SE-34.1 Numerical modelling of downdraft gasification processes (S)

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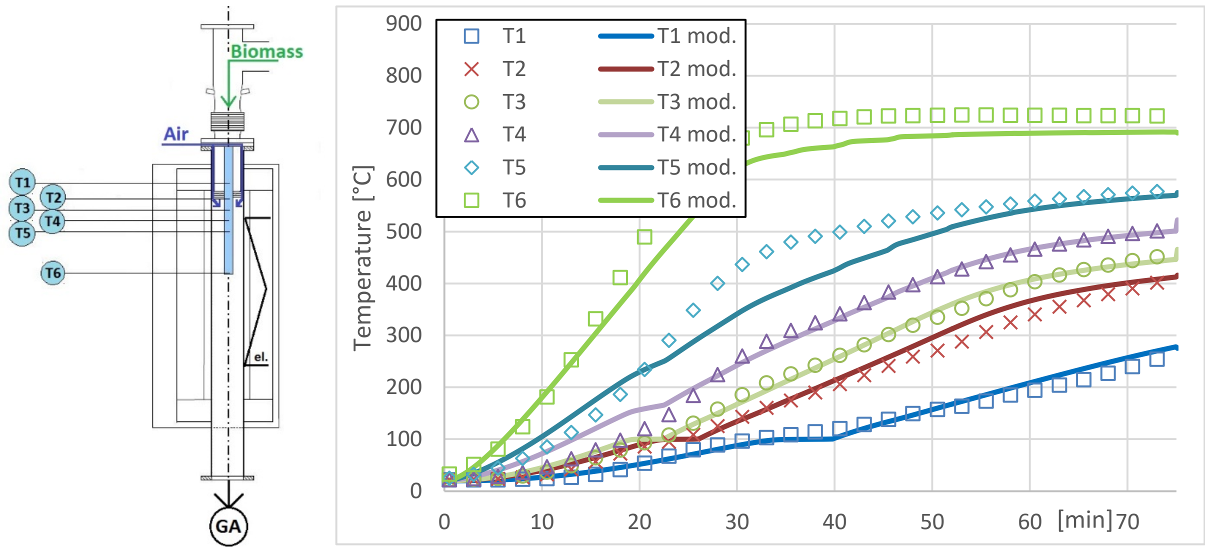
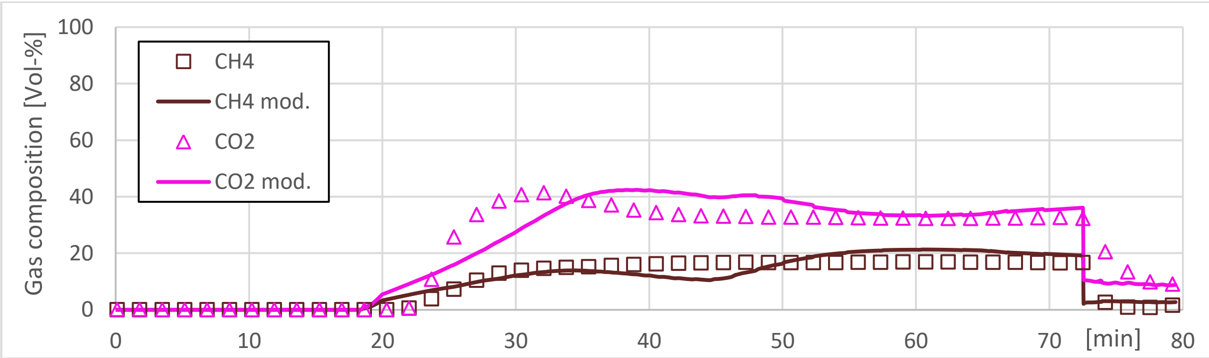
The thermal gasification of biomass is known since more than 100 years and offers perfect conditions to be used in small, flexible and decentral used power plants for cogeneration, but still there are unsolved problems in stability and purity of gas in those processes. Since there is a huge network of thermodynamic, chemical and physical reactions acting parallel in a gasifier, it is difficult to build models for the prediction of gas compositions and degrees of purity. A one-dimensional model of a downstream gasification process was developed, considering effects of chemical and thermodynamic kinetics, as well as heat and mass transport through the fixed bed reactor to predict reaction temperatures, gas compositions and gas purity at different air to fuel ratios.
The model is based on a system of differential equations that includes mass balances for 14 species in two phases, temperatures for bed, gas phase and reactor walls and bed porosity. Processes that are considered are moisture evaporation, biomass pyrolysis, combustion of char and burnable gas phase species, gasification of char with carbon dioxide, steam and hydrogen, thermal tar decomposition and the water gas shift equilibrium.
For the determination of kinetic input data, several experiments have been done with a thermogravimetric analyzer and a trial gasification plant with multichannel gas analysis for O_2, CO, CO_2, CH_4 and H_2. Elementary analyses of the feedstock and residual char after pyrolysis have been done to generate substance data. The trial plant is powered by an electric heater that enlarges the reduction zone and has six temperature measuring points to be compared with the simulation results for the heating process as shown below.



The heat transport in the fixed bed is described by a network of equations, similar to a resistor circuit containing radiative, convective and conductive components. The model can predict gas compositions and the amount of tar in the product gas to optimize airflow and temperature profile to reach maximum purity and heat value of the gas for the use in cogeneration plants. The graphic below shows the measured and calculated CO_2 and CH_4 production from wooden biomass. After 73 minutes, the oxidation zone reached 400°C and the airflow was activated.



Gas composition [Vol-%]
100
80
60
40
20
0
CH4
CH4 mod.
CO2
CO2 mod.
0
10
20
30
40
50
60
70
[min]
80