The development of rotary drum dryer for palm fruit sterilization

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Abstract. The aim of this research was to design and develop a rotary drum dryer for palm fruit sterilization. In this article, the results of the effect of ventilation hole number on the reduction of moisture content in palm fruit were presented. The experimental set up was a drum dryer which has 57.5 cm in diameter and 90 cm in length (the size was similar to 200-litre steel drum container). A driving gear and a gear motor rotated the drum dryer. The ventilation hole were drilled on the lateral side of the drum. The diameter of ventilation hole was 10 mm, and the number of ventilation hole were 18, 36 and 72 hole (each side was 9, 18 and 36 hole, respectively). In the experiment, the palm fruit was dried by using LPG to burn and heat the bottom of the drum. The flow rate of LPG was controlled to keep the temperature inside the drum steadily at 120°C.

1. Introduction
Oil palm is economic crop in many countries such as Indonesia, Thailand and Malaysia. It could provide mean income and economic development for living people. Oil palm could use 71 percent for foods (margarine, processed food, chocolate, etc), 24 percent for consumer products (cosmetics, detergents, candles, etc) and 5 percent for energy uses (electricity, heating fuels, etc). Oil palm become raw material for many kind of purposes because of its high pressure oxidation resistance, capability to dissolving chemicals insoluble, high coating power and does not irritation to the body for cosmetic uses.

Oil palm industry undergo two type of processes, the first one is the steam process which uses steam of 140°C for 75 – 90 minutes to stop free fatty acid formation and to soften the palm [1]. In this process it produces crude oil palm (CPO) and crude palm kernel oil (CPKO). Crude oil palm is obtained from mesocarp in orange color of oil palm while for crude palm kernel oil is came from kernel in the nut in white color. Crude oil palm is processed at oil palm milling machine and kernel were removed from nut is kind of byproduct of oil palm milling machine.

The second process is the batch sterilization that is mostly used in small factories. Mostly small factories in Thailand accept falling/defoliate fruit from farmers. That kind of falling fruit/defoliate fruit separated from fresh fruit bunch. During batch sterilization, oil palm was heating. This process will heat by grill. Hot air flow up by burning fuel, namely firewood or fuel oil (figure 1).
In the grilling process, several problems have been found in that oil palm was burned due to exposure to direct fire and not heated well. The palm fruit on the ground layer is dried faster than on the upper layer. During grilling process, workers should flip the oil palm from ground layer to the upper layer. In addition, it takes about 30 hours to dry oil palm fruit.

This kind of problem could be solved by designing a rotary drum dryer as shown in figure 2. The falling palm fruit is put into a rotating drum. Then it will be heated from below site. In commercial use, the heating fuel may be firewood. The rotating drum will rotate slowly. The oil palm is mixed together in rotating drum, which will transfer heat to oil palm fruit.

In past, rotary drum principle has been applied to herbal steam [2] however but the baking bin was sieve. This will lose a lot of hot air. In addition, Computational fluid dynamic (CFD) in study of particle dispersion behavior in rotary drum has been used [3]. The purpose of this research was to develop a rotary drum drying of oil palm, which has the advantage: (1) the drying oil palm not expose to smoke, (2) the drying oil palm is mixed in lower layer and upper layer. During drying process, the fuel of rotary drum are LPG. Initially, the effect of number 18, 36 and 72 (two sides) ventilation hole of the rotary drum on the moisture content of the palm fruit was studied.

2. Method
2.1 Experimental design
Figure 2 show prototype of rotary drum dryer used in the experiment. The rotating drum is made of sheet steel and rolls into a cylindrical shape. With a diameter of 57.5 cm and a length of 90 cm, the rotary drum is mounted on four supported bearings, with one top roller located opposite the drive gear. It serves the drum to rotate in a fixed position.

The roller on top and the gear set pressed with the spring set to adjust the press on the drum. The side of rotating drum has a gear set and a gear motor. It could adjust the rotation speed of the rotating drum.
using the inverter. The rotary drum slowly rotated at 1.68 rev/h and 8.34 rev/h to prevent palm fruit bruise from contusion that result in high FFA.

2.2 Experimental methods

Figure 3 shows a diagram of a rotary drum design. Oil palm fruit 50 kg dried for each batch. LPG was used to burn at the bottom of rotating drum by placing the four gas stoves at the bottom of the rotating drum, which directly heated.

In addition, a rotameters installed to measure the flow rate of LPG fuel for controlling the temperature inside the drum. Every gas pipe in the experiment controlled the flow rate of LPG fuel in order to keep the temperature inside the rotary drum constantly at 120°C (±3°C).

The 50-kg oil palms were load into the drum for drying. The 200-g oil palm sample was put into the small grill. This 200-g oil palm sample was included in those 50-kg oil palms. After finishing the drying, the 200-g oil palm sample was dried again in electric oven to evaluate the dry matter of the oil palm. During drying process, the drum including oil palm was weighed every 1 hour to evaluate moisture content of the oil palm. A data logger which was rotated together with drum was used to detect temperature inside the drum. The parameters in this study were (1) rotating speed of drum at 1.68 rev/h and 8.34 rev/h and (2) ventilation hole number (for releasing moisture) at 9, 18 and 36 for each cap of the drum.

Figure 3. Rotary drum experimental setup

2.3. Calculation of moisture content and moisture ratio

Percentage of moisture content (kg of water/kg of dry matter) was determined using the following equation:

\[
\%MC (db) = \left( \frac{W - D}{D} \right) \times 100
\]  

(1)

where W is weight of sample at every time, D is the dried weight of oil palm. In drying experiment, the initial moisture content compared to the different conditions. The moisture ratio is derived from following equation:

\[
MR = \frac{(M_t - M_{eq})}{(M_{in} - M_{eq})}
\]  

(2)

where \(M_t\) is the moisture content at time of drying, \(M_{eq}\) is final percentage of moisture content, \(M_{in}\) is initial of moisture content.
3. Results and Discussions

Figure 4 shows the effect of ventilation hole and rotating speed on the moisture content at different times. The results showed trend that various drying period of oil palm sample weight decreased. There is small effect of the number of ventilation hole and rotating speed, because of moisture content inside drum. Rotating speed of 1.68 rev/h with ventilation hole of 18 and 9 indicated similar trend but after 6 hours the temperature was increase. The initial moisture content was 12.69 % and reduced to 10.18 % and the ventilation hole 9 the moisture content reduced from 11.52 % to 7.25 % respectively.

![Figure 4. Moisture content of each cases](image1)

![Figure 5. Moisture ratio of each cases](image2)

The moisture content of rotation speed 1.68 rev/h with ventilation hole of 36 and rotating speed of 8.34 rev/h and ventilation hole of 9 it also changes due to temperature changes at 6 hours of drying. The initial moisture content was 17.23 % to 9.82 % followed by moisture content of rotary speed of 8.34 rev/h and ventilation hole of 9 also decrease from 18.89 % to 17.33 %. When the drying process
throughout passed 12 hours, it was found that, the sample weight dropped almost linearly then almost constant. In addition, LPG fuel consumption per hour in each cases ventilation hole of 36, 18, 9 namely 0.53 kg, 0.61 kg, 0.61 kg, while for rotating speed of 8.34 rev/h with 9 ventilation hole case was 0.56 kg. For drying process, it took about 13-14 hours for changing the color from yellow to brown and palm kernel from white to colorless.

4. Conclusion
In this research, the effect of ventilation hole and rotating speed of rotary drum dryer were studied on moisture content and moisture ratio of oil palm. According to this study, it has been found that for all ventilation hole and rotating speed showed small effect of moisture content and moisture ratio of each cases. For the lowest fuel consumption is case ventilation hole of 36 which is 0.53 kg per hour. This kind of visual appearance oil palm represent that oil palm could proceed to screw pressure machine. For drying in real factory, it takes up to 30 hours to achieve this condition. However, this article presents only preliminary result. This is needed further study for energy cost of drying process compare to factory.

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