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Extraction of fuel from domestic wastes

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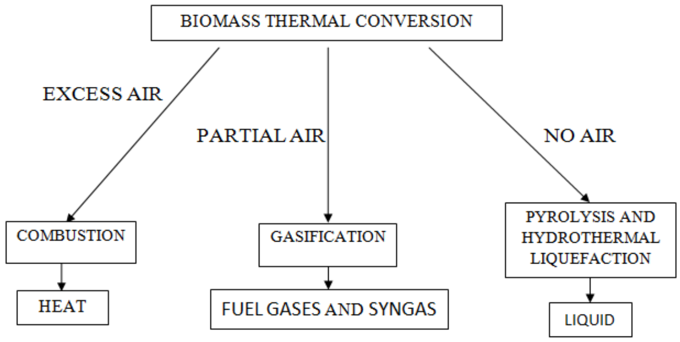
Abstract
Reducing our dependence on the fossil fuels and other non-renewable sources is the immediate need of the time. Biomass conversion technology is an important process that aims at doing this by extracting energy out of the biomass. Thermo chemical conversion is a process under the biomass conversion technology that aims at doing this in the best way by extracting fuel oil out of the biomass. Direct liquefaction, a specific technology under the thermo chemical conversion has been effectively used in the recent times to extract the oils from the biomass. Here, it has been proposed to apply the thermo chemical conversion for the proper disposal of the domestic wastes and the extraction of the fuel oils from the domestic wastes by using the same. The wastes are first categorized and are dumped separately, based on their composition (animal or plant wastes) they are processed in the thermochemical processors designed to work under different operating conditions based on the requirement for a feed of specific composition. Liquefaction process is the key process to obtain the liquid fuel or oil and is designed so as to enhance the quality of the fuel obtained by increasing the hydrogen to carbon ratio of the fuel obtained. It thus creates a more hydrocarbon like fuel and thus a better bio-fuel or oil.

Keywords: TCC, biomass, bio-fuel

Introduction
In today's world of energy crisis, it's the immediate need of the time to search an effective alternative for the fossils fuels on which we rely too far much extent. Although there has been several options available like solar energy, wind energy, thermal energy, hydroelectric energy and a few more but yet the need of the oils to effectively power our automobiles and various factories is still needed. Such an alternative for the oils is yet under research. Although we have a few more options available like biodiesels obtained from various plants but yet the availability is so scarce that it seems not much hope for the future demands.
Thus we need to immediately find a better alternative for the limited petroleum supply. We thus need to produce these fuels directly without undergoing the long await of the millennia required for their formation. We now are left only with one option and that is to artificially obtain the fuels directly from the vegetable sources or the other organic substances. And this is exactly we are trying to search in this project and remain focused upon.
Here we are going to start with the basic organic wastes produced from our daily household wastes. The basic need is thus to start with the separation of the organic and inorganic wastes and then to classify these based on the type of process required for the extraction of oil from it. These processes will be detailed in the project. This technology that we hereby employ is commonly called biomass conversion technology.
Biomass conversion technology is the technology that is commonly used for hastening and extraction of the fuels from the common biomass or organic sources. In this process the biomass is collected and is stored under suitable conditions for no more than seven days. During this the solid waste and the water contents are separated. The water so obtained is treated separately and the solid wasted is further processed for the preparation of the solid feed.
Out of the various technologies available under the biomass conversion technologies, thermo chemical conversion is the one most suitable for obtaining liquid oils.



Biomass Thermal Conversion Process

Material and Methods

Experiment setup

The experimental setup of the TCC process includes the key apparatus, thermo chemical reactor or TCC processor, the temperature and pressure control system, and the TCC process integration unit.

Batch TCC Processor

The basic requirements for a TCC processor that can perform the task in this study includes being able to work under high temperatures and pressures, easy to control for research purposes, and safe. Based upon these criteria, a floor-stand stirred-tank pressure reactor, Model 4572, was chosen from Parr Instruments Company (Moline, Illinois). The reactor is made of T316 stainless steel with an extreme operation condition of 34.5 MPa (5000 psi) at 375 °C (705 °F). The reactor has a volume of 1.8 liters (a half gallon) equipped with two 6-blade impellers and a serpentine cooling coil. The agitation propellers are driven by a quarter-horse power motor through a magnetic drive with 16 in-lb torque. A rupture disc and a pressure relief valve are also equipped with the reactor to ensure safety. A condensing-reflux unit is attached to the reactor for reflux purpose when needed. A sketch of the reactor and a picture of its components are shown in Figure 1 and 2.

Temperature and Pressure Control System

Temperature is most important in the thermo chemical conversion process. It affects thermal de-polymerization reactions directly. Therefore, temperature was employed as the key control parameter. In the first stage study, pressure control was indirectly achieved through temperature control because the water vapor-liquid system was in equilibrium when the operation reaches its steady state. In other words, the pressure was coupled with temperature in such a system A temperature controller of Model 4842 from Parr Instruments Company (Molline, IL) was chosen. The controller features three term PID control, high temperature limit indication/cutoff, high pressure limit indication/cutoff, and thermocouple burnout or malfunction protection control as well. The resolutions are 1 ° C and 69 kPa (10 psi), and accuracies ± 2 ° C and ± 1.5% of working pressure range, respectively. Two type J thermocouples (iron-constantan) are adapted as temperature sensor, placing in the thermo well of the reactor. One serves as control signal detector, the other as high temperature cutoff control detector. The controller supplies a full power of 1500 watts to the heater for temperature rise-up and one-half of its full power for temperature control operation. The cooling water to the cooling coil is controlled by a solenoid valve triggered by over-limit signal from the controller. The agitation speed of the impellers is controlled through the controller and is continuously monitored by a digital tachometer.

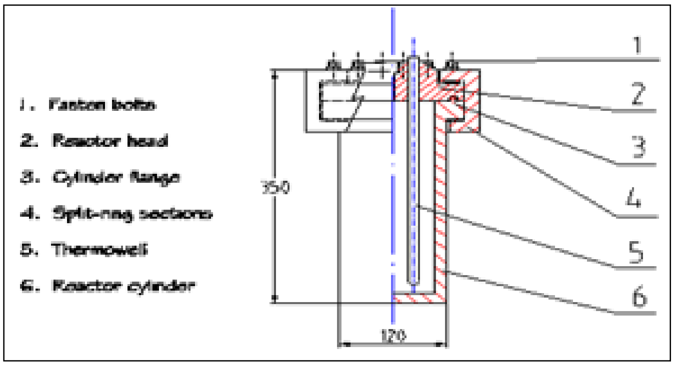


Fig 1: Sketch of the TCC reactor

Process assembly and flow chart

The reactor unit and control system were mounted on a floor-stand cart. Picture of the floor-stand reactor unit is shown in Figure 3-3. A process flow chart of the batch mode TCC process is shown in Figure 3-4.

Process parameters

Experimental design here refers to all the considerations to fulfill the objectives of this research, including parameters affecting the process, variables to be investigated, methodology of the parameter examination, and statistically effective experimental design. However, there were only some of the key parameters considered during the feasibility study. There are four parameters considered in the first stage study: temperature, CO initial pressure (CO initial ratio to total volatile solids), solids content, retention time, and pH of the feedstock.

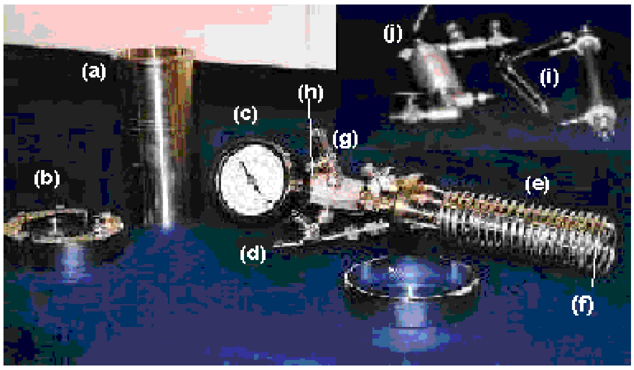


Fig 2: Picture of the TCC processor components. The main parts are (a) cylinder; (b) split-ring closure; (c) pressure gauge; (d) pressure transducer; (e) cooling coil; (f) propellers; (g) pressure relieve valve and rupture disc; (h) magnetic drive; (i) condenser; (j) condensate collector.

Fig 3: Picture of the floor-stand reactor unit

Temperature (T)
Temperature is the most important parameter in the TCC process. In the experimental design for feasibility study, temperature was assigned as the presenting parameter. Since equilibrium is established between water vapor and liquid water in the close system, and water vapor condensation compensates the pressure increase contributed by the gases produced during the course of reaction. Therefore, the temperature and total operating pressure of the close system are coupled.

CO initial pressure (pco)
Carbon monoxide (CO) serves as reductive reactant in the system. The amount of CO added will affect the oxygen content in the depolymerized products, or the quality of the oil product. In the closed system, the initial pressure of CO presents the initial amount of CO added. If fixing the amount of feedstock, the same CO initial pressure also means the same ratio of CO to total volatile solids.

Solids content (TS)
Solids content is another major parameter affecting the TCC process. Based on preliminary tests, about 85-88% of the total solids is volatile. The volatile solids content is the most possible potential of the manure to be converted to oil products. More volatile solids content is desirable for the purpose of oil production. However, manure with 25%wt or more solids content is hard to pump and not suitable to the TCC process. Practically, the solids content from under slat manure pit usually is about 12% or even less. To start with, the level of solids content was assigned to 20% for the feasibility study and total solids (TS) was chosen as the presenting parameter.

Retention time (RT)
Retention time is a kinetic parameter of the TCC process. It affects the organic conversion rate or product yields. Inefficient retention time of the reactants will lead to incompleteness of the conversion process. However, too long retention time will result in over-oxidization of the products and formation of char. The levels of retention time were set to 120 minutes for the feasibility study.

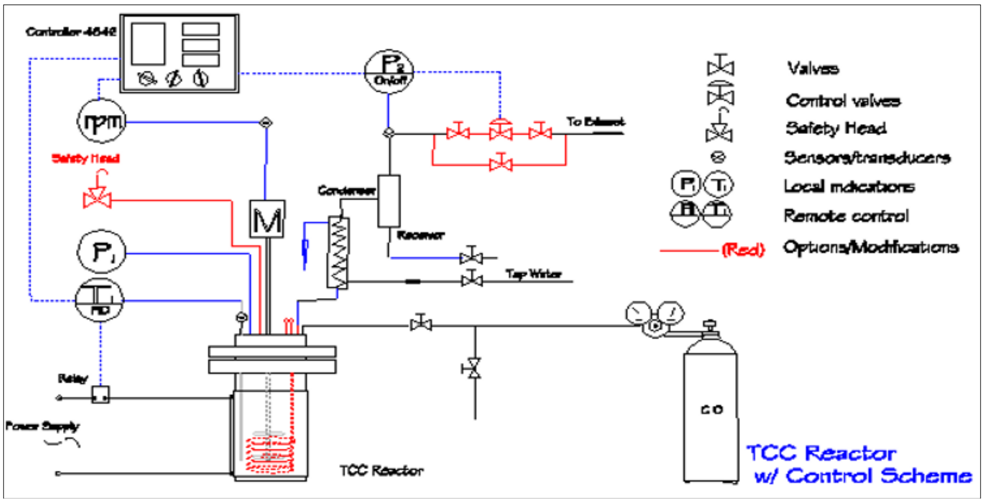


Fig 4: Flow chart of the batch mode TCC process for the feasibility study

pH
The pH value is the indication of the strength of acidity/alkalinity, or the concentration of hydrogen ion (H+) in the feedstock. The concentration of hydrogen ion affects the TCC process by serving as catalyst for the hydrolysis of cellulose and other carbohydrates and polymers. The statistical data of pH values for raw swine manure is about neutral, 7.5 ± 0.57 (ASAE, 1997). Preliminary test of the fresh manure used in the study indicates that the pH is 6.5 ± 0.5, lower than that mentioned above. Deviation of pH from neutral, either too high or too low, will affect the chemical process of the system, and will create severe chemical erosion on the apparatus under high temperatures as well. To focus on other parameters, the natural pH (pH = 6.5) of the fresh manure was accepted and monitored but not controlled.

Product Separation
There are gaseous, liquid, and solid products after the TCC process. The gaseous product is the gases produced during the process, which contributes to the pressure increase after the reaction ceased, and un-reacted carbon monoxide. The solids after the reaction are the inert foreign materials such as dirt as well as a small amount of char. Liquid products include the post-processed water with most of soluble minerals and the oil product.

Gas product separation was readily done after the reactor was cooled to about room temperate. The gases were released slowly through a 100-ml serum bottle (as gas product sampler) equipped with three syringe needles. One was the inlet and the other two as outlets.

Oil product separation was also readily done after the run since it is lighter than aqueous solution and floats at the top of the post-processed water. Oil product was sticky too. It was carefully collected and stored in a 100-ml wide-mouth sample bottle.

Solids and post-processed water separation was achieved through filtration. The solids and post-processed water were collected in a 1000-ml wide mouth bottle. Some of the char particles formed during the process were so fine that they suspends in the liquid. Vacuum filtration was used to remove the suspended fine char particles from the liquid phase with a glass fiber filter as well as the inert solids that were mainly the dirt.

Effects of various parameters on the TCC process

Temperature

As we know, the temperature plays a very important role in the chemical conversions and thus it's very important to determine the correct operating temperature and pressure conditions. The increase in temperature increases the oil yield and the benzene solubility of the oil. However, the extreme temperature conditions leads to the low oil yield and the low benzene solubility of the oil.

Moreover the hydrogen content of the oil decreases as the temperature increases. Increased benzene solubility of the raw oil products with the increases of temperature is due to the oxygen elimination from the oil at the high temperature. The high temperature also generally increases the oil yield but tends to eliminate the oil product. Thus, temperature affects the TCC process significantly on the oil product quality.

The post processed water is a major output of TCC process. All though most of the organic matter is converted into the oil yet a small amount of organic matter remains the post processed water. This leads to greater COD of the post processed water.

Retention time

Retention time is the time for which the feed stock remains in the TCC processor. It affects the organic matter conversion and the product distribution. Insufficient retention time will lead to incomplete conversion process. This leads to the following:

- Increased char formation
- Increased solid waste
- Increased COD of the post processed water
- Decreased oil yield

pH

pH affects the conversion process as optimum pH is an important factor in hydrolysis of organic compound, de-polymerization of bigger organic molecules and hydrogenation of oil.

An extreme pH condition also leads to the chemical erosion of the apparatus.

Results and Discussion

The feedstock, the waste products were converted into raw TTC oil, processed wastes, solid residue, gases. In this process the conversion rate of the feed stock into the oil was fairly high and thus it was not considered as a parameter to characterize the thermochemical conversion process.

The conversion process of the feed stock into the raw oil is similar to any other liquefaction processes commonly employed for the extraction of the oil from other types of biomasses.

One of the key factors that contributed to greater oil yield was the lignin content of the feed stock. Higher lignin content was found to be directly related to higher oil yield. High lignin content implied higher energy content of the feed stock and thus the higher yield of the raw oil.

Moreover it is generally observed that the waste products or the feed stock have high oxygen to carbon ratio (O/C ratio) and low hydrogen to carbon ratio (H/C ratio). This adds to our difficulty of our extraction of the better fuel or raw oil. And thus has negative impact on our oil yield and its quality. This is so because high oxygen content implies low heating value. But this is something that we cannot overcome easily, not at least by simply taking the waste products directly after storage or drying. To overcome this we need to process the wasted prior to using it as feedstock in the TCC process, but that will add both to the complexity of the complete process and the overall budget of the process. Moreover we still don't have a good process to do this job efficiently.

The TCC process also relies greatly on the addition and choice of the reductive or the reducing agents. We need to keep in mind that the process is just a way of breaking down complex organic compounds in simpler hydrocarbons and that too at an accelerated pace. This clearly indicates how important the choice of suitable reductive is for the process. In the absence of reductive the conversion of the organic carbon into the fuel was very less. And for the use of common domestic waste products as the feedstock, where the composition of the fuel varies greatly from bigger bulky organic compounds of almost all classes to smaller and uncreative molecules, we need to choose our reductive very carefully so as to exploit all the classes of the compounds in the feed stock.

De-polymerization of the organic compounds in the feed is one of the crucial steps in the process. It is not initiated in the process until the activation energy is reached. Activation energy required for the polymerization to occur efficiently, so that reductive can easily do their work efficiently, is provided by the thermal energy and thus temperature and pressure becomes the key factors in the de-polymerization process. De-polymerization occurs only after a minimum temperature is achieved. The preferred operating temperature in the TCC process was 285-305^{o}C with the corresponding operational pressure of 6.8-11.5 MPa.

It was noticed that the oil product was not obtained at the same temperature each time. This happened because the composition of the feedstock did not remain same; rather it changes for every run. And thus it provides a greater challenge in the working and effective quality yield of the oil from the TCC process.

TCC as a means of waste management

Currently, land spreading of the wastes is not considered as a good practice in terms of environment protection. The most positive management and utilization of wastes is the anaerobic digestion – the biochemical treatment processes.

Through thermochemical conversion technology, the conversion rate of organic matter in the domestic wastes can be as high as 90% or more. The solids and the wastewater are separated and COD in the wastewater is greatly reduced. Thus, much less storage is required. TCC processor will be compact and much less space occupying than those of biological treatment processes such as lagoons and digesters do. Another benefit of such a short period of manure storage time is the odor reduction – less storage time means less odor emission. A successful and big enough TCC project will more over be self sustainable and will also greatly reduce the solid wastes and residues.

TCC as a means of environment protection

The TCC process converts most of the organic matters to oil and gases that are readily separated from the post-processed water. The negative environment impacts of domestic wastes due to its solids, liquid and gaseous wastes will be significantly lessened. Waste water will be reduced dramatically in nutrient concentration. Possible underground water pollution from lagoon leaking is eliminated because no lagoon is necessary with the application of the TCC technology.

TCC as a Means of Renewable Energy Production:
Through the thermochemical conversion technology, domestic wastes, the most abundant biomass wastes, can be converted to useful products, liquid fuel – a renewable energy.

Conclusion
Considering the theoretical aspects of the TCC process applied to the domestic wastes based on the similar researches on swine manure and other biomass feedstock; we see a good scope of this project proposal to be an effective measure in controlling the environmental pollution issues related to the pollution caused by the burning of the fossil fuels and the disposal of the domestic wastes. Moreover, if successful it will also effectively address the issue of energy crisis and will decrease our dependence on the non-renewable forms of the energy sources.

References

1. Chornet E, Overend RP. Biomass liquefaction: an overview. In Fundamentals of Thermochemical Biomass Conversion, Elsevier Applied Science, New Yark. 1985; 967-1002.
2. Datta BK, McAuliffe CA. The production of fuels by cellulose liquefaction. In Proceedings of First Biomass Conference of the American: energy, environment, Agriculture, and Industry. 1993; 2:711.
3. Duun BS, Mackenzie JD, Tseng E. Conversion of cattle manure into useful products. US Environmental Protection Agency. Ada, EPA. 1976; 600/2-76-238.
4. Farris SG, Weeks ST. Commercial demonstration of biomass gasification the Vermont project. In Bioenergy 96: Partnerships to Develop and Apply Biomass Technologies, eds. 1996; 44-51.
5. Garner W, Smith IC. The disposal of cattle feedlot wastes by pyrolysis. U.S. environmental Protection Agency, Washington, D.C.,EPA-R2. 1973; 73-096.
6. Glasser WG. Lignin. In Fundamentals of themochical Biomass Conversion. Eds. R.P. Overend, T.A. Milne, and L. K. Mudge. Elsevier Applied Science, New Yark. 1985; 61-76.
7. Hrubant GR, Rhodes RA, Sloneker GH. Specific composition of representative feedlot wastes: a chemical and microbial profile. Science and Education Administration, U.S. Department of Agriculture, Washington, D.C., 1978.
8. Kreis RD. Recovery of by-products from Animal wastes – a literature review. Report for the US Environmental Protesion Agency: Robert S. Kerr Environmental Research Laboratory. U.S. EPA. ADA., EPA. 1979; 600/2-79-142.
9. Primentel D, Rodrigues G. renewable energy: economic and environmental issues. Bioscience. 1994a ; 44(8).
10. Sawayama S, Inoue S, Tsukahara K, Ogi T. Thermochemical liquidization of anaerobically digested and dewatered Sludge and anaerobic retreatment. Bioresorce Technology. 1996; 55:141-4.
11. Smith SL, Graham RG, Freel B. The development of commercial scale rapid themal processing of Biomass. In Proceedings of First Biomass Conference of the Americas: Energy, Environment, Agrculture and Industry. 1993; 1194-1200.
12. Trenka AR. Preliminary operational experience from the biomass gasification (BGF) in paia. Hawaii. In Bioenergy 96: partnerships to Develop and Apply Biomass Technologies. 1996; 37-43.
13. White RK, Taiganides EP. Pyrolysis of livestock manure, Livestock manure Management, the Proceedings of 2nd international Symposium on Livestock manure. 1971; 190-191,194.