ABSTRAK

Ahmad Fadli Akbar Berutu. 2025. Analisis Emisi Gas dan Energi Panas Hasil Pembakaran Biomassa Tempurung Kelapa, Bambu dan Kardus Dalam Reaktor Insinerator. Tugas Akhir, Program Studi D3 Teknik Mesin, Jurusan Pendidikan Teknik Mesin, Fakultas Teknik, Universitas Negeri Medan.

Penelitian ini bertujuan untuk menganalisis karakteristik emisi gas dan energi panas hasil pembakaran biomassa tempurung kelapa, bambu, dan kardus menggunakan reaktor insinerator tipe fixed bed. Biomassa tersebut dipilih karena mudah diperoleh, memiliki nilai kalor berbeda, dan berpotensi sebagai bahan bakar alternatif yang ramah lingkungan. Penelitian dilakukan secara eksperimental di Workshop Teknik Mesin Universitas Negeri Medan dengan dua variasi massa bahan (1 kg dan 2 kg) serta tiga tingkat tekanan udara (20M^3/H - 30M^3/H dan 40m^3/h). Parameter yang diamati meliputi suhu ruang bakar (T_1), suhu gas buang (T_2), serta emisi gas buang berupa karbon monoksida (CO), karbon dioksida (CO_2), dan nitrogen oksida. Hasil penelitian menunjukkan bahwa peningkatan tekanan udara menyebabkan kenaikan suhu pembakaran dan penurunan kadar CO, yang menandakan pembakaran semakin sempurna. Suhu tertinggi diperoleh pada bahan tempurung kelapa sebesar 910°C untuk massa 1 kg dan 1215°C untuk massa 2 kg pada tekanan udara 40°C. Tempurung kelapa menghasilkan kadar CO terendah (54–59 ppm) dan CO_2 tertinggi (13,2–13,6%), menandakan efisiensi pembakaran paling tinggi. Sementara itu, kardus menghasilkan suhu dan efisiensi terendah, sedangkan campuran tempurung kelapa, bambu, dan kardus (1:1:1) menunjukkan hasil menengah yang stabil. Secara keseluruhan, urutan efisiensi pembakaran adalah Tempurung Kelapa > Campuran 1:1:1 > Bambu > Kardus, dengan kadar masih berada di bawah ambang batas aman menurut KLHK (2008).

Kata Kunci : Biomassa, Emisi Gas, Energi Panas, Tempurung Kelapa, Reaktor Insinerator

ABSTRACT

Ahmad Fadli Akbar Berutu. 2025. Analysis of Gas Emissions and Heat Energy from the Combustion of Coconut Shell, Bamboo, and Cardboard Biomass in an Incinerator Reactor. Final Project, D3 Mechanical Engineering Study Program, Department of Mechanical Engineering Education, Faculty of Engineering, State University of Medan.

This study aims to analyze the gas emission characteristics and heat energy generated from the combustion of coconut shell, bamboo, and cardboard biomass using a fixed-bed type incinerator reactor. These biomass materials were selected due to their availability, varying calorific values, and potential as environmentally friendly alternative fuels. The experimental research was conducted at the Mechanical Engineering Workshop, State University of Medan, using two different fuel masses (1 kg and 2 kg) and three air pressure variations ($20m^3/h$ – $30m^3/h$ dan $40m^3/h$). The ob served parameters included combustion chamber temperature (T_1), exhaust gas temperature (T_2), and exhaust gas emissions consisting of carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen oxides. The results showed that increasing air pressure led to higher combustion temperatures and lower CO concentrations, indicating more complete combustion. The highest temperature was obtained from coconut shell fuel, reaching 910°C for a mass of 1 kg and 1215°C for 2 kg at an air pressure of $40m^3/h$. Coconut shell produced the lowest CO concentration (54–59 ppm) and the highest CO_2concentration (13.2–13.6%), indicating the highest combustion efficiency. Meanwhile, cardboard produced the lowest combustion temperature and efficiency, while the mixture of coconut shell, bamboo, and cardboard (1:1:1) yielded stable intermediate results. Overall, the combustion efficiency order was Coconut Shell > Mixture (1:1:1) > Bamboo > Cardboard, with levels remaining below the permissible limits set by the Indonesian Ministry of Environment and Forestry (2008).

Keywords: Biomass, Gas Emissions, Heat Energy, Coconut Shell, Incinerator Reactor