QUARTERLY PROGRESS REPORT

9/1/13 to 11/30/13

PROJECT TITLE: Single Step Conversion of Landfill Gas to Liquid Hydrocarbon Fuels

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COMPLETION DATE: 11/26/2013

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Research Description

This research project involves intensifying conversion of landfill gas to liquid hydrocarbon fuels to improve overall economics. The goal of the project is to develop and optimize a catalyst that can generate syngas from landfill gas via a dry and tri reforming process. The generated syngas can then be turned in a single step conversion process of methane into useable hydrocarbons using Fischer-Tropsch synthesis (FTS). To do so, the entire operation has to be done under low temperatures ($T < 500°C$). A main challenge with is to maintain the desired H_2: CO ratio of 2:1 for use in FTS while tuning the reforming processes to operate at similar conditions as the fuel synthesis.

Work Completed To-Date

For the period outlined in this first report, thermodynamic modeling of methane (CH_4) and carbon dioxide (CO_2) conversion from a typical landfill gas composition was done using ChemCad® which is shown in Figure 1. The modeling then provides windows of feasibility for operating the system.

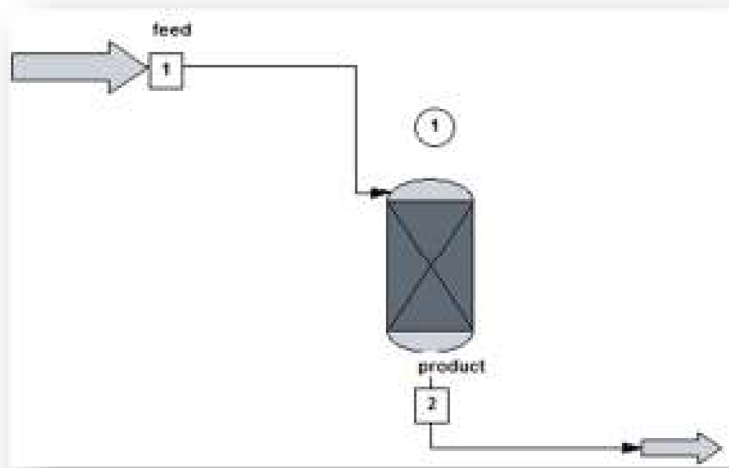

Figure 1. Shows the Gibbs reactor used to model the conversion of CH_4 and CO_2 in ChemCad ®.

The challenge faced at this stage in the modeling process was that it is very difficult to reach a low enough temperature to remain in the operable range of FTS while achieving the desired CH_4 and CO_2 conversion and the H_2: CO ratio at the same time.

The approach used to solve these obstacles included changing the pressure while maintaining a constant temperature. The result was that varying the pressure did not significantly affect H_2: CO ratio. A different approach was used to increase the temperature while maintaining constant pressure. That resulted in increasing H_2: CO ratio but still not up to the desired 2:1 ratio. The H_2: CO ratio began increasing around 475°C as can be seen in Figure 2; since one of the goals is to maintain as low temperature as possible to remain in the FTS range, it was determined to continue the modeling process at 475°C. Any lower temperature produces solid carbon and H_2O.

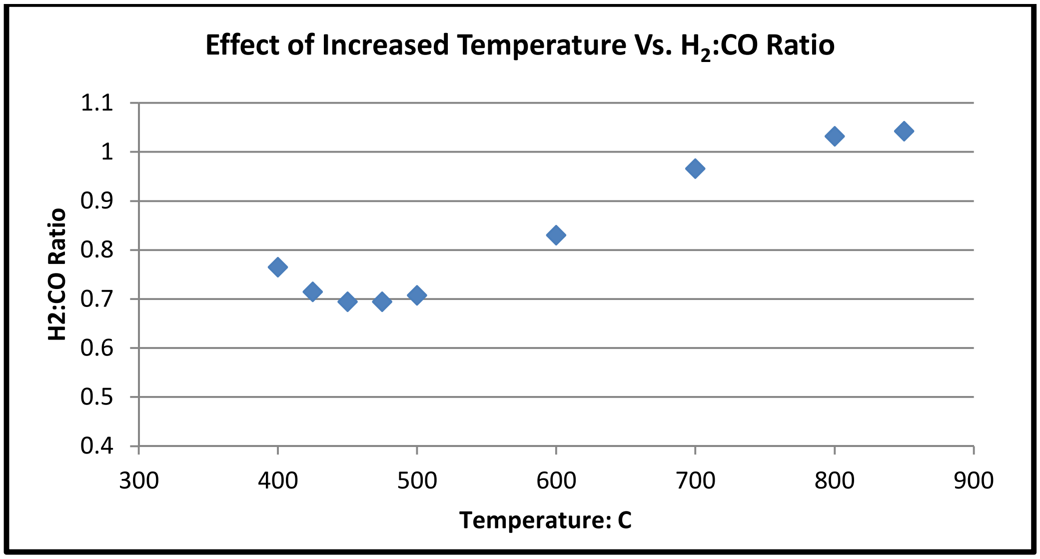

Figure 2. Shows the increase in H_2: CO ratio at 475°C.

A third approach was used which involved modifying the composition of steam in the landfill gas to achieve close to the desired conversions at as a low a temperature as possible. Adding 2% steam (3kmol/hr) has helped increase the CH_4 conversion but had an adverse effect on CO_2 conversion as can be seen in figure 3. It is also important to note that adding steam did not significantly affect the H_2:CO ratio as can be seen in figures 4.

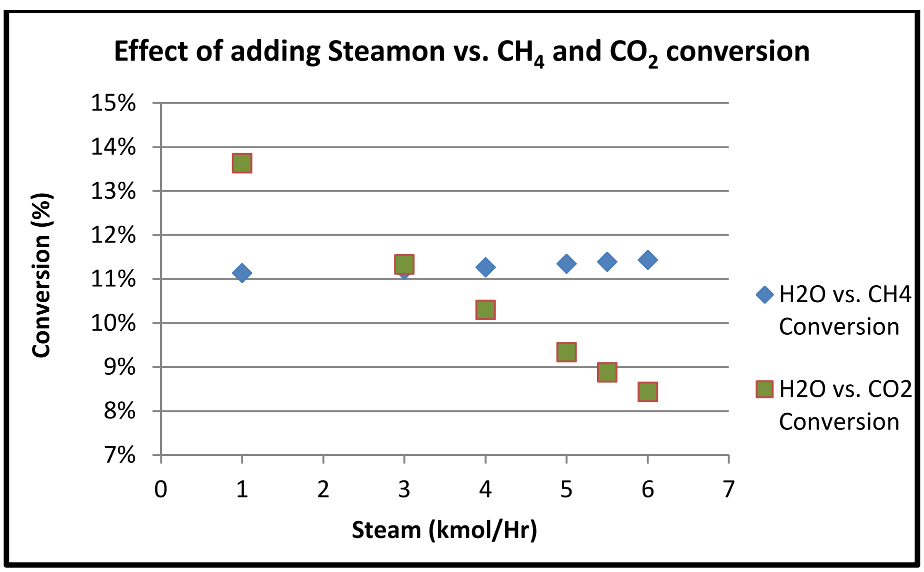

Figure 3. Effect of adding steam to the conversion of CH_4 and CO_2 at 475°C and 1atm.

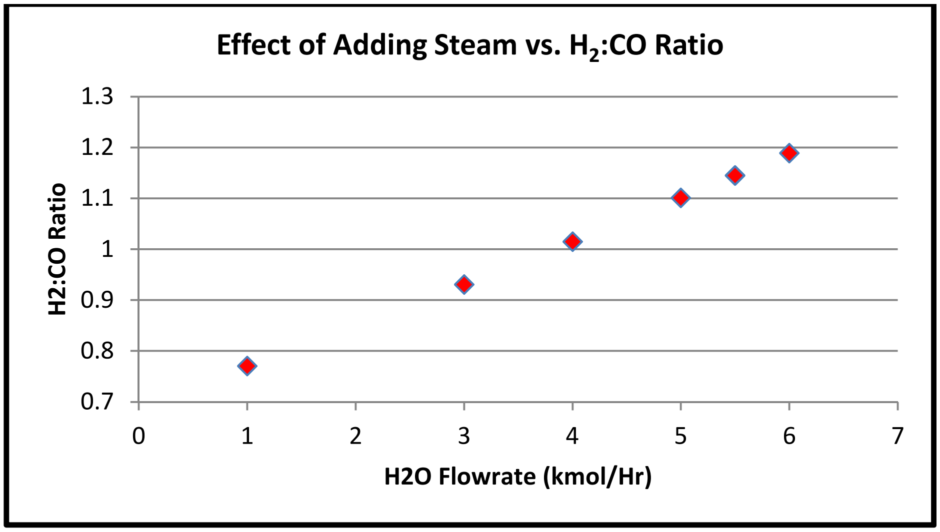

Figure 4. Effect of adding steam on the H_2:CO ratio at 475°C.

Future Tasks

The future direction would be to synthesize a unique catalyst that most likely consists of a $(Ce,Zr)O_2$ support with base and precious metals loaded. The addition of a precious metal is believed to aid in the low temperature conversion and with minimization of coke formation. Thus, it will assist in achieving the goals discussed. At this point, we have synthesized the $(Ce,Zr)O_2$ support and are beginning to add the metals and characterize the materials. To ensure that the catalyst synthesized will be effective, the catalyst will be characterized using several different techniques such as temperature programmed reduction (TPR), x-ray diffraction (XRD), and identifying the surface area using BET. Those characterization techniques will help to show the reducibility of the catalyst, the crystal structure and the surface area of the catalyst.

TAG Meetings Scheduled

Our first TAG meeting will be in January. Details will be announced soon.

TAG Members

Canan “Janan” Balaban	Asst. Director	Florida Energy Systems Consortium
Roger Lescrynski	Solid Waste Project Manager	Public Works - Solid Waste Division
Tino Prado	Engineer, Owner	Prado Tech.
Tim Roberge	Engineer	Oxy
John Schert	Executive Director	Hinkley Center

Devin Walker	Process Engineer	BASF
Matt Yung	Researcher	Nat. Renewable Energy Lab

Project Website Address (URL): (http://www.eng.usf.edu/~jnkuhn/Hinkley.html)

Student Researchers

The primary student researcher on this project is Nada Elsayed. With this project, Nada was able to join the group as a PhD student. Yolanda Daza is a senior group member in the PI's group and offering assistance to Nada with some aspects of the project. We are recruiting an undergraduate research to also assist with this research.

Seen in the picture is Yolanda Daza(left) and Nada Elsayed (right).