



Analysis of energy consumption in microwave and convective drying process of multi-layered porous material inside a rectangular wave guide

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ABSTRACT

This work applies the first law of thermodynamics to estimate the ratio of energy utilization in microwave drying process using a rectangular waveguide. Two porous packed bed systems are considered such as attaching fine bed on coarse bed (F–C) and attaching coarse bed on fine bed (C–F). The effects of layered configuration and layered thickness on drying rate, power absorbed efficiency, specific energy consumption (SEC), and energy efficiency are studied in detail. The results show that the variations of all parameters have strongly affected on microwave penetration depth and power absorbed within the packed bed. Furthermore, F–C bed with equal layer thickness corresponds to great energy efficiency.

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1. Introduction

Energy used in the drying and heating process is important for production processes in the industrial and household sectors. However, the price of energy is extremely expensive; therefore, there are a strong incentive to invent processes that will use energy efficiently. Currently, widely used drying and heating processes are complicated and inefficient; moreover, it is generally damaging to the environment. What is needed is a simplified, lower-cost approach to this process one that will be replicable in a range of situations.

The conventional drying process had been a central subject for research and development was investigated by Maroulis et al. [1] where a study of drying parameter to apply the design for conveyor belt drying has carried out: a study by Men'Shutina et al. [2] focused on thermal efficiency in the conveyor belt dryer process, and Akpınar [3] analyzed the energy and exergy in red of pepper slices drying with a convective-type dryer.

For an analysis of energy consumption during applied microwave energy on heating and drying processes has been investigated by many researches. Sharma and Prasad [4], this study examined the specific energy consumption in microwave drying

of garlic cloves. The drying processes used to microwave and hot air drying in accordance with microwave oven for comparing specific energy consumption (SEC). Other important papers [1–13] were addressing the combined microwave energy and hot air drying processes for several kinds of dielectric materials. Such as Varith et al. [5], was studying of the combined microwave and hot air drying of peeled longan, which investigated the variation of moisture content and SEC in several drying conditions. Another important studied, Lakshmi et al. [6], was comparison the variation of SEC in cooking rice among the microwave oven, electric rice cooker and pressure cooker.

For theoretical research, Rattanadecho et al. [7] studied the influence of irradiation time, particle size, and initial moisture content on drying kinetics during microwave drying of multi-layered capillary porous materials in a rectangular waveguide. Feng et al. [8] carried out combined microwave and spouted bed drying process for diced apple. Experimental results of heat and mass transport were the compared to the results from a mathematical model.

From the previous works, the effects of sample structure and the SEC were minimal studied in drying processes. The objective of this study is to experimentally analyze the effects of layered configuration and layered thickness on the microwave drying of multi-layered porous packed bed with a rectangular waveguide. An operating frequency is 2.45 GHz. The knowledge gained will provide an understanding in porous media and the parameters which can help to reduce the SEC.

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