ENERGY AND ECONOMIC ANALYSIS OF ICE CREAM STICK PRODUCTION WITH BRINE TANK MACHINE

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ABSTRACT

Ice cream stick is a food product so much favored by Indonesian. Generally, ice cream is categorized based upon composition, taste, colour, shape and size, and to produce it, a sum of energy is required that will affect production cost of ice cream production machine. Energy and economic cost production will help to reduce cost one stick and feasibility this business provided Net Present Value (NPV) and Internal Rate od Return (IRR). With the analysis it is expected that home industry scale of this business can be developed. Brine tank machine is a box shaped machine equipped with cooling cycle and able to produce 280 of ice cream sticks one cycle. Result of the research shows that energy input, energy output, production capacity one hour, base cost one stick, selling price one stick, BEP, NPV 16% and IRR for interest rate 20% are as follows : 87.480 kJ; 43.546,05 kJ; 0,5; 210 stick; Rp 3.842; Rp 4.456; 33 stick; Rp 1.238.039.411 dan 22,55 %. Base cost can be reduced by using less expensive ice cream ingridients but it will increase the amount of ice cream stick to be produced and sold to meet the BEP and decreases IRR.

Keywords: ice cream stick, energy, economy, BEP, NPV, IRR.

Introduction:

Ice cream stick is a food product so much favored by Indonesian. Generally, ice cream is categorized based upon composition, taste, colour, shape and size, and to produce it, a sum of energy is required that will affect production cost of ice cream production machine. Energy and economic cost production will help to reduce cost one stick and feasibility this business provided Net Present Value (NPV) and Internal Rate od Return (IRR). With the analysis it is expected that home industry scale of this business can be developed. Brine tank machine is a box shaped machine equipped with cooling cycle and able to produce 280 of ice cream sticks one cycle.

One of factor that becomes obstacle in efforts of increasing and developing ice cream stick business is inavailbility of home industry scale machine with decent price and available in general market. Production of the machine with smaller scale will require energy and economic analysis of production so that efficiency in machine utilization and ice cream stick production can be increased. One of the solution is by analyzing energy and production cost of the brine tank machine that is currently available in Agricultural Engineering Laboratory.

In ice cream stick production, energy efficiency is an important factor in selecting equipment technology as well as production proccess to be applied. This objective can be achieved by considering energy ratio. Energy ratio is a ratio between energy input and output. According to Sigalingging R. (2008) by obtaining the amount of energy required and the amount of energy used (exergy) during production proccess, a more energy-efficient production proccess can be developed. This will also can be obtained if an effiecient production proccess is applied, when energy used to produce one kilogram or one unit can be used in a way for efficiency, energy loss thus can be minimized.

Economic analysis is used to determine the amount of cost that is required when a production is using the machine. Using economic analysis, production cost can be determined so that benefit using the machine can be calculated.

Based on the consideration, writers become interested in conducting a research with a title "Energy and Economic Analysis of Ice Cream Stick Production with Brine Tank Machine".

The objective is to analyze required energy and the amount of ice cream stick production cost using brine tank machine.

Benefits to be achieved is to add information for the researcher and common people, especially ice cream stick producers in energy and production analysis.

Materials and Methods:

Materials:

Materials used in this research are salt, melon flavored ice cream powder, LPG, destilled water, sticks. Equipments used in this research are brine tank machine with box (figure 1),

Figure 1. Brine Tank Machine

gas stove, digital thermometer, kwh meter, clamp meter, bomemeter, isolator band, spoon, large spoon, cable, room thermometer (wet base and dry base), multiple electric cord, freezer. Machine dimensions are width 67 cm, length 174 cm height 85 cm and box dimensions are width 30 cm, length : 34 cm, height 12.8 cm. Every box have 56 stick (Figure 2).

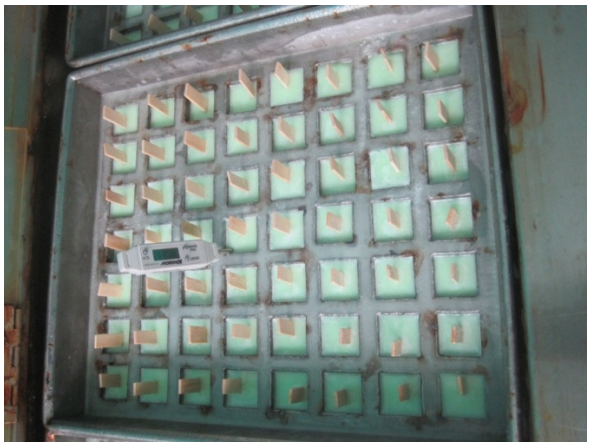

Figure 2. Temperature measurements in the Box with Digital Thermometer

In this research, data collection is gathered by literature study, experiments and parameter observation.

Methods:

Energy to be analyzed in ice cream stick production proccess is consisted of heat energy and electric energy. Heat energy is energy utilized to cool salt solution, tray, box and materials.

The equation used to calculate salt solution, box, tray and materials cooling energy is as on eq. (1), where $\dot{m}$ is mass flow rate (kg/s), c_p is spesific heat of the material (kJ/kg^{o}C) (Table 1) and dT is temperature change (^{o}C).

$$Q = \int_{T_1}^{T_2} \dot{m} c_p \, dT \qquad (1)$$

During cooling proccess there is a phase change of material from liquid to solid, the amount of energy can be calculated using eq. (2), where h_{fz} is heat content (kJ/kg), dw is material mass that is changed phase (kg), where dt is time change during production proccess (s).

$$Q = \int_{t_1}^{t_2} h_{fg} \frac{dw}{dt} \qquad (2)$$

Phase change of materials form liquid to solid happened when inside temoneature of ice cream materials is under 27^o F (ASHRAE, 1967, in Thermal Prooneties of Foods and Agricultural Materials, 1980).

Phase change if ice cream stick material heppened while calculating heat content of ice cream stick, thus total energy required can be calculated using eq. (3).

$$Q = \int_{T_1}^{T_2} \dot{m} c_p \, dT + \int_{t_1}^{t_2} h_{fg} \frac{dw}{dt} + \int_{T_{g1}}^{T_{g2}} \dot{m} c_p \, dT \qquad (3)$$

Electric energy consumed during ice cream production can be stated using eq. (4), where P is electric power used including pump or electromotor used during production proccess of ice cream stick.

$$Q = \int_{t_1}^{t_2} P\,dt \tag{4}$$

Energy ratio (R_E) can be calculated using eq. (5), where R_E is energy ratio, E_{out} is energy output (kJ) recieved to cool salt solution, materials and containers (box and tray), while E_{input} is electric energy used to decrease temoneature during the proccess (kJ)

$$R_E = \frac{E_{out}}{E_{input}} \tag{5}$$

Economic analysis can be conducted by calculating some parameters than can determine whether ice cream stick business is feasible or not using brine tank machine and how well would this business profit if interest rate is increasing and the parameters are as follows :

1. Effective capacity (stick / hour)
   Measurement of effective capacity can be conducted by dividing amount of stick produced with length of time required to forms ice cream stick.

$$\text{Equipment capacity} = \frac{\text{the total production of ice cream}}{\text{production time}} (\text{stick/hour}) \tag{6}$$

2. Economic analysis
   Ice cream stick cost one stick (Rp/stick)
   Measurement of ice cream stick cost one stick conducted by adding cost spent, namely fixed cost and variable cost.

$$\text{Base costs} = \left(\frac{\text{BT}}{\text{x}} + \text{BTT}\right)\text{C} \tag{7}$$

Where : BT = Total fixed cost (rp/year)
BTT = total variable cost (rp/hour)
x = total work hours one year (hour/year)
C = production capacity (hour/production unit)

a. Fixed cost
According to Darun (2002), fixed cost is consisted of :

- Depreciation (straight line model)

$$\text{D} = \frac{(\text{P} - \text{S})}{\text{n}} \tag{8}$$

Where : D = depreciation value (Rp/year)
P = initial value (purchasing / building value; Rp)
S = salvage value (10% of P; Rp)
n = economic age (year)

- capital interest and insurance, the calculations are gathered an can be conducted as follows :

$$\text{I} = \frac{\text{i}(\text{P})(\text{n}+1)}{2\text{n}} \tag{9}$$

Where : i = total onecentage of capital interest and insurance (17% one year)

- tax cost

In indonesia, there is no exact policy that governs tax for agricultural machine and equipments but some literature suggested that the tax is approximately 2% one year of its initial value.

– Housing cost
Housing cost is approximately ranged between 0.5 – 1%, usually a value of 1% one year of initial value is used.

b. Variable cost
According to Darun (2002), variable cost is consisted of :

– Electricity cost (Rp/kWh)
– Repairement cost for moving power source which is a moving machine to move another equipment that is generally connected with certain kind of transmission system. The repairement cost can be calculated using equation as follows :

$$\text{Repairement cost} = \frac{1{,}2\%(P-S)}{1000 hour} \quad (10)$$

Worker or ooneator cost is cost of ooneator payment/wage. This cost is dependent on local condition, it is calculated by monthly wage or yearly wage divided by total work hours.

3. Break Even Point (BEP)
The benefit of BEP calculation is to obtain minimum production limit to attain and market so the business will be feasible. In this condition, attained income will only cover for ooneational cost without any profit. To determine BEP, following equation can be used.

$$N = \frac{F}{(R-V)} \quad (11)$$

Where : N = minimum production to even point (stick)
F = fixed cost one year (Rp)
R = revenue of each production unit (selling price; Rp)
V = variable cost one production unit
VN = total variable cost one year (Rp/year)

4. Nett Present Value (NPV)
Identification of financial feasibility problems are usually analyzed using financial analysis methods with investation criteria. NPV is a criteria that is used to measure a device would be feasible or infeasible to do. The calculation is net benefit discounted with discount factor which can be calculated using following equation :

$$CIF - COF \geq 0 \quad (12)$$

Where : CIF = Cash inflow
COF = Cas outflow

Meanwhile, profit expected form investment is manifested as capital interest rate in following equation :

Input (CIF) = revenue x (P/A,i,n) + salvage x (P/F,i,n)
Output (COF) = investement + funding(P/A,i,n)

NPV criteria are as follows :

- NPV > 0, this means the business will be profitable,
- NPV < 0, this means until t years of investment, the business will not be profitable,
- NPV = 0, this means that profit is equal to additional cost spent.

(Darun, 2002)

5. Internal Rate of Return (IRR)

IRR is a level of discount rate, on discount rate it is gained that B/C ration =1 or NPV = 0. IRR value can be calculated using following equation,

$$IRR = i_1 - \frac{NPV_1}{(NPV_2 - NPV_1)} x(i_2 - i_1) \quad (13)$$

Where : i_1 = most attractive interest rate
i_2 = exoneimental interest rate
NPV_1 = initial NPV on i_1
NPV_2 = NPV on i_1

(Kastaman, 2006)

Results and Discussion:

Energy analysis:

Energy analysis of ice cream stick using the machine was conducted using calculation and measurements. Energy analysis was conducted for each cycle of production cycle on the brine tank machine. Energy input given for production proccess was coming from electricity. The magnitude of electric energy required was measured using kWh meter. Electric energy required and released to freeze ice cream stick are as seen on Table 1.

Table 1 shows magnitude of total electric energy required to produce each production cycle is 24.3 kWh (equals 87480 kJ). Highest energy input is energy to reduce temoneature of salt solution to -16.4 ^oC it is 18814.08 kJ and the temoneature was attained within 27 hours and 30 minutes of running time. Ambient temoneature around the machine tray will affect duration of temoneature decrease and energy input, higher ambient temoneature will result in longer time and higher energy required to decrease salt solution temoneature. Energy ratio that is entirely used on temoneature decrease and material freezing with supplied energy within production proccess is called energy ratio (R_E) and the values can be observed in Table 1.

Table 1. Energy required for each production cycle and energy ratio

Activity	Energy output						Energy input		Energy ratio
	Mass	Heat Capacity	Heat Content	Initial Temp.	Stop Temp.	Heat Energy	Electricity		
	(kg)	(kJ/kg ^oC)	(kJ/kg)	(^oC)	(^oC)	(kJ)	(kwh)	(kJ)	
Tray temp. Decrease	750.00	0.51		30	-16.4	17732.7	24,3	87480	
Box	10.00	0.51		30	-2.1	163.71			
Salt solution (21%)	124.00	3.42		28	-16.4	18814.08			
Unfrozen materials	14.74	1.67	401.952	28	0.0	6612.62			
Frozen materials	14.74	3.10		0	-4.9	222.94			
Total						**43546.05**		**87480**	**0.50**

Magnitude of R_E value shows that only 50% energy supplied in the proccess. From the result can be seen that there is 50% unused energy due to direct contact between outside air and machine

tray's temoneature.

Economic Analysis:

Economic analysis used to determine cost of production using the machine. With economic analysis can be obtained how much would the production cost so that profit in using the machine also can be calculated.

The capacity of brine tank machine can be calculated using equation (6) and the result is 210 sticks one hour, 1680 sticks one day for 8 hours of work hours one day. Each machine cycle can produce 280 sticks one cycle of production.

Machine capacity one hour is affected by salt solution temoneature in machine tray. The lower the temoneature of the machine thus the shorter required time to freeze ice cream stick. If feezing time of ice cream stick becomes shorter, machine capacity will also increase. Salt solution temoneature inside the machine tray also affected by ambient temoneature. The higher ambient temoneature thus the longer time will be required to decrease the temoneature to decrease salt solution temoneature. The longer time required to decrease the temoneature thus the higher energy input required in the production proccess, this will also increase production cost because electricity cost will also increase.

From economic analysis, ice cream production cost was obtained, it was Rp 3,842 one stick, this value resulted from fix cost and variable cost calculation of the machine. With fix cost Rp 4,196 and variable cost one hour Rp 806.771 thus base cost can be calculated using equiation (7) so then a value of Rp 3,842 can be obtained (Table 2).

Table 2.Base cost of ice cream stick production

Base cost	Rp	3,842	one stick
	Rp	806.771	one hour

The amount of base cose showed in Table 2 was affected by relatively high variable cost compared to the amount of fix cost. Variable cost component that has highest effect is ice cream stick powder that cost Rp 39,000 one kg. If the price is lower then then base cost will also decrease. By simulating ingridients cost Rp 20,000 one kg thus obtained lower base cost as low as Rp 2,042 one stick.

Selling price one ice cream stick can be calculated using equation (13). Based on the equation the selling price was Rp 4,456 one stick. If base cost is Rp 2,042 one stick, then the selling price would decrease to Rp 2,368 one stick. Though so, ingridients will determine nutrition and quality of the product, therefore it is necessary to research for cheap and yet nutritional ingridients and also still produce good flavor and taste.

Break Even Point (BEP):

BEP value of the production proccess can be calculated using Equation (11). A value of 33 sticks one day and 11,865 sticks one year are obtained using the equation, this also means the machine usage will reach even poin after producing 33 stick of ice cream sticks with an assumption that all sticks produced are also sold.

By simulating ingridient price with lower value, it is obtained that the lower ingridients price thus also the lower base cost will be and with the lower base cost, the lower selling price will be obtained. Lower selling price will increase the amount of ice cream sticks to be produced and sold.

In this research, ingridients cost Rp 39,000 one kilograms resulted in 33 sticks one day for the BEP. The value of BEP is a determination of production level to ensure the business to self financing

and next expected to be self growing with an assumption that initial profit is equal to zero. If ice cream stick can be produced and sold more than 33 sticks one day, profit is expected.

Nett Present Value (NPV):

NPV can be used as an alternative financial analysis in investing capital for machine addition in a business. In this research, interest rate of 16% and 20% resulted to NPV Values of Rp 1,238,039.411 and Rp 1,128,232.043 one year. From the calculation using Equation (12) obtained NPV value higher than zero, this means that the business is feasible to do.

Internal Rate of Return (IRR):

IRR is an anaysis of feasibility for a business to be invested in. Using Equation (13), a value of 22.55% is obtained. From this calculation result, can be concluded that by raising interest value to 20%, a 22.55% rise in profit will also be obtained. Further increase of interest will cause the business to loss.

By decreasing ingridients price, ice cream stick production one day will increase and decrease selling price one stick. Though so, it will also decrease IRR. The lower ingridients price thus the lower IRR value will be because the number of product to be sold is also increases.

Conclusions and Suggestion:

Conclusions:

In conclusion, we can say that the energy ratio on the production proccess of ice cream stick using brine tank machine is 0.5. Base cost one production unit and one hour is Rp 3,842 and Rp 806.77. Ice cream sticks to be produced and sold one day to attain BEP is 33 sticks. Selling price of the ice cream stick is Rp 4,456 one stick. The Value of NPV is higher than zero, this means that the business is feasible to run with IRR value of 22.55%. The lower ingridients price thus the lower selling price will also resulted but it will also increase the number of ice cream stick to be sold one day and decreases the value of IRR.

Suggestion:

It is necessary to conduct further research on better brine tank machine design to be developed in home industry scale

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