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BIOMASS GASIFICATION IN A FLUIDIZED BED REACTOR: EFFECT OF TEMPERATURE, STOICHIOMETRIC RATIO AND BIOMASS TYPE

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1. Purpose

This paper investigates the gasification of two biomass types (pine wood and olive stones) in a laboratory scale bubbling fluidized bed reactor, in order to evaluate comparatively their potential in the production of syngas.

2. Methodology

A 4 cm i.d. laboratory scale bubbling fluidized bed reactor was used in the experiments, as shown in Figure 1. Silica sand (300≤∅≤600 µm) was used as fluidizing medium. Dry (moisture content < 1.0 wt%) and ground (600≤∅≤1000 µm) biomass was fed into the reactor at 2.0 g/min just over the distribution plate. The fluidizing gas consisted of air/N_2 mixtures with different O_2 concentrations to achieve specific stoichiometric Equivalent Ratios (ER). The operating conditions investigated included: the effect of temperature (between 850 and 1000 ºC) for a fixed ER of 0.30; the effect of ER (between 0.4 and 0.15) and biomass type (pine wood and olive stone) for a fixed temperature of 950 ºC. The total gas flow rate was constant for all the experiments (10.4 L/min), equivalent to 0.14 m/s, to ensure comparable fluidizing conditions. Syngas was cleaned and analysed for its chemical composition using micro GC and gas flow rates were calculated considering the N_2 concentration in the out coming gas. The heating values of the resulting gases and their Cold Gas Efficiencies (CGE) were determined in each case.

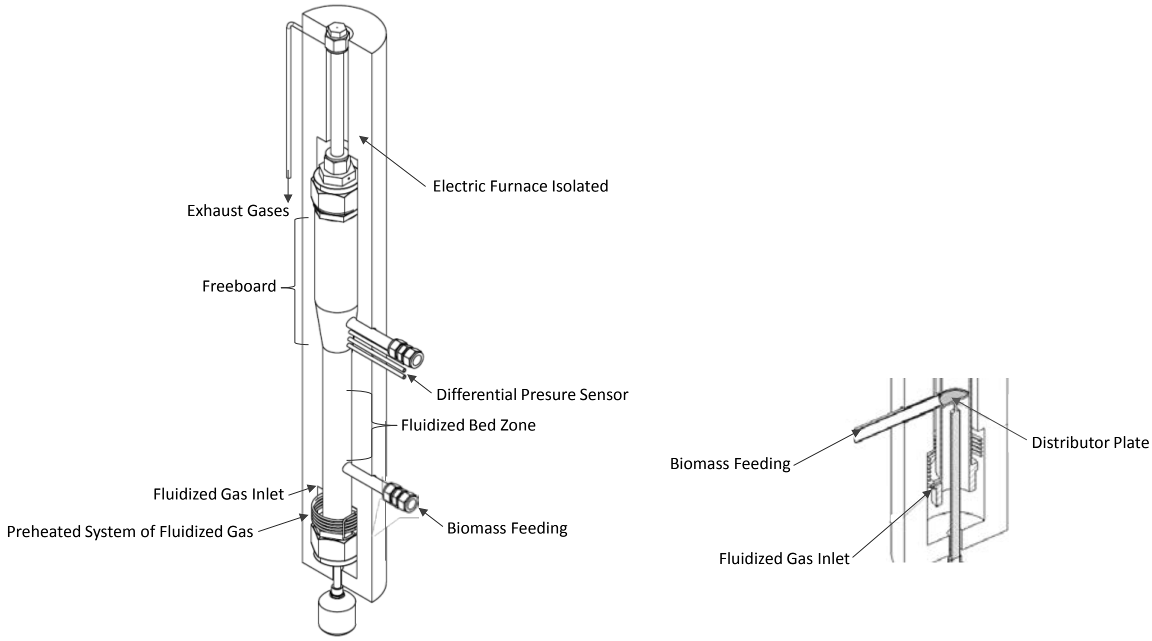

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Figure 1. Schematic representation of the fluidized bed reactor

3. Results and discussion

Figure 2 shows the effect of temperature and ER in the CGE of the system, defined as the ratio between energy output and input [1]. This parameter takes into consideration the concentration and flow rate of combustible gases (mainly H_2, CO and CH_4, but also C_2H_4, C_2H_6 and C_2H_2). The results show a significant increase in CGE as the gasification temperature increased from 850 ºC (50 %) to 900 ºC (65 %), and less marked differences at higher temperatures. These results suggest an optimum operation temperature around 900 ºC.

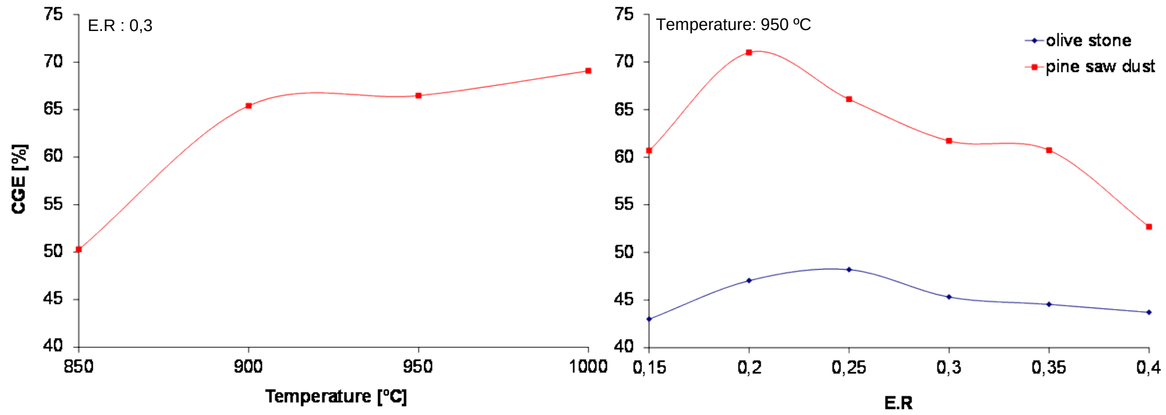

Figure 2. Cold Gas Efficiency (CGE) as function of temperature (left) and equivalent ratio (ER) (right)

Figure 2 (right) shows CGE for pine wood and olive stone gasification at 950 ºC using different ER. The results evidence an increase in CGE when increasing the ER from 0.15 to 0.20due primarily to an increase in H_2 and CO concentration. ER values above 0.20-0.25 resulted in reduced CGE, due to lower concentration of combustible gases and despite the higher syngas gas flow rates. For all values of ER, concentration of CH_4 not show significant difference, with values around 1%. Traces of C_2H_4, C_2H_6 and C_2H_2 were detected.The higher CGE values observed in pine wood, compared to olive stones, have been related to superior CO concentrations in the former. This effect has been associated with the higher fixed carbon content in the pine wood (8.8 wt% dry matter basis compared to 6.4 wt% for olive stones), which promotes Bourdouard reactions and the formation of CO [2].

4. Conclusions

Pine wood sawdust shows optimum operating temperature at 900ºC (ER=0.3), the CGE shows maxima at ER = 0.25 in olive stone and ER= 0.20 in pine wood sawdust (950 ºC). Pine wood gasification produced superior CO concentrations than olive stone, which has been associated with promotion of Bourdouard reactions due to comparatively higher fixed carbon content.

[1] P. Basu; Biomass gasification, pyrolysis and torrefaction; 2º edition, Elsevier (2013) p.304
[2] V. Skoulou, G. Koufodimos, Z. Samaras, A. Zabaniotou; Low temperature gasification of olive kernels in a 5-kW fluidized bed reactor for H2-rich producer gas; Int. J Hydrogen Energy 33 (2008) p.6515