Design, Development and Performance Investigation of Indirect Type of Solar Dryer of Flat Profile Absorber Plate for Fruit Drying Application

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***Abstract*- in this paper, solar energy is the most promising of the renewable energy sources in view of its apparent limitless potential. Due to higher prices and shortages of fossil fuels and to reduce the fuel consumption used in the drying process, more importance is given to solar energy sources as it is freely available. For these purposes, an indirect type solar dryer was designed and developed to dry agricultural products. The efficiency of solar dryer is based on the absorber and it is made of different materials. In this project paraffin wax used to increase efficiency the indirect type solar dryer. The present study is aimed at investigating the feasibility of using a solar air heater with PCM to store the solar energy during the daytime, and to release it during the night. Advantages of the solar dryers used for agricultural product drying can be proved to be most useful device from energy conversation point of view that not only saves energy but also saves lot of time, occupying less area, improves product quality.**

Index Terms- flat plate Collector, Indirect type solar dryer (ISD), paraffin wax (PCM).

1. INTRODUCTION

Drying is one of the methods used to preserve food products for longer periods. The heat from the sun coupled with the wind has been used to dry food for preservation for several thousand years. Rapid depletion of natural fuel resources and rising fossil fuel cost, environmental damages caused due to fossil fuel, the use of solar energy for drying is expected to become popular source. People, from rural India, are using open sun drying method to dry their agricultural products, but it has a number of disadvantages such as contamination of dust, pollution, damage by birds, animal, insect etc. Indirect type solar dryer is one of the options to overcome the above issues. Different types of solar dryers have been designed, developed and tested in the different regions of the topics and subtropics. The major two categories of the dryers are natural convection solar dryers and forced convection solar dryers. In the natural convection solar dryers the airflow is established by buoyancy induced airflow while in forced convection solar dryers the air blow is provided by using fan operated either by electricity solar module or fossil fuel.

An alternative solution for traditional drying method and to overcome the problem of open sun drying, indirect type solar dryer is used. The main reason are as follows,

1. Indirect type solar drying maintains good product quality compared to open sun drying.
2. Time for drying process can be significantly reduced as compared to open sun drying.
3. Dried foods can be preserved for a long time period and the product becomes extremely lightweight hence easy for transportation.

1.1 INDIRECT SOLAR DRYING WITH PHASE CHANGE MATERIAL (PCM)

The developed drying system consists of a solar air collector, solar air collector with phase change material (PCM) and a drying room. The proposed drying system contains a solar air heater, a blower, a packed bed type PCM thermal storage unit and a drying chamber. They concluded that the low mass flow rate is able to utilize the maximum capacity of the storage unit and to supply heat for a longer duration. The main objective of this present experimental work is to introduce a design of solar dryer which is implementing a paraffin wax as phase change material. The solar energy accumulator was used as heat latent storage unit. To future understand the effect of the heat provided by a solar air heater

with a latent storage in solar drying system, the ISD was tested with and without PCM. All the experiments were carried out in no load conditions under a forced convection mode. In this paper we are going to present the experimental set up, the measurement procedure, the energy analysis of the solar energy accumulator, the uncertainty analysis and experimental results and discussion.

2 MATERIALS AND METHODS

2.1 Description of Solar dryer

An Indirect type solar dryer is used here for the drying of fruits application. The indirect type solar dryer receives the sunlight feed into flat plate collector. The main parts of this indirect type solar dryer are glass, thermal insulator, trays, absorber plate, centrifugal blower, etc. To designed and built in an indirect solar dryer (ISD) types. The solar dryer with PCM was operated major role in drying modes. The solar radiation transmitted by the transparent cover is absorbed by the flat plate of solar collector. The air passes through the free passes through the free space between the glass cover and absorber plate for the solar air panel. After that, the air enters the drying chamber, where it distributes to pass over 3 trays made of stainless steel. The 2kg of paraffin is the most important component of the solar air heater collector. The PCM cavity is full to approximately 80% of the free volume according to the expansion. The thermo physical properties of paraffin wax are shown in table 2.The insulated with 0.05m layer of polyurethane, with heat conductivity 0.0028w/m k. The ambient air is sucked by a centrifugal fan from the lower side heaters to the drying chamber. To dry the fruits any impurities can be affected in this process.

2.2 Material Used

TABLE 1 Materials used in the dryer

Component	Material
The flat plate collector	G.I sheet
PCM	Paraffin
DRYING CHAMBER	G.I sheet
Absorber plate	Aluminum
Thermal Insulator	Polyurethane
Roof covering	Glass
Thermocouple	K-type
Trays	Aluminum sheet
Centrifugal blower	50W

The *galvanized iron sheet* is most probably used in every dryer fabrication, it has high resistance to corrosion, so it is used for the major parts of the dryer. The *glass fiber* tends to be one of the good thermal insulator. Its thermal conductivity is *0.036 W/m k.* The normal glass is used for covering the top roof of the dryer.

2.3 Dimensions of the components

The dimensions of the each and every component are tabulated in the following table. The dimension of each and every component is based on the requirement of the solar dryer.

TABLE 1 Materials used in the dryer

Component	Dimension (mm)
Flat plate collector	600*250*10
Insulator	50mm thickness
k-type range	-270 to 1260C
Paraffin wax	1.5 -2 kg
Absorber plate	400*300*10
Thermal Insulator	30mm thickness
Centrifugal blower50W	220Voltage
Reflector	300*300*10
Trays	350*200*30
Flat plate collector	**Ø** 23

TABLE 2Thermo physical properties of paraffin wax

Melting temperature	56-60^{0}C
Heat of fusion	214*10^3(J/kg)
Thermal conductivity	0.21(w/m^{0}c)
Specific heat	2940-3890(J/kg/^{0}c)
Density	775-850(kg/m^3)

2.4Modeling of solar dryer

The modeling of indirect type solar dryer is done in Solid works. The individual components were designed according to the dimension, and then it is assembled to the required shape. Both 2-D and 3-D dimensions.

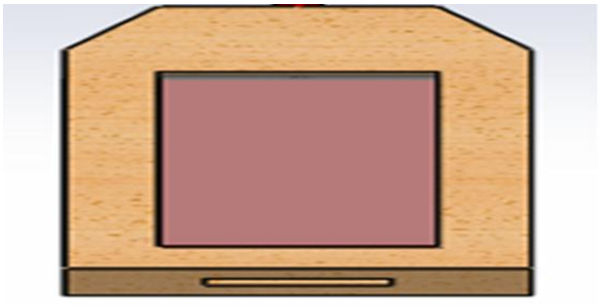

Fig. 1 Isometric view of designed flat plate collector

The above is the assembled the flat plate collector. The galvanized iron sheet was provided between

absorber sheet and bottom of the collector insulation. The length, width, the total volume of the collector are 0.6m, 0.25m and 0.006m3 respectively. The black top of the PCM cavity formed the absorber plate. The air was allowed to pass through the gap between absorber and glass in the direction perpendicular to the flat plate. edges of each and every part has to be fixed without leaving any gap, so that there will be no leakage of hot gas from the dryer. Solar collector unit is helpful in achieving higher temperature values with a controlled air flow rates. However, it is also observed that at higher temperature operation conditions, the efficiency of solar collector reduced. In general, most of the solar collectors are made up of wood or metals with appropriate coating of absorbing materials like black polythene for better heat absorption needed for product dry.

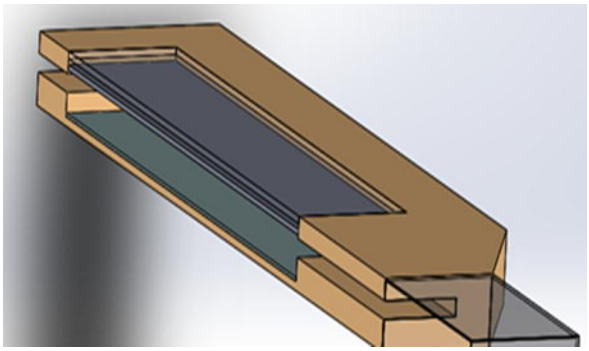

Fig. 2 Side view of collector plate

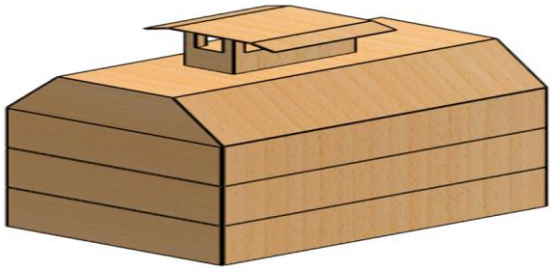

Fig 3. Designed drying chamber

The drying trays were made of galvanized iron sheet on all four sides and a wire mesh on the bottom to uphold the samples. The trays can be easily removed to load or unload the drying product from the door, which represents one side of the drying chamber. The drying chamber was fabricated from with dimensions 0.35*0.2*0.3m3(length*width*height). The drying chamber had three drying trays positioned at equal vertical spacing of 0.10m. The trays can be easily removed to load or unload the drying product from the door, which represents one side of the drying chamber.

2.4.1 Overall assembled view

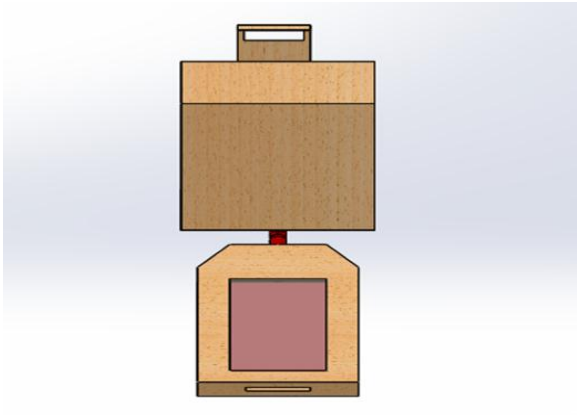

Fig 4. Overall model assembled view

3 RESULT AND DISCUSSION

The project is carried out according to the plan to designing work first planned dimensions and material selections. The designing work is carried out in software (solid works).To finalize selection material and material specification. Solar radiation can be effectively and efficiently utilized for drying of agricultural produce in our environment if proper design is carried out. This was demonstrated and the solar dryer designed and constructed exhibited sufficient ability to dry agricultural produce most especially food items to an appreciably reduced moisture level. Locally available cheap materials were used in construction making it available and affordable to all and sundry especially peasant farmers. This will go a long way in reducing food wastage and at the same time food shortages, since it can be used extensively for majority of the agricultural food crops. Apart from this, solar energy is required for its operation which is readily available in the tropics, and it is also a clean form of energy. In future scope, do as per dimensions to construction. To take values and compare with and without PCM values. .

4 CONCLUSION

The Indirect type solar dryer has been successfully designed as per the requirement. The overall drying rate of the fruit is increased. This work is focused on the available solar dryer's system technologies. The dependence of drying on the characteristics of product remains still as a problem, for comparison of drying efficiencies of various dryer. Such low cost

drying technologies can be readily introduced in rural areas to reduce spoilage, improve product quality and overall processing hygiene.

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