ABSTRAK

PENGARUH TEMPERATUR RENDAH DAN *RESIDENCE TIME* TERHADAP PRODUKSI METANA PADA PROSES METANASI CO_2

(Andini Dwinopta, 2026, 58 Halaman, 13 Tabel, 13 Gambar, 3 Lampiran)

Penelitian ini bertujuan menganalisis pengaruh temperatur rendah (170–190°C) dan *Residence Time* (10–50 menit) terhadap konversi CO_2 dan konsentrasi CH_4, mengevaluasi peran *Residence Time* dalam mengatasi keterbatasan kinetika reaksi, serta menentukan hubungan modifikasi konfigurasi reaktor dengan peningkatan produksi metana pada proses metanasi CO_2 dengan menggunakan bantuan katalis Ni/Al_2O_3 dalam sistem *catalytic batch reactor* berbasis sirkulasi loop. Penelitian dilakukan dengan menggunakan katalis Ni/Al_2O_3 sebanyak 50 gram, promotor Zn 15 gram, larutan NaOH 4 M sebanyak 250 mL, dan gas CO_2 sebagai bahan baku. Komposisi gas hasil reaksi dianalisis dengan menggunakan *Multi Gas Detector Analyzer*. Hasil penelitian menunjukkan bahwa kenaikan temperatur dan *Residence Time* meningkatkan konversi CO_2 dan pembentukan CH_4. Kondisi terbaik diperoleh pada temperatur 190°C dengan *Residence Time* 50 menit menghasilkan konsentrasi CH_4 sebesar 41,11% dan konversi CO_2 sebesar 46,82%, sedangkan hasil terendah diperoleh pada temperatur 170°C dengan *Residence Time* 10 menit (CH_4 10,82%; konversi CO_2 15,16%). Analisis kinetika menunjukkan reaksi mengikuti orde 1 terhadap CO_2 dengan konstanta laju reaksi meningkat dari 0,0067 $menit^{-1}$ (170°C) menjadi 0,0116 $menit^{-1}$ (190°C) dan energi aktivasi 46,91 kJ/mol. Modifikasi konfigurasi reaktor terbukti efektif meningkatkan kontak antara reaktan dan katalis sehingga proses konversi CO_2 menjadi metana berlangsung lebih optimal. Hasil penelitian ini diharapkan dapat menjadi acuan pengembangan teknologi metanasi CO_2 pada kondisi operasi bertemperatur rendah.

Kata kunci: metanasi CO_2, metana, temperatur rendah, *Residence Time*, Ni/Al_2O_3.

ABSTRACT

THE EFFECT OF LOW TEMPERATURE AND RESIDENCE TIME ON METHANE PRODUCTION IN THE CO_2 METHANATION PROCESS

(Andini Dwinopta, 2026, 58 *Pages*, 13 *Tables*, 13 *Figure*, 3 *Appendices*)

This study aimed to analyze the effects of low temperature (170–190°C) and residence time (10–50 minutes) on CO_2 conversion and CH_4 concentration, evaluate the role of residence time in overcoming kinetic limitations, and determine the relationship between modified reactor configuration and methane production enhancement in the CO_2 methanation process with the assistance of a Ni/Al_2O_3 catalyst in a modified catalytic batch reactor with a loop circulation system. The experiments were carried out using 50 g of Ni/Al_2O_3 catalyst , 15 g of Zn promoter, 250 mL of 4 M NaOH solution, and CO_2 as the feed gas. The product gas composition was analyzed using a Multi Gas Detector Analyzer. The results showed that increasing temperature and residence time improved CO_2 conversion and methane production. The best performance was achieved at 190°C with a 50-minute residence time, yielding 41.11% CH_4 concentration and 46.82% CO_2 conversion, while the lowest results were obtained at 170°C with a 10-minute residence time (10.82% CH_4; 15.16% CO_2 conversion). Kinetic analysis revealed that the reaction followed first-order kinetics with respect to CO_2, with the rate constant increasing from 0.0067 min^{-1} (170°C) to 0.0116 min^{-1} (190°C) and an activation energy of 46.91 kJ/mol. The modified reactor configuration effectively enhanced contact between reactants and the catalyst, leading to more optimal CO_2 conversion to methane. These findings provide a reference for the development of low-temperature CO_2 methanation technology.

Keywords: *CO_2 methanation, methane production, low temperature, residence time, Ni/Al_2O_3 catalyst.*