The investigation of biomass pyrolysis behavior: Operating variables and catalytic application

G. Chen*, H. Spliethoff, J. Andries
Section Thermal Power Engineering, Faculty of Design, Production and Engineering
Delft University of Technology, Mekelweg 2, 2628 CD Delft, the Netherlands
Fax: 0031-15-278-2460; g.chen@wbmt.tudelft.nl

Background

In the last decade, Pyrolysis, especially flash pyrolysis technology has been almost considered as a good solution to convert biomass for liquid fuel production, and therefore rare attention has been given to it for gaseous fuel production. One reason which strongly supports this fact is that gas yield from conventional pyrolysis technology is very low, normally 40 wt% below. However, the pyrolysis gas, compared with gasification gas, is more advantageous as it is higher in heating value and consequently can be applied well to the downstream gas turbine combustion for power generation or used as substitute of civil gas for cooking. Furthermore, when integrated with gas turbine combustion, this kind of gas can overcome the challenge incurred by combustion of gas formed in normal gasification process. In the latter case, more fuel gas is needed in order to operate the turbine with the same turbine inlet temperature and accordingly significant changes in turbine's configuration is required. This work tries to make people still be confident in gas production through pyrolysis route.

Experimental set-up and Procedure

The pyrolysis reactor was made of stainless steel (total height, 750mm; 80mm i.d.) and normally was immersed in external heated furnace lined with insulated materials of silica-aluminum wool. The outlet of the pyrolysis reactor was connected to an independent cracking reactor via connecting tube, followed by cold trap. The condenser was made up of two stages, one hot-water condenser (condenser I), another the mixed ice/water condenser (condenser II). Following the condenser II was a spherical dryer filled in silica-gel pellets, followed by a water tank. During startup, an inert gas is used as purge gas. As the temperature of pyrolysis reactor is raised the flow of inert gas is turned off because the released gases is of sufficient positive pressure and thus can effectively prevent air from entering the reactor. The length of the holding time allowed at a certain reaction temperature is determined by ensuring that no further condensation occurred in the cold traps. The pyrolysis reaction can be thought in the end by the indication in accumulatively volumetric flow meter or by pressure difference meter. The residence time is changeable, dependent on the velocity of carrier gas. At the end of every experiment, the pyrolysis residue was weighted to determine yields, and the gas yield was calculated based on its volume measured and the gas components analyzed by gas chromatography. However, for some pyrolysis experiments the liquid was collected under special requirement and afterwards weighted [11], then the gas yield is known by difference.

The subjects concerned

This paper investigates the effect of operating variables on the total gas yield. The studied variables includes reaction temperature, residence time of volatile phase, physico-chemical pretreatment of biomass particles, the improvement of heat & mass transfer ability of the pyrolysis reactor and the heating rate of external heating furnace. The running temperature of a separate cracking reactor and the configuration of the pyrolysis reactor are also studied. In addition, different types of catalysts are used in this work to determine their positive influences on biomass pyrolysis behavior.

Concluding results

The total gas yield of biomass pyrolysis is subjected to the confinement of many operating variables. The increase in reaction temperature can lead to the increase of gas yield. The long residence time of volatile phase is favorable to gas yield. Two pretreatments appears different effect on the gas yield, but the physically pretreatment is predominant to the production of gas. The improvement of heat &

mass transfer ability of the reactor results in the obvious increase of gas yield, however this increase is still less if heating rate is concerned. The gas yield is very sensitive to the temperature of cracking reactor and also appears a little sensitive to the configuration of the pyrolysis reactor. From economic point of view, the temperature of 700^{o}C for the cracking reactor is thought preferable. The rectangular shape of pyrolysis reactor is advantageous compared to the cylindrical reactor. In our investigation, different catalysts of metal oxides have different functions on biomass pyrolysis, some of which are obviously positive while others almost zero positive, however never negative. The total gas yield up to 60% wt. of biomass fed could be achieved if the combination of the above-mentioned factors is concerned and optimized.