Karakterisasi pembakaran partikel Batubara Indonesia di dalam drop tube furnace (DTF) = Combustion characteristics of Indonesia pulverized coal in a drop tube furnace (DTF) / Dwika Budianto

Dwika Budianto, author

Abstrak

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Pembakaran batubara dalam boiler PLTU untuk mendapatkan efisiensi yang optimal diperlukan analisis karakteristik pembakaran. Proses karakterisasi dilakukan pada alat One Dimensional Furnace (1D furnace) dan Drop Tube Furnace (DTF) sebagai representasi dari tungku boiler skala komersil. Pada penelitian ini dilakukan karakteristik pembakaran pada kedua alat tersebut dengan menggunakan 3 sampel yang berbeda masing-masing mewakili jenis bituminous, subbituminous, lignite. Ukuran sampel batubara seragam 75 m (200 mesh) dan dibakar dalam kondisi pembakaran udara lingkungan (21%O2/79%N2). Kedua alat uji tersebut memiliki geometri dan metode pemanasan yang berbeda, 1D furnace memiliki tinggi 6 m dan diameter dalam 0.3 m sedangkan DTF tinggi 1.5 m dan diameter dalam 0.07 m, metode pemanasan tungku 1D dilakukan dengan pembakaran gas LPG sedangkan DTF dipanasi melalui heater listrik. Dengan latar belakang konfigurasi yang berbeda kedua alat digunakan untuk menganalisis karakterisasi pembakaran batubara dengan sampel yang sama. Hasil parameter karakterisasi pembakaran mencakup distribusi temperatur (dinding dan gas), temperatur penyalaan, waktu penyalaan, waktu karbon terbakar seluruhnya, panjang nyala api. Berdasarkan hasil eksperimen menunjukkan bahwa hasil waktu penyalaan dalam DTF antara 13.25 ? 15.06 ms cenderung lebih lambat dibandingkan hasil 1D furnace antara 2.72 - 4.30 ms, hal ini lebih dipengaruhi oleh thermal inersia pada 1D furnace lebih besar karena didukung burning rate besar, selain itu minimnya konsentrasi O2 pada lingkungan gas dalam tungku DTF oleh karena kondisi temperatur tinggi dalam tungku menyebabkan O2 langsung berinteraksi dengan volatil menghasilkan CO2 dimana CO2 memiliki kapasitas panas besar yang berdampak terhadap penurunan temperatur dan keterlambatan penyalaan. Waktu karbon terbakar habis pada DTF antara 1936-2546 ms Karakterisasi pembakaran..., Dwika Budianto, FT UI, 2014
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cenderung lebih lambat dibanding pada 1D furnace antara 896-1230 ms. Hal ini disebabkan oleh faktor difusivitas dan faktor reaksi gasifikasi pada DTF akibat temperatur gas pembakaran tinggi dan konsentrasi O2 kecil akibat char/karbon langsung bereaksi dengan O2 membentuk CO dan CO2. Kedua sifat spesies gas tersebut akan mempengaruhi terhadap penurunan temperatur dan memperpanjang waktu karbon terbakar habis. Panjang nyala api dalam DTF antara 0.224-0.267 m cenderung lebih pendek dibandingkan pada 1D furnace antara 0.615-1.000 m, hal ini dipengaruhi oleh jumlah laju alir batubara yang berbeda signifikan dimana 1D furnace 155-175 kali lebih besar daripada DTF. Hasil temperatur penyalaan antara pada DTF dan 1D furnace terhadap jenis peringkat batubara mendekati sama yang berkisar antara 318-388 0C. Hasil eksperimen pada masing-masing jenis sampel batubara juga menunjukkan konsisten terhadap fuel ratio (FC/VM), dimana fuel ratio bituminous paling besar, diikuti lignite dan subbituminous. Sebagai prediksi dari hasil eksperimen DTF dilakukan simulasi numerik dengan Computational Fluid Dynamics (CFD). Hasil simulasi yang diinvestigasi antara lain profil distribusi temperatur, profil kecepatan, profil konsentrasi gas

buang CO dan CO2. Berdasarkan hasil simulasi menunjukkan bahwa distribusi temperatur sampel bituminous paling tinggi diikuti sampel lignite dan subbituminous, sedangkan konsentrasi CO dan CO2 menunjukkan profil sampel bituminous lebih tinggi, diikuti sampel subbituminous dan lignite. Kecenderungan hasil simulasi numerik CFD ini memiliki kesesuaian secara kualitatif dengan hasil eksperimen pembakaran dalam DTF.
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ABSTRACT
Coal combustion in coal fired power plants are required characteristics combustion analysis to obtain optimum efficiency. The process characterization have performed on One Dimensional Furnace (1D furnace) and Drop Tube Furnace (DTF) as a representation of a commercial scale boiler furnace. In this research were conducted the combustion characteristics of these two equipment using 3 different samples each representing a type of bituminous, subbituminous, lignite. The sample of coal size was prepared uniform 75 m (200 mesh) and burned in air fired environmental conditions (21% O2/79% N2). Both of the furnaces test have different geometry configuration and heated method, the configuration of 1D furnace is 6 m in height and 0.3 m inside diametre whereas DTF 1.5 m in height, 0.07 m inside diametre, the wall of 1D furnace is heated by combust LPG gas whereas DTF by electrically heated. With a different background configuration of both devices are used to characterize coal combustion with the same sample. The results of combustion characterization parameters include temperature distribution (walls and gas), ignition temperature, ignition time, carbon burn out time, flame length. Based on the experimental results presented that the ignition time results in the DTF between 13.25 - 15.06 ms tend to be slower compared to the 1D furnace between 2.72 ? 4.30 ms, it is affected by inertia thermal on 1D furnace greater due to assist more burning rate,in addition the lack of O2 concentration in the gas environment in DTF because of high temperatures in the furnace conditions cause O2 directly interact with volatiles produce CO2 where CO2 has a large heat capacity that affects decrease temperature and increase ignition delay. Carbon burn out time on DTF between 1936-2546 ms tend to be slower than in the 1D furnace between 896-1230 ms. It is influenced by diffusivity factors and gasification reactions on DTF Karakterisasi pembakaran..., Dwika Budianto, FT UI, 2014

due to high temperature combustion gas and O2 concentration less so the char / carbon directly react with O2 to form CO and CO2. Both of gas species will affect the temperature decrease and extend carbon burn out time. Flame length in the DTF between 0.224-0.267 m tend to be shorter than the 1D furnace between 0.615-1.000 m, it is influenced by a number of coal flow rate significantly different where 1D furnace 155-175 times greater than the DTF. The results of ignition temperature between DTF and 1D furnace have almost equal against each type of coal rank, which ranging 318-388 0C. The results of the experiment on each type of coal samples also showed consistent to fuel ratio (FC/VM), where the bituminous is largest one, subsequently lignite and subbituminous. As prediction of the results of experiments in DTF were performed numerical simulation with Computational Fluid Dynamics (CFD). Simulation results are investigated include temperature distribution profile, velocity profile, emission gas concentration profiles of CO and CO2. Based on the simulation results show that the distribution temperature bituminous samples is more higher and followed subbituminous and lignite samples, while the CO and CO2 concentration profile of the bituminous sample is showed higher, subbituminous and lignite samples subsequently. The tendency of the CFD numerical simulation results have good qualitatively agreement with the experimental results of

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