Neutron analysis on the Molten Salt Reactor FUJI-12 using the fissile material 233U in LiF-BeF2-UF4 has been carried out. The problem faced in the use of thorium-based fuel is that the amount of 233U is small and not available in nature. 233U was produced through the 232Th breeding at a cost of $46 million/kg. That is a very high price when compared to 235U enrichment, which is only $100/kg. The MSR FUJI-12 used in this study is a generation IV reactor with a mixture of liquid salt fuel LiF-BeF2-ThF4-UF4 and thorium-based fuel (232Th-233U). In this study, neutronic analysis was carried out by replacing thorium-based fuel with uranium-based fuel (235U+238U). Neutronic analysis was performed using the OpenMC 0.13.0 code, which is a Monte Carlo simulation-based neutron analysis code. The nuclear data library used for neutronic calculations is ENDF B-VII/1. The fuel is used in a LiF-BeF2-UF4 molten salt mixture with three eutectic compositions: fuel 1, fuel 2, and fuel 3. Each fuel composition is optimized by enriching 235U in UF4 by 3% to 8%. The optimization results show the stability of the reactor criticality value, which is the main parameter so that the reactor can operate for the specified time. The optimization results show that fuel 1 cannot reach its optimal state in each variation of 235U enrichment. Fuel 2 and fuel 3 can reach optimal conditions at a minimum enrichment of 8% and 7% 235U. The results of the analysis of the distribution of the neutron flux in the reactor core show the distribution of nuclear reactions that occur in the core. The distribution of flux values in fuel 1 shows that the fission chain reaction is not running perfectly. Fuel 2 and fuel 3 are more stable by maintaining maximum flux at the center of the reactor core.

Keywords: molten salt reactor, OpenMC, uranium fluoride, thorium fluoride, neutron flux.

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The object of the research is a measuring current transformer of the electromagnetic type, which is used as part of the electricity metering unit. The current transformers functioning in the mode of reduced primary current is accompanied by significant errors. The existence of such a regime for a long time due to downtime of production equipment leads to a significant understimation of electricity. This leads to unjustified financial losses for energy supply companies as electricity in many countries has become more expensive.

The static characteristic of the measuring current transformer at a reduced load of the metering unit is described by a linear statistical model. The parameters of the model are estimated on the basis of empirical data using methods of covariance analysis. The adequacy of the model is confirmed by analysis of regression residuals. The obtained statistical model of the static characteristic, unlike the known ones, is characterized by universality, as it describes current transformers with an arbitrary transformation ratio within the known ones, is characterized by universality, as it describes current transformers with cores composed from different magnetic materials at non-rated loads and overcurrents. IET Science, Measurement & Technology, 13 (7), 944–948. doi: https://doi.org/10.1049/iet-smt.2018.5176


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DEVIATING A METHOD FOR ESTIMATING THE SHARE OF ELECTRICITY CONSUMPTION BY A GIVEN CONSUMER, WHICH IS PROVIDED FROM RENEWABLE ENERGY SOURCES (p. 21–30)
One of the tools to confirm the origin of electricity sold in the retail market are the so-called Guarantees of Origin. They are the basis for calculating greenhouse gas emissions and reporting on carbon emissions and are the most sought-after by European enterprises.

The object of this study is the mechanism of labeling guarantees of the origin of electricity in electrical networks with renewable energy sources, taking into consideration their location and schemes of connection to the power grids.

Existing solutions for electricity labeling based on the certificates of Guarantees of Origin have a number of problems. They often do not accurately reflect carbon emissions, do not provide transparency and verifiability for end users because they do not take into consideration the physical processes of electricity transmission in the labeling system.

To solve this problem, a method has been developed that makes it possible to isolate from the flow of energy in each power transmission a component due to each connected energy source. As a result, the proportion of the load of each node of the electrical network supplied by a certain source of electricity is determined. To take into account the nonlinearity of the ratio between voltages in the nodes of electrical networks and flows in power transmissions, piecewise-linear approximation is used.

The algorithm for issuing guarantees of the origin of electricity has been improved. It takes into consideration not only indicators of the balance of electricity but also the results of assessing the volume of electricity supply to each consumer from renewable sources. Thus, the volume of sales of guarantees of origin is limited depending on the placement of consumers and their connection to the power grid. Directing proceeds from the sale of guarantees of origin to the guarantors of «green» subsidies will provide them with additional financial support to compensate for the costs of the «green» tariff.

Keywords: renewable energy, guarantees of origin, carbon regulation, green tariff, blockchain.

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IDENTIFYING OF THE EFFECT OF THE NUMBER OF TESLA FUSES IN A COILED COLLECTOR ON DIRECT AND REVERSE HEAT TRANSFER (p. 31–36)

Hasan Shakir Majdi
Al-Mustaqbal University College, Babil, Iraq
ORCID: https://orcid.org/0000-0001-6752-4835
Mustafa Abdul Salam Altlib
Al-Rafidain University College-Baghdad, Baghdad, Iraq
ORCID: https://orcid.org/0000-0003-1186-1351

Ali Najim Abdullah Saied
Al-Rafidain University College-Baghdad, Baghdad, Iraq
ORCID: https://orcid.org/0000-0001-8115-1529

Waleed AbdulMunem Abbas
Al-Farabi University, Baghdad, Iraq
ORCID: https://orcid.org/0000-0002-6761-3018

Omar Talal Hamid
Al-Turath University College, Baghdad, Iraq
ORCID: https://orcid.org/0000-0001-5396-0804

Hussein Alawia Ibrahim Al-Saaidi
Dijlah University College, Baghdad, Iraq
ORCID: https://orcid.org/0000-0002-4824-2952

Work was done on the Tesla valve in this study with a coiled and three-dimensional shape, where a different number of these channels and a direct and reverse flow turbine were used to compare the changes that obtain the amount of pressure and temperatures. With the conception of the technology of transferring heat energy in various heat exchangers, it became necessary to develop our technologies that increase the transmission of this energy, and we must refer to the inventions that contributed to the development of the heat transfer system and the three energy laws. They contributed to the development of some mechanical systems, where the Tesla valve is considered one of the valves that have two directions of flow, the first is direct, in which the pressure value is low, and the other is reverse, which occurs when movement is disturbed due to the direction of the channel in which it can be used. This concept can be used to improve heat transfer.

Where the results establish that an increase in the number of channels positively affects the pressure and thus gives more outlets for the passage of water, a study has shown. In the case of four channels an exit temperature of 304.14 K was obtained, which is the highest temperature reached in cases where the direction of flow is direct. The pressure value was in the case in which the channel is a quadrilateral, and the pressure value reached 209 pa. These data are useful and important because the direct exit score has reached 305.74 K for the Tesla valves, which are designed to give enough time for the heat to transfer to the water. The main principle of the Tesla valve is the reverse direction, which works to obstruct the movement of the fluid, and thus increases the pressure and reduces the velocity of the flow.

**Keyword:** tesla valve, COMSOL multiphysics, natural circulation loop, heat and mass transfer.

**References**


**DOIs:**


**Development of Tin Copper Alloys in Shell and Tube Evaporator Heat Exchanger Systems in Ocean Thermal Energy Converse Power Plant (p. 37–52)**

Mawardi
Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia
Universitas Al-Azhar, Kwala Bekala-Padang Bulan, Medan, Indonesia
ORCID: https://orcid.org/0000-0002-6539-4051

Basuki Wirjosentono
Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia
ORCID: https://orcid.org/0000-0003-0302-7113
A case study of the manufacture of an OTEC factory on a floating ship has been carried out using 100 MW Titanium material at a fairly expensive cost, so the OTEC system was researched using a copper-tin alloy. The behavior of the tin-copper heat exchanger between the Aspen Plus simulation and the Computational Fluid Dynamics (CFD) simulation on Shell And Tube evaporators of Bonnet Divided Flow fixed and Bonnet One-pass Shell fixed (BEM) types is investigated. The difference in temperature between water at sea level of 29 °C and water at a depth of 1000 meters at a temperature of 5 °C is assumed to produce electricity. A marine thermal energy conversion power plant is a continuous source of energy sourced from nature an evaporator heat exchanger with ammonia working fluid will produce power that can drive a turbine forwarded to a generator. The simulation results of CFD of a Bonnet Divided Flow fixed type Heat Exchanger on the hot water inlet line has a temperature of 29.9 °C, when exiting the evaporator shell the temperature decreases to 26.4 °C. At the outlet line, the working fluid of ammonia enter the evaporator at 7.9 °C when it enters the tube, the temperature rises to 26.3 °C. The best results of the simulation of Aspen Plus Heat Exchanger type BEM Inlet Ammonia temperature 8 °C and CFD 7.99 °C. Meanwhile, at the ammonia outlet at 28 °C and in the CFD simulation, the ammonia outlet temperature was 28.21 °C, Aspen Plus Inlet heating water temperature is 30 °C, and in CFD simulation, the temperature is 29.9 °C. While the heating water outlet is 28 °C, and in the CFD simulation, the heating water outlet is 28.15 °C. The conclusion from the simulation results is that the BEM-type heat exchanger is very good and suitable for experimental prototyping.

Keywords: OTEC, ORC, renewable energy, CFD simulation, Shell and Tube heat exchanger, seawater temperature, close cycle, copper-tin alloy.

References
In this study, an indirect burner system for solid biomass fuel is designed. The design is motivated by the need to solve the problem related to a direct burner system, such as slugging and high pollutant emissions due to the high-temperature burning process. Therefore, the utilization of an indirect burner is expected to improve the reliability of the solid biomass combustion process. It also can be used to reduce coal consumption by using an indirect burner where the working fluid reaches a relatively higher temperature before entering the boiler. The design used the first principle method for creating the regenerator heat exchanger. The regenerator consists of a mantle and coil heat exchanger. The test used solid biomass fuel for the combustion process where the working fluid first enters the mantle heat exchanger and then the coil heat exchanger. As a result, the mantle absorbs sufficient heat losses from the combustion chamber with the highest temperature increment of 19 °C. The warm water from the mantle then flows to the coil arrangement within the combustion chamber. As a result, the highest temperature of the coil is 84.5 °C. The heat transfer rate for the coil and mantle is 57.2–85.6 and 124.9–141.5 W. The key finding is that the combined regenerative heat exchanger can deliver a higher transfer rate. This can be achieved since the heat exchanger utilizes the same flow distribution, increasing the mean temperature differences at the inlet. Thus, it can produce an average heat transfer rate of 210.5 W. Therefore, energy consumption for coal or other fossil fuels can be reduced significantly. The data can be used for further improvement of the existing boiler system and help to increase the thermal efficiency of the system.

**Keywords:** biomass, indirect burner, regenerative heat exchanger, regenerator, mantle heat exchanger.

**References**

Abstract and References. Energy-saving technologies and equipment


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DEVELOPMENT AND CREATION OF A HYDRODYNAMIC LIQUID HEATING UNIT (p. 62–69)

Bekbolat Nussupbekov
Karaganda Buketov University, Karaganda, Republic of Kazakhstan
ORCID: https://orcid.org/0000-0003-2907-3900

Yerlan Oshanov
Karaganda Buketov University, Karaganda, Republic of Kazakhstan
ORCID: https://orcid.org/0000-0003-4419-2025

Michael Ovcharov
Karaganda Buketov University, Karaganda, Republic of Kazakhstan
ORCID: https://orcid.org/0000-0001-7436-813X

Elmira Mussenenova
Karaganda Buketov University, Karaganda, Republic of Kazakhstan
ORCID: https://orcid.org/0000-0001-5458-3641

Didar Ospanova
Karaganda Buketov University, Karaganda, Republic of Kazakhstan
ORCID: https://orcid.org/0000-0001-7243-4965

Madina Bolatbekova
Karaganda Buketov University, Karaganda, Republic of Kazakhstan
ORCID: https://orcid.org/0000-0002-0169-3430

The work is devoted to the study of the parameters of an installation for heating a coolant using liquid forcing through throttle openings. A scheme of a full-size experimental stand has been developed and the principles of operation are described in detail. For visual observation of the state of the liquid at different angular speeds of rotation of the rotor, a transparent drum model is made. The influence of the shape of the rotor skirt and the depth of its immersion in the liquid on the filling capacity of the rotor cavity at an angular velocity of 100 rad/s was obtained. The optimal parameters of the depth of immersion of the drum skirt with a diameter of 0.5 m in the liquid, at low rotor speeds of 16, 24, 32 rad/s, were determined. The optimal parameters of the depth of immersion of the drum skirt with a diameter of 0.5 m in the liquid, at low rotor speeds of 16, 24, 32 rad/s, were obtained. The angle of inclination is calculated and it is experimentally proved that for a conical shape it is 5 degrees. It was found that at angular velocities of the rotor more than 100 rad/s, the shape and depth of immersion of the skirt in the liquid do not affect the filling of the rotor, since the feed is higher than its flow through the throttle openings. It is shown that the use of rotational forces to heat the liquid allows using an electric motor with less power, since it is spent only on unwinding the rotor with the liquid. The calculated dependence of
the liquid pressure on the side walls of the rotor, the liquid heating temperature on the angular velocity of rotation of the rotor and on two values of the area of the throttle openings, at $31.4 \times 10^{-6}$ m² and $64.34 \times 10^{-6}$ m², is obtained. When the total area of the throttle openings is doubled, the temperature of the liquid heating at the same angular velocities increases from 35.6 °C to 82.5 °C. The above installation parameters allow you to get hot water when using small shell-and-tube heat exchangers.

**Keywords:** installation, inertial forces, throttling, pressure, temperature, rotor, liquid heating, pump, drum.

**References**


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**ANALYSIS OF THE SEASON EFFECT ON ENERGY GENERATED FROM HYBRID PV/WT IN MALANG INDONESIA (p. 70–78)**

**Bambang Irawan**
State Polytechnic of Malang, Malang, Indonesia
**ORCID:** https://orcid.org/0000-0002-1253-9746

**Wirawan**
State Polytechnic of Malang, Malang, Indonesia
**ORCID:** https://orcid.org/0000-0001-7168-2967

**Beauty Anggraheny Ikawanty**
State Polytechnic of Malang, Malang, Indonesia
**ORCID:** https://orcid.org/0000-0002-6949-7073

**Akhansu Takwim**
State Polytechnic of Malang, Malang, Indonesia
**ORCID:** https://orcid.org/0000-0003-2953-3786

This research is about the effect of seasons on the energy produced by hybrid solar photovoltaic (PV) and wind turbines (WT). This study measures the amount of energy produced by the hybrid from PV/WT for 24 hours/day for a full year. The weather in Indonesia changes every day, with this change, the energy produced by PV/WT hybrids also changes. Data collection was carried out in the city of Malang, Indonesia.

The results showed that there are two seasons, namely the dry season and the rainy season. The dry season is from May to October and the rainy season is from November to April. Between the two seasons there is a transition period, namely May and November. Transition time is a month whose weather follows the dry season and the rainy season. The results of research using PV energy generators of 100 WP and 500 Watt WT show that there is a significant effect on the energy produced by PV/WT hybrids between the dry season and the rainy season. The total energy in the dry season is 78.296 Wh and in the rainy season it is 43.790 Wh. The energy ratio of the dry season to the rainy season is 1.7:1. Total energy every month in the dry season is between 11.242 Wh to 14.174 Wh and for the rainy season is between 5,821 Wh to 10,677 Wh. The ratio of the highest to the lowest monthly energy is 2.4:1. The total energy per day in one year is between 88 Wh to 477 Wh. The daily energy ratio from the highest to the lowest is 5.4:1.

This research data is very important because energy data for one year can be used as a reference and basis for designing hybrid PV/WT energy plants. This can be used as a basis for designing loads that match the generator capacity for a period of one year and also designing the capacity requirements of energy storage devices. The results of this study can also be used by other countries that have seasons such as Indonesia.

**Keywords:** hybrid photovoltaic and wind turbines, photovoltaic energy wind turbines energy, dry season, rainy season.

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Increasing the efficiency of harnessing solar energy should be one of our top concerns because it is a renewable resource. The challenge in utilizing this energy is to increase efficiency as well as reduce production costs. So, a dual-axis solar tracker was developed in this study to ensure that the tracked solar cells create more electrical energy than the eugenol content in dried cloves. Renewable Energy, 137, 290–302. doi: https://doi.org/10.1016/j.renene.2020.05.003


Abdalla Saad Ahmed Eltawati
ORCID: https://orcid.org/0000-0002-9753-6092

Yasin Ali Mezaal
Al-Farabi University, Baghdad, Iraq
ORCID: https://orcid.org/0000-0002-4066-953X

Laith Jaffar Habeeb
University of Technology, Baghdad, Iraq
ORCID: https://orcid.org/0000-0002-2808-4432

Fossil fuels are non-renewable, finite, and exhausting. Therefore, it is necessary to find alternative sources of energy. Solar energy is abundant in nature, so it can be considered as the best alternative to meet the energy demand. It is sustainable, renewable, and scalable. Increasing the efficiency of harnessing solar energy should be one of our top concerns because it is a renewable resource. The challenge in utilizing this energy is to increase efficiency as well as reduce production costs. So, a dual-axis solar tracker was developed in this study to ensure that the tracked solar cells create more electrical energy than stationary solar cells, improving the performance of the solar panels.
and expanding their ability to make the most of the solar radiation. The experiment yielded great results. Due to its constant exposure to sunlight, the temperature of the mobile cell is higher than that of the stationary cell. The radiation intensity of the tracked cell is more than that of the fixed cell. The radiation intensity for the traced cell is more than that of the fixed cell and peaks at 1282 W/m² on September 10 and 1028 W/m² on September 11. For day 10, there was a daily rate of rise in radiation intensity on the tracker cell of 42 % compared to the fixed. Day 11 saw a difference of 210 W/m²; or 61 percent. The results are almost the same from midday until dusk. During the day, the tension in the vacuum is somewhat different for stationary cells and tracking cells, with the value of the tracker being marginally lower than the fixed value. The increased temperature in the cell caused by more solar radiation and a warmer environment is thought to be the reason for the lower energy gain in the tracker.

**Keywords:** solar tracker, light dependent resistor (LDR), Arduino, solar cells, dual-axis.

**References**


Ahmad Muzaki Mabruri, Ratna Dewi Syarifah, Indarta Kuncoro Aji, Zein Hanifah, Artoto Arkundato, Gaguk Jatisukamto

Performed a neutron analysis on the fuel of reactor Fuji-12 with subcritical material $^{235}$U in LiF-BeF$_2$-UF$_4$. Problem, which arises in using fuel on the basis of thorium, is the limited amount of thorium. Neutron analysis was conducted by using the code OpenMC 0.13.0, which is an open-source neutron analysis code based on Monte Carlo method. For neutron calculations, the rare salt fuel LiF-BeF$_2$ was used, which costs $100/\text{kg}. The FR FUJI-12 used in this study is the 4th generation reactor with a mixture of $^{233}$U. Results of optimization show that the fuel $^1$ does not reach its optimal state with 3–8%.

**Key words:** subcritical reactor, OpenMC, fission reactor, neutron analysis.
У цьому дослідженні була проведена робота над клапаном Тесла зі спіральною та тривимірною формою, де використовувалась різна кількість цих каналів, а також турбіна з прямим та зворотним потоком для порівняння змін, які отримують величину тиску та температури. Згідно з концепцією технології передачі теплої енергії в різних теплообмінниках виникає потреба у розробці таких технологій, які підвищують передачу цієї енергії, що передбачає необхідність аналізу випадків, які сприяли розвитку системи теплообміну та трьох енергетичних законів. Вони сприяли розвитку деяких механічних систем, де клапан Тесла вважається одним із клапанів, що має два напрями потоку, перший – прямий, в якому значення тиску низьке, а інший – зворотний, він виконує порушення руху через напрям каналу, з якого можна використовувати. Ця концепція може бути використана для покращення теплообміну.

Дослідження показало, що збільшення кількості каналів позитивно впливає на тиск і таким чином дає більше вигоди для проходження води. У разі чотирьох каналів була отримана температура на виході 304,14 К, що є найвишою температурою, яка досягається у випадках, коли напрям потоку перший. У випадку, коли напрям потоку третій, на виході з кожуха температура 304,24 К.

Ключові слова: тесла-клапан, COMSOL multiphysics, контур природної циркуляції, тепломасоперенесення.
Забруднюючих речовин внаслідок процесу високотемпературного горіння. Таким чином, очікується, що використання пальника з непрямим нагріванням дозволить підвищити ефективність системи. Результати цього дослідження також можуть бути використані в інших країнах, де є пори року, які відповідають потужності генератора, на період в один рік, а також для розрахунку вимог до потужності пристроїв спалювання.

**Ключові слова:** пальник, підведення тепла, енергія, споживання енергії, регенеративний теплообмінник.
Виконані види палива є невідновлюваними, кінцевими та такими, що виснажуються. Тому потрібно шукати альтернативні джерела енергії. Сонячна енергія рясніє в природі, тому її можна розглядати як найкращу альтернативу для задоволення попиту на енергію. Вона є стійкою, відновлюваною та масштабованою. Підвищення ефективності використання сонячної енергії має бути одним із наших головних завдань, оскільки це відновлюваний ресурс. Завдання використання цієї енергії полягає в тому, щоб підвищити ефективність, і навіть знизити виробничі витрати. Отже, в цьому дослідженні був розроблений двовісний сонячний трекер, щоб гарантувати, що сонячні елементи, що відстежуються, виробляють більше електроенергії, ніж стаціонарні сонячні елементи, покращуючи продуктивність сонячних панелей і розширюючи їх здатність максимально використовувати сонячне випромінювання. Експеримент дав чудові результати. Через постійну дію сонячного світла температура рухомого осередку вище, ніж у стаціонарного. Інтенсивність випромінювання комірки, що відстежується, більша, ніж у фіксованої комірці. Інтенсивність випромінювання для простеженого осередку більша, ніж для фіксованого осередку, і досягає максимальну 1282 Вт/м² 10 вересня і 1028 Вт/м² 11 вересня. Трекерний осередок на 42 % порівняно з фіксованим. На 11 день різниця склала 210 Вт/м²/год, або 61 відсоток. Результати практично однакові з полудня до заходу сонця. Протягом дня напрута у вакуумі децьо відрізняється для стаціонарних осередків та осередків стеження, при цьому значення трекера трохи нижче фіксованого значення. Підвищення температура в осередку, що викликана великою кількістю сонячного випромінювання та більш теплим навколишнім середовищем, вважається причиною нижчого приросту енергії в трекері.
Ключові слова: сонячний трекер, світлозалежний резистор, Arduino, сонячні елементи, двовісний.