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Design and analysis of flat plate solar air dryer

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ABSTRACT

Solar dryer is machines and use solar energy to dry things, especially food. There are two common types of solar dryers: Direct & Indirect. This is a type of drying in which the product to be dried absorbs direct sunlight. Also called natural convection cabinet dryer, because the sun's rays fall directly on the surface; product quality is declining. The hot air from the locker room is blown away. The basic function of the sun dryer is to heat the air with solar energy at a constant temperature, which causes moisture to evaporate from the plants inside the drying room. The main purpose of the flat plate is the air-drying model based on circular & square air flow in Solid Works software & computational fluid dynamics in Ansys software. In general, solar drying heat loss is possible, so it is reduced with the help of inserts (polystyrene and fiberglass). Predicting differences in air flow temperature variations with differential components. In addition, select a section on the best cross-section of tube and insulation material.

Keywords: Flat Plate Collector, Circular & Square Tube, Polystyrene & Fiber Glass, Temperature difference, Solid Works, & ANSYS software

INTRODUCTION

In the drying of the sun, the product is exposed directly to the sun's rays and - more or less effectively- in the air. In the setting of the sun, the product is contained in a closed space, and the contact air is heated by the sun's rays. By heating the air 'their humidity is reduced and therefore its efficiency as a dehumidifier is increased.

For small driers, compliant with the single-farmer airflow requirements in this product is often the result of a natural supply - the tendency for warm air to rise. In large parts - suitable for public or corporate or industrial use - air is transmitted through a fan; this is called "forced transfer". The latter units work more efficiently, but require an additional source of power to drive the fan.

Fig. 1 Flat Plate Collector

Benefits of making dehydrated food

- Tastes Great
- Less Expensive
- All Natural
- Portable
- Reduces Waste

Literature review

Kaivalya and Premkumar the drying process is different for different products and depends on the initial humidity of the product, the geometry of the product, the intensity of the sun's rays, and the free movement of air inside the dryer. Mandatory convection solar dryer configurations offer higher drying levels than those of convection-free solar dryer. The drying process is affected by the properties of dry matter e.g. content of humidity, size, shape and conditions, including solar radiation and temperature. Vaibhav Pakhare and Sanjay

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Salve variations in air flow temperature, drying time read, as the flow rate increased the exhaust temperature of collectors decreased and drying efficiency was achieved by 22%. At the similar time the outcome of thermal energy storage during the drying process of peppers is also tested without the initiation of thermal energy storage.

Hajar Essalhi et al., The experiment was carried out on two different types of solar wind collectors that were considered for use in an indirect solar dryer. Comparisons between the two collectors show that the aluminum metal collector produced has improved thermal presentation than polyethylene. Nice one to the design of the two aluminum plate placed at the top form an absorber, we have found wide cylinders that satisfy good air circulation. The efficiency of the collector with a metal aluminum absorber is enhanced by the increase in air flow.Kumavat Mukesh Manilal we know that drying food with the help of a glossy plate collector is more effective than conventional procedures because it will dry food at higher dry temperatures without contamination. CFD analysis is a practical tool by which we can update models in a variety of non-automated operating conditions and compare their results.

AvesahemadSayyadnaimutullaHusainy and Kulkarni Grapes have a pre-dried treatment with an advanced sunscreen. The designed dryer is integrated with Phase Change Material to extend evening / night drying use. The effect of air flow levels on humiditysatisfied, humidity rate, drying rate, drying time & drying effectiveness have been tested in grapes. Nay Win SeinThe needed capacity to remove humidity from 22 to 14% paddy is 116.28 MJ, according to the assessed design for 500 kg of solar paddy dryer. The established power from the collector is 6525 MJ/daym^2 in May. The complexity of the rice bed is 100mm. Therefore, the floor area of the paddy bed is 0.83m^2. The essential collector area is 25.458m^2. The proportions of the air intake are 0.996m^2& the funnel crossing area is 0.23897m^2. For this design, the height of the solar chimney is used 3m from the crushed level. A solar paddy dryer is analysed by varying the drying power with the same funnel height. Due to the rise in drying capacity, the quantity of paddy volume increases.

Ambesange and KusekarEnergy are an important factor in the economic, social and industrial development process of any nation. In recent decades, global demand for power has been steadily increasing at an alarming rate due to population growth, industry, transportation, etc. Continued consumption of mineral oil has led to energy crisis and global degradation. In many other ways, solar energy is an important source of renewable energy that can meet all energy needs. Virendra Bhagwat et al., The distribution of hot air from the solar collector & that high temperature air is provided to the room. In India, we have 12hrs. of sunlight & 12hrs of sunshine so the solar wind heater is imperfect to sunlight hours. Running it at night required external power supply, so the cost of solar heaters increased. Our need is to bring hot air into the room up to 60 to 65ºC day and night temperatures.

Manjunath Basude et al., The drying of Pease's and Grapevine was investigated under a forced contract. The indirect type of forced solar dryer delivery by tube collector conveyor produces higher air temperature inside the chamber and improves the drying rate thereby reducing the drying time required for drying the product. The time taken by the solar dryer with convection forced access to the desired moisture content is less than the time required for natural display.Eklabya Gupta et al., Can be concluded that the absence of a suction plate has a significant impact on the high loss coefficient and consequently the performance of the Flat plate collector. The efficiency of FPC is found to increase with increasing temperature. Using solar fuel in the use of solar collectors has great potential in the future and is less of a global focus on getting clean and green energy.

Working methodology

- ✓ Study (Flat Plate Solar Air Dryer)
- ✓ Problem Identification
- ✓ Material Selection
- ✓ Design of Flat Plate Collector in Solid Works Software
- ✓ Analysis of Flat Plate Collector using Computational Fluid Dynamics in Ansys Software
- ✓ Predict the Temperature Difference in Various Air Flow
- ✓ Result & Conclusion

Problem identification

The ability of a plate to absorb heat and absorb more heat from the sun and to retain heat is the key to the success of flat plate collectors. The heat absorbed by the flat plate collector depends on both the thermal properties and the construction of the heat absorption plate. Due to the hot climates, heat plate heaters play an important role in heat absorption performance. But the main problem is heat loss in the collector, thus reducing heat loss with the help of better insulation materials and various cross-section tubes.

Objective

The project is conducted with the following objectives to be achieved:

- ➢ To design a model of flat plate collector with various cross section tubes & analysis based on computational fluid dynamics.
- ➢ To study the effect on polystyrene & fiberglass insulation material using in flat plate collector efficiency, its reason of reduced the heat loss
- ➢ To study the effect of circular and square tube flat plate collector model

Table 1 Material Property

Description	Glass	Aluminium	Polystyrene	Fiberglass	Steel	Copper
Density (kg/m^3)	2500	2719	1050	150	8030	8978
Specific Heat (j/kg-k)	1090	1004.832	1200	700	502.48	381
Thermal Conductivity (w/m-k)	0.8	235.222	0.033	0.04	16.27	387.6

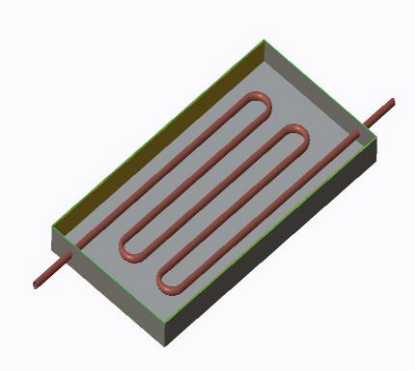

Fig. 2 Circular Tube Model

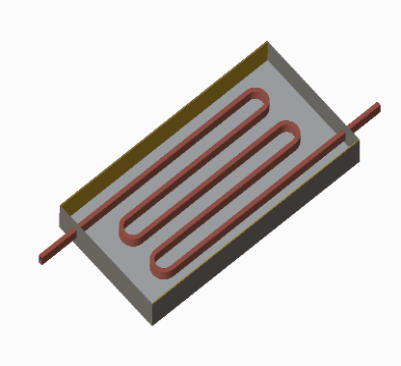

Fig. 3 Square Tube Model

Analysis of flat plate solar air dryer

Finite element (FEM) is a numerical method for resolving differences or integrated combinations. It has been used in many physical disorders, where controlling divisive statistics are found. This approach actually involves considering the ongoing work of the solution issues and finding the function parameters in a way that minimizes the error in the solution.
As mentioned in the introduction, a limited technique is a mathematical process for finding solutions to border value difficulties. The goal of the technique is to substitute the entire incessantarea with a number of subdomains where the unidentified function is signified by modest translation functions with unidentified coefficients. Therefore, the problematic of the first boundary rate with an unlimited number of free degrees is rehabilitated into a problematic with a limited number of free degrees, or in additional words, the solution of the whole arrangement is measured by a limited number of unidentified coefficients.
Computational Fluid Dynamics (CFD) is a fluid flow analysis using mathematicalmethods. Using CFD, you are able to analyse complex problems including fluid-fluid, fluid-solid or fluid-gas interactions. The engineering fields in which CFD analysis is most generally used are for sample aerodynamics & hydrodynamics, where value such as lifting & drag or field structures such as pressure detection and velocities.
Domain guidance is the first & perhaps greatestsignificantstage in at all minor analysis because the way the domain is determined will disturb computer storingnecessities, computational time, &exactness of mathematical results

RESULT & DISCUSSION

Table 2 Analysis data for circular tube using fiber glass

Mass Flow Rate in kg/s	Air Inlet Tem. in ℃	Air Outlet Tem. in ℃			
		15 min	30 min	45 min	60 min
0.01	30	40.98	44.73	46.5	47.54
0.02	30	37.31	38.78	39.39	39.72
0.03	30	35.46	36.24	36.56	36.73

Table 3 Analysis data for circular tube using polystyrene

Mass Flow Rate in kg/s	Air Inlet Tem. in ℃	Air Outlet Tem. in ℃			
		15 min	30 min	45 min	60 min
0.01	30	41.01	44.84	46.81	48.02
0.02	30	37.33	38.83	39.54	39.94
0.03	30	35.48	36.27	36.64	36.84

The flat plate collector circular tube model is both fiber glass & polystyrene insulation material analysis result is show in the above Table 2 & 3. The comparatively maximum temperature obtained in the polystyrene material at 60min, so temperature, pressure & velocity difference image show in the below Fig. 4 to 6

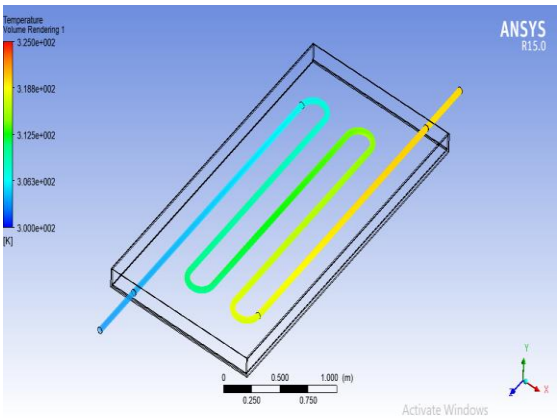

Fig. 4 Temperature Difference air flow rate in 0.01kg/s at 60min (Circular)

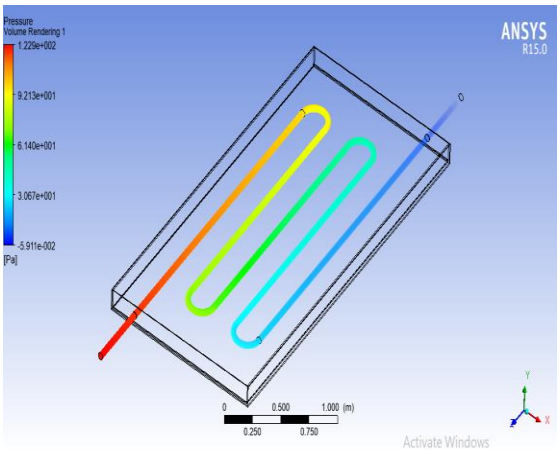

Fig. 5 Pressure difference in Circular Tube

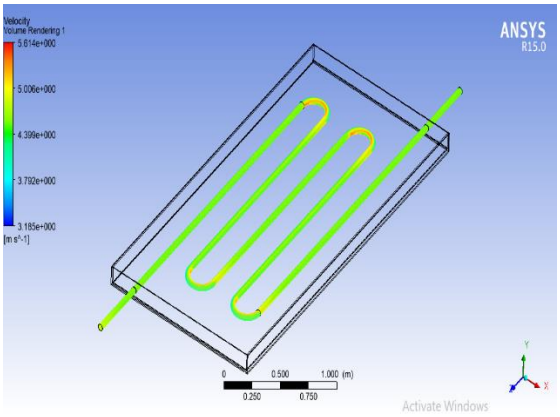

Fig. 6 Velocity difference in Circular Tube

Table 3 Analysis data for square tube using fiber glass

Mass Flow Rate in kg/s	Air Inlet Tem. in ℃	Air Outlet Tem. in ℃			
		15 min	30 min	45 min	60 min
0.01	30	42.34	47.38	49.91	51.44
0.02	30	38.61	40.73	41.64	42.16
0.03	30	36.58	37.76	38.23	38.49

Table 4 Analysis data for square tube using polystyrene

Mass Flow Rate in kg/s	Air Inlet Tem. in ℃	Air Outlet Tem. in ℃			
		15 min	30 min	45 min	60 min
0.01	30	43.84	48.08	50.31	51.69
0.02	30	39.29	40.99	41.78	42.24
0.03	30	36.97	37.89	38.3	38.53

The flat plate collector square tube model is both fiber glass & polystyrene insulation material analysis result is show in the above Table 3 & 4. The comparatively maximum temperature obtained in the polystyrene material at 60min, so temperature, pressure & velocity difference image show in the below Fig. 7 to 9.

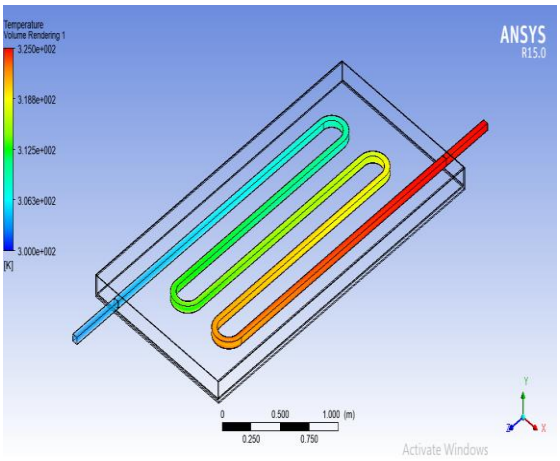

Fig. 7 Temperature Difference air flow rate in 0.01kg/s at 60min (Square)

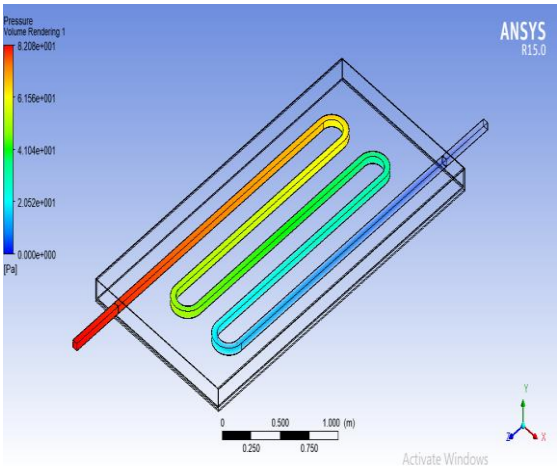

Fig. 8 Pressure difference in Square Tube

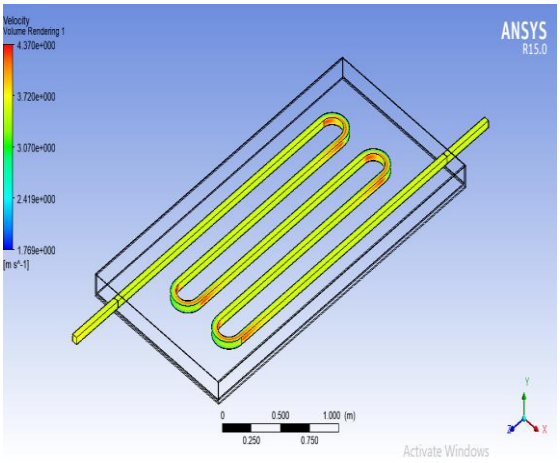

Fig. 9 Velocity difference in Square Tube

Advantages

- ✓ Easy to manufacture
- ✓ Low cost & little maintenance
- ✓ Improve flat plate collector efficiency

Applications

Flat plate collectors are used for both

- ✓ Domestic applications
- ✓ Commercial applications

CONCLUSION

Solar dryers help provide more heat than atmospheric heat. In solar dryers, air enters the drying room through a natural convection process or through an external source such as a fan, pump, suction device, etc. The air heats up as it passes through the room and cools down slightly as it absorbs moisture from the food product placed in the room. After that, the humid air is removed by a car fan or chimney. Our research based on reduced heat loss & efficiency of plate collectors is enhanced with the help of coating materials and various cross tubes in Ansys software. Looking at our project polystyrene material is better to lose heat reduced to a flat plate collector. Slow air flow rate achieved a maximum temperature difference of 51.69 ℃ at 0.01kg/s at 60min in the square model for better heat transfer performance in flat plate collector

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