TECHNO ANALYSIS STUDY OF SILICA FACTORY FROM GEOTHERMAL BRINE

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Abstract

In Geothermal power plant, brine from geothermal steam is reinjected again into the geothermal field. Brine is contains several valuable metal such as silica and lithium. Silica is important material for development of renewable energy since it is main component for fabrication of silicon solar cell. In this research, we investigated the feasibility study of silica extraction factory from geothermal brine with production capacity of 5000 ton/year. The techno-economy analysis is applied for feasibility study. Silica is obtained from polycondensation and nucleation process of dissolved silica in brine with operating condition of 1 atm and temperature of 30°C*, Then it will be separated using 3-stage membrane ultrafiltration to get 871.9875 kg/h of silica nanoparticles with 99.8% purity. The amount of separated geothermal water needed are 1,350,000 kg/hr. From the economy analysis: pay out time is* 2.14 *years, return of investment is* 46.77%, *break even point is* 17.3966%, *and shutdown point is* 6.86 %. *Based on techno-economny analysis, the silica extraction plant from geothermal brine is feasible to develop.*

Abstrak

Di Pembangkit Listrik Geotermal, *brine* dari uap geothermal biasanya direinjeksi lagi ke dalam lapangan geotermal. Brine mengandung beberapa logam yang bernilai tinggi seperti silika dan litium. Silika merupakan material penting dalam pengembangan energi terbarukan karena silika merupakan komponen utama dalam pengembangan sel surya *silicon*. Di dalam penelitian ini, kami melakukan investigasi kelayakan pembangunan untuk pabrik ekstraksi silika dari *brine* geotermal dengan kapasitas 5000 ton/tahun. Analisis tekno-ekonoi diaplikasikan di dalam studi kelayakan pembangunan, Silika diperoleh dari proses polikondensasi dan nukleasi *dissolved silica* dalam *brine* dengan kondisi operasi 1 atm dan suhu 30°C kemudian akan dipisahkan dengan membrane ultrafiltrasi 3-stage untuk mendapatkan silika nanopartikel dengan kemurnian 99.8% sebanyak 871,9875 kg/jam. Jumlah *separated geothermal water* (SGW) yang diperlukan di dalam proses produksi silika adalah sebesar 1.350.000 kg/jam. Dari analisis ekonomi, prospek ekonomi untuk pabrik ini setelah pajak berupa *pay out time* selama 2,14 tahun, *return of investment* sebesar 46,77 %, *breakeven point* sebesar 17,40 %, dan *shutdown point* sebesar 6,86 %.

Kata Kunci : *geothermal brine, silica extraction factory, techno analysis study*

PENDAHULUAN

Indonesia is rich in geothermal source since there are many active volcanoes in Indonesia. Geothermal sources in Indonesia are utilized for power plant. Geothermal steam from geothermal field contains several minerals that dispersed and dissolved. Brine geothermal is the side stream from the power generation process in geothermal power plant. The geothermal steam treated first in separator to separate between geothermal brine that rich in mineral and clean steam for rotating turbine. Recently, geothermal brine just injected again into geothermal field [1-5].

Geothermal brine can be extracted to obtain the minerals. The minerals that contain in geothermal brine such as Ammonia (NH_3), Mercury (Hg), Kalium (K), Calcium (Ca), Magnesium (Mg), Platinum (Pt), Seng (Zn), Timbal (Pb), Copper (Cu), Mangan (Mn), Silica (SiO2), Lithium (Li), Arsen (As), Antimony (Sb), Boron (B), Bromida(Br), Iodine (I), Strontium (Sr), Sulfate (SO4), Chlor (C), Aluminium (Al), Iron (Fe), Natrium (Na), Carbon Dioxide (CO2), Fluorine (F) and Bikarbonat Acid (HCO3) [3,5]. One of the main components in geothermal stream is silica. Silica is one of the valuable minerals. However, silica in the stream increase the possibility for scaling in geothermal power plant system.

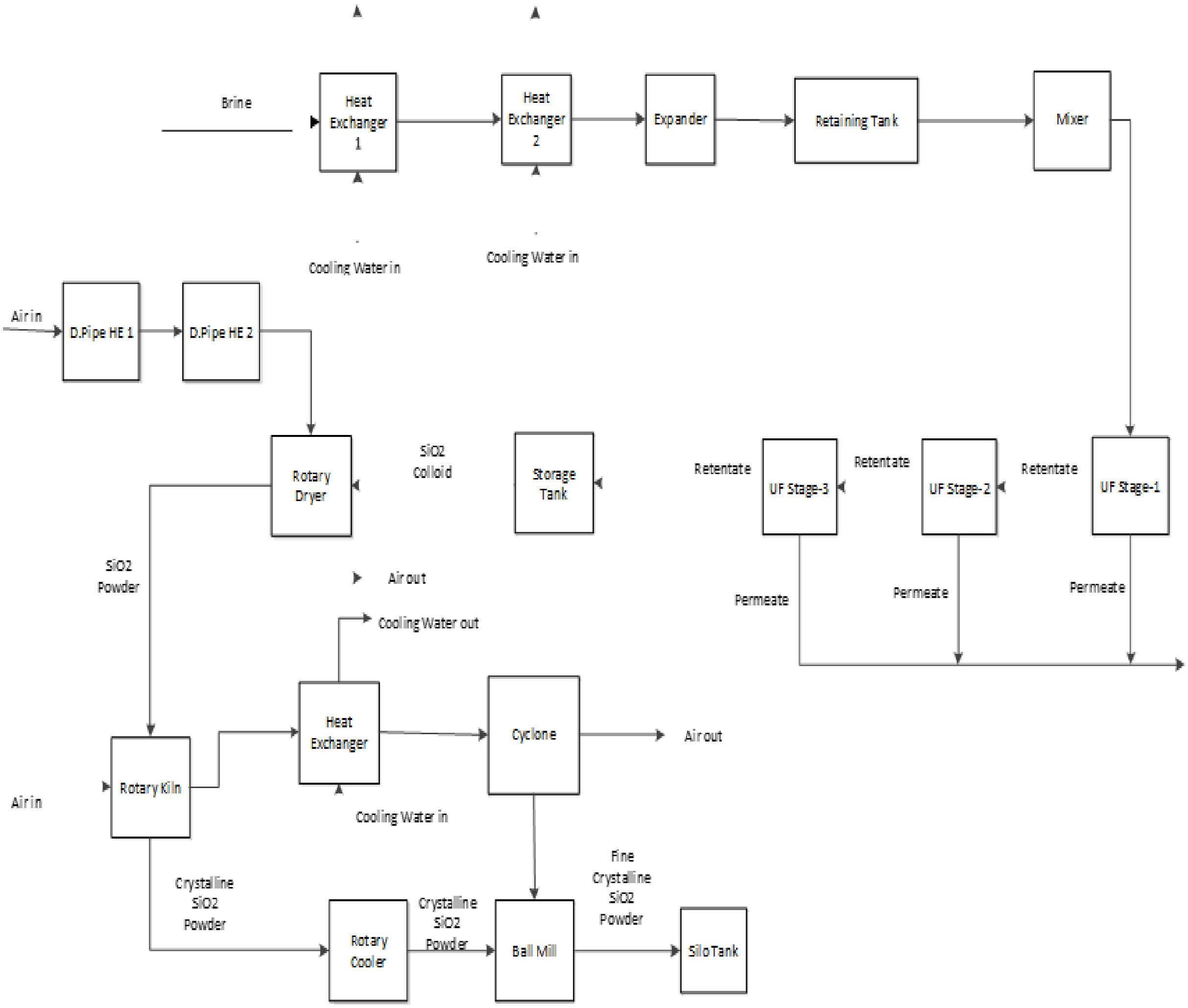
In this study, we did the techno-economy analysis study for silica factory from geothermal brine. In Indonesia, brine geothermal contains high silica concentration around 830 mg SiO2/ kg geothermal brine [3]. Furthermore, the increasing demand in Indonesia for silica in Indonesia which is 78,153 ton/year (Badan Pusat Statistik, 2018) drive the establishing of silica plant in Indonesia. Silica extraction factory from geothermal brine with production capacity 5000 ton/year planned to establish at region Alam Pauh Duo, Kabupaten Solok, Sumatera Barat. This location is chosen since it close to geothermal power plant muara laboh (PLTP Muara Laboh), since it producing high amount of geothermal brine.

METODE PENELITIAN

The unit cost for the apparatus is based on the dimension of the apparatus. All of the apparatus has been well designed. The cost estimation for apparatus is based on the reference from Aries et.al[8]. The cost estimation is based on the capacity of factory which is 5000 ton/day and the present price is corrected by using correction factor which is chemical engineering plant index.

For the economic feasibility, we are following reference from Aries et.al and Timmerhaus et.al[8-9]. The feasibility of this process is measured from capital expenditures (CAPEX) and operational expenditures (OPEX). CAPEX consists of total direct cost (factory apparatus cost, instrumentation, etc) , total indirect cost (engineering, construction fee, etc) and working capital (product inventory, process inventory, etc). OPEX consist of manufacturing cost and general expenses. APEX and OPEX measurement is used for calculating important parameter for economic feasibility such as return on investment (ROI), payout time (POT) and break even point (BEP).

HASIL DAN PEMBAHASAN



Gambar 1. Block Flow Diagram of Silica Plant for Geothermal Brine

The technology for extracting silica is following research by Potapov [8-10]. From Figure 1, Separated Geothermal Water (SGW) or brine is cooled down by using heat exchanger (HE). The purpose of cooling down is to conditioning brine at saturated condition (30°C, 1 atm). At saturated condition, brine is undergoing nucleation and polycondensation of silicic acid or ortho-silicic acid (OSA). After nucleation and polycondensation, colloid silica is formed. Several factor that affects nucleation rate and SiO_2 particle growth are such as temperature, pH, and degree of saturation. Then the solution flows to filtration unit to obtain colloid silica concentrate.

To obtain silica powder, colloid silica is dried to remove the water content by using dryer. Then, silica powder is calcinated using rotary kiln at high temperature to obtain crystalline structure. After from rotary kiln, sample is cooled by using rotary cooler. The final product from rotary cooler is silica (SiO2) crystalline nano-powder.

Table 1 shows capital expenditures (CAPEX) of silica factory. Total CAPEX of this factory is Rp 1,210,727,176,193.19. Table 2 shows manufacturing cost for this factory and Table 3 shows general expenses of this factory. Operational expenditures (OPEX) is the total value of manufacturing cost and general expense. OPEX value for this factory is Rp 408,995,719,188.59.

Table 1. Capital Expenditures for Silica Factory

Component			Price
1	Purchased Equipment Cost	Rp	195,469,439,427
2	Delivery Equipment Cost	Rp	29,320,415,914
3	Equipment Installation	Rp	304,698,948,649
4	Piping	Rp	68,414,303,799
5	Instrumentation and Controls	Rp	20,313,263,243
7	Electrical Equipment	Rp	20,313,263,243
8	Building Including Services	Rp	29,975,550,512
9	Services Facilities	Rp	107,508,191,685
10	Land and Yard Improvement	Rp	77,143,679,746
Direct Plant Cost (DPC)		Rp	853.157.056.218
12	Engineering, Construction, and Supervision	Rp	81,253,052,973
13	Contractor's Fee	Rp	20,313,263,243
14	Contingency	Rp	50,783,158,108
15	Legal Expenses	Rp	10,156,631,622
INDIRECT PLANT COST (IDC)		Rp	162,506,105,946
Fixed Capital Invesment (FCI)		Rp	1,015,663,162,165
16	Raw materials inventory	Rp	27.145.690.727.97
17	Process inventory	Rp	20.132.441.217.10
18	Product inventory	Rp	50.783.158.108.23
19	Extended credit	Rp	97.002.823.975.20
Working Capital Cost		Rp	195,064,114,028.50
CAPITAL EXPENDITURE COST		Rp	1,210,727,176,193.19

From the production capacity of this factory (5000 ton/year), total annual sales is calculated. Based on alibaba (2023), price of silica is around Rp 232,806.78/kg (~ USD 15.6). Therefore the total annual sales

Total annual sales = production capacity x silica price

= 5000,000 kg/year x 232,806.775

The total annual sales (Sa) is Rp 1,164,033,887,702.40 /year

From OPEX value in Table 3, we calculated profit before tax.

Profit before tax = Total annual sales − OPEX

=Rp 1.164.033.887.702,40 − Rp 408,995,719,188.59

= Rp 755,038,168,513.81

According to Indonesia goverment regulation (UU nomor 36 pasal 17 ayat 1(b), 2018), the industrial tax is 28%. Then the profit after tax is

Profit after tax = Profit before tax – (tax*profit before tax)

Profit after tax =Rp 543.627.481.329.94

Table 2. Manufacturing Cost for Silica Factory

A. VARIABLE PRODUCTION COST			
	Components	**Price**	
1	Raw materials	Rp	27,145,690,727.97
2	Labor	Rp	18,057,600,000.00
3	Maintenance	Rp	71,096,421,351.53
4	Operating Supplies	Rp	10,664,463,202.73
5	Utility	Rp	4,825,888,955.41
6	Laboratorium	Rp	1,805,760,000.00
7	Patent and Royalty	Rp	4,089,957,191.89
B. FIXED CHARGES			
1	Insurance	Rp	10,156,631,621.65
2	Property Tax	Rp	112,672,144.30
3	Bank Interest	Rp	48,126,409,228.68
4	Depreciation	Rp	92,171,327,786.04
C. PLANT OVERHEAD COST		Rp	332,829,832,885.96
GENERAL EXPENSES			
1	Administration	Rp	27,086,400,000.00
2	Marketing Distribution	Rp	40,899,571,918.86
3	Research and Development	Rp	8,179,914,383.77
OPERATIONAL EXPENDITURE COST		Rp	408,995,719,188.59

By using the data from Table 1 and Table 2, we calculated the discounted value (i) to prove the benefit for establishing this factory. We calculated discounted value by using equations below:

$$WC + SV + \left(C\ x\ \frac{(1+i)^N-1}{i}\right) = (FC + WC) + (1 + i)^N \quad (1)$$

Notes:

WC : working capital = Rp 195,064,114,028.50
SV : salvage value which consists of building and land price = Rp 107,119,230,258
C : cash flow which consists of profit after tax, depreciation and loan interest = Rp 683,925,218,344.66
FC : fixed capital cost = Rp 1,015,663,162,165
i : discounted value
N : operational life of factory = 9 year

By using *trial and error method*, we got discounted cash value(i) = 20.77%. The value of discounted cash (i) is higher than average saving deposito interest rate in Indonesia (3%). The higher discounted cash value prove that inverstation for silica factory in Indonesia is profitable. Another key value to calculate the feasibility of factory are return on investment (ROI) and pay out time (POT). We calculated the value of ROI and POT after tax below, based on equation from reference (peter timmerhaus):

$$\text{Return on Investment (ROI) after tax} = \frac{\text{profit after tax}}{\text{total capital investment}} \text{ x } 100\% \quad (2)$$

$$= 46.77\%$$

$$\text{Pay Out Time (POT) after tax} = \frac{\text{total capital investment}}{\text{profit after tax} + (0.1 \text{ x total capital investment})} \quad (3)$$

$$= 2.14 \text{ year}$$

The value for ROI (46.77%) is higher than highest inflation rate in Indonesia at 2022 which is 6.95 % [11]. proving the investment for silica factory from geothermal brine is acceptable. Based on reference, low risk investment that has low risk of failure should be less than 5 year [7]. The POT for silica factory from geothermal brine is lower than 5 year, proving the economic feasibility of this factory.

Break even point (BEP) and shut down point (SDP) are another parameters for proving the feasibility of investment. BEP and SDP were calculated based on equation from reference[7].

The BEP value of 17.40 % related with the production capacity in the factory that the operational cost is similar with the profit. The SDP value of 6.86 % related with the limit for the factory to shutdown the operation. If the capacity production of factory less than 6.86 % then the production should be stopped, since the operational cost is higher than the profit.

KESIMPULAN

From our study, the silica factory from geothermal brine is economicallu feasible to be established in Indonesia. The discounted cash value (20.77%) is higher than saving deposito interest in Indonesia (3%), proving the investment silica factory is more profitable than saving. The break even point (BEP) for this silica factory is 17.40%. The production capacity limit before the factory shutdown is represent by shut down point (SDP), the value of SDP is 6.86%. Furthermore, the value for return on investment (ROI) is higher (46.77%) than highest inflation rate in Indonesia at 2022 (6.95%), proving the investment for silica factory from geothermal brine is promising.

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