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Design of Thermal Storage using Phase Change Material (PCM) for Agro Products Preservation

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Abstract---Storage and preservation of agro products are receiving significance to reduce the wastage of agricultural commodities and demand of low cost and less energy intensive sustainable methods. An efficient technique is proposed to preserve farm fresh vegetables through Phase Change Materials (PCM), with lesser electrical energy consumption. In this proposed work, atmospheric air is inducted in to chamber where it is cooled by sensible cooling by passing it through PCM. The PCM changes its phase by absorbing latent heat from the outdoor hot air.. The alternate melting and freezing cycles of typical PCM is exploited for cooling the air which is further circulated into cold storage cabinet. In order to achieve the desired cold storage cabinet temperature and humidity, the amount of air circulated and mass of PCM required is estimated through cooling load and heating load calculations. Based on these load estimates, an appropriate size of equipment's such as fan, storage cabinet, PCM chamber and heat pipes are designed. Further, performance of the cold storage may be improved by enhancing thermal conductivity of PCM and design improvement of cold storage by the various improvements.

Keywords—PCM, Cold Storage, Latent Heat, Cooling Load, Load Estimation

I. INTRODUCTION

In this world, food is essential for all living being for their sustainability, due to rapid growth in population the requirement of food is also increasing but harvesting of food products is not possible to meet the demandwhich also depends upon the seasonal variation and monsoon.

Agro products are conventionally preserved by the technique called cold storage, device working with a principle of cooling by means of heat removal from the agro products through latent heat of evaporation of refrigerants. The cold air is passed outside the bundle of tubes which contain coolant in which energy transfer takes place so the air is cooled and evaporating the refrigerant by gaining latent heat. The refrigerant vapour is sucked by compressor and it is condensed while passing through condenser, where it is cooled [1,2]. Then the refrigerant is passed through expansion valve and the pressure drop occursand the refrigerant temperature is further dropped. The low pressure and low temperature refrigerant is again made to pass through the coils inside the storage compartment. The major drawback of this system is expensive and energy intensive. Large amount of electrical energy is required for running the refrigerator [3,4].

Ice filled container are used for the storage of agro products. The container surrounded by ice and entire setup is insulated by a suitable insulator and agro products are stored inside the container [5,6]. The limitation of this system is the lower preservation duration for the agro products [7].By combining these two methods, the drawbacks can be overcome by introducing the cold storage using PCM [8,9,10].

II. LAYOUT AND DISCRIPTION

The proposed system consist of two chambers contain PCM and agro products. The copper tube is passed through PCM chamber as shown in Fig.1 which is insulated and filled with PCM .The agro products are stored in another container for preservation.

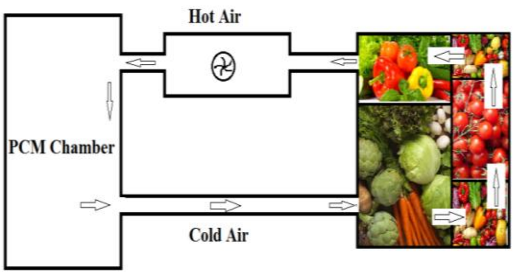

Fig 1. Layout of Proposed Thermal Storage

The hot air from the agro products chamber is drawn into the PCM [11] chamber through suction blower and enters the copper tubes in which air gets cooled and in turn PCM is heated The cold thus produced is circulated inside the agro chamber and hence the cold air will gain heat from agro products in cooledand preserved due to continuous operation of the system. The advantages of the proposed method are less power consumption, sustainability andenvironment friendly [12].

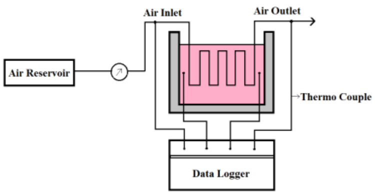

Fig2.Schematic of Experimental Setup

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The experimental setup for the thermal storage using PCM is shown in the Fig 2. In this setup, compressed air is circulated from the air receiver where the air quantity is regulated through control valve. The air compressor is run at steady state operation and the regulated air quantity is allowed to pass through the copper tube kept inside the PCM chamber. The PCM chamber is filled partially with PCM in a vessel and it is kept in a box. The space between the PCM vessel and the outer box is filled with better insulation material to reduce the heat leakage fromoutside environment to the PCM chamber.

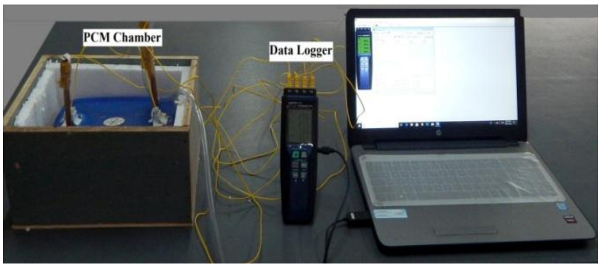

Fig.3 Photograph of Experimental Setup

When the compressed air passed through copper tube kept inside the PCM, air is cooled by PCM because of the phase change by losing its latent heat of evaporation. In this process, air is cooled and the temperature of the air at inlet, outlet and temperature of the PCM are measured by thermocouples and the measured temperatures as shown in Fig 3are stored in the 8-channel data logger for the retrieval. The flow rate of the regulated air is measured by the vane type anemometer. The experiments may be repeated for the various flow rates and the PCM temperatures [13,14]. The cold air is circulated in to the chamber where the agro products are stored for the preservation.

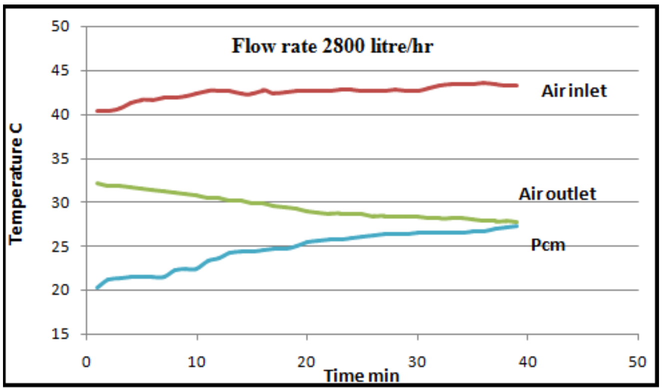

Fig. 4Temperature Variation with Time

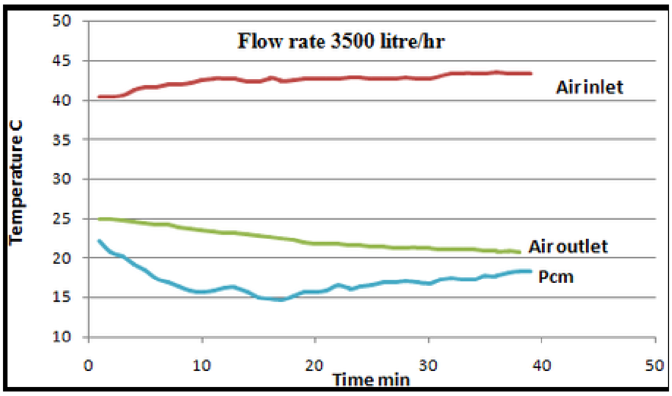

Fig. 5 Temperature Variation with Time

III. RESULTS AND DISCUSSION

The air outlet temperature drops 3^0C for an air flow rate of 3500 lts/hrs shown in Fig.5when compared to 5^0C drop for the air flow rate of 2800 lts/hr as shown in Fig.4 which is evident from the I law analysis for a steady state heat transfer. Further, an average temperature drop of 15^0C is noticed for the inlet airboth the flow rates [15]. The variation is PCM temperature is lower due to the latent heat of evaporation of PCM [16].The heat removed from the air is estimated as 12W. The model may be scaled up for the cooling applications such as cold storage for the agro products.

The performance may be improved by optimising the air flow rate for the designed storage volume with better insulating materials. PCM can be used for cooling air which is circulated into chamber which contains agro products. Energy consumption can be reduced by the integration the proposed system with solar panels

IV. CONCLUSION

Thus the PCM can be incorporated in the cold storage for the sustainable cooling system. Further,the proposed system reduces power consumption for preservation of agro products.The proposed system may be scaled up for the commercial cold storage The advantages the cold storage system are less energy intensive, environment friendly and can be portable .

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