EXPERIMENTAL ANALYSIS OF FLOW PATH OPTIMIZATION IN SOLAR DRYERS

Mr. T.VENKATESHAN[1]

S. INDRAJITH[2], L. NITHESH[3], D. PRABHU[4], A. TAMIZHARVAN[5]

2,3,4,5 UG STUDENT

MECHANICAL ENGINEERING

NANDHA ENGINEERING COLLEGE, ERODE, TAMILNADU, INDIA

Abstract--***Solar drying is generally considered to be a cost-effective method as it uses the sun's renewable energy. The final solid product can replace fuel products like wood and coal. It can also be used for industrial, and agricultural uses. Solar dryers don't produce pollution. It could be used as an alternative process for drying applications in hybrid mode. A study has been made to optimize the flow configuration and then increase efficiency in dryers. The solar flat plate collector consists of the following major parts: transparent cover, absorber plate, absorber flow channels, thermal insulation layer, frame, and back sheet. In addition to the above fact, the absorber plate adopts an imported full plate magnetic sputtering coating plate or black chrome plate, which has stable performance and durable service. Drying is used in the rural parts of the country without much technical know-how. The necessity for research work in this field was felt because of the limitations such as slow drying rate, long drying time, contamination of product, and degradation in the quality. The challenge is to develop a dryer utilizing abundant solar radiation, provided the efficiency of the dryer is not compromised. Also, it should have better temperature regulation and extended operational hours. The prime motivation behind using the dryer with latent heat storage is its huge potential to store energy and regulate temperature. The excess energy during peak daylight is absorbed and stored.***

Keywords: Solar dryer, renewable energy; solar flat plate collector; convectional; hybrid mode

I. INTRODUCTION

The use of solar energy could meet both the present and future demands of humanity. Since the beginning of time, man has used it to dry his food and preserve it for a longer time. Agricultural items are not dried not only lengthens their shelf lives but also enhances their transportation and storage costs by making them lighter to move and taking up less room. One of the potential uses for solar energy is sun drying. An effective way to use solar energy is by solar drying, which is a development of sun drying. There are two steps to the drying process. The second stage starts with a dropping (declining) drying rate. The characteristics of the substance being dried determine the second stage's state. The sun's rays, the wind's speed, the relative humidity in the air and on the ground, the kind of product, the starting moisture content, the product's absorptivity, and the mass of the product per unit exposed surface are all factors that affect how quickly a product dries. A high initial moisture content makes expensive agricultural produce particularly perishable. Most of their losses, which are estimated to be more than 30–40% in poor nations in the tropics and subtropics due to insufficient handling, shipping, and storage facilities, are caused by water loss and decay. In addition to financial and material losses, substantial reductions in the availability of vital nutrients, particularly vitamins, and minerals, do occur. Reduced post-harvest losses of perishable horticultural products are urgently needed. It is crucial for developing nations to expand their accessibility, particularly in the current environment of food production limits.

II. LITERATURE REVIEW

Halil Atalay et al. (2021) conducted this study about an energy, exergy, and sustainability analysis of the hybrid drying system that uses both solar and wind energy was covered in this study. The sun dryer was used to complete the drying process. The electrical energy needed to run the fan in the drying unit was generated from wind energy. Thus, no external drying process needed an energy source. The study's primary goal was to contribute to the creation of a drying system that was both affordable and environmentally friendly and used only two distinct types of renewable energy. Banana slices' drying properties were hindered. mined during the tests. The system's waste exergy rate, the potential for improvement, and environmental sustainability were also studied. When compared to other traditional solar dryers and solar panels, the hybrid dryer had an energy efficiency that was 57.7% and 21.52% greater, respectively. Hybrid and assisted dryers, respectively. Additionally, a 1.36- year energy payback period was calculated. This outcome demonstrated unequivocally that the system can recover the energy it used in about 38.18%. compared to other solar dryers, less time. [1] Sampson Uzoma et al. (2020) researched the optimization study of the sun drying process has been prompted by the growing need for more technological, economic, and efficient drying systems. This essay explores the optimization of drying time for red pepper slices in a response-based hybrid photovoltaic-thermal (PV/T) solar dryer surface strategy. The investigation was done in a tropical humid environment. Nigeria's climate is characterized by sporadic sunlight irradiance, brought on by the humid breeze influence of nearby bodies of water bodies. Effects of altering air temperature (50, 60) on drying and 70°C), air speeds (1, 5, and 2 m/s), (1), sample, and thicknesses on the total energy of 10, 15, and 20 m use, drying effectiveness, shrinkage percentage, and drying time of using a 33-factorial analysis, pepper samples were examined. Treatment planning. The replies were shown in 3-D surface plots with the results built-in, and they were statistically analyzed to identify variable associations. The overall sum of specific energy use varied from 1.31 to 38.9 kWh. Correspondingly 6.92-62.76 kW kg 1. The thermal percentage contribution of the solar collector and PV module at various speeds varied between 0.518% and 0.792% Qpv 23.53%. Qcol is accordingly 15.37%. Average system drying effectiveness ranged from 6.73 to 35.14%, whereas the percentage of the degree of shrinkage varied from 56.91 to 73.90%. Drying time spanned 125.5 7 to 205.5 10 minutes. The ideal drying point air temperature of 70°C, air speed of 1.88 m/s, and having a thickness of 14.31 mm, and desirability of 0.903, the overall use of energy, effectiveness of drying, shrinkage, and drying time were calculated to be 4.03 kWh, respectively by 20.46%, 67.05%, and 183.8 minutes. The projected models were confirmed and proven to have R2-

values between 0.9228 and 0.9989. accuracy utilizing % error and diagnostic graphs deviations. The findings of this study show how important the performance of some variables and process conditions of hybrid solar dryers with PV/T is. [2]

Patchimaporn Udomkun et al. (2020) have carried out a study of the most effective, affordable, renewable, and ecological ways for preserving agricultural products in Asian and SSA nations solar drying. The many types of solar dryers that are commonly utilized in Africa and Asia are discussed in this review paper. Additionally, the most significant impacts of their use on product quality are highlighted, along with their effects on the economy, environment, and society. Given the finances,l this research also discusses how external and structural factors play a significant influence in the adoption and scalability of solar dryers. Discusses how these elements affect the efficiency of solar drying devices in a few Asian and SSA regions, Countries.[3]

Rishi Richa et al. (2021) in this paper resistance heating is only used in thermochemical food manufacturing applications, and it is becoming more and more popular in the food industry. A prototype ohmic heating device is seen here over a fish processing equipment with a 6.25 kg/hr capacity has been created. The created item was employed in conjunction with a solar dryer controlled by PID, and the settings have been tuned by utilizing an artificial neural network and core composite rotatable design (ANN). During the hybrid drying procedure (solar drying with ohmic heating), the chosen input variety, able included voltage (160–200 V), salt content (0– 2%), and solar drying temperature (40– to increase the drying rate (drying time, total), loading density (109-190 g), and temperature (72C). The final moisture content, and the temperature). Under ideal conditions (180 V ohmic voltage and 1% salt concentration), the developed ohmic heater decreased the moisture in fish muscles from 348.5% (db) to 260.91% at the first stage of drying in the period of 165- final moisture content was calculated after 300 seconds for each experiment, and it was lowered to 12.66% (db), and at the second stage, the overall drying rate increased to 2.73 g/min. Optimal circumstances for solar drying (72°C temperature and 0.672 cm2 load density). The SSE (sum of square errors), R2 (determination coefficient 0.96- 0.94), and values MSE (mean square values 1–8.7) and values (0.15-025) were more significant for RSM. This created a resistive heating device for speeding up fish drying and decreased harvest post-losses, Additionally, it is regarded as a suitable technique for drying fish and producing fish powder that may be utilized to create additional value-added products. [4]

Senay Teshome Sileshi et al. (2022) in this study the final product's quality throughout the drying process heavily depends on the drying air's flow characteristics. The non-uniform airflow inside the drying chamber is the primary flaw of conventional sun dryers. The Computational Fluid Dynamics (CFD) method has been used to evaluate the flow behavior of drying air in a transient state. It was done using the Do radiation, species transport, and k-omega SST models. The numerical findings are compared. Showed a fair match between the experiment's temperature distribution and our own. Between the upper and lower trays variations in the velocity of 0.015 m/s and relative humidity of 2% were noted. The dryer delivered the necessary air. For solar drying, the temperature. The findings showed that improving the air quality using vertical by improving the distribution of drying air's homogeneity during the drying process. Combining CFD with experimental research makes it possible to modify the natural conviction mixed-type dryer.[5]

Macmanus Chinenye Ndukwu et al. (2022) the purpose of this study is to demonstrate the relationship between the efficiency and sustainability of solar dryer systems. This is done to help fabricators and energy policymakers develop design guidelines and pick the best waste energy management approach for environmental sustainability. Consequently, in this study, earned carbon credit and exergy-based sustainability measures were used to evaluate and contrast the effectiveness of four different solar dryer designs with equivalent collection capacities under the same external local surroundings in the same city. The solar dryer that uses a variety of modes and is powered by a wind turbine, however, received the most carbon credits. For the four cases, the exergy efficiency ranged from 19.09 to 52%, whereas the waste exergy ratio varied from 0.52 to 0.81. The value of LOP is between 2.95 and 19.96. The average environmental sustainability index ranged from 1.28 to 2.5. The energy recovery ratio for the four dryers ranged from 3.96 to 20.96 for the destruction coefficient, and the earned carbon credit ranged from $442. 3 to $2630.5, or from 0.001825 to 0.12405. [6]

Petros Demissie et al. (2018) this project develops and designs an indirect food dryer that is driven by solar energy. A solar collecting unit, a drying chamber with two columns of four rack shelves, a chimney for exhaust air, and a solar-powered fan make up the dryer's design. The dryer's exit is constructed with a truncated pyramid form to reduce accumulated water precipitation and to prevent additional at the exit, 15 the drying air can be heated. Ethiopia's Mekelle is where the dryer is designed and created. Computational predicting of a transient three-dimensional flow field and temperature distribution inside the fluid dynamics, CFD using a symmetric flow domain in a drying chamber. The food to be dried will reach this temperature in around 35 minutes, according to the temporal temperature distribution. Measurements of the global solar irradiance and the temperature distribution on each rack shelf are used to validate the model. The biggest variation in temperature between the two was discovered to be 4.3 °C from both measurement and the CFD simulation. Consequently, the CFD model may generate a good qualitative insight into the temperature distribution in the drying chamber, rack shelves, and symmetry plane using quantitative methods. [7]

Anas Khan et al. (2021) in this study, use natural solar drying as an efficient way to dry out agricultural products. However, several problems can occur during such operations, including bird, insect, or other animal attacks, fungal attacks, unforeseen weather changes, low or prolonged light exposure, dust mixing, etc. A solar dryer can be used to remedy these issues. The construction of a thermally effective indirect mode forced convection sun dryer is the foundation of this study. Villages in rural Bangladesh. This article's initial focus is on developing a solar drier for rural areas of Bangladesh and using simulations to assess its performance in areas. The airflow, temperature change, and loss throughout the drying chamber were observed during the simulation procedure. It was discovered an acceptable mesh fineness value and a usable simulation and validation process. Observations on how the airflow has changed in the results consider three-axis and outlet temperature changes. The steps and specifications for developing a solar system dryer were shown during this investigation.[8]

Carine Pamela et al. (2021) the current study uses a thermal network method and numerical simulation to make an equivalent two-dimensional forecast of a combined sun drying system's performance. Construction of the hybrid solar drying facility's equivalent electric circuit and research into the space and time variations of 16 the transfer of temperature in a solar drying system. The equations for the balance of the physical elements are iteratively estimated using the finite difference technique. The outcomes demonstrate that the suggested forecasts in two dimensions using a sinusoidal approximation for the inputs of solar radiation and air temperature both the collection and dryer temperature profiles are sufficiently described. Numerous characteristics, including spatial resolution, mass flow rate, average temperature, and solar radiation inputs, have been studied and discussed for their effects. The numerical simulations demonstrate that the drying system's individual elements' temperatures are not uniform. And is highly variable concerning space and time nodes, therefore it rises gradually from the first node of the drying on a macroscale flows to the terminal node. [9]

Ali Mostafaeipour et al. (2020) experimented on crops that need to be dried and have been preserved using solar energy by applying constant, relatively modest heat. The current study examines the viability of installing a solar dryer system in the Iranian city of Yazd. Appraised by looking at the practical elements. By identifying potential risk factors Affecting in some way the development, manufacture, and use of solar drying systems A questionnaire was made and given out. Six conclusions came from the analysis. The following key variables were noted: "performance," "geographical location," "infrastructures," "interactions," and "social, cultural, and political backing "Difficulties," according to the factor analysis and structural equation modeling a model was presented using the Equations Modelling (SEM) approach. The final model was subsequently created using AMOS and the path analysis method. Using the final model as a foundation, the three infrastructures (with a coefficient of 0.44), Cultural, social, and political interactions (both with a coefficient of 0.12) Directly impact whether Yazd will be able to use the solar dryer. Consequently, It was determined that authorities should concentrate their efforts primarily on the proposed model. Focusing on infrastructure, finance, research, and the economy to advance and encourage the use of solar drying apparatus. 17 [10]

Elsabet Nielsen et al. (2022) did research and done at a testing facility inside an open sorption air solar-driven system for comfortable cooling. A solar dehumidifier and cold storage with desiccant are the two primary parts of the system. 36 hours make up one operation cycle. During the first day of operation, the solar dehumidifier is charged. It's chilly at night. On day two, the cold storage is released after being charged the previous day. Various samples of silica gels and zeolites are used in a material inquiry to determine the best desiccant for both components. Finding out how well the system performs and can be used is the goal of this endeavor. An examination of the climate in fourteen distinct places is done to address the system's usability. [11]

Ali Hassan et al. (2022) performed in the terms of effectiveness and efficiency, optimized solar air dryers can address several pressing issues in the agro-industrial processing industry. Solar air dryers may lower a substantial portion of a product's energy expenses and offer sustainable energy in rural locations where access to electricity is frequently scarce. In this work, a pilot-size groove double-pass solar air collector has been thermodynamically assessed with real-time solar radiation and mass flow rate (0.021-0.061 kg/s) inputs and experimentally confirmed in terms of first and second law efficiencies. When drying pink Lady apples, the process' effectiveness was evaluated using experimental drying metrics such as ultimate moisture content, drying rate, and energy efficiency. calculations of energy payback times and precise energy usage helped to identify the system's techno-economic worth. The collector's exergy efficiency was 6.6% and its highest thermal efficiency was 88.8% at 0.061 kg/s, indicating an effective energy source for the operation. A mass greater than 0.041 kg/s delivers a greater moisture removal in terms of drier performance. 3.096 kWh/kg was the specific energy consumption (SEC). Thermodynamic models were verified using experiments that matched those in the models, with acceptable RMSE for the variety of studied metrics. The system's embodied energy was calculated to provide an energy payback period time of 0.78 18 years, which suggests that if scaled up, the system is capable of handling big-capacity drying. [12]

Vishnuvardhan Reddy Mugi et al. (2022) in the current work on indirect natural and forced convection solar dryers (NISD and FISD), the energy and exergy (2E) analysis were carried out, and the results were compared. The NISD had a collector and a drying system. In contrast, for FISD, the NISD was modified by installing a diverging tunnel equipped with DC fans that were turned on by PV panels at the collector's inlet. As a result, neither setup required the usage of commercial energy. For both dryers, the energy efficacy of the collector and drying cabinet as well as the transient temperature and moisture distribution in the trays of the drying cabinet were assessed. In both dryers, the energy inflow, outflow, losses, collection, and drying cabinet efficiency, as well as sustainability indicators, were analyzed. In NISD and FISD, respectively, the energy efficiency of the collector and drying efficiency was 58.5%, 9.39%, and 66.37%, 12.11%. The energy input for the collector and drying section in NISD was 409.9 W and 2.73 W, respectively, whereas, in FISD, the corresponding values were 375.5 W and 1.03 W. In NISD and FISD, the drying cabinet and collector's exergy efficiencies were discovered to be 45.87 and 3.46%, 55.73 and 2.43%, and correspondingly. In NISD and FISD, the improvement potential and environmental impact factor, respectively, ranged from 0.11 to 29.1 W, 0.2 to 15.51 and 0.012 to 11.35 W, 0.07 to 7.90. In FISD compared to NISD, the sustainability index rose by 60.69% and the waste exergy ratio fell by 18.52%. According to the 2E study, FISD performed better than NISD overall. All parameters underwent uncertainty analysis, which is displayed as error bars in all figures. [13]

Macmanus Chinenye Ndukwu et al. (2022) the purpose of this study is to determine the relationship between solar dryer designs and the exegeticsustainability performance of solar dryers. This is to help energy policymakers and fabricators develop design standards and choose the best waste exergy management approach for environmental sustainability. As a result, in this study, exergy-based 19 sustainability metrics and earned carbon credit was utilized to evaluate and compare the performance of four alternative designs of solar dryers of equal collector capacity in the same town under the same external environmental circumstances. Solar dryer designs with single-pass triple air movement direction and input air powered by wind generator had the best sustainability indicators, including high exergy efficiency, lower waste exergy emission, greater sustainability index, and lower lack of productivity. [14]

Dr. S. Prakash et al. (2018) in this study demonstrate the construction of a solar-powered water purifier. Reverse osmosis serves as the project's fundamental guiding principle. Solar panels are used to capture solar radiation panels. Then a battery is used to store this energy. An electromagnetic relay connects the battery to the purification device. The reverse osmosis system, water tank, and high-pressure motor make up the purification unit. The reverse osmosis process requires a high pressure, which the high pressure generates. The water tank's level is constantly monitored by microcontroller 8051, which also safeguards it from overflowing. This procedure allows us to fill the water tank with filtered water. [15]

Muruganantham et al. (2021) this study describe how Mexican mint (Plectranthus, amboinicus) was dried using a tubular sun drier while being covered in varied masses of leaves. In a tubular solar dryer with the direct sun heating operating in natural convection mode, experiments were conducted. For 0.25, 0.5, 0.75, and 1 kg of P. ambitious leaves placed in the dryer tray, variables such as the dryer tray's temperature, relative humidity, and moisture content were measured. The results indicated that the parameters, such as the dryer tray temperature, are lowered when the mass of P. ambitious leaves in the tray is raised, and the moisture content accessible with 0.75 kg of P. ambitious leaves is greater than with 0.25 kg of P. ambitious leaves. Additionally, it is discovered that when the mass of P. ambitious leaves in the drying room increases, so does the relative humidity inside the chamber. 20 [16]

H. Krabch et al. (2022) to assess the thermal performance of solar dryers, this study examined the drying kinetics and quality of dried orange slices in three indirect solar dryers with natural convection. A data collecting system was utilized to track the development of climatic variables (temperature, relative humidity, solar radiation). While the average internal temperatures for Dry3 (the third solar dryer), Dry1 (the first solar dryer), and Dry2 (the second solar dryer) are 40, 34, and 28 degrees Celsius, respectively, according to experimental measurements for a few days in April and May, the average temperature does not exceed 19.5 degrees Celsius (the second solar dryer). While the range of the relative humidity in the external environment is [60%, 85%]. It has been noted that the relative humidity readings for dryers range between [5%, 35%] for Dry3, [5%, 70%] for Dry1, and [32%, 75%] for Dry2. The orange slices are dried based on the meteorological conditions that were obtained. After 6 days in Dry3, after 15 days in Dry1, and after 18 days in Dry2, it was discovered that the orange slices had lost 72% of their initial mass. In terms of economic costs, the Dry3's single-compartment design is less expensive than traditional two-compartment solar dryers, according to the main experiments of the study, which also demonstrated that a specially formulated third solar dryer is most effective in terms of thermal performance and drying duration. Therefore, Dry3 is advantageous, and the local producer is encouraged to use it. Figure 7: Schematic video to the description of the solar dryer with single compartment 21 [17]

Hayat Hassen Mohammed et al. (2022) Due to their size, pumpkin fruits must be chopped into pieces before usage. Cuts' quality and storage life dramatically declined. Solar dryers can transform large-sized fruits into shelf-stable products to reduce postharvest loss. However, drying temperatures and RH in long solar tunnel dryers are not consistent and may have an impact on the quality of items that have been dried. To better understand how pre-drying procedures and tunnel dryer zones affect the functional characteristics, proximate composition, and bioactive elements of pumpkin pulp powder, this research endeavor set out to examine those effects. Slices of pumpkin were divided into three groups and pre-treated for 20 minutes in 1% citric acid, 20 minutes in 2% salt solution, and 20 minutes in 1% salt solution at 65°C. A control group of slices was left untreated. Three tunnel sun dryer zones were used to dry the previously treated samples (zone I, zone II, and zone III). Treatment combinations were distributed in a factorial RCBD with three replications. demonstrated that the maximum values of shrinkage, rehydration ratio, water holding capacity, and bulk density were obtained from pulp powder made from salt-pretreated slices dried at zone III. Zones I to III had lower moisture contents, and zones with salt blanching in the range of 8.2 to 6.4% did not affect the crude fat content. However, slices that had been pre-treated with 2% solution had higher crude protein and fiber contents in the zones. For samples that had been pre-treated with salt but dried in zone II of the dryer, better retention of total polyphones, beta-carotene, and ascorbic acid was observed. They also had higher DPPH scavenging activity and lower IC50 values. Slices pre-treated in 2% salt solution and dried in zone II of the sun tunnel dryer, which has conditions of 54.9 3.7 C, 31.4 3.4% RH, and 0.45 m/s air velocity, can generally preserve the powder's bioactive components, proximate composition, and functional qualities better. [18]

Michael L. Machala et al. (2022) using shielded solar drying equipment, the food and monetary losses brought on by conventional open sun drying of crops might be minimized. However, the bulk of the 470 million smallholder farmers 22 globally has not embraced solar dryers. combining primary survey and field data on dried chili crops obtained in India, this research reveals for the first time how technical, financial, and operational hurdles combine to restrict smallholder ownership of commercially accessible hoop house tunnel dryers. It then uses a systems-level strategy to remove those obstacles. First, a quantification of the economic loss caused by the deterioration of chilies during open sun drying is made, with an average loss of 34% of potential earnings. Techno-economic research shows that seasonally stranded solar dryers are not lucrative enough to overcome capital and operating cost barriers: cumulative income parity with open-sun drying is not attained for 3–7 years, despite shown revenue gains of 22% based on enhanced quality. Second, complementary multi-seasonal income streams that combine crop drying and seedling growth in the same drier structure are introduced for year-round revenue production to solve this significant adoption obstacle. Payback time is halved compared to single-season consumption when combined with the service-based operation to facilitate smallholder access. Multi-season dual-use dryers might pay for themselves in 1 year as opposed to 6.5 years for drying-only usage, lowering the financial adoption barrier by up to 85%. This shows that multi-season utility may encourage the use of solar dryers. The practical use of single- and dual-use solar dryer operations by smallholder farmers is then reviewed after a sensitivity analysis of these operations is presented. [19]

Venkateshan et al. (2015) researched the requirement of the current manufacturing and production industries directs the researchers to find an alternative system that should be most effective in efficient. This enables us to concentrate on the field of heat exchangers where the energy processing happens from the waste outlet. The study of heat exchangers is a thrust area as it is an eco-design model. The concept of heat exchangers plays a major role in refrigeration and air conditioning systems. An attempt is made in this paper to review the literature related to heat exchangers and modifications made to improve the efficiencies. Keywords: heat transfer enhancement, heat exchanger configurations, compact heat exchangers, nanofluids. In this review paper, the discussion had been done about the various 23 configurations for heat transfer enhancement. Further, the usage of various nanoparticles in the base fluid for heat transfer enhancement along with these configurations had been studied. [20]

Farhan Hussain et al. (2021) explained about Solar drying is one of the most simple and ancient drying techniques known to mankind. Even, most agricultural products like cereals, fruits, vegetables, and spices are processed under the sun. However, the direct exposure of these food materials to the open sun has many disadvantages due to dust, rain, winds and favorable environmental conditions for animals, insect infestation and animal interference, etc. These factors lead to the contamination of food products. The use of solar dryers can be helpful to overcome such problems. So, there is a need to make an efficient and cheaper dryer for on-farm processing. Many dryers have been developed depending on crop type, drying type, and air circulation. These dryers are forced and natural air circulation dryers, direct solar driers, indirect solar drying driers, mixed mode solar dryers, batch or continuous, etc. In the case of direct-type solar dryers, the product is exposed directly to solar radiation which causes the low quality of food products due to low drying rate. The disadvantages can be reduced by using indirect solar dryers. In the present study, a review has been discussed on different drying techniques, applications, and different enhancement techniques applied to improve efficiency and reduce drying time. [21]

Dounia Chaatouf et al. (2019) study has been conducted because of its numerous benefits and dependency on non-depletable resources, renewable energy technologies are crucial and have a positive relationship with the environment. In terms of development, these systems are more appealing to both investors and researchers. This paper focuses on especially curious on the contemporary method of product drying, specifically the solar-powered one, such as the indirect solar dryer, which typically consists of a solar air collector that creates a current of air that rises through its drying room. To lower drying time while maintaining the high quality of the dried product, we tried to increase the efficiency of the solar dryer in 24 this study to increase the performance of the chamber. The chamber's shape is split into two parts: The first is the one with the trays, while the second is a plenum chamber with side mountings. The latter's width and the separation between the first tray and the rooftop ANSYS FLUENT software was used to study the drying chamber, under Morocco's eastern region's climate. And the findings revealed that 0.4 meters are the ideal width for the side-mounted plenum chamber, with 0.06 meters being the ideal distance between the top of the chamber and the first tray (the upper tray). [22]

K. Singh et al. (2022) experimented with conventional sources of energy that generally lead to the emission of greenhouse gases, which in turn pollute the environment the schematic diagram of solar dryers is shown in figure 8.1. It is therefore the need of the day to resort to a green energy source, which will help mitigate the CO2 emission and make the environment less polluted. Given this, an economic analysis of a business model for the fabrication of an inclined solar dryer was considered. It will not only fetch income but also generate employment and mitigate CO2 emissions. Figure 8.1: schematic diagram of solar dryer Therefore, the economic evaluation of the business of fabricating solar dryers was carried out. The values of economic parameters were determined and found very 25 encouraging. In addition, the value of the Break-even point was also determined which came to 37 units which are equal to 111 dryers. The economic parameters were determined for fabricating 300 solar dryers annually. The net average annual benefit accrued from this business fabricating 300 solar dryers annually is INR 2,17,672. The values of other economic attributes, such as pay-back period (PBP), internal rate of return (IRR), net present value (NPV), and benefit-cost ratio (BCR) were found to be 0.47 yr., 225%, INR 1334026, and 13.8, respectively. In addition, this business can play a vital role not only in income generation but also in generating employment for four persons. Figure 8.2: solar dryer [23]

Masnaji Nukulwar et al. (2020) experimented with a drying process that is generally carried out by burning wood and fossil fuels. However, this method is expensive and may damage the environment which hurts the climate. The world is facing the problem of a shortage of fossil fuels. Some researchers did historical work on the design and development of solar technology which is a faster, more efficient, hygienic, and better quality product. Several solar dryers reviewed and enlisted the performance of dryers as per application. This paper gives an idea about the recent development of solar dryers. 26 [24]

Eke A. B et al. (2021) The solar dryers on average raised the temperature of the drying air to 147.6% of the ambient air temperature, which was 31.03oC. Over 50% savings in drying time when compared with the traditional open sun drying was achieved the three dryers were evaluated by considering the overall thermal system drying efficiencies of the dryers and the color quality of dried tomato, using open sun drying as a control. three identical prototype small-scale direct-mode passive solar dryers were constructed with locally available and affordable materials. [25]

Tageldin Hussein Nasroun et al. (2013) experimented on the two greenhouse-type solar dryers that differed from one another in the position, area, and orientation of the collectors as well as the method of transferring heated air inside the dryer. The first solar dryer denoted SL had a low, flat collector on the dryer's floor on the northern side of the timber stack. The tw o solar dryers dried wood to an M.C. lower than the equilibrium M.C. of the area, a thing which cannot be achieved by air drying. [26]

Anand Chavan et al. (2022) The basic design of most used solar dryers displaying varying fundamental principles of heat and mass transfer were compared with the recently commercialized and patented design of Solar Conduction Dryer. A bottle gourd of 100 kg by mass, having an initial moisture content of 80% from which 77.78 kg of water was required to be removed to get the desired moisture content of about 10%, was used as a drying load. The performance of various solar dryers was analyzed based on three criteria, namely, the annualized cost, the present worth of annual savings, and the present worth of cumulative savings. The economic analysis shows that the present cumulative worth of annual savings for drying bottle gourd over the dryer's lifetime works out to be 42,294, 23,027, 55,451, 58,740, and 37,594 USD for the case of solar tunnel dryer, solar cabinet dryer, solar conduction dryer, corrugated solar conduction dryer, and corrugated and electrically backed solar conduction dryer, respectively. The economic parameters of interest, such as the payback period and the internal rate of return of dryers were also estimated. The analysis shows that the 27 corrugated solar conduction dryers (CSCD) give the best performance as compared to the rest of the solar dryers when compared based on economics and product quality attributes. [27]

Pranav Phadke et al. (2015) In many countries, agricultural products are dried under the open sun. However, this way of drying degrades the quality of the dried products due to interference from external impurities and uneven drying rates. Numerous types of solar dryers have been designed and developed in various parts of the world, yielding varying degrees of technical performance. There are three types of solar dryers: direct solar dryers, indirect solar dryers, and mixed-mode dryers. This review paper is focused on natural convection direct-type solar dryers. These are the most cost-effective type of solar dryers and are easy to fabricate and use. Direct-type natural convection solar dryers do not use any auxiliary equipment and protect the products from external contamination. In this review paper, we reviewed different types of direct natural convection solar dryers and different design modifications applied to them to increase their effectiveness. With fossil fuels becoming more expensive day by day and getting depleted, the demand for solar energy is increasing drastically.[28]

III. CONCLUSION AND FUTURE SCOPE

- In this chapter, the concept of development of a solar drying system, From the test carried out, the following conclusions were made.
- The solar dryer can raise the ambient air temperature to a considerably high value for increasing the drying rate of crops.
- The product inside the dryer requires less attention, like an attack of the product by rain or pest (both human and animal), compared with those in the open sun drying.
- Although the dryer was used to dry Potato, it can be used to dry other crops like yams, cassava, maize, plantain, etc.
- There is the ease in monitoring when compared to the natural sun drying technique.
- The capital cost involved in the construction of a solar dryer is much lower than that of a mechanical dryer.
- Also, from the test carried out, the simple and inexpensive solar dryer was designed and constructed using locally sourced materials.
- In this experiment, we find how much moisture is removed from the sample which is present in the solar dryer and the sample which is present in ordinary air, and we compare both by mathematical calculation.
- In this paper we took green chili, some of the chili we put inside the dryer and some in the ordinary air, and then compare their moisture removed concerning time and temperature.
- We find that the temperature inside the dryer is two times outside the temperature.
- In the second phase of the project, we are going to implement the ideas that are taken from phase one. The fabrication of the complete project is done in the second phase.

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