

CONTINUOUS THERMOCHEMICAL CONVERSION PROCESS TO PRODUCE OIL FROM SWINE MANURE

Kim Ocfemia, Yuanhui Zhang, Ted Funk, Leslie Christianson, and Malia Appleford
 Department of Agricultural and Biological Engineering, University of Illinois at Urbana-Champaign



Thermochemical conversion (TCC)

is a process for the reduction of complex organic materials (biomass) into crude oil. It mimics the natural geological processes thought to be involved in the production of fossil fuels. Batch experiments showed that conversion of swine manure to oil is technically feasible. The next logical step was to develop a continuous-mode process, which is more applicable in the commercial scale.

CTCC development

Figures 1 and 2 show the continuous TCC (CTCC) system that was developed. It has the capacity to process 48 kg of manure slurry per day. A continuous-stirred tank reactor was selected.

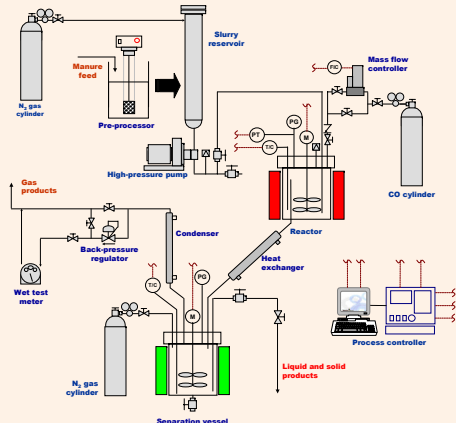
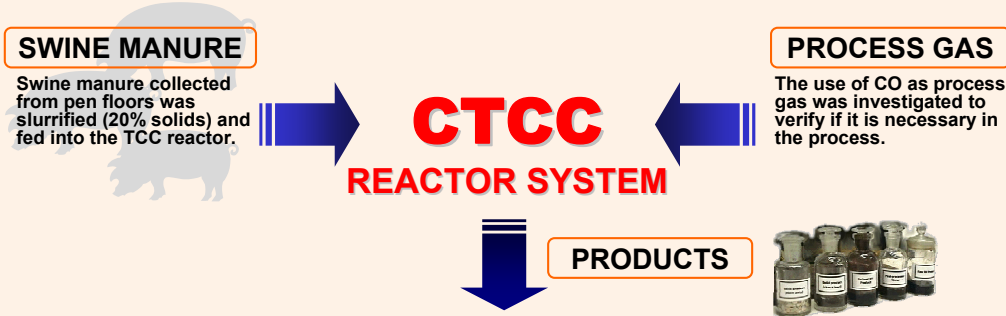


Figure 1. Schematic drawing of the CTCC design



Oil product	Post-process water	Solid product	Gas product
Oil yield based on volatile solids conversion was as high as 70%. The heating value of the oil was 31,100 kJ/kg. The crude oil product was mainly composed of asphaltenes and resins; an excellent feed for coking. It has a high N content of ~4% but a low S content of ~0.3%.	The BOD of the post-process water was ~70% less than the manure feedstock. The water was analyzed for volatiles and semi-volatiles. Acetone, 2-butanone, and ethanol was found to be in significant amounts. A variety of acids including pentaenoic and butanoic acid was detected.	The solids were primarily dirt, the remaining unconverted solids from the manure, and some char that formed during the process. The total solids left after the process was about 3.9% of the total feed; an 80% reduction of original solids in the manure.	Gas product samples were analyzed using a GC/MS. Results showed that the gas was composed of 98.0% CO ₂ and ~2.0% CO. CH ₄ , C ₂ H ₆ , C ₂ H ₄ was 173, 74.1, and 48.9 ppmv. Trace amounts of benzene, styrene, and toluene were also found.



Figure 2. Picture of the CTCC reactor system

Experiment results

The effects of process operation parameters on oil yield and quality were investigated to determine the optimal condition for producing oil. Figure 3 shows the effect of temperature and pressure on oil yield. The highest yield was obtained at 80 min retention time without the use of CO. Results indicate a narrow optimal range, which is in agreement with the batch experiment results. Figure 4 shows the average product distribution for all of the tests that were done. An energy balance of the process shows an energy production to energy use ratio of about 3:1.

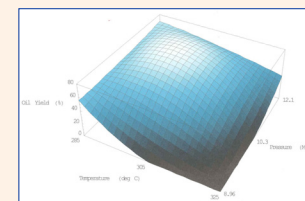


Figure 3. Oil yield optimization

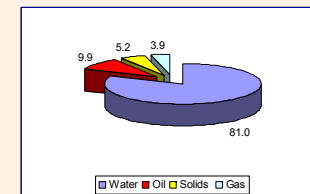


Figure 4. Average product distribution

Summary

A CTCC system capable of converting swine manure to oil was developed. Oil yield as high as 70% was achieved at 305°C, 10.3 MPa, and 80 min retention time. There was no improvement in oil yield when CO was used. Conservative estimation showed that the process was a net energy producer.

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Contact: Dr. Yuanhui Zhang (217) 333-2693, yzhang1@uiuc.edu