2ND BBEST
Brazilian BioEnergy Science and Technology Conference
October 20 to 24 - 2014

Exergy analysis of thermochemical route of bioethanol production via sugarcane bagasse gasification

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Keywords: Exergy analysis, Lignocellulosic biomass, Sugarcane bagasse, Gasification, Thermochemical route, Circulating fluidized bed, Cellulosic bioethanol (second-generation ethanol).

Nowadays, the use of lignocellulosic feedstocks to produce biofuels is a field of ever growing importance. Thus, one of the interesting residual biomass streams is sugarcane bagasse. A technological option to produce bioethanol from biomass is the thermochemical route. Biomass gasification represents a promising technology within this route for a large scale production of a variety of biofuels, including Methanol (MeOH), Dimethyl ether (DME), Fischer-Tropsch (F-T) fuels, Hydrogen (H_2) and Synthetic Natural Gas (SNG). In this paper, a detailed exergy analysis of the thermochemical route of bioethanol production from lignocellulosic biomass is presented. This process uses a steam–air circulating fluidized bed (CFB) gasification of sugarcane bagasse feedstock, with a subsequent conversion of the synthesis gas (syngas) produced into bioethanol. The operating conditions defined for the gasifier were a temperature of 850°C and a pressure of 101.325 kPa. The production process involves several steps, including biomass drying and gasification, syngas cleaning, conditioning, ethanol synthesis, separation of synthesis products, and heat recovery. The simulation process was carried out using Aspen Plus® software. The exergy analysis is performed for various gasification temperatures, gasifying medium (gasification agents) and milling capacity plant. Preliminary results show that the greatest exergy losses occur in biomass gasifier. The syngas composition (molar fraction in % wet basis) model was H_2 15.7 %; CO 17.3 %; CO_2 13.9 %; N_2 49.6%; H_2O 1.2% and CH_4 2.2%. The LHV (lower heating value) obtained in this analysis was 7.10 MJ/kg.

For this work, a biomass gasification model was developed that can be used to assess its feasibility for bioethanol and power production. Hence, a performance comparison in terms of exergy efficiency and destroyed exergy rate of the thermochemical route for bioethanol production via sugarcane bagasse gasification is determined. A brief literature review on biomass gasification systems involving simulation process, trends and challenges is given in Section 1. The first section also provides an overview of the exergy analysis technique applied to the thermochemical route. Modeling and operation settings for the selected case study are presented in Section 2 together with the exergy analysis approach. Results and discussion of the analysis are summarized in Section 3. Lastly, the conclusions of the study are shown in Section 4.

Financial Support: FAPESP (São Paulo Research Foundation) for grant 2012/23049-2, and CNPq (Brazilian National Council of Scientific and Technological Development) for grant 306033/2012-7.

Abstract submission: Oral presentation

Presentation Area: (2) Biofuel Technologies