EXPERIMENTAL INVESTIGATION ON AN ENERGY EFFICIENT SOLAR TUNNEL DRYER

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M. R. Seshan Ram
Assistant Professor
Department of Mechanical Engineering
Dr. SJS Paul Memorial College of Engineering and Technology
Pondicherry-605502, India.

Abstract

The research determines the effectiveness of the solar tunnel dryer developed and the product dried in the device is superior in quality and also it is compatible with branded products available in the market. The study also determines Acetamide as Phase Change Materials, which has high latent heat of fusion when compared to other paraffin, low flash point and inflammable. Acetamide is considered as phase change material due to its thermo-physical properties matches the energy requirement for agricultural products drying. In latent heat storage, thermal energy is stored by means of a reversible change of state or phase change in the storage medium. A shell and tube heat exchanger is designed as a Phase Change Materials container. The whole body of the container is considered to be stainless steel (SS) sheet and it is supported by SS square tubes in all the four sides. Aluminium tubes are supposed to be inserted in the container with its both ends kept open. The solar radiation penetrates through the toughened glass of the dryer and is absorbed by the selective coated absorber sheet and thereby converted into thermal energy. The melted Phase Change Materials releases and transfers heat through the heat transfer pipes and the container surface and it solidifies. As the air passes through the container, heat is transferred to the air and this hot air is used for drying during adverse weather conditions. Thermocouple is a thermoelectric device used to measure the temperature accurately. Pyranometer is also used to record solar insolation. The developed model is preferred to be well utilized for solar drying applications for partial energy requirement during night hours.

Key Words : *Solar Tunnel Dryer, Acetamide as Phase Change Materials, Conversion into Thermal Energy, Thermocouple, and Pyranometer*

Introduction : Drying of farm produce is an energy intensive operation, and improving energy efficiency by only 1% could increase the profits by 10% [1-3]. Solar energy is a promising source of drying applications. Different types of solar dryers are reported in literature for various drying applications. The solutions involving solar energy collection devices or solar dryers have been proposed to utilize free, renewable and non-polluting energy source provided by the sun [4-5]. Solar dryers can reduce crop losses and significantly improve the quality of the dried product. However, solar drying systems must be properly designed to match particular drying requirements of specific crops, which can increase the efficiency of a system [6].

Energy storage is essential, whenever the supply of consumption of energy varies independently with time, wherever reduce the time or mismatch between energy supply and energy demand and thereby playing a vital role in energy conservation. The optimum capacity of an energy storage system depends on the expected time dependence of solar radiation availability, the nature of loads in the process, the degree of reliability needed for the process, the manner in which auxiliary energy is supplied, and an economic analysis that determines how much of the annual load should be carried by solar and how much by the auxiliary energy source. The size of storage is related to the 'energy density', or the amount of energy stored per unit mass (or per unit volume) of storage material. An important characteristic of the storage material is its 'volumetric energy capacity', or the amount of energy stored per unit volume [7-10].

Objectives of the Present Study : The prime objective of the present study is to develop a solar tunnel dryer with PCM storage. A solar tunnel dryer was developed and detailed analysis was performed on it to find out the drying efficiency with products loaded and unloaded in the system. The research determines the effectiveness of the solar tunnel dryer developed and the product dried in the device is superior in quality and it is compatible with branded products available in the market. The study also determines Acetamide as Phase Change Materials, which has high latent heat of fusion when compared to other paraffin, low flash point and inflammable. Acetamide does not possess super cooling effect and has the capacity of congruent melting. Acetamide vapour pressure is small; hence no containment problems and no degradation for many freeze/melt cycles. Thermocouple is a thermoelectric device used to measure the temperature accurately, especially one consisting of two dissimilar metals. This experiment is conducted mainly to measure the accurate temperature from the box type cooker. The outcome of the test is presumed to give the best thermocouples for the experiment.

The research paper deals with the development of an efficient Solar Tunnel Dryer and usage of Acetamide as an efficient Phase Change Material, since its thermo-physical properties suit our present requirement with high latent heat fusion and transfer thermal energy in the solar tunnel dryer. The study is devoted for alleviating the drawback associated with solar dryers and extended its application during non solar hours. Extensive analysis has been done on the feasibility of thermal energy storage based on Phase Change Materials and many experiments are performed in this direction. Based on the experiments conducted, a suitable Phase Change Materials container is developed, which is preferred to be taken care of partial energy delivery for solar dryers.

Review of Related Literature : The review of related research studies throws light on the topic of the Development of a Solar Tunnel Dryer with Latent Heat Thermal Energy Storage with appropriate Phase Change Materials available in India and abroad through referring research journals, books, research summary, research abstracts, CDRAM, internet, etc. The research studies of TA. Fudholi, K. Sopian, M.H. Ruslan, M.A. Alghoul, M.Y. Sulaiman on solar dryers for agricultural and marine products; A. Sreekumar, P.E. Manikantan, K.P. Vijayakumar on the performance of indirect solar cabinet dryer; Lalit M. Bal *, Santosh Satya, S.N. Naik, on solar dryer with thermal energy storage systems for drying agricultural food products; M.V. Ramana Murthy, on new technologies, models and experimental investigations of solar dryers; A.A. El-Sebaii, S. Aboul-Enein, M.R.I. Ramadan, H.G. El-Gohary, on experimental investigation of an indirect type natural convection solar dryer; B. Khiari, D. Mihoubi, S. Ben Mabrouk, M. Sassi; on experimental and numerical investigations on water behaviour in a solar tunnel dryer; B.K. Bala, M.R.A. Mondol, B.K. Biswas, B.L. Das Chowdury, S. Janjai, on solar drying of pineapple using solar tunnel dryer; M.A. Hossain, B.K. Bala, on drying of hot chilli using solar tunnel dryer; Guls,ah C, akmak*, Cengiz Yildiz, on the drying kinetics of seeded grape in solar dryer with PCM-based solar integrated collector and S. Aboul-Enein, A.A. El-Sebaii*, M.R.I. Ramadan, H.G. El Gohary, on parametric study of a solar air heater with and without thermal storage for solar drying applications are studied on various types of Solar Dryers with Thermal Energy Storage System.

The research studies of Atul Sharma, V.V. Tyagi, C.R. Chen, D. Buddhi, on thermal energy storage with phase change materials and applications; Belen Zalba, Jose Ma Mar?n, Luisa F. Cabeza, Harald Mehling, on thermal energy storage with phase change materials, heat transfer analysis and applications; Murat M. Kenisarin, on high-temperature phase change materials for thermal energy storage; Eman-Bellah S. Mettawee, Ghazy M.R. Assassa, on experimental study of a compact PCM solar collector; C.R. Chen, Atul Sharma, S.K. Tyagi, D. Buddhi, on numerical heat transfer studies of PCMs used in a box-type solar cooker; Atul Sharma, S.D. Sharma, D. Buddhi, on accelerated thermal cycle test of acetamide, stearic acid and paraffin wax for solar thermal latent heat storage applications; H: H. Emons, R. Naumann and K. Jahn, on thermal properties of acetamide in the temperature range from 298 K to 400 K; S. D. Sharma, D. Buddhi and R. L. Sawhney on accelerated thermal cycle test of latent heat - storage materials; L. Xia, P. Zhang on thermal property measurement and heat transfer analysis of acetamide for solar heat storage; Eman-Bellah S. Mettawee, Ghazy M.R. Assassa on thermal conductivity enhancement in a latent heat storage system are analysed on various types of Phase Change Materials with Thermal Energy Storage System.

The research studies of K.A.R. Ismail, R.I.R. Moraes on numerical and experimental investigation of different containers and PCM options for cold storage modular units for domestic applications; István Péter Szabó on the design of an experimental PCM solar tank and O. Laguerre, M.F. Ben Aissa, D. Flick on methodology of temperature prediction in an insulated container equipped with PCM are examined on various types of Phase Change Materials with Containers. The review has given a clear insight and vision for the researcher in the new area of research with appropriate research tools, Phase Change Materials, design and development of solar tunnel dryer, arithmetical calculation, geographical representation, pictorial presentation of the experiments to achieve the objectives of the study. These studies inculcate a new imputes to the researchers with enormous speculation and introspection on the area of topic chosen by the researcher.

Materials and Methodology : Acetamide is considered as phase change material for the study. The reason behind the selection of acetamide is due to its thermo-physical properties matches the energy requirement for agricultural products drying. The products used for the analysis is pine apple. For the analysis, energy delivery for 4 kg product is calculated.

The quantity of the product to be dried, Mi = 4 kg

The total energy required for drying 4 kg banana from an initial moisture content of 78% to a final desired moisture content of 15% is estimated as 8.3 MJ.

The quantity of Phase Change Materials required to meet the above energy supply is calculated. The excess volume during the phase change is also taken into account in the calculation. Time required for drying the given quantity of the product for the applied mass flow rate is assumed to be 10 hours. Total time requirement is distributed to solar and Phase Change Materials drying. Then 8 hours (9.00 a.m to 5.00 pm) of the total time duration met by solar energy and the remaining 2 hours by Phase Change Materials storage during off sunshine/night time.

Hence, it is calculated that the volume requirement of the Phase Change Materials container to release 1660 kJ of thermal energy is 5054 cm3 and it is expected to have a capacity to hold 4.5 kg Phase Change Materials.

Design of Thermal Energy Storage Container : In latent heat storage, thermal energy is stored by means of a reversible change of state or phase change in the storage medium. Solid-liquid transformations are most commonly utilized, though solid-solid transitions have been investigated. Liquid-gas or solid-gas phase changes involve the most possible energy in latent storage methods. Storage of gas phase is difficult and bulky. Steam accumulators are one feasible example.

A shell and tube heat exchanger is designed as a Phase Change Materials container. The whole body of the container is considered to be stainless steel (SS) sheet and it is supported by SS square tubes in all the four sides. Aluminium tubes are supposed to be inserted in the container with its both ends kept open. The tubes are positioned equidistant from each other with a distance of 4 cm between the tubes. The total volume of the Phase Change Materials container is 5250 cm3 and the filling area is 5054 cm3.

Phase Change Materials container is to be placed very close to the air duct area of the dryer and the heat exchanger pipe is parallel to the air inflow. Airflow passage in the Phase Change Materials container is depicted in Fig. 1.

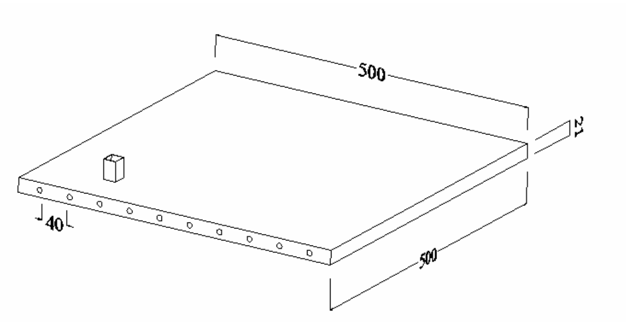

Fig. 1
Schematic diagram of the Phase Change Materials container

Working of the Principle of the Designed Model : The solar radiation penetrates through the toughened glass of the dryer and is absorbed by the selective coated absorber sheet and thereby converted into thermal energy. The fan pushes ambient air through the absorber plate. The heat absorbed by the absorber plate is transferred convectively to the air passing over it. The Phase Change Materials with whole surface painted black is placed in good thermal contact with the absorber plate to ensure maximum conductive heat transfer. It is heated due to the direct absorption of solar radiation and the heat conducted from the absorber plate. As the temperature of the container increases, it transfers heat to the Phase Change Materials, which is filled inside. Phase Change Materials begins to melt at 76.56oC and the solid Phase Change Materials will be converted in to liquid. The process continues if the intensity of solar radiation is good and when the intensity decreases, the reverse phenomenon will start. The melted Phase Change Materials releases and transfers heat through the heat transfer pipes and the container surface and it solidifies. As the air passes through the container, heat is transferred to the air and this hot air is used for drying during adverse weather conditions.

Experimental Investigation : The heat transfer occurs in a solar dryer when the hot absorber plate is in contact with the air flowing over it and the hot air is diverted into the drying chamber through a diverter. The exhaust fan is attached at the end of the drying chamber (Fig. 2). The exhaust fan forces the ambient air to flow between the absorber plate and the glass and then into the drying chamber. Thus the moisture is removed from the product and dried.

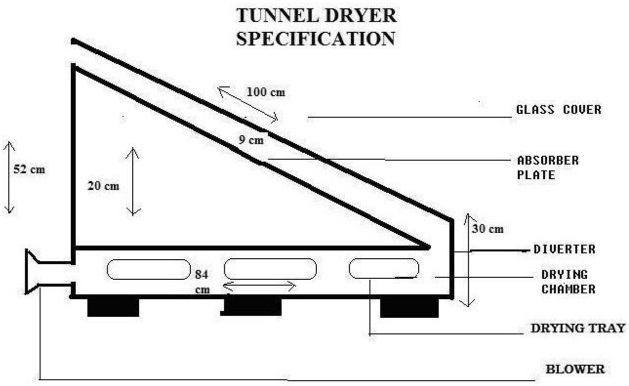

Fig. 2
Air flow path in the Solar Tunnel Dryer

Experimental Procedure : The solar cooker is cleaned and properly insulated before the commencement of the experiments. There should not be any air leakage from the cooker, it should be air tight. The cooker must be positioned in the south facing direction. The solar cooker is positioned from 10am to 7pm. No obstruction such as shadow of plants, trees and buildings are fallen on the cooker, since they may affect the performance of the solar cooker. The reflector of the cooker is covered by a cloth. There is no need for the utilization of cooker's reflector for the experiment. After 4 pm the cooker is covered with insolations or closed to prevent the sunlight falling on the Phase Change Materials container. This method is to ensure and calculate the latent heat evolved by the Phase Change Materials (Acetamide).

Four thermocouples wires are connected with four points in the temperature indicator. Four thermocouples are utilized, one is to record the temperature of the absorber of the cooker, second is to record the air temperature of the cooker, third is to record the acetamide temperature and fourth is to record the Phase Change Materials containers temperature. Pyranometer is also utilized to record the solar radiations and the ambient temperature with the corresponding time. The readings are tabulated for every 15 seconds. Seventeen experiments are carried out. These experiments are carried out with different quantity of acetamide and with different containers.

Experimental Set Up Without Load : Fig. 3&4 show the thermal performance on the dryer for two consecutive days. The solar tunnel dryer is placed facing the south direction. The absorber plate of the flat plate collector is inclined at 15 degree. Thermocouple wires are used to measure the temperature of the dryer in different parts, which is connected to a digital temperature indicator. The following temperatures are periodically monitored, they are absorber plate temperature, air inlet temperature, air outlet temperature and the product tray temperature in the drying chamber. A pyranometer is placed on the top of the dryer to monitor global solar radiation and ambient temperature also is recorded at periodic intervals. The temperature at different point in the tunnel dryer is noted for every 15 minutes time interval. The experimented is carried out from 10 am to 4 pm and the corresponding graphs are illustrating the experiments carried out for two days.

In the graph, it is clearly seen that the absorber plate temperature increases with solar radiation and the absorber temperature is high from 11 am to 2 pm. After 2 pm the solar radiation decreases in the flat plate temperature. Initially the product tray temperature is very low and increased gradually from 12 pm. In the graphs, the air inlet temperature of the solar tunnel dryer is very low when compared with the air outlet temperature coming out from the solar dryer. The outlet temperature mainly depends upon the absorber plate temperature. Ambient temperature is also monitored. The air inlet temperature mainly depends upon the ambient temperature. Solar radiation intensity plays a vital role in the temperature enhancement in solar tunnel dryer.

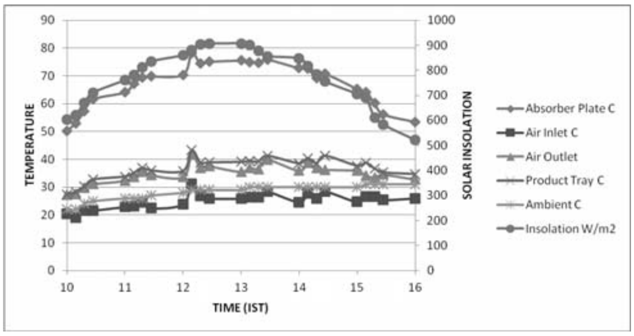

Fig. 3
Thermal Performance of the Dryer without Load Condition - Day 1

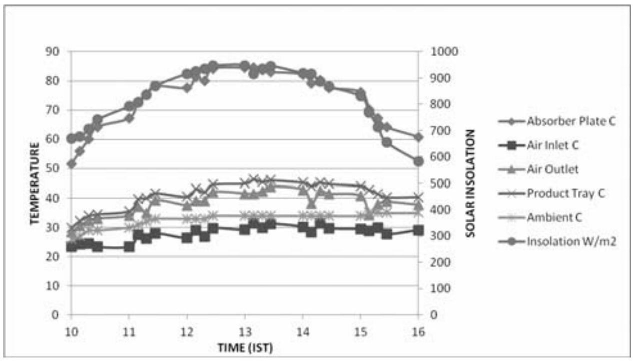

Fig. 4
Thermal Performance of the Dryer without Load Condition - Day 2

Experimental Set Up With Load Condition : The same arrangement is maintained for load conditions. 5 kgs of pineapple are sliced into pieces and are kept in the tray for drying. Before loading the pineapples into the tray the weight of the pine apples is measured. This experiment is carried out from 10 am to 4 pm. For every one hour the weight reduction of the product is monitored and hence the moisture ratio. Fig. 5 shows the dryer loaded with product.

The readings are tabulated and the corresponding graph is drawn.

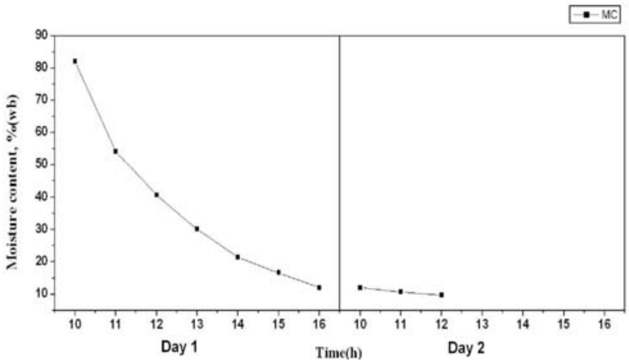

Fig. 5
Drying Curve of Pine Apple

The moisture content of the pineapple at the time of loading is 82%. Initially the moisture content present in the pineapples is removed rapidly because of removal of moisture from the surface is easy as compared to interior of the product. Fig. 5 shows the drying curve of pine apple. For the first day the moisture in rapid rate is from 10 am to 3 pm. At the end of the first day the 70 of the moisture is removed from the product and the drying is fast enough. It shows the efficiency of the developed solar dryer. In day 2 graph, the drying rate is almost steady because of the present of bound moisture. The product is weighed at 12 pm in the second day, which shows that the moisture content is reduced to 7%, which is the recommended safer moisture level to preserve the product.

Testing of the Thermocouple : Thermocouple is a thermoelectric device used to measure the temperature accurately. Three different tests are conducted to find out the best thermocouples. Six thermocouples are used for testing, from this only four thermocouples are selected. A container of 6 - 7 liters capacity is taken and it is filled with cold water. Six thermocouples are connected to the temperature indicator on the corresponding ports. The thermocouples are numbered in sequence in order to avoid confusion. The thermocouples are dipped inside the cold water and a thermometer is also dipped for comparison purpose.

The thermometer is to do a comparative analysis with the temperature indicator. The readings are tabulated for every three minutes and the corresponding T1, T2, T3, T4, T5, T6 are noted as shown in Table1. Summing up of the individual thermocouple is calculated and the average is also calculated. The average is found to be 25.7. The individual average of the thermocouple which is close to the average 25.7 is taken for experiments. Thus the accurate thermocouples wires have been selected which are being the 1, 3, 4, 5. The second and the sixth thermocouple are not matched with the average value. Similarly the experiment was repeated with hot water and corresponding values are tabulated as shown in Table2.

Table.1
Calibration of Thermocouple Wires in Cold Water

Time	Thermo couple1	Thermo couple 2	Thermo couple 3	Thermo couple 4	Thermo couple 5	Thermo couple 6
4.22	25.9	25.9	25.8	25.9	26.1	25.9
4.25	26.0	25.9	25.9	26.5	26.0	25.9
4.28	25.9	25.9	25.9	25.7	27.4	25.8
4.31	25.5	25.6	25.6	25.5	25.7	25.8
4.34	25.6	25.5	25.4	25.9	25.5	25.5
4.39	25.3	25.2	25.2	25.3	25.4	25.2
4.40	25.3	25.2	25.3	25.3	25.4	25.2
4.43	25.3	25.1	25.3	25.1	25.3	25.2
Total	25.6	25.5	25.5	25.6	25.8	26.7

The total average value was 25.78

Hence, the thermocouples with the average, which are near to the total average are selected, that are the thermocouples T1, T3, T4, T6.

Table.2
Calibration of Thermocouple Wires in Hot Water

Time	Thermo couple 1	Thermo couple 2	Thermo couple 3	Thermo Couple 4	Thermo couple 5	Thermo couple 6
9.33	62.5	62.5	62.3	61.5	60.9	60.9
9.36	57.9	56.9	56.7	56.4	55.4	56.1
9.29	53.1	54.4	54.4	54.0	53.5	54.1
9.32	51.5	52.3	52.0	51.4	51.2	51.7
9.35	49.3	50.0	49.2	51.9	48.5	49.0
9.38	47.0	47.5	47.3	47.2	47.0	47.3
9.41	45.2	45.3	45.2	45.2	45.3	45.2
9.44	43.5	44.2	44.0	43.9	43.7	43.9
Average	[illegible]	51.6	51.3	51.4	51.0	51.0

The total average was 51.15

Hence, the thermocouple with the average, which are near to the total average are selected, that are the thermocouples T1, T3, T4, and T6.

From this test, the thermocouples T1, T3, T4, and T6 are selected to carry out the experiment.

Acetamide in Glass Beaker : This experiment is mainly carried out to investigate the melting and solidifying of Acetamide in solar box type cooker. Here the container is a glass beaker. The quantity of Acetamide taken is 10 grams. This experiment is done from 10 am to 7 pm. Temperature indicator is used to measure the temperature of the cooker at different points such as absorber of the cooker, air temperature inside the cooker, Phase Change Materials temperature and the glass beaker temperature. Pyranometer is also used to record solar insolation and the corresponding Fig. 6. The readings are tabulated for every 15 minutes. This experiment has shown a clear view of acetamide melting characteristics in the peak sun shine hours and the solidifying behavior in the late evening in a glass container. The cooker's reflectors are not utilized in this experiment. Cooker is not closed or insulated at 4 pm to check the latent heat. Cooker is kept open throughout the experiment till acetamide temperature reaching the near value of ambient temperature.

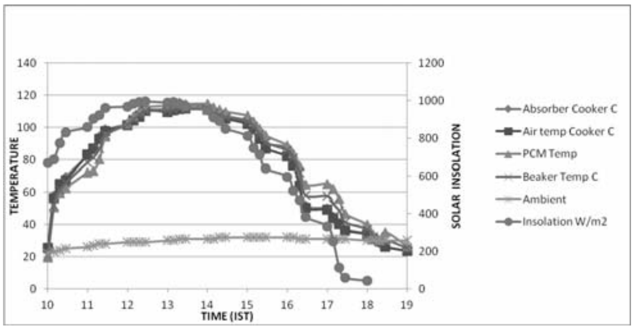

Fig. 6
Charging and Discharging Study of Acetamide Taken in Glass Beaker and Kept in Solar Cooker

Acetamide in a Glass Beaker with Insolation : This experiment is mainly carried out to investigate the latent heat generated by acetamide in solar box type cooker after non sun shine hours. Here the container used is a glass beaker. The quantity of acetamide taken is 10 grams. This experiment is done from 11 am to 4 pm. After 12 pm the solar box type cooker is closed to record the latent heat generated by Acetamide. Temperature indicator is used to measure the temperature of the cooker at different points such as absorber of the cooker, air temperature inside the cooker, Phase Change Materials temperature and the glass beaker temperature. Pyranometer is also used to record the solar insolation. The readings are tabulated for every 15 minutes and the corresponding Fig. 7. This experiment has shown a clear view of Acetamide melting characteristics in the peak sun shine hours and the solidifying behaviour in the late evening. The cooker's reflectors are not utilized in this experiment. Cooker is closed or insulated at 12 pm to check the latent heat. Cooker is kept open and the readings are taken till acetamide reaches the near value of ambient. Acetamide latent heat recovery in glass container is lesser than other materials even with insolation.

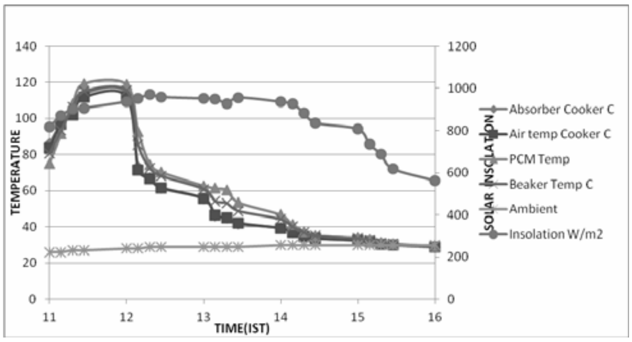

Fig. 7
Acetamide in a Glass Beaker with Insolation

Acetamide in Copper Container without Insolation : This experiment is mainly carried out to investigate the melting and solidifying of acetamide in solar box type cooker. Here the container used is copper. The quantity of Acetamide taken is 10 grams. This experiment is done from 10 am to 7 pm. Temperature indicator is used to measure the temperature of the cooker at different points such as absorber of the cooker, air temperature inside the cooker, Phase Change Materials temperature and the copper container temperature. Pyranometer is also used to record solar insolation and the corresponding Fig. 8. The readings are tabulated for every 15 minutes. This experiment has shown a clear view of Acetamide melting characteristics in the peak sun shine hours and the solidifying behaviour in the late evening. The cooker's reflectors are not utilised in this experiment. Cooker is not closed or insulated at 4 pm. Cooker is kept open throughout the experiment till acetamide temperature reaches the near value of ambient temperature. Acetamide latent heat recovery with copper container is higher than other materials even without any insolation.

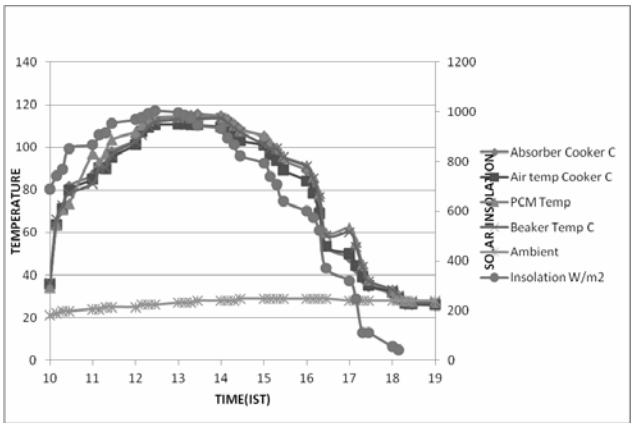

Fig. 8
Thermal Profile of Acetamide in Copper Container without Insolation

Acetamide in a Copper Container with Insolation : This experiment is mainly carried out to investigate latent heat generated by Acetamide in solar box type cooker. Here the container used is Copper. The quantity of Acetamide taken is 10 grams. This experiment is done from 10 am to 7 pm. The cooker is opened to direct sunlight from10 am to 4 pm, and then the cooker is insulated or closed to find the latent heat generated. Temperature indicator is used to measure the temperature of the cooker at different points such as absorber of the cooker, air temperature inside the cooker, Phase Change Materials temperature and the copper container temperature. Pyranometer is used to record the solar insolation. The readings are tabulated for every 15 minutes and the corresponding Fig. 9. This experiment has shown a clear view of Acetamide melting behaviour and the stored energy in the form of sensible heat while solidifying the generated latent heat. The cooker's reflectors are not utilised in this experiment. Acetamide latent heat recovery with copper container is higher than other materials with insolations.

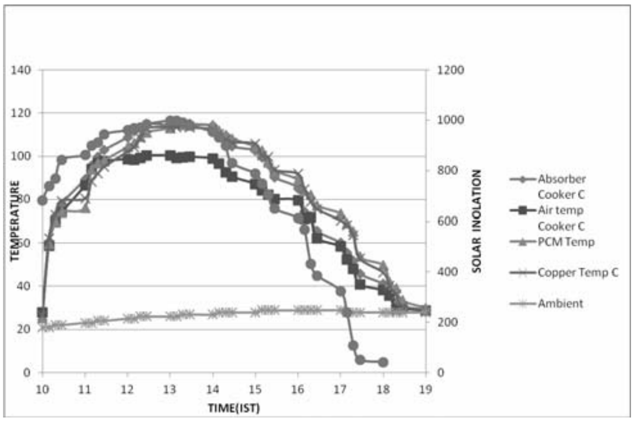

Fig. 9
Temperature Profile of Acetamide in a Copper Container

Acetamide in Aluminium Container : This experiment is mainly carried out to investigate the melting and solidifying of Acetamide in solar box type cooker. Here the container used is aluminium. The quantity of Acetamide taken is 500 grams. This experiment is done from 10 am to 7 pm. Temperature indicator is used to measure the temperature of the cooker at different points such as absorber of the cooker, air temperature inside the cooker, Phase Change Materials temperature and the aluminium container temperature. Pyranometer is also used to record the solar radiation intensity. The readings are tabulated for every 15 minutes and the corresponding Fig.10. This experiment has shown a clear view of Acetamide melting characteristics in the peak sun shine hours and the solidifying behaviour in the late evening. The cooker's reflectors are not utilised in this experiment. Cooker is not closed or insulated at 4 pm. Cooker is kept open throughout the experiment till acetamide temperature reaches the near value of ambient temperature.

Acetamide in Aluminum Container with Insolation : This experiment is mainly carried out to investigate latent heat generated by Acetamide in solar box type cooker. Here the container used is aluminium. The quantity of Acetamide taken is 500 grams. This experiment is done from 10 am to 7 pm.

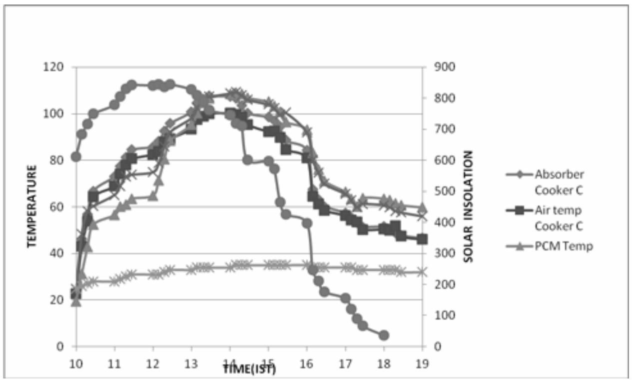

Fig.10
Acetamide in Aluminum Container with Insolation

The cooker is kept open to direct sunlight from10 am to 4 pm, then the cooker is insulated or closed at 4 pm to find the latent heat generated. Temperature indicator is used to measure the temperature of the cooker at different points such as absorber of the cooker, air temperature inside the cooker, Phase Change Materials temperature and the aluminium container temperature. Pyranometer is also used to record the ambient and solar insolation. The readings are tabulated for every 15 minutes and the corresponding Fig. 10. This experiment has shown a clear view of Acetamide melted and stored energy in the form of sensible heat and while solidifying the generated latent heat.

Findings, Conclusions and Recommendations : A sophisticated solar tunnel dryer is designed and developed suitable for drying all kinds of agricultural produce, spices, marine products, etc. Detailed performance analysis is undertaken with fruits loaded in the dryer and drying characteristics has been evolved out. The developed tunnel dryer is economically viable and preferred to be replicated for the drying applications among small and marginal farmers. Same design parameters are preferred to be applied for developing big solar drying systems for commercial applications.

A design of Phase Change Materials container is made using energy equations during freeze-melt cycle. The first step adopted is finding out the energy requirement for drying a specific amount of the product. Later it is assumed that 80% of the total requirement is expected to get from solar energy and 20 % through storage medium. The quantity of energy requirement is calculated as 8300 kJ. Hence the contribution from Phase Change Materials side is 1660 MJ. Accordingly, the quantity of Phase Change Materials required for this is calculated as 4.5 kg. Based on the data derived out, a container is designed with adequate heat transfer mechanism. The developed model is preferred to be well utilized for solar drying applications for partial energy requirement during night hours. Hence, this can be considered as an important study of the present work.

The study reveals that acetamide can be used as thermal energy storage material for applications like solar drying, where the temperature requirement is mostly below 80oC. To initiate the charging process acetamide should melt. Acetamide melting point is 80oC. From the graph, it is clear that acetamide undergoes congruent melting. There is no degradation of acetamide in the freeze/ melt cycle. The discharging process starts when acetamide reaches 78 oC realizing large amount of latent heat. The charging and discharging properties of acetamide is good with copper and aluminium. Copper has high thermal conductivity than aluminium, but based on the availability and cost aluminium are preferred. Thus copper is most compatible with aluminium for the latent heat recovery mechanism in the non solar hours and can be integrated with tunnel dryer for drying agricultural products in the non solar hours.

Solar tunnel dryer systems are to be proliferated in large scale as a means of food preservation and for the production of high quality food products. This is positively and highly expected to enhance the quality of life and socio-economic status of our farmers by producing internationally acceptable products. Government of India's ambitious programme 'Jawaharlal Nehru National Solar Energy Mission' gives sufficient platform to propagate this technology. As we have only few manufacturers acquired the technical skill for developing this complex heat and mass transfer system, solar dryers are not popular as other gadgets like solar water heaters. By considering its huge potentiality in industrial and agricultural sectors, there is an urgent need to develop skilled manpower towards designing and proliferation of solar dryers.

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