

ABSTRAK

M. Hilmi Fikri F. Simulasi Distribusi Panas Pada Reaktor Gasifikasi Tipe *Downdraft*.
Dibimbing oleh Hendri, S.T., M.T.

Kebutuhan energi global mendorong pengembangan energi terbarukan melalui pemanfaatan biomassa dengan teknologi gasifikasi. Reaktor *downdraft* menjadi pilihan karena rendahnya kadar tar, namun performanya sangat bergantung pada distribusi panas, khususnya di zona oksidasi. Penelitian ini bertujuan menganalisis karakteristik distribusi panas reaktor menggunakan simulasi *Computational Fluid Dynamics* (CFD) Solidworks dengan pendekatan *Volumetric Heat Source*. Hasil penelitian menunjukkan distribusi termal reaktor memiliki gradien suhu stabil dengan zona oksidasi sebagai pusat panas utama berintensitas 815,42 °C (literatur 629–920 °C). Dibandingkan data aktual lapangan sebesar 996,1 °C, diperoleh *error* relatif sebesar 18,14%, membuktikan validitas model dalam merepresentasikan reaksi eksotermik sebenarnya di bawah ambang batas toleransi 25%. Energi panas bergerak naik secara konvektif menuju zona pirolisis 345,25 °C (literatur 389–416 °C), zona pengeringan 285,60 °C (literatur 144–167 °C), dan zona reduksi 332,18 °C (literatur 391–427 °C). Hubungan suhu pada zona pirolisis dan reduksi menunjukkan korelasi yang cukup baik terhadap rentang teoritis, sedangkan suhu pengeringan yang melampaui literatur mengindikasikan akumulasi panas gas akibat ketiadaan model penguapan *moisture* pelet secara dinamis. Keberhasilan meminimalkan *error* di zona oksidasi mengonfirmasi bahwa pola distribusi panas berbentuk kerucut terbalik ini merupakan representasi kuat mekanisme termokimia reaktor.

Kata Kunci: Gasifikasi *Downdraft*, Biomassa, Pellet Kayu Kaliandra, CFD, Sumber Panas Volumetrik.

ABSTRACT

M. Hilmi Fikri F. *Simulation of Heat Distribution in a Downdraft Gasification Reactor.*
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Increasing global energy demand and depleting fossil fuel reserves have accelerated the development of renewable energy, particularly through biomass gasification. Among various designs, the downdraft gasification reactor is widely utilized for its ability to produce syngas with low tar content. However, its efficiency is heavily dictated by internal heat distribution. This study analyzes the thermal characteristics of the oxidation zone in a downdraft reactor using Computational Fluid Dynamics (CFD). The research methodology involves 3D geometry modeling and fluid flow simulation utilizing Solidworks with a Volumetric Heat Source approach. The simulation results demonstrate a stable temperature gradient across the reactor, identifying the oxidation zone as the primary thermal center with a peak intensity of 815.42 °C (literature range 629–920 °C). When compared to empirical field data of 996.1 °C, this zone achieved a relative error of 18.14%, providing a representation of the exothermic reaction zone within the theoretical range of established literature. Thermal energy was observed to propagate via convection toward the pyrolysis zone at 345.25 °C (literature range 389–416 °C), the drying zone at 285.60 °C (literature range 144–167 °C), and the reduction zone at 332.18 °C (literature range 391–427 °C). While the temperatures in the pyrolysis and reduction zones are slightly below the literature range, the drying zone temperature exceeds it, indicating gas heat accumulation attributed to the omission of a dynamic pellet moisture evaporation model. Despite these deviations, the simulation successfully identifies the inverted cone heat distribution pattern as a characteristic representation of the reactor's thermochemical mechanisms.

Keywords: Biomass, Calliandra Wood Pellets, CFD, Downdraft Gasification, Volumetric Heat Source