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Flow Sheet Development and Simulation of a Bio-refinery Annexed to Typical South African Sugar Mill

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Abstract : Sugar is one of the main agricultural industries in South Africa and approximately livelihoods of one million South Africans are indirectly dependent on sugar industry which is economically struggling with some problems and should re-invent in order to ensure a long-term sustainability. Second generation bio-refinery is defined as a process to use waste fibrous for the production of bio-fuel, chemicals animal food, and electricity. Bio-ethanol is by far the most widely used bio-fuel for transportation worldwide and many challenges in front of bio-ethanol production were solved. Bio-refinery annexed to the existing sugar mill for production of bio-ethanol and electricity is proposed to sugar industry and is addressed in this study. Since flow-sheet development is the key element of the bio-ethanol process, in this work, a bio-refinery (bio-ethanol and electricity production) annexed to a typical South African sugar mill considering 65ton/h dry sugarcane bagasse and tops/trash as feedstock was simulated. Aspen PlusTM V8.6 was applied as simulator and realistic simulation development approach was followed to reflect the practical behavior of the plant. Latest results of other researches considering pretreatment, hydrolysis, fermentation, enzyme production, bio-ethanol production and other supplementary units such as evaporation, water treatment, boiler, and steam/electricity generation units were adopted to establish a comprehensive bio-refinery simulation. Steam explosion with SO2 was selected for pretreatment due to minimum inhibitor production and simultaneous saccharification and fermentation (SSF) configuration was adopted for enzymatic hydrolysis and fermentation of cellulose and hydrolyze. Bio-ethanol purification was simulated by two distillation columns with side stream and fuel grade bio-ethanol (99.5%) was achieved using molecular sieve in order to minimize the capital and operating costs. Also boiler and steam/power generation were completed using industrial design data. Results indicates 256.6 kg bio ethanol per ton of feedstock and 31 MW surplus power were attained from bio-refinery while the process consumes 3.5, 3.38, and 0.164 (GJ/ton per ton of feedstock) hot utility, cold utility and electricity respectively. Developed simulation is a threshold of variety analyses and developments for further studies.

Keywords : bio-refinery, bagasse, tops, trash, bio-ethanol, electricity
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