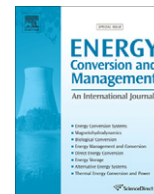




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Techno-economic analysis of a roof-integrated solar air heating system for drying fruit and vegetables

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ABSTRACT

The solar air heater was 46 m² and recorded a maximum temperature of 76.6 °C. The dryer was loaded with 200 kg of fresh pineapple slices 5 mm thick. The initial moisture content of 82% was reduced to the desired level (<10%) within 8 h. The performance of the dryer was analyzed in detail by three methods namely annualized cost, present worth of annual savings, and present worth of cumulative savings. The cost of drying 1 kg pineapple worked out to Rs. 11 which was roughly half of that of an electric dryer. The payback period worked out to 0.54 year, much less than the estimated life of the system (20 years).

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1. Introduction

Solar drying is considered as one of the most promising techniques for food preservation [1]. Drying of farm produce is an energy intensive operation, and improving energy efficiency by only 1% could increase the profits by 10% [2]. Escalating price of petroleum products and the shortage of fossil fuels have led to increased emphasis on using solar energy as an alternative energy source especially in developing countries like India. Apart from the rise in energy costs, legislation on pollution and sustainable and eco-friendly technologies has created greater demand for energy efficient drying processes in the food industry. The food processing industries can have economic savings by avoiding wastage of costlier energy. Post-harvest losses in the developing countries are estimated to be 30–40% in the case of fruit and vegetables [3].

The solutions involving solar energy collection devices or solar dryers have been proposed to utilize free, renewable and non-polluting energy source provided by the sun. Solar dryers can reduce crop losses and significantly improve the quality of the dried product [4]. However, solar drying systems must be properly designed to match particular drying requirements of specific crops, which can increase the efficiency of a system [5].

Flat plate solar air heaters are now successfully used to heat air for many industrial and domestic applications such as drying farm produce, dehydration of industrial products, and space heating [6,7]. Solar energy plays an important role in low-temperature

thermal applications, since it replaces a considerable amount of conventional fuel. Flat plate collectors are, therefore, the best candidates for heating air. The use of air as a working fluid in a solar collector eliminates the need for a heat exchanger, generally employed to transfer heat from liquid to air in a liquid flat plate collector. The air heated in a solar collector can be used more effectively for controlled drying. A solar air heater may supply hot air to a conventional dryer, or a special design may combine the heater and a drying cabinet [8,9].

All designs of solar air heaters developed so far can be grouped into two categories, namely those with non-porous absorbers and those with porous absorbers. In the first type, the air stream flows not through the absorber plate, but above and/or behind it. In the second type, the air stream flow through the absorber because it is porous and includes slit and expanded metal, transpired honeycomb or overlapped glass plate absorber [10]. Ben Slama et al. [11] tested different air collectors with different-flow pattern using baffles in the air passage area. They reported that the provision of baffle creates turbulence of the hot air carrier and thus increases the collector efficiency. Thus the efficiency is increased by approximately 60% compared to collectors without baffles. Yeh and Chou [12] investigated the efficiency of upward-type baffled solar air heaters with baffles.

Solar drying systems are classified primarily according to their heating modes and the manner in which the solar heat is utilized. In broad terms, they can be classified into two major groups, namely active solar energy drying systems (most of which are often termed hybrid or forced circulation solar dryers) and passive solar energy drying systems (conventionally termed natural circu-

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