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# ASH HOLE VARIATION IN RICE HUSK BIOMASS FURNACE WITH PARALLEL FLOW HEAT EXCHANGER TO DRYING BOX TEMPERATURE

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## ABSTRACT

The process of drying food ingredients naturally has an impact on the low quality of the products due to the non-optimal drying temperature. Moreover, in the rainy or cloudy day, the drying process cannot be carried out. In addition, for the rural communities, the drying process that is done automatically or using mechanization is difficult to be done because of the high operational costs. In this way the method of conversion of rice husk biomass energy using a furnace equipped with ash holes and heat exchangers are placed inside the furnace. The results of this research revealed that on several furnace ash hole diameters were found that the larger the hole diameter of the ash hole is directly proportional to increase the drying box temperature. For the ash holes with a 12 mm in diameter, the mean temperature and highest temperature of the drying box were 72.79 $^{o}$C and 109.20 $^{o}$C respectively.

**Keywords:** ash hole, biomass, rice husk, heat exchanger.

## INTRODUCTION

Drying of foodstuffs carried out in a household scale is still traditional, namely drying directly in the sun light. Drying a product directly in the sun light has many disadvantages such as when rainy days the harvest will be damaged, requires a large area, the product is unhygienic, susceptible to animal disturbance, temperature and drying time are not optimal. So that the drying furnace is needed as a substitute for the traditional drying process.

Drying process is a way to remove or discharge part of the water from a foodstuffs with or without the help of heat energy. Stated that drying in general can be carried out through direct sun drying, which it is dried directly in the sunlight and dried with a dryer or it is placed in a drying chamber [1]. In the drying process, the heat transfer process will occur, that is the heat flowed will increase the lower temperature in the material to be dried, and there will be a mass transfer as well, that is a process due to there is a different on the relative humidityof the drying air is lower than the relative humidity of the material to be dried.

Research on the drying process for food or handling postharvest has been carried out. Designed a model unit consisting of the upper zone for exhaust gas flow and cold air flow, the lower zone for solid biomass combustion with the upper part of the gas to gas heat exchanger, the model unit for the drying process of 2.5 kg of falmic fiber [2]. Study comparing forced convection solar dryers with 2m$^2$ designed natural and collector areas used to dry chilies and grapes [3]. The result showed that solar dryers with forced convection have better drying speed and quality compared to natural convection. The drying process with solar power has the disadvantage of being very weather dependent so that the drying continuity cannot be maintained.

Dealing with uncertainty of whether conditions, such as cloudy or rainy condition, so the heat exchangers and biomasses are used. The heat exchanger serves to convert hot air from the combustion of biomass in the furnace into the drying chamber. Heat exchanger is a tool used for the implementation of heat exchange between two fluids that have temperature differences and are separated by walls [4]. Biomass is an organic material derived from living things, both plants and animals and agricultural waste.

Susana research resulted in an average temperature of 41.30$^{o}$C in the drying chamber with a load of 20 kg of anchovy through the process of energy conversion from the combustion biomass of coconut fiber in the furnace with a heat exchanger which was placed separately from the furnace which serves to convey hot air to in the drying box [5]. Utilization of biomass provides added value from agricultural waste such as rice husk waste. Rice husk is very useful as a substitute for fossil fuel fuels. In Quispe and Navia it is stated that rice husks have a heating value of 11-15.3 mJ/kg [6]. Susana *et al.* conducted research on the use of rice husks as fuel with a heat exchanger mechanism. In this study, to obtain the optimal temperature in the drying box was tested for variations in the number of heat exchanger pipes and the distance of the hole in the furnace wall, and the highest temperature in the drying chamber was obtained in the furnace with a number of heat exchanger pipes 9 with a distance between holes 50 mm [7].

In this study rice husk waste was used as a source of drying energy. The drying process utilized thermal energy generated through the conversion of rice husk biomass energy by using a furnace to burn rice husk biomass and heat exchangers. To increase the drying temperature, variations were made to the ash hole of the biomass burning furnace.

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## MATERIAL AND METHODS

This research using materials includes rice husk biomass, heat exchanger, furnace and drying box. The process of burning rice husk biomass using a furnace and inside the furnace is placed in a heat exchanger. Hot air generated in heat exchanger pipes is transferred into a drying box for drying. This research is a further study of Susana *et al*. [7]. In this study the biomass combustion furnace is equipped with ash holes to makes it easier to remove the ash of combustion out from the furnace and improves the heat transfer process in the heat exchanger. Ash holes are placed on the bottom of the furnace and varied with several diameters covering 0.8 cm, 1 cm, and 1.2 cm as shown in Figure-1.

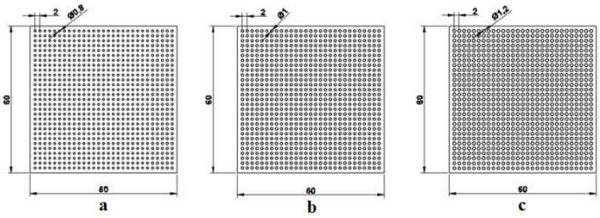


**Figure-1.** Variation of hole diameter of ash of biomass combustion furnace a) 0.8 cm, b) 1.0 cm, c) 1.2 cm.

The type of heat exchanger used is parallel with the number of 9 pipes and one fluid flow path. Heat exchanger pipes are steel pipes 25.4 mm in diameter and placed at the bottom of the furnace connected to the drying box. The tests are carried out for the drying box in a no-load state. Schematic research as presented in Figure-2.

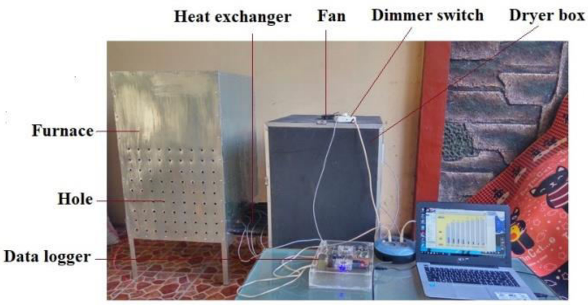


**Figure-2.** Schematic research set up.

The dimensions of the furnace are 500 mm x 500 mm x 800 mm with the furnace wall equipped with air circulation holes. The Stove has capacity of 20 kg of rice husk for one cycle combustion process. The drying box has a dimension of 500 mm x 500 mm x 600 mm made of steel sheet and rubber isolation. Air circulation in the drying box was forced convection system using a fan that placed on the upper wall of the drying box. Data observed included the heat exchanger pipe temperature, drying box temperature, ambient temperature, and time of combustion of rice husk.

## RESULTS AND DISCUSSIONS

This study utilizes rice husk biomass as an energy source with a mass of 20 kg for one cycle of the combustion process. Ash holes variations in the furnace with a diameter of 8 mm, 10 mm, and 12 mm have an effect on the duration of the combustion process of rice husk biomass and the temperature of the drying box.

The furnace capacity of 20 kg of rice husk biomass or at 800 mm level showed that the ash hole with a diameter of 8 mm gave the longest combustion time of 720 minutes and the ash hole with a diameter 12 mm gave combustion times of 590 minutes, as depicted in Figure-3.

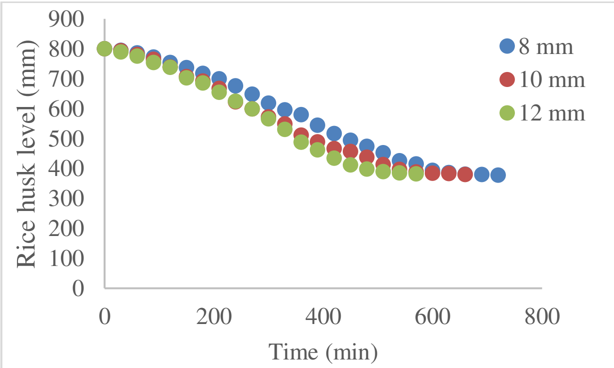


**Figure-3.** Comparison of combustion time of rice husk biomass at 8 mm, 10 mm, 12 mm ash holes diameters.

On the furnace with 8 mm ash hole diameter as presented in Figure-4, the highest heat exchanger temperature reached 228°C and the highest temperature in the drying box reached 100.6°C with the ambient temperature of 31.60°C and the combustion time was 720 minutes.

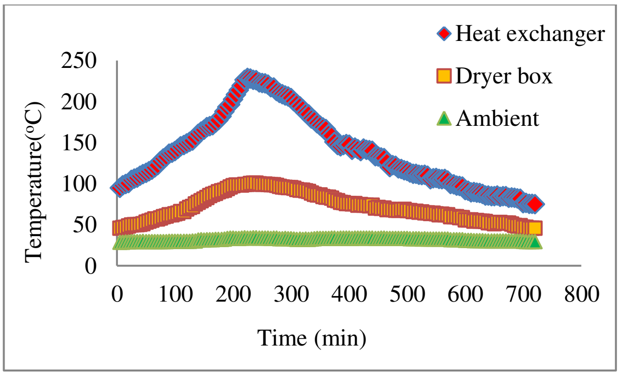


**Figure-4.** Comparison of time with temperature for the furnace with an 8 mm ash hole diameter.

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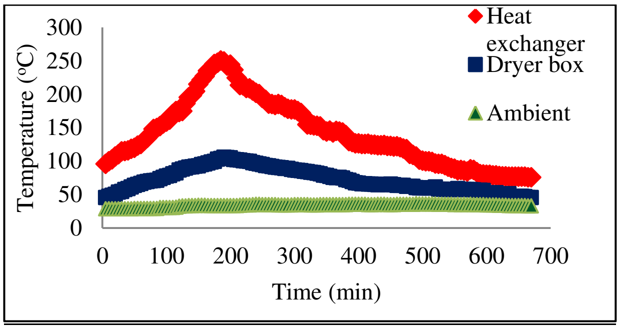


**Figure-5.** Time comparison with temperature for a furnace with a hole diameter of 10 mm.

Figure-5 shows the temperature distribution of the heat exchanger, drying box, and ambient of the furnace with a hole diameter of 10 mm. Rice husks were burned in the furnace for 670 minutes. The highest temperature in the heat exchanger reached 250°C and in the drying box was 105.4°C and the ambient temperature was 33.60°C.

Temperature distribution of heat exchanger, drying box, and ambient in the furnace with 12 mm ash hole diameter are presented in Figure-6. The highest temperature of heat exchanger reached 287.1°C and drying box was 109.2°C and the ambient temperature was 32.32°C. Rice husk was burned in the furnace for 590 minutes. The highest temperature in the drying box occurred in the largest diameter ash hole. This is directly proportional to the temperature of the heat exchanger which is higher with the enlargement of the diameter of the ash hole of the furnace. On the contrary, the burning time of rice husk biomass becomes faster, with the increasing diameter of the ash hole, the faster the rice husk burning in the furnace.

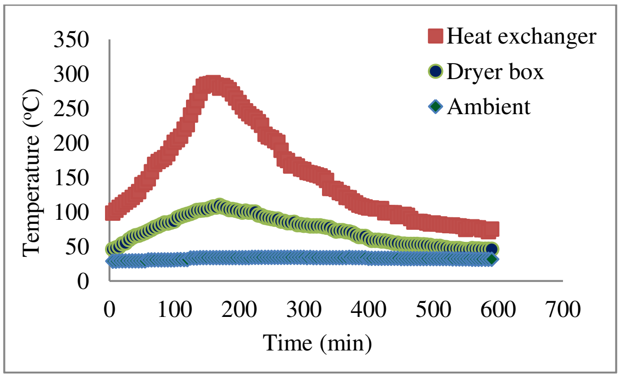


**Figure-6.** Comparison of time to temperature for a furnace with an ash diameter of 12 mm.

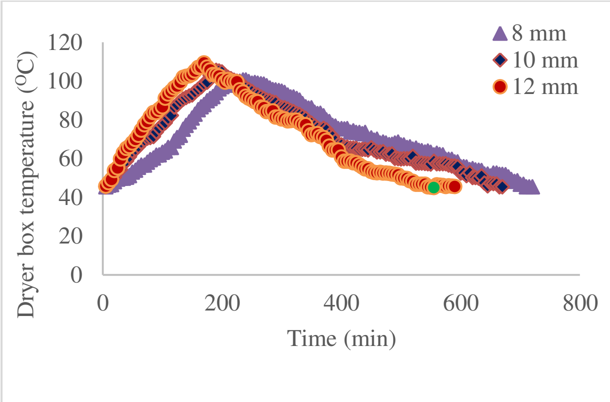


**Figure-7.** Comparison of time to drying room temperature at 8 mm, 10 mm and 12 mm ash hole diameters.

Figure-7 shows the comparison of the temperature of the drying chamber to the burning time of rice husk biomass in the variation of the diameter of the furnace ash hole. At the beginning of the burning process of rice husk biomass up to 200 minutes, the diameter of the 12 mm furnace ash hole tend to increase the temperature of the drying box higher than the diameter of the ash hole 8 mm and 10 mm. After that point, the ash hole diameter of 12 mm gave a lower trend of drying box temperature compared to the diameter of the ash hole 8 mm and 10 mm. This is due to the combustion process of rice husk biomass in the furnace with 12 mm ash hole diameter has a shorter combustion time, so that the temperature decreases faster. Generally, the furnace with 12 mm ash hole diameter gave higher temperatures than the furnace with 8 mm and 10 mm ash hole diameters. It can be seen as in Figure-8.

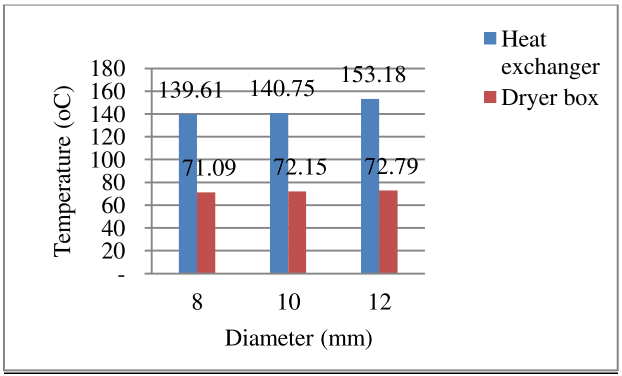


**Figure-8.** Comparison of ash hole diameter to mean temperature of drying chamber and heat exchanger.

This study showed that the better drying box temperature compared to the research conducted by Susana *et al.* [7]. In Susana *et al* research, the average temperature of the drying chamber was obtained 71.10°C and the highest temperature of the drying box reached 100.60°C, whereas in this study the mean temperature of the drying box reached 72.79°C and the highest temperature of the drying box reached 109.20°C. This increase in temperature as a result of the addition of ash holes in the furnace and the larger diameter ash holes resulted the higher temperatures.

## CONCLUSIONS

To increase the added value of waste and create energy independence, especially for farmers and household businesses through thermal energy, it can be done by using the conversion of rice husk biomass energy with heat exchanger mechanism. Based on the test results concluded that the addition of the ash hole in the furnace can increase the temperature of the drying box. The greater the diameter of the ash hole, the higher temperature of the heat exchanger and drying box will increase, however the burning time of rice husk biomass is faster.

## SUGGESTIONS

To keep the temperature stable in the heat exchanger and drying chamber, it is necessary to add the ash removal mechanism inside the furnace so that rice husk biomass can be continuously added to the furnace.

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## REFERENCES

[1] Heruwati E.S. 2002. Pengolahan Ikan Secara Tradisional, Prospek dan Peluang Pengembangan, Pusat Riset Pengolahan Produk dan Sosial Ekonomi Kelautan dan Perikanan. Jurnal Litbang Pertanian. 21(3): 92-99.

[2] Yunus Y.M., Al-Kayiem H.H. and Albaharin K.A.K. 2011. Design of a Biomass Burner/Gas-to-gas Heat Exchanger for Thermal Backup of a Solar Dryer. Journal of Applied Science. 11(11): 1929-1936.

[3] Sushrut S.H., Prajwal S., Naveen H., Karthik H. and Siddharth G. 2015. Experimental analysis of solar air dryer for agriculture products. International Research Journal of Engineering and Technology. 2(3): 1517-1523.

[4] Incropera F.P., DeWitt D.P., Bergman T. and Lavine A. 2006. Fundamental of Heat and Mass Transfer. Sixth Edition. New York: John Wiley & Sons.

[5] Susana I.G.B. 2018. Improve of Worker Performance and Quality of Anchovy with Ergonomic Hybrid Solar Dryer. ARPN Journal of Engineering and Applied Sciences. 13(5): 1662-1667.

[6] Quispe I. and Navia R. 2017. Energy Potential from Rice Husk through Direct Combustion and Fast Pyrolysis: A Review. Waste Manag. 59: 200-210.

[7] Susana I.G.B., Yudhyadi I.G.N.K., Alit I.B., Mirmanto and Okariawan I.D.K. 2017. Effect of Hole Spacing and Number of Pipe on Dryer Box Temperature. International Journal of Mechanical Engineering and Technology. 8(11): 1029-1035.