Scopus

Documents

Hussain, F.[a] , Shaik, S.[b] , Khan, S.A.[c] , Van Huynh, V.[d] , Jilte, R.D.[e] , Sundara, V.[f] , Asif, M.[g] , Linul, E.[h]

Transient solidification and melting numerical simulation of lauric acid PCM filled stepped solar still basin used in water desalination process

(2023) *Case Studies in Thermal Engineering*, 49, art. no. 103370, .

DOI: 10.1016/j.csite.2023.103370

[a] Modeling Evolutionary Algorithms Simulation and Artificial Intelligence, Faculty of Electrical & Electronics Engineering, Ton Duc Thang University, Ho Chi Minh City, Viet Nam

[b] School of Mechanical Engineering, Vellore Institute of Technology, Tamil Nadu, Vellore, 632014, India

[c] Department of Mechanical Engineering, Faculty of Engineering, International Islamic University, Selangor, Kuala Lumpur, 53100, Malaysia

[d] Faculty of Electrical & Electronics Engineering, Ton Duc Thang University, Ho Chi Minh City, Viet Nam

[e] Department of Mechanical Engineering, Lovely Professional University, Punjab144411, India

[f] Department of Engineering, University of Luxembourg, Maison du Nombre, 6 Avenue de la Fonte, Esch-sur-Alzette, L-4364, Luxembourg

[g] Department of Chemical Engineering, King Saud University, P.O. Box 800, Riyadh, 11421, Saudi Arabia

[h] Department of Mechanics and Strength of Materials, Politehnica University Timisoara, Timisoara, 300222, Romania

Abstract

It is crucial to produce potable water from salt water in arid places using a stepped solar still desalination process. This work presents the temperature distribution and phase transformation of lauric acid PCM in inclined stepped solar still desalination system. A second-order finite volume method is employed for discretizing the two-dimensional geometry, while energy, continuity, and momentum equations are solved and then coupled using the second-order PRESTO algorithm. The solidification and melting CFD models have been used to capture the melting stages of lauric acid PCM. Four steps with an inclination of 30° to ground and two different cases with saline water levels of 10 mm and 40 mm have been reported. The results reveal that the temperature and mass fraction of lauric acid PCM strongly depends on the saline water level at each step, the number of steps, the angle of inclination, and the location of the solar still step. The maximum percentage increase in PCM melting fraction is 50%, and a PCM temperature rise of 4 °C is observed in the case of SWL-max compared to SWL-min. The total enthalpy of lauric acid PCM is increased by 30% for the SWL-max water level compared to the SWL-min water level. © 2023 The Authors

Author Keywords

FVM; Inclined stepped solar still; Lauric acid; PCM; PRESTO; Solar desalination

Index Keywords

Desalination, Distillation, Finite volume method, Melting, Potable water, Saline water, Solar heating, Solidification, Water filtration; FVM, Inclined stepped solar still, Lauric acid, Phases transformation, PRESTO, Second orders, Solar desalination, Solar stills, Solidification and melting, Water desalination; Water levels

References

- Sourabh Kumar Nougriaya, M.K. Chopra, Bhupendra Gupta, Prashant Baredar, Stepped solar still: A review on designs analysis, Mater. Today: Proc.,
- Pietro, C., Andrea, C., Francesco, G.
  Thermodynamic, exergy, and thermo-economic analysis of multiple effect distillation processes
  (2018) *Renewable Energy Powered Desalination Handbook*, pp. 445-489. Butterworth-Heinemann Oxford, UK
- Tiwari, G.N., Sahota, L.
  Review on the energy and economic efficiencies of passive and active solar distillation systems
  (2017) *Desalination*, 401, pp. 151-179.
- Wang, Y.-N., Wang, R.
  Reverse Osmosis Membrane Separation Technology, Membrane Separation

Principles, and Applications
(2019), pp. 1-45.
Elsevier Amsterdam, The Netherlands

- Walton, J., Lu, H., Turner, C., Solis, S., Hein, H.
Solar and Waste Heat Desalination by Membrane Distillation
(2004), p. 81.
US Department of the Interior, Bureau of Reclamation, DWPR Washington, DC, USA

- Fath, H.E.S.
Solar distillation: a promising alternative for water provision with free energy, simple technology, and clean environment
(1998) *Desalination*, 116, pp. 45-56.

- Khalifa, A.J., Al-Jubouri, A., Abed, M.
An experimental study on modified simple solar stills
(1999) *Energy Convers. Manag.*, 40, pp. 1835-1847.

- Khawaji, A.D., Kutubkhanah, I.K., Wie, J.M.
Advances in seawater desalination technologies
(2008) *Desalination*, –221, pp. 47-69.

- Kabeel, A.E., Khairat Dawood, M.M., Nabil, T., Essa Alonafal, B.
Improving the performance of stepped solar still using graphite and PCM as hybrid store materials with internal reflectors coupled with evacuated tube solar collector
(2019) *Heat Mass Tran.*,

- Ali, F., Sopiana Muftaha, K., Alghoul, M.A.
Performance of basin type stepped solar still enhanced with superior design concepts
(2018) *Desalination*, 435, pp. 198-209.

- Alaudeen, A., Johnson, K., Ganasundar, P., Syed Abuthahir, A., Srithar, K.
Study on stepped type basin in solar still
(2014) *J. King Saud Univ. – Eng. Sci.*, 26, pp. 176-183.

- Mohammed, S.S., Abujazar, S., Fatihah, E.R., Lotfy, A.E.K., Sharil, S.
Performance evaluation of inclined copper-stepped solar still in a wet tropical climate
(2018) *Desalination*, 425, pp. 94-103.

- El-Agouz, S.A.
Experimental investigation of stepped solar still with continuous water circulation
(2014) *Energy Convers. Manag.*, 86, pp. 186-193.

- Saadi, Z., Ahmed, R., Lachtar, S., Soualmi, H.
Performance evaluation of a new stepped solar still under the desert climatic conditions
(2018) *Energy Convers. Manag.*, 171, pp. 1749-1760.

- Kabeel, A.E., Teamah, M.A., Abdelgaied, M., Abdel Aziz, G.B.
Modified pyramid solar still with v-corrugated absorber plate and PCM as a thermal storage medium
(2017) *J. Clean. Prod.*, 161, pp. 881-887.

- Sarhaddi, F., Farshchi Tabrizi, F., Aghaei Zoori, H., Mousavi, S.A.H.S.
Comparative study of two weir type cascade solar stills with and without PCM storage using energy and exergy analysis
(2017) *Energy Convers. Manag.*, 133, pp. 97-109.

- Al-harahsheh, M., Abu-Arabi, M., Mousa, H., Alzghoul, Z.
Solar desalination using solar still enhanced by external solar collector and PCM
(2018) *Appl. Therm. Eng.*, 128, pp. 1030-1104.

- Shoeibi, S., Kargarsharifabad, H., Rahbar, N., Khosravi, G., Sharifpur, M.
An integrated solar desalination with evacuated tube heat pipe solar collector and new wind ventilator external condenser
(2022) *Sustainable Energy Technologies and Assessments Volume*, 50.

- Dhivagar, R., Shoeibi, S., Kargarsharifabad, H., Mohammad Hossein, A., Sharifpur, M.
Performance enhancement of a solar still using magnetic powder as an energy storage medium-exergy and environmental analysis
(2022) *Energy Sci. Eng.*, 10 (8), pp. 2577-3215.

- Shoeibi, S., Rahbar, N., Abedini Esfahlani, A., Kargarsharifabad, H.
Energy matrices, economic and environmental analysis of thermoelectric solar desalination using cooling fan
(2022) *J. Therm. Anal. Calorim.*, 147, pp. 9645-9660.

- Shoeibi, S., Agha Mirjalily, S.A., Kargarsharifabad, H., Panchal, H., Dhivagar, R.
Comparative study of double-slope solar still, hemispherical solar still, and tubular solar still using Al2O3/water film cooling: a numerical study and CO2 mitigation analysis
(2022) *Environ. Sci. Pollut. Control Ser.*, 29.

- Shoeibi, S., Saemian, M., Kargarsharifabad, H., Hosseinzade, S., Rahbar, N., Khiadani, M., Rashidi, M.M.
A review on evaporation improvement of solar still desalination using porous material
(2022) *Int. Commun. Heat Mass Tran.*, 138.

- Ramasamy Dhivagar, A., Shahin Shoeibi, B., SeyedMasoud Parsa c, Siamak Hoseinzadeh, D., Hadi Kargarsharifabad, E., Khiadani, M.
Performance evaluation of solar still using energy storage biomaterial with porous surface: an experimental study and environmental analysis
(2023) *Renew. Energy*, 206, pp. 879-889.

- Shoeibi, S., Saemian, M., Khiadani, M., Kargarsharifabad, H., Agha Mirjalily, S.A.
Influence of PV/T waste heat on water productivity and electricity generation of solar stills using heat pipes and thermoelectric generator: an experimental study and environmental analysis
(2023) *Energy Convers. Manag.*, 276.

- Kargarsharifabad, H., Behshad Shafii, M., Taeibi Rahni, M., Abbaspour, M.
Exergy analysis of flat plate solar collector in combination with heat pipe
(2014) *Int. J. Environ. Res.*, 8, pp. 39-48.

- Omidi, B., Rahbar, N., Kargarsharifabad, H., Moziraji, Z.P.
Performance evaluation of a solar desalination-hot water system using heat pipe vacuum tube parabolic trough solar collector – an experimental study with Taguchi analysis
(2023) *Energy Convers. Manag.*, 292.

- BarghiJahromi, M., Kalantar, V., Samimi, H., Akhijahani, H.K.
(2022) *J. Energy Storage*, 51.

- Kabeel, A.E., Abdelgaied, M., Mahgoub, M.
The performance of a modified solar still using hot air injection and PCM
(2016) *Desalination*, 379, pp. 102-107.

- Dashtban, M., Tabrizi, F.F.
Thermal analysis of a weir-type cascade solar still integrated with PCM storage
(2011) *Desalination*, 279, pp. 415-422.

- Ansari, O., Asbik, M., Bah, A., Arbaoui, A., Khmou, A.
Desalination of the brackish water using a passive solar still with a heat energy storage system
(2013) *Desalination*, 324, pp. 10-20.

- Kabeel, A.E., Abdelgaied, M., Eisa, A.
Effect of graphite mass concentrations in a mixture of graphite nanoparticles and paraffin wax as hybrid storage materials on performances of solar still
(2019) *Renew. Energy*, 132, pp. 119-128.

- Hammad, F.A., Shalaby, S.M., Kabeel, A.E., Zayed, M.E.
Experimental investigation and thermo-economic performance analysis of a modified solar distiller design with thermal storage material and v-corrugated absorber basin
(2022) *Journal of Energy Storage Volume*, 52.

- Abdelgaied, M., Abdulla, A.S., Abdelaziz, G.B., Kabeel, A.E.
Performance improvement of modified stepped solar distillers using three effective hybrid optimization modifications
(2022) *Sustain. Energy Technol. Assessments*, 51.

- Khairat Dawood, M.M., Shehata, A.I., Shehata, A.S., Elnaby Kabeel, A., Ramzy, K., Abdalla, A.M., Nabil, T., Elnaghi, B.E.
Experimental investigation of a stepped solar still employing a phase change material, a conical tank, and a solar dish
(2022) *Int. J. Energy Res.*,

- Kabeel, A.E., Mohamed, M.
Khairat Dawood & Tamer Nabil & Bader Essa Alonafal, Improving the performance of stepped solar still using a graphite and PCM as hybrid store materials with internal reflectors coupled with evacuated tube solar collector. Heat Mass Tran.

- El-Sebaey, M.S., Ellman, A., Ahmed, H., Ghonim, T.
Experimental analysis and CFD modeling for conventional basin-type solar still
(2020) *Energies*, 13, p. 5734.

- MouhsinMariam, N., Bouzaid, Mourad Taha-Janan, M.O.
Modeling and experimental study of cascade solar still
(2020) *SN Appl. Sci.*, 2, p. 708.

- Keshtkar, M., Eslami, M., Jafarpur, K.
Effect of design parameters on performance of passive basin solar stills considering instantaneous ambient conditions: a transient CFD modelling
(2020) *Sol. Energy*, 201 (1), pp. 884-907.

- Shoeibi, S., Kargarsharifabad, H., Rahbar, N., Ahmadi, G., Reza Safaei, M.
Performance evaluation of a solar still using hybrid nanofluid glass cooling-CFD simulation and environmental analysis
(2022) *Sustain. Energy Technol. Assessments*, 49.

- Shokouhmand, H., Kamkari, B.
Experimental investigation on melting heat transfer characteristics of lauric acid in a rectangular thermal storage unit
(2013) *Exp. Therm. Fluid Sci.*, 50, pp. 201-212.

- Benard, C., Gobin, D., Martinez, F.
Melting in a rectangular enclosure: experiments and numerical simulations

(1985) *J. Heat Tran.*, 107, pp. 794-803.

- Brent, A.D., Voller, V.R., Reid, K.J.
  Enthalpy-Porosity Technique for modeling convection-diffusion phase change: application to melting of a pure metal
  (1988) *Numer. Heat Tran.*, 13, pp. 297-318.

- Vogel, J., Felbinger, J., Jhonson, M.
  Natural Convection in High Temperature Flat Plate latent heat thermal energy storage system
  (2016) *Appl. Energy*, 184, pp. 184-196.

- Shokouhmand, H., Kamkari, B.
  Experimental investigation on melting heat transfer characteristics of lauric acid in a rectangular thermal storage unit
  (2013) *Exp. Therm. Fluid Sci.*, 50, pp. 201-212.

- Mokashi, I., Afghan, S., Nur, Abdullah, A., Hanafi, Muhammad Azami, B., Afzal, A.
  Maximum temperature analysis in a Li-ion battery pack cooled by different fluids
  (2020) *J. Therm. Anal. Calorim.*, pp. 1-17.

- Samylingam, L., Aslfattahi, N., Saidur, R., Mohd, S., Afzal, A.
  Solar energy materials and solar cells thermal and energy performance improvement of hybrid PV/T system by using olein palm oil with MXene as a new class of heat transfer fluid
  (2020) *Sol. Energy Mater. Sol. Cells*, 218.

- Kumar, R., Gaurav, Kumar, S., Afzal, A., Muthu Manokar, A., Sharifpur, M., Issakhov, A.
  Experimental investigation of impact of the energy storage medium on the thermal performance of double pass solar air heater
  (2021) *Sustain. Energy Technol. Assessments*, 48.

- Benoudina, B., Attia, M.E.H., Driss, Z., Afzal, A., Manokar, A.M., Sathyamurthy, R.
  Enhancing the solar still output using micro/nano-particles of aluminum oxide at different concentrations: an experimental study, energy, exergy and economic analysis
  (2021) *Sustain. Mater. Technol.*, 29.

- Santhosh Kumar, P.C., Naveenkumar, R., Sharifpur, M., Issakhov, A., Ravichandran, M., Mohanavel, V., Aslfattahi, N., Afzal, A.
  Experimental investigations to improve the electrical efficiency of photovoltaic modules using different convection mode
  (2021) *Sustain. Energy Technol. Assessments*, 48.

- Kumar, R., Nadda, R., Kumar, S., Kumar, K., Afzal, A., Razak, K.A., Sharifpur, M.
  Heat transfer and friction factor correlations for an impinging air jets solar thermal collector with arc ribs on an absorber plate
  (2021) *Sustain. Energy Technol. Assessments*, 47.

- Felemban, B.F., Essa, F.A., Afzal, A., Ahmed, M.H., Saleh, B., Panchal, H., Shanmugan, S., Omara, Z.M.
  Experimental investigation on dish solar distiller with modified absorber and phase change material under various operating conditions
  (2022) *Environ. Sci. Pollut. Res.*,

Correspondence Address
Shaik S.; School of Mechanical Engineering, Tamil Nadu, India; email: saboor.nitk@gmail.com
Linul E.; Department of Mechanics and Strength of Materials, Romania; email: emanoil.linul@upt.ro

Publisher: Elsevier Ltd

ISSN: 2214157X
Language of Original Document: English

Abbreviated Source Title: Case Stud. Therm. Eng.
2-s2.0-85167453059
Document Type: Article
Publication Stage: Final
Source: Scopus