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Temperature Profile and Moisture Content during Infrared Drying of Pelletized Rice Bran

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Abstract

This paper presented the experiment concerning the effect of height between infarred tube and the heating surface.The height of 20 cm, and 30 cm were selected. Height of 20 cm exhibited the most suitable distribution of temperature contour of 70°C. Two tubes with 18 cm, 24 cm and 30 cm distance between tubes was also studied. Contour plot of two tubes at the distance of 24 cm showed well distributed temperature of 70°C. Drying of pelletizied rice bran with different power current of 0.8, 0.7, 0.6, and 0.5 A at 20 cm height gave the results at moisture content of 8% (dry basis) with drying time of 15 min, 20 min, 24 min and 29 min respectively. With two tubes heating, time to dry rice bran pellet at 0.8 A and 0.6 A were 12 min and 16 min. It can be concluded that drying condition for pelletized rice bran from 18% to 8% moisture content took 15 min at the infrared power current of 0.8 A with 20 cm height for 1 tube and 12 min for 2 tubes at 24 cm aparted.

Keywords: Infrared drying, Pelletized rice bran, Temperature distributing.

1. Introduction

Rice bran oil is proved to be beneficial to human health. It contains Gramma-orazanol, antioxidation, tocotricnols or vitamin E and high in fatty acid (25%). However, extraction of oil from rice bran is a complex process. Rice bran is a by-product from milling paddy. The outer layer of the caryopsis of paddy was polished and collected. Rice bran contain high protein of 12-14%, Carbohydrate of 25-34%, and oil of 13-25%. Rice bran can turn rancid within 2-4 days due to oxidation of fatty acid. Enzyme lipase is mostly responsible for this rancidity. However, the oxidation can be suppressed using heat treatment. Heat extrusion involved steam heating is practice in oil extraction plant. Further drying with 60°C of hot air at least 30 minutes can reduce moisture content to 8% from 18% after heat extrusion. The pelletized cooked rice bran can be stored for longer period of time but it is mostly gone through extraction process within 3 days.

Radiation is one mean of heat transfer without medium. Electromagnetic wave directly transfers energy to an object and converts energy to heat to promote water evaporation from produces. However, Infrared radiation cannot deeply penetrate through the object. In fact, only a few mm from the surface of the object is effective (Erdogdu et al., 2015). Most of drying with Infrared undergo other mean of co-heating processes such as hot air or convective drying (Jain and Pathare, 2004; Sharma et al., 2005; Pathare and Sharma, 2006; Dondee et al., 2011; Ponkham et al., 2012; and Kumar et al., 2014) or microwave assisted (Glouannec et al., 2002; Wang and Sheng, 2006; and Motevali et al., 2011) and other heating methods (Mongpranee et al., 2002; Lin et al., 2005; Pan et al., 2008; Swasdisevi et al., 2009; and Vishwanathan et al., 2013) to satisfy completetion of drying requirement.

A number of studies used solely infrared drying were reported (Nowak and Lewicki, 2004; Khir et al., 2011). Togrul (2005) used a radiator to transmit a medium to short wave infrared to dry sliced apple of 1-2 mm thick. The temperature of 50°, 60°, 70° and 80°C were used. The average drying rate at 80°C was almost double of 50°C of heating temperature. For tomato by-product, Celma et al. (2009) used 400 VA infra-red radiator to dry Industrial tomato residues (ITR). ITR is a by-product used for feeding of cattle and sheep, or otherwise dumped in land field. Reduction of moisture is important to prevent fermentation that causes environmental irritations.

In this study, rice bran pellet, after stream extrusion, formed a cylindrical shape of 1-2 cm length with a little less than 0.5 cm in diameter was used as sample. The porous texture caused by stream infiltration was suitable for IR penetration; therefore, hot air assisted is unnecessary. Ventilation was provided for the removal of moisten air.

The objectives of this study are:

- To investigate temperature contour produced by IR element at different height between element and heating surface. The target is to find an appropriated height to get the most evenly distribution of temperature over the heating surface. The temperature should not be less than 60°C. The distance of 20 and 30 cm height were used in this study. After the height is identified, experiment using 2 elements was conducted, the distance between element to element at 18 cm, 24 cm and 30 cm were studied in order to see the combine effect. The result will be used to design a tunnel for continuous drying of pelletized rice bran. Contour maps of both experiments were presented.
- To investigate effects of infrared heating element quantity and power input on drying characteristics of rice bran pellet. Drying characteristic of rice bran pellet at appropriated height of one element at different power input regulated by current controller at 0.5, 0.6, 0.7 and 0.8 A was studied. For two elements heating, 0.8 and 0.6 A was reported.

2. Materials and Methods

2.1 Specimens.

Hot steam extruded rice bran was obtained from CEO Agrifood Company limited at Singhburi province, Thailand. It was allowed to cool to room temperature before put in P.P. bag of 10 kg. It was refrigerated at 5°C until the time of experiment. Before any experiment, rice bran pellet was spreaded until it reached room temperature.

Experiment apparatus

An insulated box of 40x50x60 cm^3 was constructed using plywood. A ceramic IR radiator of 500 watt was provided as heat source. Current controller was used to control heating power. Data logger (HIOKI 8422-51 MEMORY HILOGGER, JAPAN) with type K thermocouple was used to record temperature on heating surface. Inside air and ambient air temperature was measured for record keeping. For the two elements experiment, the heating surface was double in length to accommodate the distance. Fan with flow rate of 0.0142 $m^3 s^{-1}$ was provided for moistening air ventilation. Schematic drawing is shown in figure 1.

2.2 Experimental methods.

Objective 1 Temperature distribution

Ceramic IR was suspended over the heating surface. The height of the element was set at 20 cm and at 30 cm. The element was turned on for 30 minutes. Temperature was recorded. In two elements study, distances between two elements were placed at 18 cm, 24 cm and 30 cm.

Objective 2 Drying characteristics.

Pelletized rice bran was spreaded on the heating surface as thin layer. Sample was withdrawn every 3 minute for measurement of moisture content for 30 minute. Power current of 0.5, 0.6, 0.7, 0.8 A was varied. For two elements experiment, the sampling interval was every 2 min. Power current of 0.6 and 0.8 A were conducted.

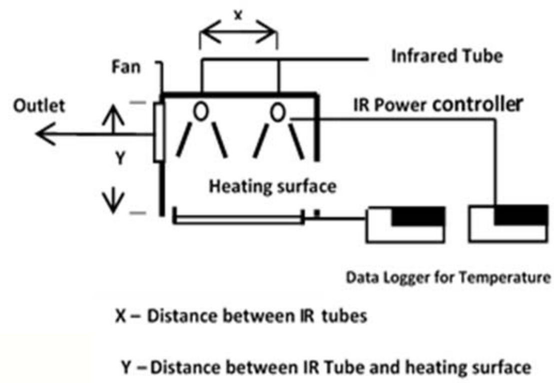

Figure 1. Shcamatics drawing of apparatus.

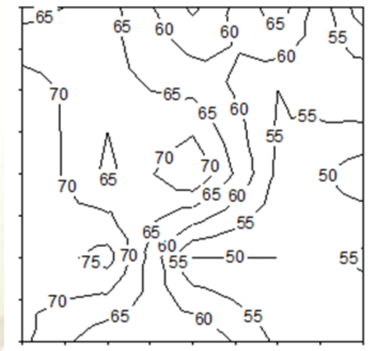

Figure 2. Contour of 1 element at 20 cm height

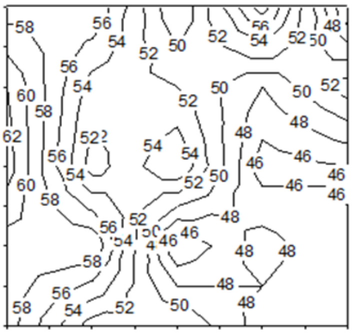

Figure 3. Contour of 1 element at 30 cm height

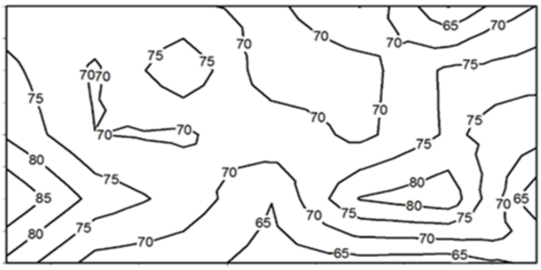

Figure 4. Contour of 2 elements at 18 cm apart.

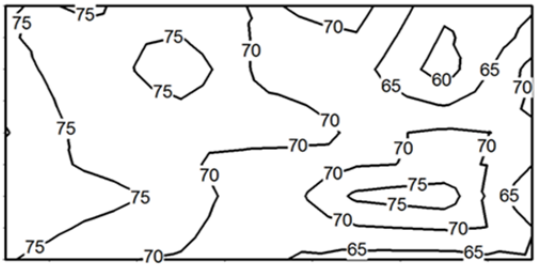

Figure 5. Contour of 2 elements at 24 cm apart.

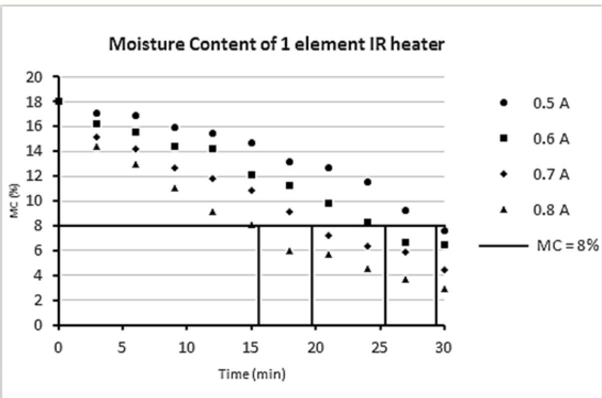

Figure 6. Contour of 2 elements at 30 cm apart.

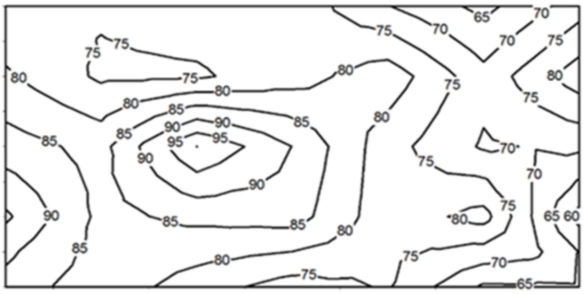

Figure 7. Moisture content of 1 element at 0.5, 0.6, 0.7 and 0.8 A

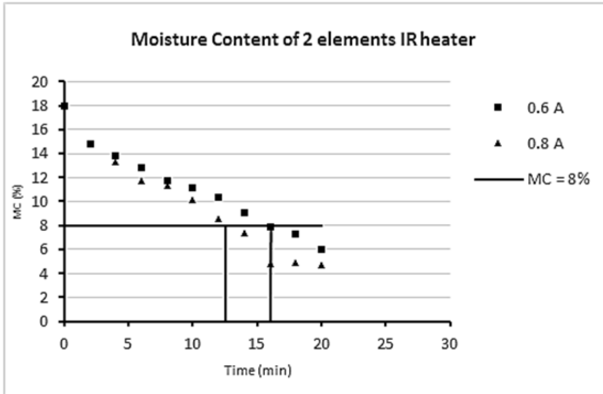

Figure 8. Moisture content of 2 elements at 0.6, and 0.8 A.

3. Results and Discussion

3.1 Objective 1 Temperature distribution.

Figure 2 showed the temperature contour of 20 cm height and figure 3 showed the contour of 30 cm. At 20 cm height, the temperature range between 60-70°C covered almost half of the area. Ventilation carried the air out through outlet, so that the higher temperature was shifted toward the outlet. The 30 cm height showed similar distribution but it did not meet the requirement of at least 60°C heating temperature. Therefore, the 20 cm height was chosen for the two elements heating. Figure 4 showed the contour of the distance of 18 cm which exhibited collection of high temperature of 90°C at the middle of heating suface so the distribution is not fulfilled. On the other hand, figure 6 of 30 cm distance, contour plot showed a clear separation of two high temperature area. So a well distributing of temperature did not meet the requirement. While in figure 5, the distance of 24 cm, contour plot showed more distribution temperature at approximately 70°C.

3.2 Objective 2 Drying characteristics.

Heating temperature of every current power continuously rise over drying period. The current of 0.5 and 0.6 A was stable while of 0.7 and 0.8 A show small temperature increase over time. After the energy was used to evaporated water from rice bran, further heating period will cause the increase of the pellet temperature. This result should be noted to prevent burning of rice bran if further heating proceeded. The incident was evident in figure 7 that rice bran pellet was dried to targeted moisture content of 8% (thicken line) in 15 minute for current of 0.8 A, 20 minute for 0.7 A, 24 minute for 0.6 A and 29 minute for 0.5 A respectively.

In heating with 2 elements, figure 8 showed that moisture content required at 8% were reached at 12 minute for 0.8 A and 16 minute for 0.6 A. It is not surprised that heating using 2 elements was faster than 1 element since the chamber is larger so it retained longer heat accumulation.

4. Conclusions

Distance between IR elements and heating surface suitable for drying of rice bran pellet was found at 20 cm. This height ensured the drying temperature of 70°C which appropriate for drying of pelletized rice bran as required by industry (compare to hot air convective blasting at 60°C). Power current of 0.8 A can dry rice bran pellet within 15 min. This is half of the time used in industry. Using of 2 elements shortened the time to 12 minute. This result showed a promising concept of using IR drying of pelletizes rice bran. Continuous process of drying rice bran pellet could be further investigated base on this finding. Compare to hot air (from heat exchange with steam), using infrared require less energy, less investment and more convenient to operate. Therefore the cost of rice bran production could be decreased.

5. Acknowledgements

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6. References

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