EE002

Development of a Small Scale Biomass Gasifier and Testing of Various Feedstock

Er. Prakash Giri[1]*, Er. Kailash Thapa[2], Er. Rejit Dulal[2], Dr. Bivek Baral[2]

[1]*Paschimanchal Campus, Institute of Engineering, Tribhuvan University.*

[2]*School of Engineering, Kathmandu University.*

Corresponding author: Er. Prakash Giri. E-mail: giri@wrc.edu.np

Abstract

Biomass is good source of energy in the field of renewable energy. Conventionally, use of biomass was made for simple firing purposes, for cooking and heating. However, more extensive use of biomass is seen in gasification process that may permit electrical utilities to obtain a portion of their fuel requirements from renewable energy sources. Gasification processes convert biomass into combustible gases. Biomass Gasification is a chemical process that converts biomass into useful convenient gaseous fuels or chemical feedstock. It has emerged as a promising technology to fulfill the increasing energy demands of the world, as well as to reduce significantly the volume of biomass waste generated in developing societies [Sastry et. al.]. Maize cones, Maize steam, Pine needle and Cones, Hog Plum Seeds, Furniture Waste, Sugarcane Waste, etc. which has no food value can be used to produce syngas. Maize cones, Pine cones, Hog Plum seeds are compact and need no fuel modification while Pine Needles need to be modified because of its low density. Maize Steam, Furniture wastes and Sugarcane wastes may or may not require fuel modifications. For this academic research, three different fuels – corncobs, sugarcane residue and wood had been selected. Proximate analysis was done at National Product Research laboratory, Kathmandu and syngas composition and temperature were found by experimental setup on 12 KW downdraft gasification systems, manufactured at Gasifier Engine Research Laboratory of Kathmandu University.

Keywords: Biomass, Gasification, Syngas.

1. Introduction

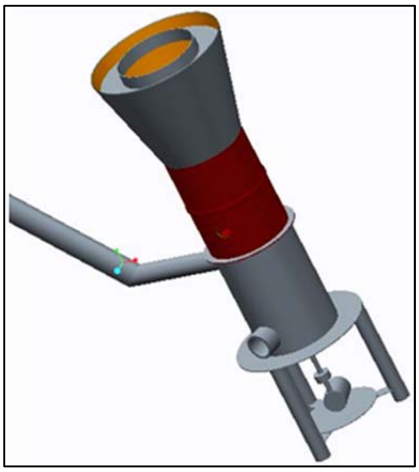
Combustion of biomass in improved biogas gasifier aids in application of improved conversion methods, such as gasification, that match biomass energy to processed liquid and gaseous fuels so that it could be utilized for energy generation. Rural areas of developing countries are very dependent on biomass fuels such as firewood and dried dung for their energy consumption. This use of energy is often coupled with many problems such as deforestation, land degrade, various health and social problems as well as giving raise to emissions of greenhouse gases [Wargert, D.]. In many areas biomass can be used as a replacement for these fuels and can help solve many of the problems that are associated with fossil fuels.

Biomass is converted into combustible gases by gasification. This thermo-chemical conversion of biomass leads to generation of gas generally termed as producer gas or syngas. The syngas is a combustible mixture consisting of mostly carbon monoxide and hydrogen. The main purpose of biomass gasification or syngas is to substitute the fossil fuel consumption in IC engines throughout the load and speed ranges [M. Dahal et. al.]. Gasification is a chemical process that converts carbonaceous materials like biomass into useful convenient gaseous fuels or chemical feedstock. Pyrolysis, partial oxidation, and hydrogenation are related processes.Combustion also converts carbonaceous materials into product gases, but there are some important differences. For example, combustion product gas does not have useful heating value, but product gas from gasification does. Gasification packs energy into chemical bonds while combustion releases it. Gasification takes place in reducing (oxygen-deficient) environments requiring heat; combustion takes place in an oxidizing environment giving off heat [Basu, 2010].

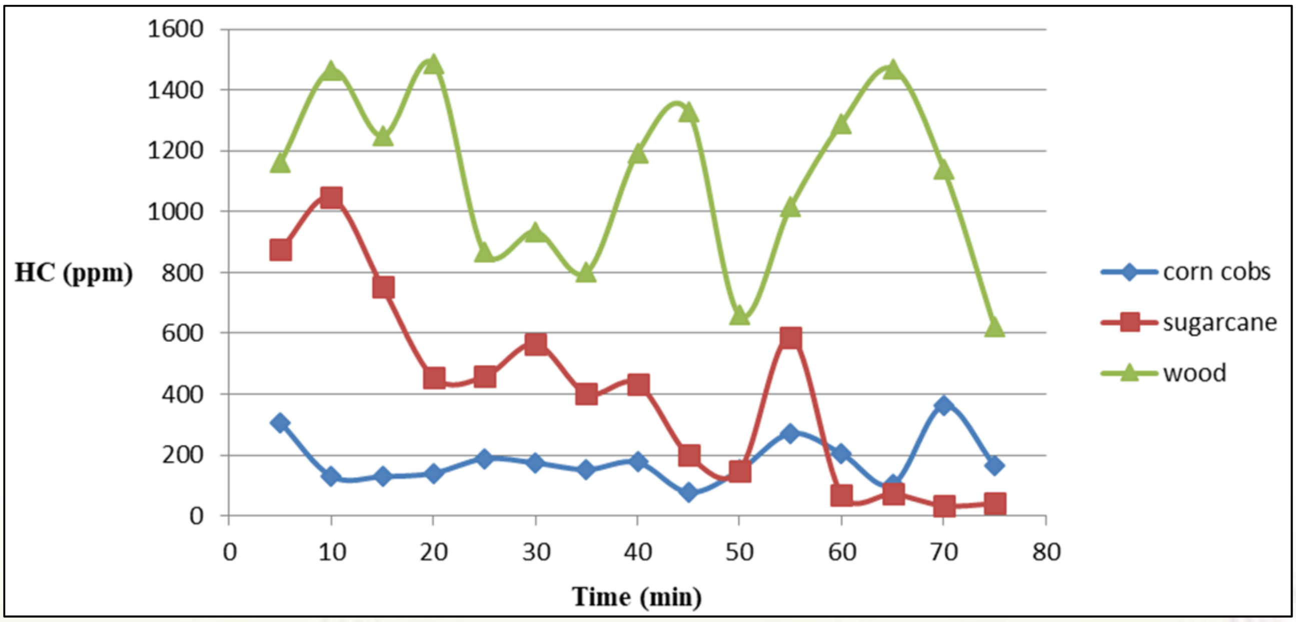
2. Materials and Methods

The design and development of 12kW downdraft biomass gasifier was prime necessity for the test using selected feedstock as fuels to make analysis regarding time, temperature and gas compositions to suggest the best alternative for the design.

Thus a downdraft Gasifier was developed at the laboratory by utilizing locally available materials, including Liquefied Petroleum Gas Cylinder, Mild Steel Sheets and Stainless Steel Pipes. It consisted of five main parts i.e., fuel storage hopper, reaction chamber, primary air inlet, combustion chamber and pot support. Each parts of the stove were independent, assembled together and disassembled by bolts and nuts.



To overcome fuel bridging, Wood of Alnus Nepalensis, Sugarcane Residue and Corn Cobs required pre-processing of cutting/chipping into pieces ensuring smooth flow in the hopper and combustion zone. All feedstock were sundried and made ready for feeding the gasifier system.



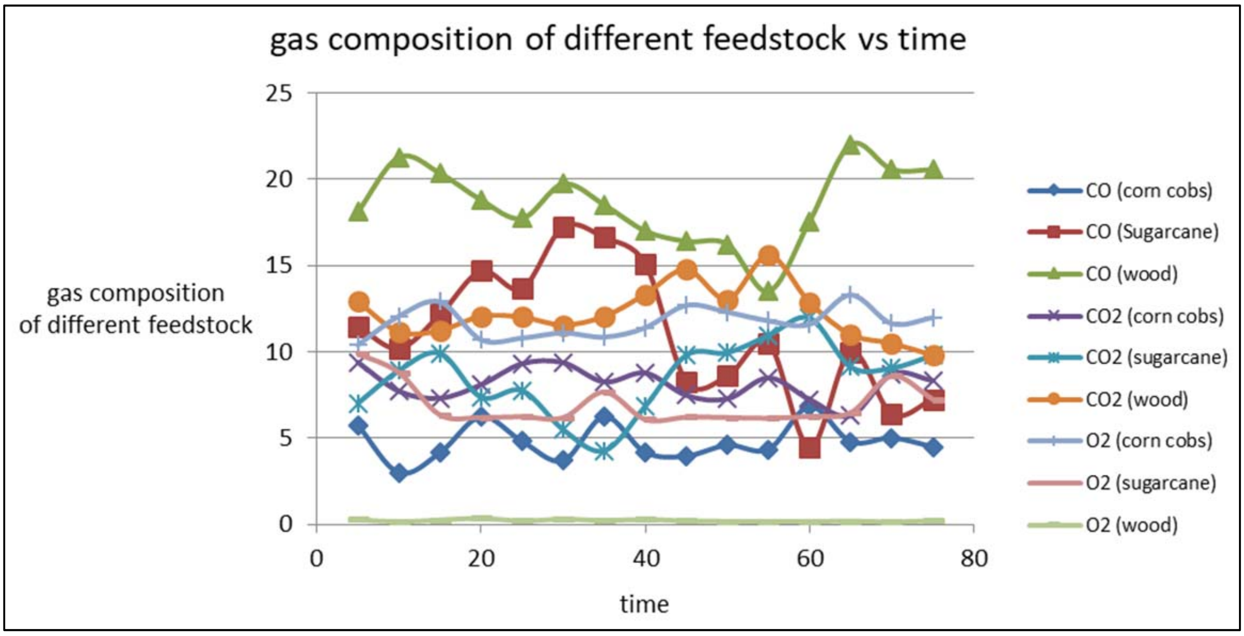
3. Results and Discussion

1) Time vs. Hydrocarbon (HC) Generation Graph of Corncobs, Sugarcane and Wood.

The value of HC of different feedstock with time is shown by the graph above. Here, we can see value of HC is gradually decreasing in all feedstock as time passes on. Lowest value of HC was obtained by sugarcane, then by corn cobs and then by the wood. We can see constant value of HC for corncobs but for other two feedstock we get fluctuating value. Both wood and sugarcane have high value of HC at beginning but get decreases as the time moves forward. The graphical result of HC of different feedstock vs. time shows the decreasing value of HC so that our designed gasifier seems to be cracking tar well.

2) Time vs gas composition of Corncobs, Sugarcane bagasse and Wood

The below mention graph shows comparison of gas composition of different feedstock with respect to time. Gases like Carbon Monoxide (CO), Carbon Dioxide (CO2) and Oxygen (O2) shows different values as time passes on. The inverse relation of CO and CO2 of all the feedstock can be seen in the above graph. We can also see the amount of oxygen obtained during the test of feedstock. The lowest amount of oxygen was obtained in wood, than in sugarcane and then in corn cobs. We found that wood is the best fuel for the designed gasifier.



4. Conclusions

The tests on these three biomass shows that Alnus Nepalensis can be the best option for designed gasifier as it contained low HC i.e. 620 ppm (can further be reduced to 300 ppm on decreasing air flow velocity) and very high CO i.e. 22.01% among all tested fuels. At lab, we varied flow rate of air from blower but result we obtained was not satisfactory. If we lower flow rate of air form blower, there won't be proper combustion and producer gas results in low CO and high CO2 which is not good for the design of downdraft gasifier. The highest temperature obtained in the combustion chamber was 1360°C in case of wood, which is good enough for cracking of tar. Similarly, O2 content in wood test was 0.15% (as the lowest amount) which is also desirable quantity. Thus, it is best fuel for the use on the designed downdraught gasifier for energy production. This implies that Alnus Nepalensis wood which were unused, or only used as firewood or furnishing purposes, could be used to generate a good form of renewable energy using gasification process.

5. Acknowledgements

We would like to acknowledge all the help for the constant guidance during the design, fabrication and testing phases, we received from Mr.Sumit Karki, Mr. Bhaskar Dahal and Mr. Shankar Dev Gyawali who played a vital role to conduct this project by sharing their precious ideas with us. Their valuable suggestions and their shared experiences was what that helped us.

6. References

Sastry, A. B. (2011). Biomass Gasification Processes in Downdraft Fixed Bed. International Journal of Chemical Engineering and Applications.

Wargert, D. (2009). Biogas in developing rural areas. Lund University.

M. Dahal, R. B. (2014). Evaluation of Agricultural and Forest Residue as a Gasifier Fuel. Dhulikhel: Kathmandu University.

Basu, D. P. (2010). Biomass Gasification and Pyrolysis. Elsevier Inc.