Energy and economic assessment of jet fuel, diesel and gasoline production from hydrotreatment of fast pyrolysis bio-oil from sugarcane straw and bagasse

Código: 06-011

Bruna Stella de Freitas Santos[1]; Antonio Garrido Gallego[1]; Silvia Azucena Nebra[1]; Adriano Viana Ensinas[1,2]; Reynaldo Palacios-Bereche[1].
[1]Federal University of ABC, Santo André – SP.
[2]Federal University of Lavras, Lavras, MG
[3]Corresponding author: adriano.ensinas@ufla.br

Abstract

The objective of this study is to perform an energy and economic evaluation of the production of renewable jet fuel, diesel and gasoline from the hydrotreatment of bio-oil produced from the fast pyrolysis of sugarcane bagasse and straw. To produce the hydrogen necessary for the hydrotreatment process, production by electrolysis will be assumed. The modelling and simulation of pyrolysis process was carried out using the Aspen Plus software. A preliminary economic analysis will also be carried out to determine capital and operating costs as well as the minimum jet fuel selling price.

Keywords: fast pyrolysis; jet fuel; hydrotreatment; straw; bagasse

Introduction

The production of biofuels from lignocellulosic residues of sugarcane, such as bagasse and straw, represents a desirable alternative to increase biofuel production without the need to expand the sugarcane planted area. Among the routes for producing biofuels from lignocellulosic residues, fast pyrolysis presents itself as a promoting route to produce liquid fuels, such as bio-oil. However, due to the presence of a variety of oxygenated compounds, bio-oil presents undesirable properties. For this reason, the bio-oil requires upgrading in order to achieve product specifications compatible with existing transportation infrastructure. Studies in literature indicate that the product of hydrodeoxygenation process presents yields and high-quality hydrocarbon for gasoline and diesel substitution. Moreover, some studies also present the potential for jet fuel production.

Methods

Modelling and simulation of fast pyrolysis was performed in the Aspen Plus® software.

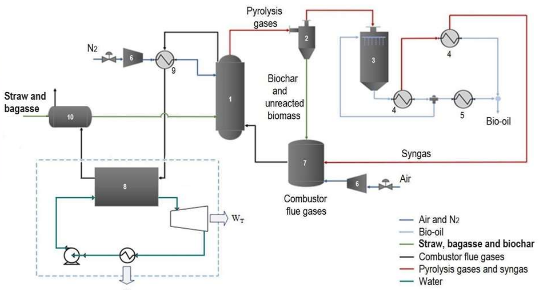

Figure. 1. Fast pyrolysis process diagram

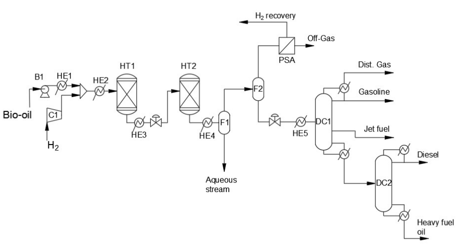

Figure. 2. Flowsheet of hydrotreatment and distillation sections of upgrading plant

Energy and mass balances in hydrotreatment and distillation processes were accomplished as well. Product yields were adjusted to consider jet fuel production

The economic assessment aims at caldulating the production cost of jet fuel keeping constant the by-products costs (gasoline, diesel and heavy oil fuel). This assessment was performed according to the following steps: i) Estimation of capital and operating costs, ii) Evaluation of revenues in each case, and iii) Determination of jet fuel production cost.

Results and Discussion

Table 1 presents the yields of products in bio-oil upgrading subsystem.

Table 1: Product yields

	kg/kg of dry biomass	kg/kg-bio-oil
Off-gas	0.129	0.244
Heavy oil fuel	0.039	0.074
Diesel	0.047	0.089
Gasoline	0.062	0.117
Jet fuel	0.045	0.086

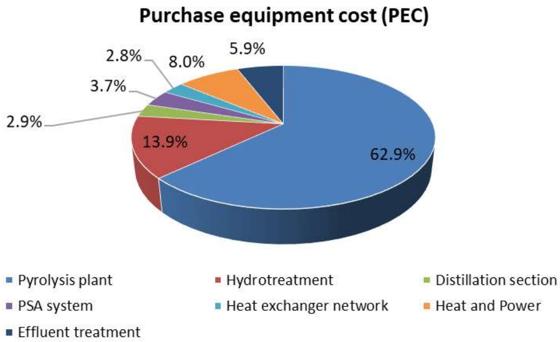

Figure. 1. Purchase equipment cost

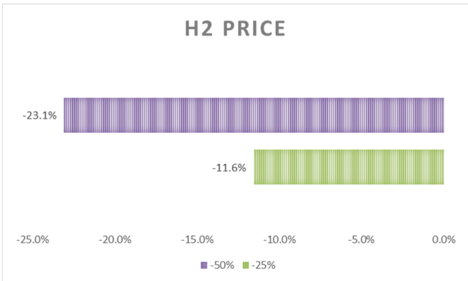

Figure. 2. Sensitivity analysis: H_2 price

Conclusions

Renewable jet fuel production resulted in 0.045 kg/kg dry biomass (0.086 kg/kg bio-oil), nevertheless, other by-products obtained were: green gasoline, green diesel, green heavy fuel oil, and bioelectricity. Emissions estimative indicate a net avoided emissions of 181,077 tCO2eq/y. Regarding the economic evaluation, from the assumed hypotheses, the minimum jet fuel selling price MJSP resulted 4.77 USD/L being that green H2 cost has a significant contribution in operating costs.

Acknowledgement

The authors wish to thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) (Process PQ 306303/2014-0 and PQ 309588/2019-7) for the researcher fellowship; and for the Research Project Grant (Process 407175/2018-0 and 429938/2018-7 and 405602/2023-5).