Energy balance and kinetics of gasification of biomass particles in thermal plasma flow

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1. Introduction

Biomass is the most common form of renewable energy, widely used in various forms. Gasification, which corresponds to the thermal decomposition of biomass under the action of heat with small amount of oxidant, is particularly well-adapted to the valorisation of lignocellulosic products such as wood or straw and various organic waste materials. Energy needed for gasification can be produced either by partial combustion of biomass, or it is brought into the reactor by gasifying medium, commonly by hot gas. The second process offers much better control of composition and quality of produced syngas. The main criteria for technology selection are high biomass – to – syngas efficiency, high content of hydrogen and carbon monoxide in produced syngas, low concentration of other reaction products (CO_2, CH_4, N_2, C_nH_m, ..) and flexibility for all types of biomass (wood, grassy materials, straw, waste biomaterials, …). Plasma is a medium with the highest energy content and thus substantial lower plasma flow rates are needed compared with other media used for this purpose. The main advantages are better control of composition of produced gas, higher calorific value of gas and reduction of unwanted contaminants like tar, CO_2, CH_4 and higher hydrocarbons. The other advantage of plasma is wide choice of treated materials.

Plasma gasification of biomass was studied in recent years in several papers [1-3]. This paper presents results of investigation of gasification of biomass in plasma generated from water in hybrid water/argon torch.

2. Experimental reactor

The experiments were performed on plasma reactor PLASGAS equipped by plasma torch with a dc arc stabilized by combination of argon flow and water vortex [1]. The wall temperature 1100 to 1400°C could be regulated by the torch power and feeding rate of the material. Wooden pellets of various size were fed into plasma jet in the position about 30 cm downstream of the input plasma nozzle. Additional gases were fed into the reactor for control of reactor atmosphere (O_2, CO_2, air, steam). The gas produced in the reactor flowed to the quenching chamber, where it was quenched by a spray of water. Further details on experimental system are given in [3].

3. Results and discussion

Energy balance of the process of gasification of wooden particles is strongly dependent on the size of injected particles. The particle size determines the rate of heat transfer from the plasma to the particle surface. Effect of the particle size on the process is illustrated in Fig. 1, where dependence of gasification rate on temperature of surrounding gas atmosphere is presented for various particle diameters. Presented dependences were calculated using film model of heat transfer between particle and the gas for conditions corresponding to the experiment.

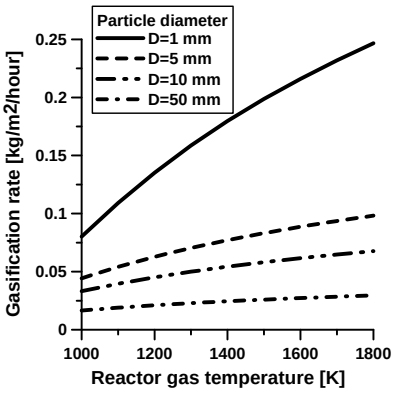

Fig. 1. Dependence of rate of gasification of wooden particles on temperature of gas in reactor

Effect of composition and flow rate of oxidizing gases was studied. While for oxygen and air the energy from oxidation of surplus carbon contained in wood increases maximum throughput of material for given plasma jet power, use of CO_2 or steam leads to reduction of throughput as some energy is spent for dissociation of molecules of added gases. Complete energy balances for various combinations of conditions were determined.

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References

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