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RESEARCH ARTICLE OPEN ACCESS

Experimental Analysis of Open, Simple and Modified Greenhouse Dryers for Drying Potato Flakes Under Forced Convection

Tanuj Kumar Sahu[1], Vishal Gupta[2], Ajay Kumar Singh[3]
[1]*M.E. Scholar, Radharaman Institute of Technology and Science, Bhopal, M.P.*
[2]*Assistant Professor, Department of Mechanical Engineering, Radharaman Group of Institutions, Bhopal, M.P.*
[3]*Head, Department of Mechanical Engineering, Radharaman Institute of Technology and Science, Bhopal, M.P.*

ABSTRACT
Drying using burning of fossil fuels and open sun drying are traditional way to dry crops, fruits, vegetables etc. But there are some disadvantages associated with them such as crops are affected by dirt and other impurities. To overcome the problems associated with open sun drying and drying using burning of fossil fuels, solar greenhouse drying is found out to be the best alternative. In present work the performance of simple and modified greenhouse dryer is evaluated and effort is made to increase the drying rate of greenhouse dryer which has been achieved in modified greenhouse dryer with inclined roof. Total weight of potato flakes was reduced by 80.1 % in modified greenhouse dryer in just 5 hours whereas it took 6 hours in simple greenhouse dryer for achieving nearly same values.
Keywords: Solar drying, solar dryer, greenhouse dryer, forced convection, active mode, Inclined roof, potato flakes.

I. INTRODUCTION

One of the mostly produced vegetable in the world is potato. According to FAOSTAT from 2010-2014 China and mainland, India, Russian Federation, Ukraine and United States of America are the top most producers of potatoes. In these top five producers India is on second position. In India from 2010-2014 the average production of potatoes was 42,427,660 tonnes. The production of potatoes has increased at a very fast rate in last few years. In 2010 it was only 36,577,300 tonnes which reached to 46,395,000 tonnes in 2014 [1]. In India it is used as vegetable, chips and also in fast foods. For reduction in post harvesting losses, long term storage and to fulfill the future needs it is required to preserve the vegetable. Solar drying is one of the best and economical way for preserving the vegetables. In solar crop drying, moisture of the product is transported to surroundings by evaporation process. It is a complex process in which simultaneous heat and mass is transferred [2]. In drying process volume of the crop is reduced while cost of the crop increases. Due to the drying of crop certain physical and structural changes occur. Crops can be dried in their entirety or slices or quarters [3]. Many researchers have worked on solar greenhouse dryer under forced convection mode [4,5,6] and they found that drying in solar greenhouse dryer is much more beneficial than open sun drying. Chouicha et. al. [7] studied and experimentally investigated the drying behaviour of sliced potato in the indirect solar dryer for solar under forced convection mode and found that hybrid solar dryer such as photovoltaic module integrated or conventional electric power solar dryer gives better drying results.Sahu et. al. [8] reviewed the types of different solar drying techniques and solar greenhouse dryers for crops drying.

II. SUN PATH IN SUMMER

Fig. 1 shows the sun's path in summer and winter seasons [9]. It is known that earth rotates about its own axis which is tilt by approximately 23.4˚ from perpendicular plane to orbit and simultaneously travels around the sun throughout the year. Because of this the seasonal change occurs on the earth. In Bhopal the angle calculated for solar panel tilt from vertical it was 83˚ in month of May where as 90˚ in month of Jun [10]. Due to this it is expected that maximum solar radiation is available in the month May-Jun.

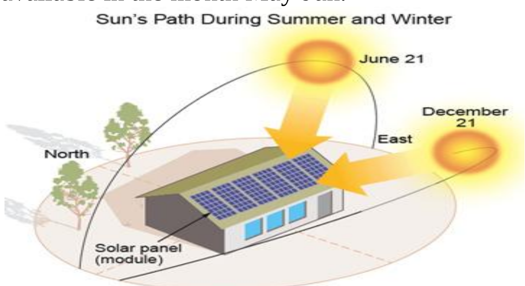

Fig. 1 Sun path during summer and winters [9]

III. AIM AND OBJECTIVES

It is noted that a lot of research has been done in the field of greenhouse dryers under forced convection for improving the performance. The aim of present work is to make a low cost economical forced convection greenhouse dryer with improved drying rate and compare results with simple forced convection greenhouse dryer. Also the effect of ambient parameters i.e. solar radiation, temperature, wind velocity and relative humidity on the performance of greenhouse dryer is discussed.

IV. MATERIAL AND METHODS

4.1 Experimental setup :-

The proposed greenhouse dryer is of inclined roof even type which consist of rectangular iron pipes covered with transparent plastic film. The bottom surface of the dryer is packed by black colored plastic for reduction in heat losses through ground. The roof of the dryer is inclined to latitude of Bhopal i.e. 23˚ such that one side central and wall height of the dryer is 48 cm and 32 cm respectively and another side central and wall height of the dryer is 72.7 × 88.7 cm² respectively with floor area of 96 × 62.4 cm². The drying tray is made of wire mesh with an effective area of 94 × 58 cm². The drying tray is also made black for absorbing maximum solar radiations. For entrance of air inside the dryer two circular holes of diameter 10 cm are provided on the south wall below the tray position. One AC exhaust fan of 12 cm diameter 20W, 0.14A and 2600 RPM is provided in upper portion of north wall of the dryer for removing the air in forced convection mode. To compare the results of this modified greenhouse dryer one simple greenhouse dryer is also made with same dimensions except the roof inclination such that the central and wall height of the dryer are 48 cm and 32 cm respectively with same floor area. Other parameters were set same as for the inclined roof greenhouse dryer. The drying procedure was performed in three different modes- open sun drying, simple greenhouse dryer and modified greenhouse dryer under forced convection (active mode). Fig. 2 shows the experimental setup and instruments used.

Fig. 2 Experimental setup and instruments used

4.2 Instruments used

For measurement of solar intesity solar power meter TM-207 manufactured by Tenmmar, Taiwan was used. For temperature measurement six channel digital indiator DTI-101 with J- Type thermocouple was used. It has temperature range of 0 to 199˚C. For measurement of relative humidity calibrated humidity meter HT-305 manufactured by LUTRON was used. For measurement of wind velocity digital anemometer AM-4201 manufactured by LUTRON was used. A calibrated digital weighing machine of top loading type with having weight capacity of 10 kg was used.

4.3 Materials

Fresh potatoes of 3 kg were procured from local market of Bhopal, India. All the potatoes were washed by water to remove the dirt from the skin of the potatoes. After cleaning, they were cut into flakes of 2 to 3 mm thickness. Equal quantity of potato flakes were kept on the wire mesh of both dryers and on open plastic sheet for drying.

4.4 Drying procedure

The drying of potato flakes is performed in open sun drying, simple greenhouse dryer and modified greenhouse dryer under forced convection modes. The model is constructed and installed at Radharaman Group of Institutions, Bhopal (23.1˚ N 77.3˚E), India. The experiment is performed between 10 AM to 4 PM on 30 May 2016. The dryer is kept on the ground which is far from shade of the buildings and trees. All the experimental observation is carried out on hourly basis.

V. RESULT AND DISCUSSION

5.1 Effect of solar radiation:-

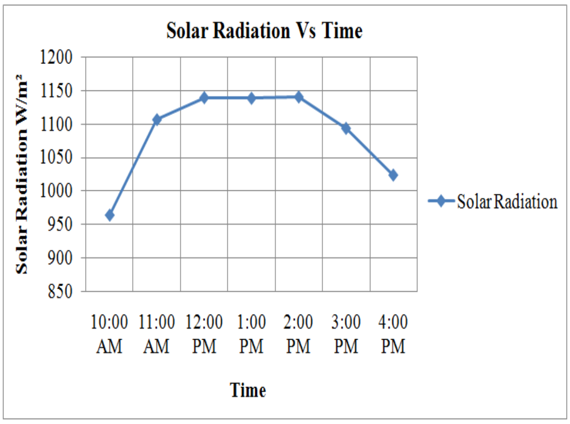

Fig. 3 Variation in solar radiation with time

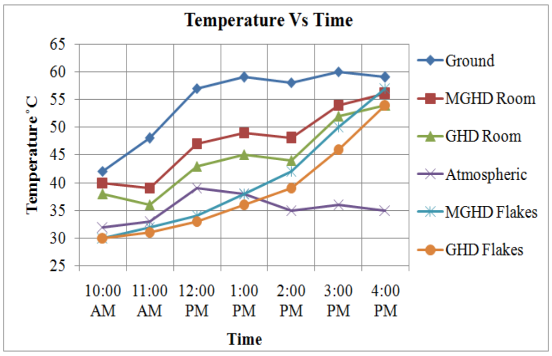

Fig. 4 Variation in temperature with time

The ambient parameter plays very important role to understand the drying behavior of any type of drying. Fig 3 shows the variation of solar radiation with respect to time. Fig 4 shows variation of ground temperature, atmospheric temperature, potato flakes temperature, modified green house temperature and simple greenhouse temperature with time.

On the day of experiment the sky was almost clear and the solar radiation varied from 964 W/m² to 1141 W/m² with maximum value at 2 PM. The ground temperature varied from 42˚C to 60 ˚C with maximum value at 3 PM. The MGHD room temperature varied from 39˚C to 56˚C. The GHD room temperature varies from 36˚C to 54 ˚C. All the above mentioned two temperatures are maximum at 4 PM. The atmospheric temperature varied from 32˚C to 39 ˚C. The maximum atmospheric temperature was recorded at 12 PM. Initially the potato flakes placed inside the dryers were at the temperature of 30 ˚C which reached to maximum temperature of 57 ˚C in MGHD and 54 ˚C in GHD at 4 PM.

As seen from Fig. 3 and Fig. 4, it is found that the temperature directly vary with solar radiation. It increases when the solar radiation increases and decreases when the radiation decreases. It is observed that the ground temperature is always higher than potato flake, atmospheric, GHD and MGHD room temperature. Also the MGHD room temperature was found to be higher than the GHD room and atmospheric temperature which is beneficial for quick drying the potato flakes. After placing the potato flakes it is found that initial temperature of MGHD and GHD room decreases because moisture increased. The potato flakes temperature was 30 ˚C during initial time which increased slowly in initial stage of drying but at last stage it increases suddenly. The reason behind that is continuous removal of moisture from potato flakes.

5.2 Effect of relative humidity and atmospheric wind velocity :-

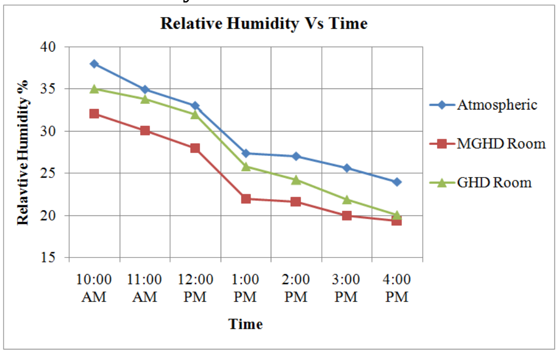

Fig. 5 Variation in relative humidity with time

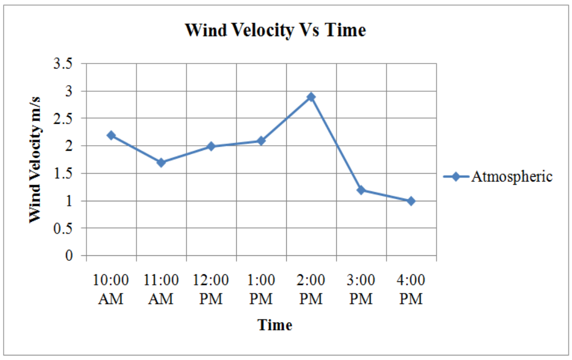

Fig. 6 Variation in wind velocity with time

Fig. 5 shows the variation in relative humidity with time. The relative humidity of atmosphere varied from 38 % to 24% whereas for GHD room it varied from 35 % to 20.1% and for MGHD room it varied from 32.1% to 19.4%. It is seen that the relative humidity inside the MGHD is less than the GHD and atmospheric relative humidity which is favorable condition for crop drying so that the drying is fast as compare to GHD and open sun. It is known that because of low density, hot air moves upward. The same principle is followed here also. In MGHD due to higher temperature and roof inclination the inside humid air moves upper side of inclined roof itself where the exhaust fan continuously removes it. Also relative humidity inside the GHD is less than the atmospheric relative humidity but higher than MGHD because hot humid air is not able to reach to the fan at high rate which can remove it at fast rate.

Fig. 6 shows the variation in atmospheric wind velocity with time. The atmospheric wind velocity which is turbulent in nature also plays an important role on the drying of potato flakes. It varies from 1 m/s to 2.9 m/s. It is also observed that at 2 PM wind velocity and solar radiation both were highest. Due to high wind velocity the temperature of ground, GHD and MGHD dryer is slightly reduced. There is very small reduction in relative humidity during that period also. The ground temperature is found to be higher at 3 PM at that time wind velocity was considerably low i.e.1.2 m/s. The inside area of MGHD for crop drying is slightly large as compare to GHD because of inclination of roof. So air enters into the MGHD circulates in larger area whereas in GHD the entered air is circulated in lesser area.

It is also observed that relative humidity increases with increase of wind velocity, decrease in temperature and decreases with decrease in the wind velocity and increase if temperature. Wind velocity also affects the temperature such that when it is high,s the temperature is reduced slightly. High temperature with less relative humidity is favorable condition for drying of any types of crop which is achieved in MGHD as compare to GHD and open sun drying.

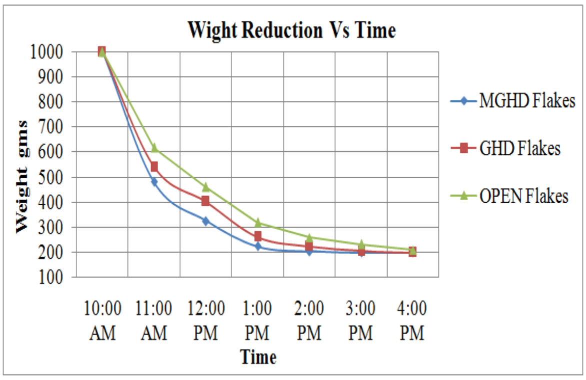

Fig. 7 Drying curve for different mode of drying

From Fig 7 it is seen that drying rate in MGHD is found to be higher than both open sun and GHD drying. The potato flakes were almost completely dry in the MGHD in 5 hours while it took 6 hours in GHD and even more in open sun drying process. Further reading could not be taken due to limitation of time. In MGHD 199 gms of dried potato flakes were obtained in 5 hrs i.e. at 3 pm while in GHD 200 gms dried potato flakes were achieved in 6 hrs i.e. at 4 pm and in open sun drying it was 210 gms at 4 pm. So higher drying rate is found out to be for MGHD than GHD and open sun drying.

5.3 Visual appearance of dried potato flakes

From visual appearance it is seen that potato flakes dried in both the dryer look better than openly dried potato flakes. In both the dryers dried potato flakes are clear from any dirt and dust particles whereas dust can be seen in openly sun dried potato flakes.

Fig.8 (a) MGHD dried potato flakes

Fig.8 (b) GHD dried potato flakes.

Fig.8 (c) Openly dried potato flakes.

VI. CONCLUSION

To overcome the disadvantages of traditional open sun drying and use of fossil fuel for drying, the solar greenhouse drying is found out to be one the of best alternatives. The modified greenhouse dryer with inclined roof and simple greenhouse dryer was developed to compare their drying rates.

The following results were obtained.

1. The room temperature of modified greenhouse dryer with inclined roof (MGHD) was always found to be higher than simple greenhouse dryer (GHD).
2. The maximum room temperature in MGHD was 56 ˚C whereas in GHD it was 54 ˚C

3. The maximum temperature of potato flakes was 57 ˚C which is achieved in MGHD whereas in GHD it was 54 ˚C only.
4. The minimum relative humidity was observed in MGHD with value of 19.4 % whereas in GHD it was 20.1 %. MGHD is suitable for high moisture content crops because relative humidity can be maintained by exhaust fan.
5. The drying in MGHD is found to be faster as compare to GHD and open sun drying.
6. Total weight of potato flakes was reduced by 80.1 % in MGHD whereas in GHD it was 80 % and 79% in open sun drying.
7. In terms of visual appearance of potato flakes dried in both the greenhouse dryers were found out to be free from dust and other impurities.

Nomenclature :-
MGHD – Modified Greenhouse Dryer.
GHD – Greenhouse Dryer.

REFERENCES

[1]. http://faostat3.fao.org/browse/Q/QC/E
[2]. Jain D., Tiwari G.N., Effect of greenhouse on crop drying under natural and forced convection II. Thermal modelling and experimental validation. Energy Conversion and Management Vol. 45 (2004) pp 2777-2793.
[3]. Prakash O., Kumar A., Environomical analysis and mathematical modelling for tomato flakes drying in a modified greenhouse dryer under active mode. International Journal of Food Engineering (2014); pp 1- 13. doi 10.1515/ijfe-2013-0063
[4]. Kumar A., Tiwari G.N., Effect of mass on convective heat transfer coefficient during onion flakes drying. American Journal of Food Technology Vol. 1 (1) (2006) pp 1-18.
[5]. Kumar A., Tiwari G.N., Effect of shape and size on convective mass transfer coefficient during greenhouse drying (GHD) of jaggery. Journal of Food Engineering Vol. 73 (200s6) pp 121-134.
[6]. Jain D, Tiwari G.N., Effect of greenhouse on crop drying under natural and forced convection I: evaluation of convective mass transfer coefficient. Energy Conversion and Management Vol. 45 (2004) pp 765-783.
[7]. Chouicha S., BoubekriA ., Mennouche D., Berrbeuh M. H., Solar drying of sliced potatoes. an experimental investigation. Energy Procedia Vol. 36 (2013) pp 1276 – 1285.
[8]. Sahu T. K., Jaiswal V., Singh A.K., A review on solar drying techniques and solar greenhouse dryer. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Vol. 13, Issue 3 Ver. III (May-Jun. 2016), PP 31-37.
[9]. http://www.thesolarplanner.com/array_placement.html. (Photovoltaic Tutorial, Optimum Array Orientation and Placement).
[10]. http://solarelectricityhandbook.com/solar-angle-calculator.html