

1.

Eco-efficient solar water desalination system: integrating phase change materials, geothermal and spraying units

Hadi Samimi-Akhijahani , Omid Shariati, Mohammad Saleh Barghi Jahromi, Hadi Kargarsharifabad

Abstract:

Desalination of seawater is a possible solution for freshwater scarcity, but conventional methods are often fossil fuel-dependent and cause significant environmental damage. Although solar energy is a promising alternative, challenges related to unstable thermal performance and low energy efficiency remain. In the present study an innovative life cycle assessment (LCA) of a solar desalination system equipped with a phase change material (PCM) and a spray unit. This research investigates the system performance under spray conditions and provides a comprehensive comparative analysis of the manufacturing and recycling stages. The analysis quantified environmental impacts in 15 different categories using SimaPro software and the IMPACT 2002 + method. Key findings show that the choice of raw materials is crucial; The use of glass instead of aluminum or copper in the collector significantly reduces environmental damage. In addition, the integration of PCM optimized energy efficiency by stabilizing thermal fluctuations and increased the thermal efficiency of the system from 41.90 % to 60.61 %. This improvement resulted in a 10 % increase in freshwater production (from 886 cc to 976 cc in a 4-hour test period). From an economic perspective, although the PCM-equipped system (Type 2) had a higher initial cost (\$60.01), due to its superior performance, its total lifetime benefit reached \$2765.916, which was \$430.595 more than the baseline system (Type 1). These results indicate that PCM integration is an effective strategy to enhance the environmental and economic performance of solar desalination systems and bridges the gap between sustainable design and practical implementation.

Journal Name: Applied Thermal Engineering

Rank: JCR, Q1, 5%



Research Paper

Eco-efficient solar water desalination system: integrating phase change materials, geothermal and spraying units

Hadi Samimi-Akhijahani^{a,*}, Omid Shariati^a, Mohammad Saleh Barghi Jahromi^b, Hadi Kargarsharifabad^c^a Department of Biosystems Engineering, University of Kurdistan, Sanandaj, Iran^b Department of Mechanical Engineering, University of Jiroft, Jiroft, Iran^c Department of Mechanical Engineering, Qo.C., Islamic Azad University, Qom, Iran

ARTICLE INFO

Keywords:

Environmental Impact
Life Cycle Assessment
Phase Change Material
Solar Energy
Water Desalination

ABSTRACT

Desalination of seawater is a possible solution for freshwater scarcity, but conventional methods are often fossil fuel-dependent and cause significant environmental damage. Although solar energy is a promising alternative, challenges related to unstable thermal performance and low energy efficiency remain. In the present study an innovative life cycle assessment (LCA) of a solar desalination system equipped with a phase change material (PCM) and a spray unit. This research investigates the system performance under spray conditions and provides a comprehensive comparative analysis of the manufacturing and recycling stages. The analysis quantified environmental impacts in 15 different categories using SimaPro software and the IMPACT 2002 + method. Key findings show that the choice of raw materials is crucial; The use of glass instead of aluminum or copper in the collector significantly reduces environmental damage. In addition, the integration of PCM optimized energy efficiency by stabilizing thermal fluctuations and increased the thermal efficiency of the system from 41.90 % to 60.61 %. This improvement resulted in a 10 % increase in freshwater production (from 886 cc to 976 cc in a 4-hour test period). From an economic perspective, although the PCM-equipped system (Type 2) had a higher initial cost (\$60.01), due to its superior performance, its total lifetime benefit reached \$2765.916, which was \$430.595 more than the baseline system (Type 1). These results indicate that PCM integration is an effective strategy to enhance the environmental and economic performance of solar desalination systems and bridges the gap between sustainable design and practical implementation.

2.

Design and performance analysis of a new flat solar heating porous collector equipped with vertical copper pipe and porous medium for medicinal plant drying

Mohammad Saleh Barghi Jahromi, Vali Kalantar, Hadi Samimi-Akhijahani

Abstract:

A suitable technique for dehydrating crops, particularly medicinal plants, is to use a combination of independent solar systems under suitable economic conditions. In the present study, Teucrium polium L (TP) was dried using an indirect solar cabinet drier with a newly designed unglazed transpired solar collector equipped with chrome color porous medium. TP samples were dried in a single layer and the experiments were carried out at two airflow speeds and compared with the samples dried in front of the Sun. Additionally, thermal behavior, temperature distribution (using computational fluid dynamics), exergy, and economic analyses were carried out for the unglazed

transpired solar collector. The findings implied that the maximum temperature of the drying chamber for the fluid flow rates of 0.01 and 0.015 kg/s was obtained at 334.07K and 333.9K, respectively. The maximum outlet fluid temperature of the proposed collector was 341.8K, which was higher than the common with the airflow rate of 0.01 kg/s. The energy saving for the presented study was 70.53 %, which was higher than the solar systems with similar conditions. In addition, the highest collector efficiency of 45.92 % during the drying process was for the flow rate of 0.015 kg/s. The employed CFD model within reasonable bounds predicted the collector's thermal performance. The drying time of TP was in the range of 960–990 min, but it lasted for 3360 min with the open sun drying method. The dryer was optimized based on the applied conditions, and the results showed a reduction in the payback period. The Page model was the best to predict the drying process of TP.

Journal Name: Energy

Rank: JCR, Q1, 5%

Energy 334 (2025) 137653



Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy



Design and performance analysis of a new flat solar heating porous collector equipped with vertical copper pipe and porous medium for medicinal plant drying

Mohammad Saleh Barghi Jahromi ^{a,b}, Vali Kalantar ^{b,*}, Hadi Samimi-Akhijahani ^{c,**}

^a Department of Mechanical Engineering, University of Jiroft, Jiroft, Iran

^b Department of Mechanical Engineering, Faculty of Mechanical Engineering, Yazd University, Yazd, Iran

^c Department of BioSystems Engineering, University of Kurdistan, Sanandaj, Iran

ARTICLE INFO

Keywords:

CFD modeling
Porous medium
Drying efficiency
Energy saving
Energetic analysis
Quality

ABSTRACT

A suitable technique for dehydrating crops, particularly medicinal plants, is to use a combination of independent solar systems under suitable economic conditions. In the present study, *Teucrium polium L (TP)* was dried using an indirect solar cabinet drier with a newly designed unglazed transpired solar collector equipped with chrome color porous medium. TP samples were dried in a single layer and the experiments were carried out at two airflow speeds and compared with the samples dried in front of the Sun. Additionally, thermal behavior, temperature distribution (using computational fluid dynamics), exergy, and economic analyses were carried out for the unglazed transpired solar collector. The findings implied that the maximum temperature of the drying chamber for the fluid flow rates of 0.01 and 0.015 kg/s was obtained at 334.07K and 333.9K, respectively. The maximum outlet fluid temperature of the proposed collector was 341.8K, which was higher than the common with the airflow rate of 0.01 kg/s. The energy saving for the presented study was 70.53 %, which was higher than the solar systems with similar conditions. In addition, the highest collector efficiency of 45.92 % during the drying process was for the flow rate of 0.015 kg/s. The employed CFD model within reasonable bounds predicted the collector's thermal performance. The drying time of TP was in the range of 960–990 min, but it lasted for 3360 min with the open sun drying method. The dryer was optimized based on the applied conditions, and the results showed a reduction in the payback period. The Page model was the best to predict the drying process of TP.

3.

Application of artificial neural network, evolutionary polynomial regression, and life cycle assessment techniques to predict the performance of a new designed solar air ventilator with phase change material

Mohammad Saleh Barghi Jahromi, Vali Kalantar, Hadi Samimi Akhijahani, Payman Salami

Abstract:

Global warming, greenhouse gas emissions, and environmental pollution are pressing issues worldwide, primarily stemming from the overuse of non-renewable energies and fossil fuels. To address this critical situation, modern building designs must incorporate natural ventilation techniques. A study was conducted to assess the effectiveness of a solar ventilator integrated with phase change material. The study compared the output velocity of the solar ventilator using artificial neural network methodology and empirical data, focusing on air flow speed and conditions with and without phase change material in a 2–4-1 proposed structure. The findings revealed a strong correlation with the experimental data ($R^2 > 0.96$) and minimal relative error ($RE < 2.76\%$). Also, for predicting the performance of the solar air ventilator, Evolutionary Polynomial Regression was used. This method validated high accuracy ($CoD > 0.99$) in predicting airflow. The results also showed that the EPR method had better performance in comparison with the ANN to predict the outlet airflow rate. But the difference wasn't significant. Furthermore, a life cycle assessment was performed to prioritize a solar ventilators with and without phase change material based on environmental impacts. The results indicated that solar ventilator, particularly those with phase change material, exhibited lower pollution levels compared to without phase change material ventilation system. Despite concerns regarding pollution risks associated with raw materials, the overall reduction in pollution levels was attributed to the clean and renewable nature of solar energy. The study emphasized the importance of transitioning towards sustainable energy sources to mitigate environmental pollution effectively.

Journal Name: Applied Thermal Engineering

Rank: JCR, Q1, 5%



Research Paper

Application of artificial neural network, evolutionary polynomial regression, and life cycle assessment techniques to predict the performance of a new designed solar air ventilator with phase change material

Mohammad Saleh Barghi Jahromi ^a, Vali Kalantar ^{b,*}, Hadi Samimi Akhijahani ^c, Payman Salami ^{c,*}

^a Department of Mechanical Engineering, University of Jiroft, Jiroft, Iran

^b Department of Mechanical Engineering, Yazd University, Yazd, Iran

^c Department of Biosystems Engineering, University of Kurdistan, Sanandaj, Iran

ARTICLE INFO

Keywords:

Artificial Neural Network
Energy analysis
Phase Change Material
Solar ventilator
Thermal efficiency

ABSTRACT

Global warming, greenhouse gas emissions, and environmental pollution are pressing issues worldwide, primarily stemming from the overuse of non-renewable energies and fossil fuels. To address this critical situation, modern building designs must incorporate natural ventilation techniques. A study was conducted to assess the effectiveness of a solar ventilator integrated with phase change material. The study compared the output velocity of the solar ventilator using artificial neural network methodology and empirical data, focusing on air flow speed and conditions with and without phase change material in a 2–4–1 proposed structure. The findings revealed a strong correlation with the experimental data ($R^2 > 0.96$) and minimal relative error ($RE < 2.76\%$). Also, for predicting the performance of the solar air ventilator, Evolutionary Polynomial Regression was used. This method validated high accuracy ($CoD > 0.99$) in predicting airflow. The results also showed that the EPR method had better performance in comparison with the ANN to predict the outlet airflow rate. But the difference wasn't significant. Furthermore, a life cycle assessment was performed to prioritize a solar ventilators with and without phase change material based on environmental impacts. The results indicated that solar ventilator, particularly those with phase change material, exhibited lower pollution levels compared to without phase change material ventilation system. Despite concerns regarding pollution risks associated with raw materials, the overall reduction in pollution levels was attributed to the clean and renewable nature of solar energy. The study emphasized the importance of transitioning towards sustainable energy sources to mitigate environmental pollution effectively.

4.

Thermo-economic evaluation and structural simulation of a parabolic solar collector (PTC) integrated with a desalination system

Donya Rahimi Telwar, Jalal Khodaei, Hadi Samimi-Akhijahani

Abstract:

In last decades because of the increase in water demand various technologies used to increase the performance of desalination systems and decreasing the cost of produced water. In the present research, the thermal and economic performance of a parabolic trough collector connected to a desalination system was analyzed. Moreover, in order to improve the thermal efficiency of the collector, the effect of wind speed (considering the position of the collector) on the deflection of the collector and thermal performance was evaluated. By increasing the wind speed the thermal efficiency decreases. The twist angle at the end of the reflecting shaft was

considered for calculations. Ansys analysis was used to survey the structural behavior of the collector at various conditions. The results of the experimental test demonstrated that for all three positions, the twist angle of the shaft increases as well. Moreover, due to the fluctuation of the solar radiation the fluid temperature flows in the collector is not homogenous. Using materials with higher latent heat decreases the thermal fluctuations. In the present work PCM in the spiral tube was installed inside of the receiver tube. The results implied that the maximum twist angle was obtained for the wind speed of 30 km/h at the right position. The deviation from the focal line increased the heat loss, thus optimization process was applied to the system considering the maximum wind speed of 124 km/h. The produced water for 15, 22 and 30 km/h is 722, 557 and 351 ml/m² in 4 h, respectively. The economic analysis implied that using proposed system would cause a decrease in the payback time.

Journal Name: Energy

Rank: JCR, Q1, 5%

Energy 299 (2024) 130428



Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Energy

journal homepage: www.elsevier.com/locate/energy



Thermo-economic evaluation and structural simulation of a parabolic solar collector (PTC) integrated with a desalination system

Donya Rahimi Telwar, Jalal Khodaei^{*}, Hadi Samimi-Akhijahani

Department of Renewable Energy and Biosystem Engineering, Faculty of Agriculture, University of Kurdistan, Sanandaj, Iran

ARTICLE INFO

Handling Editor: Dr X Zhao

Keywords:

Desalination
Performance evaluation
Structural optimization
Thermal efficiency
Wind force

ABSTRACT

In last decades because of the increase in water demand various technologies used to increase the performance of desalination systems and decreasing the cost of produced water. In the present research, the thermal and economic performance of a parabolic trough collector connected to a desalination system was analyzed. Moreover, in order to improve the thermal efficiency of the collector, the effect of wind speed (considering the position of the collector) on the deflection of the collector and thermal performance was evaluated. By increasing the wind speed the thermal efficiency decreases. The twist angle at the end of the reflecting shaft was considered for calculations. Ansys analysis was used to survey the structural behavior of the collector at various conditions. The results of the experimental test demonstrated that for all three positions, the twist angle of the shaft increases as well. Moreover, due to the fluctuation of the solar radiation the fluid temperature flows in the collector is not homogenous. Using materials with higher latent heat decreases the thermal fluctuations. In the present work PCM in the spiral tube was installed inside of the receiver tube. The results implied that the maximum twist angle was obtained for the wind speed of 30 km/h at the right position. The deviation from the focal line increased the heat loss, thus optimization process was applied to the system considering the maximum wind speed of 124 km/h. The produced water for 15, 22 and 30 km/h is 722, 557 and 351 ml/m² in 4 h, respectively. The economic analysis implied that using proposed system would cause a decrease in the payback time.

5.

Thermo-economic evaluation of a solar desalination equipped with Phase change material and spraying unit

Rashed Bahramei, Hadi Samimi-Akhijahani, Payman Salami, Naser Behroozi Khazaei

Abstract:

Solar desalination is a suitable and cost-effective system for producing fresh water from salt water. The main goal of this study is improving the thermal performance of a solar desalination with latent thermal storage system and the spraying unit. The heat loss of the solar collector increases due to the fluctuations in the intensity of solar radiation. Using phase change materials is a suitable solution for storing energy during peak hours and releasing it when the solar radiation intensity is reduced or in cloudy times. Moreover, due to the effective area of the spraying mechanism the desalination efficiency enhanced. Thermal performance of the collector was analyzed at three spraying rates of 0.25, 0.5 and 1 l/min with and without phase change material in consecutive days from 10: 00 to 14: 00. The results showed that the presented solar desalination system equipped with paraffin (as PCM) wax had the highest thermal efficiency at the spraying rate of 1 l/min and the lowest with a flow rate of 0.25 l/min. With integration PCM and spraying mechanism the amount of produced fresh water during 4 h was 1840 ml/m² and it significantly reduced the hardness of the produced water. The solar collector simulated by Ansys and the simulated results showed a good correlation between the predicted and experimental data with reasonable accuracy ($R^2 > 0.97$).

Journal Name: Desalination

Rank: JCR, Q1, 5%



Contents lists available at ScienceDirect

Desalination

journal homepage: www.elsevier.com/locate/desal

Thermo-economic evaluation of a solar desalination equipped with Phase change material and spraying unit

Rashed Bahramei, Hadi Samimi-Akhijahani^{*}, Payman Salami, Naser Behroozi Khazaei

Department of Biosystems Engineering, Renewable Engineering, Faculty of Agriculture, University of Kurdistan, Sanandaj, Iran

HIGHLIGHTS

- A new desalination system with PCM and spraying unit proposed.
- Geothermal energy was used to cool the outlet fluid of the condenser.
- Using PCM improved the thermal efficiency and overall efficiency of the system.
- Application of spraying unit increased the desalination efficiency at least 8.57%.
- The applied CFD method considerably anticipate the outlet temperature with good precision.

ARTICLE INFO

Keywords:

CFD simulation
Solar tracker
Specific energy consumption
Thermal efficiency
Water minerals matters

ABSTRACT

Solar desalination is a suitable and cost-effective system for producing fresh water from salt water. The main goal of this study is improving the thermal performance of a solar desalination with latent thermal storage system and the spraying unit. The heat loss of the solar collector increases due to the fluctuations in the intensity of solar radiation. Using phase change materials is a suitable solution for storing energy during peak hours and releasing it when the solar radiation intensity is reduced or in cloudy times. Moreover, due to the effective area of the spraying mechanism the desalination efficiency enhanced. Thermal performance of the collector was analyzed at three spraying rates of 0.25, 0.5 and 1 l/min with and without phase change material in consecutive days from 10: 00 to 14: 00. The results showed that the presented solar desalination system equipped with paraffin (as PCM) wax had the highest thermal efficiency at the spraying rate of 1 l/min and the lowest with a flow rate of 0.25 l/min. With integration PCM and spraying mechanism the amount of produced fresh water during 4 h was 1840 ml/m² and it significantly reduced the hardness of the produced water. The solar collector simulated by Ansys and the simulated results showed a good correlation between the predicted and experimental data with reasonable accuracy ($R^2 > 0.97$).

6.

Investigating the thermo-economic performance and modeling of a parabolic solar collector with phase change material in the receiver tube in a solar desalination

Jhina Seifi, Hadi Samimi-Akhijahani, Payman Salami

Abstract:

Solar desalination is a suitable and cost-effective system for producing drinkable water from salt water. The main goal of this study is improving the thermal performance of the solar desalination with latent thermal storage system and the panel detector. The heat loss from the solar collector increases due to the fluctuations in the intensity of solar radiation and the use of phase change

materials is a suitable solution for storing energy during peak hours and releasing it when the solar radiation intensity is reduced or absent. Thus phase change material (paraffin) placed in the focal tube in the form of a 6 mm spiral pipe with a pitch of 7 cm. Thermal performance of the collector was carried out at three fluid flow rates of the working fluid at 1.9, 1.3 and 4.2 l/min with phase change material and without phase change material in four consecutive days from 10:00 to 14:00. The results showed that the solar water desalination equipped with phase change materials had the highest thermal efficiency at the fluid flow rate of 4.2l/min and the lowest with a flow rate of 1.9 l/min. The results showed that the using phase change material improves the thermal efficiency by 3.05 %. Produced fresh water during 4 h was 0.722l/m² and it significantly reduced the hardness of drinking water. The solar collector simulated by Ansys and the simulated results showed a good correlation between the predicted and experimental data with reasonable accuracy ($R^2 > 0.97$).

Journal Name: Desalination

Rank: JCR, Q1, 5%



Investigating the thermo-economic performance and modeling of a parabolic solar collector with phase change material in the receiver tube in a solar desalination

Jhina Seifi, Hadi Samimi-Akhijahani^{*}, Payman Salami

Department of Biosystems Engineering, Renewable Engineering, Faculty of Agriculture, University of Kurdistan, Sanandaj, Iran

HIGHLIGHTS

- A new desalination system with PCM proposed.
- Using PCM improved the thermal efficiency and overall efficiency of the system.
- CFD simulation method applied to survey the variations of thermal parameters in the system
- The applied method considerably anticipates the outlet temperature with good precision.

ARTICLE INFO

Keywords:

CFD simulation
Solar tracker
Specific energy consumption
Thermal efficiency
Water minerals matters

ABSTRACT

Solar desalination is a suitable and cost-effective system for producing drinkable water from salt water. The main goal of this study is improving the thermal performance of the solar desalination with latent thermal storage system and the panel detector. The heat loss from the solar collector increases due to the fluctuations in the intensity of solar radiation and the use of phase change materials is a suitable solution for storing energy during peak hours and releasing it when the solar radiation intensity is reduced or absent. Thus phase change material (paraffin) placed in the focal tube in the form of a 6 mm spiral pipe with a pitch of 7 cm. Thermal performance of the collector was carried out at three fluid flow rates of the working fluid at 1.9, 1.3 and 4.2 l/min with phase change material and without phase change material in four consecutive days from 10:00 to 14:00. The results of the showed that the solar water desalination equipped with phase change materials had the highest thermal efficiency at the fluid flow rate of 4.2l/min and the lowest with a flow rate of 1.9 l/min. The results showed that the using phase change material improves the thermal efficiency by 3.05 %. Produced fresh water during 4 h was 0.722l/m² and it significantly reduced the hardness of drinking water. The solar collector simulated by Ansys and the simulated results showed a good correlation between the predicted and experimental data with reasonable accuracy ($R^2 > 0.97$).