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A REVIEW OF SOLAR ENERGY COLLECTION TECHNOLOGY TO HEAT AIR AS THERMAL, USING FLAT PLATE COLLECTOR AND INTEGRATED WITH DRYING CHAMBER FOR DRYING FOOD PRODUCTS

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ABSTRACT

The increasing energy demand for food processing and conservation of medicinal product, cost efficient energy serve giving up opportunities for the utilization of solar energy is leads to increase the interest in solar drying system. The abundance of solar energy is available in the lives of rural people, this energy being taped for drying of agricultural produce. Solar drying is one of the very old and simplest forms of drying even today most agriculture produces such as spice, under the sun area to conserve vegetables. Solar Air dryer is one of the basic equipment of converting solar radiation energy into thermal energy. Thermal application of solar energy is increasing demand in research field. In this application of solar collectors and thermal storage systems are two main components. Post harvest agriculture product like tobacco, tea, fruit, cocoa beans, rice, nuts, marine products and timber required drying for later use. Drying the products under open sun has many draw backs such as debris, rain, blowing wind, insect infestation, human and animal interference, etc, leads contamination of the products. By the use of solar dryer, the problems can be easily overcome. The Solar heating system to dry food and other crops can improve the quality of the product, while reducing the wasted produce and traditional fuels, thus improving the quality of life, there are various types of solar dryers are developed and classified based on the mode of air circulation, such as natural circulation and forced circulation solar dryer, and based on the types of drying mode that is direct solar drying, indirect solar drying and mixed mode solar drying, The solar dryer particularly design and validated using specific crops likes fruit dryer, vegetable dryer, grain dryer, Papad dryer are reviewed. This review paper presented has focused on different design and technology of different type of air based solar collector's solar dryer construction and operation principle of solar energy drying system. Solar drying system with air based solar collector, environment friendly and increasing the energy conservation. Basically two types of collector such as non-concentrating collector (low temperature application), and concentrating collector (high temperature applications. Two general groups of solar energy dryers are identified as natural air circulation (passive) solar energy dryers and forced air circulation (active) solar energy dryers. Three sub groups are identified viz direct mode (integral type) and indirect mode (distributed type) and mixed mode type. This review focus on the latest development and advances in the solar thermal applications, providing solar collectors and thermal storage systems. Various types of thermal energy storage systems and application of computational fluid dynamics (CFD) software for simulation design purpose are reviewed.

KEYWORDS: Solar Drying Technology, Systematic Classification, High Temperature Dryer, Low Temperature, Passive Solar Dryer, Active Solar Dryer, Direct Solar Dryer, Indirect Solar Dryer, Mixed Mode Solar Dryers, Solar Crop Drying, CFD

At present, the way of the people is dependent on the production and utilization of energy, as a result the demand and supplying of energy is increasing in human societies. Global warming has became a pressing issue and needs to talked about, Efficient utilization of renewable energy resources, especially solar energy, is increasingly being considered as a promising solution to global warming and means of achieving a sustainable development for human beings. Rising energy prices, diminishing energy availability and scarcity and growing environmental concerns are quickly changing the global energy panorama. The sun releases an enormous amount of radiation energy to its surrounding. Solar drying is in practical since time immemorial for preservation of food and agriculture crops. In many rural location in developing countries grid connected electricity and supplies of other non renewable sources of energy are either unavailable, unreliable or for formers too expensive. Solar energy is an abundant permanent and environmentally compatible energy sources in the world. Green energy is renewable and sustainable. Solar, hydro, wind, geo thermal, bio fuels and tidal power are some of the green energy sources that can be used as alternative to our conventional source of energy. Application of solar energy in Solar drying is one of the oldest methods of preservation of crops and it is utilized everywhere. Converted to clean energy sources such as solar, not only

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energy for humans but also for most agricultural and marine product to be dried to preserve the quality of the final products. An alternate to open sun drying solar drying system is an attractive and promising application of solar energy system. This type of system is a renewable and environmentally friendly technology. Solar drying is a dual process of, heat transfer to the product from the heat source and mass transfer in the form of moisture from the product to its surface and from surfaces to surrounding. This was done particularly by open sun drying under open sky. Since traditional sun drying is relatively slow process, considerable losses can occur, however weather conditions preclude the use of sun drying because of spoilage due to rehydrating during unexpected rainy days further, any direct exposure to the sun drying high temperature days, might cause case hardening, when a hard shell develops on the outside of the agricultural products. In addition, a reduction in the product quality takes place due to insect infestation, fungal growth, enzymatic reactions and microorganism growth, uneven types of drying, and uncontrolled moisture content in end product, causing degradation in the quality of the products. This process has several disadvantages like spoilage of product due to an adverse climate condition like rain, wind, moist, and dust. Also the process is highly labour intensive, time consuming, and requires large space for spreading the produce out to dry and the drying can only be carried out during sunshine hours. With industrial development, artificial mechanical drying came into practice. This process is highly energy intensive and expensive, which ultimately increase the product cost. Mechanized drying is faster than open air drying, uses much less land, usually gives better quality. But the equipment is expensive and requires substantial quantities of fuel or electricity to operate. Thus solar drying is the best alternative as a solution of all drawbacks of natural drying and artificial mechanical drying. The process is either to preserve them for later use, as in the case with food, or as an interest part of the production process, as with timber, tobacco, and laundering. Solar drying in the context of this technical brief, refers to methods of using the sun's energy for drying, by excludes open air sun drying. Solar drying technology offers an alternative which can process the vegetables and fruits in clean hygienic and sanitary conditions to national and international standards with zero energy costs. A typical solar food dryer improves upon the traditional open air sun system in the following important ways. It is more efficient, dried more quickly, reduces losses, it is hygienic, good quality because of controlled environment, it is faster that is shorter period of time, it is cheap, using freely available solar energy, instead of conventional fuel used. Drying helps in reducing the moisture content to a level which deterioration does not occur and the produce can be stored for a definite period of time. At the same time, this can be used to promote renewable energy sources and an income generating option.

HISTORY OF SOLAR ENERGY

Solar energy stand in the early 1920 and growth lasted until the mid 1950's when low cost natural gas becomes the primary fuel for heating. Today people use solar energy to heat building, heat water and to generate electricity. This is an energy flux of very high thermodynamic quality from an accessible source of temperature very much greater than from conventional energy sources. Solar short wave radiation passes through the earth's atmosphere, a complicated set of interaction occurs. The interactions which include absorption ,the conversion of radiant energy to heat and subsequent re-emission as long wave radiation scattering ,the wave length dependent on change in direction ,so that usually extra absorption occurs and the radiations continues at the same frequency and reflection which is independent of wave length. From the natural heat flux solar collector allows sun light through receive glass tube before it strikes the absorber tube. The glass tube or plate traps most of the solar radiation, inside collector using green house effect.

DRYING MECHANISM

Drying is a classical method of food preservation, which involves the removal of moisture through the application of heat to the products. The basic essence of drying is to reduce the moisture content of the product to a level that prevents deterioration with a certain period of time regarded as 'safe storage period'. Drying is defined as a process of moisture removal due to simultaneous heat and mass transfer. In the process of drying, heat is necessary to evaporate moisture from the material and a flow of air helps in carrying away the evaporated moisture. There are two basic mechanisms involved in the drying process: 1. Migration of moisture from the interior of an individual material to the surface, 2. Evaporation of moisture from the surface to the surrounding air. The drying of a product is a complex heat and mass transfer process which depends on ,External variables such as temperature, humidity and velocity of the air stream and , Internal variables which depend on parameters like surface characteristics (rough or smooth surface), chemical composition (sugars, starches, etc.), physical structure (porosity, density, etc.), and size and shape of product . The objective of a dryer is to supply the air with more heat than is available under ambient conditions, thereby increasing sufficiently the vapor pressure of the moisture held within the crop and decreasing significantly the relative humidity of the drying air and thereby increasing its moisture carrying capacity and ensuring sufficiently low equilibrium moisture content. Drying involves the extraction of moisture from the product by heating and the passage of air mass around it to carry away released vapour. Under ambient condition, these processes continue until the vapour pressure of the moisture held in the atmosphere. Thus the rate of moisture desorption from the product to the environment and the absorption from the environment are in equilibrium, and the crop moisture content at this condition is known as the equilibrium moisture content. Upon removing the water content in the product the quality of the dried output must be considered product quality therefore the drying extends the shelf life of the product and provides a light weight product for transportation and reduces storage space and cost.

SOLAR COLLECTORS

A solar collectors, the special energy exchanger, converts solar irradiation energy either to the thermal energy of the working fluid in solar thermal application, or to the electric energy directly in P.V (photovoltaic) application. For solar thermal application solar irradiation is absorbed by a solar collector as heat which is transferred to working fluid and can be used as domestic hot water/heating , or to charge a thermal energy storage tank from which the heat can be drawn for later use (at night or cloudy days).

SOLAR ENERGY COLLECTOR

Solar energy collector is a devices employed to gain useful heat energy from incident solar radiation. They can be of the concentrating and non-concentrating type (flat-plate). Concentrating solar energy collectors operate at higher temperatures than the non-concentrating type. For solar energy crop drying applications, the flat plate collectors provide the temperature elevations desired and more appropriates techno-economically than the more complex concentrating collector. A simple solar energy collector consists basically of an absorbing surface (usually painted black) which absorbs the irradiation and transmits (in the form of heat) to a working fluid (commonly water or air). For solar crop drying applications; air is used commonly as the wording fluid. Provision is made to circulate the air through a duct in side of the absorber.

SOLAR THERMAL COLLECTORS

Solar thermal collectors, based on the type of heat transfer liquids and their construction used (water, non freezing liquid, air, or heat transfer fluid). Solar flat plate collectors are used for water heating application, domestic application, space heating, and industrial low temperature application. Currently a large number of solar collectors are available on the market based on concentrating solar power (CSP) system which use lenses or mirrors and tracking system to focus a large area of sunlight in to a small beam which is then used as a heat source for a conventional power plant, extensive ranges of concentrating technologies developed are the parabolic trough, concentrating linear Fresnel reflector, the concentrating sterling dish and the solar power tower collectors. Solar radiation passes through the transparent cover and is converted to low-grade heat, is then trapped inside the box by what is known as the greenhouse effect the energy radiates.

TYPES OF SOLAR DRYER

Solar dryer are classified broadly into four categories such as direct, indirect, mixed, and hybrid solar dryer.

Direct Solar Drying System (Open Sun Drying)

Direct solar drying system, crop is exposed to sunlight directly such that it can be dehydrating. For this system black painted heat absorbing surface is provided that can be collecting the sun light and convert it into heat. The crop to be dried is placed directly on the surface. These dryer may have glass covers and vents in order to increase efficiency. Cabinet solar dryer is a kind of direct solar dryer.

Figure 1 shows the working principle of open sun drying by using solar energy. The short wave length solar energy falls on the uneven product surface. A part of this energy is reflected back and the remaining part is absorbed by the surface. The absorbed radiation is converted into thermal energy and the temperature of product starts increasing. This results in long wavelength radiation loss from the surface of product to ambient air through moist air. In addition to long wave length radiation loss there is convective heat loss too due to the blowing wind through moist air over the material surface thus the products are dried.

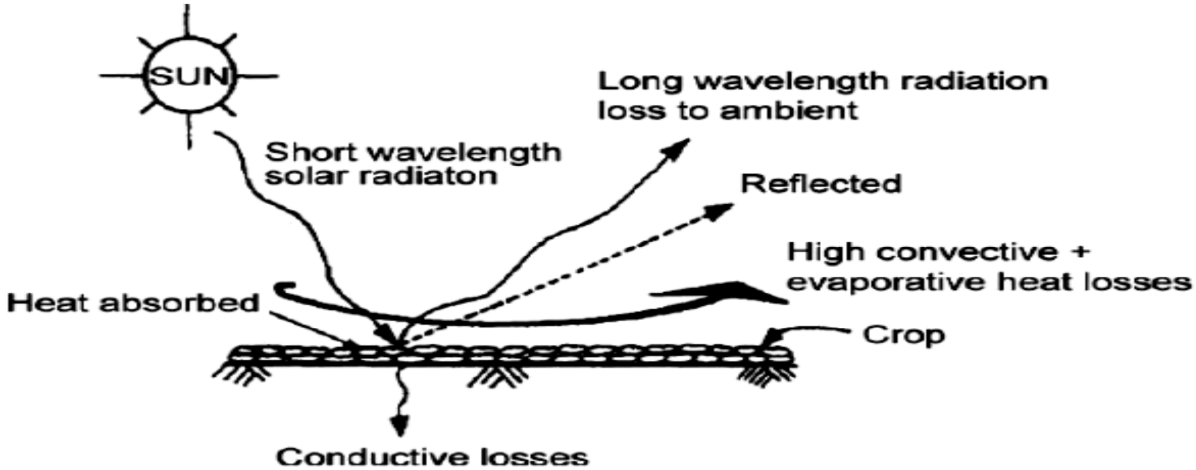

Figure 1: Open sun drying

Indirect Solar Dryer System

In this type of drying, the products are not directly exposed to the sun but, the solar radiation used to heat the air which flows through the product to be dried. Thus moisture from the product may be lost by convection and diffusion. Indirect dryer classified, as natural convection, and forced convection (passive and active) depending upon the methods used to pass the air over the products, In forced convection air is forced into drying cabinet by means of an external device such as blower, fan etc. Thus they offer better control over drying, but required more power. Indirect solar dryers, the black painted heat absorbing surface heats the ambient air, this heated air subsequently passed through the crop, taking moisture and exit, through a chimney.

Figure 2 Describes the principle of indirect solar drying which is generally known as conventional dryer. In this case, a separate unit termed as solar air heater is used for solar energy collection for heating of entering air into this unit. The air heater is connected to a separate drying chamber where the product is kept. The heated air is allowed to flow through the wet material to dry.

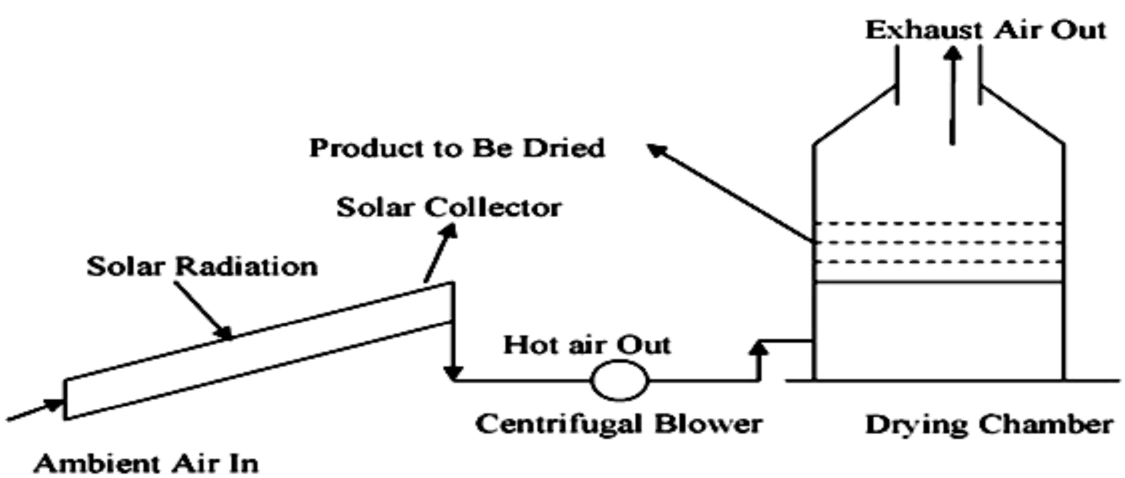

Figure 2: Indirect solar dryer system

LITERATURE REVIEW

Raymond W. Bliss Jr., 1958 found and derived that the efficiency factors of plate solar heat collector are more or less design constants of the particular collector design, and are only slightly influenced by operating conditions. The design or testing of flat plate solar heat collectors is a very worthwhile to calculate the ratio between the actual useful heat collection rate of a given design and the useful heat collection rate. They area also found that it is applicable to other types of panel heat exchanges such as floor or ceiling panels used for interior temperature control.

Niles et. al., 1977, Investigate, Design, constructed and evaluated a solar collector to assist in the dehydration of industrial food products in California by using unglazed and single glazed solar collectors to heat air at various length, they felt that close agreement between the experimental results and the predictions. And they suggested that the system will include a heat recovery unit and crushed rock heat storage unite necessary for 24 hour operation.

Diamante L.M. and Munro P.A., 1993, they conducted the experiments of indirect solar drying of sweet potato slices using thin layer mathematical model during the period of February to April 1986 at Philippines , and concluded that the mean effective chamber temperature and the sample thickness were the main factors the affected the solar drying of sweet potato slices.

Yeh H.-M. and Lin T.-T., 1995 investigated both theoretically and experimentally, the effect of collector aspect ratio on the collector efficiency of flat plate solar air heaters. They found that the theoretical prediction agree reasonably well with the experimental results. They also found that increasing the aspect ratio decreases the cross sectional area of the duct and thus increase the velocity of air flow and also the convective heat transfer rate. The constant collector area, the collector efficiency increases when the collector aspect ratio increases. However increasing the aspect ratio increase the fan power leads to increased cost.

Schirmer et. al., 1996 designed and developed solar tunnel dryer for bananas, and they found, that the drying air temperature at the outlet of the solar collector varies between 40 and 65 ºC during drying, which was sufficient to dry 300 kg of bananas with a drying time of 3-5 days and also found that the quality of the product improved and reported that the pay-back period of the dryer was to be 3 years.

CONCLUSION

A comprehensive review of the various design details of construction and operational principles of the wide variety of practically realized designs of solar energy drying system were presented and also various designs of solar dryers for drying food materials has been studied including non- concentrating and concentrating type. Also evolved systematic classifications of the solar energy dryers were reviewed. This paper has reviewed mainly the solar thermal applications, with focus on the two core sub system as solar collector and thermal storage system, also presented the easy way to fabricate and easy to operates the dryers that can be suitably employed at small scale industries or at rural forming villages. Such a low cost food drying technologies can be readily introduced in rural areas to reduce spoilage, improve product quality and overall processing hygiene. The best alternative to overcome the disadvantages of traditional open sun drying and the use of fossil fuels, it is the development of solar crop dryers. In addition to mitigation of fossil fuel use, the quality of the dried crops is also higher and the loss of dried product is considerably reduced. Various types of dryers like natural, forced, direct, indirect, integrated, green house drying, cabinet dryer, tunnel dryer, mixed mode, hybrid mode were reviewed with respect to their design and performance. This classification illustrates clearly how these solar dryer designs can be grouped systematically according to their operating temperature ranges, heating sources and heating modes, operational modes or structural modes. Solar dryers designed specifically for a particular crop like grain dryer, grapes dryer, onion dryer, potato , and Papad dryers were reviewed with their design performance.

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