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ScienceDirect

Energy Procedia 138 (2017) 325–330

Energy Procedia

www.elsevier.com/locate/procedia

2017 International Conference on Alternative Energy in Developing Countries and Emerging Economies
2017 AEDCEE, 25-26 May 2017, Bangkok, Thailand

Improvement of Airflow Distribution in a Glutinous Rice Cracker Drying Cabinet

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Abstract

Fried glutinous rice cracker or Khaotan is one of the important traditional snacks for local Thai economy. When there is no sunlight, a dryer is usually employed in moisture removal process of Khaotan products. A traditional dryer is essentially a drying cabinet with multidirectional flow of hot flue gas from liquefied petroleum gas burner. In this work, an improved design using biomass energy with recirculation of unidirectional airflow inside the drying cabinet was developed. For this improved design of Khaotan dryer, airflow distribution was crucial in providing uniform drying condition and ensuring that all rice crackers were uniformly dried. Numerical simulation based on solving Navier-Stokes equations was carried out to predict airflows in the improved dryer. Swing panel was used to vary the direction of bulk air flow. Effects of swing angle (30, 45, and 60°) and air velocity (0.5, 1, 1.5 m/s) were investigated. Good airflow distributions without dead zone can be obtained from the simulation and implemented in experimental runs. Flow trajectories in the drying cabinet were found to give good agreement between prediction and experiments. With improved design and installation of swing panel, the times used to reduce the Khaotan moisture content to 10% dry basis and the operating cost in this process were reduced, hence, better energy efficiency.

Peer-review under responsibility of the scientific committee of the 2017 International Conference on Alternative Energy in Developing Countries and Emerging Economies.

Keywords: Khaotan drying; hot air oven; energy efficiency; flow modeling; biomass

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Peer-review under responsibility of the scientific committee of the 2017 International Conference on Alternative Energy in Developing Countries and Emerging Economies.
10.1016/j.egypro.2017.10.128

1. Introduction

Fried glutinous rice cracker or “Khaotan” is a traditional snack of local Thai communities. It is made from steamed glutinous rice mixed with flavoring agents such as watermelon juice, butter etc. Mixed rice then is molded into shapes (round, rectangle, or oval) at different sizes. Drying is the next process to reduce moisture of Khaotan. It is widely known that 10% remaining moisture content is the best product quality [1]. Finally, dried Khaotan is fried in palm oil and finished with sugar cane syrup or cereal covering. From the production steps, the most important process is drying. Method of drying affects final products, shelf life and quality. Solar energy is traditionally used in this process because it has low operating cost. However, it is necessary to use hot air dryer when there is no sunlight and during rainy season. Commercially available dryer used by traditional manufactures is a hot air dryer using liquefied petroleum gas (LPG) as fuel. Quality in terms of shrinkage ratio, expansion ratio, color, hardness, and crispness) of dried Khaotan from this type of dryer is normally worse than those from direct solar drying [2]. This may be due to flue gas from burning of LPG used for direct heating in the dryer. Another disadvantage of this dryer is high production costs. Hot air dryer using biomass as fuel is interesting for these problems.

Fig. 1 shows the biomass fired, hot air dryer developed by Chiang Mai University and the Khaotan loading truck. The dryer consists of two parts. The first part is heat generation from combustion of woody biomass in a furnace. The heat from flue gas and the furnace is exchanged with clean air inside the dryer via a tube bundle heat exchanger. The wall is made from galvanized iron sheets with thick foam insulation. The second part is hot air circulation driven by an axial fan. Initially, the developed dryer showed low performance with respect to air flow distribution, because there were dead zones or areas of low flows inside the drying cabinet. Dead zone areas had very low drying efficiency. Higher moisture released can be achieved at higher air velocity, resulting in faster drying time [3]. To improve the design of current Khaotan dryer, airflow distribution is crucial in providing uniform drying condition and ensuring that all rice crackers are uniformly dried. In this work, numerical analysis of flows inside the drying cabinet was carried out. Swing panel was installed to investigate the effect of swing angle and air velocity.

2. Methodology

2.1. Design of Swing Panel

The swing panel was designed to control the air flow trajectories inside the drying cabinet. The designed panel is shown in Fig. 2. The details of the size are; at lower part, a net width of 65 cm, and at upper part, a net width of 100 cm, and net height of 1.7 m. The panel was installed near the heat exchanger and beside the furnace.

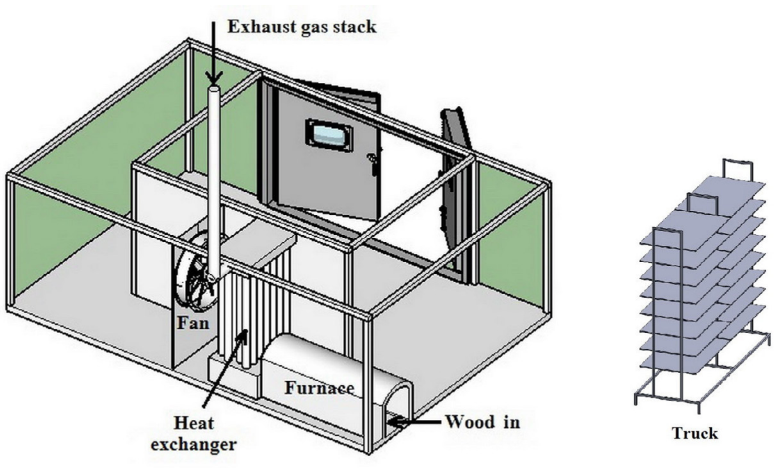

Fig. 1. Schematic of hot air dryer using biomass fuel.