COMPARATIVE ANALYSIS OF SOLAR DRYING TECHNOLOGIES: A REVIEW OF RECENT STUDIES

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Abstract: *This This review paper aims to provide a comprehensive analysis of recent studies on solar drying technologies, with a focus on comparative assessments of various designs and configurations. Solar drying is a sustainable and energy-efficient method for preserving agricultural produce, and advancements in technology have led to a multitude of innovative designs. This review critically examines the current state of knowledge by synthesizing findings from recent research articles. The analysis encompasses a wide range of solar drying technologies, including passive and active systems, greenhouse convection dryers, and hybrid approaches. The comparative aspect delves into the performance metrics employed in recent studies, considering factors such as drying efficiency, energy consumption, uniformity, and cost-effectiveness. Various design parameters, such as collector types, drying chamber configurations, and airflow systems, are scrutinized to identify trends and optimal configurations...*

Keywords: *Solar drying, Greenhouse convection, Solar drying technologies, Drying efficiency.*

1. INTRODUCTION

Industrial The growing need for sustainable and energy-efficient food preservation methods has intensified the exploration of solar drying technologies as viable alternatives to traditional drying methods. As a crucial facet of renewable energy applications, solar drying offers a promising avenue for reducing post-harvest losses and enhancing agricultural sustainability. This introduction sets the stage for a comprehensive review that delves into the recent studies on various solar drying technologies, emphasizing their comparative analyses and advancements.Solar drying leverages the abundant and clean energy of the sun to remove moisture from agricultural produce, mitigating dependence on non-renewable energy sources and contributing to environmentally conscious practices. In recent years, a surge of research has aimed to refine and optimize solar drying systems, resulting in an array of innovative designs and configurations. This review critically assesses the findings of these recent studies, shedding light on the diversity of approaches and their respective impacts on drying efficiency, energy consumption, and overall system performance[1]–[4].

The comparative analysis extends beyond traditional parameters, encompassing a broad spectrum of solar drying technologies, including passive and active systems, greenhouse convection dryers, and hybrid models. By scrutinizing the multitude of designs and configurations employed in recent research, this review seeks to identify trends, challenges, and opportunities that shape the landscape of solar drying technology. From collector types to drying chamber configurations and airflow systems, each design parameter is dissected to reveal its influence on the efficiency and effectiveness of solar drying technologies. Moreover, this review explores the integration of advanced computational models, such as Computational Fluid Dynamics (CFD), in the analysis of solar dryer designs. The incorporation of simulation techniques enhances the understanding of fluid dynamics, heat transfer, and overall system behavior, providing valuable insights into the intricacies of solar drying technologies[5]–[8].

As the global community increasingly recognizes the urgency of sustainable agricultural practices, the outcomes of this review serve not only as a compendium of recent advancements but also as a guiding resource for researchers, engineers, and policymakers. By synthesizing the current state of knowledge, this review contributes to the ongoing discourse on solar drying technologies, paving the way for informed decision-making, innovation, and the continued evolution of sustainable food preservation methods[9]–[12].

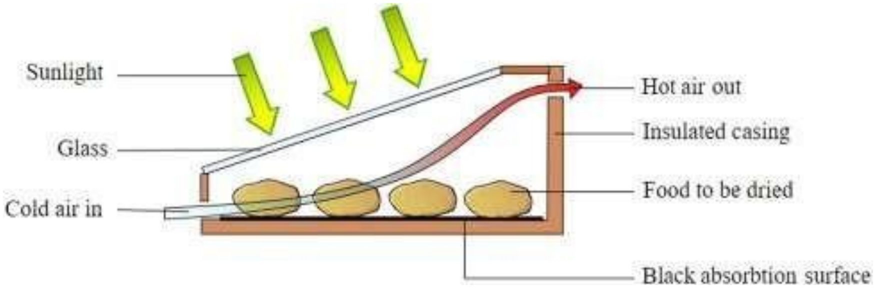

Figure 1 Basic schematic of Solar dryer

2. LITERATURE REVIEW

Richard et al. [13] (Lamrani et al., 2019) [1] The goal of this project is to use TRNSYS software to create a numerical model for trying to investigate the effectiveness of an implicit photovoltaic energy dryer for wood. To generate thermal energy, a solar compound parabolic concentrator (CPC) is used, and employee 's regular vibrant simulation results are run using Moroccan weather information. The Mean Relative Error (MRE) and the Root Mean Squared Error (RMSE) are 3.9 percent and 0.024 kg/kg, respectively, in a comparison study among both our mathematical experimental outcomes results. The effect of some operating and design specifications on drying kinetics is presented, as well as the energising achievement of the industrial drying elements.

(Kuan et al., 2019) [2] In this paper, a measurement simulation for trying to predict the electricity thermal performance compressor supported solar dryer in european environments is proposed. The model is determined by the balance of energy and mass. The energy efficiency of heat pump drying systems, photovoltaic dryers, and heating system assisted solar dryers is compared.

(Lingayat et al., 2020) [3] An indirect type solar dryer (ITSD) for drying apples and melon has been developed in this paper. The ITSD's performance as well as Watermelon and apple slices were dried in a drying chamber. Using the experimental results, the degradation rate, surface transfer coefficients, and reaction temperature of apple and cantaloupe were calculated. Since of the frequent changes in solar radiation, the average temperature inside the drying cabinet fluctuated over time. activity, according to the results of the experiments.

(Atalay, 2019) [4] The energy and and perhaps appearances of a sun drying able to integrate with a packed bed (TES) as a heat storage medium are presented in this study. The drying chamber of orange slices were studied as a case study. The goal of this research is to assess the packed bed's heat transfer possibilities by choosing to focus on electricity usage and entropy generation indicators.

(Bhardwaj et al., 2019)[5]The laboratory experiment of an implicit forced convection dryer with sensible heat storage material (SHSM) and phase change material (PCM) in the Himalayan meteorological environment (latitude 30.91 °N) is presented in this paper. In the solar collector, iron scrap mixed with gravel is positioned on the solar collector, and copper tubes containing engine oil are used as SHSM.

(Vijayan et al., 2020)[6]In this study, a reduced ambiguously defined forced convective heat transfer solar dryer with a highly permeable bed heat storage material was developed and tested for drying fenugreek slices throughout Coimbatore's environmental conditions. A solar panel with a surface area of 2 m2, a drying chamber, and a centrifugal blower make up the development setup.

(Sözen et al., 2020) [7] For the developing world, clean renewable energy production is a must. Solar energy is a widely used renewable fuel that can be used to generate both electric and thermal heat. Rooftop solar approaches have the potential to be used in a variety of processes, including space process heat. Three easy and price solar air heating systems were developed and made in this study.

(Ndukwu et al., 2020) [8]With pre-treated potato slices, the paper compares an active mix-mode wind-powered fan solar dryer (AWPFS) to a detached combination non-wind-powered solar dryer (PNWPS). The two dryers were put through their paces with and without the use of glycerol as an energy storage medium. The goal was to demonstrate a non-electric sun 's energy dryer that relied solely on clean energy sources.

(Güler et al., 2020)[9]The present study designed, analysed, assembled, and checked the double indirect solar dryer (DPISD) or a double solar thermal DPISDMA dryer with mesh absorber modification. The primary goal of this study is to use iron meshes to improve thermal efficiency of the double photovoltaic panel. The experimental investigation used specimen of de pescado fruit (Solanummuricatum L.) in two thicknesses. In addition, CFD analysis of both the solar air collection and the drying chamber was performed, as well as Quality indicators include phenolic content, flavonoids content, and antioxidant properties.

(Vigneshkumar et al., 2021)[10] Solar dryers are essential in the food industry for keeping granules, vegetables, fish, and other foods safe to eat by removing moisture levels. They are superior to outdoor public drying in that they protect the food from soot, invertebrates, and other potentially harmful elements. They are also said to save more. environment for future generations from deterioration. Solar dryers of the indirect type consist mainly of a solar concentrator and a space to place grated zucchini.

(Malakar et al., 2021)[11]The current study focused on the design and advancement of a heat exchanger gadget freak drying system with a heat exchanger for drying garlic cloves. Garlic cloves (10 kg) were dried from 69 percent to 8%

moisture content for the experimental performance evaluation (wb). At distinct air flow flow velocity (1, 2, and 3 m/s), the heat transfer performance of the evacuated tube dryer (ETSD) was tested in no-load and comprehensive circumstances

(Sözen et al., 2021)[12]The use of renewable and clean energy sources has increased in recent years to rising energy demand and depletion of fossil fuel mineral wealth. Solar thermal systems are used to generate electricity and heat that is both clean and environmentally friendly. A single process heating element with hose absorber was built and assimilated with a drying medium in this survey. Simulation results have been used to measure the influence of the insulating plate's shape and layout in this frame of reference.

3. CONCLUSION

The comparative analyses conducted across a range of solar drying technologies, including passive and active systems, greenhouse convection dryers, and hybrid models, have unveiled valuable insights into the performance metrics and design parameters that significantly influence their efficacy. Drying efficiency, energy consumption, and the economic viability of different configurations have been scrutinized, offering a nuanced understanding of the strengths and limitations inherent in each approach.The integration of computational models, particularly Computational Fluid Dynamics (CFD), emerges as a pivotal aspect of recent studies, providing a sophisticated tool for unraveling the intricacies of fluid dynamics and heat transfer within solar drying systems. This technological integration enhances the precision of design assessments and contributes to the optimization of solar dryer performance. As the global community grapples with the urgent need for sustainable agricultural practices, the findings of this review contribute to the ongoing dialogue on renewable energy applications. The synthesis of recent studies serves as a valuable resource for researchers, engineers, and policymakers seeking to implement effective and environmentally conscious solutions for food preservation. The diverse array of designs and configurations analyzed in this review underscores the adaptability of solar drying technologies to varying contexts and climates, providing a foundation for informed decision-making in the pursuit of enhanced agricultural sustainability. In moving forward, it is imperative to acknowledge the remaining challenges and areas requiring further exploration. Continued research efforts should focus on refining existing technologies, addressing issues of scalability, and promoting widespread adoption of solar drying methods. Furthermore, collaborative initiatives between academia, industry, and governmental bodies will be instrumental in translating research findings into practical applications, fostering a global transition toward sustainable and energy-efficient agricultural practices.

References

[1] Shahsavar, A., Majidzadeh, A. H., Mahani, R. B., &Talebizadehsardari, P. (2021). Entropy and thermal performance analysis of PCM melting and solidification mechanisms in a wavy channel triplex-tube heat exchanger. In Renewable Energy (Vol. 165). Elsevier Ltd. https://doi.org/10.1016/j.renene.2020.11.074

[2] El-Said, E. M. S., AbdElaziz, M., &Elsheikh, A. H. (2021). Machine learning algorithms for improving the prediction of air injection effect on the thermohydraulic performance of shell and tube heat exchanger. Applied Thermal Engineering, 185(December 2020), 116471. https://doi.org/10.1016/j.applthermaleng.2020.116471

[3] Maghrabie, H. M., Attalla, M., & A. A. Mohsen, A. (2021). Performance assessment of a shell and helically coiled tube heat exchanger with variable orientations utilizing different nanofluids. Applied Thermal Engineering, 182(September 2020), 116013. https://doi.org/10.1016/j.applthermaleng.2020.116013

[4] Chupradit, S., Jalil, A. T., Enina, Y., Neganov, D. A., Alhassan, M. S., Aravindhan, S., &Davarpanah, A. (2021). Use of Organic and Copper-Based Nanoparticles on the Turbulator Installment in a Shell Tube Heat Exchanger: A CFD-Based Simulation Approach by Using Nanofluids. Journal of Nanomaterials, 2021. https://doi.org/10.1155/2021/3250058

[5] Ocłoń, P., Łopata, S., Stelmach, T., Li, M., Zhang, J. F., Mzad, H., & Tao, W. Q. (2021). Design optimization of a high-temperature fin-and-tube heat exchanger manifold – A case study. Energy, 215, 119059. https://doi.org/10.1016/j.energy.2020.119059

[6] Singh, S. K., & Sarkar, J. (2021). Improving hydrothermal performance of double-tube heat exchanger with modified twisted tape inserts using hybrid nanofluid. Journal of Thermal Analysis and Calorimetry, 143(6), 4287–4298. https://doi.org/10.1007/s10973- 020-09380-w

[7] ShahsavarGoldanlou, A., Sepehrirad, M., Papi, M., Hussein, A. K., Afrand, M., &Rostami, S. (2021). Heat transfer of hybrid nanofluid in a shell and tube heat exchanger equipped with blade-shape turbulators. Journal of Thermal Analysis and Calorimetry, 143(2), 1689–1700. https://doi.org/10.1007/s10973-020-09893-4

[8] Sinaga, N., khorasani, S., SooppyNisar, K., &Kaood, A. (2021). Second law efficiency analysis of air injection into inner tube of double tube heat exchanger. Alexandria Engineering Journal, 60(1), 1465–1476. https://doi.org/10.1016/j.aej.2020.10.064

[9] Pu, L., Zhang, S., Xu, L., & Li, Y. (2020). Thermal performance optimization and evaluation of a radial finned shell-and-tube latent heat thermal energy storage unit. Applied Thermal Engineering, 166,114753.
https://doi.org/10.1016/j.applthermaleng.2019.114753

[10] Moya-Rico, J. D., Molina, A. E., Belmonte, J. F., CórcolesTendero, J. I., &Almendros-Ibáñez, J. A. (2019). Characterization of a triple concentric-tube heat exchanger with corrugated tubes using Artificial Neural Networks (ANN). Applied Thermal Engineering, 147,1036–1046. https://doi.org/10.1016/j.applthermaleng.2018.10.136

[11] Bahiraei, M., Mazaheri, N., &Rizehvandi, A. (2019). Application of a hybrid nanofluid containing graphene nanoplatelet–platinum composite powder in a triple-tube heat exchanger equipped with inserted ribs. Applied Thermal Engineering, 149, 588–601. https://doi.org/10.1016/j.applthermaleng.2018.12.072

[12] Said, Z., Rahman, S. M. A., El Haj Assad, M., &Alami, A. H. (2019). Heat transfer enhancement and life cycle analysis of a Shell-and-Tube Heat Exchanger using stable CuO/water nanofluid. Sustainable Energy Technologies and Assessments, 31(December 2018), 306–317. https://doi.org/10.1016/j.seta.2018.12.020

[13] Karimi, A., Al-Rashed, A. A. A. A., Afrand, M., Mahian, O., Wongwises, S., &Shahsavar, A. (2019). The effects of tape insert material on the flow and heat transfer in a nanofluid-based double tube heat exchanger: Two-phase mixture model. International Journal of Mechanical Sciences, 156(December 2018), 397–409. https://doi.org/10.1016/j.ijmecsci.2019.04.009

[14] Mahdi, J. M., Lohrasbi, S., Ganji, D. D., &Nsofor, E. C. (2019). Simultaneous energy storage and recovery in the triplex-tube heat exchanger with PCM, copper fins and Al2O3 nanoparticles. Energy Conversion and Management, 180(May 2018), 949– 961. https://doi.org/10.1016/j.enconman.2018.11.038

[15] Nakhchi, M. E., &Esfahani, J. A. (2018). Cu-water nanofluid flow and heat transfer in a heat exchanger tube equipped with cross-cut twisted tape. In Powder Technology (Vol. 339). Elsevier B.V. https://doi.org/10.1016/j.powtec.2018.08.087