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Direct Application of Steam Geothermal For Oyster Mushroom (*Pleurotus ostreatus*) Cultivation in Kamojang Geothermal Field, Indonesia

Achmad Sri Fadli, Heri Susanto,Adi Rahmadi, Tavip Dwikorianto [1]

[1]Pertamina Geothermal Energy Kamojang Field,PO BOX 120, Indonesia

Achmad.Fadli@pertamina.com, Heri.Susanto@pertamina.com, adi.rahmadi@pertamina.com, tavip@pertamina.com

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ABSTRACT

Geothermal steam has been widely used for direct and indirect applications. Farming communities around Kamojang geothermal field has been cultivated Oyster mushrooms *(Pleurotus ostreatus)* using LPG gas for sterilization of mushroom growing medium. But now, with the simple technology of heat exchanger, the people switch to using geothermal steam as a direct energy source for sterilization process. We designed the simple heat exchanger which has steam geothermal feeding inlet.The project was undertaken by engineers from PGE involving the mushroom farmers communities which is located around the Kamojang geothermal field operations the PGE owns. In this paper are shown some positive results (benefits) of the development of mushroom cultivation using geothermal steam compared to using LPG gas. Some of the main results in this project is the time period of the mushroom spores growth is much quicker (less than one week), heating sterilization temperature is more constant (110 degrees Celsius) so the the level of maturity baglog more perfect, the production cost for one baglog is cheaper and we can reduce the cost to 600 IDR per baglog. Another advantage is the dependence on fossil fuel (LPG Gas) which is using for sterilization of mushroom growing media already be resolved with geothermal steam.

1. INTRODUCTION

Geothermal energy is a clean energy that is environmentally friendly. The utilization of this energy can not be transported far from where the energy is produced. In general, the utilization of geothermal energy utilization is divided into two types, which are indirect and direct use. Utilization of geothermal energy for indirect use is for a geothermal power plant. The electrical energy is transported through the electrical transmission wires which ends at customers in homes and industrial customers. For direct use of geothermal energy can be used for aquaculture, bathing pools of warm water, salt crystallization and others (DiPippo et al. 2007).

Kamojang geothermal field has been in operation for nearly 30 years starting in 1983. Geothermal fluid quality in the field at Kamojang is the best quality with the fluid steam dryness level reached at 95.2%. Until now, in 2014, the utilization of geothermal energy in the Kamojang field for geothermal power plant is 200 MW, and in 2015 will grow more with new power plants with a capacity of 35 MW, bringing the total electrical energy generated from Kamojang geothermal field at 235 MW.

In the Kamojang geothermal field 100% utilization of the geothermal steam is used for power generation. Hence in 2013, we tried to explore the utilization of geothermal steam to be used directly in addition to generate electrical energy. To take advantage of geothermal energy directly, we chose to use the activity based on community development, so that people can know directly that geothermal energy can be widely applied. Communities around the operational area, which belongs to PT. Pertamina Geothermal Energy, are many agricultural activities include potatoes farms, vegetable farms, strawberry farms and oyster mushroom cultivation. For the cultivation of oyster mushroom farming, farmers need a source of heat energy, in the use of LPG gas, for mushroom growth media sterilization process. Thus, the heat from geothermal energy can be used to replace the need for LPG gas in mushroom growth media sterilization process. Therefore, in this phase, geothermal energy can be said to be directly utilized for sterilization. With high levels of vapor heat nearly 198 degrees Celsius, the heat from geothermal steam is enough to be used in a heat exchanger.

The use of steam from geothermal energy to substitute the use of LPG gas during the sterilization process is to look at the fact that the use of 60 Kg LPG gas for heating heat exchangers provide a heat level is not stable and not optimum. Therefore, it would need more than 60 Kg LPG gas to get the heat and pressure stable. In addition, the use of LPG gas is only able to sterilize 80 pcs of baglog for each time of heating. Unfavorable effects due to the heating temperatures and pressures leads to uneven maturity levels that will affect the success of growing oyster mushrooms in the that media (baglogs). From the results of monitoring in the field, from 80 pcs baglog sterilized for six hours, the number of perfectly ripe baglog was only about 65 pcs, which means that the success rate of maturity level is only 81.25 %. Another fact is that the sterilization process using LPG gas energy source takes over six hours, with heating temperatures less than 100 degrees Celsius and a pressure less than 3 bars. Whereas if you use a source of geothermal energy, the heating time for sterilization became faster at only four hours, with heating temperatures of about 105 degrees Celsius and pressure exceeds 3 bars.

The main objective of this study is to utilize the heat contained in the geothermal energy to be used in the oyster mushroom sterilization. This energy is able to increase maturity level ratio of baglog to 96%, at 105 degrees Celsius of temperature, with a pressure of 3 bar and also the sterilization process takes two hours less time. In addition to these things, the positive effects of the use of geothermal steam is able to reduce or eliminate dependence of oyster mushroom farmers on fossil energy, thus the activity of sterilization media of oyster mushroom can be done for 24 hours without worrying about the lack of energy to heat sterilization process.

The scope of work of this study was tested directly by making a special heat exchanger that uses geothermal energy sources as the heat source. Later during the trial, we noted several physical parameters, such as the heating temperature (the output of the heat

exchanger), heat exchanger pressure, pressure at autoclave, acidity of the geothermal steam (PH), acidity of steam output from the heat exchanger and also the time of sterilization. Observations of these parameters were then compared with the same parameters as the heat exchanger using LPG gas energy .

2. METHODOLOGY

2.1 Steam Quality

Kamojang geothermal field has the best steam quality in the world, it is based on the level of vapor dryness that reaches 92.2% to 94.5%. Kamojang geothermal steam field belonging to the superheated steam. In detail, the quality of the geothermal steam field at Kamojang can be seen in the table below:

NO.	Sampling Parameters	Average Value
1	Pressure Line	11.03
2	TEMPERATUR	181.27
	TOTAL OF TFS / YEAR	13.00
1	SAMPLING TIME	20
2	Electrical Conductivity (25°C)	34.30
3	pH/TEMP °C (25°C)	4.41
4	TDS by Calculation	1.81
5	CLORIDA CL^-	0.154
6	SULPHAT SO_4^{--}	0.533
7	Hyidrogen Sulfida	33.221
8	Sulfida S-	<1
9	CARBONATE CO_3^{2-}	<1
10	BICARBONAT HCO_3	9.434
11	NATRIUM Na^+	0.149
12	KALIUM K^+	0.214
13	CALCIUM Ca^{+2}	0.307
14	MAGNESIUM Mg^{2+}	0.091
15	FLUOR F^-	0.042
16	AMMONIUM NH_4^+	2.622
17	SILIKA SiO_2	0.490
18	TOTAL Fe	0.071
19	ARSENIC As 3+	NA
20	OXYGEN O2	NA
21	BORON (B)	4.153
22	LITHIUM Li^+	0.0609
	TOTAL OF NCGS / YEAR	13
1	CO_2 MMOL/100 MOL KOND.	340.819
2	H_2S MMOL/100 MOL KOND.	8.267
3	RESIDUAL GAS	8.632
4	CO2 MMOL/Kg KOND.	189.343
5	H2S MMOL/Kg KOND.	4.593
6	MOL RATIO CO_2/H_2S	40.680
7	Ton CO2/Ton steam	0.01
8	PCT VOLUME (%)	0.36
9	PCT WEIGHT (%)	0.86
	SAMPLE	**Kalorimeter**
1	**STEAM WETNESS**	0.0790
2	DRYNESS	92.10%

Table 1: Analysis result of water and gas on main steam pipeline 405 (Laboratorim Geothermal Kamojang Field Report, 2013)

2.2 Steam Quality for Media Sterilization

The dry steam from the production wells can not be directly used for sterilizing media/baglog, because the impurity content, pH and moisture content from the natural reservoir can not be controlled. Therefore, the utilization of geothermal steam in oyster mushroom cultivation is to heat the heat exchanger, where the heat exchanger will extract heat from the steam to heat mineral water/ground water with a neutral pH.

2.3 Fabrication of Heat Exchanger

Figure 1: Heat exchanger design and area of production for mushroom cultivation.

3. RESULT AND DISCUSSION

3.1 Heating temperature (the output of the heat exchanger)

The temperature of the heat exchanger is more stable, between 105 degrees celcius to 120 degrees celcius. With a stable temperature, the level of maturity of baglog fungi become more prevalent, in addition to the time required for sterilization process becomes shorter.

3.2 Heat Exchangers Pressure

Vapor pressure in the heat exchanger is 9 to 11 bar. While the vapor pressure in the production pipeline is 13 bar at a temperature of 181.7 degrees Celsius. Pressure on the heat exchanger is used to boil pure water at a temperature of 105 degrees Celsius. Furthermore, the steam from the boiling of pure water in the heat exchanger will be streamed to autoclave for sterilization process.

3.3 Pressure at Autoclave

Pressure in the autoclave is an acceptable pressure accumulation of the heat exchanger. The autoclave pressure is 3 bar, the pressure is sufficient to baglog sterilization process, because the temperature at the time of sterilization is at a value of 105 degrees Celsius. With a fixed pressure and temperature during the process of sterilization in an autoclave, then the maturity baglog become more prevalent.

3.4 Acidity of Geothermal Steam (PH)

Geothermal steam flow from the steam production wells is derived from natural sources, therefore acidity, impurity content and water content can not be controlled. This will obviously affect the growth of fungi, which is sourced from the destruction of fungal growth media during the sterilization process. Although the acidity of geothermal steam is 4.4, the steam will not be directly used for mushroom growing medium sterilization process. However, heat from the geothermal steam will be extracted to heat pure water in a heat exchanger.

3.5 Acidity of steam output from the heat exchanger

As has been discussed earlier, the steam that is sent to the autoclave comes from pure water that is heated in the heat exchanger. The purpose of using pure water as a source of heated fluid is to control the water quality include acidity of water sources and levels of impurities contained in the water, so as to minimize the risk of damage to baglog during the sterilization process. Pure water acidity levels that are used are at the value of 5.5.

3.6 Time of sterilization

The time required in the process of sterilization is 6 hours with a constant pressure of 3 bar and a temperature of at least 105 degrees
Celsius. This also indicates that the efficiency of a 2-hour period compared with conventional tools.

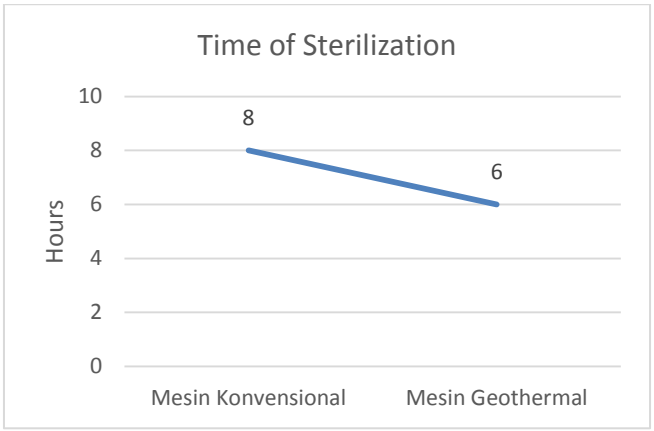

Figure 2: Graphic of time sterilization.

Table 2: Time of sterilization for 800 baglog.

Conventional Tool	Geothermal Tool	Unit
8	6	hours

3.7 Production Capacity

Production capacity by using the tools that we have developed has increased significantly.

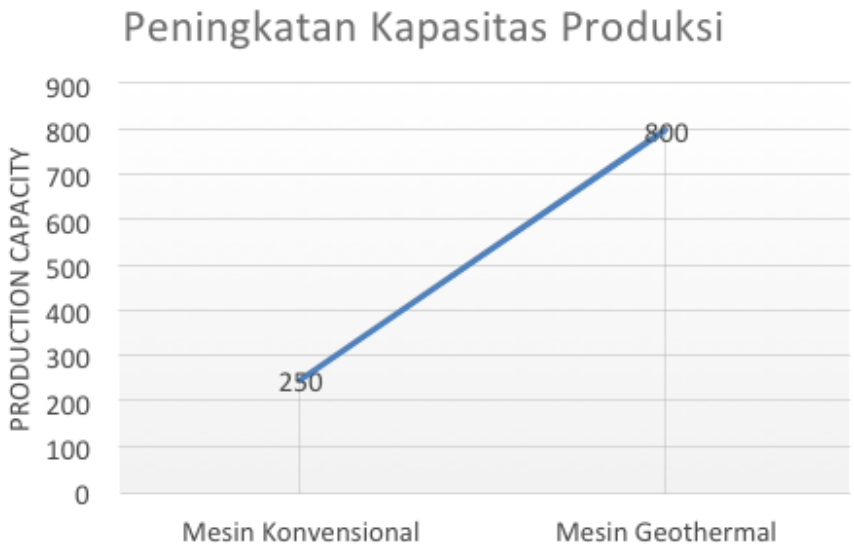

Figure 3: Graphic of production capacity increases.

Table 3: Production capacity.

Conventional Tool	Geothermal Sterilization Tool	Unit
250	800	Baglog

Figure 4: Conventional sterilizer tool.

Figure 5: Geothermal sterilizer capacity.

3.8 Economic Production Analysis

We empowered the 10 oyster mushroom cultivation group in the Kamojang village. We provided training for the farmers to improve their production management and product marketing. By using a geothermal steam mushrooms sterilizer we successfully suppressed the production cost. Steam that we used is waste steam from the steam trap so it's not a required production cost

The Comparison of the conventional mushroom production costs and geothermal steam is seen below:

Table 4: Economic Calculation for 800 baglogs oyster mushrooms.

	Conventional	Geothermal Sterilizer	Unit
LPG Used	38	0	Kg
LPG Used in a Year (365 days)	14,016	0	Kg
LPG Price (12 kg) = Rp 120,000- (Indonesian Rupiah)	1,681,920,000	0	Rupiah (Rp)
LPG Price (USD) kurs 1 USD = Rp 12,000	140,160	0	USD

3.9 Mushroom Quality

Products that are produced using the geothermal engine has the same quality as the products of the machine.

Figure 6: Geothermal oyster mushroom tereatment process.

Figure 7: Oyster mushroom (Pleurotus Ostreatus) sterilizing by geothermal steam.

3.10 Carbon Emition Reduction

We tried to calculate the ratio of the emissions produced by our machines compared with the use of conventional tool that uses LPG fuel. The net calorific value of LPG is 46.1 MJ / kg with a CO_2 emission factor of 60.4 t CO2 TJ (Baines, 1993, 30). Therefore, 1 kg of LPG used equates to 2.78 kg of CO emitted. Reduction of carbon emissions using a tool we developed is partially below:

Table 5: Carbon Emition Reduction.

	Conventional (LPG)	Geothermal (Geothermal Steam)	Unit
Production Capacity	800	800	Baglog
Fuel Used	38	180	Kg
Fuel Used in a Year (365 days)	14,016	65,700	Kg
CO^2 generated	**38,964**[1]	**626**[2]	**Kg**

[1]1kg LPG = 2.78 CO^2, [2]1 ton CO^2/1 t steam at Kamojang= 0,009525.

4. CONCLUSION

The results of the direct application of steam geothermal for Oyster Mushroom (Pleurotus ostreatus) cultivation in Kamojang geothermal field in Indonesia are:

1) Geothermal steam can be used to assist the process of sterilization oyster mushroom growing media in Indonesia.

2) Sterilization time if using geothermal steam sterilization machine can save approximately 2 hours compared to normal production with a conventional engine.

3) Capacity of production with the machine that we developed increase up to 320% when compared to a conventional engine.

4) The machine that we developed is able to reduce carbon emissions (CO^2) produced from 38,964 to 626 when compared to a conventional one.

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