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PII: S1385-8947(17)31939-3
DOI: https://doi.org/10.1016/j.cej.2017.11.027
Reference: CEJ 17998

To appear in: *Chemical Engineering Journal*

Received Date: 19 August 2017
Revised Date: 4 November 2017
Accepted Date: 4 November 2017

Please cite this article as: W. Wang, C. Bu, A. Gómez–Barea, B. Leckner, X. Wang, J. Zhang, G. Piao, O_2/CO_2 and O_2/N_2 combustion of bituminous char particles in a bubbling fluidized bed under simulated combustor conditions, *Chemical Engineering Journal* (2017), doi: https://doi.org/10.1016/j.cej.2017.11.027

O_2/CO_2 and O_2/N_2 combustion of bituminous char particles in a bubbling fluidized bed under simulated combustor conditions

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Abstract: Most of the time char particles in commercial FB units encounter considerably lower oxygen concentrations than that in the entrance, say between 2% and 10%, and the effects of the oxy-fuel atmosphere on the conversion history of char particles need to be clearly treated under these conditions. In the present work, an experimental study of combustion of bituminous coal char was carried out in a laboratory FB in O_2/CO_2 and O_2/N_2 atmospheres under simulated FB combustor conditions at O_2 concentrations of 4-10% v/v, bed temperatures of 800-900 °C and char particle sizes of 2-8 mm by continuously measuring the concentrations of O_2 and CO in the flue gas. The results indicate that the conversion of char is controlled by diffusion of O_2 in the boundary layer of the particle in O_2/CO_2 and O_2/N_2 environments and that the gasification of char in O_2/CO_2 is limited by chemical kinetics. A char conversion model, taking into account the mass transfer from the bed to the particle and the gasification kinetics of char, was built, based on the experimental results and the intrinsic reactivity of char obtained in TGA tests. Simulations, carried out under the same conditions as in the FB experiments, give good agreement in terms of burnout time and instantaneous reactivity during the conversion of single particles. Simulated results prove that the low diffusivity of O_2 in CO_2 is the main reason for the decreased reaction rate of the char particle in O_2/CO_2 compared with O_2/N_2. The contribution of gasification to the consumption of char is more notable at high bed temperature (900 °C) and coarse particles (8 mm), particularly at lower oxygen concentration (4-6% v/v).

Keywords: fluidized bed; O_2/CO_2 combustion; bituminous coal-char; combustion characteristics

Nomenclature

C	concentration, kg/m^3
d	char diameter, m
D	molecular diffusivity, m^2/s
E_a	activation energy, J/mol
$f()$	function
k_0	pre-exponential factor, 1/s
m	mass of carbon in a char particle, kg