BIOMASS GASIFICATION BETWEEN 800 AND 1400 °C IN THE PRESENCE OF O_2: DROP TUBE REACTOR EXPERIMENTS AND SIMULATION

J. Billaud[1], S. Valin[1], M. Peyrot[1], S. Salvador[2]
joseph.billaud@cea.fr
[1] CEA, 17 rue des Martyrs, 38054 Grenoble Cedex 09, France
[2] RAPSODEE, FRE-CNRS 3213, Ecole des Mines d'Albi-Carmaux, 81013 ALBI CT Cedex 9, France

This study aims at better understanding biomass gasification phenomena under entrained flow reactor (EFR) conditions, which is one of the most promising gasification technologies for biofuel production. Indeed, a high temperature (about 1500°C) and a high heat flux on the biomass particles (>10^6 W.m^{-2}) can produce a syngas (H_2 – CO) almost free of tar and of gaseous hydrocarbons with a high global conversion of biomass into gas.

The characteristics of an industrial autothermal EFR were first defined from literature data and calculated from energy balance assuming thermodynamic equilibrium at the reactor output. A beech wood biomass feeding rate of 20 t.h^{-1} was considered. The gas residence time was fixed at 4 s, the temperature at the reactor output was 1500°C, and the pressure was of 40 bars. With these characteristics, the oxygen inlet rate was calculated for several steam input rates.

On the basis of these results, we defined experimental conditions for the study of biomass gasification in an atmospheric pressure drop tube reactor. This device is able to reproduce some conditions (high temperature and heat flux) of an EFR at a lab scale. The biomass was beech wood particles with a size ranging from 300 to 450 µm. Pyrolysis experiments were first conducted in nitrogen at 800, 1000, 1200 and 1400°C. Gasification in presence of oxygen was then studied at the same temperatures with an O_2/C molar ratio of 0.41 and with a H_2O/C molar ratio of 0.14, 0.5 and 1. Gaseous products were analysed online by a gas chromatographer and a FTIR. Char and soot were collected and characterized. Tars were trapped using tar protocol and analysed by GC-FID.
Gasification results are significantly different from pyrolysis ones. As a general trend, H_2O, CO_2 and CO yields are much higher in presence of oxygen while H_2, light hydrocarbons (CH_4, C_2H_2, C_2H_4, C_2H_6 and C_3H_8) and tar yields are lower. Soot formation was observed at 1200 and 1400°C. Char yield was lower in presence of oxygen and steam. Tar analyses showed that the major species were benzene, naphthalene, phenol, indene, toluene and styrene.

These experiments were simulated with the GASPAR 1D modelling tool, already validated with experiments in inert and steam-containing atmospheres between 800 and 1400°C. The model includes thermal and chemical phenomena description: heating of carrier gas and wood particles; biomass drying; chemical reactions: pyrolysis, gas phase reactions, soot formation, soot gasification, and char gasification. The modelling tool was tested and improved by comparison with the new O_2 containing gasification experimental results.

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