Scopus

Documents

Arul, G.P.[a] , Thulasi, S.[b] , Kumar, P.[c] , Arunprasad, V.[d] , Shaik, S.[e] , Abbas, M.[f g] , Rajendran, P.[h i] , Khan, S.A.[j] , Saleel, C.A.[k]

Investigation of Dual–Pass Inclined Oscillating Bed Solar Dryer for Drying of Non-Parboiled Paddy Grains
(2022) *Sustainability (Switzerland)*, 14 (9), art. no. 5558, .

DOI: 10.3390/su14095558

[a] Department of Mechanical Engineering, Indra Ganesan College of Engineering, Tamil Nadu, Srirangam, 620012, India
[b] Department of Mechanical Engineering, University College of Engineering, Nagappattinam, Tamil Nadu, Thirukkuvalai, 610201, India
[c] Department of Mechanical Engineering, Ariyalur Engineering College, Tamil Nadu, Ariyalur, 621704, India
[d] Department of Mechanical Engineering, Theni Kammavar Sangam College of Technology, Tamil Nadu, Koduvilarpatti, Theni, 625534, India
[e] School of Mechanical Engineering, Vellore Institute of Technology, Tamil Nadu, Vellore, 632014, India
[f] Electrical Engineering Department, College of Engineering, King Khalid University, Abha, 61421, Saudi Arabia
[g] Computers and Communications Department, College of Engineering, Delta University for Science and Technology, Gamasa, 35712, Egypt
[h] School of Aerospace Engineering, Universiti Sains Malaysia, Engineering Campus, Pulau Pinang, Nibong Tebal, 14300, Malaysia
[i] Faculty of Engineering & Computing, First City University College, Selangor, Bandar Utama, 47800, Malaysia
[j] Department of Mechanical Engineering, Faculty of Engineering, International Islamic University, Selangor, Kuala Lumpur, 53100, Malaysia
[k] Department of Mechanical Engineering, College of Engineering, King Khalid University, Abha, 61421, Saudi Arabia

Abstract
This Paper determines an experimental study of dual-pass solar dryer with a bed tilt of 0.5◦ and varying oscillating frequency of drying chamber namely 1.25, 1.75 and 2.25 Hz for drying an agricultural produce namely non–parboiled paddy grains. The oscillations and bed tilt are provided to move the grains from entry to exit of the top bed and moving down to bottom bed and finally exits from the dryer. The new technology has been used in the solar dryer for drying of agricultural produce such as non–parboiled paddy grains to increase the quality and to decrease the loss of the dried produce. The present dryer model was used for drying 45 kg of non–parboiled paddy grains from 19% (w.b) to the approved range of 12–14% of moisture content obtained in a single experimental day. The dried paddy grains obtained an average moisture content are 13.03, 13.22 and 13.51% at the frequency of oscillation of 1.25, 1.75, 2.25 Hz, respectively. The maximum thermal and pick-up efficiency of the model were obtained at 1.00 p.m. in all cases. For the frequency of oscillation of 1.25, 1.75 and 2.25 Hz, the maximum dryer thermal efficiency was 44.47, 43.39 and 41.39%, respectively, and the maximum pick–up efficiency was 80.41, 79.19 and 76.21%, respectively. The optimum drying performance was obtained at the oscillating frequency of 1.75 Hz with the bed tilt of 0.5◦ .

Author Keywords
dual–pass flat plate solar collector; dual–pass oscillating bed solar dryer; moisture content; non–parboiled paddy grains; pick–up efficiency; thermal efficiency of the dryer

Index Keywords
efficiency measurement, experimental study, instrumentation, moisture content, performance assessment, wavelength

References

- Yadollahinia, A.R., Omid, M., Rafiee, S.
  Design and fabrication of experimental dryer for studying agricultural products
  (2008) *Int. J. Agric. Biol*, 10, pp. 61-65.

- Singh, S., Kumar, S.
  New approach for thermal testing of solar dryer: Development of generalized drying characteristic curve

(2012) *Sol. Energy*, 86, pp. 1981-1991.
[CrossRef]

- Umesh, T., Karale, S.R.
A review paper on solar dryer
(2013) *Int. J. Eng. Res. Appl*, 3, pp. 896-902.

- Shanmugam, V., Natarajan, E.
Experimental study of regenerative desiccant integrated solar dryer with and without reflective mirror
(2007) *Appl. Therm. Eng*, 27, pp. 1543-1551.
[CrossRef]

- Afriyie, J., Nazha, M., Rajakaruna, H., Forson, F.
Experimental investigations of a chimney-dependent solar crop dryer
(2009) *Renew. Energy*, 34, pp. 217-222.
[CrossRef]

- Bal, L.M., Satya, S., Naik, S., Meda, V.
Review of solar dryers with latent heat storage systems for agricultural products
(2010) *Renew. Sustain. Energy Rev*, 15, pp. 876-880.
[CrossRef]

- Fudholi, A., Sopian, K., Ruslan, M., Alghoul, M., Sulaiman, M.
Review of solar dryers for agricultural and marine products
(2010) *Renew. Sustain. Energy Rev*, 14, pp. 1-30.
[CrossRef]

- Kumar, R., Chauhan, R., Sethi, M., Sharma, A., Kumar, A.
Experimental investigation of effect of flow attack angle and thermo hydraulic performance of air flow in a rectangular channel with discrete V—pattern baffle on the heated plate
(2016) *Adv. Mech. Eng*, 8, pp. 1-12.
[CrossRef]

- Leon, M.A., Kumar, S., Bhattacharya, S.
A comprehensive procedure for performance evaluation of solar food dryers
(2002) *Renew. Sustain. Energy Rev*, 6, pp. 367-393.
[CrossRef]

- Sharma, V.K., Colangelo, A., Spagna, G.
Experimental investigation of different solar dryers suitable for fruit and vegetable drying
(1995) *Renew. Energy*, 6, pp. 413-424.
[CrossRef]

- Beigi, M., Tohidi, M., Torki-Harchegani, M.
Exergetic analysis of deep-bed drying of rough rice in a convective dryer
(2017) *Energy*, 140, pp. 374-382.
[CrossRef]

- Rahimi, A., Sami, S., Etesami, N.
Economical optimization of an indirect solar cabinet dryer based on mathematical modeling

(2014) *Environ. Eng. Manag. J*, 13, pp. 2615-2623.
[CrossRef]

- Na Abou, M.M., Madougou, S., Boukar, M.
Effect of Drying Air Velocity on Drying Kinetics of Tomato Slices in a Forced-Convective Solar Tunnel Dryer
(2019) *J. Sustain. Bioenergy Syst*, 9, pp. 64-78.
[CrossRef]

- Simate, I.
Optimization of mixed-mode and indirect-mode natural convection solar dryers
(2003) *Renew. Energy*, 28, pp. 435-453.
[CrossRef]

- Agrawal, A., Sarviya, R.
A review of research and development work on solar dryers with heat storage
(2014) *Int. J. Sustain. Energy*, 35, pp. 583-605.
[CrossRef]

- Arul, G.P., Shanmugam, S., Veerappan, A., Kumar, P.
Performance analysis of double-pass oscillating bed solar dryer for drying of non-parboiled paddy grains
(2018) *Energy Sources Part A Recover. Util. Environ. Eff*, 41, pp. 418-426.
[CrossRef]

- Kumar, P., Shanmugam, S., Veerappan, A.
An Experimental Study on Drying of Non-parboiled Paddy Grains Using an Oscillating Bed Solar Dryer
(2011) *Energy Eng*, 108, pp. 69-80.
[CrossRef]

- Yogendra, S.D., PydiSetty, Y.
Drying kinetics, exergy and energy analyses of kodo millet grains and fenugreek seeds using wall heated fluidized bed dryer
(2018) *Energy*, 151, pp. 799-811.
[CrossRef]

- Jain, D., Jain, R.K.
Performance evaluation of an inclined multi-pass solar air heater with in-built thermal storage on deep-bed drying application
(2004) *J. Food Eng*, 65, pp. 497-509.
[CrossRef]

- Rao, P.S., Bal, S., Goswami, T.
Modelling and optimization of drying variables in thin layer drying of parboiled paddy
(2007) *J. Food Eng*, 78, pp. 480-487.
[CrossRef]

- Shanmugam, S., Kumar, P., Veerappan, A.
Modeling and Experimental Studies on Oscillating Inclined-Bed Solar Dryer
(2013) *J. Sol. Energy Eng*, 135, p. 031009.
[CrossRef]

- Supranto, Sopian, K., Daud, W., Othman, M., Yatim, B.
  Design of an experimental solar assisted dryer for palm oil fronds
  (1999) *Renew. Energy*, 16, pp. 643-646.
  [CrossRef]

- Srzednicki, G.S., Hou, R., Driscoll, R.H.
  Development of a control system for in-store drying of paddy in Northeast China
  (2006) *J. Food Eng*, 77, pp. 368-377.
  [CrossRef]

- Resha, T., Deshmukh, S.J.
  Design, fabrication and performance analysis of a mixed mode solar dryer for drying vegetables
  (2018) *Int. J. Latest Trends Eng. Technol*, 9, pp. 51-56.

- Ronak Jain, R., Pandikesavan, M., Raghul Kumar, T., Sakthivel, U.
  Experimental analysis of curry leaves drying using an indirect solar dryer
  (2017) *SSRG Int. J. Mech. Eng*, pp. 29-33.

- Shanmugam, S., Kumar, P.
  Performance of an Oscillating Bed Solar Dryer for Sunflower Seeds
  (2013) *Energy Sources Part A Recovery Util. Environ. Eff*, 35, pp. 282-289.
  [CrossRef]

- Shanmugam, S., Kumar, P., Veerappan, A.R.
  Thermal performance of solar dryer with oscillating–bed solar dryer for non–parboiled paddy grains
  (2014) *Energy Sources Part A Recovery Util. Environ. Eff*, 36, pp. 1877-1885.
  [CrossRef]

- Bhardwaj, A., Chauhan, R., Kumar, R., Sethi, M., Rana, A.
  Experimental investigation of an indirect solar dryer integrated with phase change material for drying valeriana jatamansi (medicinal herb)
  (2017) *Case Stud. Therm. Eng*, 10, pp. 302-314.
  [CrossRef]

- Pardhi, C.B., Bhagoria, J.L.
  Development and performance evaluation of mixed-mode solar dryer with forced convection
  (2013) *Int. J. Energy Environ. Eng*, 4, p. 23.
  [CrossRef]

- Sidrah, A., Manzoor, A., Aftab, W.
  Design development and performance evaluation of a small scale solar assisted paddy dryer for on farm processing
  (2015) *J. Food Processing Technol*, 6, pp. 1-6.

- Gavhale, M., Kawale, S., Nagpure, R., Mujbaile, V.N., Sawarkar, N.S.
  Design and development of solar seed dryer
  (2015) *Int. J. Innov. Sci. Eng. Technol*, 2, pp. 1005-1010.

- Mumba, J.
  Design and development of a solar grain dryer incorporating photovoltaic powered air circulation

(1996) *Energy Convers. Manag*, 37, pp. 615-621.
[CrossRef]

- Manikantan, M.R., Barnwal, P., Goyal, R.K.
Drying characteristics of paddy in an integrated dryer
(2014) *J. Food Sci. Technol*, 51, pp. 813-819.
[CrossRef] [PubMed]

- Adelaja, A.O., Babatope, B.I.
Analysis and Testing of a Natural Convection Solar Dryer for the Tropics
(2013) *J. Energy*, 2013, p. 479894.
[CrossRef]

- Umayal Sundari, A.R., Neelamegam, P., Subramanian, C.V.
Performance evaluation of a forced convection solar dryer with evacuated tube collector for drying Amla
(2013) *Int. J. Eng. Technol*, 5, pp. 2853-2858.

- Avesahemad, S.N., Husainy, S.P., Gouri, W.
Experimental investigation of mixed mode forced convection solar dryer for turmeric (Curcuma Longa)
(2018) *Asian Rev. Mech. Eng*, 7, pp. 1-6.

- Gad, M., Ağbulut, Ü., El-Shafay, A., Panchal, H., Emara, K., Al-Mdallal, Q.M., Afzal, A.
Experimental and numerical assessment of the rotary bed reactor for fuel-processing and evaluation of produced oil usability as fuel substitute
(2022) *Case Stud. Therm. Eng*, 29, p. 101710.
[CrossRef]

- Yıldız, G., Ergün, A., Gürel, A.E., Ceylan, I., Ağbulut, Ü., Eser, S., Afzal, A., Saleel, C.
Exergy, sustainability and performance analysis of ground source direct evaporative cooling system
(2022) *Case Stud. Therm. Eng*, 31, p. 101810.
[CrossRef]

- Ağbulut, Ü., Elibol, E., Demirci, T., Sarıdemir, S., Gürel, A.E., Rajak, U., Afzal, A., Verma, T.N.
Synthesis of graphene oxide nanoparticles and the influences of their usage as fuel additives on CI engine behaviors
(2022) *Energy*, 244, p. 122603.
[CrossRef]

- Khandal, S.V., Ağbulut, Ü., Afzal, A., Sharifpur, M., Razak, K.A., Khalilpoor, N.
Influences of hydrogen addition from different dual-fuel modes on engine behaviors
(2022) *Energy Sci. Eng*, 10, pp. 881-891.
[CrossRef]

- Saleh, B., Madhukesh, J.K., Kumar, R.S.V., Afzal, A., Abdelrhman, Y., Aly, A.A., Gowda, R.J.P.
Aspects of magnetic dipole and heat source/sink on the Maxwell hybrid nanofluid flow over a stretching sheet
(2022) *Proc. Inst. Mech. Eng. Part E J. Process. Mech. Eng*,
[CrossRef]

- Shaik, S., Maduru, V.R., Kontoleon, K.J., Arıcı, M., Gorantla, K., Afzal, A.
  Building glass retrofitting strategies in hot and dry climates: Cost savings on cooling, diurnal lighting, color rendering, and payback timeframes
  (2022) *Energy*, 243, p. 123106.
  [CrossRef]

- Islam, T., Nguyen, A.V., Afzal, A.
  Bubble's rise characteristics in shear-thinning xanthan gum solution: A numerical analysis
  (2022) *J. Taiwan Inst. Chem. Eng*, 132, p. 104219.
  [CrossRef]

- Yaliwal, V., Banapurmath, N., Soudagar, M.E.M., Afzal, A., Ahmadi, P.
  Effect of manifold and port injection of hydrogen and exhaust gas recirculation (EGR) in dairy scum biodiesel—low energy content gas-fueled CI engine operated on dual fuel mode
  (2022) *Int. J. Hydrogen Energy*, 47, pp. 6873-6897.
  [CrossRef]

- Al Rashdi, S.A., Sudhir, C., Basha, J.S., Saleel, C.A., Soudagar, M.E.M., Yusuf, A.A., El-Shafay, A., Afzal, A.
  A case study on the electrical energy auditing and saving techniques in an educational institution (IMCO, Sohar, Oman)
  (2022) *Case Stud. Therm. Eng*, 31, p. 101820.
  [CrossRef]

- Murugan, M., Saravanan, A., Elumalai, P., Kumar, P., Saleel, C.A., Samuel, O.D., Setiyo, M., Afzal, A.
  An overview on energy and exergy analysis of solar thermal collectors with passive performance enhancers
  (2022) *Alex. Eng. J*, 61, pp. 8123-8147.
  [CrossRef]

- Aigba, P.A., Emovon, I., Samuel, O.D., Enweremadu, C.C., Abdeljawad, T., Al-Mdallal, Q.M., Afzal, A.
  Exergetic Assessment of Waste Gas to Energy in a Novel Integrated NGL Recovery and Power Generation Plant
  (2022) *Front. Energy Res*, 9, pp. 1-23.
  [CrossRef]

- Saleh, B., Sundar, L.S., Aly, A.A., Ramana, E.V., Sharma, K.V., Afzal, A., Abdelrhman, Y., Sousa, A.C.M.
  The Combined Effect of Al₂ O₃ Nanofluid and Coiled Wire Inserts in a Flat-Plate Solar Collector on Heat Transfer, Thermal Efficiency and Environmental CO₂ Characteristics
  (2022) *Arab. J. Sci. Eng*, pp. 1-28.
  [CrossRef]

- Samuel, O.D., Samuel, O.D., Waheed, M.A., Waheed, M.A., Taheri-Garavand, A., Taheri-Garavand, A., Verma, T.N., Dairo, O.U.
  Prandtl number of optimum biodiesel from food industrial waste oil and diesel fuel blend for diesel engine
  (2021) *Fuel*, 285, p. 119049.
  [CrossRef]

- Soudagar, M.E.M., Mujtaba, M., RezaSafaeibcd, M., Afzale, A., Raju, V.D., Ahmeda, W., Banapurmath, N., Anjum Badruddinjk, I.
Effect of Sr@ZnO nanoparticles and Ricinus communis biodiesel-diesel fuel blends on modified CRDI diesel engine characteristics
(2021) *Energy*, 215, p. 119094.
[CrossRef]

- Afzal, A., Samee, A.M., Jilte, R., Islam, T., Manokar, A.M., Razak, K.A.
Battery thermal management: An optimization study of parallelized conjugate numerical analysis using Cuckoo search and Artificial bee colony algorithm
(2021) *Int. J. Heat Mass Transf*, 166, p. 120798.
[CrossRef]

Correspondence Address
Thulasi S.; Department of Mechanical Engineering, Nagappattinam, Tamil Nadu, India; email: thulasi_oxford@yahoo.com

Publisher: MDPI

ISSN: 20711050
Language of Original Document: English
Abbreviated Source Title: Sustainability
2-s2.0-85130640996
Document Type: Article
Publication Stage: Final
Source: Scopus