INTERNATIONAL JOURNAL OF
ENERGY AND ENVIRONMENT

Volume 11, Issue 3, 2020 pp.179-184
Journal homepage: www.IJEE.IEEFoundation.org

Geothermal Direct Use for Snapper Fishpond Heating at Yogyakarta

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Received 3 Nov. 2020; Received in revised form 29 Nov. 2020; Accepted 30 Nov. 2020; Available online 5 Dec. 2020

Abstract
Surface manifestations of the geothermal activity with hot brine water temperatures approximately 44°C are found in Parangwedang, Parangtritis, Yogyakarta, Indonesia has the potential for direct utilization of geothermal energy. This study discusses a design of geothermal direct utilization for Snapper fishpond heating system by using brine to cultivate Snapper fish, which aims to maintain the ideal temperature for its growth, so it can grow faster than usual. The fishpond was designed to can be used for 3000 Snapper fishes. Water heating uses brine from the nearest hot springs with a temperature of 44°C and a mass flow rate of 1 kg/s within 100 meters with a height of 10 meters from the utilization site. It is using a double pipe heat exchanger system so that the water in the environment with a temperature of 24℃ becomes the appropriate temperature for Snapper fish cultivation, which is 28°C with the energy needed to raise the temperature is 68.1 kW. Economic analysis shows an IRR of 41% and a positive NPV with a pay-out time of 3 years. So, the Snapper fishponds heating system as geothermal direct utilization deserves to be developed.

Keywords: Direct Use; Snapper Fishpond; Heating System; Snapper Fish Cultivation; Engineering Design; Utilization.

1. Introduction

Naturally, Snapper is a slow-growing fish. Snapper from the larval stage to reach adult size takes about 1-1.5 years [1]. However, if the cultivation is carried out intensively in cultivation locations where the feeding procedure is more organized and the living conditions are optimal, the growth of Snapper will undoubtedly become faster. In the direct use of brine for Snapper cultivation, it is necessary to know the optimal conditions for design and operation. The design of direct use systems for fish cultivation includes processes and equipment in three components, they are pond design, heat exchanger systems, and pipes distribution for geothermal and surface water fluids [2]. This direct use system is equipped with a pump unit and a cooling pond of the residual heat transfer process. The pump unit is used to drain surface water at an elevation below the cultivation area [3].

Constructing a walled pond consists of several stages, starting from digging the ground according to the predetermined depth and size. Based on the author's experience, the ideal size of the wall pond for the nursery is 4x4 m^2, with a depth of about 40-60 cm. Then flatten the land at the bottom and walls of the pond so that later the cement will not crack when filled with water. Make the water inlet and outlet in the pond. If the channel model uses pipes, the position and height of the pipes are adjusted so that water flows smoothly. After the soil is even and solid, arrange the bricks and reinforce them with plaster properly, and adjust the number of bricks needed to the size of the pond. Before use, soak the pond with water for up to half a day. Also, place banana tree trunk in the pond. This functions to neutralize the pond from toxins that come from plaster or cement plaster.

2. Material and Methods

The following shows the design, operation, and some of the assumptions used in designing the direct use system for cultivating Snapper Geothermal sources that are used for direct utilization are fluids in the liquid phase called brine. Brine is assumed to come from geothermal manifestations in the form Parangtritis area such as hot springs, which appears in Parangwedang with a temperature of 44°C [4] and a mass flow rate of 1 kg/s. The location of the hot spring is 100 meters, with a height of 10 m from the utilization location (Figure 1).

Figure 1. Location Studi Area.

Fish ponds for carp cultivation are assumed to be rectangular in shape with a size of 6 meters x 11 meters with a water depth of 1.2 meters. The size of the pond is used for 3000 fishes. The walls and bottom of the pond are designed with a mixture of cement and sand. The temperature of the rock layers around the pond is assumed to be constant around 23°C. The ideal temperature for Snapper's growth is 24-28°C If the difference of day and night temperature is too large, the growth of Snapper will be disrupted. This is due to the decrease in oxygen levels in the pond below the ideal number, which is 4-6 mg/liter. The trend indicates that too cold temperatures have a high risk of developing several fish diseases. It can be seen when the rainy season arrives. The air discharge or air flowing into the pond for each type of different ponds. Polyculture fish ponds (a mixture of Snapper with other fish) require a water flow of 5-12 liters/second, in comparison for monoculture ponds (Snapper only), the water flow is ideally around 3 liters/second. Outline System is illustrated in Figure 2.

Snapper ponds ideally have a neutral pH is between 6.5-7.5. If the pH value of the water is below 6.5, the thing to do is by adding $CaCO_3$ to increase the pH, whereas adding Phosphoric Acid gradually to decrease the pH. If the oxygen content in the pond is low, it will result in the endurance of the Snapper fish. Snapper requires an oxygen content of approximately 5ppm. Oxygen levels can be increased by keeping the water flowing smoothly and leaving the pond surface open. Environmental conditions around the cultivation area have an air temperature of 5°C to 17°C with a maximum air velocity of 2 m/s in a year.

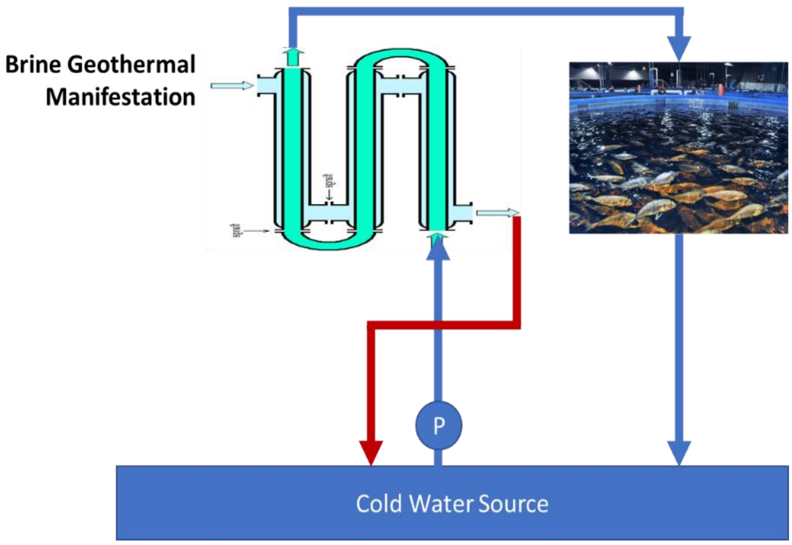

Figure 2. Outline System.

3. Theory/Calculation

The calculation data used to calculate the heat loss in the brine pipe. Pipe type selection Galvanized steel pipe is chosen to flow the brine. The reason for choosing galvanized is because the brine temperature is not too high (44°C) and is not corrosive, so it does not need pipes with high-temperature resistance and corrosivity resistance, besides that galvanized has a relatively lower price. Insulation type of glass wool insulation is chosen, because of its low thermal conductivity value, the availability of insulation in the market, and its relatively low price. In this case, zinc cladding is used as a cover for the insulator because the price is much lower than aluminum. Based on the equation regarding heat transfer, calculation results of the heat loss value in brine distribution pipe flow the total heat loss is 1.41 kW. From the heat loss can be found final heat energy (Qo) value, and from the reduction in heat energy can be found a decrease in brine temperature along the pipe. The decrease in brine temperature was 0.7°C along the 100-meter brine pipe so that the final brine temperature that could be utilized was 43.3°C.

3.1 Energy Conversion on Pond

Based on the theory of the energy balance in the pond, the results of the calculation of the energy change value in the pond are found that the energy stored by the pond is 23.01 kW, this energy is obtained from the results of reducing the energy provided by Q_{solar} with the energy out of the environment, namely $Q_{conduction}$, convection, and evaporation. By using the mass flow rate equation, the heating time needed to reach the optimal temperature can be found. From the calculation results, the heating time is it takes 16.9 hours to heat a pond from 24^o to 28^o Celcius with a Area of 66 m^3. This time is the time for preheating, so it takes quite a long time because of the large volume of the pond.

3.2 Heat Exchanger Design

These two parameters affect heat exchanger performance, which is described by the heat transfer coefficient (h) and the friction coefficient [5]. Basic considerations for choosing the type of pipe material are thermal conductivity, corrosion resistance, and pipe price [6]. The pipes used in heat exchangers require high conductivity values. This design assumes that the geothermal working fluid (brine) is not corrosive. From Table 1 comparison of pipe types, in this case, galvanized steel pipes are used for both sides (hot side and cold side) with a value of k = 115.98 W/m.K, ε = 1.6 mm, and pipe resistance up to a temperature of 200°C. The reason for choosing galvanized is because of its high conductivity value, its relatively lower price, in addition to the brine temperature that is not too high (44°C) and not corrosive, the selection of carbon and stainless steel pipes is too over-spec. From the theory of heat exchanger, the results of the double pipe heat exchanger calculation.

From the calculation found the most significant pressure drop value is on the brine flow pipe (hot side), which is 0.9 bar, while in cold water flow (cold side), the pressure drop is very small, namely 0.014 bar.

Heat loss occurs due to heat transfer from the pipes to the environment. The calculation of heat loss on a heat exchanger has the same concept as the calculation of heat loss on a brine pipe. In this case, the same insulation and cladding as the brine pipe system is used. Following are the results of the calculation of heat loss on double pipe heat exchanger is 0.18 kW for the length of the heat exchanger pipe is 5.31 meters. The heat loss value on the heat exchanger is relatively small, so the heat loss value on the exchanger is considered not to reduce the energy balance equation in the heat exchanger system.

Table 1. Specification of the double pipe heat exchanger.

Parameter	Unit	Value	
		Hot side	Cold Side
Type of Pipe		Galvanized steel	Galvanized steel
Fluid Material		Brine	Freshwater
Incoming Temperature	ºC	43.3	24
Outcoming Temperature	ºC	33	28
Incoming Flowrate	kg/s	1	1.36
Inner Diameter	meter	0.053	0.041
Outer Diameter	meter	0.060	0.048
Heat Transfer	kW	43.04	22.69
Pressure Drop	bar	0.9	1,448
Length	meter	5.31	
Log Mean Temp Different	ºC	10.59	
Overall Heat Transfer Coefficient	kW/K	2.143	
Overall Heat Transfer	kW	22.694	

3.3 Pressure Drop on Brine Pipe

Based on the fluid flow equation in the pipe and the head loss equation, the value of the difference in pressure and head loss that occurs in the flow of the brine distribution pipe with length 200 meters and elevation 15 meters from brine source to fishpond. From along the pipe from the brine surface manifestation source the position before the heat exchanger the ΔP value is (+0.43) bar, the pressure drop is due to differences in height and gravity. A positive delta pressure value indicates an increase in pressure, an increase occurs due to a difference in height.

3.4 Pressure Drop on Cold Brine Pipe

Assumption of cold water pipeline from surface water location to cultivation location 100 meters and elevation 20 meters. Along the pipe from the surface water source to position before entering the heat exchanger, the ΔP value is (-2.37) bar, the minus pressure delta value indicates a pressure drop from point 1 to point 2, the drop occurs due to a different height and friction in the pipe. The main cause of pressure drop is the difference in elevation. The pressure drop in the heat exchanger is -0.03 bar, so the total pressure drop is (-2.37) bar. With a delta pressure value of (-2.37) bar, the cold water pipe flow system requires a pump to flow cold water.

3.5 Cold Water Pump Design

The total pressure drop in the cold water flow pipe system is (-2.37) bar, referring to the total pressure drop of the cold water flow pipe system. The appropriate pump design can be calculated using an equation that considers the effect of cavitation to calculate the pump head and the equation for calculating pump power, here are the results of the cold water pump design calculation (Table 2).

Table 2. Cold water pump design.

Parameter	Unit	Value
dP Brine Pipe	Pa	274,638.09
dP Heat Exchanger	Pa	3,234.87
Total dP	Pa	277,872.96
h_p	meter	28.42
W_p	Watt	377.9

4. Results and Discussion

Cost analysis is carried out based on the calculation of prices commonly used in Snapper cultivation. Concrete ponds have advantages over tarpaulin ponds because they are more durable and permanent. In addition, pond walls or cement ponds are relatively more sterile from pests and diseases. The drawback is that the construction of a walled pond is more expensive.Constructing a walled pond must pay attention to several things such as soil consistency, texture, and pond construction. The problem that often occurs when constructing a pond is a construction error that causes cracks or breaks at the bottom or walls of the pond. If this has already happened, repairing the cracks is not enough. Marketing is an activity that determines the feasibility of a business. The total value of the business is determined by the amount of the incoming selling price and demand.

The problem that often occurs during marketing so far is the supply that cannot be absorbed by the market due to market taste that does not match the expectations of prospective buyers. Snapper is a commodity with stable demand and a high selling price. It was recorded that at the end of 2014, the price of fresh Snapper was around IDR 40,000/kg at the farm level, while in the market the price was IDR 45,000-50,000 per kilogram. Snapper marketing channels are wide open, ranging from local to export scales. However, currently the marketing of Snapper is still prioritized to meet the demand from traditional markets. The following is the investment cost where the price is stated in rupiah, assuming the cost of constructing a pond is 300,000/m^3, the pond size is 6 meters x 11 meters x 1.2 meters (Table 3).

Table 3. Investment costs [7-14].

Material	Type-size	Cost	Unit	Needs	Total Cost
Water Pump	400 Watt	4,000,000	/ unit	1 unit	4,000,000
Brine Pump	200 Watt	2,000,000	/ unit	1 unit	2,000,000
Flange	2 inch	50,000	/ pcs	2 pcs	100,000
Flange	1.5 inch	35,000	/ pcs	2 pcs	70,000
Pipe	Galvanis - 2 inch	375,000	/ 6 m	100 m	18,750,000
	Galvanis - 1.5 inch	275,000	/ 6 m	100 m	9,200,000
Isolator	Rock Wool	35,000	/ roll	250 roll	8,750,000
Cladding	Zinc	35,000	/ 2 m^2	72 piece	2,520,000
Valve	Ball valve - 2 inch	350,000	/ pcs	2 pcs	700,000
	Ball valve – 1.5 inch	250,000	/ pcs	2 pcs	500,000
Pond Construction		350,000	/ m^3	66 m^3	29,400,000
Total					84,740,000

The following are the operational costs of cultivating a Snapper pond per month. Operating costs per month, the total operating costs per month are IDR 2,305,600. Assuming that 200 fishes feed is needed 6 sacks of feed to harvest, during breeding, the dead fish is 5% of the total fish, and with the optimum fish temperature, it will accelerate the harvest period from 8 months to 6 months (Table 4).

Table 4. Profit.

Material	Cost	Unit	Needs	Total Cost
Fish Seeds	IDR 2,000	/ fish	3000	IDR 4,000,000
Fish Feeds	IDR 200,000	/ sack	60	IDR 6,000,000
Sales	IDR 30,000	/ kg	1900	IDR 57,000,000
Gross Profit				IDR 35,000,000

From the calculation above, the gross profit is IDR 35,000,000. With a fish harvest period of 6 months, the monthly gross profit is approximate IDR 5,830,000. So that you get a net profit each month in the form of gross profit minus operating costs of IDR 3,524,400. The following is a cash flow calculation with a value in thousand rupiahs and an assumed interest rate of 7% /year. Results obtained Net Present Value (NPV) of IDR 88,833,000 and an Internal Rate of Return (IRR) of 41% with a Pay out Time (POT) of 3 years.

5. Conclusion

From the studies that have been carried out in terms of engineering and economic analysis, so several conclusions can be drawn. The heat energy needed to raise the surface water temperature from 24ºC to an optimum temperature of 28ºC is 68.11 kW. It takes some equipment in the Snapper cultivation system such as double pipe heat exchangers, brine pumps, water pumps. Economically the project using brine for Snapper cultivation is feasible, by looking at the positive NPV value, an IRR of 41%, and a POT for 3 years.

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