Hydrogen Production from Florida Citrus Peel using a Pilot-Scale Biomass Gasification Unit

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Start Date = January 2005
Planned Completion = December 2007

Research Goals and Objectives

- To design, fabricate, and operate a pilot-scale gasification unit for converting abundant Florida biomass (citrus peel) into hydrogen-rich gas and thermal energy

- To validate its performance, efficiency, economics, and reliability as a sustainable local hydrogen source to meet NASA-KSC's fuel needs

Relevance to Current State-of-the-Art

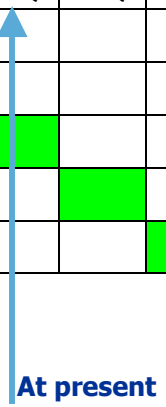
- Ascertain the feasibility and viability of biomass gasification plant as a distributed energy source
  - Pilot-scale data backed with economic feasibility studies will assist in identification of biomass suitable for energy needs
- We envision biomass gasifier systems that can be easily operated with various biomass sources generating energy up to 100 KW
  - Ideal for industrial energy needs in rural areas and for backup power

Relevance to NASA

- Successful gasifier demonstration can satisfy long-term NASA-KSC hydrogen needs
  - Local hydrogen production can assist in securing a renewable and environmentally friendly energy source for the spaceport operations
- Biomass-derived hydrogen offers an alternative to conventional energy sources and provides environmental, rural economic growth, and national energy security benefits

Budget, Schedule and Deliverables

		FY05				FY06			
	Tasks	**1Q**	**2Q**	**3Q**	**4Q**	**1Q**	**2Q**	**3Q**	**4Q**
1	Complete installation & setup of the pilot scale gasification unit								
2	Pilot-scale unit subsystem testing								
3	Comprehensive pilot-scale testing								
4	Hydrogen membrane module development & installation								
5	Sugarcane Bagasse and Municipal unders analysis								



Project is on schedule

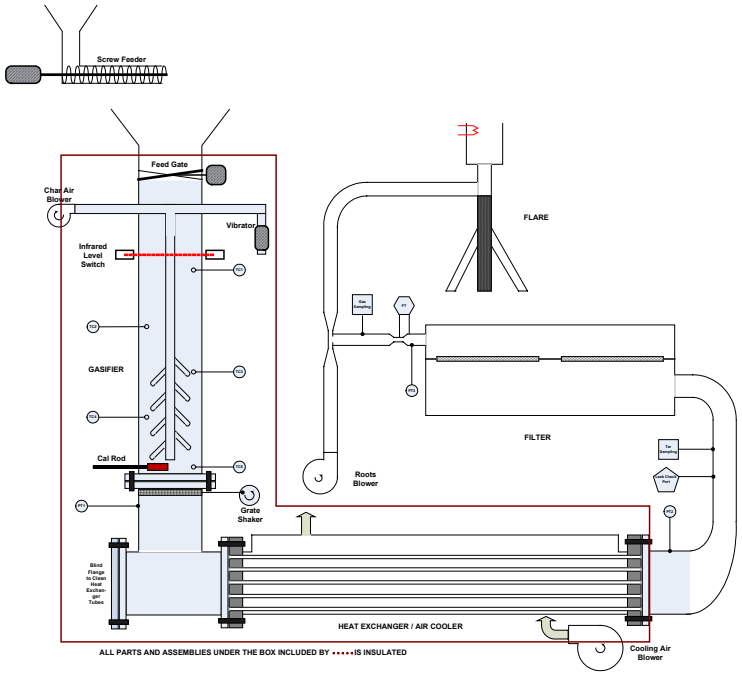
- Completed testing of the gasifier with citrus peel and wood chips for hydrogen yield by varying process parameters such as bed temperature, feed rate, etc.
- System currently undergoing modifications for steam addition
  - citrus peel ($C_2H_4O_{1.7}$) + $H_2O(g)$ → gases (H_2…) + char

Anticipated Technology End Use

- Generation of Hydrogen and Energy from local resources
  - Biomass
    - Citrus Peel (availability: 1 million dry tons/year)
    - Sugarcane Bagasse
    - Forest Residues
  - Waste
    - Municipal Solid Waste
    - Lube Oil
    - Paper and Plastic Waste

Accomplishments and Results

- Gasifier System Setup

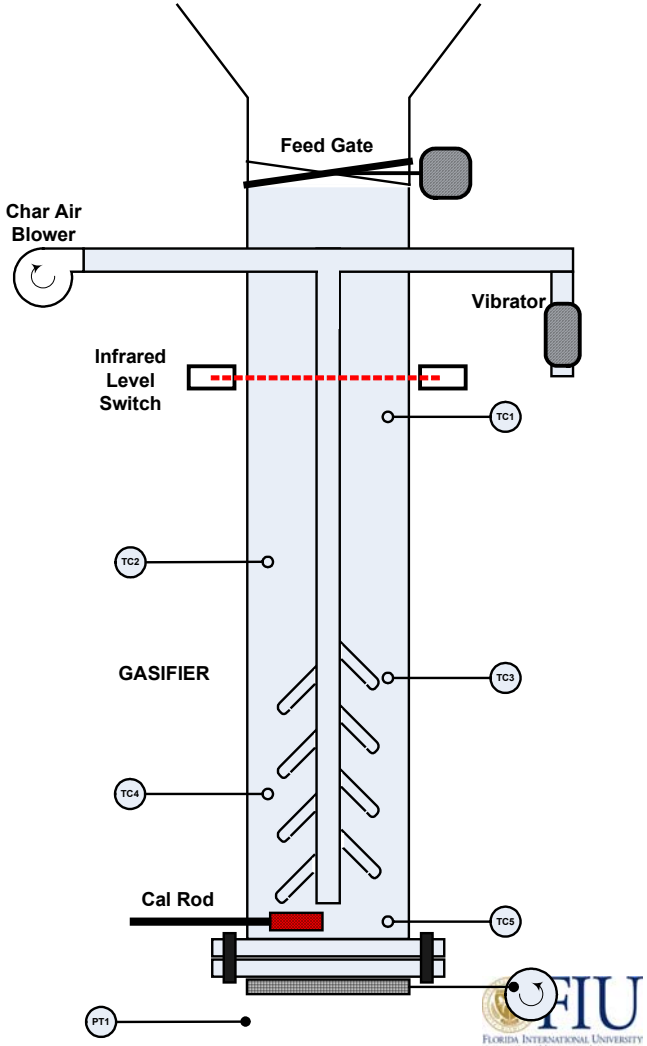


System Schematic

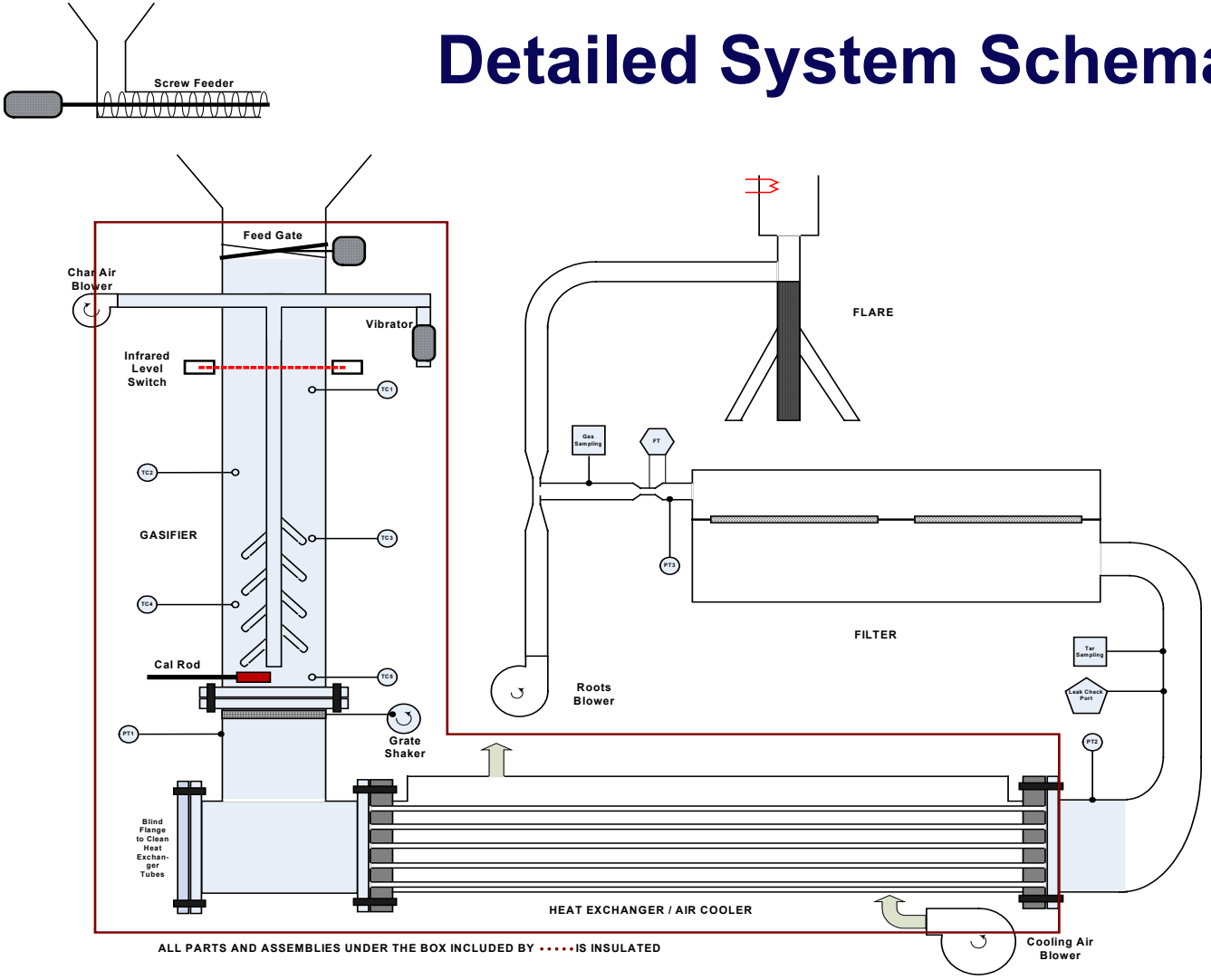
System under Operation

Accomplishments and Results (cont'd)

- Gasifier Details



Detailed System Schematic



System Details Video

Accomplishments and Results (cont'd)

- Gasifier Bed Control and Char Air System

Char Air Tree

Vibrator System

Char Air Blower

Accomplishments and Results (cont'd)

- Feeder Control System and Ash Removal

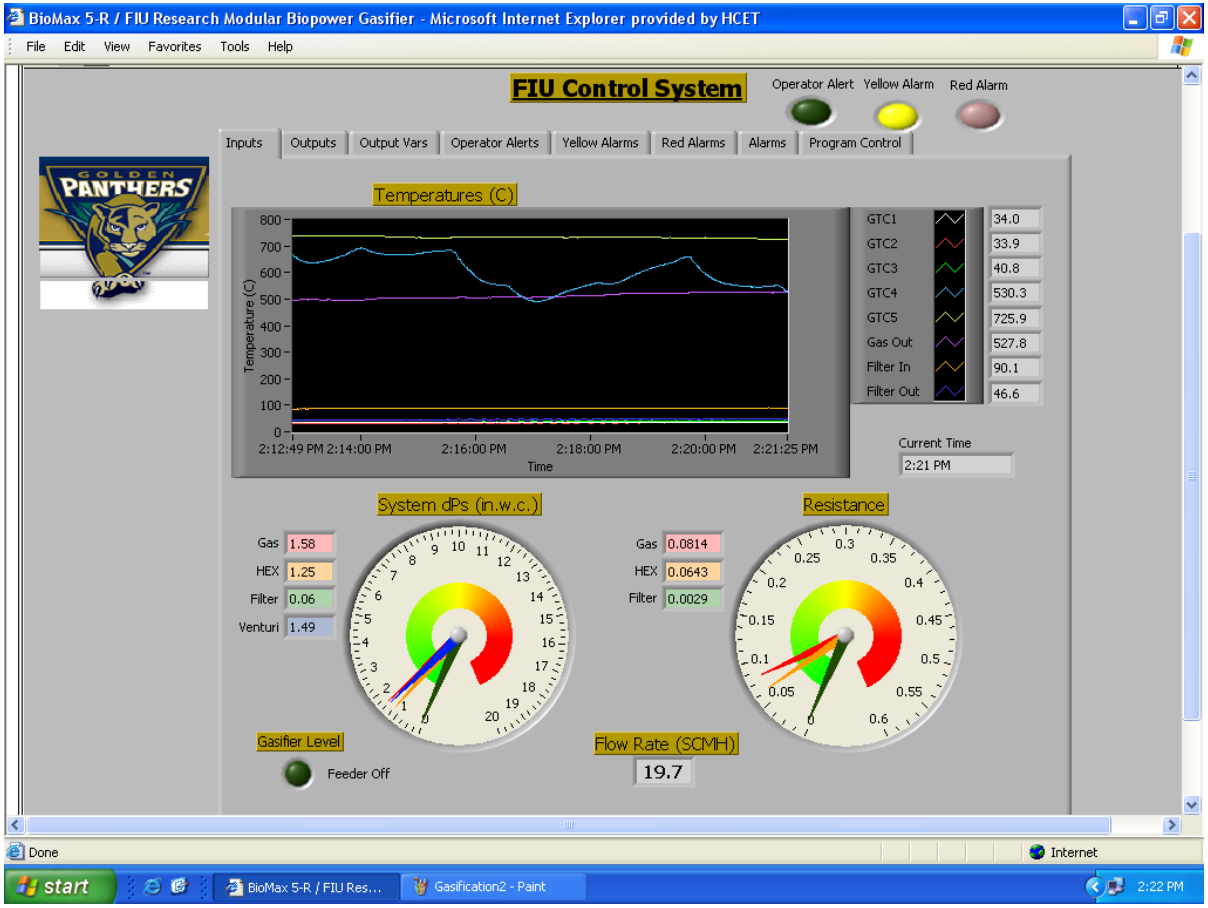
LabView RTU

Grate Shaker

Automated Feed System

Accomplishments and Results (cont'd)

- Operational Graphical User Interface

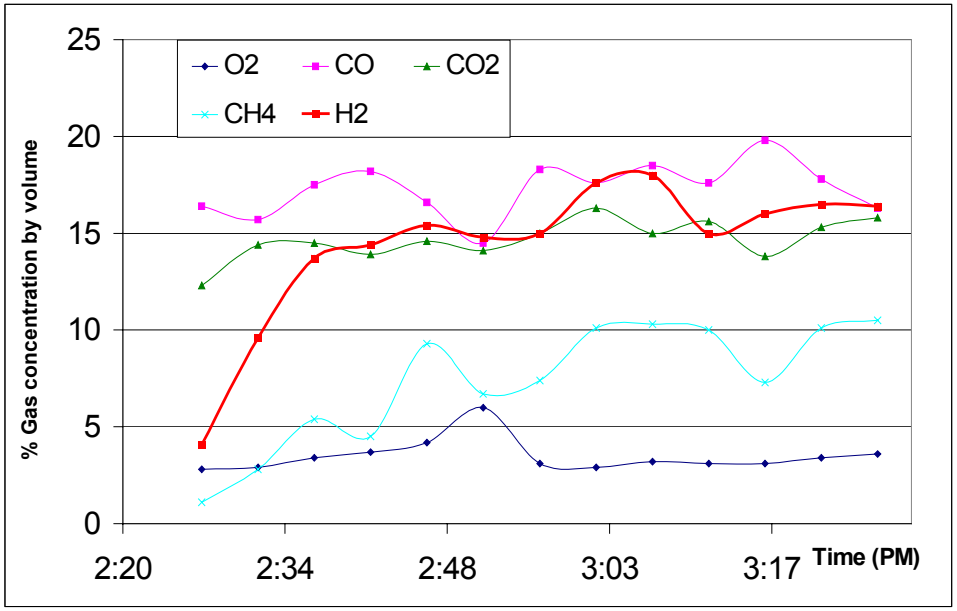


Accomplishments and Results (cont'd)

- Typical Gas Composition with Citrus Peel Feed

Time (PM)	O_2 (%)	CO (%)	CO_2 (%)	CH_4 (%)	H_2 (%)
2:27	2.8	16.4	12.3	1.1	4.1
2:32	2.9	15.7	14.4	2.8	9.6
2:37	3.4	17.5	14.5	5.4	13.7
2:42	3.7	18.2	13.9	4.5	14.4
2:47	4.2	16.6	14.6	9.3	15.4
2:52	6	14.5	14.1	6.7	14.8
2:57	3.1	18.3	15	7.4	15
3:02	2.9	17.6	16.3	10.1	17.6
3:07	3.2	18.5	15	10.3	18
3:12	3.1	17.6	15.6	10	15
3:17	3.1	19.8	13.8	7.3	16
3:22	3.4	17.8	15.3	10.1	16.5
3:27	3.6	16.3	15.8	10.5	16.4

Concentrations Data in Producer Gas



Concentrations Profiles

Accomplishments and Results (cont'd)

Typical Operation Yields and Efficiencies

- 1 kg of feed (dry basis) yields 1 kWhr equivalent of Producer Gas
- 1 kg feed yields 3 Nm^3 of gas with 17% H_2, 10% CH_4, 18% CO, 16% CO_2, 3% O_2 and 36% N_2
- After steam reformation/shift reaction, yield increases to 4.7 Nm^3 gas with 47% H_2, 28% CO_2, 2% O_2 and 23% N_2
- Overall gasification efficiency is 81% (considering LHV of feed to LHV of Gas Output)
- 18 experimental runs with citrus peels completed as of 10/21/05

Future Plans

- *In situ* steam reformation of gasifier hydrocarbons to maximize hydrogen generation
- Shift reaction of the carbon monoxide to hydrogen
- Cleanup of produced hydrogen
- Screening of Florida-specific biomass for hydrogen yield and energy
  - Sugarcane bagasse, *Melaleuca quinquenervia*, municipal "unders"
- Techno economic assessment of technology