Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

Instore-Drying Method Utilization in Shallots Drying using Geothermal Energy

Dede Irama[1], Wita Rosmala Sari Anggraini[1] and Jooned Hendrarsakti[1,2]

[1]Program Study of Geothermal Technology, Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung

[2]Faculty of Mechanical and Aerospace Engineering, Institut Teknologi Bandung

Jl. Ganesa No. 10, Bandung 40132, West Java, Indonesia

de2.irama@gmail.com, witarosmala.sa@gmail.com, jooned@ftmd.itb.ac.id

Keywords: shallots, instore-drying, geothermal energy

ABSTRACT

The shallot (*Allium cepa*), or it is usually known as small red onions in Indonesia, is one kind of horticultural crops that is widely cultivated in Indonesia. Shallots cultivation has many advantages, but it also has a high risk when post-harvest handling is handled inappropriately. Improper handling can cause loss in weight, as well as damage to its bulbs because of being rotten, moldy and new shoots grow. The drying and storage processes play important roles in post-harvest. Preserving shallots bulbs is usually done with drying. The method that is usually used in post-harvest is solar energy drying which normally takes 7-9 days. This becomes a constraint when the season and weather become unpredictable in Indonesia. Instore-drying method design, utilizing a drying warehouse and storage model, when applied with a heat source from geothermal energy becomes a solution to avoid fresh shallots damage because the availability of geothermal energy does not depend on the season and weather. By extending the retention age and maintaining shallots quality with avoiding its bulbs damage, so farmers would add value in the selling price that remains stable during the peak of harvest time. The shallots are stored by hanging on ties in a special warehouse at a temperature of 25-30 °C with an equilibrium moisture content of 50%. The economical assessment indicated that the drying cost using geothermal fluids is more economical than using diesel energy.

1. INTRODUCTION

1.1 Background of Study

Shallot cultivation is widely performed by farmers because it is a profitable commodity. In addition to the promised benefits, shallot cultivation also contains enormous risks, one of them is failure in post-harvest handling. Therefore, it is necessary to improve the post-handling process more precisely, so it can prolong the shelf life of shallot.

The process of drying and storage in shallot cultivation is an important thing to do in post-harvest. Preservation of onion bulbs is usually conducted by drying (Wirakartakusumah et al., 1992; Hartuti and Asgar, 1994; Ruhtadi et al., 1995). Drying techniques are widely used in the processing of agricultural products and food products by drying with solar energy and heat and water vapor pressure differential treatment. In addition to lowering water levels, drying can also reduce the volume of the product, making it easier for storage and transport.

Drying and storage improvement at the farmer level using instore-drying method, as a method of artificial drying, is giving the opportunity for the shallot farmers to overcome the difficulty of shallot postharvest handling, especially at harvest during the rainy season which currently the time of arrival cannot be predicted. Utilization of drying and storage warehouse models (instore drying) to avoid damage due to fresh shallot when bad weather happened and maintains its quality by avoiding shallot bulbs being rotten, growing bulbs and bulbs growing empty, so that farmers will gain added value in the form of shallots selling prices at the end of the harvest. Geothermal energy as a source of heat is applied together with a drying instore drying method is an alternative that can be used by farmers in all seasons, because of this energy is available all year long.

1.2 Objectives

The objectives of this study are:

1. To design and calculate shallots drying equipment requirements of instore drying method using a source of heat energy from the geothermal fluid.

2. Comparing costs based on heating energy used for drying between diesel fuel and geothermal fluid.

1.3 Problem Assumption

The problem limitations of this study are:

1. The amount of shallot that is being dried is one ton per week.

2. The calculation design is solely devoted to the needs for shallot drying and it does not include requirements for geothermal power plants.

In resolving the issues that have been mentioned previously, a flow chart is made as a reference so the steps will be done as follows.

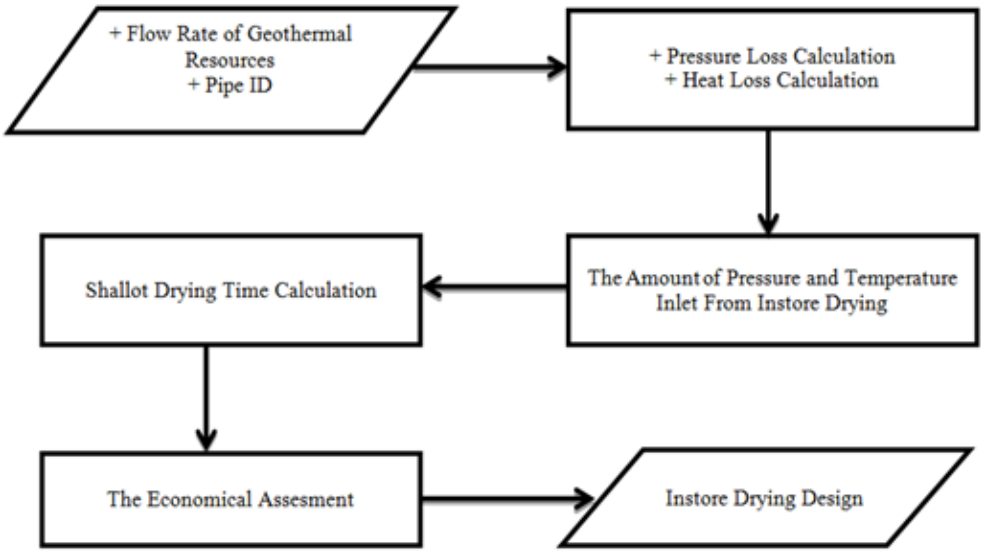


Figure 1: Research flow diagram.

2. THE PATTERNS OF PLANTING AND HARVESTING SHALLOTS

The planting and harvesting of shallots is normally three times per year, with shelf life of shallots in a warehouse between 2-3 months especially the bulbs that will be used as seeds. Over the years, the drying technique used by farmers is drying under the sun which takes 7-9 days. This drying technique depends on weather conditions.

Based on the research results on utilization, drying and storage warehouse models (instore drying) could avoid shallots damage due to bad weather and maintain quality by avoiding rotten bulbs, growing bulbs and bulbs grow empty. Some specifications that should be noted in the design include: (pipe size and material), safety (security), reliability.

The basic principle of heat exchange is needed in the process of drying shallots with geothermal energy. Ambient air temperature can be increased by passing the air where geothermal fluid flows in the heat exchanger. This heat exchange process is simply formulated as:

$$m_1.Cp_1.\Delta T = m_2.Cp_2.\Delta T \tag{1}$$

Where m, Cp, ΔT are mass of flow rate, specific heat at constant pressure and delta temperature for T_2-T_1, respectively.

The heat loss calculation used is from the formula proposed by Lyle (1947) presented in the paper written by Russel James as follows:

$$H = \frac{2.019P^{0.321}}{t^{0.737}} \tag{2}$$

Where H, P, t are heat loss calculation, pressure and thickness, respectively.

Pressure losses occurs in the pipe due to three factors, namely due to friction, acceleration and gravity. In the pressure loss calculation in the pipelines with a geothermal resource within 400 meters from the location of shallots drying we used the Homogeneous method. The basic pressure loss calculation is:

$$\left(\frac{dp}{dz}\right)_t = \left(\frac{dp}{dz}\right)_f + \left(\frac{dp}{dz}\right)_g + \left(\frac{dp}{dz}\right)_a \tag{3}$$

This theory is used in the shallot drying process, especially with the dehumidification method applied in a room (instore drying). The dehumidification process is the process of taking water masses in moist air from the source specified in the conditions of constant pressure. Illustration of the process is shown in Figure 2.

Evaluation in the dehumidification process in the above calculation is done with the mass and energy balance as shown in the following formula (Moran, 2006).

$$\begin{aligned} &m_{a1} = m_{a2} \\ &m_{v1} = m_w + m_{v2} \\ &m_t(h_i - h_e) + (m_a h_{a1} + m_{v1} h_{v1}) - m_w h_w - (m_a h_{a2} + m_{v2} h_{v2}) = 0 \end{aligned} \tag{4}$$

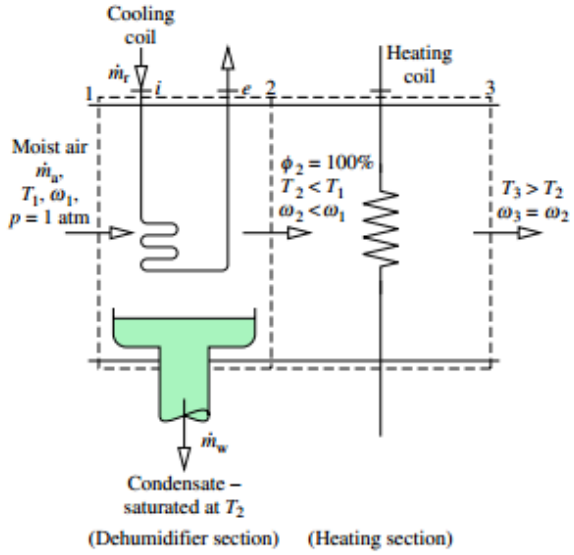


Figure 2: Dehumidifier schematic (Moran et al., 2003)

3. CASE STUDY

The design is conducted for a system of drying 1 ton of shallots per week in which the geothermal resource is located within 400 meters and a head of 20 meters, with the characteristics of: fluid temperature of 180°C; pressure of 1 atm and flow rate of 500 gpm. The calculation is trying to approach the actual condition and needs with some assumptions used.

Some considerations and assumptions used in solving these problems are: the mass flow rate of the geothermal resource; the diameter and thickness of pipeline and pressure at the drying location. The things need to be considered in the shallot drying with instore drying method include:

- Minimum temperature of fluid injected to the reservoir is 80°C, preventing deposition on injection wells.
- To maintain the quality and extend the shelf life of shallot seeds it is needed to apply storage techniques by setting the temperature and humidity of the storage warehouse. Shallot storage at low temperature (0-7.5°C) and high temperature (25-30°C) with environment humidity of 65-80% can delay shallot's sprouting (Yamaguchi et al., 1957 in Soedomo, 2006), whereas according to Sutarya and Grubben (1995), shallot bulbs are stored by hanging shallot on ties in a special warehouse at a temperature of 25-30°C and low humidity (± 50-80%).
- So the 50% value becomes Equilibrium Moisture Content (EMC) in the design of drying, and the shallot humidity level should be reduced from 100% to 50%.

Here is a schematic of the drying process:

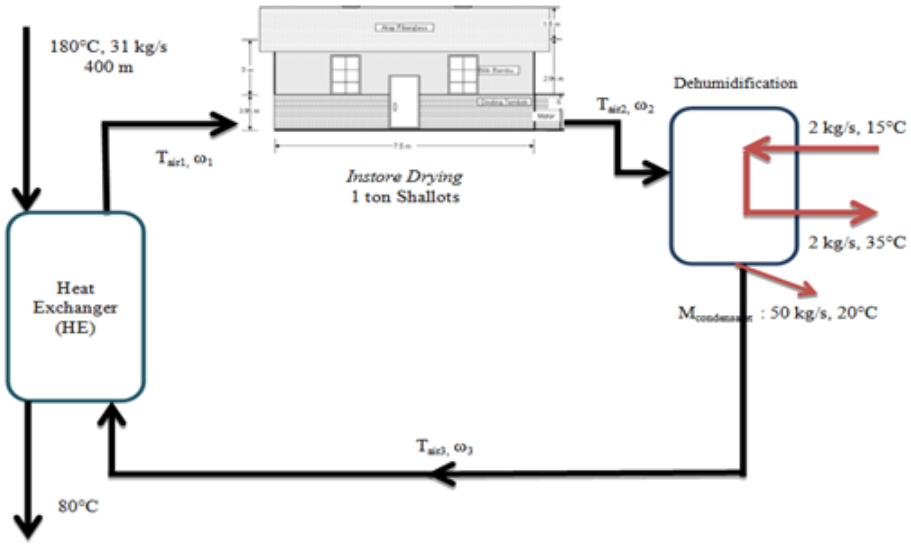


Figure 3: Schematic process of shallot drying process with instore drying method.

To determine the inlet pressure and temperature of shallot drying then pressure loss calculation is done along 400 meters pipeline that connects the geothermal resource with shallot drying.

Table 1: Pipeline inside diameter determination.

Velocity	Temperature	Ps	v_s	ρ_s	Flow rate	A	Pipe Diameter		Pipe Length
m/s	°C	bar	m^3/kg	kg/m^3	kg/s	m^2	meter	inch	meter
40	180.0	10.0	0.194	5.158	31.5	0.15	0.44	17.36	400

Table 2: Pressure loss along the pipeline per 20 meters.

x	Flowrate	Velocity	NRe	A	B	λ	ΔP	P_2
	kg/s	m/s					bar	bar
1	31.5	40	6.05E+06	2.64E+22	4.80E-36	0.0126	0.0236	9.9764

Table 3: Pressure loss in the pipeline along 400 meters.

ΔP	Pressure Inlet of Instore Drying	Inlet Temperature of Instore Drying
	bara	°C
0.548	**9.5**	**177.6**

Calculations show the pressure loss in pipeline along 400 meters is 0.548 bar.

To determine the value of heat loss in the pipeline use the Russel James formula in Equation (2) using a pipe ID of 0.44 meters from pressure loss calculation and to determine the mass flow rate of dry air entering the heat exchanger, then use the Equation (1). From the calculation of all these, the obtained mass flow rate of dry air entering the heat exchanger is 26.4 kg/s. The amount of water that should be removed from wet shallots can be determined by using initial moisture content relationship with EMC, and in this case is 60% at Bandung city. The known shallot drying system is equal to 1 ton (1000 kg). As mentioned of all these things that need to be considered in this design, the initial amount water in the shallot is 100% and the amount of water in the shallot on EMC is 50%. So from the above calculation, we can estimate the mass of water that must be subtracted from the shallot. The air coming out from the instore drying is the sum of the mass and energy of the incoming dry air and vapor as a result of evaporation in shallot. If the results from the equation above is continued then we can calculate the amount of water vaporised in a given time unit. To determine T_2, the temperature is guessed because dry air and vapor enthalpy is a function of temperature. After repeated iterations, T_2 is obtained as approximately 96.74°C.

Table 4: Parameter calculation result 1.

H	Q	m_2	m_{1w}	m_{2w}	m_w	m_v	ω_2	T_2
KW/m_2	J/s	Kg/s	Kg	Kg	Kg	Kg air/s	%	^0C
0.236	26.02	26.4	500	334	166	0.92	3.4	96.74

There is 0.92 kg of water taken from the water content in the shallot every second. If the total mass of water that must be removed is about 166 kg, the time required to dispose of all the water mass is about 5 hours, or about 180,000 seconds in the instore drying. As for drying 1 ton of shallots, then it takes approximately **30 hours/week**.

4. ECONOMICAL ASSESSMENT

The economical assessment is conducted in order to compare the cost efficiency of any energy or fuel used. Comparison is referred to the cost-effectiveness of geothermal steam to fossil fuels such as diesel fuel. The parameter calculation results and vapor needed to dry shallots are summarized in Table 5.

The difference in the drying cost is highly associated with supporting facilities. For example, the consideration of drying with steam will have piping and insulation costs. Meanwhile, drying using diesel fuel will need a boiler. Cost comparison from two types of drying system will be carried on drying process per day.

- Diesel Fuel
- If diesel fuel is used and the heating value is 39,000 kJ/kg, so the required diesel fuel is 1,132.37 kg. If the density of diesel fuel is 0.81 kg/liter, the volume of diesel fuel needed is 1,397.9 liters. If the price of economical diesel fuel, which is the type of diesel fuel used for industrial sectors in Indonesia, during the period of December 15-30, 2013 was IDR 11,700.00 per liter, then the total cost of diesel fuel needed is IDR 16,355,430.00.
- Geothermal Fluid

- For shallot drying using geothermal steam, the price of geothermal steam is approximately IDR 420.00/kWh. This price is referred to Kamojang field. So the total cost needed for shallot drying using geothermal steam is IDR 5,152,392.00.

Table 5: Parameter calculation results 2.

Parameters	Value	Unit
Steam needed	5.1	kg/s
Drying time	30	Hour/week
Mass of dry steam	550,800	kg/s/week
Energy needed for drying	2332,2	kW
Energy needed	12,267.6	kWh
	44,162,546.1	kJ

Both calculations are done to compare economically the different usage of energy. Those calculations show that the cost of drying 1 ton shallots per week using geothermal steam is more economical.

5. CONCLUSIONS

- Through engineering review, it has designed a dehumidification instore drying facility and theoretically it takes over 30 hours for drying 1 ton shallots per week using geothermal fluid.

- Through economical assessment, the cost of energy used for drying facility shows that the use of geothermal fluid is more economical than diesel fuel.

6. RECOMMENDATION

- Futher engineering should also review and perform a sensitivity analysis to drying air flow rate and the rate of cooling water in the dehumidifier.

- Locate drying (Instore Drying) of shallot grown closer to the geothermal resources (<400 Meters) to the cost of piping and insulation efficiency.

REFERENCES

DiPippo, R.: Geothermal Power Plant: Principles, Applications, Case Studies and Environmental Impact, Elsevier, Massachusets (2008).

Hartuti, N., and Asgar, A.: Pengaruh Suhu Pengeringan dan Tebal Pengirisan Terhadap Mutu Tepung Dua Kultivar Bawang Merah, Proceedings, Seminar Ilmiah Nasional Komoditas Sayuran, Balai Penelitian Tanaman Sayuran, Lembang (1994), 617-624.

http://infosolarindustri.wordpress.com/2013/12/20/harga-keekonomian-bbm-pertamina-wilayah-jakarta-15-31-desember-2013, accessed on December 28, 2013.

http://www.litbang.deptan.go.id/special/komoditas/files/0104-BMERAH.pdf, accessed on December 22, 2013.

James, R.: Heat Loss and Pressure Drop Balance for Geothermal Steam Transmission, Wairakei, New Zealand.

Moran, M.J. et al., Intoduction to Thermal Systems Engineering: Thermodynamics, Fluid Mechanics, and Heat Transfer, John Wiley & Sons, New York (2003).

Musaddad, D., and Sinaga, R.M.: Pengaruh Suhu Penyimpanan Terhadap Mutu Bawang Merah (Allium cepa), Buletin Penelitian Hortikultura, XXVI (2), (1994), 134-141.

Nugraha, S., Adiandri, and Yulianingsih, R.S.: Inovasi Teknologi Instore Drying Untuk Mempertahankan Mutu dan Nilai Tambah Bawang Merah, Balai Besar Penelitian dan Pengembangan Pascapanen Pertanian, Departemen Pertanian, Bogor, Indonesia (2010).

Rafferty, K. D. Heat Exchangers. Gene Culver. Geo-Heat Center: Klamath Falls, Oregon, USA.

Sinaga, R.M., and Darkom, M.: Pengaruh Suhu dan Kelembaban Terhadap Mutu Bawang Putih (Allium Sativum l.) Kultivar Lumbu Hijau di Penyimpanan, Buletin Hortikultura, 26 (3), (1994), 153-163.

Stallen, M.P.K, and Hilman, Y.: Effect Plant Density and Bulb Size on Yield and Quality of Shallot, Buletin Penelitian Hortikultura, XX (1), (1991).