Experimental Study of Paddy Grain Drying in Continuous Recirculation System Pneumatic Conveyor

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Abstract. Nowadays, paddy drying using conventional method is irrelevant to used. The increasing need of grain each year is one of the main factor that pushes scientist to invent new methods of drying paddy grain. The old method is unusefull since it takes up space, needed the sun as the drying media which causes a long drying time. One of the alternative of drying paddy grain is by using mechanic dryer. By using this dryer type, the process of drying takes faster comparing to the old method and the distribution of grain is supplied continuously. The dryer which uses pneumatic conveyor can be one of the solution due to its less energy consumption, a better drying result, and high drying capacity. The variable used to identify drying performance is temperature and loading weight. From the experiment, it is resulted that the best temperature for drying paddy grain is 60^0C with the weight loading of 150 gram.

1 Introduction

Indonesia is the largest rice consuming country in ASEAN with the numbers 132 kg per capita per year. In 2006, demand for rice in Indonesia increased by 1.6 % per year [7]. The amount of demand for rice in Indonesia requires the development of quality and quantity of rice product. High humidity causes paddy easy to deteriorated, especially in tropical areas [8]. In the rainy season paddy drying can not run optimally, causing decay and decrease the quantity of quality rice.

During this process the grain dried sorted performed in a conventional manner, by direct heating under sunlight on the floor. Conventional drying spend 3-8 days and greatly depends on the intensity of solar radiation [1]. Continuous recirculation drying technology conveyor pneumatic type is a mechanical dryers as an alternative to the previous dryers. This type advantage is recirculation during drying of grain moving at constant speed. Thus the grain to be dried and the dried grain can be maintained at a consistent drying rate of the drying capacity. Recirculation systems that run continuously can help prevent over-drying, drying time is short, high percentage of head rice, grouts bit, and can homogenize paddy drying results [3]. In addition, the tool is not dependent on the season, the capacity of drying has a uniform moisture content, grain condition is not damaged due to sudden changes in temperature (thermal shock), as well as small operating costs and small area required [1].

This research studied the effect of drying air temperature and drying load (load) on the rate of grain drying system with a pneumatic conveyor dryer recirculation type. By reviewing these two variables, expected to be known the optimum conditions that can be used in a predetermined range of values. In addition drying rice profile obtained by a pneumatic conveyor dryer recirculation type.

2 Materials and methods

The raw material used is grain obtained from paddy fields in the area Meteseh, Semarang, central Java, Indonesia. The series of recirculating dryers pneumatic conveyor type equipped by temperature sensors and humidity gauges. Scheme of dryers illustrating in figure 1. The experimental procedure as follows : Wet grain crops incorporated into the winnowing machine, cleaned, and weighed as much as 20 kg of each variable. Turning on the heater blower and continuous recirculation dryer pneumatic conveyor type then heated to the desired temperature variable is obtained. Then enter the appropriate grain into the hopper in desired mass variable. Running circulation of grain in the dryer for the desired time variable. During the process, temperature and flow of the material is kept constant and measured the temperature of the drying air out, air humidity, and temperature of rice grains every 5 minutes. Once the process is completed the tool is switched off and the grain removed. Measured the weight of the grain. The level of air moistrure is checked by Kett moisture tester. Repeating the steps above for the other variables.

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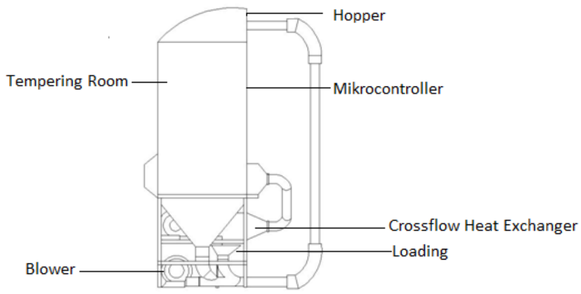

Fig 1. Scheme of paddy drier resirculation type

3 Result and discussion

3.1. Effect of inlet air temperature to the moisture content of grain

From figure 2, it can be seen that the water content of the material (x) will decrease with the decreasing drying rate and constant rate drying over time. Longer drying time will entrained amount of water from material more and more. According to Mujumdar 2004, the mechanism of water evaporation in the material occurs through heat and mass transfer process simultaneously, among others [5] :

1. Convection heat transfer from the air to the grain surface to evaporate the water in the grain surface.
2. Heat conduction from the surface of the grains into the grain.
3. Mass transfer of water from the granules to the surface diffusion or capillary.
4. Mass transfer of water from the surface of the grain to the drying air.

Decrease rate of water content of material is affected by mass and heat transfer process of moisture grain surface. Water displacement in grain surface occurs due to temperature difference on the surface of grains with air conditioning, causing driving force to move the water content in surface materials to the drying air in the form of moisture. The rate of decline relatively quickly and occurred for a short time. It is because during this period, only temperature difference with the material which affects and aren't influenced by thick of medium drying materials and water diffusivity in the material. At the same drying air temperature, it appears that the increase of drying loads number caused moisture content release of the material become smaller. It's because for the same amount of heat, the amount of water vapor that is released from the material will be greater. With the increase of quantity of water vapor, the amount of water vapor released per unit of time will be smaller.

This phenomenon also occurs in the drying material with the same load on the temperature variation of 40, 50, 60 ^{0}C. Seen in the figure 2 that as the temperature rises, the amount of water vapor that is released from the material per unit time was greater. As the temperature increases, the amount of heat used in the drying process the greater. The greater amount of heat will result in water diffusivity of material towards dryers media increased. This is consistent with the proposed drying mechanism of Mujumdar (2004), that the water diffusivity in the solid material is a function of temperature and moisture content [5-6].

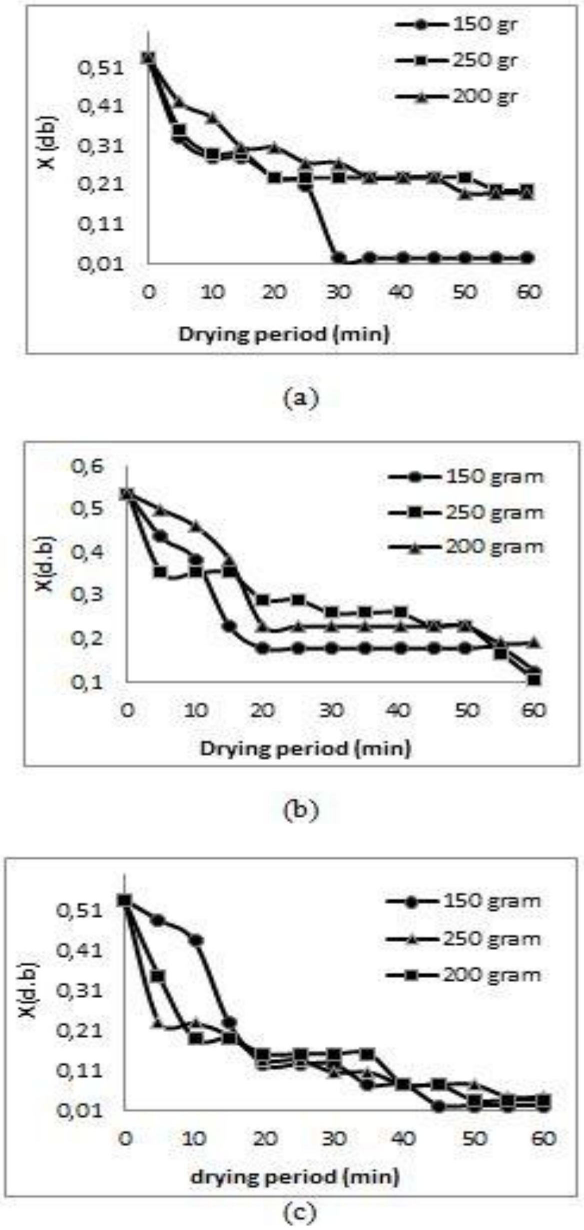

Fig 2. Grain drying grain moisture content (x) at various drying load with drying air temperature (a) 40^{0}C, (b) 50^{0}C, (c) 60^{0}C

3.2 Dynamics of drying out the air temperature

In figure 3, it is seen that drying air temperature will increase over time. When examined further, at the same temperature with different drying load variation, more mass of material drying caused exit air drying temperature smaller. It can be seen in temperature difference every minute for air conditioning in each drying load variations. For comparison, at 60^{0}C appears that the value of exit air drying temperature at 5 minutes early with a load of 150 grams is 59.23^{0}C while 250 gram load is 58.09^{0}C, decrease of 1.14 ^{0}C.

More material drying load has more moisture content to be evaporated, so the heat required will also greater and exit drying air temperature will be smaller.

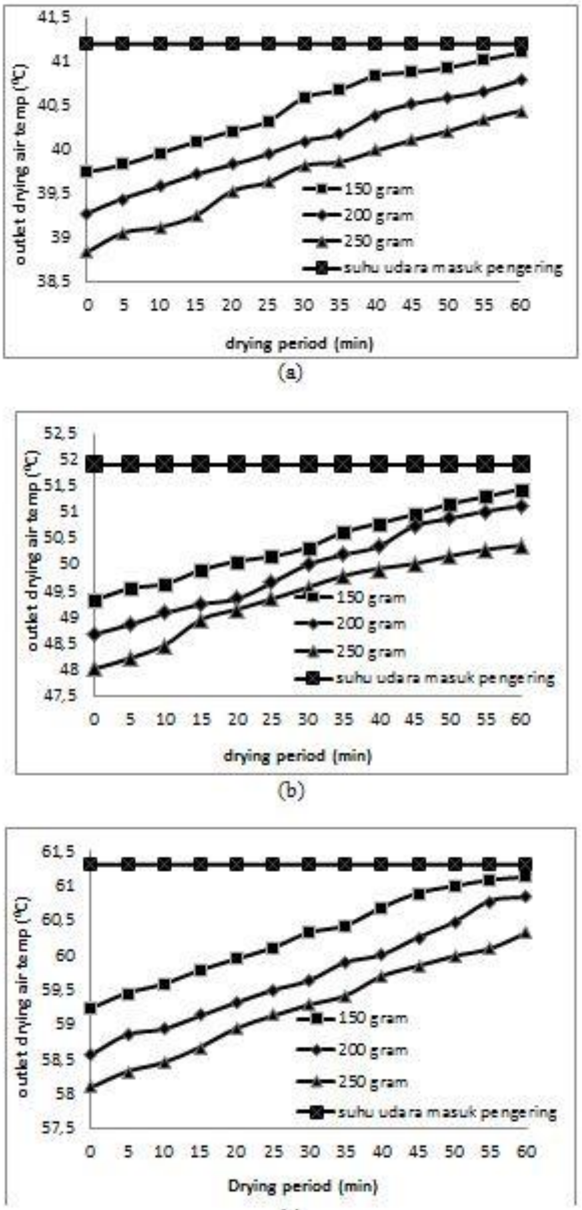

Fig 3. The results of grain drying for dynamic of outlet drying air temperature on various drying loads with drying air temperature (a) 40^0C, (b) 50^0C, (c) 60^0C

In the drying temperature variations with the same drying load seen that the higher air temperature entering dryer, the exit air temperature will rise to near dryer temperature when empty yet filled materials. It due to longer drying time will reduced water content in materials so that less heat is used. When heat is needed less, the exit dryer temperature will rise closer to the air temperature in the dryer when empty. In the drier, temperature distribution in the material will uniform so can accelerate the rate of heat transfer from the air to the material. Moreover, it also can be seen that at the beginning of drying process, occurs temperature gradient between temperature of the empty dryer and temperature when filled materials. Gradient occurs because the heat provided by drying air is used to evaporate water in the material and heat transfer mechanism occurs by convection, and conduction causing the exit air drying temperature be lower than currently empty.

3.3 The dynamics of granular temperature drying results

Based on figure 4 can be seen that temperature of particles on the grain in temperature and load variations will increase along increasing drying time and air temperature. Particle temperature will rise faster from initial temperature in the beginning of drying. It is because at beginning of drying water that vaporized on the surface particle decreases more and more until the end of drying. The reduced of water vaporized caused by water content on the surface have been unable to form a continuous film layer, so that heat conduction used by materials to provide driving force in order to water inside material diffuses out. At the same temperature with drying load variations, it is seen that the temperature will decrease with increasing particle drying load. It happens because the same amount of heat used to dry larger mass of material so the heat transfer process will result in decrease particle temperature.

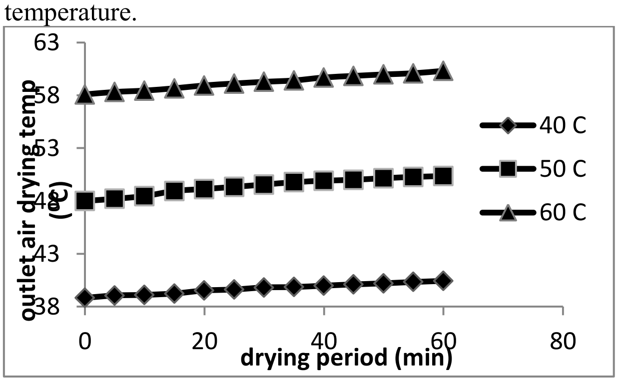

Fig 4. The results for grain drying for dynamic of outlet drying air temperature on drying loads 250 grams with various inlet air temperatures

In the first 5 minutes of drying process with same temperature and load variations drying temperature gradients obtained are quite high, but when 50 minutes the temperature gradient begins to diminish. For example drying temperature 60^0C, in the first 5 minutes occurred temperature gradient 10.33^0C and at 50 minutes become 15.77^0C. This phenomenon can be explained by basic mechanism of drying. At the beginning of drying process where the surface moisture content begin vaporized, the particle temperature will rise rapidly due to mass and heat transfer mechanisms that will form a water vapor continuous film on the surface. With the formation of water film, the heat will be used to release water on the surface and the measured temperature is it's film temperature. Along with increasing drying period, the particles temperature will be nearly constant because the main process is water vapor diffusion in heading out material. This process utilizes heat conduction of the material itself.

Therefore, the particle temperature gradient progressively smaller and tends towards constant .

Another point to be observed is that in the same drying load with dryer air temperature variations, it is seen that drying air temperature increases will further increase particles temperature. An increase of 27% in 5 minutes early looks at 40^0C towards 60^0C. The temperature rise in accordance with the basic drying law that drying is a function temperature and increasing drying air temperature used will cause heat transferred to material greater and rise the material temperature itself.

3.4 Effect of inlet air temperature of the air humidity

In figure 5 shows that over drying process the % RH will decrease. Decreased % RH is influenced by increase in air temperature [4]. At the beginning of drying process the air humidity is high because large amount of entrained water from the particles. Air humidity will decrease until the end of drying process because entrained water from particle fewer. Moreover, greater air temperature will decrease water vapor content of air due to water evaporation capacity will be greater while water contained in the air constant anyway.

At the same temperature with drying load variations, it appears that the increasing drying load will increase relative humidity drying air. Its look from %RH gradient at each load. For example in the first 5 minutes, the value of %RH at 40^0C is 35.45 %RH and at 50 ^{0}C the value is decreased by 53.8 % become 16.37 %RH, then at 60^0C the value of %RH become 8.49 %. It is because more drying load will release more water vapor from material to air conditioning. Thus, the air conditioning will acquire additional water vapor from water vapor material that has been released and will add value of drying air relative humidity.

In figure 6 shows that at temperature variations with same drying load the higher air temperature dryer used will decrease the relative humidity. In addition, in line with increase in temperature, relative humidity of the air will be smaller. This is consistent with the relationship of air - water systems in the psychometrics diagram. With rising temperatures, the ability of the air to evaporate water in the material will be even greater. Furthermore, the amount of vaporized water vapor in the air will change into vapor so the moisture content in the air will be less when compared to increase ability to evaporate moisture and % RH is getting smaller. When compared with air at room temperature, with the same amount of water, air with higher temperature will be able to get more water vapor [2].

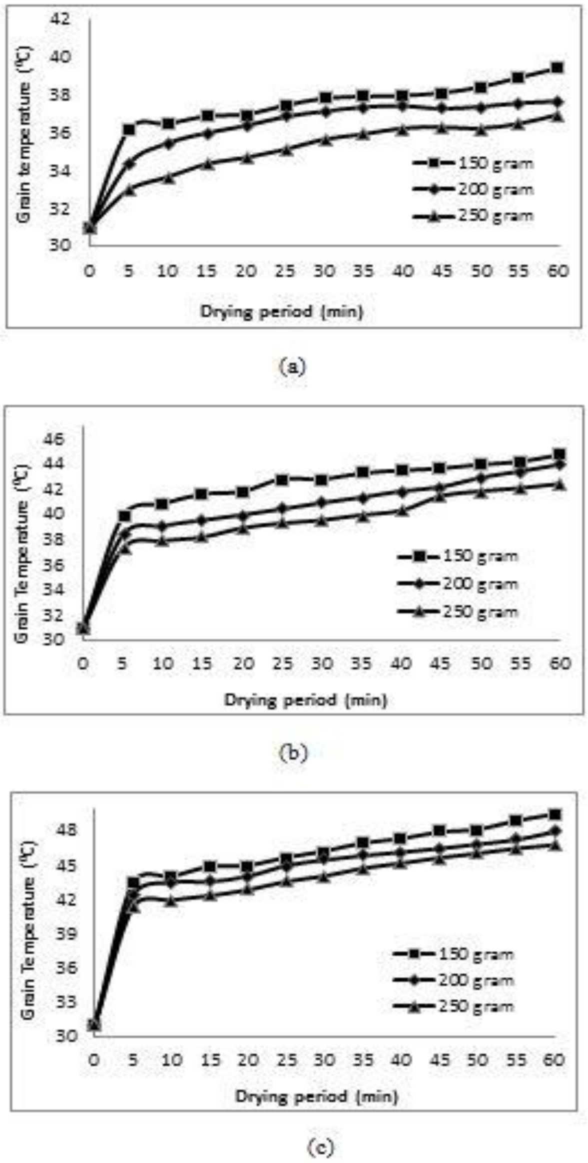

Fig 5. Results for grain drying for dynamic of grain temperature at various drying loads with air temperature (a) 40^0C, (b) 50^0C, (c) 60^0C

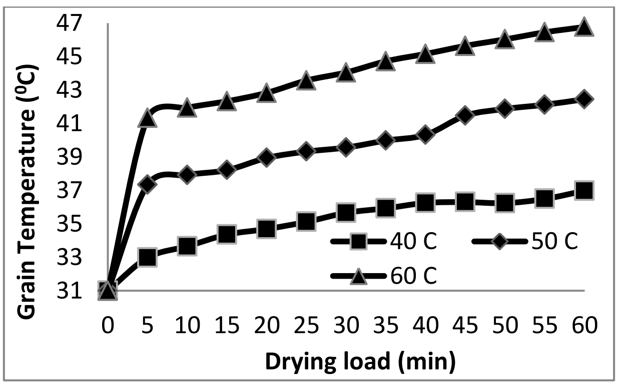

Fig 6. The result of grain drying for dynamics of grain drying temperature on the drying loads 250 grams with different inlet air temperatures

[17].

4 Conclusions

Total drying time to result moisture content 14%, is faster then sun drying that took 2-3 days and it depends on weather. Drying air temperature about 60 ^{0}C obtained 72 -74.3% head rice rendement, while direct drying resulted head rice rendement of 68 – 72 %, in bright weather.

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