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PREFACE: Proceedings of the Transdisciplinary Symposium on Engineering and Technology (TSET) 2022

"Development of Digital and Green Technology on Post Pandemic Era"

It is with great pleasure to welcome you to Transdisciplinary Symposium on Engineering and Technology (TSET) 2022 hosted by Universitas Dian Nusantara on September 21, 2022. The event aims to a venue for engineers, researchers, scholars, and policy makers to explore the challenges and opportunities from the post pandemic era on civil engineering, mechanical engineering, electrical engineering and computer science. For civil engineers, they will play a significant part in the recovery since design and construction services will be needed in the future, and they need to develop new construction methods, materials, and technologies in order to build a sustainable and resilient infrastructure. For engineers, they need to start thinking about the long-term change of their operations and adapt to the "new normal" that has emerged because of the epidemic. We welcome all parties to share their research and thoughts in the symposium.

Participants of the symposium were invited to submit their papers and disseminate them through oral presentation covering such scope as civil engineering, mechanical engineering, electrical engineering and computer science. To enrich the discussion under the theme of "Development of Digital and Green Technology on Post Pandemic Era", we invited speakers with reputable expertise, namely Prof. Josaphat Tetuko Sri Sumantyo, Ph.D. from Chiba University, Japan; Prof. Dr. rer. nat. Evvy Kartini, M.Sc. from National Nuclear Energy Agency of Indonesia; Prof. Dr. Ir. Bambang Sugiarto,, M.Eng. from Universitas Indonesia, Indonesia; and Sulfikar Amir, Ph.D. from Nanyang Technological University, Singapore. In addition to presenting their research results, the participants of the symposium were also encouraged to submit their papers to be proposed for publication to American Institute of Physics (AIP), one of the world's top publishers as conference proceedings. There were 125 manuscripts submitted to the committee comprising 99 papers of Biology, Chemistry, Computer Science and Technology, and Engineering.

Finally, on behalf of the editors of TSET 2022, I would like to extend my most sincere gratitude to the organizing committee, co-hosting institutions, and most importantly, participants, speakers, presenters, and authors of the symposium. I do hope the proceedings bring significant contribution, particularly to the field of advances of sustainable engineering. I look forward to seeing you all at the upcoming symposium.

The Editors,
Ade Gafar Abdullah
Desi Ramayanti
Henri Septanto
Yohanes Galih Adhiyoga

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Air circulation types on Albizia Chinensis refrigerated drying

Petrus Kanisius Purwadi; A. Prasetyadi

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Air Circulation Types on Albizia Chinensis Refrigerated Drying

Petrus Kanisius Purwadi[1, a)] and A. Prasetyadi [1, b)]

[1]*Department of Mechanical Engineering, Sanata Dharma University, Yogyakarta, Indonesia*

[a)] pkpurwadi@gmail.com
[b)] Corresponding author: pras@usd.ac.id

Abstract. Air circulation is important for drying especially in furniture industry. Choice of air circulation type can affect speed of drying, production time, and logistic process. Understanding the effect of air circulation types in refrigerated drying for wooden boards was the aim of this experimental research. Seventy Albizia Chinensis boards of 2 x 0.2 x 0.02 m^3 were tested under closed air circulation and opened air circulation. The closed air circulation recorded 34 hours with 30.4% air humidity and 50°C of the inlet air. The RH outlet air was 65%, and its temperature was 40°C. The opened air circulation had inlet air temperature of 40°C with 32% RH. The outlet air of the opened air circulation was 29°C and 75% in temperature and RH, respectively. It also needed 39.5 hours for the opened air circulation to provide expected boards dryness. It can be concluded that close air circulation is more suitable for drying the boards with COP of 17 in comparison to open air circulation with COP of 10.7.

INTRODUCTION

Drying is important in wood processing before it is crafted to be a product. Principally, drying is a process to reduce the water content of a wood. The process increases durability of the wooden product and its density. It also makes processing product easier at the same time. Water content of a wood affects its fiber quality. The water trapped among carbonic compound of the wood allows oxidation of the protein compound, keep the insect eggs and hatch them. At the same time, the water also increases its weight. Therefore, it is important for drying wood before its processing.

To dry an object, generally people diffuse the water of the object into environment. The 1st common method is thermal method where people increase the temperature of the environment where the product lied. Therefore, relative humidity of the environment decreases and the water can be transferred into air. Such method has a drawback of high temperature meaning high energy consumption and risking the object of getting into fire. The 2nd method applies vapor compression cycle to reduce the water content of the air. The method can work in low temperature, which is applicable for inflammable stuff.

Research on refrigerated drying has been conducted for many applications [1-10]. It is applied for chips [2], herbs [4], grains and clothes [1,5-7]. Basically, the process of the machines follows psychrometric which is applicable for any objects. Less RH of the space provide faster drying process. While the drying process depends on absolute humidity, temperature of the air becomes another determinant factor. Handayani et al. [4] applied a heater for drying ginger. Another researcher put heat exchanger for increasing the drying speed. Density of the product affects time of drying process in addition to air circulation type.

Studying refrigerated drying for wooden planks of Albizia Chinensis is the content of this works. Aiming to understand the air circulation type effect for refrigerated drying wooden planks was the main issue of the article. The performance comparison included drying time, COP, humidity difference and working temperatures. Experimental

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method was the main approach of the work consisting experiment design and evaluation of wooden planks. The method becomes part following the introduction. Results and discussion is the 3rd part and concluded in the final part.

THEORY

The refrigerated drying is based on vapor compression process and psychrometric approach. Vapor compression process is the main method the machine working to pump the water from the air of the drying room. Psychrometric approach becomes the main way for explaining the process of air in drying room. The following part exposes both in respective way.

Vapor Compression

Drying process of the wooden plank is performed by exposing wooden plank to dry air. The dry air allows the water trapped in plank to diffuse. To create dry air, vapor compression machine is applied. The machine has four main parts, they are evaporator, condenser, compressor, and expansion device such as capillary tube. Firstly, it works as a heat pump to remove the heat of the air by decreasing the air temperature in evaporator. This step can remove the water contain of the air through condensation. Then it works as the heater to increase the air temperature using the condenser. The process applies vapor compression cycle depicted in Fig. 1 and Fig. 2.

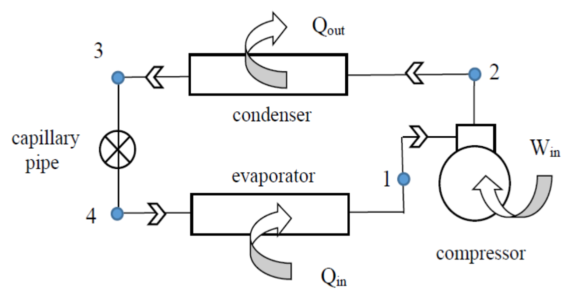

FIGURE 1. Energy flow in a vapor compression machine dryer.

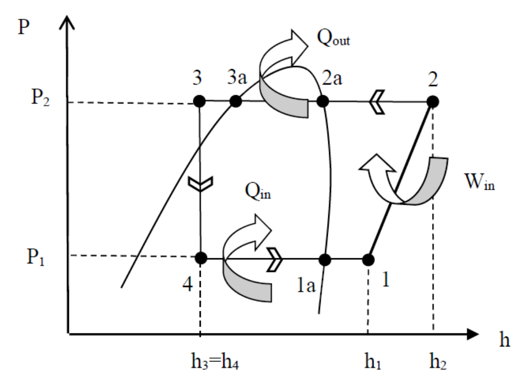

FIGURE 2. Ph diagram of vapor compression cycle.

Figure 1 and 2 show the energy flows of vapor compression in relation to the machine parts and its Ph diagram, respectively. The points numbers on both figures are corresponded. At evaporator, there is heat transfer from air to the refrigerant. Then it flows in refrigerant from evaporator to compressor as shown in point 1. From point 4 to point 1, the enthalpy increases from h4 to h1. The compressor increases the pressure of the refrigerant and transfers it to condenser as mentioned in point 1 to point 2. At compressor, work is added to the system, then the enthalpy increases from h1 to h2. At the same time, the pressure also increases from P1 to P2. In condenser, the heat is released to the air usually using force convection and temperature of the refrigerant cools down or the enthalpy decreases from h2 to h3. It is the action of point 2 to point 3. Then it moves to capillary pipe to conduct point 3 to point 4. In capillary pipe, the refrigerant is expanded and the pressure decreasing P1. The refrigerant is ready for the next cycle.

Performance of the machine is determined by Coefficient of Performance (COP). It is the ratio of used energy to energy needed by the machine [11-16]. This COP can be shown in Equation (1). Used energy involves the heat transferred from air to evaporator and heat transferred from condenser to air. The COP can also be calculated using equation (2). The variables of h_1, h_2, h_3 and h_4 are the enthalpy of the respective indexes, while Q_{in}, Q_{out}, and W_{in} are heat pumped from the air, heat released to the air, and work supplied by compressor, respectively.

$$COP = \frac{used\_energy}{needed\_energy} = \frac{Q_{in} + Q_{out}}{W_{in}} \qquad (1)$$

$$COP = \frac{\left[(h_1 - h_4) + (h_2 - h_3)\right]}{(h_2 - h_1)} \qquad (2)$$

Psychrometric

Psychrometric is about physical and thermodynamic properties of air mixtures. It also mentions relation of water content of the air and its thermodynamic properties. They are the enthalpy, dry bulb temperature, wet bulb temperature, and humidity. Generally, to reduce the water content of the air, temperature of the air is decreased below its condensation point. While the temperature decreases, the absolute humidity gets lower. After the temperature gets less than the condensation point, some of the water condensed. This process reduces absolute humidity. In the opposite direction, increasing temperature reduces relative humidity. Therefore, increasing the air temperature is also important for drying.

Psychrometric processes of closed air drying and opened air drying are a bit different. It is shown in Fig 3 and Fig 4. The closed air drying is mentioned in Fig 3. The process is started from decreasing temperature of the air to its condensation point as shown from point A to B. Then, the temperature is decreased to condensed some of water content as the process from B to C. After that, the air temperature is increased to reduce its relative humidity as the process of C to D. Following is the process of increasing its absolute humidity through transferring water from the dried object to air as the drying process. This process follows the line D to E and point E is equal to A. It is different part of closed air drying from the opened air drying. It can be seen at Fig. 4 that the opened air drying process has opened curve lines. The final position E is not equal to A as starting point.

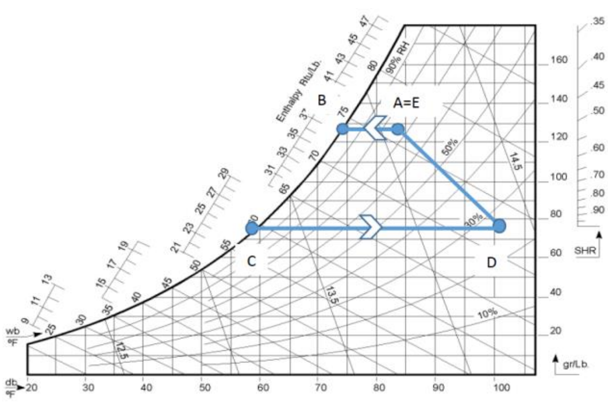

FIGURE 3. Proses of drying in closed air method.

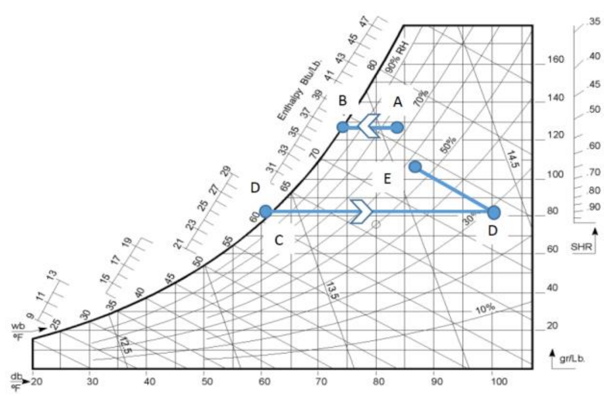

FIGURE 4. Proses of drying in opened air method.

METHODS

The experiment setup evaluating the air circulation in drying the Albizia Chinensis planks comprises dried object description in addition to drying machine setup and steps of experiment. The dried object describes the planks types, size, and number. The drying machine setup shows the equipment for drying and its settings. The steps will be followed by experiment steps completed with variables.

Equipment Setup

Albizia Chinensis planks are the object for being dried. For the experiment, 70 planks were lied on 14 staggers in drying room. These planks have 27,6% water content and have 2 m x 0.2 m x 0.02 m dimension. The targeted water content was 10%. Two conditions of drying were applied. They are closed air drying and opened air drying. To circulate the air, two fans of 20 W each. The evaporator and condenser have 20 W fan each. To circulate the refrigerant, 1 hp compressor was applied. The total electricity load of the machine was 850 W. The design of the machine can be seen in Fig. 5.

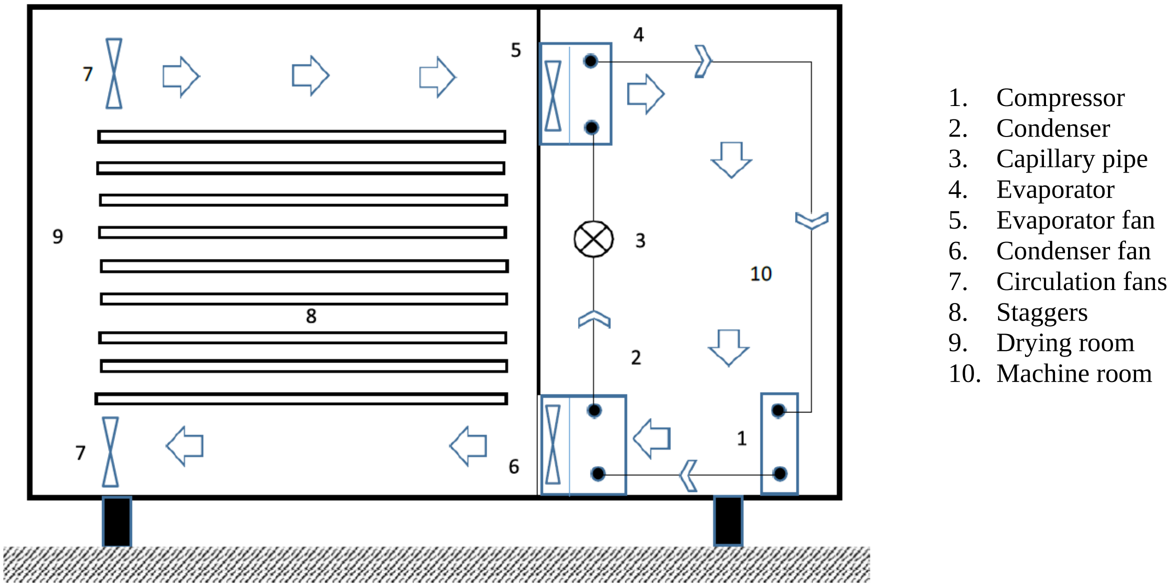

FIGURE 5. Drying machine setup for closed air drying.

Measurement Steps

The experiment was conducted to measure time needed for drying the Albizia Chinensis planks. Two machine conditions are set up. They are closed air drying and opened air drying. In closed air drying, the air is circulated between drying room and machine room. In opened air drying, the outdoor air was suctioned to evaporator. Then it moved to condenser for heating. After that it went to drying room before it left. The water condensed on evaporator was collected. To show the drying process, time, water content of the planks, electricity current, electricity voltage, condenser pressure, and evaporator pressure were measured.

The experiment also has intention for depicting the psychrometric processes in the drying process. The variables measured in the experiment for this aim were the dry bulb of inlet air, the dry bulb of outlet air, the wet bulb of inlet air, the dry bulb of outlet air, the dry bulb and wet bulb air leaving evaporator, the dry bulb and wet bulb air leaving condenser, and the dry and wet bulb air entering the condenser. The data of variables were collected every hour until the water content of the planks reach 10%.

RESULTS AND DISCUSSION

Closed air drying was faster than opened air drying as shown in Table 1. The closed air drying needed 34 hours to meet the required condition. The opened air drying needed 39.5 hours to make the planks water content being 10%. Both methods can dry the planks faster than conventional methods applying thermal drying. The conventional method using LPG or wooden chips needs 2 weeks to make the water content of the planks 10%. Faster drying process in comparison to conventional thermal approach is considered promising alternative method. The methods whether closed or opened air drying, both only needed 2 – 3 days. Therefore, in term of time, the method can increase the productivity by 5 times.

The parameters of drying are shown in Table 2. The table shows dry and wet bulbs of the inlet and outlet air drying room. The relative humidity and temperature differences of the opened air drying are 43% and 11^{o}C, respectively. The closed air drying has relative humidity difference of 34.5. It also has temperature difference of 10^{o}C. Even the opened air has higher temperature and relative humidity difference, the opened air circulation has less effectivity. The opened air needed longer time to get the water content reaching 10%. Opened air circulation has working temperature of 29

^{o}C for air leaving the drying room. It recorded 40^{o}C for the air going to the drying room for the closed air drying. Higher temperature of the closed air drying, even had less air temperature, provided more absolute humidity difference. The closed air drying had absolute humidity difference of 5 10^{-3} kg/kg, while the opened air drying only made the absolute humidity difference of 3 10^{-3} kg/kg. The difference of absolute humidity affects the speed of drying process.

Closed air drying dried the wooden planks faster. In addition of higher absolute humidity different, the closed air drying also had higher COP as mentioned in Table 3. The closed air drying could reach COP of 17 while, the opened air drying only reached COP of 10. The opened air drying worked with higher Q_{in} and Q_{out}, but it needed also higher W_{in} than the closed air drying. The opened air drying also had also higher difference of Q_{in} and Q_{out} in comparison to the closed air drying. It confirmed that the opened air drying needed more work than the closed air drying. The COP shows that the closed air drying worked more effectively than the opened one.

TABLE 1. Time drying according to type of air circulation**.**

Type of air circulation	% of starting water content	% of final water content	Time
Opened air drying	27.6	10	39.5
Closed air drying	27.6	10	34

TABLE 2. Air conditions on inlet and outlet of drying room.

Type of air circulation	Entering drying room			Leaving drying room		
	Dry bulb temperature (^{o}C)	RH (%)	Absolute humidity (10^{-3}kg/kg)	Dry bulb temperature (^{o}C)	RH (%)	Absolute humidity (10^{-3}kg/kg)
Opened air drying	29	75	18	40	32	15
Closed air drying	40	65	29	50	30.5	24

TABLE 3. Drying machine performance.

Type of air circulation	Q_{in} (kJ/kg)	Q_{out} (kJ/kg)	W_{in} (kJ/kg)	COP
Opened air drying	130.5	157.3	26.8	10.7
Closed air drying	127.2	143.1	15.9	17.0

CONCLUSION

The work shows that closed air drying can dry the Albizia Chinensis faster and more effectively than the opened air drying. The closed air drying needed 34 hours for drying 70 planks of 2 x 0.2 x 0.02 m^3 with COP of 17. The opened air drying needed 39.5 hours for the same tasks with COP of 10.7. The closed air drying works in higher temperature than the opened air drying. Although the opened air drying has higher RH difference than closed air drying, it has less absolute humidity difference. Improvement can be proposed to make the system working in higher temperature of drying room.

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