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Thermal Conductivity Analysis of Solar Drum Dryer Machine as a Drying Machine for Corn Seeds

Sisilia Nur Hikmah Anggraeni[1*], Niken Nila Dewi[1], Ragil Martatino[1] , Forteen Kristina Marbun[1], Sudarti[1], Kendid Mahmudi[1]

[1] *Physics Education Study Program, University Jember, Indonesia*

**E-mail: sisilianur03@gmail.com*

ABSTRACT

Drum dryers are an important component in the agro-industry, particularly in corn processing. These dryers are designed to dry materials at high temperatures, utilizing a mechanical motor system that opens and closes the exhaust valve to control and stabilize the heat inside the *rotisserie. This research employed a mixed-method approach, as well as* direct observation. The results of this corn drying machine study revealed a device equipped with an inlet and outlet. The inlet is a funnel, and the outlet is a hole under the drum. This device is very economical for drying corn.

Keywords: Thermal conductivity, drying machine, solar drum dryer

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INTRODUCTION

Agroindustry is an industrial sector focused on processing agricultural raw materials into products with added value. In Indonesia, the agroindustry sector plays a crucial role in the economy due to the country's significant potential for producing agricultural raw materials such as rice, corn, soybeans, palm oil, and other agricultural products. Agroindustry also plays a strategic role in increasing farmer incomes, creating jobs, and meeting consumer demand with quality products.

The electrical agroindustry is a subset of the agroindustry that utilizes technology and electricity to process and cultivate agricultural raw materials. The use of electricity in the agroindustry can increase production efficiency, reduce losses, and enable the implementation of modern technologies such as drying, food processing, and improved storage. The importance of electricity in the agroindustry is evident in various production stages, such as dryers, milling machines, and food processing machines. Furthermore, electricity also supports the temperature and humidity control systems required in various agroindustry processes. This leads to improved product quality, durability, and ease of packaging.

A drying machine is designed to dry materials at low pressure, accelerating drying without damaging the ingredients being dried. This machine operates using a vacuum heating system at low temperatures. In conventional heating processes, the boiling point of the material can reach a high point, resulting less than optimal heating results and the possibility of burning. The vacuum drying oven works by lowering the pressure in the heating

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tube, and as the temperature drops, heating occurs at a lower temperature. This allows materials that should not be heated further to be heated, resulting in a good product without damaging the nutritional content that remains intact (Elfiana et al., 2022) .

Drum dryers are a crucial component in the agro-industry, particularly in corn processing. Corn plants are abundant and produce year-round, but to be sold as food or animal feed, they must have a low moisture content to prevent moisture damage. This is why drying machines like drum dryers are crucial in the corn agro-industry. Drum dryers are used to reduce the moisture content of corn to a level safe for storage and shipping. They work by placing the corn in a heated drum and slowly rotating it. The heat from the drum and its rotation evaporates the moisture from the corn, leaving a drier product. The use of dryers for corn crops requires sunlight for seed production. Adjusting the drying air temperature is essential for drying corn seeds, with a maximum temperature of 38ºC - 40ºC for one week until the moisture content reaches 10-11%, compared to the moisture content of the corn seeds being dried (> 20%). Meanwhile, the corn seeds in cob form are air-dried and then shelled.

In relation to the agroindustry, the drum dryer is one example of the use of electrical technology in processing agricultural products (corn) to increase its added value. Without electricity in this drying machine, the corn drying process would be much more difficult and less efficient. Furthermore, the drum dryer also enables large-scale production, which is an integral part of the agroindustry to meet domestic and international market demand. study This For know conductivity thermal on Dreyer Drum machine as machine dryer on seed corn.

RESEARCH METHODS

This research was conducted at the University of Jember by a research group of 2021 Mechanical Engineering students, Fahrul Tohari, Putri Meila Susanti, M. Bawavi Taufik Nur, and Rio Martha Febriana Rossy. The study employed a *mixed-method approach,* combining qualitative and quantitative research methods. Furthermore, this research was conducted through direct observation. The research was preceded by qualitative methods, followed by quantitative methods. Since these methods are not sufficiently accurate when used individually, the research problem will be more accurate if this combination of methods is used.

Data collection is done by conducting research and observation on a corn drying machine with a rotary dryer type corn grain machine. With an object mass of 0.8 kg, an initial temperature (T0) of 38 ℃,

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a final temperature after heating (T1) reaching 140 °C, a material thermal conductivity (K) of 73 W/M °C, an object surface area (A) of approximately 12.815 m², the time required (t) is 2400 s, and an object thickness (L) of approximately 0.025 m, then the initial weight before and after drying is also recorded.

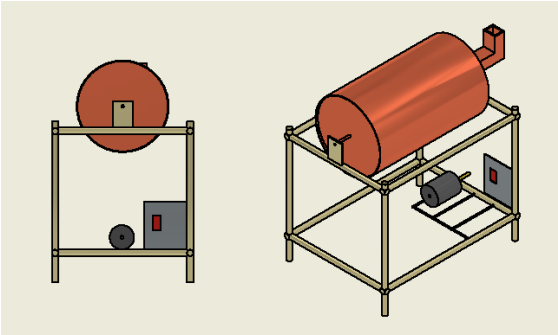
RESULTS AND DISCUSSION

Research by Pratama *et al.* (2016) describes thermal conductivity as a transport phenomenon that transfers heat energy from one region to another at a lower temperature. The thermal conductivity equation can be used to measure it indirectly. From the thermal conductivity equation:

$$k = \frac{Q\ L}{A\ \Delta T} \quad (1)$$

$$\frac{\Delta Q}{\Delta t} = kA\ \frac{\Delta T}{L} \quad (2)$$

The tool used by Fahrul Tohari, Putri Meila, M. Bawavi, and Rio Martha as 2021 Unej Mechanical Engineering students, has a design with the main components of a drying drum, a support frame and a drive system along with a switch.



Picture 4.1 Drum Dryer Design

In their research, Fahrul and his friend, Putri, stated that this device is also equipped with an inlet and an outlet. The inlet is a funnel, and the outlet is a hole beneath the drum. The rotating parts inside the drum are the shaft and the stirring fins. Below is a detailed illustration of the drum.

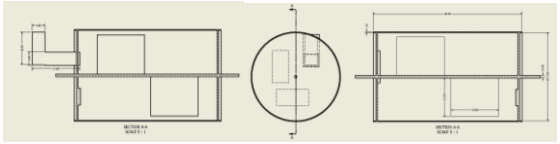


Figure 4.2 Det

Picture 4. 4 Machine *Solar Drum Dryer*

Study This in the form of study in a way direct or observation drum kit for data collection at the time determine mark conductivity thermal. The data obtained on tools / machines the is

Table 1. Results Observation on Solar Drum Dryer Machine.

Known data	The size

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m object (mass object)	0.8 kg
T_0	38°C
T_1 (temperature end when heated)	140°C
K (conductivity thermal on material)	73 W/M°C
A	12,815 m^2
t	2400 s
L	0.025 m

Moment determine conductivity thermal, the first time it was done is determine Q value (heat) at tool the:

$Q = m \cdot c \cdot \Delta T$

$= 0.8 \cdot 460 \cdot 102$

$= 37{,}536$ J

After know mark heat from object said, can carry on on look for mark conductivity thermal. So:

$k = \frac{Q\ L}{A\ \Delta T}$

$k = \frac{37.536\ .\ 0{,}025}{10{,}065\ .\ 102} = 9.50$ W / m°C

And the conductivity thermal on Solar Drum Dryer Machine of 9.50 W / °Cm.

The research we did only limited to analyze conductivity thermal on machine *Solar Drum Dryer.* For study advanced on study This is testing This done with use sample seed corn for see how much percent the decline water content in seed corn. Weight corn used is 350 gr (weight) wet). In literature usually seed corn Alone own water content around 70-75%.

The corn kernels were then placed in a drying drum set to a maximum temperature of 140 degrees Celsius for 40 minutes. The machine was then operated at this temperature for 40 minutes. After drying using the *Solar Drum Dryer,* the corn's mass decreased by 70 grams.

Picture 4. 6 Seed Corn Wet Along with the weight

An analysis conducted by Fahrul Tohari, Putri Meila, M. Bawavi, and Rio Martha, 2021 Mechanical Engineering students from Unej, revealed that the 40-minute test did not achieve maximum efficiency due to insufficient testing time. The ideal test time should be between 90 and 120 minutes.

With efficiency calculations

- Efficiency (%) = Mass Lost / Final Mass x 100%
  = 70 grams / 350 grams x 100%
  = 20%

This 20% efficiency result falls short of the market standard for drum dryer efficiency, which ranges from 55 to 65%. The primary factor contributing to this low efficiency is the insufficient testing time. This short testing time prevented the moisture content from decreasing as expected. A 90 – 120 minutes test could

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potentially match the efficiency of commercial drum dryers. Based on the mass loss data and drying time, the drying rate can be calculated as follows.

- Rate drying = Mass lost / time drying
  = 70 grams / 40 minutes
  = 1.75 grams/ minute

Beside that also obtained calculation final water content use formula as following.

- Final water content
  $$\frac{(\text{Berat Awal} - \text{Berat Akhir})}{(\text{Berat awal} - (\text{Kadar Air Awal} / 100) \text{ x Berat awal})} \text{ x } 100$$
  $$= \frac{(350 \text{ gram} - 280 \text{ gram})}{(350 \text{ gram} - (75\%100) \text{x } 350\text{gram})} \text{x } 100$$
  = 57.1%

These calculations revealed an 18% decrease in water content from the initial 75% with a 40-minute heating process. From temperature observations at three points, the temperature distribution within the drum, with a heater temperature of 140 degrees Celsius, can be calculated.

- Distribution temperature
  =P1 + ((P2 – P1) x 0.5) + ((P3 – P2) x 0.5)
  = 78.1 + ((55.3 – 78.1) x 0.5) + ((62.8 – 55.3) x 0.5)
  = 70.45 degrees Celsius

In this study, Fahrul Tohari, Putri Meila, M. Bawavi, and Rio Martha, as 2021 Unej Mechanical Engineering students, stated that the efficiency obtained from testing using wet corn kernels for 40 minutes at a temperature of 140 degrees Celsius was still below the market value, at only 20%. This low efficiency was due to the limited testing time, which prevented optimal results. Furthermore, the maximum capacity of our drum dryer is 800 grams; this can actually be maximized to 1,500 grams if the stirring motor has sufficient power and stability.

CONCLUSION

A solar drum dryer is a drying machine that uses solar energy as its heat source. This device is very economical because it doesn't use electricity and is very hygienic because the food doesn't come into direct contact with air. Our research was limited to analyzing the thermal conductivity of the solar drum dryer. For further analysis, this study was conducted using corn kernel samples to determine the percentage reduction in moisture content. The corn kernels used were 350 grams (wet weight). In the literature, corn kernels typically have a moisture content of around 70-75%.

Furthermore, there are two groups of factors that influence the drying process itself, namely factors related to the drying air and factors related to the nature of the material being dried. Factors included in the second group are the size of the material, the initial water content, and the partial pressure in the material. The effect of drying temperature on the type of corn shows that drying temperatures of 50°C and 70°C on sweet corn and hybrid corn provide significant differences in the vitamin C content of corn silk herbal tea, while at a drying temperature of 60°C on sweet corn and hybrid corn does not provide significant differences.

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