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EXPERIMENTAL INVESTIGATION OF VARIOUS SIZES OF SOLAR DRYER FOR DRYING AGRICULTURAL PRODUCTS

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ABSTRACT

A solar dryer is specially designed for drying purpose. The designed system is efficient because, the energy is trapped in greenhouse system thus maintains high temperature and leads to drying of products in an efficient and quickly manner. The theoretical calculations of greenhouse solar dryer is calculated by using various parameters such as solar intensity, mass flow rate, slope angle of the dryer for two different areas (CASE-I 2m² and CASE-II 1.125m²) of dryer. To improve the life time of drying product storage without changing its aroma, colour, volatile content, etc by using solar dryer.

1 INTRODUCTION

Drying is one of the most efficient methods used to preserve food products for longer periods. A solar dryer is an enclosed unit, to keep the food safe from damage, birds, insects, and unexpected rainfall. The food is dried using solar thermal energy in a cleaner and healthier way.

Solar energy has been used for the preservation of agricultural produce since generations all over the world. Recent research on drying reveals the shortcoming of the open sun drying. In order to minimize the shortcoming of the open sun drying, various drying techniques are proposed. Among them previous effort on dryer has been presented in this study. It can be used to do low temperature drying of cereal grains, fruits, vegetables, spices etc. The dryer is operated in the two different modes of drying— natural convection and forced convection. Recently development of dryers namely solar tunnel dryer, solar tent dryer, improved solar tunnel dryer, and roof type even span solar dryer. Products dried in the dryer are found to be superior in quality as compared to those in open sun drying. In addition, the product is completely protected from external calamities such as rain, insects, and animals. All recent developments in greenhouse drying are emphasized in this communication.

2 OBJECTIVES AND METHODOLOGY

2.1 OBJECTIVES

The main objective of the project is,

- To evaluate the performance of solar dryer.
- To drying the product to changing the conventional drying mode to solar drying.
- To find the variation of moisture removal rate.

2.2 METHODOLOGY

- To develop the mathematical model for the solar dryer.
- To fabricate the experimental setup.
- To conduct the test for reduction of moisture upto safe limit of moisture content.

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3 THEORETICAL MODEL

3.1 DETERMINATION OF MOISTURE REMOVAL RATE

The moisture removal rate is calculated by given as

$$MR = \frac{m_i - m_f}{t_d} \quad \text{(kg/s)}$$

where,

m_i Mass of sample before drying, kg

m_f Mass of sample after drying, kg

t_d The drying duration time, s

3.2 MOISTURE LOSS

The moisture loss is given by

$$ML = m_i - m_f \quad \text{(kg)}$$

where,

m_i Mass of sample before drying, kg

m_f Mass of sample after drying, kg

3.3 FLUID FLOW CHARACTERISTICS

3.3.1 Reynolds Number

Reynolds number is defined as the ratio of inertia force and viscous force.

$$\mathrm{Re} = \frac{\rho V D_h}{\mu}$$

where,

$\dot{m}$ Mass flow rate of air, kg/s

μ Absolute viscosity of air, Ns/m²

ρ Density of the air, kg/m³

v Velocity of air, m/s

A_c Cross sectional area of the dryer, m²

D_h Hydraulic diameter, m

$$D_h = \frac{4(W \times H_a)}{2(W + H_a)} \quad \text{(m)} \qquad (4.4)$$

where,

H_a Average height of the dryer, m

W Width of the dryer, m

3.3.2 Nusselt Number

Nusselt number is defined as the ratio of convective heat transfer to heat transfer by conduction in the fluid and involve the heat transfer co-efficient (h) and thermal conductivity.

$$Nu = 0.0.158 \times \mathrm{Re}^{0.8}$$

3.4 HEAT TRANSFER CO-EFFICIENTS

3.4.1 Radiation Heat Transfer Coefficient between the Cover to Sky ($h_{r,c-s}$)

$$h_{r,c-s} = \varepsilon_c \sigma (T_c^2 + T_s^2)(T_c + T_s)$$

where,

σ Stefan – boltzman constant, Wm²K⁴

ε_c Emisivity of the cover

T_c Cover temperature, K

T_s Sky temperature, K

3.4.2 Radiation Heat Transfer Coefficient between the Product to Cover ($h_{r,p-c}$)

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$$h_{r,p-c} = \varepsilon_p \sigma \left(T_p^2 + T_c^2\right)\left(T_p + T_c\right)$$

where,

ε_p Emisivity of the product

T_p Product temperature, K

3.4.3 Convective Heat Transfer Coefficient (h_c)

$$h_c = \left(\frac{Nu \times k_a}{D_h}\right)$$

where,

Nu Nusselt number

k_a Thermal conductivity of air, W/mK

3.4.4 Convective Heat Transfer Coefficient between Cover to Ambient (h_w)

$$h_w = 5.7 + 3.8V_w \qquad \text{(W/m}^2\text{K)}$$

3.5 OVERALL HEAT LOSS CO-EFFICIENT FROM THE COVER (U_c)

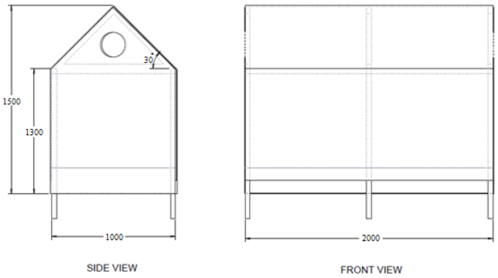
$$U_c = \frac{k_c}{\delta_c} \qquad \text{(W/m}^2\text{K)}$$

where,

k_c Thermal conductivity of the cover, W/mK

δ_c Cover thickness, m

4 MODELING



5 RESULTS AND DISCUSSION

5.1 CONVECTIVE HEAT TRANSFER COEFFICIENT WITH RESPECT TO MASS FLOW RATE

The convective heat transfer coefficient for various mass flow rate range from 0.02kg/s to 0.08kg/s.

In the figure 5.1 represents on the convective heat transfer coefficient for Case-I & Case-II were with respect to mass flow rate. Generally convective heat transfer coefficient for Case-I & Case-II were increased with increase of mass flow rate. The convective heat transfer coefficient of Case-I was lower than Case-II. The convective heat transfer coefficient values were obtained in the range of 0.03 W/m²K to 0.26W/m²K for Case-I and 0.07W/m²K to 0.40W/m²K for Case-II. The radiative heat transfer coefficient was depends only emissivity, inside and outside ambient air temperature. So that values were not changed with respect to mass flow rate.

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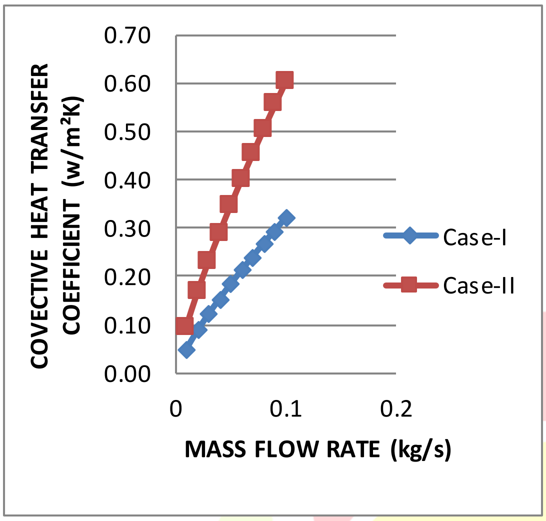

Figure 5.1 Convective heat transfer coefficient with respect to Mass flow rate

5.2 HEAT GAIN WITH RESPECT TO SOLAR INTENSITY

The theoretical results of heat gain for various solar intensity range from 650W/m² to 900W/m².

In the figure 5.2 represents on the heat gain for Case-I & Case-II with respect to solar intensity. Generally heat gain for Case-I & Case-II were increased with increase of solar intensity. The heat gain of the Case-I was higher than Case-II. The heat gain was rise in the range from 302.38W to 607.57W for Case-I and from 103.45W to 276.76W for Case-II. The convective heat transfer coefficient was not changed with respect to solar intensity. Because its depends only conductivity, Nusselt number, hydraulic diameter. The heat gain was not depends only solar intensity so only no change with respect to mass flow rate on before case.

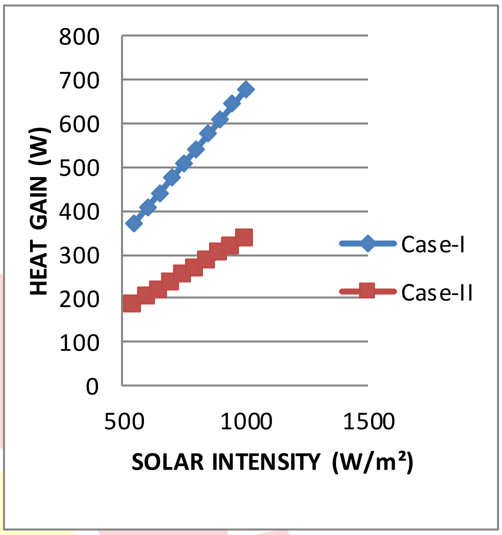

Figure 5.2 Heat gain with respect to Solar Intensity

6 CONCLUSIONS

Based on the theoretical calculation following conclusion were arrived,

- The heat gain of the green house solar dryer was achieved 414.63W and 184.73W for Case-I and Case-II respectively for the mass flow rate of 0.02 kg/sec.
- Two sizes of design each having size of Case-I & Case-II (2m² & 1.15m²). The maximum heat gain of dryer obtained from the Case-I.
- When the mass flow rate will increases from 0.02 to 0.08 kg/sec the convective heat transfer coefficient will increases form 0.03W/m²K to 0.26W/m²K and 0.07W/m²K to 0.40W/m²K respectively for Case-I and Case-II.

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