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Direct Use from Geothermal Brine to Subtitute Conventional Raw Material in Heating Process for Drying Palm Sugar in Lahendong Geothermal Field, Indonesia

Rahindradi Puntho SAMBODHO, Mukhamad NASHIR, Bagus Dimas WIBISONO, Apriyansah TONI

PT Pertamina Geothermal Energy Area Lahendong. Jl. Raya Tomohon No.420, Tomohon-Sulawesi Utara, Indonesia 95431

rahindradi.puntho@pertamina.com

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ABSTRACT

Currently, PT PGE Lahendong is generating 120 MW of power electricity to meet the needs of energy for people of North Sulawesi. Despite it is the main purposes for power generation, then geothermal energy also can be used for direct use such as drying of palm sugar. By utilizing the remaining heat contained in geothermal brine with temperature around 184 °C, it will subtitute conventional raw materials in aim to acquire a heating process for drying palm sugar, so it will be environmentally friendly and has a great impact on the community empowerment. PT PGE has been collaborated with Masarang foundation in drying palm sugar since 2006 until now.

1. INTRODUCTION

Indonesia has the largest potential of geothermal energy in the world, with a potential of more than 28,910 MW. Most of Indonesia's geothermal resources are hydrothermal. Even though it has the potential of large geothermal energy, the use of geothermal energy in Indonesia is 1,533 MW (5%), and is limited to electricity generation (indirect use). The location of geothermal resources is generally located in mountainous areas adjacent to the location of agricultural land (including plantations), forestry, bathing and spa resorts, etc., therefore it is very potential for various direct use applications. Based on the Republic of Indonesia's geothermal law (Law No. 21/2014), geothermal utilization is divided into two, namely direct use and indirect use.

Since 2006, PT Pertamina Geothermal Energy (PGE) as a subsidiary of Pertamina, has developed geothermal energy for electricity generation (indirect use). Currently PGE manages 14 Geothermal Concession Areas (WKP) with a total installed capacity of 617 MW. One of the managed geothermal WKPs is the Lahendong Region in North Sulawesi Province with an installed capacity of 120 MW for 6 Units.

In addition to electricity generation, geothermal energy in the Lahendong area is also used for drying palm sugar (direct use). Liquid palm sugar which is tapped from sugar palm trees, then dried into sugar with the help of geothermal energy contained in geothermal brine.

2. PALM SUGAR

Tomohon is one of the cities in North Sulawesi province which is famous for its wealth of palm sugar with the result of palm sugars processed by traditional palm farmers from Tomohon indigenous people. The profession as a palm farmer is not only regarded as a livelihood but also contains cultural values or traditions therein, as in the picture below. The Tomohon community, also known as the Minahasa people, believes that their profession is a legacy of the Minahasa ancestors (Masarang Foundation,2017).

Figure 1: A Man is Climbing The Sugar Palm Tree (Gunawan, 2018)

Figure 2: Traditional Palm Sugar Production (Pontoh and Roeroe, 2015)

Palm sugar is one of the products produced from the sugar palm tree (Arenga pinnata) or Aren tree. The stalk of a female flower of the tree was treated by beating it several times in a period of a month and cut near the inflorescence. The cut stalk will produce sugary juice of about 10 to 50 liters a day with an average of 20 liters a day. The juice, containing about 12 to 16 percent with an average of 14 percent sucrose (Pontoh, 2007), is boiled till become thick juice then molded into a pike of bamboo or a coconut shell to produce a block of brown sugar or the thick juice is continually stirred to produce granulated brown sugar. Traditionally, the brown sugar is produced by the farmers by boiling the juice in a pan of about 25 liters in the field using firewood. The boiling time for one pan is about 4 to 5 hours. It is estimated that one farmer needs about 30 kg of wood per day. The wood is gathered around his farm or taken from the forest. This practice concerned the Masarang Foundation as a Non Government Organization working in the environmental issues such as protection of the lands through reforestation. If there are about 3,500 sugar palm farmers then they need 200 m^3 of wood per day while their farm can only produce about 50 m^3 per day from 3,000 ha of their lands. Its mean they have to take about 50,000 m^3 per year from the forest (Smits, 2006). This can cause significant impact to the environment. Therefore, the foundation is looking for alternative energy to the farmers. The solution comes from the collaboration with the PT Pertamina Geothermal Energy, Lahendong Area (Pontoh and Roeroe, 2015).

Figure 3: Masarang Palm Sugar Factory (Pontoh and Roeroe, 2015)

The company give some of the remaining brine water from the separator output to the Masarang Palm Sugar Factory, so that the remaining heat contained in geothermal brine was used to dry palm sugar.

3. GEOTHERMAL SCHEMATIC PGE AREA LAHENDONG

Lahendong geothermal field is a hot water-dominated system situated within a structurally complex volcanic setting (e.g., Koestono et al., 2010; Utami, 2011; Brehme et al., 2014; Wiegand et al., 2015). Its location is in North Sulawesi province in Indonesia, about 750 m above sea level, between two active volcanoes, namely Lokon (9 km to the north) and Soputan (20 km to the south). Lahendong Geothermal Area is the only operating geothermal power plant in northern Sulawesi and supports up to 60% electricity

needed in the north and middle Sulawesi region. Exploration of Lahendong geothermal field began in the 1970s (e.g., Surachman et al., 1987; Wiegand et al., 2015).

Figure 4: Location of Lahendong Geothermal Field (Tesha,2006)

Currently the installed capacity of the Lahendong area reaches 120 MW, which consists of Unit 1 PLTP of 20 MW (Commercial operation Date / COD in 2001), Unit 2 PLTP of 20 MW (COD in 2007), PLTP Unit 3 of 20 MW (COD in 2009), PLTP Unit 4 of 20 MW (COD in 2011), PLTP Unit 5 of 20 MW (COD in 2016), and PLTP Unit 6 of 20 MW (COD in 2016). Business contract agreements for unit 1 up to unit 4 are steam sales contracts with PLN, while units 5 and 6 are energy sales contracts with PLN.

Lahendong geothermal field has a twophase fluid system; therefore a special process using a separator is needed to dissociate the water contents within the two-phase fluid. Dry steam can be yielded to minimum power plant fulfillment standard steam requirements (Tesha,2006).

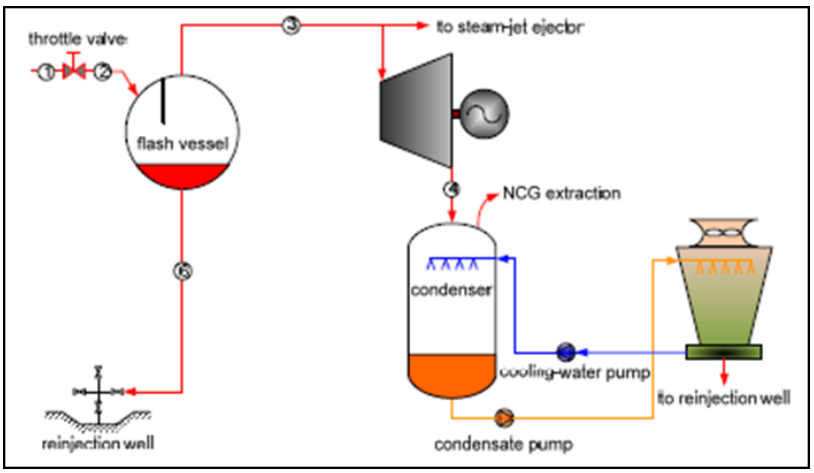

Figure 5: Schematic Diagram for a Flash System with a Condensing Turbine (Nugroho,2007)

After passing through the separation process, two-phase fluid inside the separator is separated to water (brine) and dry steam. The dry steam is piped directly to Geothermal Power Plant to drive the steam turbine while the brine water is collected in a cooling pond from where it is pumped to the re-injection well (Tesha,2006). In fact, brine water which is injected into the reinjection wells, still has enough heat to be utilized. The Hot Brine will flashing, so that hot steam can be used for the drying process of coffee and palm sugar, sterilization process, food cooking process, spa, and etc.

4. PALM SUGAR PRODUCTION

Palm sugar drying process uses the remaining heat contained in brine as a result of the separation of geothermal fluid. Geothermal fluids flowed from production wells LHD-8, LHD-11, LHD-12, LHD-15, LHD-38 to separator at LHD-13 cluster locations through a 18 inch and 22 inch diameter pipe. The geothermal fluid is then separated into two, dry steam and brine. Brine was then supplied to the factory through a 10 inch diameter pipe. The factory only needs 3 inch and 2 inch pipe to supply its need.

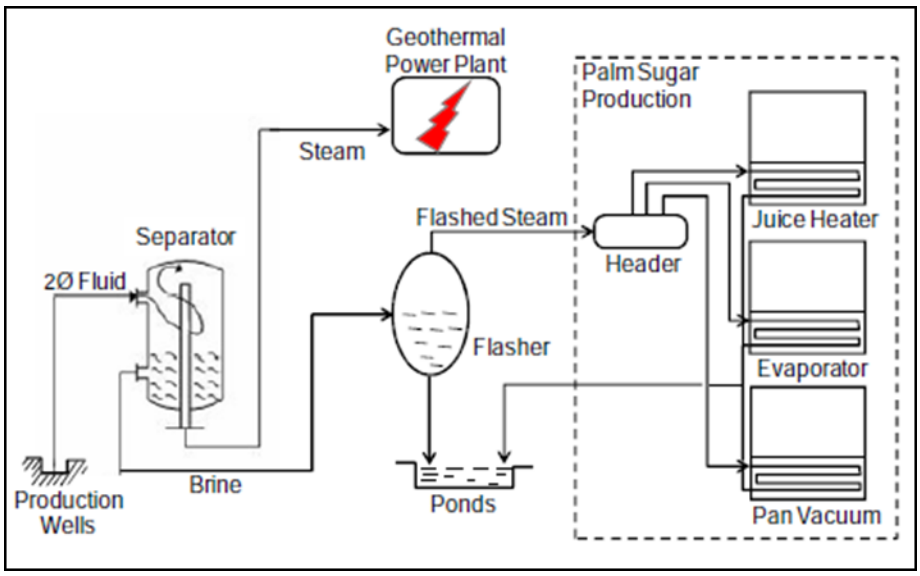

Figure 6: Schematic Diagram of Palm Sugar Production by Utilizing Brine (e.g.,Surana et al,2010)

Table 1 Temperature, pipe diameter, and flow rate at PT PGE Area Lahendong Cluster LHD-13 (Lope,2018)

Temperature (°C)	Diameter (inch)	Diameter (meter)	Flow Rate (ton/jam)	Flow Rate (ton/jam)	Flow Rate (kg/s)
184	3	0,0762	87,84-110,16	24,75	6,875

Table 2 Diameter of pipe and brine flow rate at PT Gunung Green Gula Aren Masarang (Lope,2018)

Process	Diameter (inch)	Diameter (meter)	Flow Rate (ton/jam)	Flow Rate (kg/s)
Evaporated	3	0,0762	7,43	2,06
Cooking	2	0,0508	4,95	1,38
Drying	2	0,0508	12,38	3,44

Table 3 Temperature of the brine (Lope,2018)

	T initial (°C)	T final (°C)	ΔT (°C)	Entalphy
Evaporated	184	68,2	115	485,8
Cooking		86,47	97,50	408,5
Drying		46,8	137,2	576,9

Based on the data obtained, brine from the separator used in the factory company A, has a temperature of 184 Celsius with a flow rate speed of 87.84-110.16 tons/hour. The value of enthalpy that is utilized for the production of palm sugar by the factory is 1000.748 kj/s for evaporation water Nira, 563.73 KJ/s for cooking process to be palm sugar and 1984.536 KJ/s for palm sugar drying. The geothermal steam used by PGE to produce 1 MW of electricity has a temperature of 170-180 Celsius (steam), steam enthalpy 2771.2 KJ,/s and flow rate speed of 7 tons/hour (1.94 kg), where the price of geothermal steam per KWH amounted to IDR 780,- (Lope,2018).

Evaporation of water Nira as much as 82.706 liters for 2 hours need 511.903 KWH brine with the price of IDR 399.284 in a day. Cooking water nira to palm sugar for 7 hours produces 703 kg of palm sugar requires 734.005 KWH brine with the price of IDR 572,523.9 in a day. Drying 720 kg of palm sugar for 6 hours requires KWH brine with the price of IDR 1,727,565.84 done once a week giving brine PT. PGE Area Lahendong to PT. Gunung Green sugar Aren Masarang in IDR conversion for drying a week by IDR 1,727,565.84 for evaporation and cooking in a day IDR 971,807.9 (Lope,2018).

5. CONCLUSION

Remaining brine from the production process of geothermal power plants, can still be used for direct use, because it still contains hot temperatures, one of which is for the production of palm sugar.

The purpose of using brine that is flowing PT PGE Area Lahendong to PT Gunung Green Gula Aren Masarang is to improve the welfare of society. The utilization of brine will have an impact on the number of water demand for farmers. Demand for water that has been processed to obtain a good PH can increase the revenue of palm farmers through an increase in the amount of water that is tapped. In addition, the use of brine geothermal for palm sugar drying, will bring an impact on the reduction of the tree logging that was originally used for the drying fuel.

The use of brine in the drying process cannot be carried out simultaneously with the evaporation and / or cooking process. Simultaneous operation using brine can only be done in the evaporation and cooking process. The value of the enthalpy brine PT. PGE Area Lahendong utilized by PT Gunung Green Gula Aren Masarang in the conversion of rupiah for drying worth IDR 1,727,565.84 for evaporation and supply of IDR 971,807.9.

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