An Overview of Solar Energy and its Application in Solar Dryers with Brief Concept of Energy and Energy Analysis

T.K.Chand[1] ; M.K.Mohanty[2] &R.C.Mohanty[3]

1 (Faculty, Dept. of Mechanical Engg. CEB, Bhubaneswar, BPUT, India)
2(Faculty, Dept. of Farm machinery and Power. Engg. CAET, Bhubaneswar, OUAT, India)
3(Faculty, School of Mechanical Engg.CIT,Bhubaneswar,CUTM,India)

ABSTRACT

Now a days we are generally depends on fossil fuels for heat and power. We are using them much rapidly than they are being produced and the time comes when these energy sources will run out. As these energy has also some disadvantages like waste disposal problem, environmental hazardous, limited quantity leads to think about renewable energy sources which can able to help the fill the gap. We may call renewable energy as "green"or "clean"energy as it produces very little pollution to the atmosphere. "Solar energy" is one of the better renewable energy sources when it is being converted to required form of energy. Energy developed in the sun is due to thermonuclear fusion reaction where hydrogen is fusing into helium and developed unlimited quantity of energy. The sun has enough quantity of hydrogen in his core so that no need to fear that it will run out. Solar energy is used in different solar dryers in an effective manner for drying the agricultural products which can significantly reduce product wastage. The objective of this paper is to present the concept of solar energy and various types of solar dryers and their effectiveness.

Key word:

Renewable energy; Solar energy; Solar drying; Exergy; Anergy

1.INTRODUCTION

Preservation of agricultural products is essential for keeping them for a long period without further deterioration. Several technologies have been employed by the scientist to preserve food products. Some major techniques are

Canning
Freezing
Dehydration.

Among these drying is especially for developing countries with poorly established low temperature and thermal processing facilities. This technique provides better preservation to post harvest losses .Drying is a process of removal of moisture from a product to reach the desired moisture contain. The drying not only provides storage life but also improves quality, easy handling.

The objective of drying apart from extended storage life and is energy. Drying means application of heat to vaporise the moisture from the products and some means of removing water molecules after its separation from the food products. So it involves both heat and mass transfer. The advantages of drying is that it prevents the growth and reproduction of micro organisms like bacteria,yeast,molds as moisture is being reduced. It helps in reduction in weight and volume so minimizing packing, storage and transportation costs .These features is very much essential in military feeding and space food formulations. Drying is an ancient technology was used primarily in the sun, now many modern technologies are used for drying. During the past few decades lot of efforts have been carried out to understand some of the chemical and bio-chemical changes that happen during drying and to develop techniques for preventing undesirable quality losses. Convective drying

is one of the widest application i.e.by blowing heated air circulating either over the upper side, bottom side or both or across the products. Hot air heats up the product and moisture is removed and transfer to atmosphere. In "sun drying" process the product is heated directly by sun rays and moisture is removed by natural circulation of air due to density gradient. In order to maximize its advantages and optimize the efficiency of drying using solar radiation in the form of thermal energy is an alternative source of energy for drying dry fruits, vegetables, agricultural products. So appropriate technology need to be applied in order to keep this technique a sustainable one. Such technology is known as "solar drying". Solar drying is a rather economical method for agricultural products especially for medium to small amounts of products. It may be helpful from domestic upto small commercial size drying products.

Due to higher cost of fossil fuels and uncertainty regarding future cost and availability, use of solar energy in food processing will probably increase and become more economical in future. Solar dryers give the better result than sun drying when it properly designed. They provides faster drying rate when heating the air above atmospheric temperature which causes air to circulate faster through the dryer .However care must be taken when drying fruits to prevent too fast drying, which will prevent complete drying and would result in case hardening and subsequent mould growth. Solar dryers also protect foods form dust, insects, birds and animals.

"Relative humidity" and "absolute humidity" are two important technical factors for designing solar dryers.

2. CONCEPT OF SOLAR ENERGY:

Solar energy is quite simply the energy produced through a thermonuclear process directly by the sun. The process creates heat and electromagnetic radiation. The heat remains in the sun and the electromagnetic radiation in the form of visible light, infra-red light, and ultra-violet radiation streams out into space in all directions. Small fraction of the total radiation produced reaches the Earth. The radiation that reaches the earth is the indirect source of nearly every type of energy used today(Geothermal energy, Nuclear energy are exceptions). Much of the world's required energy can be supplied directly by solar power. More still can be provided indirectly.

Two essential components are required to store and convert to usable form of solar energy. One is "collector" and other is "storage unit". The function of the collector is simply collects the radiation that falls on it and converts a fraction of it to required forms of energy. The function of the storage unit is required to store the excess solar energy produced during striking high intensity of solar radiation. At night or when energy produced by the collector is less it releases .This storage unit is essential because of non constant nature of solar radiation.

There are three types of collectors i.e flat plate collectors, focusing collector and passive collector and many varieties of storage units.

Now days flat plate collectors are more commonly used. Arrays of solar panels arranged in a simple plane and can be made of any sizes. The output is depends on the parameters like size,facing,cleanliness as the amount of solar radiation that actually strike the collector is always depends on the above parameters .Auto mated collector may be used so that keeps them facing the sun according to rotation of the sun.

In focusing collector an optical device is attached to the flat plate collector to get maximum radiation falling on the focus of the collector. They can produce more amount of energy than flat plate collectors but ignore some amount of radiation i.e. the radiation reflected off the ground. The reflected radiation is significant in snow covered zone. Another problem it has that as it is made of with silicon components they absorbs the incoming radiation and loss efficiency at

higher temperature. so extra safeguards provide to protect them.

The technology for passive collectors is different from the other two types of collectors. The passive collectors absorb radiation and convert it to heat naturally, without being designed and built to do so. All objects have this property to some extent, but only some objects (like walls) will be able to produce enough heat to make it worthwhile. Often their natural ability to convert radiation to heat is enhanced in some way or another (by being painted black, for example) and a system for transferring the heat to a different location is generally added.

Solar energy can applied to transportation, heating, cooling and generation of electricity which are the some of the vital areas in which people are generally consumed more energy. Solar energy is the best suited for heating. It requires almost no energy transformation, so ultimately it has high efficiency. Heat energy is store either in a liquid or in a packed bed which is filled with small objects that can hold energy in the form of heat with gap between them. Heat energy may be stored in a phase changer unit or fusion unit which contain chemicals that changes phase from solid to liquid at temperature that can be produced by the solar collector. The chemical converts to its liquid phase by releasing the latent heat of fusion by the application of collector energy and further revert to its original solid form. This is generally used for domestic application to heat water. Solar water heater can be a cost effective technique which provides hot water in the homes instead of relying on gas or other methods is more expensive .Swimming pools are often heated by solar power. Swimming pool heating cost drastically reduced by simply installing a swimming pool heater. Swimming pool heater has a solar collector,filter,pump and a valve. Water pumped through the filter where debris is trapped and removed. This water is then passes through the solar collector where water is heated by solar radiation before returned to the pool. Solar energy may be used to directly heat a house or a building requires much more energy than heating water or swimming pool, so much larger panels are required. Fusion storage unit is most appropriate for heating a building .This method is less popular due to high cost of large panels and storage system. Passive collector is used in addition to one of the other two types for taking the advantages of passive collectors. These passive collectors have few different forms. The most basic type and first category is the incidental heat trap. The technique is to allow the maximum amount of light possible inside through a window and allow it to fall on a floor made of stone or another heat holding material. During the day, the area will stay cool as the floor absorbs most of the heat, and at night, the area will stay warm as the stone re emits the heat it absorbed during the day. Second major form of passive collector is thermos phoning walls and/or roof. Heat is normally absorbed and wasted in the walls and roof is re routed into the area that needs to be heated. The third major form of passive collector is the solar pond. This is very similar to the pool solar heater. With swimming pools, the desired result is a warm pool. The whole purpose of the pond is to serve as an energy source for a building. The pond is placed either adjacent to or on the building, and it will absorb solar energy and convert it to heat during the day. Solar energy can also be used for cooling. Solar cooling is far more expensive than that of solar heating. The technique applied here is changing a phase of a liquid to gas by application of heat and forcing the gas into a lower pressure chamber. Solar energy can be used for other things besides heating. It may seem strange, but one of the most common uses of solar energy today is cooling. Solar cooling is far more expensive than solar heating, so it is almost never seen in private homes. Solar energy is used to cool things by phase changing a liquid to gas through heat, and then forcing the gas into a lower pressure chamber. Keeping other thermometric properties constant the same gas under lower pressure will have lower temperature. This low temperature cool gas

will be used to absorb heat from the required space and then forced into the region of higher pressure where the excess heat will be lost to the atmosphere. Solar energy can be directly converted to electricity. The solar collectors that convert radiation into electricity can be either flat plate collectors or focusing collectors and the silicon components are photovoltaic cells. The basic concept behind is conversion of electrical energy with the use of photovoltaic (PV) cell. The solar cell is the heart of the PV system is made of semiconductor materials. The sun rays are absorbed and converted into electricity by the solar cells and a conditioner works to make the electricity clean. The PV system will produce a small amount of power. To get large amount of power several solar cells has to be connected to form a panels

The least suited to solar power is transportation. Large, relatively slow vehicles like ships could power themselves with large solar panels, small constantly turning vehicle like car,bike,scooter couldnot.The only possible way for these could be completely solar powered then the battery has to be charged by solar power at some stationary place and then later loaded into these vehicles.

3. TYPES OF SOLAR DRYER:

Solar dryer broadly classified into two categories:

1) Natural convection solar dryer

2) Forced convection solar dryer

In natural convection solar dryer the airflow is due to buoyancy while in forced convection solar dryer the air flow is provided by using a fan or blower. It has advantages over forced convection solar drying as because of lower investment and easy to handle.

Natural convection solar dryer again classified as

1) Indirect natural convection dryer

2) Direct natural convection dryer

3) Mixed mode natural convection dryer

In indirect natural convection solar dryer a solar collector having transparent cover and a drying unit with an opaque cover lying on the top. Here product is kept within a cabinet in relatively thin bed. Air flows because of density gradient from the temperature difference up through the crop bed. The drying rate is not found to be very satisfactory till date. Some research has been made and provide mathematical model to stimulate the indirect natural convection and developed a technique for optimization result.

In direct type solar dryer essentially a solar hot box is attached where product can be dried on a small scale. Quadrilateral shaped cabinet, trays are made for the product and single layered transparent plastic/glass at the top .Holes are made through the base for circulation of air into the cabin. Outlet is provide on the upper parts of the cabinet side and rear panels. The main disadvantages of this are small capacity of the crop, drying time is more, evaporation of moisture and its condensation on the glass cover, over heating of the product. The capacity of the dryer is about 30kg to 50 kg per batch. It is suitable for domestic application.

In mixed mode solar dryer a separate solar collector and a drying unit are attached and both having a transparent cover on the top. The integral part of this dryer is solar collector, the product box, and the chimney. The solar collector having matt-black coated on the ground and provide with transparent top and side covers. Though it produce quality product but due to economic factor it is not widely accepted.

In forced convection solar drying a small fan is attached to provide optimum air flow to enhance the drying rate much higher than those achieved by an indirect natural convection solar dryer. The fan can get the driving power either through electricity, solar, or fossil fuel. The PV operated system

has the advantages that it can be operated independent of electric grid.

Many modifications of PV ventilated forced convection solar dryer have been designed such as

(i)Solar tunnel dryer with plastic cover

(ii)Solar tunnel dryer with polycarbonate cover

(iii)Green house solar dryer

(iv)Roof integrated solar dryer

Brief Description of Solar tunnel Dryer and Green house solar dryer:

3.1Solar tunnel dryer:

University of Hohenheim, Germany developed solar tunnel dryer.A flat plate air heating collector and a tunnel drying with a small fan to provide the optimum air flow over the product to be dried. The collector and the drying unit are covered with UV stabilized plastic sheet. It is provided with PV module so that the temperature of the drying air could be controlled automatically.

3.2Greenhouse solar dryer:

Silpakorn University developed a PV-ventilated greenhouse solar dryer. A parabolic shape greenhouse with a black concrete floor is the essential parameters. The parabolic cross section helps to minimize the wind load in case of tropical rain stroms. Galvanized iron bars are better for its structure. The roof is made with polycarbonate plates. The products are kept in a thin layer on two arrays of trays. These arrays are placed on single level raised platforms with a passage in the middle for loading and unloading.

4. DRYING PRINCIPLE:

When hot air is circulated over the moist product moisture will remove from the product till the hot air is fully saturated i.e. means absolute humidity has been reached. But moisture removal is depends on the temperature. The higher the temperature the larger is the removal of moisture. If the air is warmed and the moisture contains in it remains the same, but the relative humidity falls so the air removes more moisture from the product. For getting better result economically, the drying rate must be high but without using excessive heat which tends to degrade the product. In the drying process heat is required to evaporate moisture from the product and flow of air is required to carry away the evaporated moisture. Two basic mechanisms are involved in the drying process.

(i) Migration of moisture from interior surface to outer surface

(ii)Evaporation of moisture from outer surface to the surrounding

The rate of drying is basically depends on

(i)Initial moisture content of the crop

(ii)Temperature of the crop

(iii)Temperature of the circulated air

(iv) Absolute humidity and Relative humidity

(v)Circulation velocity of the air

In thermal drying removal of moisture is achieved by application of heat to the product, as the vapour pressure of the moisture of the product increases. Due to pressure gradient and temperature gradient moisture both in the form of liquid and vapour to the surface of the product .Water vapour is transferred to the surrounding due to evaporation. In the agricultural product moisture are present in free and bound forms. Free moisture release without any resistance. Its movement is independent of structure of the products. When moisture is evaporated the moisture content of the product falls and the product temperature is close to the wet bulb temperature of the drying air. This period of drying process is termed as “constant rate drying period”. When there is insufficient free moisture (critical moisture content) to maintain the

maximum drying rate as the moisture can't move freely through the product surface and gradually falls and consequently drying rate decreases. This period of drying is termed as "falling rate period" .

The rate of drying dM/dt is the final moisture content divided by the drying time.

The magnitude of the constant rate drying depends on the following parameters

(i)Heat and mass transfer coefficient

(ii)Area exposed to drying medium

(iii)Humidity gradient

The falling rate period depends on the parameters affecting the diffusion of moisture away from the evaporating surface and the parameters which are affecting the rate of internal moisture movement.

For estimation of total drying time both constant rate drying time and falling rate drying time are required.

5. CALCULATION OF MOISTURE CONTAIN:

There are generally two methods are adopted for expression of moisture contain in a product. Such as

i.Wet basis (%wb)

ii.Dry basis(%db)

In case of wet basis the moisture contains is expressing the ratio of amount of water in the product to total weight of the product at any time and incase of dry basis the moisture contains is the ratio of amount of water in the product to the amount of dry matter in the product at any time.

The wet basis is mostly used in commercial application where as dry basis is used in research and academic applications.

Let

M=Moisture content

W_m=Mass of the moisture

W_d=Mass of the dry material

For wet basis

$M=(W_m/W_m+W_d)x100\%$

For dry basis

$M=(W_m/W_d)x100\%$

Moisture content is always expressed in percentage.

6. SELECTION OF THE SOLAR DRYER:

The following some typical parameters are required for selecting a solar dryer

(i)Physical features of a solar dryer which includes size and shape, collector area, drying capacity/loading density, tray area, no of trays, solar loading and unloading convenience

(ii)Thermal performance like drying time/drying rate, dryer efficiency, solar insolation,air temperature, air circulation velocity

(iii)Drying characteristics of the product like initial moisture content, final moisture content, permissible drying temperature.

(iv)Loading and unloading of the product which includes quantity to be handled per hour, continuous or batch operation

(v)Product quality like shrinkage, contamination, over drying, bulk density

(vi)Installation space like availability of the fuel,availability of electric power, temperature, humidity, exhaust gas outlet.

(vii)Economical factor like cost of the dryer, cost of the drying

(viii)Other parameters like skilled operator, safety, maintaince.

7. CONCEPT OF ENERGY AND EXERGY ANALYSIS:

The term exergy comes from two Greek words “ex”means external and “ergos”means work.This “exergy”term was used by Rant in 1956 for the first time.It is based on second law of thermodynamics. The general definition of exergy is the maximum theoretical work that can be obtained from an amount of energy.A more comprehensive definition is the work that can be obtained from an amount of energy under ideal condition using the environment only as a reservoir of heat and matter i.e. means exergy relates to ideal work and exegy losses relates to lost work.This thermodynamics analysis techniques estimate the efficiency of a process and determines the energy quality and its usefulness.It specify the maximum performance of a system and the sources of irreversibilities.In particular,exergy analysis yield efficiencies which provide a true measure of how nearly actual performance approaches the ideal. Consequently it helps in improving and optimizing design.

First law of thermodynamics based on principle of “conservation of energy” .The energy can ‘t be created nor destroyed it only converts from one form to another. Energy analysis depends on energy entering and exiting. The efficiency calculated on energy based are often misleading that they do not always provide a measure of how nearly the performance of a system approaches ideally system because of the exiting energy may be broken down into products and wastes and thermodynamic losses within a systems. The shortcoming of energy analysis to be overcome by “exergy analysis”. Energy analysis is based on the principle of first law of thermodynamics and a traditional approach to estimate various energy conversion processes. However, it does not provides the information regarding the irreversibility aspects of processes. Due to the deficiencies and shortcomings of energy analysis, the exergy analysis which provides a more realistic view of the systems and processes has been widely used. It is a powerful to study and optimize various types of energy sys- tems. The exergy analysis associated with the quantitative approaches of usefulness or quality. It identifying the cause,location and magnitude of process inefficiencies. Its concept is that exergy is always degraded its quality during the conversion because of irreversible nature of energy conversion gradually and reaching a dead state and no further use for performing work.

In exergy analysis maximum potential energy is determined for an incoming energy and this maximum energy is retained and recovered if the energy passes through a reversible process for an energy storing device.As actual processes are irreversible hence loss of exergy has to be considered.Exergy relared to ideal work and exergy losses related to lost work.Exergy analysis evaluates the efficient uses of solar energy.By determining the sources and magnitude of irreversibilities ,exergy analysis can be used to improve the efficiency of a system.

CONCLUSION:

One of the most important potential applications of solar energy is the solar drying of agricultural products. The postharvest losses of agricultural products in the rural areas of the developing countries can be reduced drastically by using well-designed solar drying systems.Furthermore, before using the drying systems on large scale, computer simulation models must be performed to simulate the short and long terms performance of the drying systems.

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