© INTERNATIONAL JOURNAL FOR RESEARCH PUBLICATION & SEMINAR
ISSN: 2278-6848 | Volume: 13 Issue: 04 | July - September 2022
Paper is available at http://www.jrps.in | Email : info@jrps.in
Refereed & Double Blind Peer Reviewed

Thermal Performance of The Different Fin Geometries for Heat Dissipation in Engine Cylinders

Anant Kumar[1], Shivendra Singh[2]

[1]*Research Scholar, Department of Mechanical Engineering, Corporate Institute of Science and Technology*

[2]*Assistant Professor, Department of Mechanical Engineering, Corporate Institute of Science and Technology*

ABSTRACT

This study investigates the drying performance and thermal behaviour of a solar dryer that is combined with a flat plate collector and phase change materials. In order to improve the solar collector's thermal efficiency, three distinct designs of the collector were investigated: one without ribs, one with straight ribs, and one with V-shaped ribs. Computational fluid dynamics was also used to model the temperature distribution of the collector under varying conditions of solar radiation throughout the day. Due to the fact that the heat flux intake from the sun is at its peak about one in the afternoon, the highest temperatures of the day have been measured close to that time. The thermal performance of solar collector designs that include ribs has been found to be superior than the performance of solar collector designs that do not include any ribs. The collector with V-shaped ribs produced the highest output temperature, which was 346.679 Kelvin, followed by the collector with straight ribs, which produced 345.262 Kelvin. Both of these temperatures were achieved about 1:00 PM. Both the sun collectors with straight ribs and the solar collectors with V-shaped ribs have obtained a virtually identical maximum temperature of the PCM; specifically, 352.214 and 352.507 K, respectively. The highest possible value of the liquid fraction, namely 0.560582, was found to be reached in the case with V-shaped ribs.

Keywords: Solar Dryer, Computational Fluid Dynamics, Heat Flux, Solar Collector Designs

INTRODUCTION

Solar thermal collectors are not as well-known as solar panels, but they are also very effective in collecting heat from the sun. Radiation from the sun is utilised in solar thermal systems; this is the electromagnetic radiation with both infrared as well as ultraviolet wavelengths, and is a renewable source of energy. This is possible because of the enormous amount of sunshine that falls on Earth every day. Both concentrating and non-concentrating solar collectors exist. The primary distinction between concentrating and non-concentrating collectors is the relative size of the interceptor and absorber. Homeowners may use flat-plate as well as evacuated-tube solar collectors for the space heating, hot water, plus cooling.

Most applications that need high temperatures for drying may benefit from solar heating. Solar dryers make use of air heated by the "solar energy collectors", that can be set up in the modules according to hot air needs. Using the sun to dry clothes is a straightforward idea. The dimensions of solar collectors are a key component of the solar drying systems. Collectors need to be able to provide the drying chamber with appropriate amounts of hot air based on the volume of objects to be dried. Collectors that are inadequate in relation to the quantity of food to be dried will inevitably lead to wasted effort and food. A solar dryer's ability to convert light into heat is enhanced by any black coating on its inside. Separating the dryer's interior air from the ambient environment is crucial. A plastic bag or a glass cover, both of which are transparent, would let light in but would retain the generated heat. As a result, it is feasible to achieve temperatures comparable to those seen on hotter, windier days. Convection of hot air is used by both the natural convection dryer as well as the "forced convection dryer" to transfer heat to the food

LITERATURE REVIEW

(Ebrahimi et al., 2021) (Ebrahimi et al., 2021) One of the primary issues with using the solar collectors in many industries is their low thermal efficiency. This research looked at how incorporating "phase change materials" (PCM) into a "Flat plate collector" (FPC) affected its thermal performance as well as overall drying efficiency. Four PCM locations inside the collection were evaluated, and the results were compared to those obtained with no PCM. Drying tomato slices uses an estimated 11.12–9.01 MJ/kg of energy, according to experiments. Using the collector's PCM-equipped tailpiece cut drying time for the slices by around 21.87 percent. The "thermal efficiency of FPC" changed by between 5.02% and 10.13% according on where the PCM was placed. For various PCM placements, total efficiency ranged from 21.92% to 25.72%. Ansys 2015 was used to do a computational fluid dynamics (CFD) simulation of the system, and the results indicated that the collector's thermal performance could be anticipated with a high degree of accuracy ($R^2 > 0.9432$). In addition, at each PCM point, the outcomes of "evolutionary polynomial regression" models are provided. Collector output temperature as well as thermal efficiency predictions were found to be within acceptable ranges ($R^2 > 0.98$). Putting PCM at the collector's tail end ensured a uniform drying cycle, a constant temperature, and a rapid drying period. The solar drier produced superior tomato slices than those dried in conventional methods.

(Mani & Thirumalai Natesan, 2021) (Mani & Thirumalai Natesan, 2021) Under the same circumstances, the research compares the passive and active thermal performance of even span as well as "parabolic roof type solar greenhouse dryers". The 200-m UV-stabilized polyethylene sheets were used to cover dryers in order to maximise the drying impact of the sun's rays. The effectiveness of various dryers in curing lima beans is assessed (Phaseolus lunatus). The Lima beans' original 75% (w.b.) moisture content was lowered to 11%. (w.b). The parabolic drier could dry in 28 hours under active mode and 32 hours under passive mode, whereas the even span dryer would take 32 and 36 hours to get to the same point. Lima beans dried under the open sun for as long as 40 hours. Parabolic dryers operating in active mode were predicted to have a thermal efficiency of 14.7%, with even span dryers operating in passive mode having a thermal efficiency of only 12.03%. The payback time for the parabolic active mode dryer was just 2.15 years, compared to the dryers' estimated solid life duration of 10 years; hence, the usage of these dryers is strongly suggested for the small-scale, economically-disadvantaged farmers.

(Lakshmi et al., 2021) (Lakshmi et al., 2021) Here, researchers conduct experimental assessments of two different types of active horizontal solar dryers for drying Piper nigrum: a mixed-mode dryer (Case-I) and an indirect dryer (Case-II) that are both integrated with a latent heat storage system (black pepper). In both scenarios, drying time to the target moisture content of 0.14(d.b) from 3.46(d b) was 14 hours and 23 hours, respectively. Yet, drying it in the open sun took 59 hours (case-III). For cases I and II, the designed dryers cut drying times by 76% & 60%, respectively, compared to instance III. Solar dryers that have been created are more cost-effective. It can be shown that Case-I has a 20% greater total dryer efficiency than Case-II. Proximity analysis as well as anti-oxidant studies were performed on fresh & dried samples in all three instances to determine overall quality. Case-I had higher values for carbs and proteins than case-II and case-III. Dried case-I & case-III samples had 45.69 & 23.25 micromoles total phenolic antioxidants (TE) per gramme of material, respectively. When compared to the other two drying conditions, case-III resulted in a higher amount of ash in the samples.

(Mohana et al., 2020) (Mohana et al., 2020) Due to the continuing energy shortage, renewable energy sources are desperately needed. Renewable energy sources should be considered for use in the food processing industry as an alternative to traditional, high-energy-consumption unit processes, such as drying. In terms of cost-effectiveness, energy efficiency, as well as rural application, food drying using solar energy is still an appealing option. However, there is a significant technology gap; it is difficult to design inexpensive and effective dryers for the mass production of safe, nutritious food. The efficient use of thermal energy requires careful consideration in the solar dryer's design as well as component selection. In light of these factors, this study compiles a description of several dryer applications for various foods, as well as a comprehensive analysis on the many dryer designs now available. In addition, new developments, problems, and limits in technology, energy concerns, and other socioeconomic elements for implementing the large-scale sun drying of foods are given. In light of this, this study sheds light on the current status of solar dryers, contributing to the development of an environmentally friendly and sustainable technology for use in the food industry.

(Kumar & Singh, 2020) (Kumar & Singh, 2020) With solar drying, the moisture content of the items is reduced down below the point of no more product degradation. Direct solar dryers, indirect solar dryers, and mixed-mode solar dryers come in a wide range of sizes, capacities, and designs, but they all rely on the sun to dry their contents. The primary objective of this research was to compare and contrast the various solar dryer designs based on product-specific factors as well as technical, economic, and ecological considerations. Research has shown that air temperature as well as velocity are the most important factors in determining the drying rate and efficiency of a solar dryer, followed by the solar radiation, product type, beginning moisture content, total product mass, as well as "thermal energy storage" materials. The product may be dried in a variety of methods, such as by utilising fossil fuels, solar radiation, a hybrid drying system, etc. Using fossil fuels presents a number of issues, including resource scarcity, high costs, and environmental damage. There are several problems associated with open sun drying, such as exposure to dirt, rain, wind, insects, human and animal intervention, and so on. When compared to other types of solar dryers, the mixed mode solar dryer that makes use of "thermal energy storage" materials is among the most effective and fastest.

(Aramesh & Shabani, 2020) (Aramesh and Shabani, 2020) Evacuated tube solar collectors (ETSCs) have gained a significant share of the solar thermal collector (STC) market. Compared to other collector types, ETSCs cover a relatively wide range of operating temperatures, mostly offer higher thermal efficiency, and are available at reasonable prices. But similar to other solar energy technologies, ETSCs are suffering from two main drawbacks associated with intermittency of solar radiation. Phase change materials (PCMs) have been widely used to overcome this challenge. If properly designed and utilised, PCMs can reduce the energy fluctuations and store the solar thermal energy during the daytime and release it in the absence of sunlight. There have been many studies conducted on the integration of PCMs with ETSCs, but the lack of a comprehensive systematic review study focused on such integrated energy systems has remained to be a gap in the literature. This gap is addressed by the present review study. Based on both theoretical and experimental results reported in the literature, the present study focuses on PCM assisted ETSC systems from different perspectives such as integration types, design parameters, and performance. Four main types of integration between PCMs and ETSCs are identified and advantages and disadvantages of each type compared to the others are discussed. Furthermore, state of the art is also clarified, the knowledge gaps are identified, and a roadmap for further studies on these energy systems is provided accordingly.

(Tegenaw et al., 2019) (Tegenaw et al., 2019) This study utilises both CFD and lumped capacitance modelling approaches to simulate the "transient heat transfer" in a solar food dryer. The dryer's airflow and "transient heat transfer" are simulated with the use of a CFD model. Energy exchanges between the drying chamber's numerous components inspired a "lumped capacitance model", which is contrasted at length with the CFD model's output. Both models agree that there will be a steady-state temperature increase of 40 C in the drying chamber. The two models' predictions of the transient temperature before reaching this point differ by roughly 8°C RMS. The heat transmission coefficient near the shelves of the refrigerator is mostly responsible for this discrepancy. When these coefficients are fitted, the two models' mean temperature differences on the bottom and top shelves of the rack are only 1.8 and 0.9 degrees Celsius, respectively. By confirming the basic premise of the lumped capacitance modelling, CFD simulations of rapid heat transfer phenomena shown that temperature distributions are uniform 30 minutes after the event. This illustrates that the computationally intensive CFD modelling approach may be replaced by the simpler "lumped capacitance model" for forecasting transient heat transport phenomena in the solar food dryers.

(Aravindan et al., 2017) (Aravindan et al., 2017) For agriculture to be successful in meeting the needs of an expanding population, it must overcome numerous formidable obstacles. Produce storage and use are equally as crucial as production. For several reasons (such as the distance between the production and consumption sites, the seasonality of some crops, the need to store extra supplies for a sudden uptick in demand, etc.), it is crucial that agricultural goods be kept in good condition until they are ready for consumption. In addition to other considerations, moisture is very important in the rotting of agricultural goods. Molds, yeasts, and bacteria may all develop in damp environments and destroy food. Utilizing solar dryers at the point of production is a cost-effective, simple, and efficient method of removing moisture. Concentrating the sun's rays into a small area allows solar dryers to reduce the product's moisture content by evaporating and venting the water. Several designs for solar-powered dryers were developed and analysed to see which would be most successful in retaining heat from the sun. The purpose of this study is to analyse and evaluate various designs depending on how efficiently they remove moisture.

© INTERNATIONAL JOURNAL FOR RESEARCH PUBLICATION & SEMINAR
ISSN: 2278-6848 | Volume: 13 Issue: 04 | July - September 2022
Paper is available at http://www.jrps.in | Email : info@jrps.in
Refereed & Double Blind Peer Reviewed

MATERIAL AND METHODOLOGY

1. Material And Design

A Solar dryer with the following details have been considered for the CFD analysis:

Absorber plate: Steel sheet, insulated by glass wool, painted in black, with dimension of 1800 × 900 mm^2 and thickness of 1 mm.

Glazing: Single layer glass cover with 4 mm thick, the distance between the glass cover and absorber plate was about 180 mm, with radiative properties 0.89, 0.06 and 0.08 for transmittance, absorptance and reflectance, respectively.

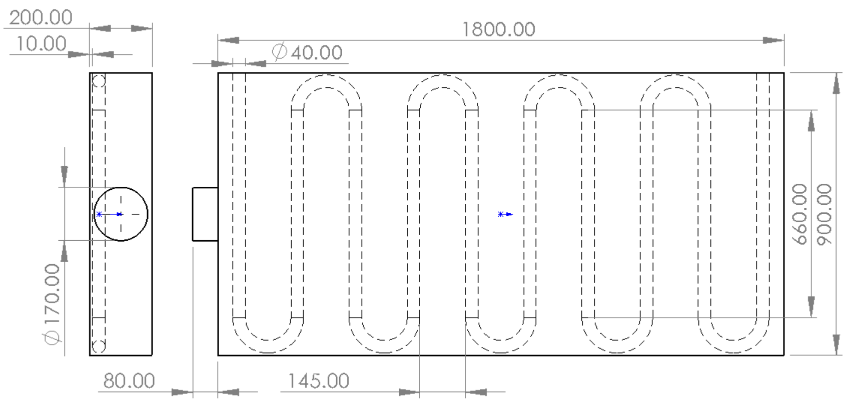


Figure 1 Design of the Solar Dryer

Solar dryer cabinet: A medium-density fiberboard (MDF), 10 mm thick, and with the dimension of 300 × 400 × 500 mm3, all sides insulated by 40 mm thick of glasswool

Trays: 250 mm × 350 mm perforated polyethylene PCM Paraffin RT50S, 5.95 kg, filled in a spiral copper, number of turns 10

PCM Containing tube: A copper tube with thickness of 1 mm

The high latent heat and favourable thermal features of paraffin wax—including a low vapour pressure in the melting state, a variable phase transition temperature, and the ability to self-nucleate—made it an appealing candidate for use in the thermal system. Paraffin is a corrosion-free, durable, and dependable substance. Parafin's distinctive property is that it maintains its thermal performance throughout the phase shifting cycle. The properties of the paraffin wax used as PCM in the collector have been mentioned below in the table 3-1:

Table -1 Properties of the Paraffin Wax

Properties	Values
Thermal conductivity	0.185 W/mK
Specific Heat	2.156 kJ/kgK
Oil Content	0.49%
Density	780 kg/m^3
Melting point	54.2° C

© INTERNATIONAL JOURNAL FOR RESEARCH PUBLICATION & SEMINAR
ISSN: 2278-6848 | Volume: 13 Issue: 04 | July - September 2022
Paper is available at http://www.jrps.in | Email : info@jrps.in
Refereed & Double Blind Peer Reviewed

Kinematic viscosity at 100° C	6.12
Latent Heat	170 J/kg

2. Cases For Cfd Analysis

The following cases have been considered for the Solar Collector in order to evaluate its thermal efficiency.

- **CASE 1: Without Ribs**

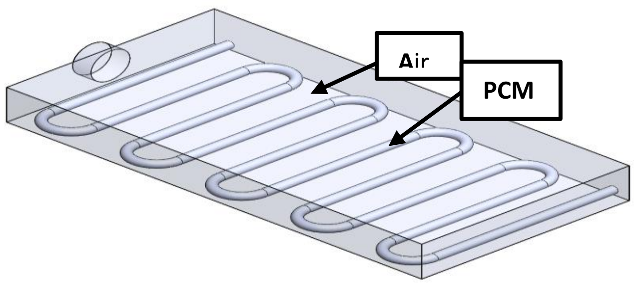


Figure-2 Case 1: Without Ribs

- **CASE-2: With Straight Ribs**

The design of the Solar Collector with 3mm thick straight ribs has been shown in the figure 3-6 below:

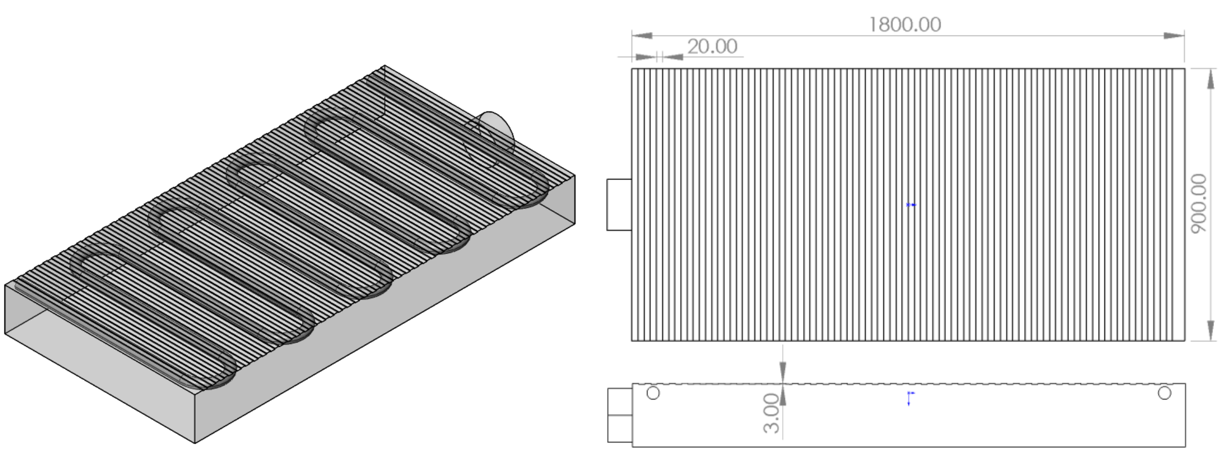


Figure 3 Case 2: Collector with Straight Ribs

- **CASE-3: With V-shaped Ribs**

The design of the Solar Collector with 3mm thick V- shaped ribs, forming a 125° angle, has been shown in the figure 3-8 below:

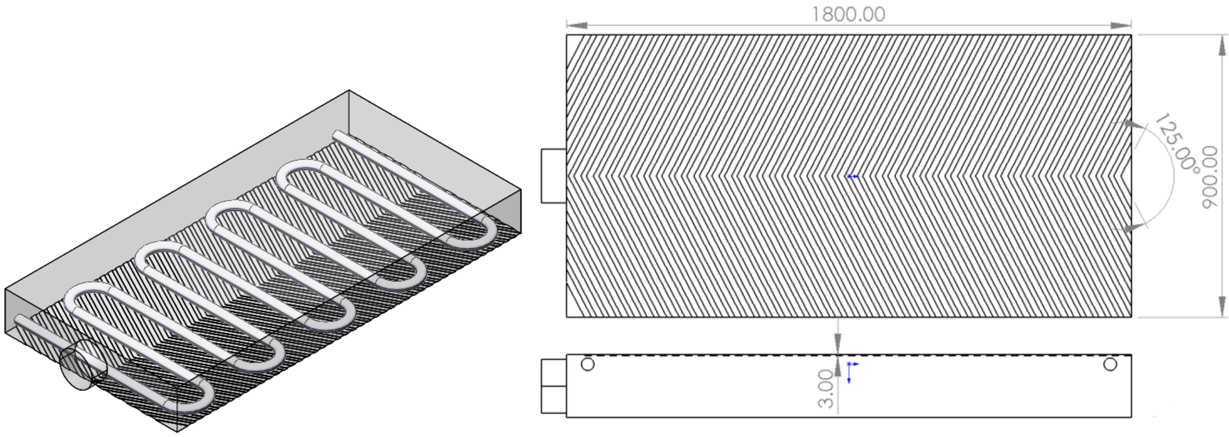


Figure -4 Case 3: Collector with V-shaped ribs

3. Mesh Generation

The technique of meshing involves breaking down an item's continuous geometric space into thousands or more different forms in order to accurately describe the physical shape of the thing in question. The 3D CAD model will be more precise and allow for higher fidelity simulations if the mesh is more dense. When a complicated geometry is divided into discrete components, it is called meshing. Mesh generation may be used to discretize a domain into two or three dimensions. Automated methods for meshing may offer quicker and more accurate solutions since meshing usually occupies a large part of the time it takes to get simulation results.

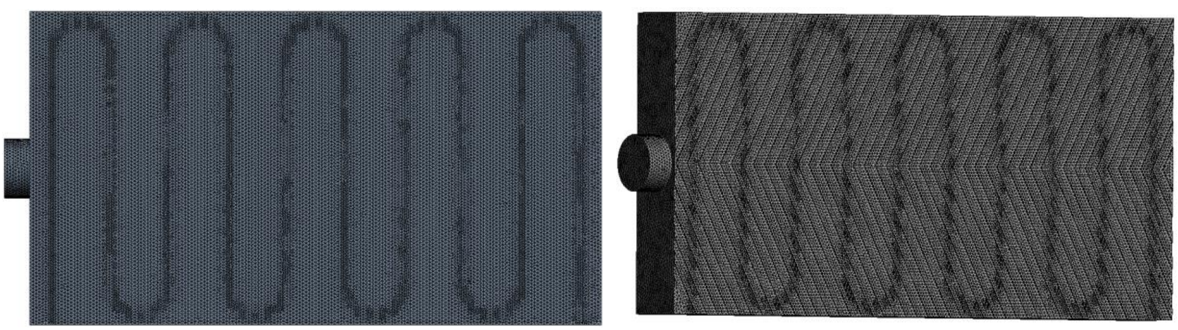


Figure 5 Mesh generation

4. Boundary Conditions

The general boundary Conditions for all the cases have been mentioned below:

Figure 6 Boundary Conditions: Position of inlet and outlet

- Energy ON
- Transient analysis is used
- Model- Standard K-e model
- Radiation is turned on for solar effects
- Solidification and Melting is turned ON for PCM melting and solidification
- Paraffin wax is used as PCM material
- Air is used as flowing fluid
- Inlet mass flow rate is used as 0.025 kg/s
- Inlet air temperature is selected as 300 k
- Study is performed for the whole day from 8:00 to 18:00

The variation of the heat flux according to the solar radiation throughout the day has been shown in the figure 3-5.

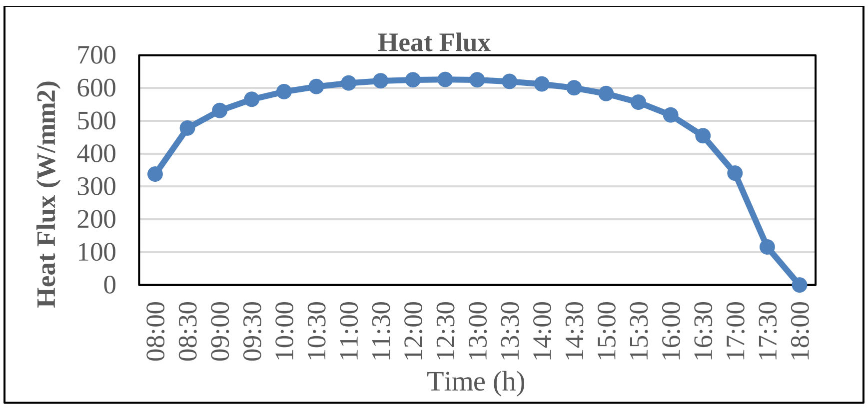


Figure 7 Heat Flux According To Radiation

The total number of cases considered are:

cases	Type
Case-1	Without ribs
Case-2	Straight ribs
Case-3	V- type ribs

RESULTS AND DISCUSSIONS

The temperature contours at 1:00 PM on the plane has been shown in the figure 8. The curve for the average outlet temperature of the air follows the trend of the heat flux curve as shown in the figure , it increases with the solar radiation attaining its maxima at around 1:00 PM and then decreases again. The maximum average outlet temperature of the air obtained is 343.139 K for the case without ribs, 346.679 K for straight ribs and 345.262 K for V-shaped ribs.

The curve for the PCM temperature also follows the similar trend with the maxima obtained at 1:00 PM of 348.863 K in case of no ribs, 352.214 K in case of straight ribs and 352.504 K in case of V-shaped ribs, as can be observed in the figures 9&10 . As the solar radiation and the temperature of the air in the chamber increases, it facilitates the phase change process of the PCM.

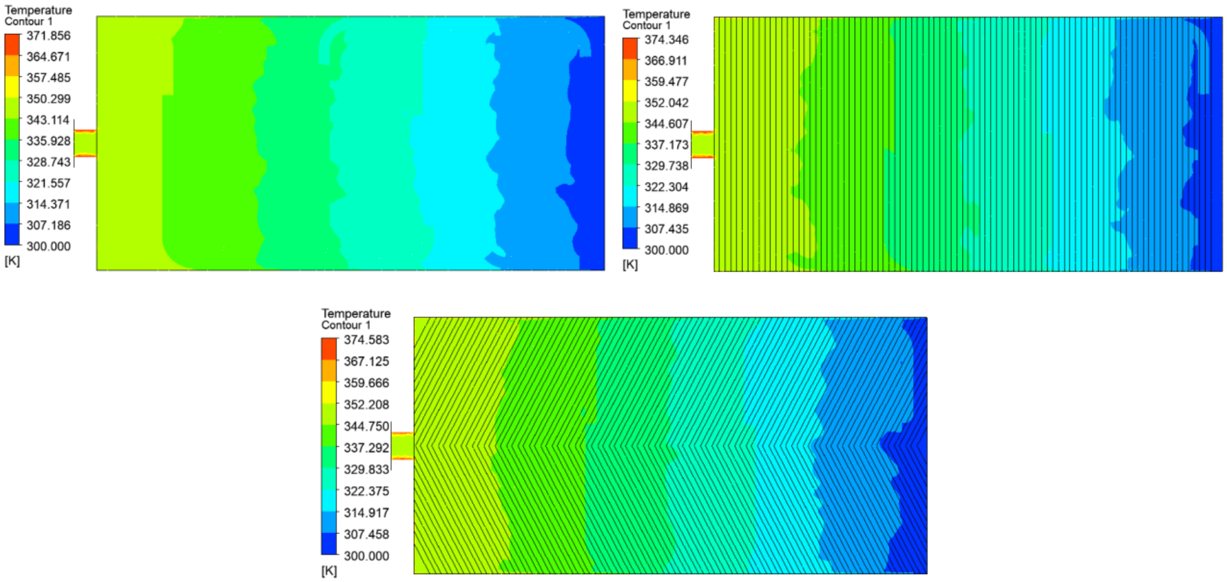


Figure 8 Temperature at 1:00 PM

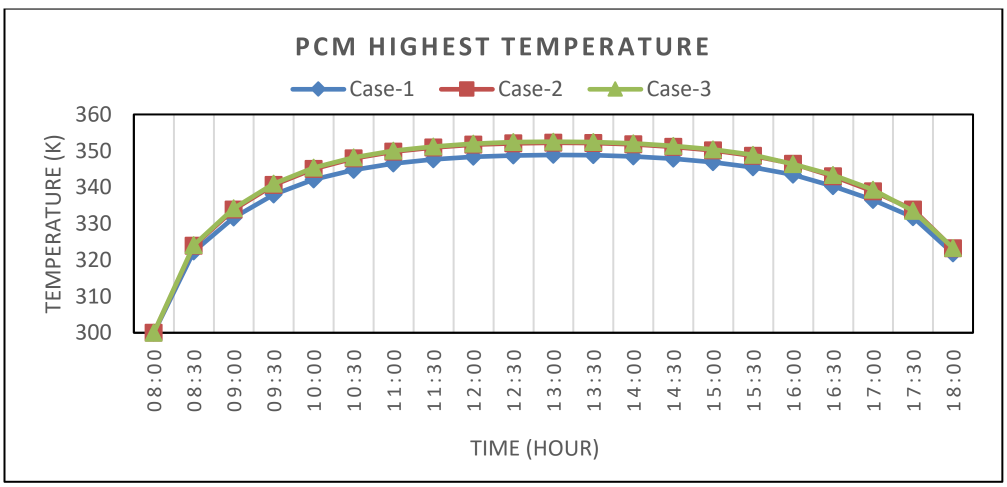


Figure 9 PCM HIGHEST TEMPERATURE COMPARISON

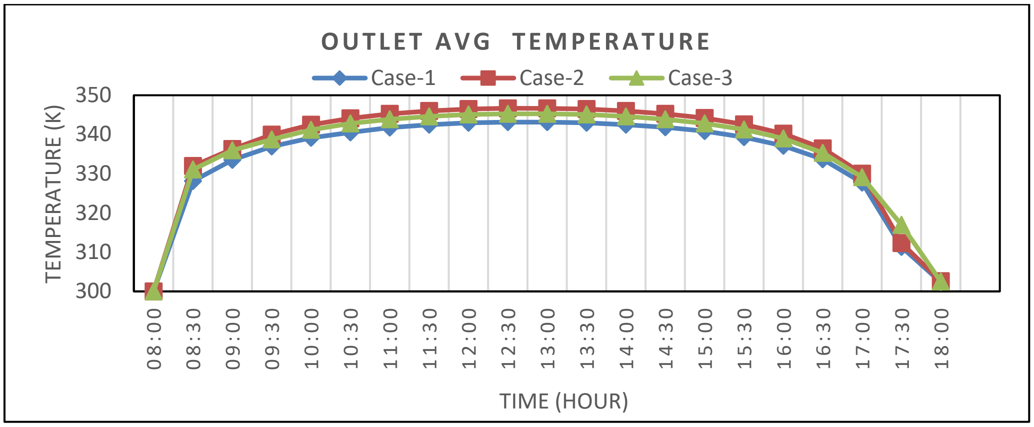
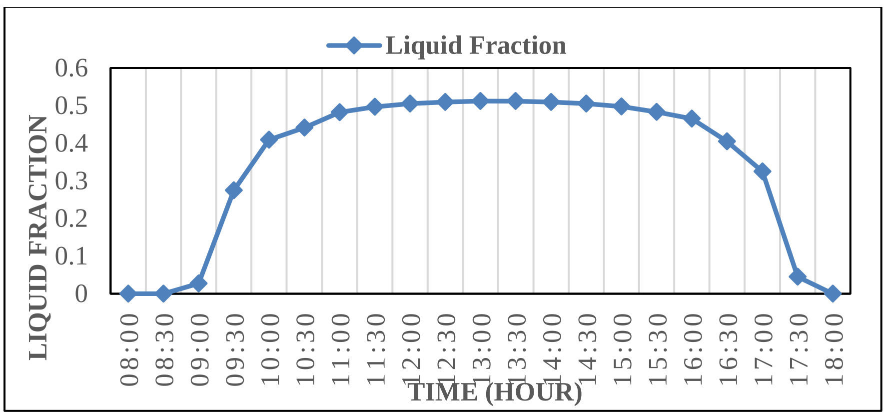
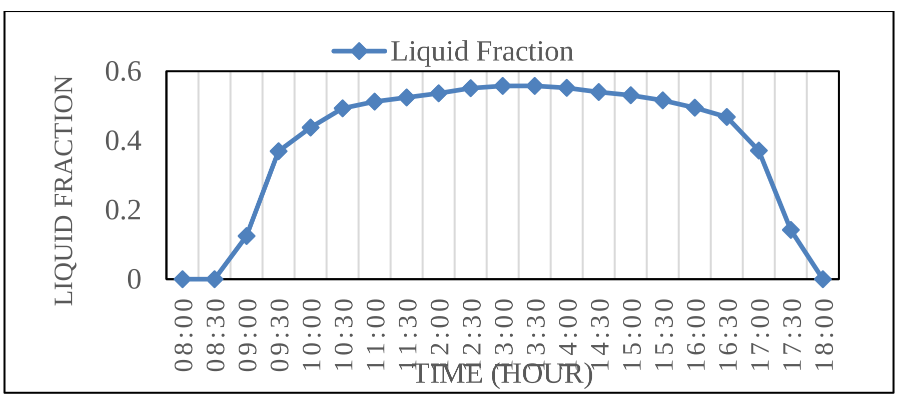


Figure 10 OUTLET AIR TEMPERATURE COMPARISON





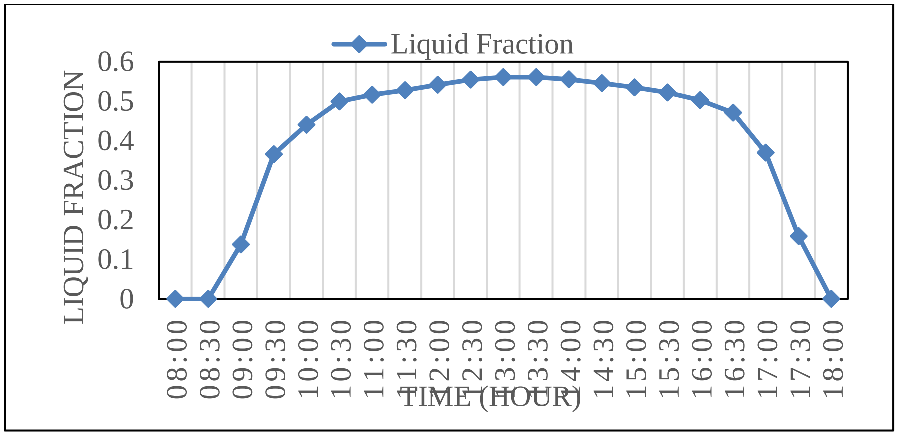


Figure 11 Liquid fractions

Liquid fraction is the ratio of the liquid phase of the PCM during its phase change. As the solar radiation and the temperature of the air in the chamber increases, it facilitates the phase change process of the PCM. As can be observed in the figure 11, the curve for the liquid fraction of the PCM is also quite similar to the heat flux curve with the maximum liquid fraction obtained at 1:00 PM of 0.511738 for no ribs, 0.557598 for straight ribs and 0.560582 for V-shaped ribs.

CONCLUSION

In this paper, drying performance and thermal behavior of a solar dryer integrated with flat plate collector and phase change materials has been investigated. To enhance the thermal efficiency of the solar collector, 3 different cases of the collector without rib design, with straight ribs as well as with V-shaped ribs has been analysed. The temperature distribution of the collector at different solar radiation during throughout the day was also simulated using computational fluid dynamic (CFD). The maximum temperatures have been obtained near about 1:00 PM during the day due to the maximum heat flux input of the solar radiation. The solar collector with rib designs have shown an improvement in the thermal performance over the solar collector design without any ribs. Maximum outlet temperature has been obtained in the case of straight ribs near about 1:00 PM, i.e. 346.679 K followed by the collector with V-shaped ribs, i.e. 345.262 K. Both the solar collectors with straight and with V-shaped ribs have attained almost same maximum temperature of the PCM, i.e., 352.214 and 352.507 K, respectively. Maximum value of liquid fraction has been obtained in the case of V-shaped ribs, i.e., 0.560582.

REFERENCES

Aramesh, M., & Shabani, B. (2020). On the integration of phase change materials with evacuated tube solar thermal collectors. *Renewable and Sustainable Energy Reviews*, *132*(February), 110135. https://doi.org/10.1016/j.rser.2020.110135

Aravindan, V., Dineshkumar, A., Giriprasath, B., Karthikeyan, V., & Ebenezer, D. (2017). Moisture removal rate of solar dryers – A review. *Journal of Chemical and Pharmaceutical Sciences*, *7*, 218–224.

Ebrahimi, H., Samimi Akhijahani, H., & Salami, P. (2021). Improving the thermal efficiency of a solar dryer using phase change materials at different position in the collector. *Solar Energy*, *220*(March), 535–551. https://doi.org/10.1016/j.solener.2021.03.054

Kumar, P., & Singh, D. (2020). Advanced technologies and performance investigations of solar dryers: A review. *Renewable Energy Focus*, *35*, 148–158. https://doi.org/10.1016/j.ref.2020.10.003

Lakshmi, D. V. N., Muthukumar, P., & Nayak, P. K. (2021). Experimental investigations on active solar dryers integrated with thermal storage for drying of black pepper. *Renewable Energy*, *167*, 728–739.

https://doi.org/10.1016/j.renene.2020.11.144

Mani, P., & Thirumalai Natesan, V. (2021). Experimental investigation of drying characteristics of lima beans with passive and active mode greenhouse solar dryers. *Journal of Food Process Engineering*, *44*(5), 1–12. https://doi.org/10.1111/jfpe.13667

Mohana, Y., Mohanapriya, R., Anukiruthika, T., Yoha, K. S., Moses, J. A., & Anandharamakrishnan, C. (2020). Solar dryers for food applications: Concepts, designs, and recent advances. *Solar Energy*, *208*(July), 321–344. https://doi.org/10.1016/j.solener.2020.07.098

Tegenaw, P. D., Gebrehiwot, M. G., & Vanierschot, M. (2019). On the comparison between computational fluid dynamics (CFD) and lumped capacitance modeling for the simulation of transient heat transfer in solar dryers. *Solar Energy*, *184*(November 2018), 417–425. https://doi.org/10.1016/j.solener.2019.04.024