The International Conference on Renewable Energy, Climate Change and Ecosystem Restoration (ICRECC-2025)

Contribution ID: **104** Type: **Oral presentation**

Mathematical Modeling and Parameter Estimation of an Optimal Solar Food Dryer

Thursday 24 April 2025 10:45 (20 minutes)

Eminent threat caused by post-harvest losses due to inadequate drying and poor storage is responsible for up to 40-60% loses 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 η_c=80% efficiency is able to heat water from 〖T_in=22〗^0 C to T_co= 〖70〗^0 C 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^2 K cumulatively dissipates hot air of maximum 〖230〗^0 C at v˙=250cm^3/s, and minimum of 〖90〗^0 C 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 insolation. 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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Track Classification: Renewable Energy: Solar, wind and geothermal sources of energy