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Particularities of High Oxygen Content Biofuels Pyrolysis Process

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1. Introduction

Biofuels employed in energy applications have high oxygen contents and are mainly represented by solid biomass and poultry manure. The rich oxygen content represents an advantage for ignition development, reducing the amount of air necessary for combustion.
In the present paper, implications of oxygen presence in the fuel mass entering in the pyrolysis process is evaluated, with some experimental applications on poultry waste. Most of the time, the poultry waste is mixed with some biomass flooring in the birdhouse (straws or sawdust), which represents about 10-15% of the total mass, having energy characteristics similar to this waste.

2. Energy characteristics of the high oxygen content biofuels

$C^i + H^i + S_c^i + O^i + N^i + A^i + W_t^i = 100$ [%]

$H_i^i = 339C^i + 1029H^i - 109(O^i - S_c^i) - 25.1W_t^i$ [kJ/kg]

$\boldsymbol{C_f^i + V^i + A^i + W_t^i = 100}$ [%]

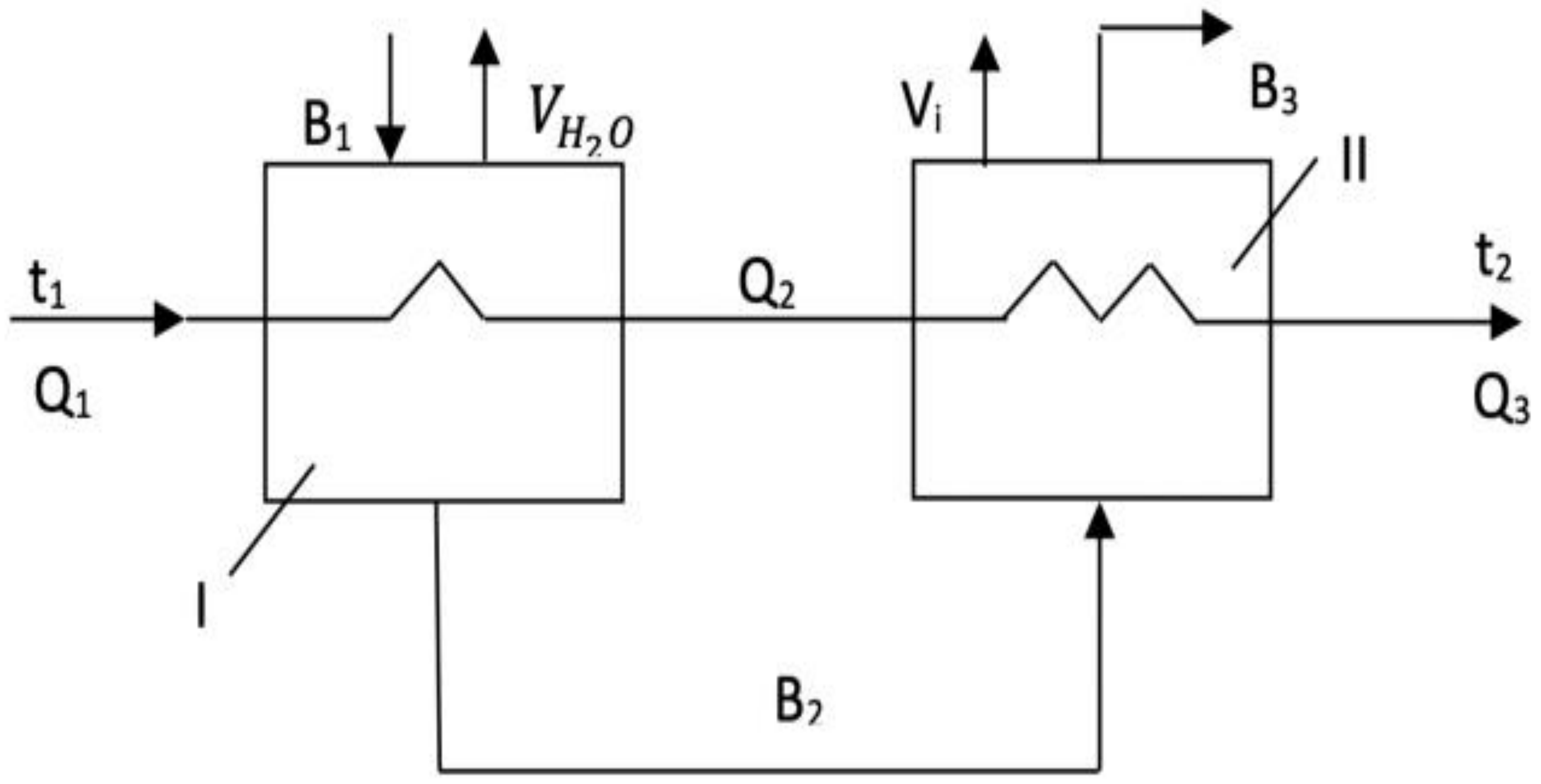
Biofuel	C^i [%]	H^i [%]	S_c^i [%]	O^i [%]	N^i [%]	A^i [%]	W_t^i [%]	H_i^i [kJ/kg]
Sawdust	27-30	3.5-3.8	-	25.3-26	0.4-0.5	0.1-0.5	40-45	8.3-10.5
Beech	12-40	1.4-4.7	-	10-38	0.2-0.5	2.0-6.1	15-75	2.5-14.1
Elm	12-40	1.3-4.7	-	10-33	0.2-0.4	0.5-2.1	15-75	2500-14200
Spruce	13-44	1.4-4.8	-	10-33	0.1-0.2	0.8-2.6	15-75	3000-16500
Straws	41-42.2	4.9-5.2	-	44-45.7	0.1-0.4	4.5-5.8	8-14	13100-16500
Corn stalks	38-42	4.2-5.3	-	35-38	1.2-2.6	11-16.8	3.4-5.4	14100-15600
Ropes of vines	40-44	3.5-4.5	-	37-45	0.6-2.7	10-27	2.7-4.3	14700-15700
Poultry manure	12.1-16.1	4.3-4.9	1.6-1.8	34.3-36.2	1.6-1.8	6.1-6.8	36.1-40.1	3810-5950
Poultry manure with bed	12.3-22.5	4.3-5.2	1.7-2.0	35.1-37.4	1.4-2.3	6.1-12.9	34-40	3850-6000

3. Particular aspects of pyrolysis technology

For drying stage is recommended a temperature range of 150-200 °C.
t1 and t2 represent the temperature at the inlet and at the outlet of the installation
The heat required for drying is $Q_1 - Q_2$, while the heat for pyrolysis itself is $Q_2 - Q_3$.
From the fuel flow (B_1) a certain amount of moisture (V_{H_2O}) is eliminated within the first step.
In the pyrolysis stage, from the anhydrous fuel (B_2), the volatiles are eliminated, resulting a quantity of coke (B_3) which also contains the ash percentage (Ai/100) of the fuel.
For the high oxygen content fuels semi-pyrolysis is recommended.
Due to the low temperature level, the oxidation cannot go on to CO_2 formation. Thus, a fuel bed comprising CO is obtained.

Conducting semi-pyrolysis experiments at a temperature of 550 °C on poultry manure led to the following results:
- moisture removed: $V_{H_2O} = 0.4$ kg/kg fuel;
- volatiles, including carbon oxide from the internal oxidation: $V_i = 0.5$ kg_{vol}/kg fuel;
- coke, $B_3 = 10\%$ kg_{cocs}/kg fuel.

Compared to the fix carbon that had $C_f^i = 0.33$, the semi-coke decreased significantly. Conducting an elemental analysis of the semi-coke in mixture with the ash resulted in obtaining a 9481.3 kJ/kg calorific value.



The two-step pyrolysis process (I. Drying step; II. Pyrolysis step).

4. Conclusion

The paper addresses the carbon oxidation in biofuels during the pyrolysis processes. For the low-temperature pyrolysis, the oxidation leads to the formation of CO combustible gas, which is added to the volatiles. Instead, for high-temperature pyrolysis, CO2 will form, so that the oxidized carbon will lead to energy loss.
Pilot scale research facility for a low-temperature pyrolysis process of poultry manure has emphasized the above-mentioned issues.
The reduction of the final quantity of coke (semi-coke), evaluated at up to 72%, may lead to an energy loss, highlighted by crucial aspects in the general energy balance.