Study on Solar Dryer Coupled with Flat Plate Collector

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***Abstract*:- In this present work solar dryer with a flat plate collector (FPC) was fabricated and experiments were conducted on the dryer with two different arranges of free and forces convection. Detailed analysis was made for both of the arrangements. Comparison of both the arrangements is made with the help of graphs obtained from the experimental values. Dryer with forced convection (coupled to FPC) gives higher drying rates. Maximum dryer efficiency obtained in case of dryer with free convection (coupled to FPC) maximum efficiency obtained is 5.157 % and in the arrangement, dryer with forced convection (coupled to FPC) maximum efficiency obtained is 7.99 %.Maximum FPC efficiency obtained was 29.26 % in case of forced convection arrangement. The food products used during the experiments were potato slices. Experiments are conducted by taking a sample of 1Kg.**

Keywords:- Solar energy, solar energy applications, solar dryer, mixed mode solar dryer.

1. INTRODUCTION

It has been estimated that the about 600 to 900 million people do not have enough food to eat now and this number likely to increase with the increase in population. There are obviously two direct ways of solve problems: (i) increase food production by bringing more area under cultivation, better irrigation and using newer and mechanized methods of agriculture practices (ii) reduce the food demand by reducing population growth. The third alternative which is equally important but not given adequate attention is reducing the loss of food during and after harvesting. The actual estimate of food loss during post harvesting periods, due to spillage, contamination, attack by birds, rodents, and insects; and during storage is difficult to estimate due to technical and practical reasons [1].

In developing countries where cold storage facilities are not adequate available, post harvesting losses between 30-50 percent in perishables are reported. This food loss can be reduced in developing countries if these countries establish and maintain adequate harvesting, storing, and handling practices, particularly in rural areas and create efficient policy and administrative infrastructure. The post harvesting losses vary considerably and social and cultural setting. The developing countries produce about 15 per cent of the world crop. Many commercial crops like tea, coffee cocoa, tobacco, nuts, etc., are grown only in developing countries. Crops like wheat, paddy, potatoes, barely, chilies, etc., contribute about 40 per cent of the world harvest. About 36 percent of the vegetables and 50 per cent of the food of the world are produced in developing countries. Even if the 50 per cent of post harvest food losses are reduced then many developing countries will become self sufficient in food. [1]

There are several ways of preserving food for later use. Drying is a traditional method for preserving food. It also helps in easy transport since the dried food becomes lighter because of moisture loss. Drying of seeds prevents germination and growth of fungi and bacteria. The traditional old age practice of drying food crops is spreading food products in open sun which may be termed as open sun drying or natural drying. In this technique the product is spread in thin layers on hard platforms and the product is turned once or twice a day and drying takes place due to solar radiations incident on the products and also by some extent of atmospheric air. This natural sun drying is simple and economical but suffers from many drawbacks such as, there is no control over drying rate, ni uniform drying, process is slow, damage by birds, animals etc,.

Solar drying is one of the important means of utilizing solar energy for low and moderate temperature applications. Solar drying of crops, fruits and vegetables has been practiced in various parts of the world for centuries the conditions in tropical countries make the use of solar energy for drying foods particularly attractive. The introduction of solar dryers in developing countries can reduce crop losses and improve the quality of dried product significantly compared to traditional drying methods. Bukola Olalekan bolaji [2] has made exergic analysis of different drying systems such as direct mode, indirect mode and mixed mode. The obtained results show that mixed mode and indirect mode solar dryers are more effective than the direct mode dryers. The overall efficiency of mixed mode, indirect mode, and direct mode systems were found to be 55.2%, 54.5%, and 33.4%. D. Jain and G.N Tiwari [3] studied and, cocoa, tobacco, nuts, etc., are grown only in developing countries. Crops like wheat, paddy, potatoes, barely, chilies, etc., contribute about 40 per cent of the world harvest. About 36 percent of the vegetables and 50 per cent of the food of the world are produced in developing countries. Even if the 50 per cent of post harvest food losses are reduced then many developing countries will become self sufficient in food. [1]

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2. OBJECTIVES

The main objectives of this work were;

1) To fabricate solar drying system with FPC (Flat Plate Collector).
2) To conduct experiments with different arrangements like, free convection, forced convection mode.
3) Performance analysis of both the arrangements.
4) To study the process of drying and parameters affecting the drying process.

3. MATERIALS USED

In present work complete drying system was constructed using the low cost materials that were available in the local market of Davanagere, Karnataka, India. Dryer cabin Dryer cabin is made using GI sheet of thickness 4mm.Insulation: Complete Insulation is provided to all sides of the dryer cabin is by using thermocol. 5mm thick glass was used as cover material. Flat plate collector absorber material is made of copper sheet coated with selective coating. A blower used for forced connection arrangement.

4. INSTRUMENTATION

Thermometers: Thermometers are being used to measure the temperature at different locations of the dryer which are having the range from 0 ^{0}C to 150 ^{0} C.

Solar intensity meter: Incident solar radiation flux was measured with the help of Solar intensity meter which is having range from 0 Langley/hour to 100 Langley/hour.

Weighing machine: Digital weighing machine is used measure weight of the products during the experiments. and which is having range from 5grams to 12 Kg. Technical details of the experimental setup is shown by below table.

Table 1. Details of experimental setup

Parameter	Deatils
Location of Davanagere	14.31^0 N 75.58^0 E
Dryer gross area	(1.15 m ×0.73 m) = 0.839 m2
FPC gross area	1 m2
Mass flow rate of air	8.2866 × 10-3 Kg/s.
Number of trays used	1
Glass thickness	5 mm
FPC absorber	Copper
FPC insulation material	Rock wool
FPC casing frame	GI

5. EXPERIMENTAL SETUP

5.1 Dryer with Free Convection (Coupled with FPC)

In this arrangement, a FPC is coupled to dryer cabin in such a way that exit of FPC is connected to the inlet of the dryer. When solar radiation falls on the dryer, rises the temperature of products resulting in evaporation moisture and temperature of air inside the dryer also increases. This hot moist air goes out through outlet vent and creating partial vacuum inside the dryer and due to this partial vacuum hot air inside the tubes of FPC start to move into the dryer which is placed at higher height than FPC. At the same time atmospheric air enters at the inlet of FPC. At the exit of the FPC a thermometer is provided to measure outlet temperature of air from the FPC.In this type of arrangement rate of moisture removal rate is higher than that of dryer without coupled to FPC arrangement. This system is complicated and costlier than the first one. As in first case this system also does not need any external power for its operation. As in first case, solar radiation fluxes and free convective motion of the air are the two important parameters which are significantly affecting the process of drying. Arrangement of free convective dryer coupled to FPC is shown by the figure 2. This type of solar dryer is also called as mixed mode solar dryer with free convection because in this case solar radiations directly falls on the product through the transparent glass and separately a FPC is employed to heat the air and this air will pass through the trays of the dryer.

Fig 1: Free convection arrangement

5.2 Dryer with Forced Convection (Coupled with FPC)

In this type of arrangement, electric blower was used to achieve air circulation and this blower needs external power for its operation. With the help of blower atmospheric air is blowing through the pipes of FPC. During its way, air gets heat from FPC and its temperature rises then it is move to the dryer and at the same time dryer recessives heat from direct solar radiation falls on it. Finally after absorbing moisture air will exhaust through outlet vent. One thermometer is fixed at the exit of FPC to measure outlet temperature of FPC. This type of arrangement is more effective than first two arrangements but main disadvantages are system becomes more complicated, needs external power supply for its operation and costly. This type of system is shown by the figure 3 given below. (This arrangement is also called as mixed mode solar dryer with forced convection).

Fig 2: Forced convection arrangement

7. RESULTS AND DISCUSSIONS

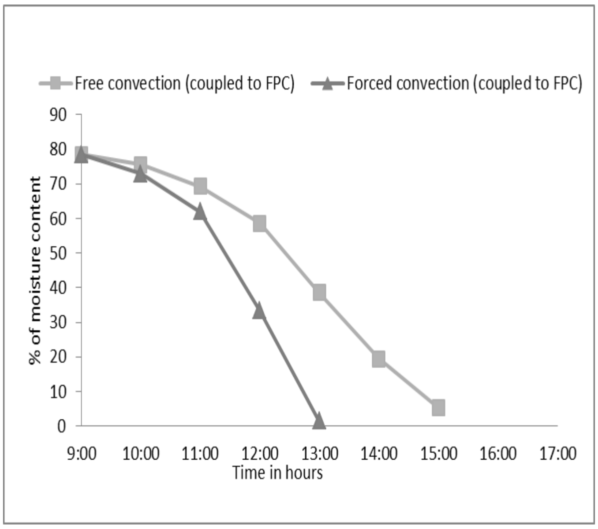

Fig 3: Time V/S % of moisture content

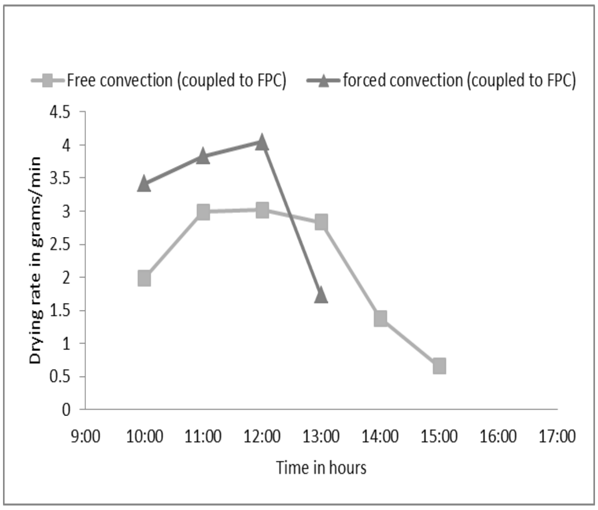

Fig 4: Time V/S Drying rate

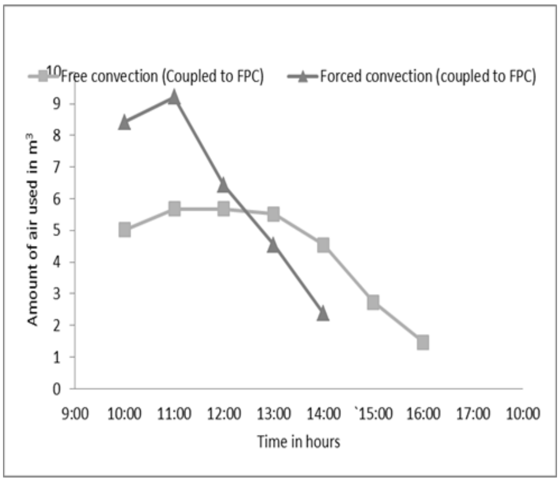

Fig 5: Time V/S Amount of air used

In this present work, experiments were conducted on the dryer with free and forced convective arrangements. All the experimental results were taken carefully from morning 9:00 AM to till product reaches the safe moisture content level.

1 Kg of potato slices were used during the experiments. At the initial stages product contains higher percentage of moisture. When product is exposed to the sun radiations, moisture removal rate is high because more water vapour present at the outer surface of the product and this is shown by figure 3. From figure 3, it can also be observed that, in forced convection arrangement, moisture takes less time to reach safe moisture content level as compared to free convection arrangement. This is due to fact that, mass flow rate of air high and in free convection arrangement amount of air circulation is comparably at slower rate.

Figure 5 shows the amount air used in free convection and forced convection. The drying process involves complicated heat and mass transfer mechanism. The process of drying depends on the many parameters such as type and nature of the product, surface area exposed porosity of the product, density of the product, humidity of atmospheric air, temperature, mass flow rate of air, solar radiation.

8. CONCLUSIONS

In this work free and forced convective solar dryer with FPC (Flat Plate Collector) was fabricated. Experiments were conducted with free and forced convective arrangements. Some of the important conclusions of this work are summarized as below;

• At the initial stages, amount of moisture removed is more and drying rate reduces at the end stages.

• The drying process is different for different products and it is depends on initial moisture content of the product, geometry of the product, intensity of solar radiation flux, and also free convective motion of the air inside the dryer.

•Forced convection solar dryer arrangement gives higher drying rates than that of free convection arrangement.

• The drying process is affected by the properties of drying materials e.g. moisture content, size, shape as well as ambient conditions, which include solar radiation and temperature.

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