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Efficiency of a hybrid solar–gas dryer

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Abstract

The thermal and drying efficiency of three operating configurations for a hybrid solar-gas dryer were calculated in transitory state. The hybrid dryer, comprising a solar collector, auxiliary LPG (liquid propane gas) combustion heater, and a drying chamber, can be operated through an LPG (GHS) heating system, a hybrid solar-gas (HHS) heating system, or a solar (SHS) heating system. Global efficiency was calculated considering the energetic contributions of the solar collector and/or the auxiliary heating system, in accordance with the mode of operation being evaluated. Losses resulting from reflection and absorption were considered in the analysis of the solar collector. The thermal efficiency of the collector was principally affected by air mass flow, collector angle of inclination, and the difference between ambient temperature and the collector's internal temperature. A simulation varying air velocity parameters inside the solar collector was utilized to estimate the air mass flow needed to produce a thermal efficiency greater than the efficiency calculated under current design and operational conditions (26%). Maximum drying efficiencies were 86%, 71%, and 24% for GHS, HHS, and SHS, respectively. HHS and GHS exhibited similar drying rates in the constant period of the curve (~0.030 kg H_2O/kg d.s. min). The efficiency of the hybrid drying system was similar to the LPG drying system, with the advantage of consuming 20% less fuel without sacrificing quality in the dried product.

Keywords: Hybrid dryer; Solar-gas dryer; Thermal efficiency; Drying efficiency

1. Introduction

More than 80% of the food is being produced by small farmers in countries in development (Murthy, 2009; Jairaj et al., 2009). In these countries, small producers need agriculture equipment with low investment and maintenance and easy to operate, such as small size dryers operated by solar energy (Farkas et al., 1999). On the other hand, the preservation of the quality becomes more and more important in the processing of agricultural products. (Seres and Farkas, 2007). Solar energy has great potential for many low temperature applications, especially the drying of agricultural products (Karim and Hawlader, 2006; Shobhana and Subod, 2012). Air heated with solar energy can be utilized directly in the drying process, reducing consumption of non-renewable sources of energy.

Current foodstuff drying systems have high operating costs. The 7–15% of the quantity of industrial energy in industrialized countries is utilized in foodstuff drying (Keey, 1992).

Brooker et al. (1974) found that high temperature drying processes, both continuous and discontinuous, require up to 6.9 MJ of energy per kg of water extracted, that is why non-renewable fuels such as carbon, petroleum, and wood are widely used to heat air for drying processes (Murthy, 2009).

According to Bennamoun and Belhamri (2003), storage of fresh produce is one of the most important stages of the

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