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Potential for generation of thermal and electrical energy from biomass of sugarcane: a exergetic analysis

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Abstract – As one of the major systems of energy conversion in Brazil, the cogenerations systems allows to transformation of chemical energy from bagasse and straw of sugarcane into thermal and electrical energy. For its assessment the exergie is considered as one of the most efficient tools, because it allows to quantify and to identify the quality of energy available in each of these inputs. The results of this work show that the straw has a specific exergie of 1799.17kJ/kg and the bagasse 9743.42kJ/kg, which indicates the workability of using sugar cane straw as a better fuel for boilers.

Due to the need of new investments in the energy sector with the use of techniques that minimize the damage to the environment, the generation of electricity from renewable sources has been important in the world and Brazilian energy matrix.

The sugar cane is known as one of the most important Brazilian agricultural crops. Besides being in relief as a feedstock in the production of ethanol, the biomass from sugar cane has been outstanding in the Brazilian energy sector due to its potential for producing electricity and heat in sugar cane industries. The cogeneration systems allow transforming the chemical energy from bagasse and straw of sugarcane into thermal and electrical energy.

As one of the key tools for Thermodynamics, exergy analysis allows the quantification and evaluation of quality of energy available in any process of energy conversion, in its inputs, outputs or flows [1]. The goal is to figure out the specific exergies of the main solid wastes of the sugar cane and ethanol production in Brazil: the bagasse and straw of sugarcane. The bagasse is commonly used in cogeneration systems together with ethanol production in Brazil and the straw of sugarcane is normally burned on the field prior the harvesting. So, there is a potential work that has not being used, which this paper intends to identify.

The calculation is performed according the chemical exergy of technical fuels (ex_{fuel}) of these solid fuels, correlating these values with the moisture according to the equation bellow that was written by Szargut et al [1]:

$$ex_{fuel} = \beta(PCI_{fuel} + h_{water} Z_{water}) + ex_{water} Z_{water} \quad (1)$$

Whose β is given by the mass fractions (Z_i) of chemical components of the fuel and it is calculated according to the next equation:

$$\beta = \frac{1.0412 + 0.2160\left(Z_{H_2}/Z_C\right) - 0.2499\left(Z_{O_2}/Z_C\right)\left[1 + 0.7884\left(Z_{H_2}/Z_C\right)\right] - 0.0450\left(Z_{N_2}/Z_C\right)}{1 - 0.3035\left(Z_{O_2}/Z_C\right)} \quad (2)$$

The main element of the bagasse and the straw is the cellulose whose chemical formula is $C_6H_{10}O_5$. Thus, the mass fractions of elements are 0.44 of C (Carbon); 0.06 of H (Hydrogen) and 0.49 of O (Oxygen). The other values for the calculation of specific exergy were taken from literature. The enthalpy of vaporization of water (h_{water}) is 2442 kJ/kg and the exergy of water (ex_{water}) is 50 kJ/kg [1].

The exergies obtained were 9743.42kJ/kg and 17900.17kJ/kg of bagasse and straw sugarcane, respectively. These results show that straw, even with 15% of moisture (Z_{water}), lower than the bagasse which owns 50% [2], denotes almost twice of exergy. This indicates the workability of using sugar cane straw as a better fuel for boilers.

The difference among the exergetic values of those biomass sources can be explained by their net calorific values (PCI_{fuel}), since straw has 15173.49 kJ/kg and bagasse 7000.16 kJ/kg [3], which make evident its use as an energy input in cogeneration systems. According to these results it is possible to verify that boilers can become more efficient if there are more investments in the use of straw from sugar cane as fuel to produce heat and electricity in conversion systems of energy (cogeneration) in sugarcane industries.

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