International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 06 | June 2018 www.irjet.net p-ISSN: 2395-0072

A Review On Solar Drying Process With Thermal Energy Storage System

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Abstract - *Solar dryer is usage of natural energy resources. Thermal energy storage materials used in these solar dryers are used to stored energy during sunshine times and it is use during off sunshine times. Range of the temperatures for continuously drying agricultural and food products in constant state condition. Thermal energy storage is need for solar dryer for continuous processing of drying and it's enhance the efficiency of the system. In this paper a review on solar dryer based on various thermal energy storage were investigated the recent development of mixed mode solar dryer. And also investigated of solar dryer techniques and its efficiency compared to other techniques of solar dryer with thermal energy storage system.*

Key Words: **solar dryer, solar energy, drying process, thermal storage, energy storage.**

1. INTRODUCTION

Most one of the thing to living for humans is food. As the world population is increasing, it is very difficult to fulfil everyone's need of food. So food losses can be avoid. The preventing of the food from damages by the traditional technique is drying. The drying process takes in natural by using of solar energy.

Food products, particularly fruits and vegetables require hot air in the temperature range of 45–60 °C for safe drying i.e., drying the products so as to keep their edible and nutritious properties intact. Requisite moisture content and superior quality of the product can be achieved under controlled conditions of temperature and humidity [1].

Solar dryers can reduce crop losses and improve the product quality significantly when compared to the traditional methods of drying such as sun/shade drying. The food loss occurs due to various reasons in developing countries such as improper cultivation and fertilization, lack of suitable technology, improper transportation, lack of marketing channels, high post-harvest losses, etc. The food loss occurs from10% to 40% of total production due to above stated reasons. The food preservation is the only technique to reduce the post-harvest food losses [2].

Drying is an essential process in the preservation of agricultural products. Food products, especially fruits and vegetables require hot air in the temperature range of 45-60 °C for safe drying. Drying under controlled conditions of temperature and humidity helps the agricultural food products to dry reasonably rapidly to safe moisture content and to ensure a superior quality of the product. Controlled drying is practiced mostly in industrial drying processes. Hot air for industrial drying is usually provided by burning fossil fuels, and large quantities of fuels are used worldwide for this purpose. High costs of fossil fuels, gradual depletion of its reserve and environmental impacts of their use have put severe constraints on the consumption. Many rural locations of developing countries suffer from non-access to grid electricity; supplies of other non-renewable sources of energy are also either unavailable, unreliable or, for many farmers, too expensive. In Such areas, crop-drying systems that employ electrically operated fans, heaters and other accessories are inappropriate. The large capital and running costs of fossil fuel powered dryers are often not affordable for small farmers.

India is blessed with good sunshine. Most parts of the country receive mean daily solar radiation in the range of 5-7 kWh m^2, and have more than 275 sunny days in a year. Hence, solar drying has a high potential of diffusion in the country, and offers available option in the domestic sector. It is identified as an appropriate technology for Indian masses, and has numerous advantages such as no recurring costs, potential to reduce drudgery, high nutritional value of food, high durability, etc. In spite of these advantages, the main hurdles in its dissemination are reluctance to acceptance as it is a novel technology, intermittent nature of sunshine, limited space availability in urban areas, higher initial costs and convenience issues. Solar energy is free, environmentally clean, and therefore is recognized as one of the most promising alternative energy recourses options. In near future, the large-scale introduction of solar energy systems, directly converting solar radiation into heat, can be looked forward. However, solar energy is intermittent by its nature; there is no sun at night. Its total available value is seasonal and is dependent on the meteorological conditions of the location. Unreliability is the biggest retarding factor for extensive solar energy utilization. Of course. Reliability of solar energy can be increased by storing its portion when it is in excess of the load and using the stored energy whenever needed. Energy storage is, therefore, essential to any system that depends largely on solar energy. It adjusts temporal mismatches between the load and the intermittent or variable energy source, thereby improving the system operability and utility. Solar radiation cannot be stored as such, so first of all an energy conversion has to be brought about and depending on this conversion, a storage device is needed. Solar energy can be stored by thermal, electrical, chemical, and mechanical methods.

2. TYPES OF SOLAR DRYING PROCESS

Drying rate of crops is controlled by the external factors of the process. The individual crops physical properties like its type and size also affect the drying rate, apart from the external factors. Thus drying of crops may be classified in two ways.

1. Thin layer solar drying
2. Deep bed solar drying
3. Modes of solar dryer

2.1. Thin layer solar drying

In thin layer drying, the ratio of air volume to the crop volume is infinitely large. After this assumption, drying rate depends only on the properties of the material to be dried, its size, the drying air temperature and the moisture content [3].

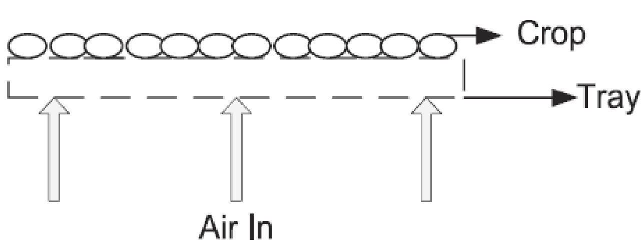

Fig-1: Thin layer solar drying

2.2. Deep bed solar drying

In deep bed solar drying first air comes in contact with lower zone. So, due to high moisture carrying capacity of air drying rate is high at lower zone. As air moves up, to the upper zones, increases in moisture content and cools due to evaporation so drying rate is decreases. The governing factor of drying rate are air flow rate, drying air temperature and the bed's depth. By adjusting these parameters, a moderate drying operation can be achieved without over-drying in the lower material zone [4, 5].

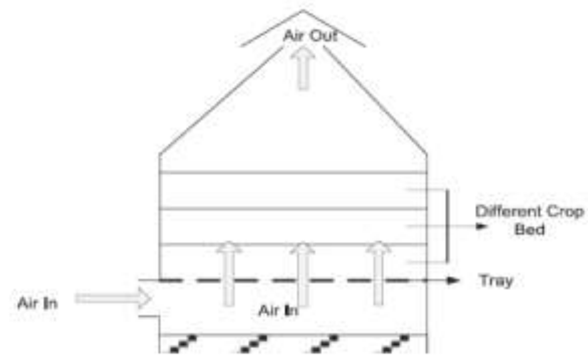

Fig-2: Deep bed solar drying

2.2. Modes of solar dryer

There are different of solar dryers basically differ in the modes used for transferring heat to the product. The flow chart shows the modes of solar dryer.

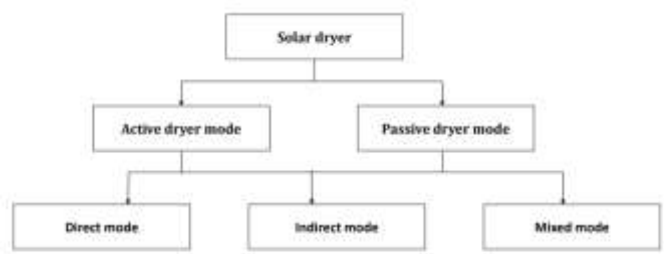

Fig-3: Modes of solar dryer

3. THERMAL ENERGY STORAGE

Thermal energy can be stored in well-insulated materials as a change in internal energy of the material, as sensible heat, latent heat and thermochemical or combination of these.

3.1. Sensible heat storage

In the sensible heat storage, thermal energy is stored by increasing the temperature of a liquid or solid, using the heat capacity and change in temperature of the material during the process of charging and discharging. The specific heat of the material decides the amount of heat storage [6].

3.2. Latent heat storage

Latent heat storage (LHS) is the heat absorption or release when a storage material undergoes a change of phase from solid to liquid or liquid to gas or vice versa at more or less constant temperature. The storage capacity of the LHS system with a phase change material (PCM) medium [7].

3.3. Thermo-chemical energy storage

Thermo-chemical systems rely on the energy absorbed and released in breaking and reforming molecular bonds in a completely reversible chemical reaction. In this case, the heat stored depends on the amount of storage material, the endothermic heat of reaction, and the extent of conversion.

3.4 Storage of Latent Heat In Phase Change Materials

Phase change materials are ''Latent'' heat storage materials. They use chemical bonds to store and release heat. The thermal energy transfer occurs when the chemical bonds with the material break up as the PCM changes from a solid to a liquid, or from a liquid to a solid. The heat stored during the phase change process of the material is called latent heat. The effect of latent heat storage has two main advantages: (i) it is possible to store large amounts of heat with only small temperature changes. (ii) Because the change of phase at a constant temperature takes some time to complete. They store 5–14 times more heat per unit volume than sensible storage materials such as water, masonry, or rock [8].

3.5 Classification of Phase Change Materials

There are three types of phase change materials used in application.

1. Organic,
2. Inorganic
3. Eutectic.

3.5.1 Organic phase change materials

Organic materials are further described as paraffin and nonparaffins. Organic materials include congruent melting.

3.5.1.1 Paraffins

Paraffin wax consists of straight chain n-alkanes $CH_3–(CH_2)–CH_3$. The crystallization of the (CH_3) – chain release a large amount of latent heat. Thermal properties of some technical grade paraffins, which are essentially, paraffin mixtures and are not completely refined oil Paraffin is safe, reliable, predictable, less expensive and non-corrosive.

3.5.1.2 Non-paraffins

The non-paraffin organics are the most numerous of the phase change materials with highly varied properties. Abhat [9] and Buddhi and Sawhney [16] have conducted an extensive survey of organic materials and identified a number of esters, fatty acids, alcohol's and glycol's suitable for energy storage Some of the features of these organic materials are as follows: (i) high heat of fusion, (ii) inflammability, (iii) low thermal conductivity, (iv) low flash points, (v) varying level of toxicity, and (vi) instability at high temperatures.

3.5.2. Inorganic phase change materials

Inorganic materials are further classified as salt hydrate and metallics. These phase change materials do not supercool bottom of the container. One solution to this problem is to add a nucleating agent, which provides the nucleon for initiation of crystal formation.

3.5.2.1. Salt hydrates

Salt hydrates may be regarded as alloys of inorganic salts and water forming a typical crystalline solid of general formula $ABnH_2O$. The solid–liquid transformation of salt hydrates is actually a dehydration of hydration of the salt, although this process resembles melting or freezing thermodynamically. A salt hydrates usually melts to either to a salt hydrate with fewer moles of water, At the melting point the hydrate crystals breakup into anhydrous salt and water, or into a lower hydrate and water. One problem with most salt hydrates is that of incongruent melting caused by the fact that the released water of crystallization is not sufficient to dissolve all the solid phase present [10].

3.5.2.2. Metallics

This category includes the low melting metals and metal eutectics. These metallics have not yet been seriously considered for PCM technology because of weight penalties.

3.5.3. Eutectics

A eutectic is a minimum-melting composition of two or more components, each of which melts and freezes congruently forming a mixture of the component crystals during crystallization [11].

4. CONCLUSION

This study gives an overview of solar dryers with thermal energy storage systems with effect of design, development of suitable energy saving unit for solar dryer. The different types of thermal energy storage systems studied. The above study discussed the modes of solar dryer and thermal energy storage systems for drying agricultural food products, medical plants. The effective thermal energy storage technology in solar dryers for drying of agricultural food products for continuous drying process after sunshine hours. Using of thermal energy storage unit increases the rate of drying time and its efficiency.

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