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A ONE-DIMENSIONAL STEADY MODEL FOR DOWNDRAFT BIOMASS GASIFIERS

M. Costa[*], M. La Villetta[**], A. Mauro[**], D. Piazzullo[***,§], V. Rocco[*]
[*]CNR - Istituto Motori, Viale Marconi, 4, 80125, Naples, Italy
[**]Engineer Department, University of Naples "Parthenope", Centro Direzionale, Isola C4, 80143
[***]University of Tor Vergata,Via del Politecnico 1, 00133 Rome, Italy,
[§]Correspondence author. Email: daniele.piazzullo@students.uniroma2.eu

ABSTRACT The paper presents the experimental validation of a one-dimensional (1D) model of biomass gasification in a downdraft gasifier. The model considers the main processes underlying the thermo-chemical transformation of the biomass into a syngas suitable of being used as a fuel in reciprocating internal combustion engines. The downdraft gasifier is discretized as a sequence of layers where drying, pyrolysis, combustion and gasification take place. The biomass is assumed as entering the system with its content of moisture, volatile matter, ash and fixed carbon. Nine species participate chemical reactions: O_2, N_2, H_2O, CO_2, H_2, CO, CH_4, H_2S, TAR. The mass and energy conservation equations are written by considering the heat transfer between the solid particles, the gaseous phase and the reactor walls. The resulting system of differential-algebraic equations is numerically solved by splitting it into two sub-systems: one made of differential equations solved through algorithms suitable for the solution of stiff problems, one made of non-linear algebraic equations solved through the Newton-Raphson algorithm. The developed 1D model is a suitable tool to study the influence of process parameters as biomass size and composition, equivalence ratio, kind of gasification agent and gasifier geometry.

A validation of the proposed model is presented with reference of a real gasifier, being a part of the CMD ECO20 biomass powered micro-cogeneration system under development by CMD. The system is analysed in its operation as connected to a reciprocating spark ignition engine and a generator. Woodchip is the treated biomass, whose composition is determined through proper proximate and ultimate analyses. Biomass composition is given as input to the 1D gasifier model. Obtained results in terms of gasification temperature and chemical species conversion along the gasifier axis are reported and compared with measurements effected through thermocouples in the reactor and with gas chromatograph analyses of syngas samples collected at the plan site.