Analysis of heating system on fluidized bed dryer for corn

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Abstract. This study aims to determine the heat produced from the heating system of the fluidized bed dryer on corn drying process and to calculate the thermal efficiency of the heating system. The method used was experimental with three variables of biomass of 3.5 kg, 4 kg and 5 kg. The corn initial moisture content of around 22% is used and the heating equipment used are a biomass furnace and heater. The parameters in this study are temperature, material moisture content, and thermal efficiency of heating system and biomass furnace. The biggest thermal efficiency of heating system at air velocity 12.19 m/s and material mass of 3.5 kg at 14.93%. The value of thermal efficiency of the largest biomass furnace system at air velocity 12.19 m/s and 3.5 kg material mass of 74.68%.

1. Introduction
Drying is the removal of water from a product and is an important unit operation. The reasons for drying are to preserve the product, modify product texture and reduce transport weight. The most important of these is preservation or extension of shelf life.

Drying of grains of agricultural products, usually done by rural communities by utilizing solar energy. Ambient temperature usually ranges from 30 °C, while drying for agricultural commodities has a temperature between 45-70 °C, therefore drying with direct sunlight will take a long time. In addition to taking a long time, drying by using solar energy has several disadvantages including it is easily contaminated, difficult to control, and requires a wide area.

Along with the development of technology, the artificial drying method also develops. One of the artificial dryer is a fluidized bed dryer [1-4] to increase the temperature in the drying chamber, the existing fluidized bed dryers are added heat exchangers along the hot air duct before entering the drying chamber. Heat exchanger is designed as much as possible for heat transfer between fluids takes place efficiently.

2. Method
The methodology used in this research is an experimental method. The two stages of the research procedure are:

2.1. Sample Preparation
Prepared shelled corn with an initial moisture content around 22%.
2.2. Research

The steps in this study are as follows:

- Prepared Fluidized Bed Dryer in a suitable position to be easy at work and prepared the candlenut shell as a biomass fuel.
- Turn on heater and biomass furnace
- The process of drying corn take place, air temperature between 40 °C – 50 °C and observed the temperature in every 10 minutes.
- Take data retrieval for each of the specified measuring parameters.

Research parameters

As for the research parameters to be used in the testing of heat energy analysis tool Fluidized Bed is among others:

- The temperature of each thermodigital point
- The temperature of each thermodigital point is the term used to describe each temperature measurement point on a fluidized bed drying device. The number of thermodigital dots used is as many as 8 temperature points spread from the heater heating system to the drying chamber.
- Analysis of the heating system efficiency

Thermal efficiency of biomass furnace (%) is a comparison of the amount of heat gained from the hazelnut shell with the amount of heat used to heat the material during the drying time.

\[ \eta = \frac{Q}{Q_{biomassa}} \times 100\% \] (1)

Drying efficiency (%) is a comparison between the amount of heat used to heat the material during the drying time with the amount of heat given during the drying process.

\[ \eta = \frac{Q}{q} \times 100\% \] (2)

**Figure 1.** \( T_1 = \) Temperature of blower; \( T_2 = \) Temperature of Heater; \( T_3 = \) Temperature of inlet water to spiral pipe; \( T_4 = \) Temperature of plenum pipe; \( T_5 = \) Temperature of water out of spiral pipe; \( T_6 \) dan \( T_7 = \) Temperature of inlet of drying chamber; \( T_8 = \) Temperature of the bottom of drying chamber; \( T_9 = \) Temperature of the middle of drying chamber; \( T_{10} = \) Temperature of outlet of drying chamber
3. Result and Discussion

Temperature is one of the very important factors in the drying process using an artificial dryer. The greater the temperature flowing to the dryer space and the air speed provided the larger it will accelerate the drying process of agricultural materials.

The thermal efficiency of the biomass furnace is a comparison of the amount of heat obtained from the candlenut shell in the biomass furnace with the amount of heat used to heat the material during drying time. Biomass furnace serves as a heat producer utilizing biomass in the form of a candlenut shell as a fuel. The higher the heat produced from the biomass furnace then the heating rate of the material will be better, it can be seen from the thermal efficiency of the resulting biomass furnace.

Table 1. Thermal Efficiency of Biomass Furnace Heater

| Mass (kg) | 12.19 m/s | 16.25 m/s | 19.27 m/s |
|-----------|-----------|-----------|-----------|
| 1.5       | 55.39     | 41.39     | 38.27     |
| 2.5       | 58.30     | 46.79     | 40.14     |
| 3.5       | 74.68     | 59.01     | 51.39     |

The drying efficiency can be calculated based on the amount of heat used divided by the number of heat given the air to heat the material. From the result of data calculation, obtained efficiency value of drying as follows:

Table 2. Drying Efficiency

| Mass (kg) | 12.19 m/s | 16.25 m/s | 19.27 m/s |
|-----------|-----------|-----------|-----------|
| 1.5       | 68.73     | 51.36     | 47.49     |
| 2.5       | 74.14     | 59.50     | 51.05     |
| 3.5       | 94.7      | 74.82     | 65.16     |

The table above shows the value of the largest drying efficiency at 12.19 m/s airflow speed and 5 kg biomass of 94.7% and the lowest efficiency value of the air flow speed of 19.27 m/s and the biomass 3.5 kg of 47.49%. This indicates that the higher the airflow speed, the lower the efficiency value.

4. Conclusion

The value of biomass furnace efficiency and highest drying efficiency is obtained at the lowest airflow speed.

5. References

[1] Syahrul S, Mirmanto M, Hartawan, Y and Sukmawaty 2019 Heat Mass Transfer 55 293 https://doi.org/10.1007/s00231-018-2414-3
[2] Sukmawaty, Yuni A, Rahmat S, Mirmanto and Syahrul 2018 International Journal of Mechanical Engineering and Technology (IJMET). 9 (11) 1501-1510
[3] Mirmanto, Syahrul, Sulistyowati ED, and Okariwan IDK 2017 Effect of Inlet Temperature and Ventilation on Heat Transfer Rate and Water Content Removal of Red Chilies Journal of Mechanical Science and Technology. 31(3) 1531-1537
[4] Syahrul and Sukmawaty 2016 The Effect of Initial Mass of Shelled Corn for Fluidized Bed Drying System International Journal on Smart Material and Mechatronics IJSM 3

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