INTISARI

Dimetil karbonat (DMC) merupakan senyawa organik ramah lingkungan yang banyak digunakan sebagai pelarut industri, bahan aditif bahan bakar, bahan antara poliuretan tanpa isosianat, serta elektrolit pada baterai *lithium-ion*. DMC dapat diproduksi melalui beberapa metode, di antaranya fosgenasi, transesterifikasi, dan sintesis langsung dari metanol serta karbon dioksida (CO_2). Pada perancangan ini, dipilih proses sintesis langsung (*direct synthesis*) karena bersifat bebas fosgen, lebih aman, serta memanfaatkan CO_2 sebagai bahan baku berbiaya rendah sehingga mendukung konsep *green chemistry*.

Reaksi utama berlangsung dalam *multitube fixed bed reactor* pada suhu operasi 120°C dan tekanan 30 atm dengan menggunakan katalis ceria (CeO_2) dan agen dehidrasi 2-cyanopyridine (2-CP) untuk menghasilkan produk utama DMC dan produk samping 2-picolinamide. Reaksi ini merupakan proses *reversible* sehingga keberadaan *dehydrating agent* diperlukan untuk menggeser kesetimbangan ke arah produk. Produk hasil reaksi kemudian dimurnikan melalui unit pemisahan yaitu menara distilasi, guna memperoleh DMC dengan kemurnian tinggi.

Berikut merupakan spesifikasi pabrik DMC yang direncanakan:

- Sistem operasi : kontinyu
- Waktu operasi : 330 hari/tahun; 24 jam/hari
- Kapasitas produksi : 30.000 ton DMC/tahun
- Kemurnian produk : 99,9%
- Kebutuhan bahan baku utama dan katalis :
  - Metanol : 21.556.596,16 kg/tahun
  - Karbon dioksida : 1.485.021,7988 kg/tahun
  - Katalis : 74.519,238 kg/tahun
- Utilitas
  - Air Sanitasi : 1.782 m^3/tahun
  - Air Sungai : 1.460.870,69 m^3/tahun
  - *Steam* : 18.572.926,57 kg/tahun
  - Tawas : 10,14 ton/tahun
  - Listrik umum : 4.237.946,46 kWh/tahun

- Bahan bakar steam : 1.079.519,04 L/tahun
- Poliakrilamida : 0,1 ton/tahun
- Pasir Silika : 13,51 kg/tahun
- Antrasit : 0,68 ton/tahun
- Resin kation : 1,11 m^3/tahun
- Resin anion : 1,66 m^3/tahun

- Lokasi Pabrik : Bontang, Kalimantan Timur
- Luas Pabrik : 10.000 m2
- Jumlah Pekerja : 89 orang
- Pembiayaan
  - FCI : Rp1.147.152.693.975,29
  - WCI : Rp202.438.710.701,52
  - TCI : Rp1.349.591.404.676,81
  - TPC : Rp1.916.371.311.433,02
  - Penjualan/tahun : Rp2,540,411,950,054.18
- Analisa Ekonomi
  - ROE : 50,8%
  - IRR : 33,24%
  - POT : 3,274 tahun
  - BEP : 33,6849%

Berdasarkan pemaparan proses dan analisa ekonomi di atas, desain proyek pabrik DMC dengan kapasitas 30.000 ton/tahun dinyatakan layak didirikan dan dapat dilanjutkan ke tahap perencanaan.

ABSTRACT

Dimethyl carbonate (DMC) is an environmentally friendly organic compound that is widely used as an industrial solvent, fuel additive, intermediate for non-isocyanate polyurethanes, and as an electrolyte component in lithium-ion batteries. DMC can be produced through several methods, including phosgenation, transesterification, and direct synthesis from methanol and carbon dioxide (CO_2). In this design, the direct synthesis process is selected because it is phosgene-free, safer to operate, and utilizes CO_2 as a low-cost feedstock, thereby supporting the principles of green chemistry.

The main reaction is carried out in a multitube fixed-bed reactor operating at a temperature of 120°C and a pressure of 30 atm, using ceria (CeO_2) as the catalyst and 2-cyanopyridine (2-CP) as a dehydrating agent to produce DMC as the main product and 2-picolinamide as a by-product. This reaction is reversible; therefore, the presence of a dehydrating agent is required to shift the equilibrium toward product formation. The reaction products are subsequently purified in separation units, namely distillation columns, to obtain high-purity DMC.

The planned specifications of the DMC plant are as follows:

- Operating system : Continuous
- Operating time : 330 days/year; 24 hours/day
- Production capacity : 30,000 tons of DMC per year
- Product purity : 99.9%
- Main raw material and catalyst requirements:
  - Methanol : 21,556,596.16 kg/year
  - Carbon dioxide : 1,485,021.7988 kg/year
  - Catalyst : 74,519.238 kg/year
- Utilities:
  - Sanitation water : 1.782 m^3/tahun
  - River water : 1,460,870.69 m^3/year
  - Alum : 10.14 tons/year
  - Electricity : 4,237,946.46 kW/year
  - Steam fuel : 1,079,519.04 L/year
  - Polyacrylamide : 0.1 ton/year

- Silica sand : 13.51 kg/year
- Anthracite : 0.68 ton/year
- Cation resin : 1.11 m^3/year
- Anion resin : 1.66 m^3/year

- Plant location : Bontang, East Kalimantan
- Plant area : 10,000 m^2
- Number of employees : 89 persons
- Financing :
  - Fixed Capital Investment (FCI) : IDR 1,147,152,693,975.29
  - Working Capital Investment (WCI) : IDR 202,438,710,701.52
  - Total Capital Investment (TCI) : IDR 1,349,591,404,676.81
  - Total Production Cost (TPC) : IDR 1,916,371,311,433.02
  - Annual sales revenue : IDR 2,540,411,950,054.18
- Economic analysis:
  - Return on Equity (ROE) : 50.8%
  - Internal Rate of Return (IRR) : 33.24%
  - Pay Out Time (POT) : 3.274 years
  - Break Even Point (BEP) : 33.6849%

Based on the process description and economic analysis presented above, the design of a DMC plant with a capacity of 30,000 tons per year is considered feasible to be established and can be further developed to the detailed engineering design stage.