Optimisasi Kolom Distilasi-Adsorpsi untuk Pemisahan Bioetanol-Air Menggunakan Adsorben Zeolite 3A = Optimization of Distillation-Adsorption Column for Separation of Bioethanol-Water Using Zeolite 3A Adsorbent

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Abstrak

Indonesia berencana meningkatkan kapasitas energi terbarukannya dengan bioetanol dapat berkontribusi sebagai campuran bahan bakar kendaraan. Bioetanol harus memiliki kemurnian 99,5mol/mol% yang tidak dapat dicapai dengan teknologi konvensional karena adanya titik azeotrop. Oleh karena itu, dibutuhkan kombinasi teknologi seperti distilasi-adsorpsi. Penelitian ini menganalisis optimisasi kondisi operasi dan sizing proses distilasi dan adsorpsi pada pemisahan bioetanol-air. Proses distilasi disimulasikan menggunakan Aspen HYSYS v14, sedangkan sizing kolom dan kondisi operasi adsorber dilakukan secara manual menggunakan Microsoft Excel dengan data acuan proses adsorpsi adalah Pressure Swing Adsorption (PSA) dan desikan/adsorber zeolite sintetis 3A. Asumsi yang digunakan adalah masa pakai alat 10 tahun, masa ganti adsorben 2 tahun, dan interest rate 8% berdasarkan pada penelitian terdahulu (data sekunder). Komponen biaya adalah pembelian dan instalasi alat, serta pembelian adsorben sebagai Total Investment Cost (TIC), konsumsi listrik, steam, cooling water, dan penggantian adsorben sebagai Total Operational Cost (TOC), serta nilai Total Annual Cost (TAC) adalah TIC dikalikan dengan Capital Recovery Factor (CRF) ditambah TOC. Nilai TAC terkecil menjadi kondisi optimal, yang mana tercapai pada konsentrasi outlet kolom distilasi 85mol/mol%. Biaya TIC sebesar Rp37.731.845.143,27, TOC sebesar Rp73.315.142.410,87, dan TAC sebesar Rp78.938.300.000,17. Proses distilasi memerlukan energi sebesar 2,01 x 10^7 KJ/h (5580 kWh) dan PSA 2,0 x 10^5 KJ/h (55,5 kWh). Hasil penelitian ini dapat membantu industri dalam mengoptimalkan proses distilasi-adsorpsi untuk meningkatkan efisiensi dan mengurangi biaya operasional.

.....Indonesia plans to increase its renewable energy capacity by bioethanol can be utilized as fossil fuel blend. Bioethanol must have a purity of 99.5mol/mol%, which cannot be achieved with conventional technology due to the presence of an azeotropic point. Therefore, a combination of technologies such as distillation and adsorption is required. This study analyzes the optimization of operating conditions and process sizing for distillation and adsorption in bioethanol-water separation. The distillation process is simulated using Aspen HYSYS v14, while the sizing of the column and adsorber conditions are manually calculated using Microsoft Excel with data from the PSA process and zeolite synthetic adsorber 3A. Assumptions used include an equipment lifespan of 10 years, adsorbent replacement every 2 years, and an interest rate of 8% based on previous research (secondary data). The components of the cost include the purchase and installation of equipment, as well as the purchase of adsorbents as Total Investment Cost (TIC), electricity consumption, steam, cooling water, and adsorbent replacement as Total Operational Cost (TOC), and the value of Total Annual Cost (TAC) is the product of TIC and Capital Recovery Factor (CRF) plus TOC. The optimal condition is achieved at a concentration of 85mol/mol% in the outlet column of the distillation process. The TIC is approximately Rp37.731.845.143,27, TOC is approximately Rp73.315.142.410,87, and TAC is approximately Rp78.938.300.000,17. The distillation process requires

energy of 2.01 x 10^7 KJ/h (approximately 5580 kWh) and PSA 2.0 x 10^5 KJ/h (approximately 55.5 kWh). This study's results can help industries optimize the distillation-adsorption process to increase efficiency and reduce operational costs.