

## ABSTRAK

Christian Hendro Setiawan. Analisis Pengaruh Temperatur Oksidasi Terhadap Efisiensi Eksergi Proses Gasifikasi *Municipal Solid Wasted* dengan *Gasifier Tipe Downdraft*.

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Peningkatan kebutuhan energi nasional dan kompleksitas pengelolaan limbah padat perkotaan (Municipal Solid Waste/MSW) menuntut solusi transisi energi yang berkelanjutan di Indonesia. Teknologi gasifikasi hadir sebagai metode konversi Waste-to-Energy (WtE) strategis untuk mengubah limbah padat menjadi syngas. Penelitian ini bertujuan untuk menganalisis kinerja termodinamika sistem gasifikasi MSW menggunakan pendekatan analisis eksergi guna mengevaluasi kualitas energi dan lokasi kerugian sistem secara akurat. Pengujian dilakukan secara eksperimental menggunakan reaktor tipe downdraft skala laboratorium dengan bahan bakar pelet MSW 100% organik. Fokus utama penelitian adalah mengevaluasi pengaruh variasi temperatur oksidasi (640,1°C - 737,4°C) terhadap efisiensi eksergi total dan destruksi eksergi sistem. Hasil pengujian menunjukkan bahwa pelet MSW memiliki nilai kalor atas (HHV) sebesar 15,02 MJ/kg dengan kandungan karbon 38,4 wt%. Berdasarkan analisis energi, efisiensi tertinggi dicapai pada temperatur oksidasi 737,4°C sebesar 32,8%. Namun, pada analisis eksergi (kualitas energi), ditemukan bahwa efisiensi meningkat seiring kenaikan temperatur hingga mencapai titik optimum pada 717,7°C dengan nilai efisiensi eksergi sebesar 30,1%. Peningkatan suhu lebih lanjut ke 737,4°C justru menurunkan efisiensi eksergi menjadi 29,1%, yang mengindikasikan adanya peningkatan degradasi energi internal dan irreversibilitas sistem. Nilai LHV syngas ditemukan stabil pada kisaran 10,77-10,83 MJ/kg, menunjukkan bahwa variasi temperatur lebih memengaruhi kualitas energi (eksergi) dibandingkan kuantitas energi (LHV). Temuan ini diharapkan menjadi rujukan teknis dalam optimalisasi operasional pembangkit listrik berbasis biomassa sampah untuk mendukung target Net Zero Emission.

Kata Kunci: *Gasifikasi, Municipal Solid Waste (MSW), Reaktor Downdraft, Analisis Eksergi, Temperatur Oksidasi.*

## ABSTRACT

Christian Hendro Setiawan. *Analysis Of The Effect Of Oxidation Temperature On The Exergy Efficiency Of The Municipal Solid Waste Gasification Process Using A Downdraft Gasifier. Guided by Hendri, S.T., M.T.*

*The increasing national energy demand and the complexity of Municipal Solid Waste (MSW) management require sustainable energy transition solutions in Indonesia. Gasification technology serves as a strategic Waste-to-Energy (WtE) method to convert solid waste into syngas. This study aims to analyze the thermodynamic performance of an MSW gasification system using an exergy analysis approach to accurately evaluate energy quality and the location of system losses. The research was conducted experimentally using a laboratory-scale downdraft gasifier reactor with 100% organic MSW pellets as fuel. The primary focus of the study was to evaluate the effect of oxidation temperature variations (ranging from 640.1°C to 737.4°C on the system's total exergy efficiency and exergy destruction. The experimental results showed that the MSW pellets had a High Heating Value (HHV) of 15.02 MJ/kg with a carbon content of 38.4 wt%. Based on the energy analysis, the highest efficiency was achieved at an oxidation temperature of 737.4°C, reaching 32.8%. However, the exergy analysis revealed that the efficiency increased with rising temperature until it reached an optimum point at 717.7°C, with a maximum exergy efficiency of 30.1%. Further increasing the temperature to 737.4°C actually decreased the exergy efficiency to 29.1%, indicating an increase in internal energy degradation and system irreversibility. Syngas LHV values remained relatively stable between 10.77 and 10.83 MJ/kg, suggesting that temperature variations significantly impact energy quality (exergy) rather than energy quantity (LHV). These findings are expected to serve as a technical reference in optimizing the operational performance of waste-based biomass power plants to support Net Zero Emission targets.*

**Keywords:** *Gasification, Municipal Solid Waste (MSW), Downdraft Reactor, Exercise Analysis, Oxidation Temperature.*