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Procedia Engineering 42 (2012) 283 – 294

Procedia Engineering

www.elsevier.com/locate/procedia

20th International Congress of Chemical and Process Engineering CHISA 2012
25 – 29 August 2012, Prague, Czech Republic

A one-dimensional two-fluid gas–solid model applied to fluidized bed reactors: The SMR and SE-SMR processes

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Abstract

A one-dimensional two-fluid Eulerian–Eulerian model is adopted for numerical simulations of gas–solid flows in fluidized bed reactors. The simulation results obtained with the one-dimensional model are compared with the results of a two-dimensional model for the SMR and SE-SMR processes. For the species concentrations and temperature predictions, the one-dimensional and two-dimensional models are in good agreement. Deviations in the simulation results are observed between the models in the phase area fractions and gas phase velocity. The one-dimensional model should therefore be further extended to include the effect of the gas bubbles in the dense bed zone. Moreover, it is necessary to compensate for the radial convective flow pattern by extended conductive fluxes.

Keywords: SE-SMR; SMR; fluidized bed; two-fluid model; CO_2-capture; numerical simulation

1. Introduction

Steam methane reforming (SMR) is currently the predominant industrial route for hydrogen production. The development of alternative concepts for production of hydrogen via SMR has attracted a lot of attention. A novel concept is the sorption-enhanced steam methane reforming (SE-SMR) process, which involves the addition of a solid sorbent into the SMR reaction system for the selective removal of

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doi:10.1016/j.proeng.2012.07.419

Nomenclature

Latin Letters

Cp	Heat capacity
D	Diffusion coefficient
d	Diameter
G	Modulus of elasticity
g	Gravity
h	Heat transfer coefficient
H	Tube height
ΔH	Heat of reaction
k_k	Thermal conductivity of phase k
$\mathcal{M}$	Interfacial drag force
p	Pressure
Q^i	Interfacial heat transfer
R_i	Reaction rate of reaction i
R_j	Formation rate of component j
T	Temperature
t	Time
v	Velocity
w	Weighting function
z	Axial reactor dimension

Greek Letters

α	Sorbent-to-catalyst ratio
β	Inter-phase drag coefficient
ε	Area phase fraction
Γ	Interfacial mass flux
τ	Shear stress
μ	Dynamic viscosity
ρ	Density
ω	Mass fraction