DESIGN AND MODIFICATION OF SOLAR SEED DRYER

MOHAMMED SHADAB
Student, Department of Mechanical Engineering, Dr. D.Y. Patil College of Engineering and Innovation, Varale, Pune, M.S.,India

SAYED IRFAN MASTAN
Student, Department of Mechanical Engineering, Dr. D.Y. Patil College of Engineering and Innovation, Varale, Pune, M.S.,India

SHAH MO TARIQUE
Student, Department of Mechanical Engineering, Dr. D.Y. Patil College of Engineering and Innovation, Varale, Pune, M.S., India

SHAIKH MOHAMMED SHOEB AHMED
Student, Department of Mechanical Engineering, Dr. D.Y. Patil College of Engineering and Innovation, Varale, Pune, M.S., India

PROF. S.S.SUMAN
Department of Mechanical Engineering, Dr. D.Y. Patil College of Engineering and Innovation, Varale, Pune, M.S., India

ABSTRACT:

Agriculture sector in India is contributing to Indian economy to around 15 to 20 % when data of last five year is considered. The products cultivated from this sector are mainly affected by the processing for preservation. The developing countries of the world are lacking with facilities in agriculture sector and there are several factors affecting agriculture. In India near about 50% people are directly or indirectly associated with agriculture sector through farming and associated byproduct manufacturing. Agricultural application of solar dryer is used widely in developed countries to preserve the vegetable. The preservation of many products from agriculture is possible with solar dryers. The solar energy is available in India in abundant amount. Use of solar energy for drying the product will be very economic. Authors have presented the design of solar dryer in this paper.

KEYWORDS: Solar Dryer, DC Motor, Relays, Arduino, Heater, etc.

INTRODUCTION:

Solar energy is available in almost all regions of India. With developing technology, solar energy is used for many portable applications used in day to day life. The applications of solar in agriculture such as pumps and tractors are proposed by the researchers. The processing of crop with solar drying technology is proposed by authors. The design of solar drying system is presented in this paper in application to Indian agriculture sector.

Crop preservation is always challenging for farmers in India. Indian farmers are mainly the owners of small lands. For a small land purchasing the technology is very uneconomical and many of them are not having money to purchase modern equipments. Product quality can also be improved in the process of preservation as we can add or remove any substance from crop in any amount.

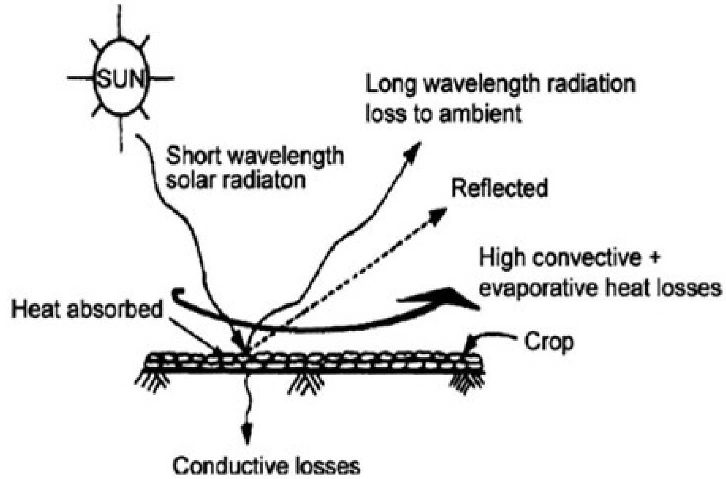

Fig. 1: Open Solar Sun Drying Method

The solar energy has huge potential to produce heat. The heat produces is useful for drying the agriculture products in order to preserve them for future use. The air is heated to dry it so that it can be used for absorbing the moisture from products. Solar energy potential of India and advantages of it over other energy generation methods made it important to use solar energy effectively for as many applications as we can. Automation of control drying is very important to use it effectively.

OBJECTIVES OF WORK:

Following are the objectives of work carried out:

- Utilizing solar system for agricultural applications
- Manufacture sophisticated electronic solar driven dryer for few grains.
- Designing and developing the agricultural food product dryer

SYSTEM DESIGN:

Approximation of Collector plate temperature

$G \times \alpha sun = \alpha copper \times \sigma (Tcopper^4 – Tsurrounding^4)$ ....(1)

Total incidence radiation = G × aperture area

$= 1000 \times 436 \times 1000 \times 10^{-6}$

Q incidence $= 436\ W/m^2$ ....(2)

Q transmitted = τ glass x Q incidence...(3)

$= 0.726 \times 436$

$= 316.536\ W/m^2$

Substituting (3) In (1)

$316.536 \times 0.12 = 0.65 \times 5.667 \times 10^{-8} \times [T\ collector\ plate^4 – 308^4]$ T collector plate = 43.4488 ℃

Where,

G = Solar Constant

σ = Stefan Boltzmann constant = $5.669 \times 10^{-8}\ W/m^2$

α copper = absorptivity of copper

τ = Transmitivity of glass

- **Time required to reach the calculated temperature**

$$\frac{Tt-Ta}{Ti-Ta} = e^{-(\frac{hAs}{\rho V\,Cp})\,xt} \quad \text{.............................. (4)}$$

$$\frac{50-35}{25-35} = e^{-\frac{10\,x\,0.23\,x\,0.46}{8960\,x\,4\,x\,0.23\,x\,0.46\,x\,0.003\,x\,386}}$$

$$-1.5 = e^{-2.40948\,x\,10^{-4}\,x\,t}$$

Taking log on both side,

$-1.5 = 2.40948 \times 10^{-4} \times t$ t = 1682.7909 sec
t = 28.04 min

Where,

T_t = Temperature at‘t’ sec (°C)
T_a = Ambient temperature (°C)
Ti = Initial temperature (°C)
h = convective heat transfer coefficient = 9.1 W/m^2
A_s = Surface Area (m^2)
ρ = Density (Kg/m^3)
V = Volume (m^3)
C = Specific heat (J/Kg/K)

- **Rate Of Heat Transfer**

q_c = hc (Tair - Ts) x A..............................(5)
T_{air} = Tch = 43.44° C = 316K
$T_{surface}$ = 35°
C = 308K $A_s = 533 \times 10^{-3}\ m^2$
$q_c = hc (316 – 308) \times 533 \times 10^{-3}$
$q_c = 42.68\ W/m^2/K$

- **Radiative heat transfer is given by,**

q_r = hr (Tch - Ts) x..(6)
$h_r = 6.54488\ Watt/m^2 /k$

Hence

$q_r = 6.54488 \times (316 - 308) \times 0.5 \times 1.066$
$q_r = 27.90\ Watt/ m^2 /k$

Where,

T_{air} = Surrounding Hot air Temperature
$T_{surface}$ = Food grain surface temperature
A = Surface area of the product
H_c = Convective heat transfer coefficient ($W/m^2/K$) = 10 $W/m^2/K$
ε = emissivity of food grain = 0.95
σ = Stefan boltzmann constant = 5.669 x 10-8 W/m^2

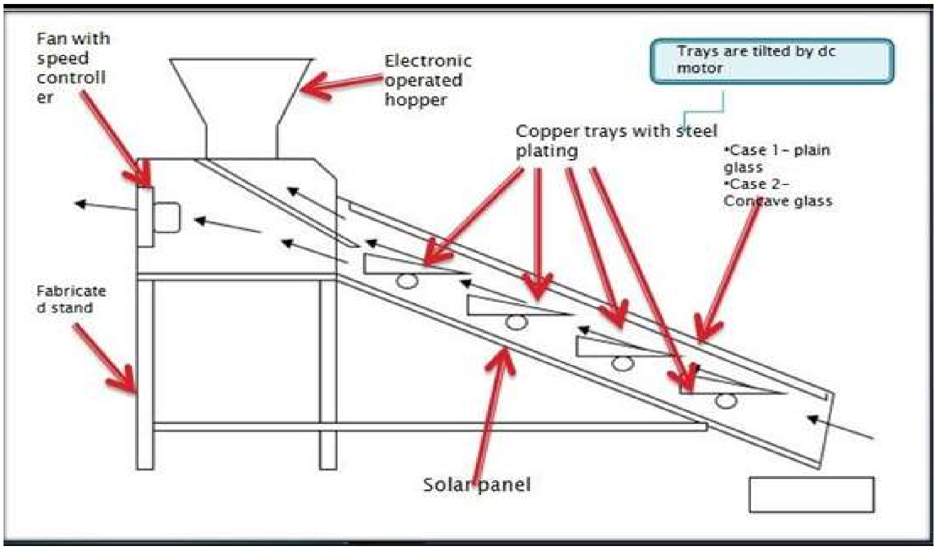

Fig.2: Working Diagram of Solar Seed Dryer

Indication of 3D view of solar seed dryer as shown below

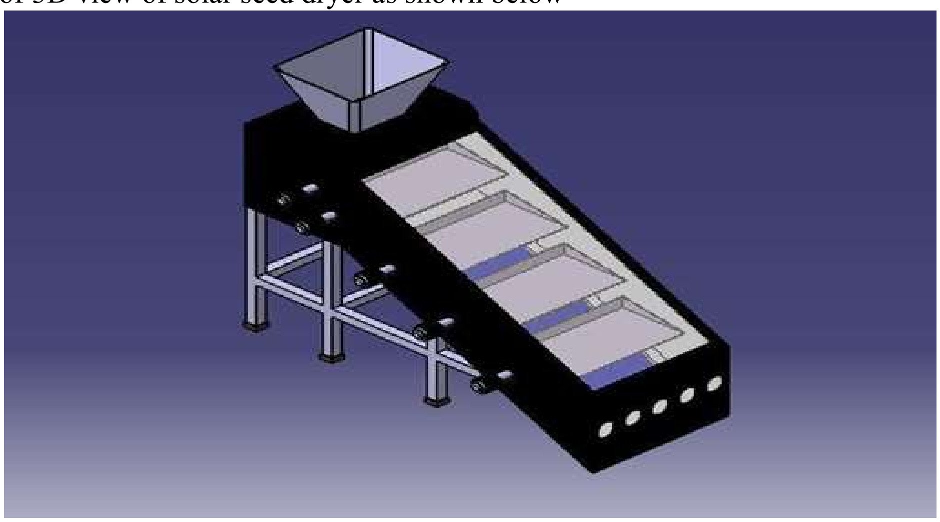

Fig.3: 3D View of Solar Seed Dryer

FUTURE SCOPE:

The design can be further modified with following modifications.

- Providing parabolic reflector on both sides of the collector
- Increasing the absorptivity of the absorber plate. The Replacing copper plate with aluminum plate.
- Increasing the air flow rates.
- Providing PVT operated electrical heating coil.
- Incorporating PCM based thermal energy storage system in the dryer to maintain required temperature in the evening/night hours.
- Increasing collector tilt angle length and breadth to a certain limit to raise the temperature of the dryer.
- Providing dehumidifier before the drying chamber for removing moisture in the air to improve the drying rate.
- Provision of parabolic trough solar collector instead of black coated aluminum absorber plate to be used as a concentrated solar power plant and industrial process heat with a temperature range of $100^{O}C – 250^{O}C$.

- Decreasing the distance between the tray and bottom plate of the drying chamber using two layers of glazing to reduce the thermal loss from the collector.
- Providing copper tubes to the side wall of the dryer to recover heat from the sidewalls.

CONCLUSION:

Agriculture is one of the major sectors in India. Being population over 135 Cr, many people are depended on farming for their earnings. The problem associated with present farming is to preserve the cultivated crop as many products have very small life without processing. Many factors such as environmental affect the production and hence the return on investment made for cultivation is not assured for farmers. Solar energy has huge potential to be utilized in India. The application of solar dryer system for Indian farms is developed by the authors. The CAD model for such system is presented in this paper with the objective of cost reduction.

REFERENCES:

1) Ezekoye, B. A., and O. M. Enebe. "Development and performance evaluation of modified integrated passive solar grain dryer." *The Pacific Journal of Science and Technology* 7.2 (2006): 185-190.
2) Mumba, J. "Design and development of a solar grain dryer incorporating photovoltaic powered air circulation." *Energy conversion and management* 37.5 (1996): 615-621.
3) Ekechukwu, O. Va, and Brian Norton. "Review of solar-energy drying systems II: an overview of solar drying technology." *Energy conversion and management* 40.6 (1999): 615-655.
4) Brenndorfer, B., et al., eds. *Solar dryers: their role in post-harvest processing*. Commonwealth Secretariat, 1985.
5) Sharma, Atul, C. R. Chen, and Nguyen Vu Lan. "Solar-energy drying systems: A review." *Renewable and sustainable energy reviews* 13.6-7 (2009): 1185-1210
6) Diamante, Lemuel M., and Peter A. Munro. "Mathematical modelling of the thin layer solar drying of sweet potato slices." *Solar energy* 51.4 (1993): 271-276.
7) Tiwari, G. N., et al. "Design parameters of a shallow bed solar crop dryer with reflector." *Energy conversion and management* 35.6 (1994): 535-542.
8) Fudholi, Ahmad, et al. "Review of solar dryers for agricultural and marine products." *Renewable and sustainable energy reviews* 14.1 (2010): 1-30.
9) Sharma, V. K., A. Colangelo, and G. Spagna. "Experimental performance of an indirect type solar fruit and vegetable dryer." *Energy conversion and management* 34.4 (1993): 293-308.
10) Moray, R. Vance, et al. "Evaluation of the feasibility of solar energy grain drying." *Transactions of the ASAE* 22.2 (1979): 409-0417.