

Mathematical Modeling and Parameter Estimation of an Optimal Solar Food Dryer #104

Eminent threat caused by post-harvest losses due to inadequate drying and poor storage is responsible for up to 40-60% losses of agricultural produce each season. In order to address this issue, this paper seeks to formulate a mathematical model and simulate the characteristics of a solar dryer for the purpose of designing an effective and sustainable, low cost thermal solar dryer suitable for dehydrating a variety of agricultural products. The modeled solar food drier has four major parts, namely: Solar heat collector: Closed loop pipe network: Heat exchangers: and the Drying Chamber. The mathematical model was formulated using differential equations, and simulation using SIMULINK. The simulation results showed that, a solar collector with aperture area of $A_c=14.4m^2$ and a fluid volume of $V_c=500l$, when exposed to solar irradiation of $I_c=1.367KW/m^2$ at $\eta_c=80\%$ efficiency is able to heat water from $[T_{in}=22] ^0C$ to $T_{co}=[70] ^0C$ in 12 hours at a flow rate of $v_c=1.128l/s$. This energy if transmitted by insulated pipes to a set of 5 heat exchangers each of area $A=1m^2$, and radiative heat transfer coefficient $h_r=100W/m^2K$ cumulatively dissipates hot air of maximum $[230] ^0C$ at $v=250cm^3/s$, and minimum of $[90] ^0C$ at $v=2000cm^3/s$ air mass flow rate. This output temperatures of dry air is regulated as desired according to the specifications of the food products to be dried. In absence of solar energy, Liquefied Petroleum Gas is intermittently used depending on the level of solar insolatation. It was found that the optimal cost of the gas in this energy mix is reduced by over 67.86%. This strongly makes the use of solar in food dryers an ideal green energy to be used in mitigating post-harvest losses.

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