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The Effect of Angle Slope Variation And Dark Light Chimney For Humidity And Temperature Full Transparent Walled Dryer Chamber

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Abstract. Solar dryer is an energy conversion device that absorbs solar radiation, then the heat generated is distributed to the drying chamber by the working fluid. One of passive solar dryer type utilizes chimney to optimize air flow rate through the drying chamber. Moreover, it has a function to keep the heat flows from the environment through the drying chamber in order to the temperature and humidity get better and more efficient in the process of drying materials. One way to improve solar dryer performance is modify the chimney. This study aimed to determine the performance of passive type solar dryer. The method used in this study is an experimental research with quantitative descriptive analysis. Modification included the height (1 m and 1.5 m), the angle slope variation (450 and 900) and transparency wall of chimney. Based on the result of drying material (0.32 kg sand and 0.8 kg water) starting from 11.00 - 14.00 with the composition variation of chimney, got average value of temperature 50.20 C – 51.10 C, humidity 19.1% - 2.4% and air flow out 0.32 m/s – 0.55 m/s. From the overall data, dryer with chimney variations 1 m inclined 450 (eastern-western transparent wall) is the best with efficiency value 3.93%, mass flow rate 1.66E-03 kg/s. It was proved that chimney 1 m inclined 45° (eastern-western transparent wall) to the north, cause the dark southern wall absorbs more radiation, meanwhile eastern-western transparent wall forward radiation then absorbed by the dark northern wall. The temperature difference between the chimney and the environment 15.440 C increased the bouyancy force. Chimney 1 m height result in pressure drop caused by the altitude, temperature difference and friction between air and wall get greater, increasing bouyancy force and optimizes the air flow rate out of 0.51 m / s. The conclusion is chimney 1 m inclined 450 (eastern-western transparent wall) give possitive effect to improve efficiency and mass flow rate in the dryer.

INTRODUCTION

The sun is one of the energy sources that has been used, both conventional and non conventional. The location of Indonesian territory which is in the equator makes it possible to obtain sufficient light intensity bigger every year continuously. Based on data from solar radiation, Indonesia solar energy radiation average 4.8 kWh / m2 per day with a monthly variation of 9%. Based on these data into a considerable opportunities to develop technologies that harness the sun as the main energy source. Development of various energy conversion devices that have been conducted, one of which is a solar dryer. Solar dryer is an energy conversion device that utilizes solar collectors to absorb radiation from the sun, and the heat generated will be distributed to the drying chamber by the working fluid. In the drying chamber, the incoming heat will evaporate the water that is on the material is dried. Water vapor will flow out through the chimney due to differences in the density of the air inside and outside the drying room. As for the benefits to be gained by using solar dryers are : (1) The drying process will be faster, (2) The drying process is more efficient, (3) results product is more hygienic and healthy, (4) requires little cost to operations. Solar dryers can be separated into two categories, namely passive-type solar dryer and active type solar dryer. The difference is based on the flow of air in the dryer. Dryer passively rely on convection currents obtained from hot to move air. Active dryer has a fan to circulate air from the inside to the outside dryer. Low air flow rate in a passive-type solar dryer is a great loss to

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achieve the efficient performance of the system. When the air flow rate is low will cause the temperature inside the drying chamber is high enough. To obtain optimal drying results - agriculture, air flow rate average - average required for 0.035 kg / M2S [5]. Indicators of the temperature required for optimum drying on the results - agricultural produce C range is 45.50 - 55.50 C [2]. Many factors can be optimized to increase the drying efficiency. One is to add height of chimney can improve drainage and airflow thermosiphoning [6]. Proper chimney design will improve the bouyant flow in all types of dryers [1].

RESEARCH METHOD

The method used is experimental research. This research was conducted at the GARNESA workshop State University of Surabaya at 3 until 29 October 2015. The conditions and equipment were adjusted in order to obtain data on the effect of variation chimney to change temperature, humidity drying chamber and the air flow rate in the drier versatile then the result of the study analyzed. The analysis used is descriptive quantitative. The steps used in this research :

Research design

The study design is a description of the research procedures conducted by researchers in an effort to collect and analyze research data. This is a flowchart study the effect of variation chimney to changes in temperature and humidity in the drying chamber dryer versatile tool can be seen in figure 3.1 as follows :

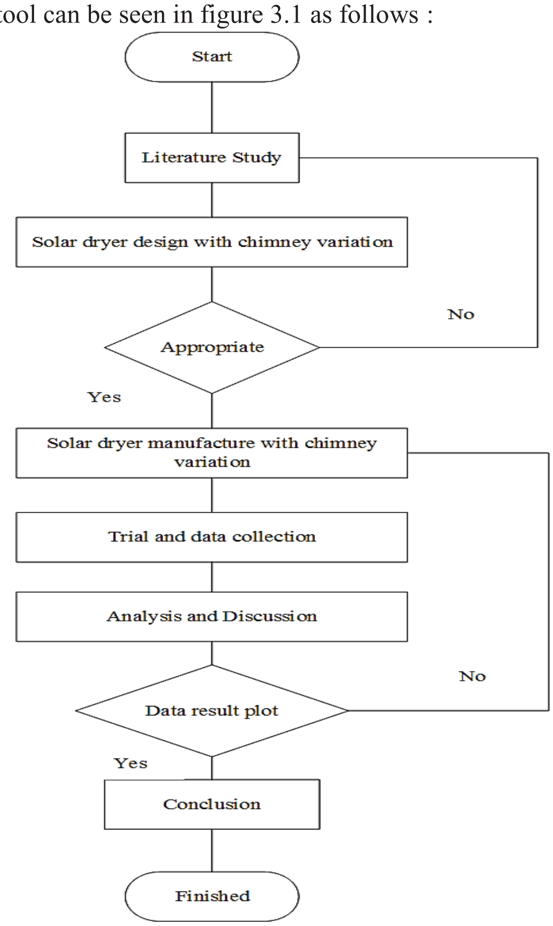


FIGURE 1. Research design

Research Instrument

a) Thermocontrol
Thermocontrol is an instrument used to measure the temperature of the walls and the room on a solar dryer.
b) Thermohygrometer
Thermohygrometer is a tool used to determine the humidity and air temperature.
c) Anemometer
Anemometer is a device used to determine the air flow rate.
d) Scales
Scales is a tool used to determine the weight of the object.
e) Lux meter
A lux meter functions as a tool used weeks to measure the intensity of sunlight during the test.

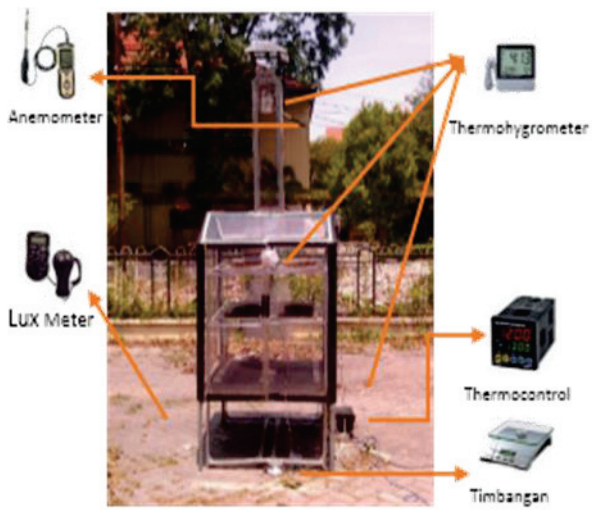


FIGURE 2. Research instrument

Research Variable

a) Predictor variable
Chimney height variation is 1 m and 1.5 m, variations in the composition of the transparency of the wall chimney are:

- ✓ Position transparent (East and West) and the position of dark (South and Noth).
- ✓ Position transparent (North and South) and the position of dark (East and West).

Variations chimney corner is canted vertical 45^0 and 90^0

b) Response variable
The dependent variable in this study is temperature, humidity and the air flow rate at the chimney

c) Control variable

TABLE 1. control variable of solar dryer

Control variable	Information
Passive type solar dryer	Dimension 1 m x 1 m x 1 m
Material drying room	Transparent acrylic 3 mm
Chimney material	Acrylic (transparent and black) 3 mm
Tray (4 trays)	Dimensions of 30 cm x 70 cm ; Aluminium 0.2mm
Dried material	Sand
Drying capacity	4 kg of sand (0.32 kg 0.8 kg sand + water). Each tray 1 kg of sand (0.8 kg 0.2 kg sand + water).

Research procedure

Preparation phase

- ✓ **Preparation before the study**
  The initial phase of this research is required in determining the location of the laying of solar dryers. Once the location has been determined next is preparing materials to be used in research that chimney with a variety of pre-defined, and then prepare the tools and materials used.
- ✓ **Preparation of measuring instruments**
  The measuring instruments used in the study must be considered beforehand specifications and calibrated in advance in order to obtain the data - data that is valid. Tools used include *scales, termohygrometer, anemometer and thermocontrol*.

Data retrieval

In this study, there were eight experiments using variations of composition have been determined. Testing every variation of the composition of the chimney using 4 rack / tray along with a heavy load of 1 kg (0.8 kg 0.2 kg of sand and water). The tests are carried out beginning at 11.00 am - 14.00 pm. Beginning of this test is a measurement of weight and then enter the load into the dryer chamber Afterwards measurements on each - each instrument has been determined.

a) Temperature
Temperature measurement using Thermocontrol / Thermocouple with intervals of checking 15 minutes

b) Relative humidity
Measurement of relative humidify using Thermohygrometer with intervals of checking 15 minutes.

c) Airflow
Measurement of the air flow (m / s) using the anemometer placed at the entry and exit air holes (chimney). Measurement of airflow in check with 15-minute intervals.

d) Material
Measurement of weight / material using scales with intervals of checking 15 minutes.

e) Sun intensity
Measurement of light intensity using a lux meter with a time interval of checking 15 minutes.

f) Air pressure
Air pressure measurement data obtained from BMKG Surabaya.

g) Calculation of dehydrator efficiency / Drying Room
Dehydrator efficiency is the percentage of water released from the material over time, compared to the total amount of water retained in the dried material. The calculation determines the humidity ratio (w, humidity Kg / Kg of dry air) from ambient air, air out the dryer, and the likelihood ratio in accordance with the maximum humidity of 100% relative humidity at a temperature, measured in the room with the highest temperature.

$$\boldsymbol{Dehydrator\ efficiency} = \frac{\boldsymbol{W\ end - W\ surrounding}}{\boldsymbol{W\ air\ max - W\ surrounding}} \quad (1)\ [7]$$

h) Calculation of mass flow rate
Mass flow rate of drying can be searched by using the following formula :

$$\boldsymbol{Vf = Vk\ x\ Lc} \quad (2)$$

$$\boldsymbol{V} = \frac{\boldsymbol{287.055(273.15+Tk)(1+1.6078Wk)}}{\boldsymbol{Pling(1+Wk)}} \quad (3)$$

$$\boldsymbol{m} = \frac{\boldsymbol{Vf}}{\boldsymbol{V}} \quad (4)\ [7]$$

i) Calculation of heat transfer in drying chamber
Calculation of heat transfer by conduction.
The process of heat transfer by conduction of the dimensions calculated using equation fouriers law. By using equation :

$$\frac{\boldsymbol{q = -kA\Delta T}}{\boldsymbol{\Delta X}} \quad (5)\ [4]$$

Calculation of heat transfer by convection.
The process of heat transfer by convection is calculated using the equation:

$$q = hA\,(T_s - T_\infty) \quad (6)\ [4]$$

Calculation of heat transfer by radiation.
The process of heat transfer by radiation is calculated using the following equation:

$$q = \varepsilon\sigma(T_s^4 - T_{sur}^4) \quad (7)\ [4]$$

Data analysis technique

This study used quantitative descriptive analysis techniques to gather information or data of any results of thechanges that occur through direct experiments. Intended use descriptive method to describe the nature of a temporary nature walk at the time of the study and analyze the cause - the cause of a particular symptom (Suharsimi, 2006).

RESULTS AND DISCUSSION

Field Test Results

Based on the results of field data collection was held from 3 untill 29 October 2015 GARNESA workshop page Unesa data obtained as follows:

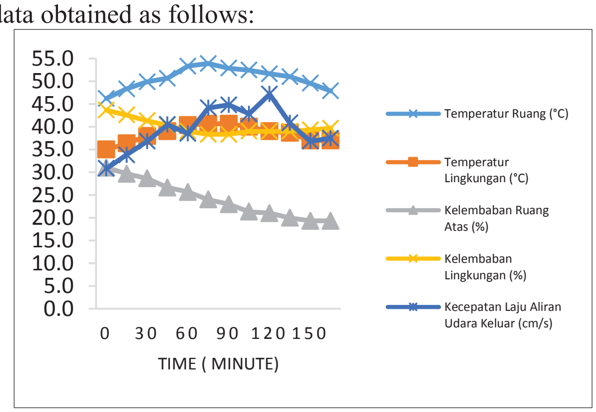


FIGURE 3. Graph Measurement Results In Vertical Chimney 1 m (Eastern and Western Walls Transparent)

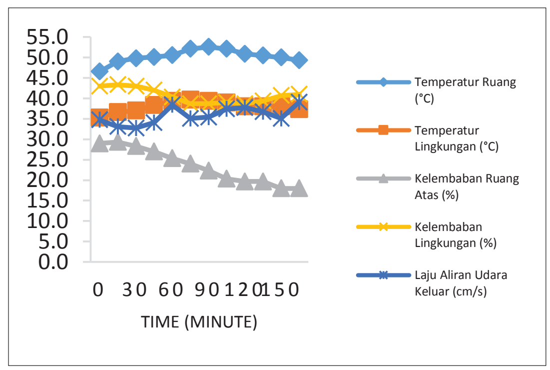


FIGURE 4. Graph Measurement Results In Vertical Chimney 1 m (Southern and Northern Wall Transparent)

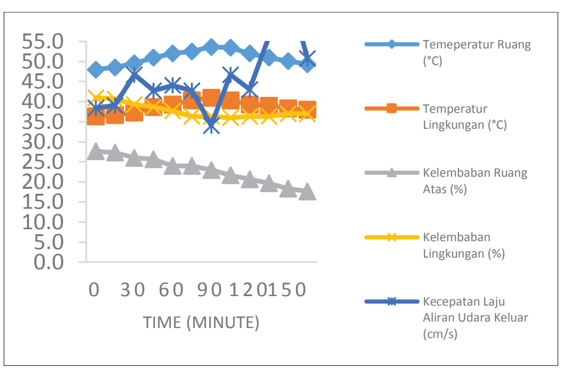


FIGURE 5. Graph Measurement Results At Chimney Variation 1 m inclined 45 ° (Northern and Southern Walls Transparent)

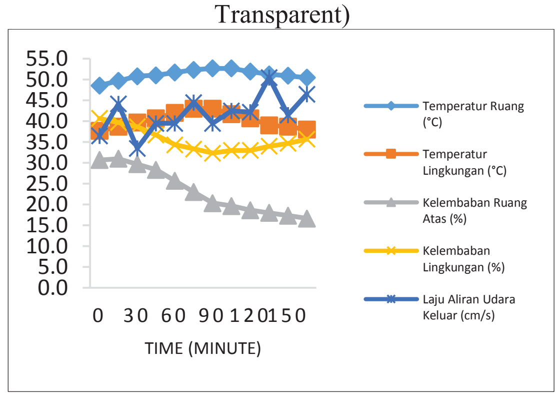


FIGURE 6. Graph Measurement Results On Variation Vertical Chimney 1.5 m (Eastern and Western Walls Transparent)

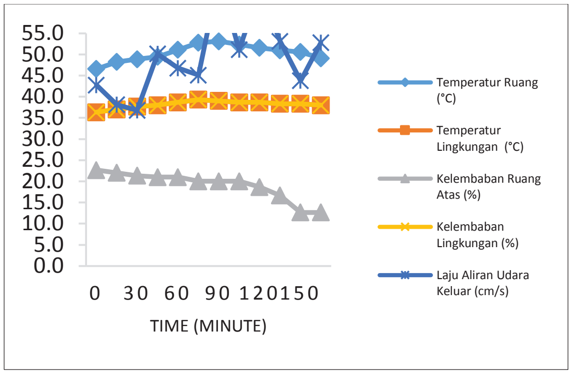


FIGURE 7. Graph Measurement Results At 1.5 m inclined Chimney Variation 45 ° (Eastern and Western Walls Transparent)

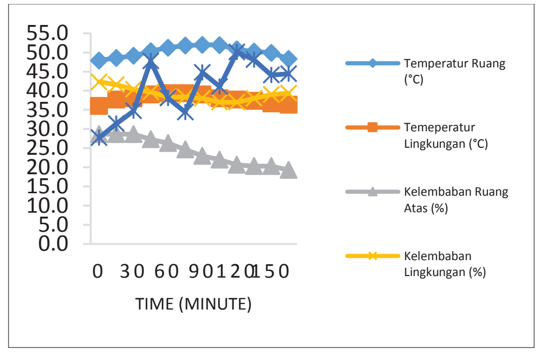


FIGURE 8. Graph Measurement Results On Variation Vertical Chimney 1.5 m (Southern and Northern Wall Transparent)

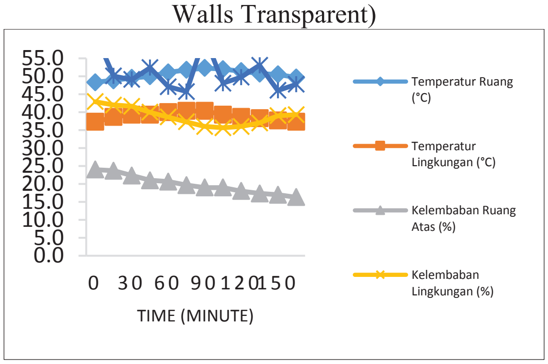


FIGURE 9. Graph Measurement Results At Chimney Variation 1 m inclined 45 ° (Eastern and Western Walls Transparent)

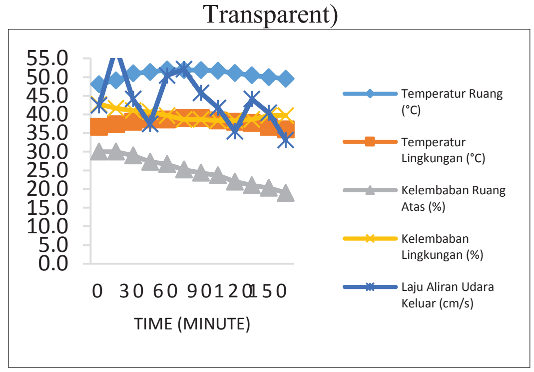


FIGURE 10. Graph Measurement Results At 1.5 m inclined Chimney Variation 45 ° (Northern and Southern Walls Transparent)

DISCUSSION

After getting the data by direct measurements in the field. Then it is discussed and incorporated into the equation, to look for heat transfer by conduction, convection and radiation, seeking efficiency of the dryer and seek mass flow rate at the time of drying the sand.

Analysis of Temperature, Humidity and Air Flow Rate

These is the results from the analysis of elevated temperatures, kelmbaban and air flow rate based on the results of data collection in the field :

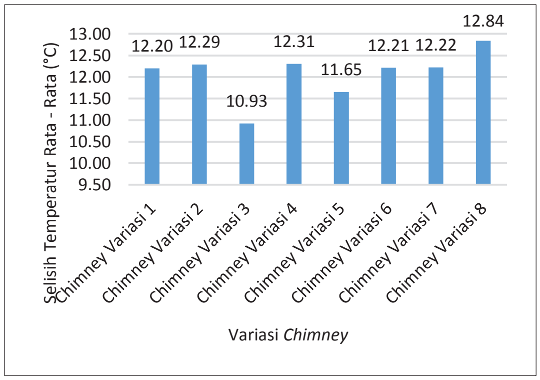


FIGURE 11. Comparison Chart Temperature Difference On Any variation Chimney

From the picture above, the temperature difference between the environment and the highest drying chamber at variations on variations chimney or chimney 8 1.5 m inclined 45 ° (South North Wall Transparent) with a value of 12.84 ° C. Sedangkang lowest value in four variations or variations in vertical chimney 1.5 m (east-west wall is transparent) with a value of 10.93 ° C. In figure 10 it can be seen that the value of a dryer at room temperature chimney eighth variation in temperature average - average worth 50.17 ° C - 51.15 ° C. Based on research conducted by El sabai et all 2002, explains that the optimum temperature is needed to dry the product - agricultural products ranged from 45.5 ° C - 55.5 ° C. From the temperature data obtained and the results of research by El sabai et all 2002, the dryer has qualified versatile and can be used to dry the product from the farm.

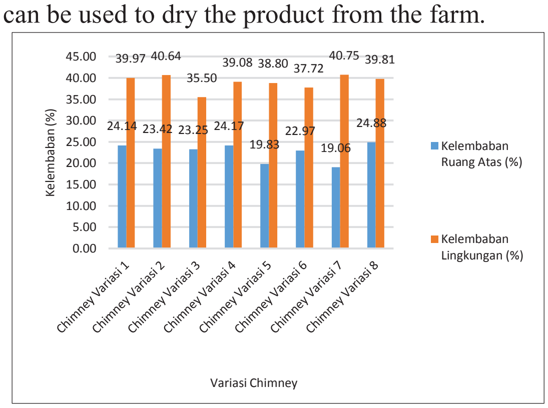


FIGURE 12. Comparison Chart of Environmental Humidity and Moisture Upper Room On Any variation Chimney

In the drying process, air condition plays a role in binding moisture in the air. The content of moisture in the air can be seen from the percentage of relative humidity values. Based on table 4.9 above, the environmental humidity ranged between 37.72% - 40.75% while the humidity inside the drying chamber ranges between 19.06% - 24.88%. In research conducted by Foster, Sean Andrew in 2013 explained that the income amount of material is dried in the drying chamber can increase humidity inside the drying chamber [3]. Humidity conditions inside the drying chamber is low it can be assumed that the humidity of the air inside the drying chamber is more influenced by the evaporated water from the material than by environmental factors. That is because the condition of air enters the drying chamber has experienced warming prior to the basement.

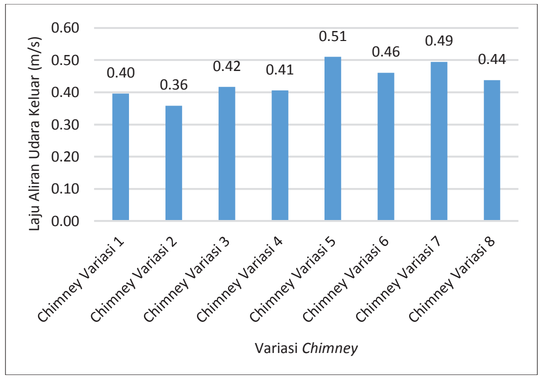


FIGURE 13. Air Flow Rate Comparison Chart Out On Any variation Chimney

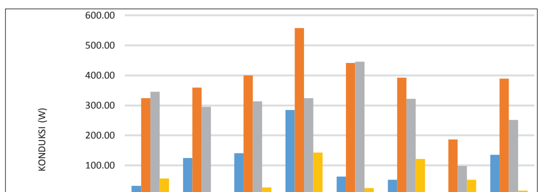
From Fig. 13 above the rate of air flow out the chimney eighth variation ranged from 0.36 m / s - 0.51 m / s. The highest value (0.51 m / s) contained in the chimney variations on variations chimney 5 or inclined 45 ° (east-west wall is transparent). The highest velocity air flow rate (0.51 m / s) will enhance the value of volumetric flow and mass flow rate during the drying process.

Heat transfer

To determine the heat transfer by conduction, convection and radiation, the following is a discussion:

Conduction

Calculation of heat transfer by conduction to analyze heat transfer through the walls of the drying chamber to the environment. Data heat transfer by conduction through the walls of the drying chamber can be seen as follows:



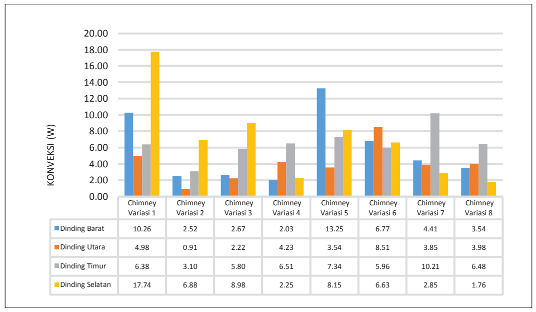
	Chimney Variasi 1	Chimney Variasi 2	Chimney Variasi 3	Chimney Variasi 4	Chimney Variasi 5	Chimney Variasi 6	Chimney Variasi 7	Chimney Variasi 8
Dinding Barat	31.67	124.91	140.74	285.00	63.33	52.78	5.28	135.46
Dinding Utara	323.70	358.89	399.35	557.69	441.57	392.31	186.48	388.80
Dinding Timur	344.81	295.56	313.15	323.70	445.09	321.94	98.52	251.57
Dinding Selatan	56.30	3.52	26.39	142.50	24.63	121.39	52.78	15.83

FIGURE 14. Conduction Heat Transfer Diagram On Wall Space

From the picture above conduction values obtained on the wall of the north side of the chimney vertical variation of 1.5 m (north-south wall transparent) has the highest value of 557.69 W. While the value of the smallest on the wall of the south side of the vertical variation chimney 1 m (wall north south transparent) with a value of 3.5 W. the value of a high conduction shows that the calorific value which flows out through the wall of the dryer too high. The highest conductivity value on the vertical variation chimney 1.5 m (north-south transparent wall) has a total value of 1023.89 W.

Convection

Calculation of heat transfer by convection to analyze heat transfer in the drying chamber. Data convection heat transfer in the drying chamber can be seen as follows:



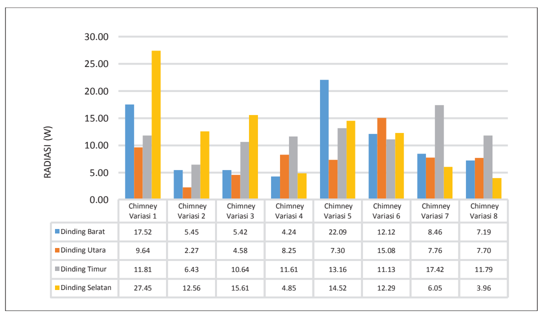
	Chimney Variasi 1	Chimney Variasi 2	Chimney Variasi 3	Chimney Variasi 4	Chimney Variasi 5	Chimney Variasi 6	Chimney Variasi 7	Chimney Variasi 8
Dinding Barat	10.26	2.52	2.67	2.03	13.25	6.77	4.41	3.54
Dinding Utara	4.98	0.91	2.22	4.23	3.54	8.51	3.85	3.98
Dinding Timur	6.38	3.10	5.80	6.51	7.34	5.96	10.21	6.48
Dinding Selatan	17.74	6.88	8.98	2.25	8.15	6.63	2.85	1.76

FIGURE 15. Convection Heat Transfer Diagram In Drying chamber

From the picture above convection highest values obtained in the wall of the south side of the vertical variation chimney 1 m (east-west wall transparent) has the highest value of 17.74 W. The total value of convection on the wall of the drying chamber highest vertical variation chimney 1 m (wall north south transparent) with a value of 39.36 W.

Radiation

Calculation of heat transfer by radiation to analyze heat transfer in the drying chamber. Data heat transfer by radiation in the drying chamber can be seen as follows :



	Chimney Variasi 1	Chimney Variasi 2	Chimney Variasi 3	Chimney Variasi 4	Chimney Variasi 5	Chimney Variasi 6	Chimney Variasi 7	Chimney Variasi 8
Dinding Barat	17.52	5.45	5.42	4.24	22.09	12.12	8.46	7.19
Dinding Utara	9.64	2.27	4.58	8.25	7.30	15.08	7.76	7.70
Dinding Timur	11.81	6.43	10.64	11.61	13.16	11.13	17.42	11.79
Dinding Selatan	27.45	12.56	15.61	4.85	14.52	12.29	6.05	3.96

FIGURE 16. Radiation Heat Transfer Diagram In drying chamber

From diagram above shows that the highest radiation heat transfer on the south wall of the chimney 1m vertical variation (diding west east transparent) with a value of 27.45 W and the lowest value on the side of the north wall on the vertical variation chimney 1m (diding north south transparent) , Referring 4:14 table above, it can be said that the value of heat transfer by radiation bigest on variations chimney 1 m inclined 45 ° (east-west wall is transparent) with a value - average of 66.42 W.

Drying chamber Efficiency

To determine the efficiency of the drying chamber versatile dryer can be seen in the picture below 4:16 this:

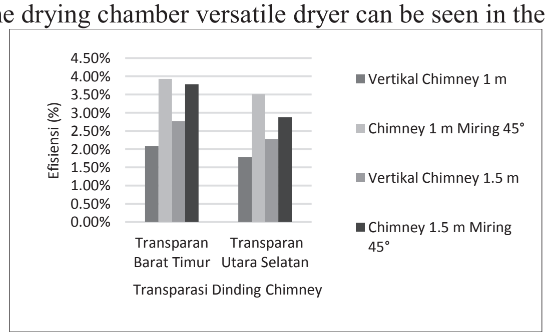


FIGURE 17. Space Efficiency Comparison Chart dryer In Sand Drying Process For 3 Hour

Based on picture above we can conclude that the efficiency of the drying chamber on the chimney 1 m inclined 45 ° (east-west wall is transparent) is greater than the other variations of the chimney with the efficiency of 3.93%. The second highest efficiency in the variation chimney 1.5 m inclined 45 ° (east-west wall is transparent) with the efficiency of 3.78%. Efficiency was lowest for the vertical chimney 1 m (transparent wall north-south) with a value of 1.78%.

Mass Flow Rate

To determine the mass flow rate during the drying process on the multipurpose dryer can be seen in the picture below :

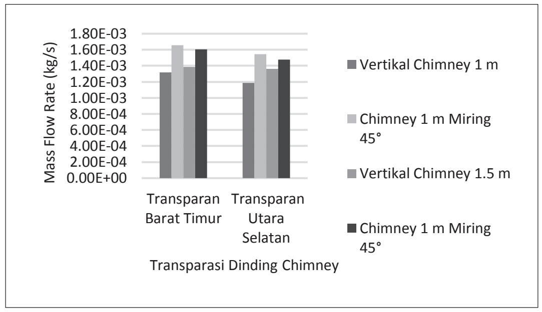


FIGURE 18. Mass Flow Rate Comparison Chart Sand Drying Drying Process For 3 Hours

From the picture above shows that the dryer using a variation chimney 1 m inclined 45 ° has a greater mass flow rate compared with other chimney variations. In a variation chimney 1 m inclined 45 ° (east-west wall is transparent) has a value of mass flow rate of 1.66E-03 kg / s and the chimney variation of 1.5 m inclined 45 ° (east-west wall is transparent) of 1.60E-03 kg / s. From research conducted by Forson FK 1999, recommending the value of mass flow rate of between 0.02 kg / s - 0.9 kg / s. Of the eight variations chimney which has been tested, show that the mass flow rate value that comes close is 1.66E-03 kg / s on a variety chimney 1 m inclined 45 ° (east-west wall is transparent).

The rate of drying

When taking the drying rate data obtained from Behan weight measurement every 15 minutes for 3 hours of the drying process. Of weight reduction material (sand) each measurement will get the weight of water in the material (sand). This is a figure 19 drying rate of materials on eight different variations of chimney :

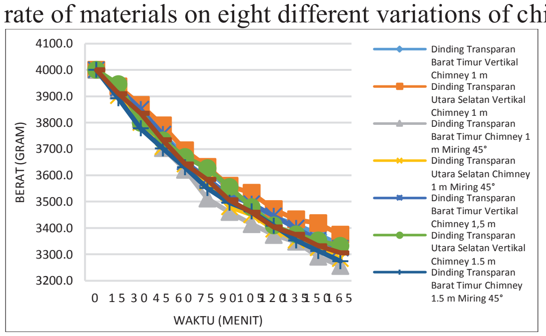


FIGURE 19. Comparison chart of Sand Drying rate Drying Process For 3 Hours

Based on the figure above the drying rate during the drying process, moisture reduction obtained the longer it will be lower. Decreased levels of water in the dryer with a variation versatile chimney 1 m inclined 45 ° (east-west wall transparent) has the highest water weight at the same time in drying.

CONCLUSION

From the results of field data collection and data analysis were conducted on the effect of variation chimney to temperature and humidity in the drying chamber versatile dryer can be concluded as follows. Chimney height variation of 1 m and 1.5 m that has been applied to the multipurpose dryer, variations chimney 1 m has a value - average room temperature of 50.61 ^{0} C, average humidity - above average space of 22.59% and the air flow rate of 0.43 m / s, while the chimney variation of 1.5 m value - average room temperature of 50.59 ^{0} C, average humidity - above average space of 22.84% and the air flow rate of 0.44 m / s. From these data it can be seen the temperature, humidity and speed of air flow rate is higher at 1.5 m chimney variations. Of the value of the temperature, humidity and air flow rate will be obtained values of efficiency and mass flow rate. In a variation chimney 1 m of 2.83% and 1.43 x 10-3 kg / s, while the chimney variation of 1.5 m of 2.93% and 1.46 x 10-3 kg / s. It can be concluded chimney variation of 1.5 m is the most optimal in terms of the efficiency and mass flow rate during the 3-hour drying process materials (the sand).

Besides adding chimney heights thermosiphoning can improve and optimize air flow rate caused by the difference in pressure and density of the air.

Transparency of variation chimney wall (east-west and north-south transparent), variations in wall chimney (west east transparent) has a value - average room temperature of 50.68 ^{0} C, average humidity - above average space of 21.57% and the air flow rate 0,46 m / s, while the variation diding chimney (north-south transparent) value - average room temperature of 50.52 0 C, average humidity - above average space of 12.41% and the air flow rate of 0.42 m / s. From these data it can be seen the temperature, humidity and speed of air flow rate is higher in the variation of chimney wall (west east transparent). Of the value of the temperature, humidity and air flow rate will be obtained values of efficiency and mass flow rate. In variations of chimney wall (west east transparent) by 3.14% and 2.98 x 10-3 kg / s, while the variation diding chimney (north-south transparent) of 2.61% and 1.40 x 10-3 kg / s. It can be concluded variation chimney wall (west east transparent) is the most optimal in terms of the efficiency and mass flow rate for 3 hours drying material (sand). East west wall is transparent can forward the received radiation, thereby making the temperature in the chimney is higher than the environment. The big difference in temperature and air density will produce a stack effect pressures are used to enhance the convective flow in chimney.

Variations in the tilt of chimney 45^0 and 90^0 (vertical), variations slanted chimney 45^0 has a value - average room temperature of 50.66 ^{0} C, average humidity - above average space of 21,69% and the air flow rate of 0.48 m / s , while the vertical variation chimney value - average room temperature of 50.57 0 C, average humidity - above average space of 23.75% and the air flow rate of 0:39 m / s. From these data it can be seen the temperature and speed of the air flow rate is higher, while the upstairs room humidity is much lower in the variation of the slope of the chimney 45^0. The value of the temperature, humidity and air flow rate will be obtained values of efficiency and mass flow rate. At 45^0 sloping chimney variation of 3.53% and 1.57 x 10-3 kg / s, while the chimney vertical variation of 2.23% and 1.31 x 10-3 kg / s. Judging from the value of efficiency and mass flow rate during a 3-hour drying process variation sand sloping chimney 45^0 is the most optimal. Chimney sloping 45^0 enables optimal absorb more radiation from the sun than in the vertical (900). Rated temperature inside the chimney sloping 45^0 higher than the vertical position (90^0) with a ratio value of 49 ^{0}C and 47 ^{0}C. The big difference in the temperature in the chimney to the environment that the higher will increase the buoyant force (buoyancy force) and optimize the flow rate of air through the drying chamber.

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