Application of hybrid solar dryer for supporting community business on the new normal era

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Application of hybrid solar dryer for supporting community business on the new normal era

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Abstract. The Covid-19 pandemic has an impact on people's economic activities, causing income difficulties. It takes technological innovation that can be applied at the community level to support its activities. This technology serves to support community groups. For developing dryers this has been carried out in the laboratory using experimental methods. This type of dryer is a tray dryer, which uses solar energy and the stove as a source of heat. The experiment used 80 kg of cassava for drying. The results showed that the energy available for 8 hours was 5374.96 Joules, the temperature of the dry product increased by 3336 kJ, and the relative humidity was 34.29%. The drying efficiency reaches an average of 28.36%, and the resulting air content is an average of 7.48%. Drying is effective for 8 hours from 08.00 to 16.00 hours. The capacity of this dryer is 80 kg. This technology can be applied to increase the productivity for community businesses during the pandemic and the new normal era.

Keywords: Dryer; community; business

1. Introduction

The Covid-19 pandemic has had an impact on industrial activities, including small and medium industries. A total of 180 businesses have been closed and 11,000 workers in NTB, have been dismissed [1]. As many as 5,000 Micro, Small and Medium Enterprises in NTB are affected by Covid-19 [2]. The number of small and medium industrial enterprises in NTB Province until 2018 was 96,205. A total of 86,213 (89.61 percent) are micro industries, and the rest are small industries. Small and Medium Industries absorb a workforce of 259,140 people, and more than 60 percent are women workers. The food industry, amounting to 19,132, is the Industry Group that absorbs the most labor, which is 15.28%.[3,4]

In the period from August 2019 to August 2020, the employment sector that experienced a decline was in the manufacturing industry (a decline of 2.02 percentage points). The Covid-19 pandemic that has occurred since March 2020, has paralyzed several sectors, and has an impact on layoffs of many workers in NTB. Small and medium industries that experience difficulties in operating their businesses, as much as 60.96%, including the food industry as much as 21.75%. The most difficult forms were capital (62.54%) and energy or fuel (10.78%). Other difficulties are raw materials, marketing, transportation, skills, labor wages and others [3,4].

One of the efforts to help Small and Medium Industries (MSMEs) is to support the application of technology to assist them in production activities, particularly for drying raw materials and products, which are affordable and can take advantage of cheap energy sources. This hybrid dryer application uses abundant solar energy as an energy source, and can be combined with a heat source from electric heating for its application.

Heat energy from solar energy is absorbed using an absorber, collected and trapped using a heat collector system so that heat accumulates, then heat is channeled to the chamber (drying room). The drying temperature required for agricultural commodities generally ranges from 60-70 °C. The application of this technology is expected to reduce work time, labor and costs. It is in this context that the technology for utilizing solar energy is proposed as an effort to produce an effective, efficient drying process that can use abundant energy sources (alternative energy sources), and to help ease the burden on community businesses during the pandemi Covid-19 and new normal era.

This technology has developed in various forms, the challenge is how to provide technology that is inexpensive and can be applied on a community scale and is able to speed up th e drying process and increase the value of the product being dried. For this reason, a rack-type hybrid drying system has been developed for a community scale which is expected to help business groups on a community scale, as an alternative that can be developed. This research aims to produce a hybrid dryer that can be used by the community for drying their products and can be operated at a community scale, as well as supporting community business activities.

2. Materials and Method

The method used in this research is an experimental method in the laboratory. The first stage is to prepare a solar energy collector and a device or system to supply electrical energy as a source of heat energy for the dryer that will be used to conduct experiments. This dryer is Solar Hybrid Dryer Tray Type, developed based on the results designed and built by Rahmat Sabani, et al [5]. The drying experiment was carried out for the cassava commodity, which is widely used by the community for processing businesses and producing various food products. Cassava is obtained from the local market. This research was conducted at the Laboratory of Machinery and Power, Faculty of Food and Agro-Industry Technology,University of Mataram.

2.1. Treatments and design

This dryer is designed to be able to dry agricultural products including cassava as much as 60 kg to 80 kg per day. This capacity is based on the results of a survey of drying practices carried out by community business groups at a community scale and a household scale. From the survey, it is known that the number of dried products on average is 60 kg to 80 kg per day. This hybrid dryer was developed to be able to dry the product for approximately 7 to 8 hours, using a hybrid system of solar energy and electrical energy [5]. The supply of heat energy comes from the solar energy collector and hot air from the electric heater . The expected heat available in the drying room is around 60°C, to dry the product to reach a moisture content below 14%. This solar energy collector construction has an area of 183 cm x 82 cm, functions as a solar radiation energy trap consisting of ice glass with an installation angle of 25° at the top, so that it can be passed through by solar radiation, and a heat trap space made of painted plates. the surface with black paint. The glass cover aims to collect heat, reducing conduction and convection of heat lost from the collector. The drying room construction has dimensions of 82 cm x 82 cm x 170 cm, consisting of 8 levels of shelves. Each shelf is filled with 10 kg of dried material. The drying chamber is made of angled iron and zinc as a wall and covered with

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plywood on the outside to keep the heat out of the drying chamber. Air circulation to supply hot air and regulate humidity in the drying room, using a blower. Supporting equipment consists of: temperature control, thermocouple, light sensor, exhaust fan (forced exhaust fan), fan (mixer fan), heater.

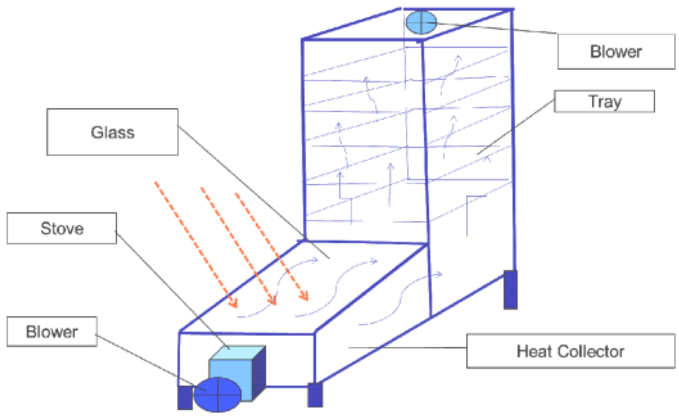

Figure 1. Hybrid Solar Dryer Tray Type

2.2. Implimentation of experiment

The implementation of this research consisted of a drying design with a hybrid system that had been developed, an experiment for drying the sliced cassava with a thickness of 3 mm and 6 mm, drying operations from 08.00 am to 04.00 pm. Data collection, measurement and determination of dryer performance consist of sunlight intensity, ambient temperature, collector temperature, heat exchanger temperature, product temperature, drying room temperature, drying room humidity, environmental humidity, and material moisture content. Furthermore, calculating the performance of the dryer based on data and indicators of collector energy, energy to increase the temperature of the drying room, useful energy, energy for evaporation, energy to increase material temperature, efficiency of drying system, and moisture content. To calculate the performance indicators of this hybrid dryer using the following equation [5-11] ;

2.2.1. Energy of Collector

The energy obtained from solar energy is calculated using the equation, is as follows;

$$Q = I \times \tau \times A \times t \quad \ldots\ldots\ldots \quad (1)$$

Where ; Q is absorbed solar energy (kJ), I is solar radiation (W / m2), τ is transmissivity, A is collector area (m2), t is drying time (seconds).

2.2.2. The energy needed to raise the temperature of the drying chamber

The energy needed to increase the temperature of the drying chamber derived from the collector temperature is using the equation;

$$Qu = m \times Cp \times (Ti-To) \quad \ldots\ldots (2)$$

Where ; Qu is the heat energy collected (kJ), m is the mass flow rate of air (Kg / hr), Cp is the density of air (kJ / kg°C), To is the exit temperature (°C), Ti is the inlet temperature (°C).

Temperature in (Ti), calculated using a mathematical equation, is as follows:

$$T_i = T_o - \frac{q_u}{mC_p} \quad \ldots\ldots (3)$$

Where: Ti is the inlet temperature (°C), To is the exit temperature (°C), qu is the heat absorbed by the collector (W/m^2), m is the mass of the product (kg), and Cp is the specific heat of the product (kJ/kg°C).

Temperature out (To), is calculated using a mathematical equation as follows:

$$T_o = \frac{T_a + (\tau\alpha)I}{U_L + [T_i - T_a - (\tau\alpha)I/U_L]\exp(-F'U_L/GC_a)} \quad \ldots\ldots (4)$$

Where: Ta is the ambient temperature (°C), UL is the total heat loss coefficient (W/m^2), Ti is the inlet temperature (°C), I is the intensity of solar radiation (W/m^2), F is the efficiency factor, G is a constant solar (1353 W/m^2), Ca is the specific heat of air humidity (J/kg°C).

The useful energy, Qu (W / m2), is calculated using the equation, which is as follows;

$$Qu = Ac\,(S - U_L (T_i - T_a)) \quad \ldots\ldots (5)$$

Where: AC is the collector surface area (m^2), S is the solar radiation absorbed by the absorber (W/m^2), UL is the Total Heat Loss coefficient (W/m^2), where Ti is the inlet temperature (°C), and Ta is the ambient temperature (°C).

2.2.3. Energy for evaporation

The energy to increase the temperature of the material for evaporation is calculated using a mathematical equation, as follows:

$$Q = V \times Hfg \quad \ldots\ldots (6)$$

Where Q is the energy to evaporate water (kJ), V is the water vapor load (kg H_2O), and Hfg is latent heat (kJ/kg), V is weight of water evaporated (kgH_2O).

2.2.4. Energy to increase the temperature of the material in chamber

Energy to increase the temperature of the material The energy to evaporate material water is the energy to heat the material temperature from the initial material temperature before the drying process can be calculated based on the equation, as follows:

$$Q = m \times Cp \times \Delta T \quad \text{(7)}$$

Where ; m is the mass of the dried material (kg), Cp is the specific heat of the material, which is dried (kJ/kg ^{o}C), ΔT is the increase in material temperature (^{o}C)

2.2.5. Efficiency of collector.

Collector work efficiency, ηc (%), is calculated using the equation, as follows:

$$\eta_c = \frac{Qu}{Ac.It} \times 100\% \quad \text{(8)}$$

Where: Qu is the useful energy (W/m^2), Ac is the collector area (m^2), It is the radiation intensity (W/m^2).

2.2.6. Efficiency of drying system.

The efficiency of the drying system is calculated using the mathematical equation, as follows:

$$\eta = (Qout / (Qin + P)) \times 100\% \quad \text{(9)}$$

Where Ƞ is the value of efficiency (%), P is the electric power used (kwh), Qout (kJ) is the amount of heat energy used during drying, Qin is the energy entering the drying chamber (kJ),

2.2.7. Moisture content.

The moisture content of the dried material is calculated using the equation;

$$M = 100\,(Mw - Md) / Mw \quad \text{(10)}$$

Where ; M = water content of the material, Mw = mass of wet product, Md = mass of dry product.

3. Results and Discussion

This dryer works quite well, accumulated heat in the drying room, especially after 09.00 am and sufficient heat is available until 02.00 pm and reaches its peak at 02.00 pm. The drying process runs effectively for 6 (six) hours, and gives drying results on products that are dried with a moisture content is 8.95% dry basis, Furthermore, drying was stopped at 16.00 hours, resulting in an average air content of the material was 7.48%, from the initial moisture content was 64%.

3.1. Useful energy for drying

The heat energy used is the amount of energy a material needs to reach a certain drying rate. The extent to which the material dries, the total amount of heat energy absorbed and collected by collectors and received by the dried product. The use of heat energy is a value that shows the rate of heat and mass transfer processes from the use of heat energy in the drying process [5,6] .

From the experiments carried out as shown in Figure 2, the available heat energy generated by the collector increases starting at 9.00 am and reaches a peak at 02.00 pm, then gradually decreases in the afternoon, in line with the increase in the intensity of energy emitted by sunlight, because this useful energy is a function of the intensity of solar radiation received at the collector surface.

Heat energy is useful in the drying process of the experiment, as shown in Figure 3, the energy has increased from 09.00 am, is 12387,917 Joules to 22983,336 Joules and reaches its peak at 01.00 pm, is 40380.048 Joules to 63356,849 joules. Then it decreased to 6683,523 Joules, and 13992,912 Joules at 04.00 pm. Seeing the data generated, the useful energy available for drying is quite high between 09.00 am to 04.00 pm.

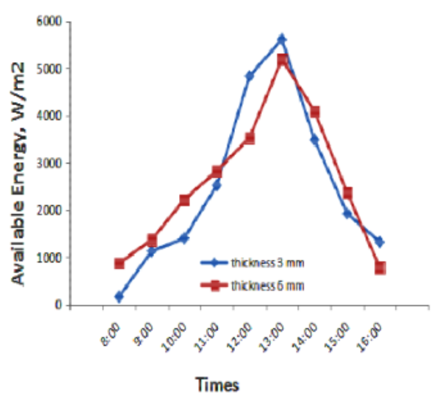

Figure 2. Available of Energy, w/m2

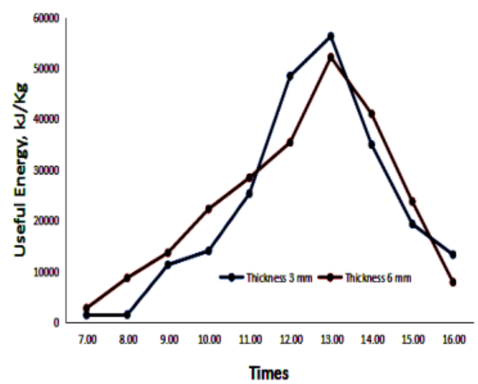

Figure 3. Useful Energy, kJ/Kg

.The distance factor between the glass and the plate affects the amount of heat lost. The heat loss that occurs in glass solar collectors is influenced by the distance of the glass to the plate. The greater the distance between the plates and the glass, the higher the heat loss that occurs. Conversely, the smaller the distance of the glass to the plate, the lower the heat loss. If the heat loss is small, it can be said that the collector produces more useful energy [8-10] . Other factors that affect the amount of useful heat energy are the absorbent plate, heat loss due to convection, conduction and radiation. The amount of useful heat energy collected also depends on optical properties (tranmissivity and reflexivity), the properties of the absorbent plate (absorptivity and emissivity) and heat loss due to convection. conduction, and back radiation [5,6,11].

3.2. Temperature for drying.

The character of the drying temperature in the drying room has increased exponentially from 30°C at the beginning of the drying process, increasing to reach at 11.00 am at 65°C, then fluctuating and peaking at 02.00 pm, which is 68°C. Furthermore, it decreased by 62°C at 03.00 pm, then decreased to 55°C at 04.00 pm. The temperature of the drying chamber is in line with the characters of the collector cover (glass) temperature, absorber temperature, and collector temperature, which experience an increase in temperature with the same characters, as shown in Figure 2. This process takes place in sunny weather with strong sun intensity with a temperature of 35°C, and relative humidity between is 85% - 89%.

The higher temperatures in the collector, absorber and drying chamber are a result of the transmission of long-wave solar radiation on them, blocking short waves originating from the absorber. This condition gives a heating effect to the collector, and results in a difference in intake temperature (collector temperature), causing heat accumulation [5,8,11].

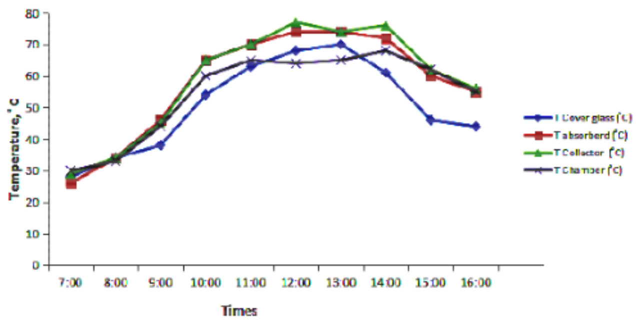

Figure 5. Temperature for Drying

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Heat energy which is quite effective is obtained from 10.00 pm to 01.00 pm, resulting in collector temperatures ranging from 65°C to 76°C, with radiation intensity of 548.7 watts to 731.6 watts. Then the collector temperature decreased by 62°C at 03.00 pm, and decreased to 56°C at 04.00 pm, with a radiation intensity of 919.4 watts to 1433.7 watts. The temperature value is influenced by the intensity level of solar radiation and the transmissivity of the glass [9,10] . This condition reaches a maximum when solar radiation reaches its maximum point (the collector's position with the sun is 90°), because the temperature transmitted by the glass to the solar collector chamber reaches its peak. This is also influenced by the absorption and accumulation of heat by the glass. The type of cover glass used determines the amount of solar energy absorbed by the glass, and transmitted to the air between the glass and plate (collector room) and which is reflected back into the atmosphere [9,10] .

The heat trapped in the collector chamber occurs because the glass can effectively trap shortwave radiation, and this affects the high and low temperature of the collector chamber [9,10]. The fluctuating pattern of collector room temperature during the drying process is related to the sun irradiation pattern which increases in the morning and decreases in the afternoon. In the morning, which is 07.00 am, the temperature of the collector room is almost the same as the ambient temperature.

3.3. Relative Humidity.

Drying is influenced by a combination of temperature and air humidity which causes the release of water from the material so that a balanced water content is achieved [12-14]. The relative humidity conditions of the environment, collector and drying room are likely to be different, but have a similar pattern. At 07.00 West Indonesia Time, the RH environment conditions ranged from 84.25% to

91.61%, while RH in the collector or drying room was 53.76% to 69.65%. Furthermore, at 11.00 am, the RH of the environment is 52.38% to 67.61%, and the RH of the drying room is 37.99% to 46.6%. At 01.00 am, the RH condition of the environment is 48.78% - 77.08%, and the RH of the drying room is 32.79% - 44.76%. Judging from the RH value of the collector or drying chamber, drying is relatively low at 11.00 am to 02.00 pm.

Figure 6 and Figure 7 show that relative humidity is influenced by temperature. During the drying process, the relative humidity of the collector chamber tends to decrease at high temperatures as well as the humidity of the environment. However, the decrease in the relative humidity of the collector space during the drying process is higher than the relative humidity of the environment.

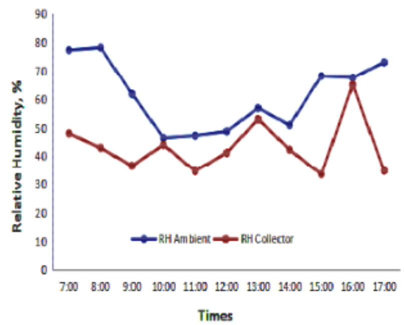

Figure 6. Relative Humidity of Collector and Ambient

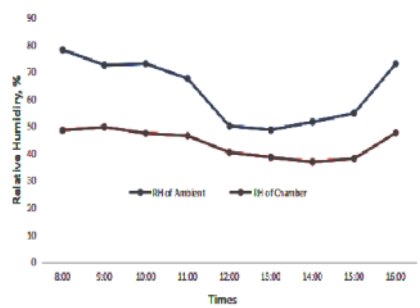

Figure 7. Relative Humidity of Chamber and Ambient

The relative humidity will decrease if the temperature increases, conversely if the temperature decreases, the relative humidity will increase [12-14]. At high temperatures the water content of the material and relative humidity becomes low, so the air is dry. At 10.00 am, 01.00 pm, and 04.00 pm, the relative humidity of the collector space has increased, approaching the relative humidity of the environment.

3.4. Moisture Content and Trend of Drying

One of the main indicators seen from the drying process using this dryer, as well as in other drying processes, is the moisture content of the product being dried. Drying using this hybrid dryer lasts for 8 hours, from 08.00 am to 04.00 pm, able to dry the product in the form of sliced cassava, from the original water content of 64% to a product with an average water content of 7.48%.

The drying characteristic that occurs in this drying process is that the drying rate decreases. The rate of reduction in the water content of the product began rapidly at 09.00 am to 11.00 am, which was 10.92% per hour, previously at 08.00 am was 18.69% per hour. Furthermore, at 12.00 am, the rate of reduction in water content decreased by 4.27%. Furthermore, the drying rate decreased towards a constant, namely 3.74% at 01.00 pm, 4.59% at 02.00 pm, 1.01% at 03.00 pm, and 0.46% at 04.00 pm.

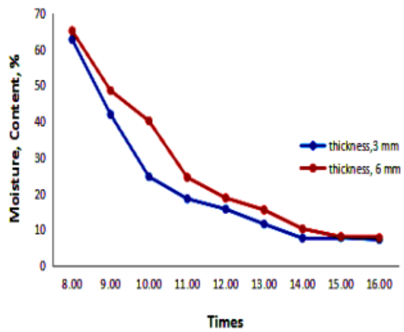

Figure 8. Moisture Content Produk

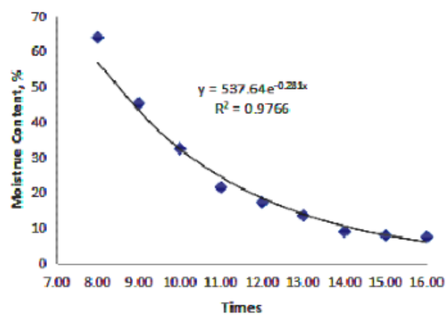

Figure 9. Trend of Drying

The decrease in the water content of the product is influenced by the thickness of the slices. The thicker the slices, the more time and energy it takes to evaporate the water from the product [5,6]. The change in water content is a function of the product temperature change profile during drying. In addition to reducing moisture content, drying is also intended to obtain good product quality [13,14]. In addition to thickness, the decrease in water content is also influenced or determined by the properties of the dryer (temperature, relative humidity, the amount of solar thermal energy absorbed by the collector and the air flow velocity which has an impact on the high and low temperature of the collector room, and the surface heat transfer coefficient), and the properties of the dried material.

3.5. *Efficiency of Dryer*

Collector efficiency, as a whole includes the temperature at the dryer and the heat source is calculated from the radiant heat absorbed by the collector and available for the drying process [8-10]. The experimental results showed that the drying efficiency was an average of 28.36%. An efficient drying process occurs from 10.00 am to 04.00 pm, which is between 27.28% and 33.50%. The highest efficiency occurred at 01.00 pm, which was 33.50%.

The fluctuating efficiency value, influenced by the drying system, still needs improvement, both in terms of engineering components and construction, which causes several leaks. Judging from the efficiency value, this dryer operates quite well for 6 to 8 hours, from 08.00 am to 04.00 pm. The fluctuation of the efficiency value is influenced by the factors of the intensity level of solar radiation reaching the collector surface, emissivity and absorption, intake temperature, ambient temperature and heat loss. The intensity of solar radiation is influenced by cloudy weather conditions, which causes a decrease in intensity which then has an impact on efficiency [9-10]. The collector efficiency depends on the outside temperature (environment), the level of solar radiation reaching the surface of the earth and the temperature that can be absorbed [9] .

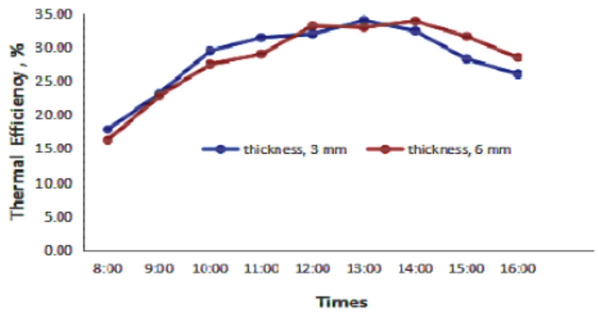

Figure 9. Efficiency of Dryer

4. Conclusion

Based on the results of experiments and performance tests of this solar hybrid dryer tray type which is designed and developed, it can be applied to drying operations of agricultural products and other processing industries. This dryer has a capacity of 80 kg, suitable for community scale and household scale, which can be operated from 08.00 am to 04.00 pm, and can dry products with moisture content which is expected to be effective with good efficiency.

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