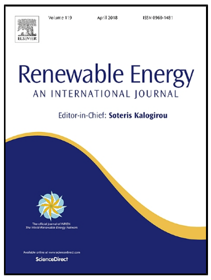
Accepted Manuscript



Numerical Analysis of Wood Biomass Packing Factor in a Fixed-bed Gasification Process

William A. González, Juan F. Pérez, Sergio Chapela, Jacobo Porteiro

PII: S0960-1481(18)30063-6

DOI: 10.1016/j.renene.2018.01.057

Reference: RENE 9662

To appear in: *Renewable Energy*

Received Date: 23 August 2017

Revised Date: 22 December 2017

Accepted Date: 17 January 2018

Numerical Analysis of Wood Biomass Packing Factor in a Fixed-bed Gasification Process

William A. González [a], Juan F. Pérez [a,*], Sergio Chapela [b], Jacobo Porteiro [b]

[a] Grupo de manejo eficiente de la energía (GIMEL), Departamento de ingeniería mecánica, Facultad de ingeniería, Universidad de Antioquia; Calle 67 No. 53-108, Medellín, Colombia
[b] E.T.S. Ingenieros Industriales, Universidad de Vigo, Rúa Maxwell s/n, Campus Lagoas-Marcosende, 36310 Vigo, Pontevedra, Spain.

Abstract

The biomass gasification process in fixed bed was studied by means of computational fluid dynamics (CFD) numerical analysis. The aim was to evaluate the effect of the biomass packing factor on the thermochemical process. The fuel-wood used was *Jacaranda Copaia* in various shapes: chips, cylinders, and cubes with packing factors (PF) of 0.38, 0.48, and 0.59, respectively. The mathematical model is a transient 2D CFD model, which was developed through the implementation of User Defined Functions in ANSYS-Fluent. The model was extended to simulate the gasification process by expanding the chemical kinetic mechanism and by adapting the stages of pyrolysis, oxidation, and reduction. The model was validated with experimental data. The average relative error between experimental and numerical data was 5.45%. By means of the sensitivity analysis, it was found that with an increase in the packing factor from 0.38 to 0.59, the absorption of radiative heat transfer increases by 27% leading to increase the solid temperature in the reaction front, but due to a lower penetration of radiation, the drying and pyrolysis reaction rates decrease. But nevertheless, the higher solid temperature with packing factor favors the convective solid-gas heat transfer in the drying stage.

Keywords: biomass; packing factor; fixed bed gasification; CFD; numerical analysis; heat transfer

1. Introduction

Biomass is a renewable energy source and its energy use in fixed bed gasifiers is an important process for power generation and cooking systems [1]. The comprehension of thermal, physical, and chemical phenomena involved in the biomass to gas (BTG) transformation enables improved reactor efficiency and reduced pollutant emissions [2]. The gasification process includes mass transfer mechanisms associated with drying, pyrolysis, oxidation, and reduction stages, and energy transfer mechanisms, such as convection and radiation. Therefore, acquisition of experimental data with complex

*Corresponding author. Phone: (+57 4) 2198552. Fax: (+574) 2110507. e-mail: juanpb@udea.edu.co (Juan F. Pérez).