ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ

ҚАЙЫРЫМДЫЛЫҚ ҚОРЫ
HALYK
CHARITY FOUNDATION

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN
«Halyk» Private Foundation

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

3 (465)
MAY – JUNE 2024

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением,
Благотворительный Фонд «Халык»!

«ҚР ҰҒА» РҚБ Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.
Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*
Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.
Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19
http://www.geolog-technical.kz/index.php/en/

«Известия РОО «НАН РК». Серия геологии и технических наук».

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*
Periodicity: 6 times a year.
Circulation: 300 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19
http://www.geolog-technical.kz/index.php/en/

NEWS of the National Academy of Sciences of the Republic of Kazakhstan
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 3. Number 465 (2024), 179–195
https://doi.org/10.32014/2024.2518-170X.418
IRSTI 87.15.15

Sh.Yessenov Caspian University of Technology and Engineering, Aktau, Kazakhstan.

E-mail: ainur.zhidebayeva@yu.edu.kz

DEVELOPMENT AND EVALUATION OF THE EFFECTIVENESS OF NEW DESIGNS OF SOLAR DESALINATION POOLS FOR THE PRODUCTION OF FRESH WATER IN HOT CLIMATES

Syrlybekkyzy Samal — PhD, Associate Professor, Caspian University of Technology and Engineering named after Sh. Yessenov, Aktau, Kazakhstan
E-mail: samal.syrlybekkyzy@yu.edu.kz. ORCID 0000-0002-0260-0611;
Zhidebayeva Ainur — doctoral student in the field of training 8D060800 – "Ecology", Sh.Yessenov Caspian University of Technology and Engineering, Aktau, Kazakhstan
E-mail: ainur.zhidebayeva@yu.edu.kz. ORCID 0000-0002-1217-5305;
Aitimova Ainazhan — Assistant Professor of the Department of Ecology and Geology of the Caspian University of Technology and Engineering named after Sh. Yessenova, Aktau, Kazakhstan
E-mail: aitimova_ainazhan@mail.ru. ORCID 0000-0003-3135-7531;
Baimbetov Dinmukhambet — Assistant Professor of the Department of Energy and Automation of the Caspian University of Technology and Engineering named after Sh. Yessenova, Aktau, Kazakhstan
E-mail: kamshat.dzumasheva@yu.edu.kz. ORCID 0000-0003-0105-787X;
Taizhanova Lyailim — PhD, Assistant Professor of the Department of Ecology and Geology of the Caspian University of Technology and Engineering named after Sh. Yessenova, Aktau, Kazakhstan
E-mail: lyailim.taizhanova@yu.edu.kz. ORCID 0000-0002-9617-3218.

Abstract. The emergency for fresh water production is especially high in hot dry climates without any sources of drinking water but with abundance of sea and underground water. The problem solution is water desalination with efficient solar powered water treatment plants. This article proposes a new modification of a basin made of the thin finned corrugation with the 43 °angle inclined sides equal to the region latitude, what provides their stronger heating. The experiments were carried out in hot climate of Aktau city (43° 49'N 51°1'E). The work outcomes can be useful for the regions with drinking water scarcity. To define the level of the corrugated basin efficiency, 2 versions (SS-1, SS-2) of experiments were carried out on a 2-slope distiller completed with 2 basins. In SS-1, the basin-2 heated air. By 15:00, the basin-2 heated up to 98.5 °C, and acrylic cover above heated up to 101.6 °C, what led to its "deformation". By 12.00am, the temperature differential among the glass 40.7 °C, the air-water mixture 57.3°C, and the basin-1 61.1 °C, was 16.6 °C and 20.4 °C. That resulted from wind increase up to 5.9 m/s. The large temperature differential contributed to condensate yield increase from 0.128 kg. at 11 o'clock to 0.293 kg at 12 o'clock. The throughput capability of the basin-1 per day equaled to 2.094 kg. The basin-2 input to the SS-1 performance was only the thermal effect. In SS-2, the basin-2 was used as a regular basin. The plexiglass temperature was lower than the water and the basin-2 temperatures. The temperature differential between the glass and air-water mixture at 10:00am was 20 °C, at 12:00am it was 30.6 °C, and the value of 30.6 °C was recorded at 3:00pm. The thermal differential between the glass and the air-water mixture provided the highest condensate yield of 1.114 kg. at 3.00pm. The condensate yield from the basins via SS-2, resulted in 8.72 kg., including 3.5 kg from basin-1, what is 1.7 times more than from basin-1 via SS-1. The experimental results are consistent with the equations coming from the models obtained (by Clark J.A. and Dunkle R.V.). $T_{condensation} \neq T_{evaporation}$ is irreversible process. When the basins heat, the heat is consumed, when the glass cools down, the heat is given off. Heat losses minimized at the account of the "gap" and positive exergy is provided. The stills throughput capability can be larger by increasing the basins area, reducing the water layer thickness and regulating the flowrate of the desalinated water.

Keywords: Solar energy; 2 slopes, 2 basins, finned and corrugated basin, air heater, air gap; brackish water, distiller

Acknowledgments: *This research has been funded by the Ministry of Science and Higher Education of the Republic of Kazakhstan within the framework of the project "Zhas Galym" (AP19175489 - Scientific substantiation of ecological aspects of biodiversity conservation on the territory of Shetpe - Southern Chalk quarry using GIS technologies).*

© С. Сырлыбекқызы, А. Жидебаева*, А. Айтимова, Д. Баимбетов, Л. Тайжанова, 2024

Ш. Есенов атындағы Каспий технологиялар және инжиниринг университеті, Ақтау, Қазақстан.

E-mail: ainur.zhidebayeva@yu.edu.kz

ЫСТЫҚ КЛИМАТТА ТҰЩЫ СУ ӨНДІРУ ҮШІН КҮН ТҰЩЫЛАНДЫРУ БАССЕЙНДЕРІНІҢ ЖАҢА КОНСТРУКЦИЯЛАРЫНЫҢ ТИІМДІЛІГІН ӘЗІРЛЕУ ЖӘНЕ БАҒАЛАУ

Сырлыбекқызы Самал — PhD, доцент. Ш. Есенов атындағы Каспий технологиялар және инжиниринг университеті, Ақтау, Қазақстан
E-mail: samal.syrlybekkyzy@yu.edu.kz. ORCID 0000-0002-0260-0611;
Жидебаева Айнур — 8D060800 – «Экология» дайындау бағыты бойынша докторант, Ш. Есенов атындағы Каспий технологиялар және инжиниринг университеті, Ақтау, Қазақстан
E-mail: ainur.zhidebayeva@yu.edu.kz. ORCID 0000-0002-1217-5305;
Айтимова Айнажан — Ш. Есенов атындағы Каспий технология және инжиниринг университетінің «Экология және геология» кафедрасының профессор ассистенті, Ақтау, Қазақстан
E-mail: aitimova_ainazhan@mail.ru. ORCID 0000-0003-3135-7531;
Баимбетов Динмухамбет — Ш. Есенов атындағы Каспий технология және инжиниринг университетінің «Энергетика және автоматизация» кафедрасының профессор ассистенті, Ақтау, Қазақстан
E-mail: kamshat.dzumasheva@yu.edu.kz. ORCID 0000-0003-0105-787X;

Тайжанова Ляйлим — PhD, Ш. Есенов атындағы Каспий технология және инжиниринг университетінің «Экология және геология» кафедрасының профессор ассистенті, Ақтау, Қазақстан
E-mail: lyailim.taizhanova@yu.edu.kz. ORCID 0000-0002-9617-3218.

Аннотация. Теңіз және жер асты сулары мол, ауыз су көздері жоқ, құрғақ және ыстық климатта тұщы су өндіруге деген қажеттілік ерекше жоғары. Мәселені шешудің жолы - тиімді гелиоқұрылғылармен суды тұщыландыру. Жұмыста бассейннің жаңа дизайны ұсынылады, жіңішке үшбұрышты гофрдан жасалған, қабырғалары рельефтің ендігіне тең 43° бұрышпен, бұл олардың қатты қызуын қамтамасыз етеді. Тәжірибелер Ақтау қаласының ыстық климаты жағдайында жүргізілді (43°49 ‹N 51°1› E). Жұмыс нәтижелері ауыз су тапшылығы бар аудандар үшін пайдалы болуы мүмкін. Гофр бассейнінің тиімділік дәрежесін анықтау үшін эксперименттер 2 бассейні бар 2 дистиллятор негізінде 2 нұсқада (SS-1, SS-2) жүргізілді. В SS-1, бассейн-2 ауаны жылыту үшін қолданылады. Сағат 15-те бассейн-2 98.5 °С дейін қыздырылды, ал оның үстіндегі акрил 101.6 °С дейін қыздырылды, бұл оның «деформациясына» әкелді. Сағат 12-де ішінде шыны 40.7 °С, бу-ауа қоспасы 57.3 °С және бассейн – 1–61.1 °С арасындағы температура айырмашылығы 16.6 °С және 20.4 °С болды, бұл желдің 5.9 м/с дейін жоғарылауымен байланысты болды. 12 сағат ішінде шыны 40.7 °С, бу-ауа қоспасы 57.3 °С және бассейн – 1–61.1 °С арасындағы температура айырмашылығы 16.6 °С және 20.4 °С, бұл желдің 5.9 м/с дейін жоғарылауымен байланысты болды. Сағат 12:00-де 0.293 кг. 1 бассейннің өнімділігі бір күнде - 2.094 кг жетті. Сағат 12:00-де 1 бассейннің өнімділігі-0.293 кг., бір күнде-2.094 кг. 2 бассейннің үлесі-SS-1 өнімділігіне тек жылу әсері болды. SS-2, 2 бассейн кәдімгі жылы бассейн ретінде пайдаланылды. Плексигласс температурасы су мен 2 бассейн температурасынан төмен болды. Шыны мен ПВС арасындағы температураның 10 сағаттық айырмашылығы 20 °С, 12 сағатта 30.6 °С болды, ал бұл 30.6 °С 15:00-де тіркелді. Шыны мен ПВС арасындағы температураның бұл айырмашылығы 1.114 кг мөлшерінде конденсаттың ең көп шығуын қамтамасыз етті. 15 сағатта SS-2 - де, бассейндерден конденсаттың шығымы - 8.72 кг құрады, оның ішінде 1 бассейннен 3.5 кг, бұл SS-1-дегі бассейннен 1.7 есе көп. Эксперименттердің нәтижелері алынған модельдер негізінде жасалған теңдеулерге сәйкес келеді (Clark Ja and dunkle RV). бұл қайтымсыз процесс. Бассейндер қызған кезде жылу тұтынылады, ал әйнек салқындаған кезде ол бөлінеді. Жылу шығыны «алшақтық» есебінен азайтылып, оң эксергия қамтамасыз етілді. Тұзсыздандырғыштардың өнімділігін бассейндердің көлемін ұлғайту, су қабатының қалыңдығын азайту және тұзсыздандырылған судың шығынын реттеу арқылы арттыруға болады.

Түйін сөздер: күн энергиясы; 2 сәуле, 2 бассейн, гофрленген пластина бассейні, ауа жылытқышы, ауа қабаты, тұзды су, дистиллятор

Каспийский университет технологии и инжиниринга имени Ш. Есенова, Актау, Казахстан.

E-mail: ainur.zhidebayeva@yu.edu.kz

РАЗРАБОТКА И ОЦЕНКА ЭФФЕКТИВНОСТИ НОВЫХ КОНСТРУКЦИЙ СОЛНЕЧНЫХ ОПРЕСНИТЕЛЬНЫХ БАССЕЙНОВ ДЛЯ ПРОИЗВОДСТВА ПРЕСНОЙ ВОДЫ В УСЛОВИЯХ ЖАРКОГО КЛИМАТА

Сырлыбеккызы Самал — PhD, доцент. Каспийского университета технологии и инжиниринга имени Ш. Есенова, Актау, Казахстан
E-mail: samal.syrlybekkyzy@yu.edu.kz. ORCID 0000-0002-0260-0611;
Жидебаева Айнур — докторант по направлению подготовки 8D060800 – «Экология» Каспийский университет технологии и инжиниринга имени Ш. Есенова, Актау, Казахстан
E-mail: ainur.zhidebayeva@yu.edu.kz. ORCID 0000-0002-1217-5305;
Айтимова Айнажан — ассистент профессор кафедры «Экология и геология» Каспийского университета технологии и инжиниринга имени Ш. Есенова, Актау, Казахстан
E-mail: aitimova_ainazhan@mail.ru. ORCID 0000-0003-3135-7531;
Баимбетов Динмухамбет — ассистент профессор кафедры «Энергетики и автоматизации» Каспийского университета технологии и инжиниринга имени Ш. Есенова, Актау, Казахстан
E-mail: kamshat.dzumasheva@yu.edu.kz. ORCID 0000-0003-0105-787X;
Тайжанова Ляйлим — PhD, ассистент профессор кафедры «Экология и геология» Каспийского университета технологии и инжиниринга имени Ш. Есенова, Актау, Казахстан
E-mail: lyailim.taizhanova@yu.edu.kz. ORCID 0000-0002-9617-3218.

Аннотация. Потребность в производстве пресной воды в условиях сухого и жаркого климата с обилием морской и подземных, без источников питьевой воды особенно высока. Путь решения проблемы – опреснение воды в эффективных гелиоустройствах. В работе предлагается новая конструкция бассейна из тонкого треугольного гофра со сторонами под углом 43°, равными широте местности, что обеспечивает сильный их нагрев. Эксперименты проведены в условиях жаркого климата г. Актау (43°49›N 51°1’E). Результаты работы могут быть полезны для районов с дефицитом питьевой воды. Для установления степени эффективности бассейна-гофра эксперименты проведены в 2-х вариантах (SS-1, SS-2) на базе 2-хскатного дистиллятора с 2-мя бассейнами. В SS-1, бассейн-2 использован для нагрева воздуха. В 15 ч. бассейн-2 был нагрет до 98.5 °C, а акрил над ним – до 101.6 °C, что привело к его «деформации». В 12 ч разность температур между стеклом 40.7 °C паровоздушной смесью 57.3 °C и бассейном-1 - 61.1 °C составила 16.6 °C и 20.4 °C. Это было связано с усилением ветра до 5.9 м/с. Большая разность температур способствовала увеличению выхода конденсата с 0.128 кг. в 11 ч. до 0.293 кг в 12:00 ч. Производительность бассейна-1 за день составила 2.094 кг. Вклад бассейна-2 в производительность SS-1 заключался только в тепловом эффекте. В SS-2 бассейн-2 был использован в виде обычного бассейна. Температура оргстекла была ниже, чем температура воды и бассейна-2. Перепад температур между стеклом и ПВС в 10 ч. был равен 20 °C, в 12 ч. 30.6 °C, и эта величина 30.6 °C была зафиксирована в 15:00 ч. Этот перепад температуры между стеклом и ПВС обеспечил

наибольший выход конденсата в количестве 1.114 кг. в 15 ч. Выход конденсата в SS-2 от бассейнов составил - 8.72 кг, в том числе 3.5 кг от бассейна-1, что в 1.7 раза больше, чем от бассейна-1 в SS-1. Результаты экспериментов согласуются с уравнениями, которые составлены на основе моделей, полученных (by Clark JA and Dunkle RV). – это процесс необратимый. При нагреве бассейнов теплота потребляется, а при охлаждении стекла – выделяется. Тепловые потери минимизированы за счет «зазора» и обеспечена положительная эксергия. Производительность опреснителей можно увеличить за счет увеличения площадей бассейнов, уменьшения толщины слоя воды и регулирования расхода опресняемой воды.

Ключевые слова: солнечная энергия; 2 ската, 2 бассейна, бассейн из гофрированной пластины, воздухонагреватель, воздушная прослойка; солоноватая вода, дистиллятор

Introduction

An acute shortage of fresh water is experienced by more than 40 countries located in arid territories with hot climate, including Mangistau region of the Republic of Kazakhstan located on the eastern coast of the Caspian Sea, which has no fresh water sources. (Syrlybekkyzy et al., 2014: 1631).

Water desalination is carried out by the Mangyshlak Nuclear Power Plant "MAEK-Kazatomprom", what provides the regional center, enterprises and adjacent settlements with all types of water. In remote areas, water deficiency is solved by imported water and underground sources. At the remote enterprises technical purposes are satisfied with the seawater. "CaspiCement" plant built by "HEIDELBERG CEMENT GRoup" (Germany) in order to keep chalk dust low, water roads with the sea and underground water, what leads to even greater salinity of the saline soils. (Zhidebayeva et al., 2018: 1065). In this regard, groundwater and seawater need indispensable demineralization via solar energy-driven desalination, what is a great deal for hot dry climates.

Refs. (Serikbayeva et al., 2023: 24). propose methods of waste and sea water desalination for arid regions lacking fresh water. The works propose the methods of ground and sea waters desalination for the arid regions lucking fresh water. Hitesh N. Panchal et al, clime that groundwater contains harmful bacteria, coastal marine areas water is abundant but not suitable for drinking. It is economically feasible to distill and purify these waters in simple solar-powered stills. Their massive use is constrained by their low throughput capability. Remote coastal regions where advanced desalination technology is not available, sustainable fresh water production method is absolutely crucial. Development of economically and technically efficient stills attracts extensive researchers' attention - notes Tiwari Anil Kr.

(Sangeeta Suneja et al., 1998: 120). defined the optimal number of still basins should be no more than 7. To enhance heating and boost the still throughout capability, much attention is paid to the use of thin corrugated sheets Gupta CL. In order to determine the optimal inclination angle in an efficient solar still, Tanaka H (2011) determined that 23 ° is the best angle of the transparent cover inclination, for the latitude of Muscat in Oman. This made it possible to increase the condensate yield by 13 % more than in a conventional solar still. (Hilal Al-Hinai et al., 2002: 150). in their research, the performance of a three-basin solar still was compared with that of a single-basin still. At the same time, it was found that three-basin still high efficiency is conditioned by minimization of heat losses of the lower basins surface by the upper (heat-insulating) basin. (El-Sebaii, 2004: 45). in his work, analyzed the wind effect on the performance of solar plants of passive and active type. Also, El-Sebaii A., in his works, showed the results of the temperature regime of a three-basin still. It demonstrated increase of the three-basin solar still output by 12.6 l/m^2 per day, compared to a conventional solar sills. (Al-Hinai et al., 2002: 75). investigated multi-slop solar still throughput capability in relation to climatic factors, a slope angle and insulation thickness. Rahul et al. formulated the characteristic equation for a 2-slope solar still in the conditions of Delhi. The work concluded that the graphs determining the basin heating linear dependence on a slope angle, are less accurate than the graph curves of nonlinear dependence. (Hanane et al., 2012: 33). studied the efficiency of a 2-slope solar distiller with account for a change in the temperature of water and glass depending on radiation intensity. It was established that a higher distillate yield is achieved at a higher temperature differential between the glass and heated water temperatures. The still output totaled 4 l/m2 per day, which is consistent with Kalidas studies results. In experiments, (Rajamanickam et al., 2012: 1701) studied the effect of the water level of a double-basin solar still, on the processes of mass exchange in its capacity. It was assumed that a basin water depth of 0.1 m would increase the distiller's throughput capability. Hence, according to the experiments outcomes, the condensate yield was 3.074 l/m^2 day. This result value turned out to be less than the throughput capability value obtained in Hanane's work. Trad et al, conducted comparison studies of the efficiency of single and double solar stills. They came to the following conclusion. So, with the orientation of a plant with its one slope to the north-south, the maximum throughput capability temperature was achieved in comparison with the 2-slope plant.

(Halimeh et al., 2013: 113) in their studies compared the energy efficiency and exergy efficiency of a solar still equipped with a staged absorber-basin. Thus, the efficiency of solar energy use equaled to 83.3 % while the exergy (energy efficiency) equaled to 10.5%. Low exergy efficiency factor is conditioned by the biggest absorber surface heat loss to the environment. (Sadineni et al., 2008: 71) in their work, carried out experiments on a solar still where its throughput capability was 20 % higher than of the conventional ones. Therewith, they also avoided scale formation on the plates of a staged absorber. Nabil, in his work experiments, used a condenser to remove vapour from the glass surface. Thus, water vapor was captured by the condenser and did not reach the glass surface.

In Rahim's work a staged aluminum liner covered with black paint. Shallow water allowed maximum basin heating, what ensured night production of distillate. Velmurugan et al., in their studies carried out an analysis of the thermal characteristics of a stage-type desalination still with heat-accumulating materials (sand, pebbles, etc.). Productivity increased by 98% compared to the stage-type asphalt-cover unit.

Evaluation of efficiency of a modified corrugated basin with air heater and a conventional basin in a 2-slope distiller.

Methodology

Figure 1 a, b show a 2-slope still equipped with two basins (for the sake of discussion solar still - SS) in two versions. That is to establish how much the corrugated basin contributes to the solar still throughput capability in whole. There was setting up the experimental facilities in the workshop of the Engineering Faculty of Yessenov University.

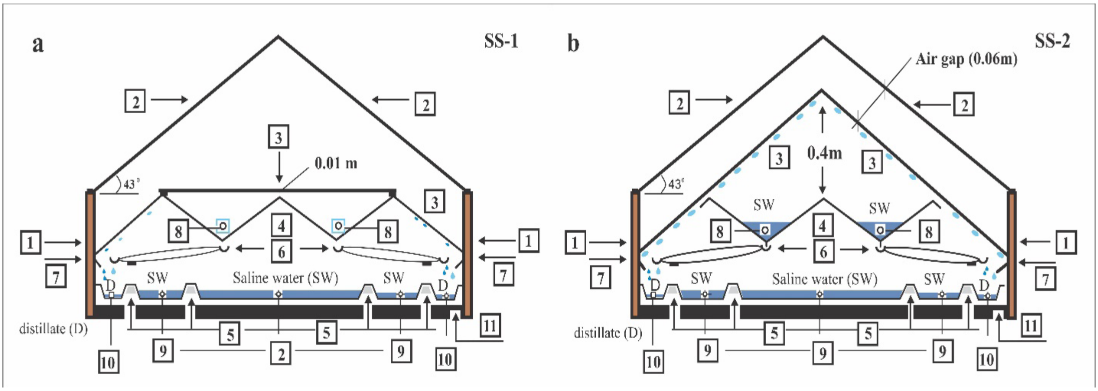

Figure 1 - Schematic of the basin-type solar still versions,

a) the upper basin is in the form of an air heater, (SS-1);

b) the upper basin is in a conventional distiller (SS-2)

In the 1st version (**SS-1**) plexiglass 3 was over the upper basin 4, the curved edges paralleled two slopes of the glass 3 and covered the basin 5. In the 2nd version (**SS-2**), the plexiglass 3 covered the two basins. It should be noted, that in the 1st version, water was not supplied to the upper basin, since we, in this case, considered the "dry" basin in form of an air heater. (Zhidebaeva, 2024: 9128).

The body housing 1, 0.40 m high, of chipboard (aka DSP), with a thickness of 0.02 m. The housing dimensions 0.7 × 0.9 m. Further, the description of the plant continues from its top downwards.

2-slope cover 2, of plexiglass 0.003 m thick, sealed around the unit body. Plexiglas Acrima 82 (Russia), with a light transmission coefficient of 92 %, (tensile strength (23 °C) - 70 MPa). Vicat softening temperature is 114°C, and the fact that glass is environmentally friendly material is the most important.

For efficient use of the solar energy, the angle of both slope inclination and the sides of the finned corrugation basin-2, to the horizon was 43 °, which corresponds to the angle of region latitude corresponding to 43°49'N. The presence of a 2-slope glass cover 3 above the upper basin-2 (position 4) and above the lower basin-1 (position 5) prevents the inner surface of the cover 2 from condensing, and facilitates to partial incoming solar radiation of the basin-1. A "thermal insulation" e.g. air gap is formed by the virtue of the second cover 3.

On the inner basin-2 side facing the basin-1, there are the condensate collectors 6. They are fixed on the body 1 walls, with condensate runoff side channels of the basin-1. The basin-1water level is below the level of the basin shelves, what provides heating of 25 % of the entire surface. For the purpose of condensate drainage, the glass 3 lower edges are curved towards the same channels of the basin-1 (position 7). Silicone pipes are inserted in holes 8 to feed and drain colder sea water. Holes 9 with silicone connecting pipes, feed the basin-1 channels with water. The distillate resulting from the outer channels, flows through the connecting pipes 10 into a container (not shown). The plant DSP bottom has on its surface foam plastic and basin-1 hermetically fixed with mounting foam. The temperature of glass covers 2 and 3, basin 1 and 2, water, and the ambient air temperature per the unit volume as a whole, were thermocouple-measured every 30 minutes, SMD resistance temperature detector Pt 100. Therewith, the thermocouples maximum measurement range is 150°C, with a probe length of 1.0 m and a cable of 2.0 m.

To measure the temperature in the absorber water and the silicone connecting pipes, we used testo 905-T contact thermometer with an immersion/penetration probe of 30 cm long.

The regulation of the amount (flow rate) of water supplied to the solar still was carried out using Acetal tubing clamps of durable plastic with serrated jaws. The water level in basin 1 and 2, and their capacity pressure were measured with a transparent U-shaped pressure gauge.

A silicon pyranometer SP-Lite (manufactured by Kipp & Zonen) measured the solar radiation flux density. (Serikbayeva et al., 2023: 8181).

The site for the experiments was selected at the trials site of the Ecology Faculty, 21 km from the city of Aktau, in the coastal zone of the Caspian Sea (43°49’N 51°1’E). The distance from the site to the sea shore is 487.5 m, shown in the upper part of Fig. 2. On August 1 and 2, 2023, from a depth of 5–6 m seawater was sampled from a rubber boat, in the more seaward part of the sea, at a distance of 166 m from the seashore.

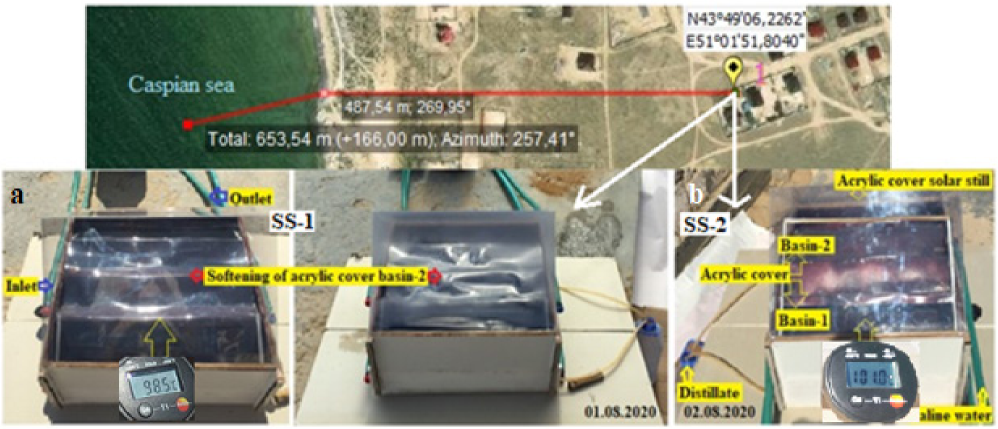

Figure 2 - Photographs of the experimental setup versions

a) SS-1; b) SS-2

The elements of the solar still, their dimensions, the angle of inclination of the translucent covers and the thermal characteristics are presented in Table 1.

Table1. Thermotechnical properties of the still elements and water

Parameters	Glass cover SS	Glass cover of basins	Basin-2	Basin-1	Water	
					Basin-2	Basin-1
α	$\alpha_{g.cover} - 0.03$	$\alpha_{g.c.b2+g.c.b1} - 0.03$	$\alpha_{b2} - 0.93$	$\alpha_{b1} - 0.93$	0.05	0.05
A (m^2)	0.72	0.73	0.38	0.62	0,21	0.48
τ	0.92	0.92	-	-	0.93	0.93
ε	0.88	0.88	-	-	0.94	0.94
C_p (J/kg K)	500	500	630	630	4190	4190
ρ (kg/m^3)	2500	2500	7850	7850	1010	1010
Thickness, mm	3.00	3.00	0.7	0.7	20-40-50	20-30
Slope of glass, (°)	38	38	38	-	-	-

Mathematical model of a solar still thermal process

The complexity of using the solar energy lies in of the radiation power intensity change during a day, a month, a year. This creates inconvenience in maintaining the temperature regime in solar powered units. The air gap between the upper 2-slope cover and the lower cover above the basins complicates the system with radiation-conduction heat exchange. Mass-transfer processes in the system occur during condensation of moisture on the basin-2 inner surfaces and the glass over the two basins in their entirety (Kabeel et al., 2016: 59).

The following assumptions are made in the modeling:

a) heat losses through the sides and the bottom are insignificant, the heat capacity of the cover glass is minimal, no water stratification in the basins is observed;

b) the heat transfer radiated into the environment from the transparent cover of the still is considered to be negligible due to the “interlayer” and is not taken into account;

c) the temperature of the inner surface of the transparent glass covers differs from its outer surface temperature: $T_{gi} \neq T_{go}$.

Heat balance equations for the capacity of a basin-type still

In the solar powered still, the upper transparent cover is made of Acrima 82 plexiglass. The inner transparent cover above both the upper basin-2 and the lower basin-1, is also Acrima 82 (Fig. 1, b). The figure shows that the solar radiation coming on the surface of the basin-2 is 89%, on the surface of the basin-1 is by 27 % for 2 sides.

1. The heat balance for transparent covers above the still, basin 2 and 1, can be estimated with the equation formulated by (Velmurugan et. al., 2009: 249) in their studies:

$$\alpha'_{g(ss)} I_s A + \alpha'_{g(b.2)} I_s A + \alpha'_{g(b.1)} I_s + (q_{e.w(b.2)-g} + q_{c.w(b.2)-g} + q_{r.w(b.2)-g})A + (q_{e.w(b.1)-g} + q_{c.w(b.1)-g} + q_{r.w(b.1)-g})A = m_{g(b.2)} C_{\rho g} \frac{dT_{g(b,2)}}{dt} + m_{g(b.1)} C_{\rho g} \frac{dT_{g(b,1)}}{dt} + q_{c.g(ss)-a} \quad (1)$$

where $q_{g(ss)}, q_{g(b.2)}, q_{g(b.1)}$ is the heat flow absorbed by the glass, ($W/^{m2}$); A - surface area of the transparent coatings, (m^2); Is - intensity of the radiation transmitted through the glass, (W/m^2); $\alpha'_{g(ss)}, \alpha'_{g(b.2)}, \alpha'_{g(b.1)}$, - the radiation fraction absorbed by the glass; $q_{c.w(b...)-g}, q_{c.w(b...)-g}, q_{c.w(b...)-g}$, - heat flow from water in the basin 2 and 1 to the inner surface of the cover, (W/m^2); $q_{g(ss).c-a}$ - the cover originated heat flow into the environment via convection, (W/m^2);$m_{g(b.2)}$, $m_{g(b.1)}$, - the mass of the glass cover over the basins, (kg); $C_{\rho.g}$- specific heat of glass, (J/kg • K);$T_{g(b,2)}$, $T_{g(b,1)}$, - glass temperature of the cover over the basin 2 and 1;$q_{c.g(ss)-a}$ - heat flow transferred via convection from the top cover to the environment.

It should be noted, that the glass surfaces temperature measurement difficulties lead to unforeseen errors in predicting the performance of the stills, as shown in studies (Tsilingiris, 2011). Also, equation (1) does not take into account the radiated heat flow due to the air gap between transparent covers.

Heat transfer to the environment via convective heat exchange in the interlayer between the covers, will be carried out through the upper translucent cover of the still:

$$q_{c.g(ss)-a} = h_{c,g(ss)}A(T_{g(ss)} - T_{g(ss)a}) \quad (2)$$

where $h_{c,g(ss)-a}$ - the coefficient of convective heat transfer from the glass to the environment, (W/m$^{2\circ}$C);$T_{g(ss)}$ - temperature of the inner surface of the plexiglass;$T_{g(ss)a}$ - temperature of the outer surface of the solar powered still cover glass, (°C).

As for the convection coefficient, then, as shown in, Juan Cristóbal in gives Jurges' data obtained for a 0.5 m^2 plate where the coefficient $h_{c,g}$ depends on the wind speed V, no more than 5 m/s and is assigned by the dimensional equation:

$$\mathrm{h}_{\mathrm{c,g\,(ss)}} = 5.7 + 3.8\ \mathrm{V} \quad (3)$$

The area of the upper basin-2 is 0.38 m^2, of the lower basin-1 - 0.62 m^2, that is, for our case, equation (3) is usable.

Convective heat flow $q_{cg(ss)-a}$ can be estimated with the following expression:

$$q_{cg(ss)-a} = \varepsilon_{g(ss)}\sigma\left[T^4_{g(ss)} - T^4_{g(ss)a}\right] \quad (4)$$

where $\varepsilon_{g(ss)}$ - the emissive ability of the glass inner surface, 0.9; σ - Stefan Boltzmann's constant = 5.669 x 10^{-8} W/m^{2}K.

Heat flows transferred from basin 2 and 1 water to the inner surface of the glass during evaporation and due to convection and radiation. It can be written using the instance of basin-2:

$$q_{e.w(b.2)-g.inner} = h_{e,w(b.2)-g} \cdot A_{w(b.2)}(T_{w(b.2)} - T_{g.inner}) \quad (5)$$

$$q_{c.w(b.2)-g.inner} = h_{c,w(b.2)-g} \cdot A_{w(b.2)}(T_{w(b.2)} - T_{g.inner}) \quad (6)$$

$$q_{r.w(b.2)-g.inner} = h_{r,w(b.2)-g} \cdot A_{w(b.2)}(T_{w(b.2)} - T_{g.inner}) \quad (7)$$

$h_{e,w(b.2)-g}$ - coefficient of evaporation heat transfer, can be determined utilizing an equation for the model obtained in the heat transfer development (Pattarumadathil Unikkatt Suneesh., 2012):

$$h_{e.w(b.2)-g_{inner}} = 16.273 \cdot 10^{-3} h_{c.w(b.2)-g_{inner}} \cdot \frac{(P_{w(b.2)} - P_{g_{inner}})}{(T_{w(b.2)} - T_{g_{inner}})} \quad (8)$$

At the same time, we define and $h_{c,w(b.1)-g}$ and $h_{r,w(b.1)-g}$ employing the equations from the Dunkle' s model:

$$h_{cw(b.2)-g} = 0.884 \cdot \left[(T_{w(b.2)} - T_{g_{inner}}) + \frac{(P_{w(b.2)} - P_{g_{inner}}) T_{w(b.2)} + 273.15}{268.9 \cdot 10^3 - P_{w(b.2)}} \right]^{\frac{1}{3}} \quad (9)$$

$$h_{r.w(b.2)-g_{inner}} = \varepsilon_{w(b.2)} \sigma (T^2_{w(b.2)} + T^2_{g_{inner}}) \cdot (T_{w(b.2)} - T_{g_{inner}}) \quad (10)$$

where $P_{w(b.2)}$ - the partial pressure of water vapor at a certain temperature (N/m^2);

$P_{g.inner}$- air-water mixture partial pressure on the inner surface of the glass.

2. The heat balance equation for the water of still basin 2 and 1, is formulated as the equation in:

$$\tau_{g(b.2)} \alpha_{w(b.2)} I_s A_{w(b.2)} + \tau_{g(b.1)} \alpha_{w(b.1)} I_s A_{w(b.1)} + q_{c.(b.2-w)} + q_{c.(b.1-w)} =$$
$$= m_{w(b.2)} C_{\rho w} \frac{dT_{w(b,2)}}{dt} + m_{w(b.1)} C_{\rho w} \frac{dT_{w(b,1)}}{dt} + q_{c.w(b.2)-g(ss)} + q_{c.w(b.1)-g(ss)} \quad (11)$$

3. The heat balance equation for the basins 2 and 1:

$$\tau_{g(b.2)} \tau_{w(b.2)} \alpha_{(b.2)} I_s A_{(b.2)} + \tau_{g(b.1)} \tau_{w(b.1)} \alpha_{w(b.1)} I_s A_{w(b.1)} = m_{(b.2)} C_{\rho(b.2)} \frac{dT_{w(b,2)}}{dt} +$$
$$+ m_{(b.1)} C_{\rho(b.1)} \frac{dT_{w(b,1)}}{dt} + q_{c.w(b.2)-g(ss)} + q_{c.w(b.1)-g(ss)} q_{c.g(ss)-a} \quad (12)$$

The hourly condensate output, for basin 2 and 1, is detected with formulations (13) based on the formula from the studies (Clark, 1990: 44):

where L is the latent heat of evaporation. For seawater heated above 70 °C: $L = 3{,}1615 \cdot 10^6[1 - 7{,}6160 \cdot 10^{-4} T_w]$ and less 70°C $L = 2{,}4935 \cdot 10^6[1 - 9{,}4779 \cdot 10^{-4} T_w + 1{,}3132 \cdot 10^{-7} T_w^2 - 4{,}7974 \cdot 10^{-9} T_w^3]$. $A_{b.2}$, $A_{b.1}$ - area of the basin 2 and 1, (m^2).

The daily throughput capability of the solar-powered system is figured out with the formula:

$$M_{ew} = \sum_{i=1}^{24} m_{ew} \qquad (14)$$

The efficiency of a 2-slope double-basin solar still with seawater heating, the seawater heats in the upper basin-2 and runs to the lower basin-1 for desalination, is established with the following formulation:

$$\eta_{\text{eff}} = \frac{\sum_{i=1}^{24} m_{ew}}{\sum(I(t)_{b2} \cdot A_{b2} \cdot 3600) + \sum(I(t)_{b1} \cdot A_{b1} \cdot 3600)} \qquad (15)$$

Results and discussion

Efficiency of the basin-2 in a double - basin distiller

on 01.08.2023 SS-1: the upper basin-2 as an air heater (water free)

The corrugated basin employed as an air heater with no water fed.

The plexiglass cover is horizontal, with a gap of 0.01 m from the top of the basin-2 (Fig. 1, a).

The ambient conditions as of 01 and 02 August 2023 are tabulated in Table 2.

Table 2. Ambient conditions as of 01 and 02 August 2023

(Ambient conditions)	01 August 2023		02 August 2023	
	morning	afternoon	morning	afternoon
Sunrise time, (hour)	6:22	-	6:26	-
Outdoor air temperature (°C)	20.3 (7:00)	32.0 (12:00)	21.7 (7:00)	31 (12:00)
Solar radiation intensity (W/m²)	96.1 (7:00)	795 (12:00)	101 (7:00)	840 (12:00)
Atmospheric pressure, (mm Hg)	759	758	756	756
Wind speed, (m/s)	3.4 (В)	5.9 (Ю)	2.1 (З)	3.0 (СЗ)
Relative air humidity, (%)	75	39	51	41
Precipitation amount, (mm)	-	-	-	-
Cloudiness	Clear	Low	Clear	Clear

SS-1. 01 August 2023. Sunrise time - 6:22 am. It is clear. Outdoor air temperature: in the morning - 20.3 °C, temperature maximum at 12:00am - 32°C. Relative air humidity: 75 % in the morning, 39 % in the afternoon. Wind speed: in the morning - 3.4 m/s (East) in the afternoon - 5.9 m/s (South). The maximum value of solar radiation intensity at 12:00am was 795 W/m².

The dynamics of temperature variability of glass, water and basin 2 and 1, depends on the outdoor air temperature, radiation intensity, for version: SS-1, given in Table 3.

A. The temperature) above basin-2, at 7:00 am, was 2.4 °C lower than that of the basin capacity; at 8pm the temperature was 4.7 °C. The basin-2 temperature prevailed the glass temperature). Heating basin-2 at 3:00pm, up to 98.5 °C, and heating the acrylic up to 101.6 °C, what resulted in acrilic "deformation". The reason is the tight adjacency (0.01 m) of the glass to the "hot" tops of the basin-2 corrugation (Fig. 2, a). As the studies show, application of corrugation requires a gap of at least 0.35 m between the tops, or plexiglass replacement with a regular one.

So, Alessandro Franco came to the conclusion, that for air heating it is advisable to utilize thin corrugated sheets. But at the same time, the main requirement is to ensure a gap between the absorbing surface and the cover glass. This is also was noted by A. Alahmer.

Starting at 3.00pm, the glass temperature was dropping from 101.6 °C to 76 °C at 8:00pm. The temperature of the basin capacity also was decreasing from 98.5 °C at 3:00 pm to 71.3 °C. The temperature gradient totaled 3–5 °C.

The excess of the glass temperature) over the temperature of the basin-1 glass) totaled 0.2 °C at 7:00am, 48.5 °C at 3:00pm, and 48.0 °C at 8:00pm. This displays that the heat transfer from basin-2 glass to basin-1 glass was negligible.

B. The glass temperature) was also lower than the temperature of the water and basin-1. At 12:00am, the temperature differential between the glass (40.7°C), air-water mixture (57.3 °C), and basin-1 (61.1 °C) was 16.6 °C and 20.4 °C. This difference is the biggest one obtained in the course of the experiment, due to the wind speed increase up to 5.9 m/s starting from 11:00 am with the maximum air temperature (32 °C) and intensity of 795 W/m^2. The temperature drop made condensate yield risen from 0.128 kg. at 11.00 am to 0.293 kg at 12.00 am. Thus, a high wind speed provokes glass cooling, air-water mixture condensing and distiller performance increase, what agrees with the conclusions of El-Sebaii A.A., and Badran O.O. On the other hand, high wind speed causes heat losses to the environment. In our case, the heat losses are minimized due to the "air gap" between the covers.

C. The SS-1 solar still throughput capability. The contribution of basin-2 to throughput capability is conditioned with heat transfer from the lower surface to the water surface in basin-1. The condensate output from the basin-1, from 9:00 am through 8:00pm, was 2.094 kg.

Table 3. Dynamics of a change in temperature for the glass, water and basins in SS-1 version. 08/01/2023.

Time (hour)	(W/m^2)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	Distillate output (b.1) (kg)
7:00am	96.10	21.3	18.6	21.0	18.4	18.7	19.5	0.00
8:00 am	155.00	22.8	34.6	33.2	21.4	23.7	24.8	0.00
9:00 am	220.17	24.1	43.3	41.0	27.0	29.5	32.3	0.014
10:00 am	390.51	27.2	54.0	50.3	31.3	37.1	40.5	0.071
11:00 am	590.70	29.3	64.1	61.3	42.1	44.7	49.3	0.128
12:00 am	795.00	32.0	76.1	73.5	40.7	57.3	61.1	0.293
1:00pm	781.33	31.4	85.0	81.2	43.0	45.8	49.4	0.173
2:00 pm	776.40	31.1	96.8	91.1	51.4	53.1	57.3	0.270
3:00 pm	713.51	30.6	101.6	98.5	53.1	58.3	61.1	0.337
4:00 pm	681.70	30.2	97.3	92.4	49.2	54.6	58.0	0.283
5:00 pm	635.50	29.0	93.6	89.3	45.0	50.1	55.3	0.219
6:00 pm	593.00	28.5	88.1	84.0	39.3	45.2	48.9	0.121
7:00 pm	475.30	28.1	81.6	77.5	31.4	39.6	44.7	0.088

8:00 pm	189.65	27.0	76.0	71.3	28.0	36.0	40.3	0.052
-	-	-	-	-	-	-	-	2.049

02 August 2023 The upper basin-2 in the form of a conventional basin (with water)

The basin-2 plexiglass cover, 2-slope, parallel to the still cover, with a gap of 0.06 m, common for the two basins (the upper one and the lower one). The height from basin-2 plane to the top of the cover glass, was 0.4 m (Fig. 1b).

SS-2. 02 August 2023 Sunrise time - 6:26 am. In the afternoon - slightly cloudy. Air temperature: in the morning - 21.7 °C, maximum at 12:00am – 31 °C. Relative humidity: 51 % in the morning, 41 % in the afternoon. Wind speed: in the morning - 2.1 m/s (West) in the afternoon - 3.0 m/s (North-West).

The peak intensity of the solar radiation at 12:00 was 840 W/m2. The dynamics of changes in the temperature of glass, water and basins 2 and 1, for version: SS-2, are given in Table 4.

A. In contrast to the option without water (air heater) in SS-1, during the day, the temperature of the glass) above basin-2 in the SS-2 version (for heating water), was lower.

At 7 am the temperature differential between the glass and the water was 0.5 °C, at 10.00am the differential was 20 °C, at 12 noon the differential was 30.6 °C, and a value of 30.6 °C was recorded at 3:00 pm.

The largest condensate yield was 1.114 kg at 3:00 pm and 0.94 kg. at 4:00 pm at a differential of 28.4 °C (Table 4). Large amounts of the air-water mixture condensation is justified by equation (13) where it is clear, that the value of the hourly output of condensate is directly proportional to the evaporation heat transfer coefficient (calculated with equation (5). Equation (8) demonstrates that the heat transfer coefficient (depends on the temperature differential between the glass, the air-water mixture and the partial pressures difference. The difference between is inversely proportional.

The basin-2 throughput capability from 7:00 to 20:00 inclusive, was 5.2 kg.

B. The glass temperature) neither exceeded the water and the basin-1 temperature.

The maximum values of the temperature gradient between the glass above basin-1 and the water, were recorded at 3:00pm and 5:00 pm and amounted to 32.2 °C and 31.6 °C respectively. During those hours, there was the highest condensate yield accompanying of 0.49 and 0.43 kg.

The distillate output of the basin-1 surface in SS-2 was 3.519 kg, what is 1.47 kg more than distillate production (2.049 kg) obtained from the basin-1 surface in SS-1.

C. Productivity of the SS-2 solar still. In SS-2, the total daily distillate output from the surface of the upper basin-2 and the lower basin-1, was 8.717 kg.

Table 4. Dynamics of change in temperature of glass, water and basin in SS-2. 02.08.2023.

Time (hour)	(W/m^2)	(°C)	(°C)	(°C)	(°C)	°C)	(°C)	(°C)	Distillate output, (kg)		
									(b.2)	(b.1)	∑ (b.2+b.1)
7:00am	101.5	21.7	19.3	19.8	22.0	19.0	19.7	20.0	0.000	0.000	0.000
8:00 am	160.19	22.4	21.7	32.5	36.0	20.3	25.6	26.4	0.031	0.000	0.031
9:00 am	225.07	26.0	23.6	40.8	45.1	22.5	31.8	35.0	0.114	0.026	0.14
10:00 am	379.00	29.6	27.0	47.0	54.8	25.0	38.5	42.8	0.216	0.040	0.256

11:00 am	580.13	30.1	32.3	61.3	67.1	28.3	46.0	50.8	0.410	0.186	0.596
12:00 am	840.00	31.5	38.7	69.3	76.0	32.7	55.3	61.1	0.452	0.271	0.723
1:00pm	811.36	31.2	46.4	76.2	84.5	38.0	63.1	69.0	0.475	0.421	0.896
2:00 pm	792.16	31.0	56.5	87.0	96.1	43.1	73.4	79.0	0.513	0.448	0.961
3:00 pm	731.41	30.6	64.8	95.4	101.0	48.8	81.0	88.3	0.621	0.493	1.114
4:00 pm	698.62	30.4	61.2	89.6	94.3	43.7	75.3	82.7	0.527	0.413	0.940
5:00 pm	730.09	29.8	57.9	85.4	90.7	38.0	70.0	76.1	0.493	0.436	0.929
6:00 pm	583.10	29.0	53.3	78.2	81.4	32.7	62.3	71.5	0.481	0.410	0.891
7:00 pm	481.00	28.5	49.7	69.0	76.1	28.4	56.1	65.0	0.450	0.267	0.717
8:00 pm	124.83	28.3	43.5	61.8	69.3	23.1	49.2	58.6	0.415	0.108	0.523
-	-	-	-	-	-	-	-	-	5.198	3.519	8.717

Less condensate output from the surface of basin-1 in SS-1 is linked to the thickness of the water layer in the basin. In order to increase productivity in SS-1, the water layer in basin-1 was equaled to 25 mm, what did not bring to a greater condensate output. In the SS-2 version, the water layer thickness in the basins 2 and 1 was 20 mm, what achieved higher productivity compared to SS-1 (Fig. 3). The employment of basin-2 in SS-1 for heating the air did not contribute to the distillate output and productivity.

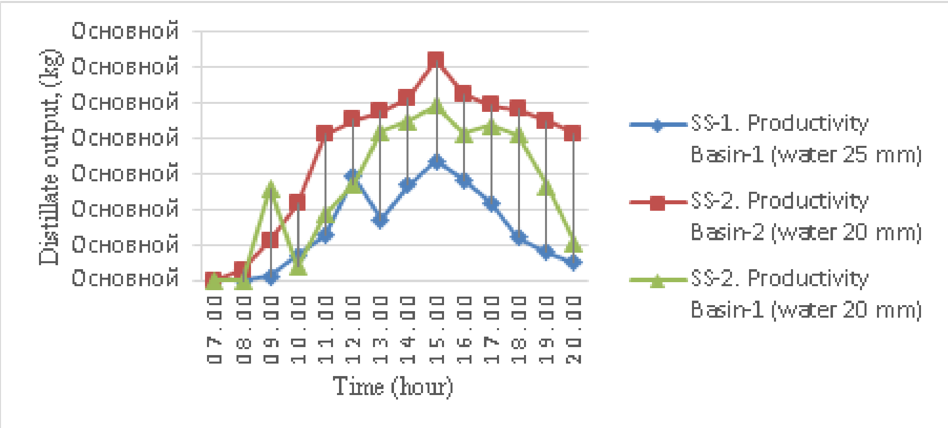

Figure 3 - Hourly output of condensate conditioned by the thickness of the water layer

Thus, the SS-2 thinner (20 mm) water layer in the basin increased the productivity of the solar distiller by 1.5 times in comparison with SS-1.

This matches to the results obtained in (Sathish Kumar et al., 2013: 413)

Conclusions

In this work, the efficiency of a finned corrugation basin was evaluated by comparison, which was employed as an air heater and a conventional basin, in the plants (SS-1 and SS-2) manufactured on the basis of a 2-slope distiller with 2 basins.

The basin-2 sides positioned at an angle equal to the region latitude, thus, providing the sun rays fall “vertically”, ensuring their outmost heat with 95 % absorption of the rays.

The basin-2 effective area was 98 % of its real area.

The angle of inclination of the acrylic covers is 43 °, reduces reflections to zero.

Employment of basin-2 in SS-1 at 3:00pm, brought the basin-2 temperature (air heater) up to 98.5°C, the acrylic cover above the basin heated up to 101.6 °C, resulting in its “deformation”. The wind getting up to 5.9 m/s strong, cooled the glass and differed the temperature between the glass and the “corrugation”.

The significant temperature differentiation supplied an increase in the condensate yield of from 0.128 kg. at 11:00am to 0.293 kg at 12:00am. Daily productivity of the basin-1 is 2.094 kg.

The basin-2 contribution is expressed in heat transfer without any donation to the SS-1 productivity.

In SS-2, basin-2 was used as a conventional basin. The plexiglas temperature was lower than the water and the basin-2 temperatures. The temperature differential between the glass and air-water mixture at 10:00am was 20 °C at 12:00 was 30.6 °C, and the value of 30.6 °C was recorded at 3:00pm.

The temperature differential between the glass and the air-water mixture was more than 30 °C, what provided the highest condensate yield of 1.114 kg. at 3:00pm and at 4:00pm with the temperature differential of 28.4 °C. The overall amount of the condensate from SS-2 basin 2 and 1 totaled 8.717 kg, which is 4.2 times more than SS-1 amount.

The experimental results are consistent with the equations (5), (8) and (13) drawn based on the formulas and models obtained (by Clark, 1990 and Dunkle, 2013: 44).

It was established that is an irreversible process. When the basins heat, the heat energy is consumed, when the glass cools down, the heat energy is released. Heat losses are minimized with the “gap” and positive exergy is furnished when a corrugated basin is used.

A thinner (20 mm) water layer in the basin-1 increased the throughput capability of the SS-2 solar distiller almost by 1.5 times as compared to the (25 mm) thickness of the water layer in basin-1 of SS-2.

The productivity of the stills can be boosted by escalation of the basin area, diminishing the water layer thickness, and adjusting the flowrate of desalinated water.

REFERENCES

Clark JA. (1990). The steady state performance of a solar still. Solar Energy 1990; 44. — 43–9. — https://doi.org/10.1016/0038-092X(90)90025-8

El-Sebaii A.A. (2004). Effect of wind speed on active and passive solar stills. Energy Conversion and Management 2004; — 45(7): —1187–1204. — https://doi.org/10.1016/j.enconman.2003.09.036

Zhidebayeva A., Kenzhetayev G., Syrlybekkyzy S., Aitimova A. (2018). // Studying state of soils in South shetpe chalk deposit. EEC-EM – Ecology, Environment and Conservation (0971765X-India-Scopus). — 24 (3): 2018. — Pp. 1065–1068. http://www.envirobiotechjournals.com/article_abstract.php?aid=8860&iid=258&jid=3

Zhidebaeva A.E., Syrlybekkyzy S. (2024). Solar Desalination Plant of the Basin Type. Patent. — No. 9128. —17 May 2024

Kabeel A.E., Omara Z.M., Essa F.A., Abdullah A.S. (2016). Solar still with condenser-A detailed review. Renew. Sustain. Energy Rev. 2016; — 59: — 839–857. — https://doi.org/10.1016/j.rser.2016.01.020

Hanane Aburideh, Adel Deliou, Brahim Abbad, Fatma Alaoui, Djilali Tassalit, Zahia Tigrine (2012). An Experimental Study of a Solar Still: Application on the sea water desalination of Fouka. Procedia Engineering 2012; — 33: — 475–484. https://doi.org/10.1016/j.proeng.2012.01.1227

Hilal Al-Hinai, Al-Nassri M.S., Jubran B.A. (2002). Parametric investigation of a double effect solar still in comparison with a single-effect solar still. Desalination 2002; — 150: — 75–83. — DOI:10.1016/S0011-9164(02)00931-1

Halimeh Aghaei Zoori, Farshad Farshchi Tabrizi, Faramarz Sarhaddi, Fazlollah Heshmatnezhad (2013). Comparison between energy and exergy efficiencies in a weir type cascade solar still. — Desalination 2013. — 325. — 113–121. https://doi.org/10.1016/j.desal.2013.07.004

Rajamanickam M.R., Ragupathy A. (2012). Influence of Water Depth on Internal Heat and Mass Transfer in a Double Slope Solar Still. Energy Procedia 2012. — 14. — 1701–1708. —https://doi.org/10.1016/j.egypro.2011.12.1155

Velmurugan V., Pandiarajan S., Guruparan P., Subramanian H., David Prabaharan C., Srithar K. (2009). Integrated performance of stepped and single basin solar stills with mini solar pond. — Desalination 2009, — 249. — Pp. 902–909. https://doi.org/10.1016/j.rser.2016.01.020

Syrlybekkyzy S., Kenzhetaev G.Zh., Permyakov V.N., Nurbayeva F.K. (2014). Investigation into the Physico-Chemical Properties of Soils of Caspian Sea Coastal Area in Mangystau Province // *ORIENTAL JOURNAL OF CHEMISTRY.* — December 2014. — Vol. 30. — No. (4). — Pp. 1631–1638. DOI: http://dx.doi.org/10.13005/ojc/300422

Serikbayeva A., Taizhanova L., Suleimenova B., Altybayeva Zh., Seidalieva L. (2023). Intensification of the Wastewater Treatment Process of a Bitumen Plant with the Production of Recycled Water. — *Journal of Ecological Engineering* 2023. — *№24(2).* — 295–301. — https://doi.org/10.12911/22998993/157021

Sangeeta Suneja, Tiwari G.N. (1998). Optimization of number of effects for higher yield from an inverted absorber solar still using the Runge-Kutta method. Desalination 1998; — 120. — 197–209. — https://doi.org/10.1016/S0011-9164(98)00218-5

Sathish Kumar T.R., Raja Bharathi B. (2013). Effect of Water Depth on Productivity of Solar Still with Thermal Energy Storage. International Journal of Science and Research (IJSR), India Online. — ISSN: 2319–7064. — Volume 2. — Issue 3. — March 2013. — Pp. 413–417. — (IJSR) 2(3). — 2319–7064

Sadineni S.B., Hurt R., Halford C.K., Boehm R.F. (2007). Theory and experimental investigation of a weir-type inclined solar still. Energy 2008; — 33: — 71–80. https://doi.org/10.1016/j.energy.2007.08.003

Serikbayeva A.K., Taizhanova L.S. (2023). Wastewater Treatment Method. — Patent. — No. 8181. — 16 June 2023

CONTENT

Publication Ethics and Publication Malpractice in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the originality detection service Cross Check http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will onh accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайте:

www:nauka-nanrk.kz

ISSN 2518-1483 (Online), ISSN 2224-5227 (Print)

http://geolog-technical.kz/en/archive/

Подписано в печать 15.06.2024.
Формат 60х88 $^{1}/_{8}$. Бумага офсетная. Печать - ризограф.
15,0 п.л. Тираж 300. Заказ 3.

РОО «Национальная академия наук РК» 050010,
Алматы, ул. Шевченко, 28, т. 272-13-19