FLORIDA SOLAR SENERGY CENTER

Aspen Plus[™] Process Model for Production of Gaseous Hydrogen via Steam Gasification of Bagasse



Mohamed Elbaccouch and Ali T-Raissi

Florida Solar Energy Center University of Central Florida Cocoa, FL, USA

A Research institute of the University of Central Florida

Objectives

- Determine the potential of producing hydrogen gas from an air-fired biomass gasifier utilizing local resources for use in the NASA Shuttle program
- Use Aspen Plus[™] chemical process simulator (CPS) platform to model the process

Simulation Criteria

- Thermo-neutral plant design for production of H₂ from bagasse
- Aspen Plus[™] Chemical Process Simulator: no heat generation
- Flowsheet consisted of four sections:
 - 1) Dryer section to partially dry the bagasse
 - 2) Gasifier consisting of bagasse combustion zone and gasification zone
 - 3) Gas clean up section to purify the H₂ product
 - Pressure swing adsorption unit to recover H₂ at desired purity levels

Methodology

- Part of the bagasse was used as fuel to supply heat to the plant
- Temperature of the combustor was set at 1550° C
- Heat generated was inputted to the plant's reactors and flow streams
- All other process units operate adiabatically
- 900 kg/hr of bagasse was used to produce 17.4 kg/hr of ultra pure hydrogen gas

Rationale

Biomass gasification is a well-developed & old technology (see examples below)
Syngas (H₂+CO_X) so generated is a renewable energy source



Hydrogen via Biomass Gasification Simple Capital Equipment Layout









McNeil Station, VT



Biomass Resources in Florida: Flexible, Available, and Inexpensive





Why Aspen PlusTM CPS?

- Process design oriented language facilitates complex chemical process calculations
- Applies mass and energy balances and chemical equilibrium relationships to predict design performance
- Small sections of a complex integrated system can be generated and tested as separate modules before integration
- Contains large property data bank and thermodynamic models

Simulation Assumptions

- Linear plant capacity
- Ultimate analysis of bagasse used as the feedstock composition input to the plant
- Process yields no tar
- Residence time in the gasification zone is long enough to allow approach to chemical equilibrium (Gibbs reactor model)

Modeling Approach



Process Flow Diagram Bagasse to Gaseous H₂



Aspen Optimized Gasification Conditions (17 kg/hr H₂ gas)

Biomass feed	900 kg.hr ⁻¹
Combustor-1 temp	1550 °C
Combustor-2 temp	1550 °C
Gasifier output temp	1150 °C
Water removed from Dryer	159 kg.hr ⁻¹
Split ratio: biomass to combustors 1&2	0.47

Simulation Results

Ultimate Analysis of Bagasse (dry basis)

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Α

С

Н

S

Itimate Analysis	Wt%
sh	8.61
	46.38
	5.86
	0.19
	0.01
	0.05
	38,9

Gasifier Output kg.hr ⁻¹		
H ₂ O	481	
С	None	
H ₂	12	
N ₂	1919	
Cl ₂	0.06	
CO	219	
NH ₃	0.001	
H₂S	0.3	

Hydrogen Flow Rate in Aspen PlusTM CPS Results



Biomass Feedstock Requirements for Multiple Shuttle Launches



Number Launches

Summary

- Hydrogen production from bagasse gasification process for Shuttle program at the NASA-KSC was analyzed using Aspen Plus™ CPS
- Plant consisted of dryer, gasifier, clean-up, & PSA sections
- Gasifier operates with no carbon formation nor heat production
- Plant functions within the typical range of industrial processes

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