AUTOTHERMAL SLOW PYROLYSIS OF POPLAR WOOD CHIPS IN AN AUGER REACTOR

Giacomo Lombardi, RE-CORD, University of Florence, giacomo.lombardi@re-cord.org
Andrea Maria Rizzo, RE-CORD
David Chiaramonti, Polytechnic of Turin (DENERG), RE-CORD

Key Words: Oxidative pyrolysis, autothermal, auger reactor

In this work, oxidative slow pyrolysis of poplar wood chips was investigated in a continuous auger-type pyrolyzer (SPYRO). Pyrolysis trials were carried out at a feed flow rate of 1.5 kg h^{-1}, reaction temperature of 500 °C and solid residence time of 30 min, at distinct amount of air injected into the pyrolysis reactor to study its effect on plant power consumption, as well as on products' yield and composition. The main aim of the present study was to evaluate the feasibility of a self-sustained process through oxidative pyrolysis. As a second objective, the study aimed at performing a detailed characterization of the obtained products and the overall mass and energy balances. Mass balance calculations showed that the total mass of char, liquid and gas products was 89-95% of the total input fed into the pyrolysis reactor. An increase in the air flow rate led to an increase in gas and water of reaction yields and a decrease in organics yield, whereas char yield was almost preserved and equal to 25 $wt\%_{feed\ db}$. It is clear that the heat for the process was provided mainly by the homogeneous oxidation of volatiles matter rather than by the heterogenous oxidation of char. With respect to permanent gas, the yields ($wt\%_{feed}$) of CO, CO_2, CH_4 and H_2 increased under oxidative atmosphere. Besides the change in product distributions, the key advantage of autothermal pyrolysis is its self-sustainability in terms of heat supply and requirement, facilitating the ease of further scaling up[1]. The additional power input required for the pyrolysis of poplar wood chips is shown in *Figure 1* for various equivalence ratio, which is defined as the ratio of the actual flow rate of air to the flow rate of air that would be required to achieved stoichiometric combustion of the biomass fed to the reactor[2]. The enthalpy for conventional pyrolysis was 0.47 $MJ \cdot kg_{feed}^{-1}$, while autothermal operation of the pyrolysis process was achieved with an equivalence ratio of 0.06. The energy recovery in the pyrolysis products of the energy present in the original biomass was calculated. The energy recovered in char, condensates and permanent gas are shown in *Figure 2* for various equivalence ratios. *Figure 2* shows that the partial oxidation shifted the energy recovered in the condensates to the gas phase, while the energy retained in char was almost constant. As more air was fed into the pyrolyzer, the total energy content of the pyrolysis products further decreased because the organics were partly burned to provide the energy to drive the pyrolysis process.
Different analytical techniques were adopted on solid and liquid samples, such as proximate and ultimate analysis, GC-MS, HPLC, TOC, ph, whereas permanent gas was continuously analyzed and quantified using an Agilent MicroGC during the pyrolysis trials. In addition, char specific surface area (BET) and PAHs content were determined. With respect to char quality, the addition of air had a positive effect on char surface properties, and it was observed that the BET surface area of char was increased up to 100 $m^2 \cdot g^{-1}$. The proposed solution opens new opportunities in the sector of biomass thermochemical process, as. the proposed oxidative pyrolysis process could represent an innovative pathway for reducing pyrolysis plant process energy demand, while improving char quality without affecting its yield.

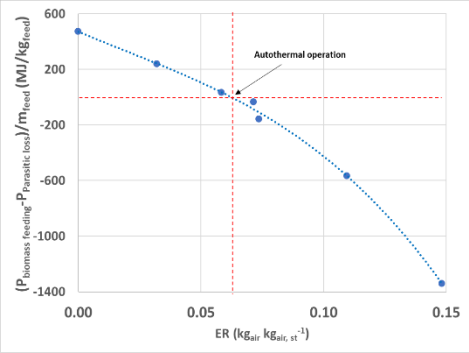

Figure 1 – Power input of pyrolysis process at various equivalence ratio.

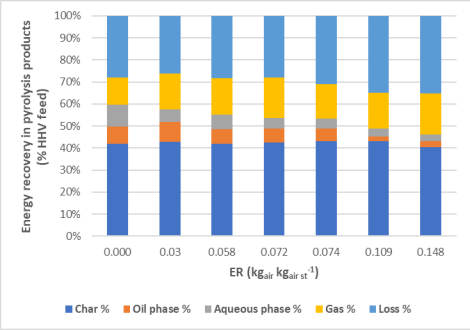

Figure 2 – Energy recovery in the pyrolysis products at different equivalence ratio.

[1] Yong Huang, Bin Li, Dongjing Liu, Xing Xie, Hong Zhang, Hongqi Sun, Xun Hu, and Shu Zhang, Fundamental Advances in Biomass Autothermal/Oxidative Pyrolysis: A Review ACS Sustainable Chemistry & Engineering 2020 8 (32), 11888-11905 DOI:10.1021/acssuschemeng.0c04196.

[2] Dongbing Li, Franco Berruti, Cedric Briens, Autothermal fast pyrolysis of birch bark with partial oxidation in a fluidized bed reactor, Fuel, Volume 121, 2014, Pages 27-38, ISSN 0016-2361, https://doi.org/10.1016/j.fuel.2013.12.042.