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Review on various modelling techniques for the solar dryers

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ABSTRACT

This review paper is focused on the various modelling techniques for the solar dryer system. The modelling techniques are very important to develop, increase drying efficiency, analyse and predict the performance of different kinds of solar drying system. The modelling techniques are also important for predicting the temperature of crop moisture content, drying rate, quality of crop and colour of crops. Computational fluid dynamics (CFD can be applied for analysing and investigating of air flow and spry of temperature in the drying system. Adaptive-network-based fuzzy inference system (ANFIS) can be used to predict the behaviour of the solar drying system. ANN is used to calculate the mass of the dried crops on hourly basis. FUZZY is very important software for using the simulation of drying system. That can also be used to accurately predict the results with a minimum error. The mathematical modelling techniques are used for testing the drying behaviour of crops in the laboratory. It act in effect tool between scientists and investigators. It helps short of spending vast amount of time, energy and money in experimental events. Before fabrication the modelling techniques are very supportive in simulation of different types of solar drying system. Thus, analysis on the base of modelling techniques is not only save time but also save the capital investment in solar drying system. The advantage and future scope of modelling techniques is also discussed.

Contents

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1. Introduction

The solar dryer technology is used in agricultural field to preserve food, fruits, seeds and vegetables, and has been proved economical as well as eco-friendly in practical life. In many countries solar dryer is used extensively for drying the crops.

Energy, which is freely available in the atmosphere, is known as green energy. This is the renewable form of energy. The energy can be used in the various processes, for example, to generate electric power, heating, drying, etc. If the moisture content is present in any substance like Food, it has to be consumed before their spoilage; therefore it is required to dry it for a long time use.

The drying process is the oldest method for preserving food. In ancient time people dried the crops openly and in this method colour, quantity and quality of the product degraded. Now this technique is modified by using several technologies. The dry process is needed in various industries, basically in food and chemical industry. Not only industries, this process are used in agricultural area also, for drying seeds and crops. At present, the demand of drying technology is increasing mainly in medicinal plants, farming and food industries. The drying process is used to reduce the moisture content to the safe limit. The dryness percentage depends upon wetness or dryness basis in the agricultural produce. Table 1 shows the safe limit of moisture for the different crops [1].

The process of drying occurs in a closed chamber. Therefore, the quality and colour of crops are not affected. The drying process is done by using different ways like spray dryer, solar dryer, electrical dryer, mechanical dryer etc. there has been a rapid increase in the price of fossil fuel and thus, solar energy qualifies as a useful source of energy. Solar drying system is mainly of three types: direct, indirect and mixed dryer.

The Direct solar dryer uses direct sunlight to dry. Its design is simple, the operation/maintenance is also less and has ability to dry small quantities of crop. Hence, the direct solar dryer is made for smallholders. Fig. 1 shows the direct solar dryer system [2]. This model is designed and developed by Barnwal and Tiwari in 2008 having capacity of 100 kg. Thompson seedless grapes was dried in this model [3].

In Fig. 2 the indirect solar dryer system is shown. It consist of a collector of air, collector of solar radiation, an auxiliary heater, a fan for circulation and cabinet of drying. Indirect solar drying is the latest technique of drying. It is more efficient as compared to direct solar drying system. In indirect solar drying method; atmospheric air is heated with the help of collectors (flat plate or concentrated solar collector).This hot air flow in the cabin where the product is stored [4].

A Mixed dryer is the combination of direct and indirect solar drying method. In this method, the product is dried either indirect

Table 1
Various crops with their moisture content details [62].

Crop	Initial moisture content (wb%)	Final moisture content (wb%)	Maximum allowable temp. (1 °C)
Paddy, raw	22–24	11	50
Paddy, parboiled	30–35	13	50
Maize	35	15	60
Wheat	20	16	45
Corn	24	14	45
Rice	24	11	50
Pulses	20–22	9–10	50
Oil seed	20–25	7–9	40–60
Green Peas	80	5	40–60
Cauliflower	80	6	65
Carrot	70	5	65
Green beans	70	5	75
Onion	80	4	75
Garlic	80	4	55
Cabbage	80	4	55
Sweet Potato	75	7	75
Potatoes	75	7	75
Chilies	80	5	65
Apricot	85	18	65
Apples	80	24	70
Grapes	80	15–20	70
Bananas	80	15	70
Guavas	80	7	65
Okra	80	20	65
Pineapple	80	10	65
Tomatoes	96	10	60
Brinjal	95	6	60