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Economic Evaluation and Sensitivity Analysis of Methanol Plant from Glycerol

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Abstract. *Methanol plant from glycerol is a good prospect in Indonesia. Until 2021, methanol is only supplied by one methanol producer located in East Kalimantan, namely PT. Kalimantan Timur with a production capacity of 660,000 tons/year. Therefore, the methanol plant from glycerol has a very important meaning for the acquisition of foreign exchange as well as employment. This article presents an economic evaluation of a methanol plant from glycerol with a capacity of 40,000 tons/year. Profitability analysis calculation is done by two methods, the method that do not consider the time value of money and the method that consider the time value of money. The results of the method that do not consider the time value of money obtained ROI value (before tax) 34.62%, ROI value (after tax) 24.24%, and the value of PBP 2.98 years. Using the method that consider the time value of money, the NPW value was Rp. 1,458 billion and the DCFRR / IRR was 39.25%. The sensitivity analysis also deserves to see the effect of the factor that influence the economic viability, and provide more information for the optimization of Methanol production.*

Keywords: *Economic Evaluation, Glycerol, Methanol, Profitability Analysis, Sensitivity Analysis;*

INTRODUCTION

The development of industry in Indonesia is currently experiencing an increase in quality and quantity in the chemical industry, so that the need for raw materials, supporting materials, and labor is increasing. In the chemical industry, Methyl alcohol or known as methanol is widely used as a primary fuel, a mixture of the main fuel (gasoline), solvent, Anti-freeze in piping systems, and can also be converted into formaldehyde which will produce products such as plastics, paints, explosives, and textiles. Methanol (CH3OH) is one of the chemical compounds that can be produced through the gasification process and is widely used in various sectors of life, such as the health sector, cosmetic sector, and others. Methanol acts as a raw material in producing hydrocarbon compounds that are useful as fuels or organic compounds commonly used to increase the octane rating of fuel, such as MTBE (Goessch et al, 2008).

Methanol will become more necessary as Indonesia's chemical sector develops, particularly those that need fuel. It is quite feasible to build a methanol plant in Indonesia with the help of the country's plentiful raw materials and the potential to create new jobs. A fundamental factor in the decision to build this methanol plant is the significance of methanol's involvement in other chemical industries. With a production capacity of 660,000 tons per year,

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PT. Kalimantan Timur is the sole operating methanol plant in Indonesia at the moment. Most of the methanol products from these plants are exported abroad, so for domestic needs, Indonesia must import methanol. Therefore, Indonesia still needs methanol-producing plant that can meet domestic needs, so that it will reduce state spending and have a positive impact on industrial growth and the domestic economy.

Plant design is the initial stage that must be passed in the establishment of a plant. This stage begins with searching for various data and information related to the plant to be built. Next, calculate the mass balance and energy balance, then calculate the process equipment and utility equipment (Baasel, 1989). Economic calculation is the final stage of plant design. In this economic calculation, the capital investment and production costs will be obtained. To determine the economic feasibility, an economic analysis was carried out which included an after-tax rate of return and sensitivity analysis (Peters et al, 2003). This paper aims to describe the economic feasibility of establishing a methanol plant based on the results of the design of a methanol plant from glycerol with the syngas process.

BACKGROUND

1.1. Economic Studies

In the design of a methanol plant from glycerol, an economic analysis is needed to get an estimate of the feasibility of investing in production activities by reviewing the investment capital requirements, the amount of profit earned, the length of the investment capital that can be returned and the total production cost equal to the profit earned. In addition, the economic analysis aims to determine whether the plant to be established can be profitable and feasible or not to be established.

Economic analysis includes the calculation of Total Capital Investment (TCI), Total Production Cost (TPC), and profitability analysis. There are seven methods used in calculating the TCI value, including Detailed-Item Estimate, Unit Cost Estimate, Percentage of Delivered-Equipment Cost, Lang Factors for Approximation of Capital Investment, Capacity Ratio, and Investment Cost per Unit of Capacity. The choice of method is based on the available information, the desired calculation accuracy, and the need for economic analysis. TPC calculation is based on a predetermined parameter percentage range (Peters et al, 2003).

Total Capital Investment (TCI) is obtained from the sum of Fixed Capital Investment (FCI) and Working Capital Investment (WCI). FCI is the sum of direct and indirect costs (Peters et al, 2003). FCI indicates the funds required for the installation of process equipment with all its complementary components for the process to run properly. Costs for land

preparation, piping, instrumentation, insulation, utilities, buildings, and other supporting facilities.

One way to get a better initial estimate is to add an unexpected cost to each estimate. The addition of these unexpected costs will later be able to cover forecast errors in the future (Carl, 1989). Expenditures for engineers and supervision, expenses for legalization, construction expenses, contractor wages, and unexpected costs are part of indirect costs (Peters et al, 1993). Working Capital Investment (WCI) is the cost invested in production, including raw material inventory, salaries, and taxes. WCI is estimated to be 15% of TCI (Peters et al, 2003).

Total Production Cost (TPC) includes daily plant operating costs consisting of Direct Production Cost (DPC), Indirect Production Cost (IPC), and general expenses (Zhang et al, 2003). DPC includes raw material costs, operator wages, supervisor and administrative wages, utilities (including waste disposal), maintenance and repairs, operating supplies, laboratory expenses, and costs for patents and royalties. Calculation of the raw materials cost and other process support materials is based on price and flow rate of use. Operator fees are derived from operator requirements for various process equipment. Other expenses, such as supervisory and administrative wages, maintenance and repair expenses, and operating supplies expenses are calculated individually using certain multipliers. IPC covers overhead, packing, storage, local taxes, insurance, and depreciation. All of these costs are not affected by the rate of production. General expenses include administrative costs, distribution, and sales costs as well as research and development costs (Peters et al, 2003).

The calculation of the profit level of the establishment and operation of the factory is called profitability analysis. Profitability analysis is carried out using two methods, the method that do not consider the time value of money and the method that consider the time value of money. Evaluation for the first method can be seen from the value of Return on Investment (ROI), and the Payback Period (PBP) by using the depreciation method in the form of the Modified Accelerated Cost Recovery System (MACRS). The MACRS method was chosen because it considers the value of money which changes every year. While the evaluation for the second method can be seen from the value of Net Present Worth (NPW) and Discounted Cash Flow Rate of Return (DCFRR) or Internal Rate of Return (IRR) (Peters et al, 2003).

1.2. Sensitivity Analysis

Sensitivity analysis indicates what factors are most important. Furthermore, the process engineer can decide what data is most needed as critical data before the next design stage is

carried out. From the results of this sensitivity analysis can also be obtained an overview of the risks that may occur so that the assumptions can be corrected. Sensitivity analysis was conducted to see the effect that occurs if the assumption of a factor is changed (Baasel, 1989). The sensitivity analysis carried out is the effect of decreasing product selling prices and increasing raw material prices on the profits obtained

PROCESS DESCRIPTIONS

1.3. Raw Material Preparation

The main raw material in the manufacture of methanol plants is pure glycerol. Glycerol to be used must be pretreated first so that there are no more impurities contained in it.

1.4. Glycerol Purification Process

Pretreatment of crude glycerol requires a series of purification steps before turning it into a quality product by removing impurities such as soap, free fatty acids, and other non-glycerol organic matter. Pure glycerol can be produced from organic production through reaction, heating, and separation processes to obtain glycerol with a purity of 98% which will be stored in the product storage tank (Goessch et al, 2008).

The pure glycerol then goes through a reforming process by adding steam at a pressure of 75 bar. Glycerol is reacted with steam and a Ni-based catalyst at a temperature of 500℃. In the steam reforming reaction, glycerol is reacted into a syngas consisting of H_2, CO, and CO_2 (Goessch et al, 2008).

Methanol synthesis occurs when syngas (H_2, CO, and CO_2) is fed to the reactor. The product stream from the methanol synthesis is fed to the Flash Drum. The unreacted gas will be fed back into the methanol synthesis reactor. As for the mixture of water and methanol, it is separated through a distillation column so that it will produce a top product in the form of methanol and a bottom product in the form of water. The top product is stored in a methanol storage tank (Goessch et al, 2008).

ECONOMIC ASSESSMENT

1.5. Basic and Scope of Calculations

The calculation basis used in the estimation of the cost of the methanol plant from glycerol is: (1) It is estimated that it will be established in 2025. (2) Operate in 2027. (3) Construction time is 2 years. (4) The operating life of the factory is 20 years. (5) Production capacity of 40,000 tons/year. (6) Employee salaries of 36 billion rupiahs. (7) Product sales amounted to 2,019 billion rupiahs. (8) The dollar exchange rate in 2025 is 15 thousand rupiahs.

1.6. Results and Discussion

The economic analysis of the methanol plant from glycerol begins with knowing the specifications of the equipment and the amount of raw material needed. Based on the calculation results obtained purchased cost for plant equipment amounted to 249 billion rupiahs. In this analysis of the methanol plant from glycerol, the production capacity of the methanol plant from glycerol is planned to be 40,000 tons/year with the assumption of an operating time of 300 days/year. The need for raw materials and products in a methanol plant from glycerol can be seen in Table 1.

Table 1. Raw Material and Product Requirements in Methanol Plants from Glycerol

Raw Material	Demand (tons/year)
Gliserol	49,143.599
NaOH	57,526.920
H_2SO_4	56,659.680
$Cu/Zn/Al_2O_3$	1,155.765
$Al_2(SO_4)_3$	3,808.624
Na_2CO_3	2,837.462
Product	**Production (tons/year)**
Metanol	43,640.640
Air	11,045.376

TCI estimation is heavily influenced by the capacity of the plant to be established; the larger the factory capacity, the greater the investment in equipment. TCI is calculated using the Delivered Equipment Ratio Factor in this article (DERF). This method was chosen because it is commonly used in calculating preliminary plant case studies. The fluid processing plant was chosen because the raw materials used in the production process are in the liquid phase. Calculations using the DERF method use a percentage in each parameter detail, so the calculation can only be completed by multiplying the purchased cost by each parameter percentage that has been determined. The TCI calculation yields 1.491 billion rupiah.

TPC is calculated by adding MC and GE. The calculation outcomes are obtained by multiplying FCI by detailed data on each parameter in the form of a percentage range. The TPC calculation yields 1.311 billion rupiahs. Table 2 shows the results of the economic analysis calculated from TCI and TPC at this plant.

Table 2. Economic Analysis Calculation

Parameter	Calculation Result (Billion Rupiah)
Total Direct Cost	908
Total Indirect Cost	359
Fixed Capital Investment	1,267
Working Capital Investment	223
Total Capital Investment	1,491
Manufacturing Cost	1,193
General Expenses	118
Total Product Cost	1,311

The methanol plant from glycerol took two years to build and is expected to operate for twenty years. The plant was built with a 30% stakeholder investment and 70% bank loan capital. Bank interest is 8%, and taxes are 30%. These figures serve as inputs for the calculation of cumulative cash flow.

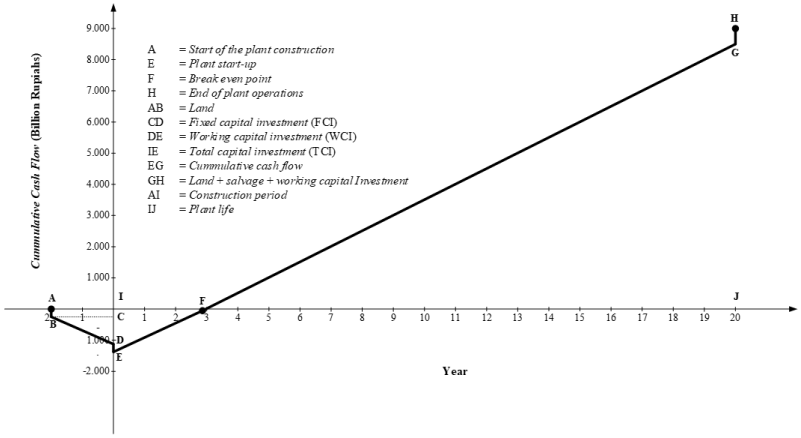

Fig. 1. Cumulative Cash Flow.

Figure 1. cumulative cash flow graph illustrates the correlation between the cumulative cash flow value and the estimated plant economic analysis for the given year of operation. The year prior to the plant start-up was when there was a negative cumulative cash flow. The plant incurred expenses over the two years of construction, resulting in a loss. The cumulative cash flow for the following year is positive, demonstrating that the plant started operating at a profit in its first year, and it will continue to do so. Given that profits can be made quickly, this situation demonstrates the economic viability of building a methanol production from glycerol.

The methods used in the calculation of profitability analysis include ROI, PBP, NPW and DCFRR/IRR. The results of the calculation of profitability analysis are shown in Table 3.

Table 3. Profitability Analysis Calculation Results

Parameter	Calculation Result
ROI (*Before tax*)	34.62%
ROI (*After tax*)	24.24%
PBP	2.98 years
NPW	1,458 Billion Rupiahs
DCFRR/IRR	39.25%

From the calculation of profitability analysis, the ROI value is 24.24%. The methanol plant from glycerol is included in the type of plant with a new product or new process technology, with a mar range of 16-24. The ROI value in Table 3 shows that the calculation results have exceeded the minimum range of mar which indicates that the rate of return on capital has exceeded the minimum limit. The PBP value obtained from the calculation of

profitability is 2.98 years. According to this statistic, the investment made to start the factory can be repaid in two years and eleven months. While PBP describes the duration of the return on capital after the plant is operating, ROI describes the annual rate of return on capital in terms of percent.

The reference PBP value based on the mar value can be used to determine whether the PBP value in this plant is feasible. According to the calculation's findings, the reference PBP value is 2.86 years. Since the PBP value acquired for the methanol plant from glycerol is higher than the reference PBP, it can be concluded that the PBP value produced in the glycerol based methanol plant can be accepted and utilized as one of the profitability parameters.

SENSITIVITYANALYSIS

In the design of the methanol plant from glycerol, sensitivity analysis was carried out in the form of the influence of raw material prices and product prices on the DCFRR/IRR value which was calculated using the trial and error method.

The percentage change for raw materials is obtained from market price histogram data (www.selinawamucii.com). Based on the histogram data, it can be seen that the price of raw materials experienced the lowest decline of 50% and the highest increase of 89%. So, in this sensitivity analysis, the percentage is chosen for an increase of 50% and a decrease of 50% by assuming that all components of raw material prices have increased and decreased at an approximate rate of 10%.

The percentage change for the product is obtained from the market price histogram data (www.tradingeconomics.com). Based on the histogram data, it can be seen that product prices experienced the lowest decline of 45% and the highest increase of 41%. So, in this sensitivity analysis, the percentage is chosen for an increase of 50% and a decrease of 50% by assuming that all product price components increase and decrease by an approximate number of 10%.

The effect of each main factor on economic analysis can be seen in Figure 2 based on the sensitivity analysis, which shows the effect of raw material prices and product selling prices on DCFRR/IRR. The increase in the price of glycerol as a raw material can have an impact on the increase in the price of methanol factory raw materials from glycerol. Glycerol price fluctuations in recent years show significant changes. Glycerol prices have soared up to 89% and down to -25% of the average price.

Based on Figure 2, it can be seen that the DCFRR/IRR for raw materials experienced the lowest decrease of 39.63% and the highest increase of 39.85%. Meanwhile, the product experienced the lowest decline of 39.69% and the highest increase of 40.11%. From these data

it can be concluded that changes in product prices will have a greater influence on the level of profit than other economic factors

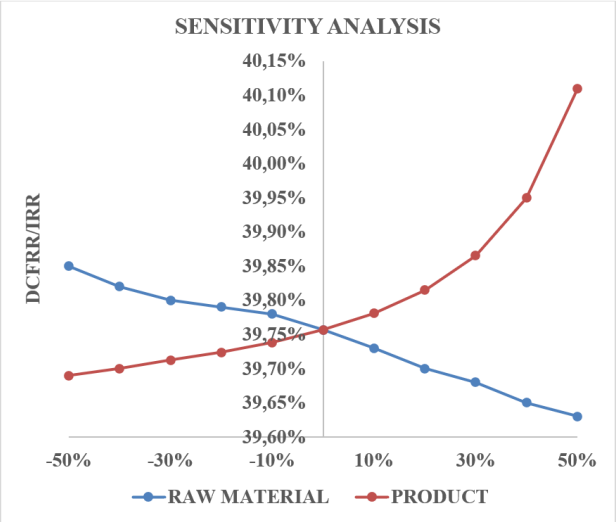

Fig. 2. Graph of Methanol Plant Sensitivity Analysis of Glycerol

CONCLUSIONS

The construction of a methanol plant employing the syngas process from glycerol has a strong economic future. ROI (before taxes) is 24.24%, PBP is 2.46 years, NPW is 1.458 billion rupiahs, and DCFRR/IRR is 39.25%, according to profitability study. These results indicate that building a glycerol based methanol facility will be highly profitable. Meanwhile, it is clear from the sensitivity analysis that changes in product pricing will have a bigger impact on profit levels than other economic factors.

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