r_m''}{r_m'}&=\frac{r_m''+d}{d-r_m'}\\ r_m''-r_m'&=2(h-r)\\ r_m''+r_m'&=2Y_0\end{aligned}\right\} \qquad (3)$$

Solving the system of equations (3), we find

$$h=\frac{r^2+\left(a'\right)^2}{2a'} \qquad (4)$$

Given that $y_0=h-a'$.

For the second cylindrical surface with radius *R*:

$$H=\frac{R^2+\left(a''\right)^2}{2a''} \qquad (5)$$

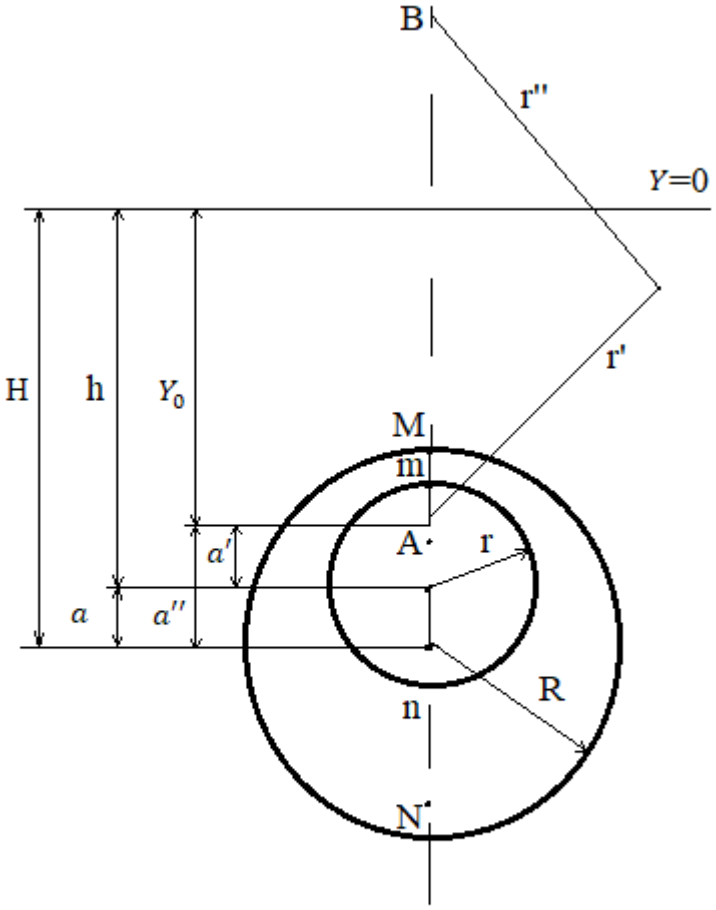

Fig. 1

Also for both surfaces we can write:

$$\frac{r_m^{''}}{r_m^{'}} = -\frac{r}{a^{'}} \tag{6}$$

$$\frac{r_M^{''}}{r_M^{'}} = -\frac{R}{a^{''}} \tag{7}$$

Temperature difference between eccentric cylindrical surfaces

$$\Delta t = \frac{1}{2\pi\lambda} Q_t \ln \frac{ra^{''}}{Ra^{'}} \tag{8}$$

We use the last expression and express $a^{'}$ and $a^{''}$ in terms of the eccentricity a

$$\left.\begin{aligned} a^{''} - a^{'} = a \\ H - h = a \end{aligned}\right\} \tag{9}$$

Using expressions (9), as well as (4) and (5), we find

$$a^{'} = \frac{R^2 - r^2 - a^2 - \sqrt{\left(R^2 - r^2 - a^2\right)^2 - 4a^2r^2}}{2a}, \tag{10}$$

$$a^{'} = \frac{R^2 - r^2 + a^2 - \sqrt{\left(R^2 - r^2 - a^2\right)^2 - 4a^2r^2}}{2a}. \tag{11}$$

From (8), (10) and (11) we get

$$\lambda = \frac{Q_l}{2\pi\Delta t} \ln \frac{r\left[R^2 - r^2 + a^2 - \sqrt{\left(R^2 - r^2 - a^2\right)^2 - 4a^2r^2}\right]}{R\left[R^2 - r^2 - a^2 - \sqrt{\left(R^2 - r^2 - a^2\right)^2 - 4a^2r^2}\right]}. \tag{12}$$

From (9), (4) and (5) we find the second solution for $a^{'}$ and $a^{''}$

$$a^{'} = \frac{R^2 - r^2 - a^2 - \sqrt{\left(R^2 - r^2 + a^2\right)^2 - 4a^2R^2}}{2a}, \tag{13}$$

$$a^{'} = \frac{R^2 - r^2 + a^2 - \sqrt{\left(R^2 - r^2 + a^2\right)^2 - 4a^2R^2}}{2a}, \tag{14}$$

as well as

$$\lambda = \frac{Q_l}{2\pi\Delta t} \ln \frac{r\left[R^2 - r^2 + a^2 - \sqrt{\left(R^2 - r^2 + a^2\right)^2 - 4a^2R^2}\right]}{R\left[R^2 - r^2 - a^2 - \sqrt{\left(R^2 - r^2 + a^2\right)^2 - 4a^2R^2}\right]}. \quad (15)$$

From (12) at $a = 0$, for the case of coaxial cylinders we have

$$\lim_{a\to 0} \frac{r\left[R^2 - r^2 + a^2 - \sqrt{\left(R^2 - r^2 - a^2\right)^2 - 4a^2r^2}\right]}{R\left[R^2 - r^2 - a^2 - \sqrt{\left(R^2 - r^2 - a^2\right)^2 - 4a^2r^2}\right]} = \frac{R}{r}. \quad (16)$$

Then, under certain assumptions, we can obtain an approximate formula

$$\lambda = \frac{Q_l}{2\pi\Delta t} \ln \frac{r\left[R + r + a - \sqrt{\left(R + r - a\right)^2 - 4\frac{ar^2}{R - r}}\right]}{R\left[R + r - a - \sqrt{\left(R + r - a\right)^2 - 4\frac{ar^2}{R - r}}\right]}. \quad (17)$$

The last equation for the values $d_1 = 0{,}1mm, d_2 = 1{,}5mm, a = 0{,}1mm$ gives the error 0.5%, and equation (12) 0.02%.

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POSSIBILITIES FOR DISTRIBUTED RESOURCE DELIVERY FOR DIGITAL ECONOMY APPLICATIONS: ANALYSIS OF WEB SERVICES

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ВОЗМОЖНОСТИ ПРЕДОСТАВЛЕНИЯ РАСПРЕДЕЛЕННЫХ РЕСУРСОВ ДЛЯ ПРИЛОЖЕНИЙ ЦИФРОВОЙ ЭКОНОМИКИ: АНАЛИЗ ВЭБ СЕРВИСОВ

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https://doi.org/10.5281/zenodo.7032338

Abstract

To date, companies and organizations have become convinced of the benefits of duly and proper use of information resources as a factor in increasing the competitive advantages of activities in the digital economy. Web services represent an important component of accessing to digital resources that are widely used in everyday life and have become an integral part of modern business. The paper explores the features of providing web services, considers the features of web services model for the platform implementation of resources, and demonstrates the implementation possibilities using the example of a specific service for e-government applications.

Аннотация

На сегодняшний день предприятия и организации убедились в преимуществах своевременного и должного использования информационных ресурсов как фактора увеличения конкурентных преимуществ деятельности в условиях цифровой экономики. Важным элементом доступа к цифровым ресурсам являются веб-сервисы, которые широко используются в повседневной жизни и стали неотъемлемой частью современного бизнеса. В статье исследуются особенности предоставления веб-сервисов, рассмотрены положения модели веб-сервисов для платформенной реализации ресурсов и на примере конкретного сервиса для приложений электронного правительства показаны возможности реализации.

Keywords: web service, resources, applications.
Ключевые слова: веб-сервис, ресурсы, приложения.

Введение

В условиях формирования и развития цифровой экономики все большее значение приобретает использование ресурсов разных категорий: это особенно актуально в связи с позиционированием цифровых ресурсов в экономике и их влиянием на конкурентные преимущества компаний [1-3].

Цифровая экономика поддерживается распространением информационных и коммуникационных технологий (ИКТ) во всех секторах бизнеса для повышения его производительности. Цифровая трансформация экономики меняет традиционные представления о том, как устроен бизнес, как потребители получают товары и услуги и как государства должны адаптироваться к новым задачам по регулированию отраслей экономики.

В настоящее время все больше людей работают в Интернете, и с ростом активности в Интернете, которая способствует развитию мировой экономики, компании, поддерживающие системы Интернета, становятся более прибыльными. При этом сеть Интернет становится общепризнанным фактором деловой и общественной жизни. Широкая распространенность и возросшая пропускная способность создают условия, при которых выгодно решать многие задачи при помощи интернет-технологий.

Однако Интернет объединяет в себе много различных платформ, а информация содержится в разнообразных источниках данных. Поэтому актуальна проблема связи таких разнородных данных, а также создания способа, который позволяет получать их в виде, удобном для дальнейшей обработки. Концепция веб-сервисов (Web Services) призвана решить эту задачу объединения, интеграции разнородных систем на основе открытых стандартов [4,5].

Веб-сервисы быстро становятся важной технологией в процессе развития сети и распределенной обработки данных. Интерфейсы веб-сервисов являются оболочками, которые отображаются в любые типы программ, систем связующего программного

обеспечения, систем управления базами данных или пакетов приложений.

На основе стандартных структурных блоков веб-сервисов создаются новые типы приложений, что позволяет обеспечить значительную экономию за счет автоматизации взаимодействия организаций и потребителей через Интернет. Технология веб-сервисов изменяется очень быстро и для получения более полного представления о ней потребуется изучить большой список характеристик и функциональных возможностей.

На сегодняшний день сформировались стандарты регистрации, поиска и качества услуг, веб-сервисы используются в повседневной жизни и стали неотъемлемой частью всемирной паутины. Это действительно даёт предприятиям возможность находить друг друга и осуществлять любого вида операции между собой в кратчайшие сроки. В связи с этим, далее в статье исследуются особенности предоставления веб-сервисов, рассмотрены положения модели веб-сервисов для платформенной реализации ресурсов и на примере конкретного сервиса для приложений электронного правительства и показаны возможности его реализации.

Особенности платформы и средств разработки Веб – сервиса

При создании веб-сервиса целесообразно использование языка программирования Java. Платформа Java (https://www.java.com/ru/) предлагает ряд программных интерфейсов реализации технологии Web-сервисов. Созданный с их применением набор классов, представляющий Web-сервис, не является самостоятельным приложением для операционной системы, а разворачивается в определенной среде выполнения. В данном приложении «веб - сервис» такую среду выполнения предоставляет реализация платформы Java 2EE.

Платформа Java 2EE, дополнительно к реализациям технологии Web-сервисов платформой Java SE, обеспечивает поддержку технологий Web-сервисов в таких спецификациях, как Java API for RESTful Web Services (JAX-RS), Implementing Enterprise Web Services, Java API for XML-Based RPC (JAX-RPC), Java API for XML Registries (JAXR), Java API for XML messaging (JAXM), и использовались в данном случае для формирования ответов в формате .json и .xml. В целях лаконичности статьи, мы опускаем детали технического описания реализации сервиса в этой платформе и остановимся на некоторых практических аспектах.

Данный веб – сервис разработан на основе Spring Framework –это фреймворк с открытым исходным кодом, он предоставляет набор легковесных инструментов, которые облегчают решение задач в приложениях корпоративного масштаба. Область применения данного фреймворка не ограничивается разработкой программных компонентов, выполняющихся на серверной стороне приложений. Любое приложение может использовать Spring для устранения сильной связанности, и облегчения тестирования. Главная цель использования фреймворка – упрощение разработки приложения на языке Java. В приложениях на основе Spring используемые объекты хранятся в контейнере.

При разработке веб - сервиса был использован модуль WEB-MVC (рис.1). Фреймворк Spring MVC обеспечивает архитектуру паттерна Model – View – Controller при помощи слабо связанных готовых компонентов. Паттерн MVC разделяет аспекты приложения (логику ввода, бизнес-логику и логику пользовательского интерфейса), обеспечивая при этом свободную связь между ними.

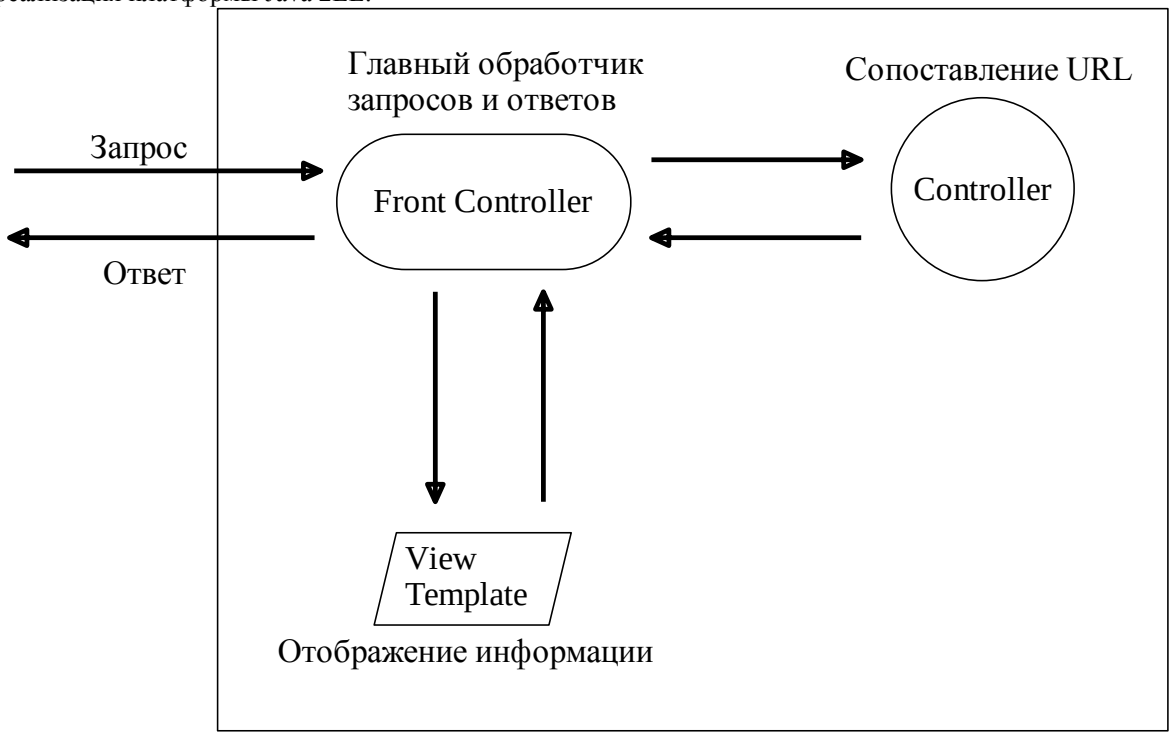

Рис. 1. Структура модуля Web-MVC

Конфигурируемая передача объектов Java через вызов удаленных методов (Remote Procedure Call): основная цель применения этой концепции состоит в разделении бизнес-логики (модели) от её визуализации (представления, вида), позволяя, разделить данные, представление и обработку действий пользователя на три отдельных компонента:

- Модель (Model). Модель инкапсулирует (объединяет) данные приложения и предоставляет знания: данные и методы работы с этими данными, реагирует на запросы, изменяя своё состояние. Не содержит информации, как эти знания можно визуализировать.
- Представление, вид (View). Отвечает за отображение информации (визуализацию), как правило, генерируя HTML, которые мы видим в своём браузере.
- Контроллер (Controller). Обеспечивает связь между пользователем и системой: обрабатывает запрос пользователя, контролирует ввод данных пользователем и использует модель и представление для реализации необходимой реакции.

Веб – сервис для приложений электронного правительства предоставляет услугу, позволяющую дистанционную электронную запись - «электронная очередь», на приём к государственным органам в режиме реального времени. Идентификация в веб – сервисе может быть организована с помощью системы ID.UZ (проект UZINFOCOM https://www.id.uz/uz/info/11).

Веб – сервису требуется работать в распределенной сети, принимать запросы, обрабатывать их по требованию отправителей запросов, заносить запросы в базу данных требуемых организаций, а также возвращать результаты в строго ограниченном времени. В ответе веб – сервиса должна быть подробная информация, которая точно описывает, когда отправитель запроса может прийти на приём к государственному органу. На данный момент веб - сервис должен предусматривать реализацию услуг по обработке очередей к двум государственным органам.

Веб – сервису полагается иметь интерфейсы (Application Programming Interface, API) для того чтобы, обращаться к нему с других систем, а также для просмотра информации об очереди к государственным органам. Нужно, чтобы форматы ответов этих API отвечали требованиям консорциума W3C (https://www.w3.org), чтобы обеспечить кроссплатформенность, для связывания различных устаревших и новых платформ. Форматы ответных сообщений должны быть минимум двух расширений, это делается в целях поддержки как можно больше систем на разных платформах.

Описание веб – сервиса

Веб – сервис имеет набор методов, с помощью которых осуществляет дистанционную электронную запись (Электронная очередь) к органам государственной власти. Он был создан в качестве нового модуля для системы «Электронное правительство», в частности, для «Единого портала государственных услуг» my.gov.uz (рис.2).

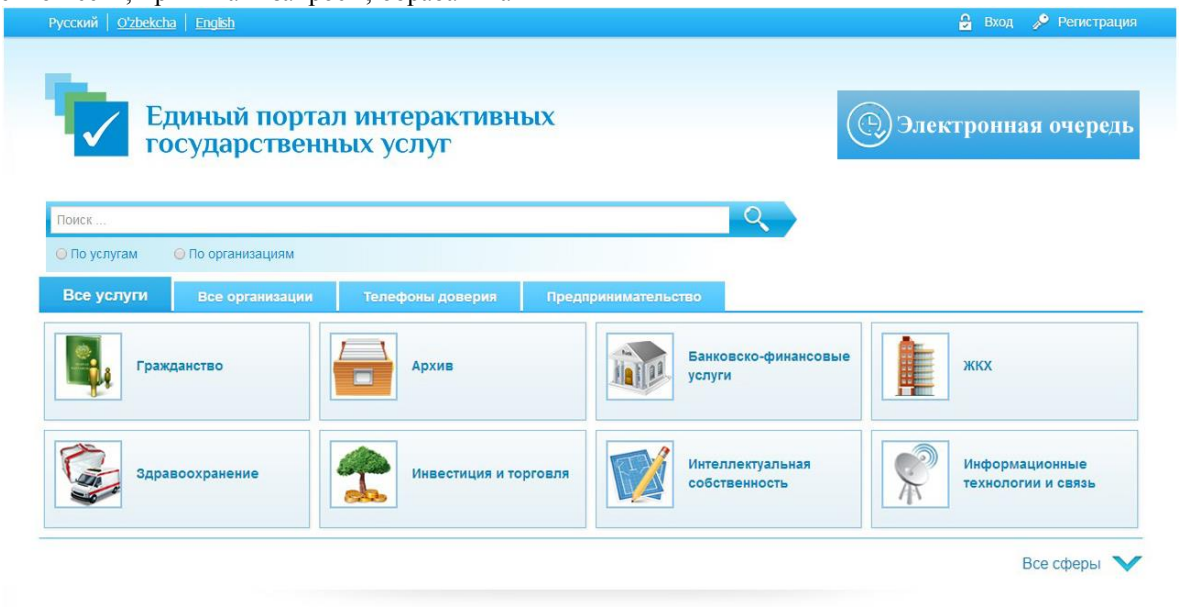

Рис. 2. Окно единого портала государственных услуг, где расположена ссылка на веб-сервис

Сервис предназначен для обеспечения полного цикла информационного взаимодействия в рамках оказания услуг в электронном виде. Под полным циклом взаимодействия подразумевается: прием заявления в электронном виде, предоставление интерфейсов, а также информирование о результате обработки заявления, являющегося результатом оказания услуги.

После регистрации субъект попадает на страницу, где предоставляется возможность выбирать государственную организацию, в которую планирует отправить запрос на запись в очередь (Рис. 3, в списке имеются две услуги, это запись на очередь на замену паспорта, а также запись на очередь на приём к участковому врачу).

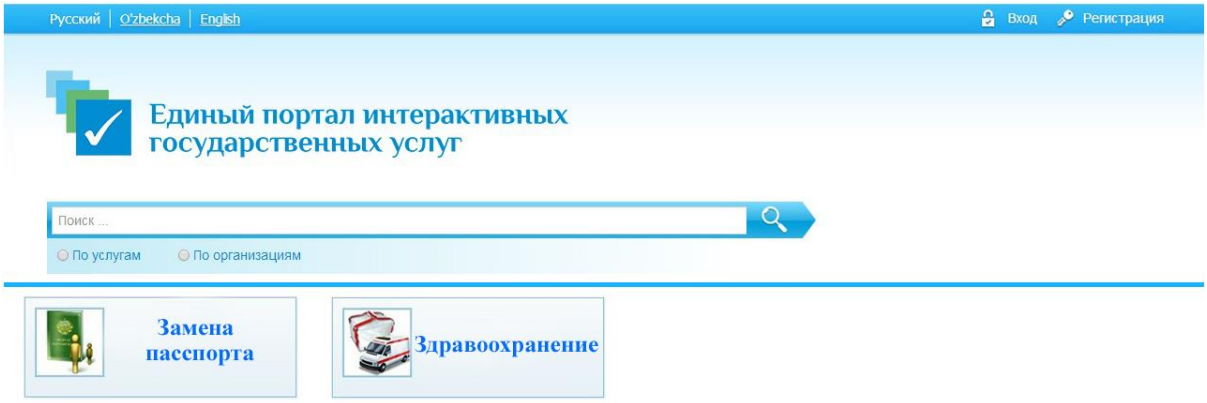

Рис. 3. Окно выбора организации

Следующий этап – это подтверждение субъектом информации, подтверждающей личность: на экран выводится таблица (рис. 4) и вся информация о субъекте: город, район, улица, дом, квартира, серийный номер паспорта и т.д. (из системы ID.UZ). Это делается для того чтобы субъект мог просмотреть и проверить свои данные на неизменность и достоверность.

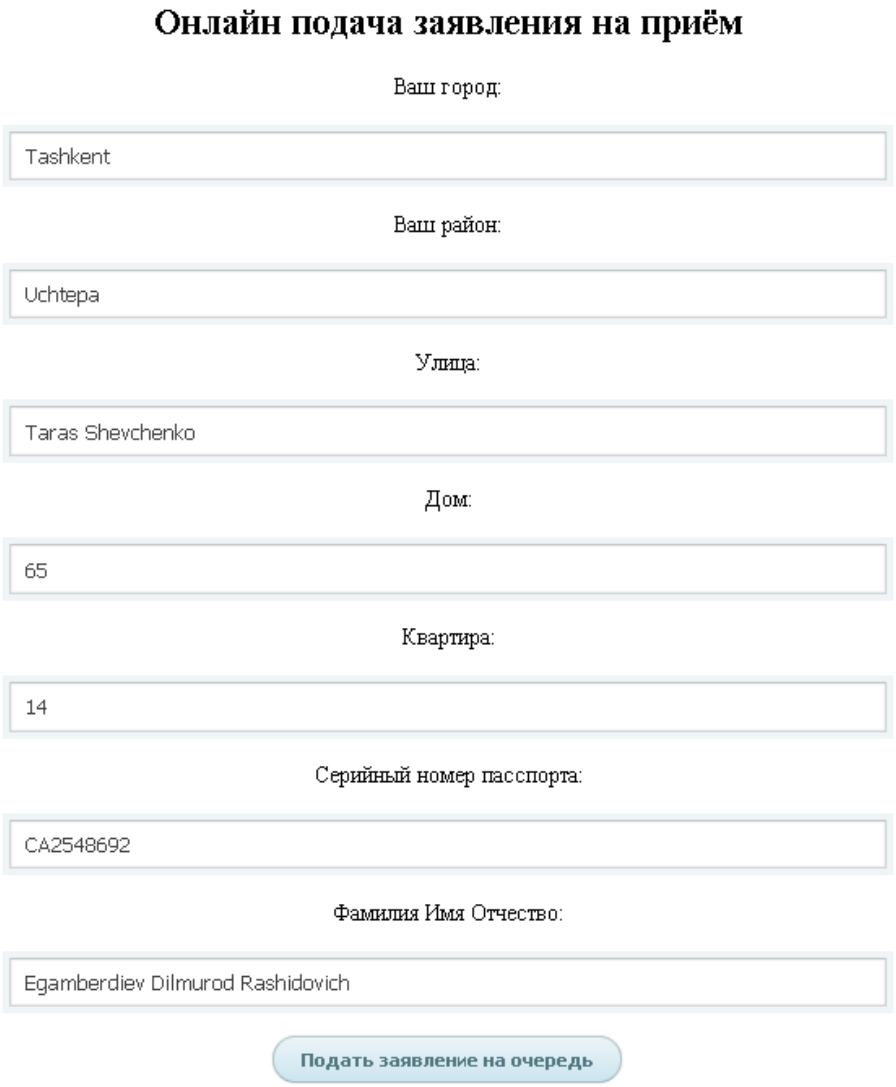

Рис. 4. Форма отправки запроса

После нажатии кнопки «подать заявление на очередь», форма методом POST отправляется в веб – сервис, где он обрабатывается, записывается в базу данных требуемой организации и обратно отправляется информация об успешной операции с подробной информацией. Обработка сервисом поступающих запросов состоит в следующем: во-первых, сервис определяет, на приём какого государственного органа субъект хочет записаться, в зависимости от этого сервис соединяется с базой данных этой организации, затем определяет график работы данной организации, государственные праздничные и выходные дни, после этого осуществляется запись на очередь.

Далее сервис создаёт уникальный идентификационный номер каждому новому субъекту, выясняет количество принимаемых субъектов данной организации на каждый день, а также по полученным данным с системы ID.UZ определяет дополнительные сведения (это могут быть как адреса государственных организаций, так и фамилия, имя, отчество участкового врача и т.п.). Ответ сервиса на данный запрос содержит точную дату, когда настанет очередь субъекта, подавшего заявление, уникальный идентификационный номер каждого субъекта, номер в очереди и общее количество очереди на тот день, а также дополнительную информацию об участковом враче и т.д. В ответе сервиса отображение дополнительной информации об общем количестве очереди на день прихода субъекта на приём к государственной организации, безусловно, помогает ему максимально ориентироваться во времени.

Заключение

Технология Web-сервисов обеспечивает взаимодействие между приложениями, работающими на различных платформах, с помощью программных компонентов. Web-сервисы призваны согласовывать работу больших, состоящих из множества частей приложений, предоставляя для приложений бизнес-функции обмена данными. Помимо функции обмена данными между различными приложениями и платформами, Web-сервисы могут выступать как повторно-используемые компоненты приложения, предоставляющие разнообразные сервисы. В условиях формирования цифровой экономики эти особенности вэб-сервисов обеспечивают множество возможностей для развития и расширения предоставляемых услуг в Интернете. Веб-сервис считается универсальным инструментом при работе с данными, что, безусловно, делает эту технологию привлекательной для реализации приложений.

В качестве объекта дальнейших исследований авторы намерены провести разработку системных основ создания и функционирования рабочего модуля для информационной системы в области трудовых отношений (для программного обеспечения поддержки взаимоотношений участников рынка труда и агентов), с использованием принципов, описанных выше для вэб-сервисов.

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VETERINARY SCIENCES

REGIONALIZATION OF SHEEP BREEDS IN AZERBAIJAN AND INNOVATIVE WAYS OF HORMONAL POLYOVULATION

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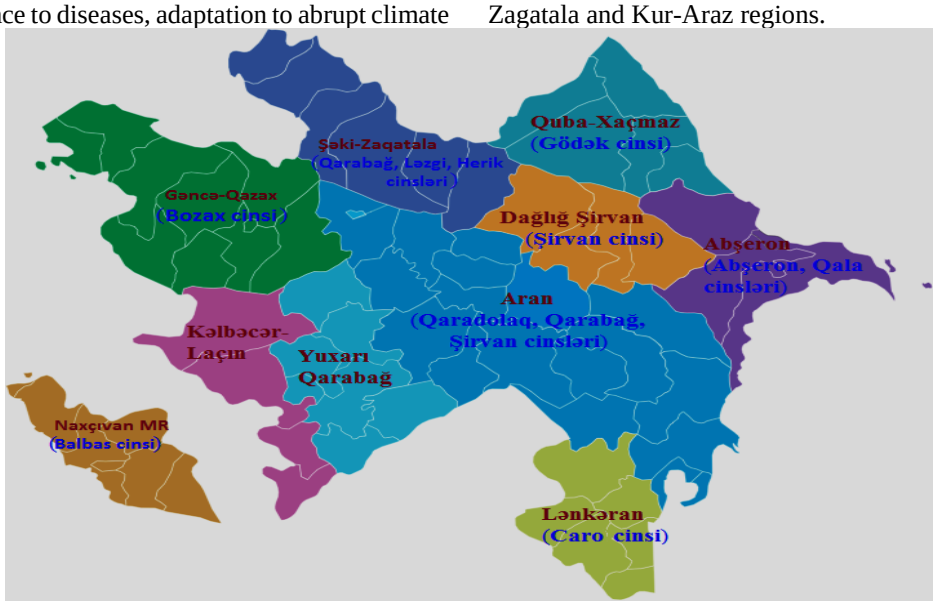
https://doi.org/10.5281/zenodo.7032348

Abstract
The article investigates the intensive development of the sheep breeding farms of the republic, their mating campaigns and their peculiarities. Also, a month before the ram rush, the hormones of melatonin and progesterone were added to the powder of barley and corn in the powder form, and the percentage of motivation and puppies was studied.
At the same time, specific features of Balbas breeds and their mating campaign was also analyzed.

Keywords: zegionalization, exterior, rational feeding, infections, congenital company, selection, breed, adapted.

Developing reproductive and feeding strategies under the project "Sustainable Sheep Development and Creating a Value Chain for Food Production" funded by the Government of Azerbaijan and implemented in December 2018 under the FAO-Azerbaijan Partnership Program. sustainable development of the value chain is intended as a goal.

Specific characteristics of local (local) sheep breeds should be analyzed and taken into account during regionalization in order to ensure and regulate sustainable, sustainable, rational development of sheep breeding in the Republic. Many sheep breeds should be studied with unique features and their adaptation (genetic resistance to diseases, adaptation to abrupt climate change, high calving, etc.). Thus, sheep are easily adapted to the influence of environmental factors in geographically diverse areas. Strong control over genetic biodiversity of sheep and the establishment of a proper management system provide a great guarantee for global food security, the needs of the population for food products, as well as other raw materials (fur, wool, puppies, etc.). Thus, Balbas breeds in Nakhchivan AR, Ganja and Gazakh regions of Bozakh breed, Gadabay and Shamkir regions of Azerbaijan Mountain Merino, Absheron peninsula and Gala rocks, Agjabadi of Karadalak, Lankaran It would be more desirable for breeding of Karabakh, Lezgi and Herik breeds in Sheki-Zagatala and Kur-Araz regions.



According to the sex zoning plan, the Balbas breed, widely cultivated and purified in the Nakhchivan Autonomous Republic, is white, with black spots around the eyes, ears and feet, below the glass. According to productivity indicators, Balbas sheep are still cultivated in the South Caucasus region, including the best breeds of sheep, meat, dairy and dairy. Balbas sheep is hornless, wool is of high quality and milk is fat. Sheep live weight is 55 kg and rams weigh more than 65 kg. The fat content in the tail is 6-7 kg in rams and 4-5 kg in the main sheep, and the wool is white and sufficiently long, 12-17 cm long. Sheep weighs 3-4 kg and 2.5-2.8 kg in sheep. The wool of lamb sheep is highly valued in weaving, especially carpet weaving. Milk productivity of fattening sheep is higher than that of other local sheep breeds. Fatty sheep give 70-75 kg of milk during lactation. This breed was created as a result of folk selection. Nails have long, well-developed joints, and nails are strong. Therefore, these sheep can travel about 18-20 km a day during the migration and can graze on the slopes. In well-fed flocks, the live weight of mother sheep is 60-70 kg, and the live weight of rams is 80-88 kg, sometimes 100-110 kg. The characteristics of feral sheep are very high. Therefore, it is advisable to regionalize this genus in the Autonomous Republic in accordance with the biological and economic characteristics of this genus.

Materials and methods of research

The research was conducted mainly on the experimental animals kept in the subsidiary production practice of Araz Scientific Production Association named after academician Hasan Aliyev in the Nakhchivan Autonomous Republic and in the Shakhbuz district support station. In the experiment used 40 head of Balbas breed sheep. The studies analyzed the specific characteristics of Balbas breeds of sheep kept in sheep farms of different regions of the autonomous republic and their mating campaign. In order to organize the mating campaign, a month before the ramming, sheep were given parchment and barley and cornmeal, along with melatonin and progesterone hormones. As a result, the sheep show a desire to escape at the same time, and the fat sheep give birth at the same time. Because of the high number of eggs in the mother sheep, which are used for hormone melatonin and progesterone, the number of twin lambs born during calving also increases. We have learned about mating campaigns in sheep breeds and their breeding characteristics. For this purpose, one month prior to slaughter, sheep were divided into 4 groups and fed in four forms: A (usual feeding - control group), B (intensive feeding - group 1), C (mixed feed from barley, sorghum and corn – group 2), D (meltingin and progesterone hormone supplementation in powdered barley and corn sprout - group 3).

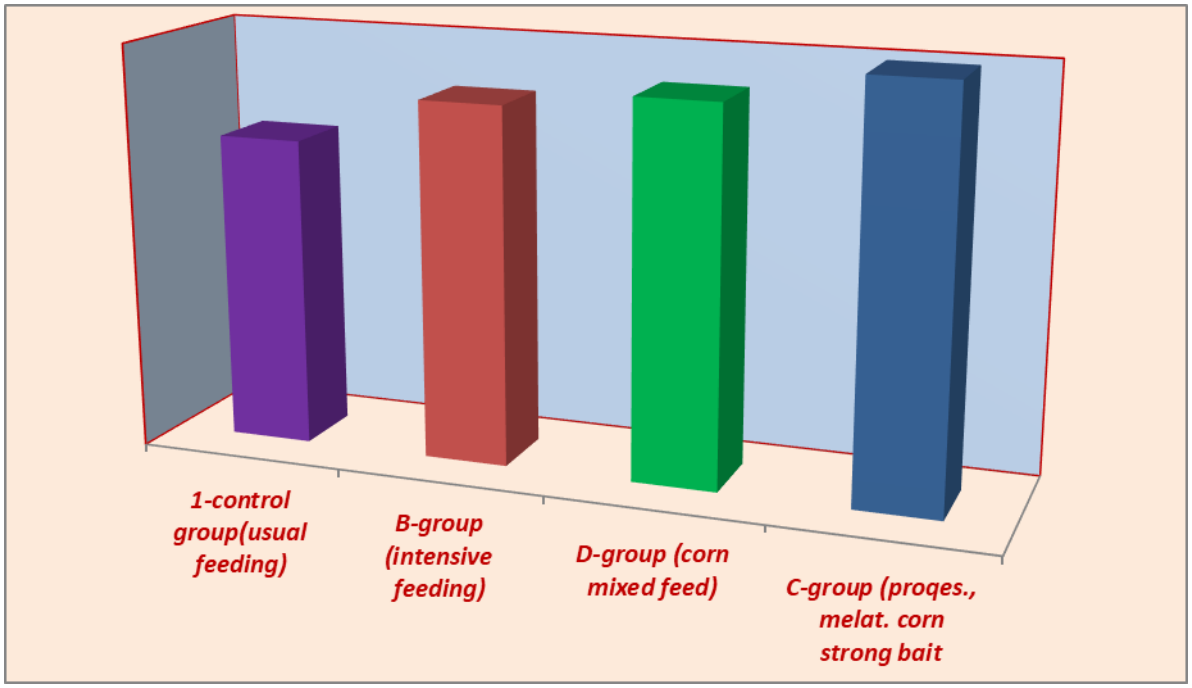


Diagram. *Feeding in groups of ewes one month before the lambing*

During the analysis of the research and experiments, motivation and calving in the sheep fed different feeding norms in the Araz Research and Production Association subsidiary farm (**Table**):

Table. Motivation and calving in maternal sheep fed with different feed norms

№	Group	Number of practice sheep	One month before feeding	Motivation (with-%)	Childbirth	Live weight in lambs (kg)
1	A-control	10	Usual feeding	70	80	2,5-2,8
2	B-1	10	İntensive feeding	80	90	2,6-3,0
3	C-2	10	Mixed feed: barley, sorghum, corn	90	110	2,0-2,7
44	D-3	10	Mixed fodder: melatonin, progesterone, barley, corn starch	100	140	1,8-2,5

Newborn lambs, active in control A-group, 2.5-2.8 kg, weaning -80%; B - live weight of lambs born in the 1st group is 2.6-3.0 kg, weaning -90%, C - average weight of lambs born in the 2nd group is 2,0-2,7 kg, weaning - 110%, D - average live weight of lambs in the 3rd group was less than 1.8 - 2.5 kg compared to the twin lambs and weighed 140%.

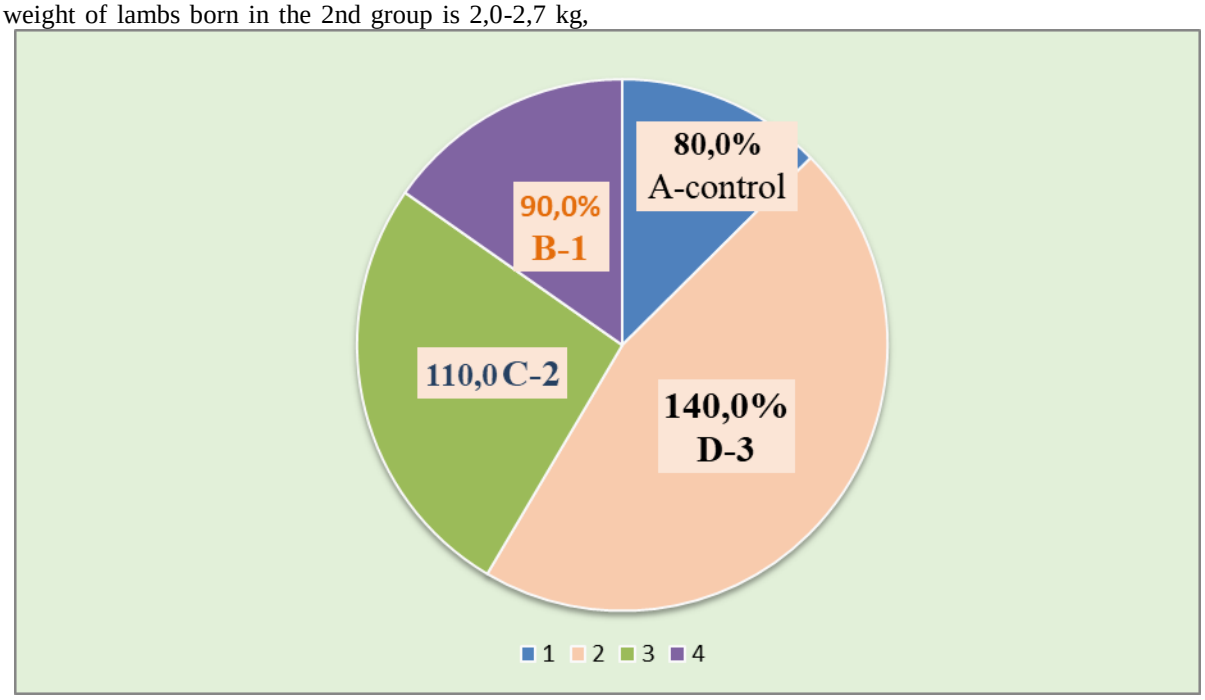


***Chart**. Percentage of breeding in domestic sheep*

Apparently, one month before the start of the mating campaign, 120-140 heads of baby sheeps can be obtained from one hundred head sheep per month if the mother sheep are given melatonin and progesterone hormones along with barley and corn starch. Sheep reaches puberty of 8-9 months, but it is advisable to carry out the first pair at 12-18 months. In sheep, the sex cycle is on average 17 days, stimulation is 24 hours, duration of throat is 145-150 days. Sheep breeds belong to short-days animals, that is, they have sexual activity in the autumn and short of the day. Different types of mating are used during this time. In a freely pairing, rams are freely driven in the sheep flock. (for every ram there are 20-25 mother sheep). Although this type of mating is simple, it requires a lot of rams. During manual pairing, the test rams are released into the herd, and the willing sheep are identified and paired on a special bench. In this pairing, one ram holds 60-80 head sheep. Artificial insemination allows you to make extensive use of the most valuable producer. During artificial insemination, 300-400 heads of sheep are fertilized with one ram's seed. Thanks to such measures the sheep show a desire to escape at the same time, and the fat sheep give birth at the same time. Normal calving usually takes about 30-40 minutes. As soon as the lamb is born, its mouth must be cleaned. After the mother licked and dried baby sheep, the the person who controls the fetus must feed the baby sheep. It is important that the lamb be fed with breast milk. In the absence of milk in the sheep, the lamb eats eggs yolk or the milk of another sheep that gave born at the same time. Contains the ability to function in the oral milk, which regulates the stomach and intestines of the lamb. Oral milk increases resistance to the body and prevents infections as well as gastrointestinal diseases. The giving birth sheep, were kept in the sheepfold for 2-3 days with a lamb. Also, the sheep 6-7 days are not allowed in the herd. Birth in sheep breeding takes place in winter and autumn. For winter lambing, having a sufficient forage base, lambs with high survival rate and productivity are born in warm pastures. Lambs born in winter eat quality food. Each lamb should be fed at least 0.6-0.7 kg of dry

grass and mixed feeds (compound feed) per day. One lamb is given 5-7 grams of granulated salt per day. In addition, the salt is added to the stable (lick salt).

Result. 1. Zoning of sheep breeds in the republic should be carried out in accordance with the regional zoning plan.

2. In order to organize the mating campaign, it is advisable to give the sheep a month before the start, with the addition of barley and cornflour, as well as melatonin and progesterone hormones.

3. On the sunny days in winter, the pregnant sheep should be allowed to go outdoors every day. This has a positive effect on the health of the sheep, the easy birth and the normal development of the baby.

4. Feeding of sheep should be properly compiled and feed rate for sheep kept in pasture conditions should be increased by 15-20%. The wintering period should be 70% in the diet, 20% in grains, 8% in juicy fodder and 2% in mineral feed supplements.

5. External environmental factors have a negative effect on the body of the sheep in the cold or extreme heat of the breed and the extreme heat, the change of air, and the presence of bilateral air currents in the stall. The temperature in the stove should be 10-120° C, and 150° C where baby lambs are stored. In the winter, the stables should be kept dry, at normal heat and clean.

6. Two weeks before the birth, the mother sheep should be selected, grazed under the supervision of experienced shepherds, as well as cared for, fed, cleaned and other processes must be conducted at the same time every day according to their working hours.

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№91/2022

Norwegian Journal of development of the International Science

ISSN 3453-9875

It was established in November 2016 with support from the Norwegian Academy of Science.

DESCRIPTION

The Scientific journal "Norwegian Journal of development of the International Science" is issued 24 times a year and is a scientific publication on topical problems of science.

1000 copies

Norwegian Journal of development of the International Science

Iduns gate 4A, 0178, Oslo, Norway

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