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Tribological Studies of Pin Fin type Forced Convection Solar Air Dryer with Help of PCM as a Thermal Storage Medium

R. Mani[1], P. Manikandan[2], N. Harish[3], G. Balasubramanian[4]
[1]*Principal &Head of the Department of Mechanical Engineering, Muthayammal Polytechnic institution, Rasipuram, Namakkal-637408, India*
[2]*Assistant Professor,* [3, 4]*Under Graduate Student, Department of Mechanical Engineering, VSB College of Engineering Technical Campus, Coimbatore-642109, India.*

Abstract: In the modern world solar energy is used various types of applications. This research uses solar energy to dry agricultural products (Ginger). The scientific and family name of ginger is Zingiber officinale. Ginger is used in the Medical field, cooking, etc. Dried ginger is used by enhancing digestion, which aids in burning fat that has been accumulated and digesting blood sugar, dry ginger promotes weight loss. In scientific studies, dry ginger has been shown to reduce triglyceride and total cholesterol levels. Dry ginger is a fantastic all-natural treatment for lowering excessive blood sugar levels. In this research, the solar dryer is consist of a pin fin with phase change materials. Paraffin wax is a phase change material here used to store latent heat. At sunrise, the energy is stored in the paraffin wax, and at sunset, the energy is released to heat the air. The result shows that thermodynamic performance has improved and hot air discharging time has increased by three and a half hours.
Keywords: Phase Change Materials, Paraffin wax, Solar Energy, Ginger.

I. INTRODUCTION

Dried fruits give more fiber and antioxidants to health. In this research, the forced convection solar air dryer consisted of locally available materials. The phase change materials are used here to store the energy to additionally heat the air. The air is passed inside the solar air heater (SAH) with different velocities with help of a blower. The air velocity is measured with help of an anemometer. So we can easily calculate the velocity of air. The valve system controls the air-flowing velocity. Paraffin wax is a phase change material used here to store heat energy. Block color paint-coated glass is used as a flat plate collector. Paraffin wax materials are filled inside the hollow tube called a pin fin. The pin fin is an aluminum pipe material. The solar dryer was consisted and tested in the local area of VSB College of Engineering Technical Campus, kinathukadavu, Coimbatore.

II. PROBLEM IDENTIFICATION

Solar dryers consist of different types. In the open drying method, the agriculture products are affected by fungi and odor and birds. Solar dryers are used to reduce this kind of problem and increase efficiency and quick drying.

III. METHODOLOGY

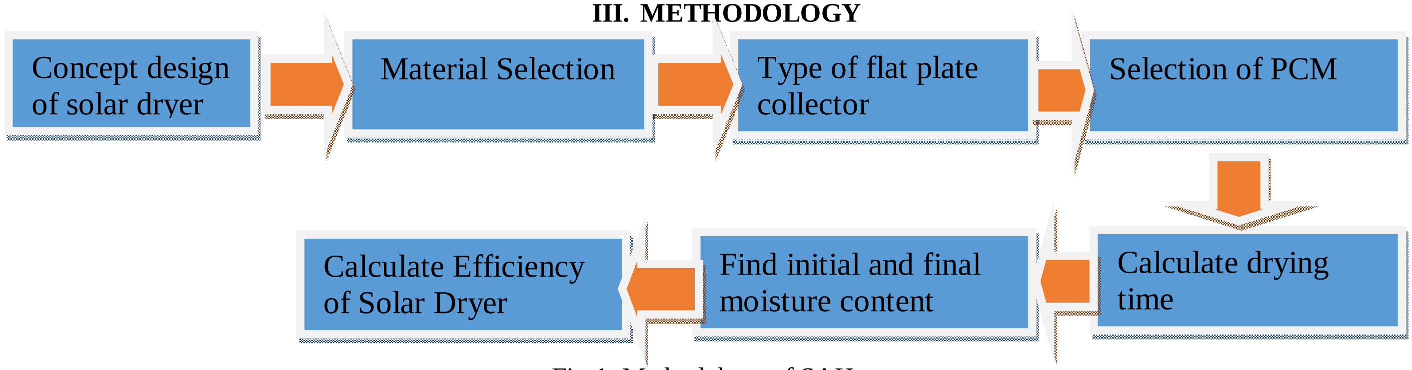

Fig 1: Methodology of SAH

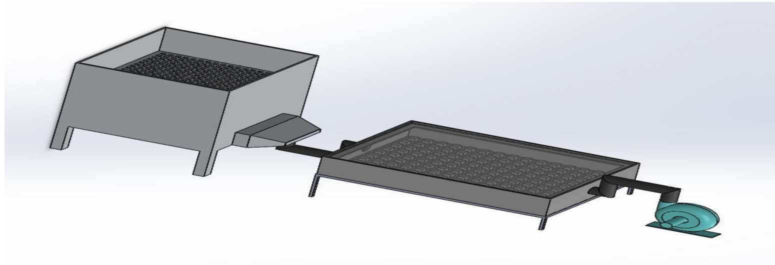

Fig 2: Conceptual design of solar dryer

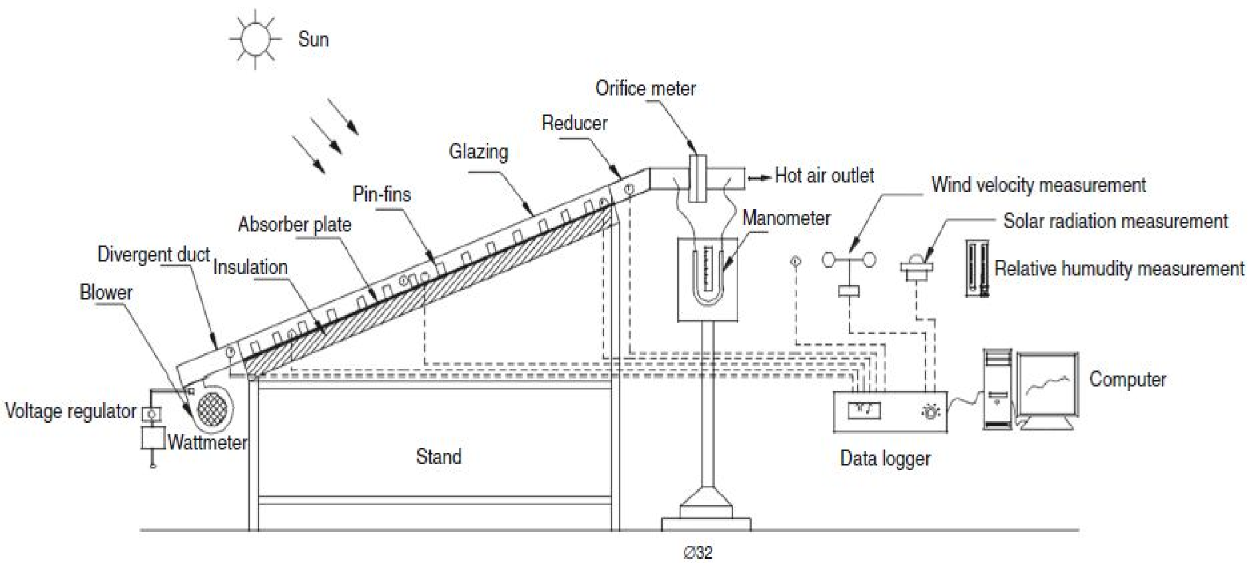

Fig 3: Installation of the forced solar convection dryer in an experiment

S.No	Material	Specification
1	Wood (Solar air heater)	(5*2*0.5)=(L*B*H) in feet
2	Flat plate collector (Glass)	(5*2)=(L*B) in feet
3	Flat plate collector (Glass) Thickness	0.5mm
4	½” Nails	1/2 Kg
5	Glue	1 Kg box
6	Drying net	2*2 in feet(2 Nos)
7	Wood (Drying Chamber)	(2*2*4) in feet
8	1” PVC pipes	10 Feet
9	1” Aluminium Pipe (0.5 feet)	25 Nos
10	Paraffin Wax	5Kg
11	Blower	1 No
12	Anemometer	1No

Table 1: Materials used in SAH

IV. CHARACTERISTICS OF DRYING

The amount of moisture present in the material can be stated as a percentage or a decimal, and it can be expressed on a wet or dry basis. When expressed as initial moisture contents, the moisture content on a wet basis is the mass of moisture present in the product per unit mass of un-dried matter in the product.

$$M_{wb} = \frac{W_o - W_d}{W_o}$$

While the initial moisture content, which is the amount of moisture existing in the product per unit mass of dry matter, is the moisture content on a dry basis,

$$M_{db} = \frac{W_o - W_d}{W_o}$$

Final moisture content

$$M_f = \frac{W_{wet} - W_d}{W_d}$$

The formula for drying experiments with reported mass losses must be used to calculate the immediate value of the moisture content.

$$M_{tdb} = \left[\frac{(M_{odb}+1)W_o}{W_t} - 1\right] \times 100\ \%$$

$$M_{twb} = 1 - \left[\frac{(1 - M_{owb})W_o}{W_t}\right] \times 100\ \%$$

V. RESULT AND DISCUSSION

Dry Ginger, a number of tests were run on the solar drying system. A single-layer drying procedure was used for the drying. When the solar insolation drops below 200 W/m2, the drying process incorporates the desiccant unit. The figure displays the hourly variation in solar radiation and outside temperature on an average summer day. The ambient air's daily minimum and maximum temperatures were 32°C and 38°C, respectively.

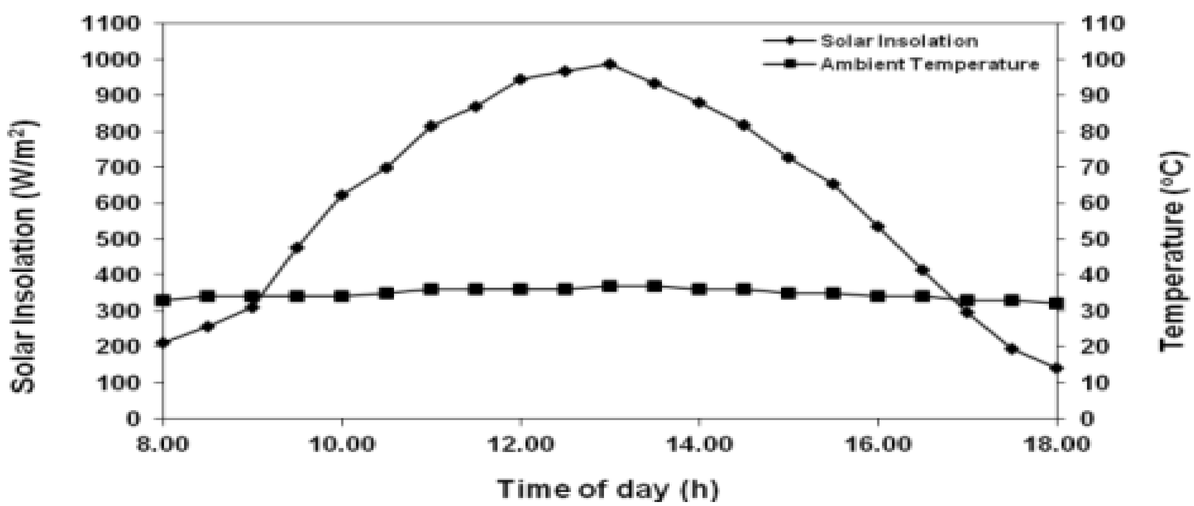

Fig 4: Hourly changes in solar radiation and the surrounding temperature on an average summer day

A maximum of 987 W/m2 of solar radiation has been measured. Figure 5 depicts the change in collector outlet air temperature over time for mass velocities ranging from 0.01 to 0.04 kg/m2/s.

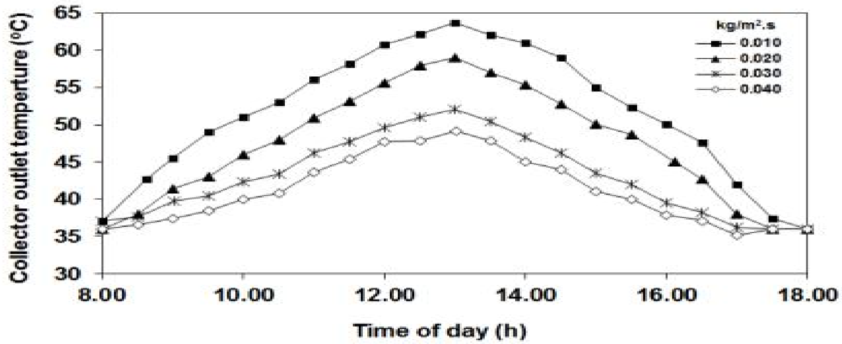

Fig 5: Temperature variations at the collector output during the course of a normal day

The maximum temperature is reached in all mass flow rates of air at the highest solar radiation, and the flat plate collector outlet temperature variation is virtually identical to the variation of solar radiation.

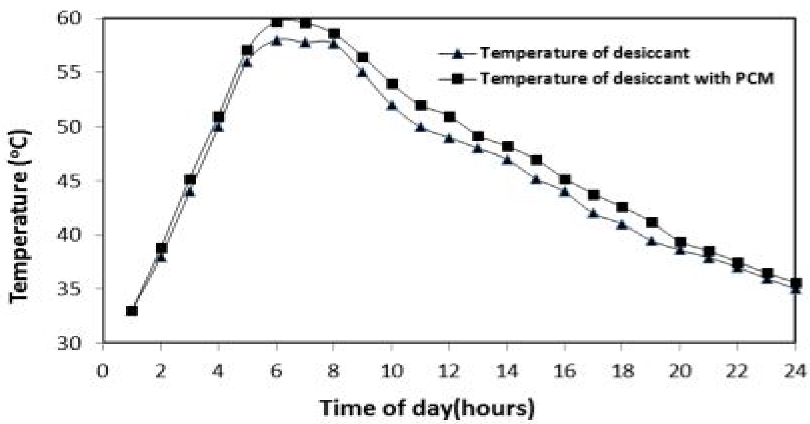

Fig 6: Variations in the desiccant's temperature when using and without using phase-change materials

The maximum temperature of the exit air increases to approximately 64°C at a mass velocity of 0.01 kg/m2 s and to 47°C at a mass velocity of 0.04 kg/m2 s. The longer contact time between the drying air and the heated surfaces inside the collector is what causes the higher collector outlet temperature of 0.01 kg/m2. s. As air mass velocity rises, the temperature at the collection outlet falls.
The level of drying air must rise above 10^0 to 25^0 C in order to dry the majority of agricultural products. With a mass flow rate of 0.02 kg/m2 s, the dryer is run. When solar drying is used, the temperature variation of the desiccant inside the drying chamber with and without phase change material is shown in figure 7.

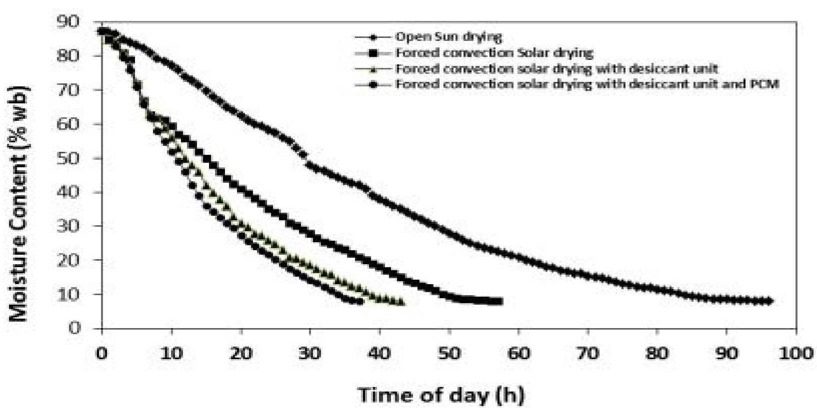

Fig 7: Ginger's moisture content changes under various drying conditions

The average temperature rise of desiccant with paraffin wax is approximately 59.7^0 C, whereas it is approximately 57^0 C for desiccant. The temperature varies by roughly two to three degrees Celsius overall, reaching its peak at about one in the afternoon. In five trays, a mass of 25 kg of ginger was dried, and the weight of the sample in each drying mode was determined every hour. Figure 7 depicts the changes in moisture content of turmeric dried using the open-air method, the solar dryer, and both with and without a desiccant unit integrated during the course of the trial period.

In the case of open sun drying, the equilibrium moisture content of about 8% was reached in 94 hours; in the case of forced convection solar drying without the integration of a desiccant unit, in 57 hours; in the case of forced convection solar drying with the integration of a desiccant and phase change material, in 43 hours; and in the case of forced convection solar drying with the integration of a desiccant and phase change material, in 37 hours. When forced convection solar drying is used for 8 hours, from 9 am to 5 pm, the moisture level variation is nearly the same at the end of the first day. There is no evidence of a steady rate of drying for any of the drying situations; only falling rate periods were observed. The solid desiccant's use of paraffin wax advances the drying process by 6 hours.

VI. CONCLUSION

An integrated solid desiccant has been incorporated into the design and construction of the forced convection solar dryer and paraffin wax mixed. Simple tools and resources were used to construct the experimental apparatus. Under various weather circumstances, the dryer was tested using forced convection solar drying with the integration of a desiccant unit and paraffin wax. The results of the current study show the following: During gloomy and non-sunny hours, the solid desiccant may aid in the drying process. When solar dryers are combined with desiccant and paraffin wax, the dryer can dry 25 kg of ginger in two sunny days. Without integrating the desiccant unit into the drying system, the drying time is found to be reduced by 50% of the time needed. Paraffin wax is added to the desiccant mold to assist store a little more energy and speed up the drying process. The incorporation of desiccant units into the drying process and the low-cost desiccant materials discovered to have potential in drying applications can result in more continuous drying.

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