ABSTRAK

KARAKTERISTIK ALIRAN FLUIDA PADA PEMBAKARAN BATUBARA-*WOODCHIPS* DALAM *FURNACE CIRCULATING FLUIDIZED BED* SECARA NUMERIK (STUDI KASUS UP SEBALANG)

Oleh

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Pembangkit Listrik Tenaga Uap (PLTU) berbasis batu bara masih menjadi tulang punggung penyedia energi listrik di Indonesia, namun menghasilkan emisi gas rumah kaca yang tinggi. Salah satu solusi untuk mengurangi dampak lingkungan tersebut adalah melalui teknologi *high co-firing*, yaitu pencampuran batubara dengan biomassa seperti *woodchips*. Meskipun implementasi *co-firing* telah dilakukan, masih terdapat keterbatasan dalam pemahaman karakteristik aliran fluida dan pembakaran dalam *furnace* secara menyeluruh, khususnya pada sistem *boiler* tipe *Circulating Fluidized Bed* (CFB).

Penelitian ini bertujuan untuk menganalisis karakteristik aliran fluida dalam *furnace* CFB PLTU Sebalang melalui pendekatan simulasi numerik menggunakan simulasi *Computational Fluid Dynamics* (CFD) dengan model *multiphase Eulerian, k-ε turbulence* model, serta *discrete phase* untuk injeksi partikel batu bara. Simulasi dilakukan untuk tiga variasi bahan bakar: 100% batu bara, 90% batu bara + 10% *woodchips*, dan 80% batu bara + 20% *woodchips*. Parameter yang diamati meliputi distribusi temperatur, tekanan, kecepatan udara, dan fraksi volume material padat (pasir) di dalam *furnace*.

Hasil simulasi menunjukkan bahwa penambahan fraksi *woodchips* menurunkan temperatur rata-rata *furnace* dari 945 °C menjadi 810 °C dan tekanan dari 224 Pa menjadi 88 Pa. Kecepatan aliran udara meningkat dari 4,7 m/s menjadi 7,5 m/s, serta terjadi penurunan fraksi volume pasir di zona *dense phase* dari 0,703 menjadi 0,655. Meskipun terdapat perbedaan nilai antara hasil simulasi dan data aktual, tren perubahannya tetap linear dan konsisten. Ketidaksesuaian disebabkan oleh terbatasnya cakupan simulasi yang tidak mencakup efek *induced draft fan* dan area *backpass*.

Implikasi dari temuan ini menegaskan bahwa meskipun *co-firing* dengan *woodchips* berpotensi mengurangi emisi dan mendukung transisi energi bersih, diperlukan pengaturan yang cermat terhadap rasio bahan bakar, distribusi udara, dan sistem pencampuran agar efisiensi pembakaran dan stabilitas aliran tetap optimal. Hasil penelitian ini diharapkan dapat menjadi dasar pengembangan strategi operasional PLTU dalam menerapkan *co-firing* secara lebih efektif dan berkelanjutan.

Kata kunci: *co-firing, woodchips, Circulating Fluidized Bed*, simulasi numerik, fluidisasi.

ABSTRACT

NUMERICAL STUDY OF FLUID FLOW CHARACTERISTICS IN COAL AND WOODCHIP CO-FIRING WITHIN A CIRCULATING FLUIDIZED BED FURNACE (CASE STUDY AT UP SEBALANG)

By

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Coal-fired power plants remain the backbone of electricity generation in Indonesia but are major contributors to greenhouse gas emissions. One promising solution to mitigate these environmental impacts is the implementation of high co-firing technology, which involves blending coal with biomass such as woodchips. While co-firing has been applied in practice, there remains a knowledge gap regarding the comprehensive understanding of fluid flow and combustion characteristics within the furnace, particularly in Circulating Fluidized Bed (CFB) boiler systems.

This study aims to analyze the fluid flow characteristics within the CFB furnace at PLTU Sebalang through a numerical simulation approach using Computational Fluid Dynamics (CFD). The simulation employs a multiphase Eulerian model, a k-ε turbulence model, and a discrete phase model for coal particle injection. Simulations were conducted for three fuel compositions: 100% coal, 90% coal + 10% woodchips, and 80% coal + 20% woodchips. The observed parameters include temperature distribution, pressure, air velocity, and the volume fraction of solid materials (sand) within the furnace.

The simulation results indicate that increasing the woodchips fraction reduces the average furnace temperature from 945 °C to 810 °C and the pressure from 224 Pa to 88 Pa. Airflow velocity increases from 4.7 m/s to 7.5 m/s, accompanied by a decrease in sand volume fraction in the dense phase zone from 0.703 to 0.655. Although numerical differences exist between the simulation results and aktual data, the overall trend remains linear and consistent. The discrepancies are primarily due to the limited scope of the simulation, which does not account for the effects of the induced draft fan and the backpass area.

These findings imply that although co-firing with woodchips has the potential to reduce emissions and support a cleaner energy transition, careful control of fuel ratio, air distribution, and mixing systems is essential to maintain combustion efficiency and flow stability. The results of this study may serve as a reference for optimizing operational strategies in implementing co-firing technology more effectively and sustainably in coal-fired power plants.

Keywords: *co-firing, woodchips, Circulating Fluidized Bed, numerical simulation, fluidization.*