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Analysis of Physics Concepts in Crop Drying Technology

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Abstract

The drying process of crops is a crucial stage in production that affects quality and efficiency. One of the principles of physics that plays an important role in this process is the concept of heat, which allows the transfer of heat from heat sources to crops to evaporate their moisture content. This study aims to analyze the physics concepts in the process of drying crops using Rotary Dryer and Bed Dryer technology. The research is conducted through literature studies using relevant scientific articles and sources. The results show that both technologies involve the mechanism of heat transfer by conduction and convection, as well as the interaction of centrifugal and centripetal forces in the drying process. The conclusion of this study confirms that understanding the concept of physics allows the optimization of energy use, thereby improving the efficiency of the drying process and the quality of crop yields. This finding is expected to be a reference in Physics learning, especially in understanding the application of physics concepts in the crop processing industry.

Keywords: *Concepts of physics, technology, drying, yield*

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INTRODUCTION

The industrial sector known as agroindustry focuses on processing agricultural raw materials into products that have higher added value. With Indonesia's great potential in producing various agricultural raw materials such as rice, corn, soybeans, palm oil, and other products. Agroindustry is a vital part of national economic growth. Agroindustry not only meets consumer needs for quality products, but also expands employment and increases farmers' income (Anggraeni et al., 2024).

One of the main commodities in agroindustry is rice or grain, a cereal crop that is a staple food source for most of the world's population, especially in Asia. Rice (*Oryza sativa*) is a rice field plant that produces grains called rice, which are still wrapped in husks when harvested. To become ready-to-consume rice, rice must go through a series of processes, one of which is drying. According to Damayanti *et al*. (2022) The drying stage is the main key stage in determining the quality of crop yields. This drying stage greatly determines the quality of the rice produced, because it is related to the process of reducing the moisture content in the rice. In the drying process, the concept of heat plays an important role, namely the transfer of heat energy from the heat source to the grain to evaporate the water contained in it. An understanding of this concept is important for optimizing drying efficiency (Fatimah *et al*., 2024).

Traditionally, drying usually takes direct sunlight which takes about 3–7 days depending on the volume of rice and the intensity of sunlight which ranges from 15°C to 35°C. If using a modern machine, the drying time will become faster and the temperature can be adjusted. At temperatures below 45°C, microorganisms and destructive parasites can still survive, while temperatures above 75°C can damage the chemical and physical structure of rice (Robbi *et al*., 2024).

Modern drying technology that is often used is *Rotary Dryer* and *Bed Dryer*. This is because this tool is very effective and efficient in the process of drying crops. According to Tika (2022), *rotary dryers* have the advantage of distributing evaporation evenly during the drying process. This happens because the dried product is stirred in the cylinder tube, so that heat can be dispersed more effectively and increase the efficiency of the drying process. According to Savitri *et al*. (2024), *bed dryers* are effective in the rice drying process because they are able to produce good quality. This technology allows for a more even distribution of heat, so that the moisture content in rice can be optimally reduced without damaging the seed structure.

In the heat exchange process, heat moves from high to low temperature through three mechanisms, namely conduction, convection, and radiation. Conduction is the transfer of heat between atoms through direct contact without the overall displacement of particles. Convection involves the transfer of heat through the movement of fluids, in this case the hot air that envelops the crop. Meanwhile, radiation is the transfer of heat through electromagnetic waves without the need for intermediate media (Nurhidayat *et al*., 2020).

In the process of drying crop yields, the concept of heat becomes the center of analysis, where the heat that moves through the mass and water will change the structure of the crop. In physics, the heat that moves between objects with temperature differences is known as heat. This term is often used to describe two things, namely the heat energy itself and the transfer of that energy. The rice drying process involves three heat transfer mechanisms. Conduction occurs when hot air comes into direct contact with rice, convection brings hot air to the surface of the rice, and although radiation is less dominant, it still plays a role in supplying heat from the source to the rice (Khikma *et al*., 2023). In addition to the concept of heat, there is also a mechanical concept that is reviewed from the rotation process in *the rotary dryer*, namely centrifugal force and centripetal force. Based on the description above, this study aims to analyze the physics concept in the process of drying crops using *Rotary Dryer* and *Bed Dryer technology* so that it is hoped that energy efficiency can be improved to produce quality crops and can be used as a learning reference in Physics subjects to help students understand the application of physics concepts in the crop processing industry.

LITERATURE REVIEW

Physics Concepts

The concept of physics is a collection of basic ideas that function to understand, explain, and predict natural phenomena that occur around us. These principles include various aspects such as force, energy, motion, electricity, magnetism, waves, as well as the structure of matter, all of which are developed

through observation, experimentation, and rational reasoning. In its application, these concepts are not only explained qualitatively, but also formulated quantitatively in the form of precise mathematical models. Mastery of the concept of physics is very important to build solid scientific theories and solve various problems in science and technology. Reif (1995) in *the American Journal of Physics* states that the concept of physics is the main foundation in compiling natural models, while McDermott (1993) emphasizes that a strong understanding of the basic principles and the relationships between them is an important part of learning physics.

Technology

Technology is the application of scientific knowledge to meet practical needs in human life, covering various fields such as industry, communication, health, education, and other sectors. In practice, technology includes the development of tools, systems, and methods designed to facilitate human activities, increase productivity, and solve a wide range of problems. Arthur (2009) in *The Nature of Technology* describes technology as a collection of tools and practices that continue to develop, based on scientific principles and human needs. On the other hand, Hughes (2004) through his article in *Social Research* states that technology is not only limited to physical products, but is also part of social and cultural systems that interact with each other. Therefore, technology has a huge role in driving the change and progress of modern civilization.

Drying

Drying is a process that aims to reduce the moisture content in a material, either through natural means or using special equipment, with the aim of extending the shelf life, reducing weight, or facilitating the next stage of processing (Irawan *et al.,* 2021). This technique is widely applied in various sectors, such as the food industry, agriculture, pharmaceuticals, and material technology. From a physical point of view, drying involves the transfer of heat into the material and the evaporation of water to the surrounding environment. According to Kumar *et al*. (2014) in *Renewable and Sustainable Energy Reviews*, the effectiveness of the drying process is highly dependent on the methods applied, such as drying using sunlight, hot air, and vacuum systems.

Yields

Yield is a term that refers to the amount of agricultural products that have been successfully harvested from a field after going through a certain planting period. In the context of agriculture in Indonesia, crop yields are closely related to land productivity and cultivation efficiency of crops such as rice, corn, and soybeans. This term includes quantitative aspects, such as tonnage per hectare, as well as qualitative aspects such as seed size, moisture content, and nutritional value. Crop yields are determined by various factors, including the type of plant variety used, fertilization methods, irrigation systems, planting distances, and local climatic and geographical conditions (Xiao and Mujumdar, 2020).

Based on data from the Central Statistics Agency (BPS) in 2022, rice productivity in Indonesia was recorded at an average of 5.2 tons per hectare. The areas with the highest productivity include several provinces on the island of Java, such as Banten and East Java, which are known as national rice production centers. Meanwhile, the national corn yield reached 5.71 tons per hectare, with the highest

productivity recorded in West Java Province. Corn plants are widely cultivated in low- to middle-income areas, and their yields are influenced by cultivation techniques. For soybean crops, national productivity is still relatively low, at around 1.54 tons per hectare, with Central Java recording the highest yield among other provinces. Soybean cultivation in Indonesia still faces challenges such as limited land, low availability of superior seeds, and attacks by plant pest organisms (Ifah *et al*., 2024).

RESEARCH METHOD

The research method used is a literature study. Literature study is a research process that is carried out by collecting, studying, analyzing, and synthesizing information that has been published in the form of writings, articles, books, scientific journals, theses, dissertations, and other sources relevant to the topic or issue being researched. The first step in this research is to find relevant and reliable sources of information. Then read and analyze the information. Finally, writing a literature report that has been summarized and analyzing the literature. The purpose of the research is to analyze the physics concepts in the process of drying crops and provide recommendations to improve the efficiency and quality of the process.

RESEARCH RESULTS AND DISCUSSION

Physics Concepts in *Rotary Dryers*

Rotary dryer is a tool used to dry agricultural products such as rice and corn. The working principle is that the material or agricultural product is rotated inside the drum accompanied by steam or hot air that is flowed inside or outside the drum. There are 2 types of *Rotary Dryers,* including *direct* type *rotary dryer* and *indirect type rotary dryer* . In *Direct Rotary Dryer,* hot air is flowed inside the drum directly in contact with the dried material, so that heat transfer occurs through convection. Meanwhile, in *Indirect Rotary Dryers,* hot air does not directly come into contact with the material but is flowed outside the drum, usually through a heating jacket or an external heating system. The heat is then transferred to the material through conduction from the heated drum wall (Ifah *et al*., 2024). Here is a picture of the *Rotary Dryer*:

Figure 1. Rotary DryerSource: https://www.sentrakalibrasiindustri.com/wp-content/uploads/2024/05/Panduan-Lengkap-Tentang-Rotary-Dryers-Dalam-Proses-Manufaktur.jpg

The drying system in a rotary dryer machine consists of several main components, including a feeder funnel used to feed grain into the drying chamber. Inside is a rotary dryer that rotates while receiving heat from the burner. This burner can adjust the size of the flame automatically. In addition, the AC motor drives the drying chamber, and the speed can be controlled both manually and automatically.

To keep the temperature stable, the exhaust fan chamber will activate if the temperature exceeds the threshold, and the system will automatically eject the dried grain through the available valve (Imaduddin *et al.,* 2023).

Convection is the mechanism of heat transfer in fluids (both gaseous and liquid) that occurs due to differences in temperature and density. This mechanism also involves the transfer of intermediates, which are moving hot air or gases that carry heat energy to the dried material. In a *direct convection* type *rotary dryer* system, it plays a role in the flow of hot air that is in direct contact with the dried material (Jimoh *et al*., 2023). Mathematically, the concept *of Convection* in *Direct Rotary Dryer* can be expressed with the following equation:

$$\frac{Q}{t} = hA\Delta T \ldots\ldots\ldots\ldots Persamaan\ (1)$$

With:

Q = Heat (J or cal)
T = Time(s)
h = Convection coefficient ($W\backslash m^2K\ \ atau\ W/m^2$°C)
A = Cross-sectional area (m^2)
ΔT = Temperature difference ($K\ atau$°C)

Conduction is the process of transferring heat through a substance without being accompanied by the physical transfer of the substance. Heat moves from higher temperature areas to lower temperature areas through the interaction between particles in a solid. In *an indirect* type *rotary dryer* system, conduction is the main mechanism by which heat from the heated drum wall is transmitted to the dried material without direct contact with combustion gases. This mechanism allows for better temperature control and reduces the risk of contamination of processed materials (Siyati, 2022). In *the indirect type rotary dryer* , the conduction concept can be expressed by the following mathematical equation:

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

With:

Q = Heat (J or cal)
t = Time(s)
h = Thermal conductivity ($W\backslash mK\ \ atau\ W/m$°C)
A = Cross-sectional area (m^2)
ΔT = Temperature difference ($K\ atau$°C)
L = Length of object (m)

Centrifugal force is a pseudo-force or inertial effect that occurs when an object moves in a circle, causing the object to appear to be pushed outward. Meanwhile, centripetal force is a real force that works towards the center of rotation to maintain the circular trajectory of the object (Nasution and Rahmawati, 2019). In *a rotary dryer*, centrifugal force aids in the dispersion of materials by pushing them against the drum wall, while centripetal force ensures that the material stays in the system and does not go out of the rotational trajectory. The balance between these two styles is essential to maintain drying efficiency, allowing for optimal distribution of materials as well as maximum interaction with hot air. In general,

centrifugal force (and centripetal force (have the same value but in opposite directions.F_{sf})$\left(F_{sf}\right)$

$$F_{sp/sf} = \frac{mv^2}{R} = m\omega^2 R$$

With:

$F_{sp/sf}$ = Gaya Centripetal/ Gaya Centrifugal (N)
m = Mass (Kg)
v = Linear velocity (m/s)
ω = Angular speed (rad/s)
R = Rotary drum radius (m)

Physics Concepts in *Bed Dryers*

A bed dryer is a drying device that works by circulating hot air through a layer of dried material. This technology allows for efficient heat transfer, especially for granular or powdery materials, so that the drying process takes place quickly and evenly. In addition, the system allows precise temperature control to maintain the quality of the dried material (Adeyeye *et al*., 2022). Here is a picture of *the Bed Dryer* :

Figure 2. Bed DryerSource: https://ptkubota.co.id/wp-content/uploads/2015/09/mesin-dryer.jpg

Bed dryers operate by blowing hot air from the bottom up through a layer of dried material. Heat sources can come from electric heaters, biomass furnaces, or heat exchanger systems that optimize heat efficiency. Hot air causes suspended material particles, increasing contact with airflow and speeding up the drying process. With this design, the temperature and airflow can be controlled to suit the specific needs of the material being dried. The components that make up *a bed dryer* include a drying furnace or heater, an air distribution system, a drying room (*bed*), a blower or fan, and a *control* panel. This tool functions as a rice drying machine that uses biomass as its energy source. Biomass is an organic material that comes from various sources such as agricultural waste, plants, and by-products from animals (Alit and Susana, 2020). This resource can be utilized as fuel for the drying furnace in the bed dryer, where heat energy is generated through the thermal conversion process.

The heat energy generated from the combustion of biomass will be channeled into the pipe, and the heat steam produced will be sucked by the blower to then be used in the drying process of rice grains. The working system of this dryer consists of several simple stages designed to support the drying process

effectively. In the initial stage, biomass fuel is burned in the combustion chamber to generate heat, which is then directed to the drying chamber where the rice is arranged. This system ensures that the heat energy from combustion is optimally used to dry the rice. The heat from the combustion chamber is flowed to the drying chamber with the help of a blower or fan, allowing for an even distribution of heat to remove moisture from the grain of rice (Pakaya *et al.,* 2021). In addition, the system is equipped with precise temperature and airflow control, which allows for temperature and humidity regulation during the process. With proper control, this tool is able to dry rice to the ideal moisture content for long-term storage, resulting in high-quality and durable rice.

Heaters for drying rice operate on the principle of heat flow passing through the rice layer arranged on a rack or inside a drying silo. This process takes place by passing hot air through the bottom of the heater, which then moves up and penetrates the rice grain layer. This heat flow functions to absorb moisture from the granules and evaporate the water content in them (Putra and Novrinaldi, 2019). As hot air passes through the rice layer, the lifted moisture will be expelled through a ventilation system or suction fan. Once some of the moisture is gone, the hot air returns to the bottom of the heater to be reheated, allowing the drying cycle to continue until the rice reaches the desired moisture content. This working system ensures that heat circulation takes place continuously and efficiently, so that the drying process becomes more effective and energy is not wasted.

CONCLUSION

Drying of crops, especially rice, is a crucial stage in ensuring the quality and shelf life of post-harvest products. Analysis of rotary dryer and bed dryer technology shows that physical principles such as heat transfer (conduction and convection) and mechanical concepts (centrifugal and centripetal forces) play an important role in the effectiveness of the drying process. Rotary dryers rely on drum rotation and hot air to even out the distribution of heat and moisture, while bed dryers utilize the flow of hot air from the bottom to the top to evaporate the moisture content in the rice efficiently. The understanding and application of these physical concepts allows for the optimization of temperature, airflow, and rotational speed regulation, so that energy efficiency can be improved and high-quality crops can be achieved. In addition, this analysis is expected to be a reference in Physics learning, especially in relating scientific theory to real applications in the field of agricultural technology.

BIBLIOGRAPHY

Adeyeye, S. A. O., Ashaolu, T. J., & Babu, A. S. (2022). Food drying: A review. *Agricultural reviews*, 1(8), 1-8.

Alit, I. B., & Susana, I. G. B. (2020). The effect of air speed on the corn dryer with a heat exchanger mechanism. *Journal of Mechanical Engineering*, *11*(1), 77-84.

Anggraeni, S. N. H., Dewi, N. N., Martatino, R. N., Sudarti, S., Mahmudi, K. N., & Marbun, F. K. (2024). Thermal conductivity analysis of solar drum dryer machine as drying machine on corn kernels. *Scientific Journal of Mechanical Engineering*, 12(1), 63-68.

Arthur, W. B. (2009). *The nature of technology: What it is and how it evolves*. Simon and Schuster.

Damayanti, A. G., Ulfa, R., & Setyawan, B. (2022). The process of drying grain in the rice hatchery industry at PT. The Archipelago Priest Mangir-Rogojampi. *Journal of Food Technology and Agricultural Sciences (JIPANG),* 4(1), 8-12.

Fatimah, U., Sukma, A. F., Saputra, A. B. M., & Mahmudi, K. (2024). Analysis of mechanical concepts on combine harvester machines in rice processing to improve the efficiency and quality of crop yields. *Indragiri Agro Journal*, 9(2), 78-84.

Hughes, T. P. (2004). *Technological momentum*. *Social Research*, 71(3), 451–478.

Ifah, K. N., Wulansari, E. T., Anggraeni, F. K. A., & Septiviana, F. I. (2024). Analysis of electrical concepts in the use of several agricultural drying machines. *Journal of Information, Science and Technology*, 7(1), 131-144.

Imaduddin, I. R., Basri, M. H., & Jannah, R. (2023). Design and build a grain rotary dryer machine. *ELKOMICS: Journal of Electrical Energy Engineering, Telecommunications Engineering, & Electronics Engineering*, 11(4), 822.

Irawan, B., Yusuf, M. A., & Parjono, P. (2023). Analysis of grain drying rate on flat bed dryer type grain drying machine in Salor Indah Village, Kurik District, Merauke Regency. *Musamus AE Featuring Journal*, 5(2), 40-45.

Jimoh, K. A., Hashim, N., Shamsudin, R., Man, H. C., Jahari, M., & Onwude, D. I. (2023). Recent advances in the drying process of grains. *Food Engineering Reviews*, 15(3), 548-576.

Khikma, I., Afitah, S. N., Syaputra, D., & Mahmudi, K. (2023). Analysis of the concept of heat in the tofu making process. *GRAVIATION: Journal of Physics and Science Education*, 6(02), 25-31.

Kumar, C., Karim, M. A., & Joardder, M. U. H. (2014). Intermittent drying of food products: A critical review. *Renewable and Sustainable Energy Reviews*, 34, 491–499.

McDermott, L. C. (1993). How we teach and how students learn — A mismatch? *American Journal of Physics*, 61(4), 295-298.

Nasution, H. M., & Rahmawati, E. (2019). Design and build a microcontroller-based centripetal force experiment kit. *Indonesian Physics Innovation*, *8*(2), 33-38.

Nurhidayat, W., Aprilia, F., Wahyuni, D. S., & Nana, N. (2020). Ethno Physics is in the form of the implementation of the concept of heat in the mojang priangan dance. *ORBITA: Journal of Education and Physical Sciences*, 6(1), 138 141.

Pakaya, A. R. (2021). Construction of biomass-fueled alternative grain drying furnaces. *Journal of Agricultural Technology Gorontalo (JTPG),* 6(1), 19 24.

Putra, S. A., & Novrinaldi, N. (2019). Heat energy analysis on swirling fluidized bed type grain drying device. *Engineering*, *40*(2), 84-90.

Reif, F. (1995). Understanding and Teaching Important Scientific Thought Processes. *American Journal of Physics*, 63(1), 17-32.

Robbi, A. D. F., Maharani, A., Maharika, M., Anggraeni, F. K. A., & Mahmudi, K. (2024). Literature study: the use of fluids in agroindustrial technology in the

form of dryers in the processing of agricultural products. *PHYDAGOGIC: Journal of Physics and Its Learning*, 7(1), 53-62.

Savitri, M. D., Sari, D. A., & Hakiim, A. (2024). Thermal efficiency analysis on box dryer equipment in the chemical industry. *SYNTEK JURNAL: Scientific Journal of Mechanical Engineering*, 18(1), 44–48.

Siyati, R. (2022). Analysis of cow frequency culture in Madura as an ethnoscience-based learning resource. *Luminous Journal: Scientific Research in Physics Education*, 3(2), 89-95.

Tika, Y. Y. (2022). Mechanism of some agricultural drying machines. *Journal of Physics and Applied Research (Jupiter*), 4(1), 20-28.

Xiao, H. W., & Mujumdar, A. S. (2020). Importance of drying in support of human welfare. *Drying Technology*, 38(12)s, 1542-1543.