Construction of an Updraft Biomass Gasifier and Composition Analysis for Different Biomass Fuels

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Abstract - *Biomass gasification is a process of converting solid biomass fuel into a gaseous combustible gas (called producer gas) through a sequence of thermo-chemical reactions. In this paper the updraft type biomass gasifier constructed and operated with three biomass fuels- wood chips, sugarcane wastes, and coconut shell and to check whether the required composition of the producer gas can be achieved successfully and when the gasifier operated at the constant air velocity the composition of these fuels were found with the help of gas analyzer. In this work, a typical updraft biomass gasifier successfully constructed. The results of the composition of the produced Producer gas for three different biomass fuels were not up to the desirable level but it is expected that a few modifications with this gasifier provides better results.*

Keywords -*Biomass Fuels, gasification, updraft gasifier, construction, composition analysis.*

1. Introduction-

Biomass is the mass of living biological organisms living in an ecosystem at a given time. It can also refer to plant and animal waste that is used for fuel. Biomass is organic material made from plants and animals. Biomass contains stored energy from the sun. Some examples of biomass fuels are wood, crops, manure, and some garbage. Biomass is a renewable energy source because we can always grow more trees and crops, and waste will always exist. Biomass gasification is a process of converting solid biomass fuel into a gaseous combustible gas (called producer gas) through a sequence of thermo-chemical reactions. The gas is a low-heating value fuel, with a calorific value between 1000-1200 kcal/Nm^3 (kilo calorie per normal cubic metre). Almost 2.5-3.0 Nm^3 of gas can be obtained through gasification of about 1 kg of air-dried biomass. Since the 1980's the research in biomass gasification has significantly increased in developing countries, as they aim to achieve energy security. Fuel such as methane produced from renewable biological resources such as plant biomass and treated municipal and industrial waste. Biomass fuels are a specific type of biomass used to produce synthetic fuels or which can be burned in its natural state to produce energy.

In this study, the goal is to construct a updraft biomass gasifier at laboratory scale and operates with different biomass fuels like – wood chips, sugarcane wastes, and coconut shell and to check whether the required composition of producer gas can be achieved successfully.

1.1Theory of gasification – Air biomass gasification can be expressed in four stages as follows -

1. *Drying*:- In this stage, the moisture content of biomass is typically reduced to be 5-35%.In drying zone the temperature is about 100-200°C.

2. *Pyrolysis*:-It is the first step in the combustion or gasification of biomass. When biomass heated in the absence of air to about 350C-600C, it form charcoal, gases and tar vapors. Biomass + heat → solid, liquid, gases products (H_2 , H_2O, CO , CO_2)

3. *Combustion*: - In this process the reaction between solid carbonized biomass and oxygen in the air, resulting in formation of CO_2. Hydrogen present in the biomass is also oxidized to generate water. Large amount of heat is released with the oxidation of carbon and hydrogen.

$C + O_2 \rightarrow CO_2$

4. *Reduction*: - In absence of oxygen, several reduction reactions occur in the temperature range of 600-1000ºC. These reactions are mostly endothermic. The major in this category are as follows:

$C + H_2O \rightarrow CO + H_2$

$C + CO_2 \leftrightarrow 2CO$

$CO_2 + H_2 \leftrightarrow CO + H_2O$

$C + 2H_2 \leftrightarrow CH_4$

2. Construction of Updraft Biomass Gasifier: -

The original aim with this gasifier project, were to build a compact and simple gasifier, that used inexpensive feedstock (like wood chips or mulch that is available very inexpensively, or even free), and produced high-quality gas. The research showed that the updraft gasifier design generally produced the best quality gas. Some gasifier designs are quite complex and difficult to fabricate, others much simpler. So naturally, we gravitated toward the simpler design. The work originally aimed to building a simple open core design.

The basic structure of the gasifier is built around 13 inches inside diameter, 2.5 mm thickness, and 21 inches long air tank of trucks, and a steel tube 5 inches in inside diameter, 3mm thickness, and 22 inches long. These dimensions are not really critical. The tube could be a little longer or shorter, and a little wider or narrower in diameter. The air tank (fig. 2.1 & fig 2.2) and steel tube brought from a scrap market. The purpose of the drum is to be the main body of the gasifier unit. It contains everything and collects all the gas, ash and char the unit will produce. The steel tube serve as a flame tube where the gasification processes takes place.

Figure 2.1-Air Tank (Top View)

Figure 2.2-Air Tank (Front View)

The work has been started by cutting a large hole in the top of the drum so the stainless steel flame tube can be inserted (figure 2.4). The hole was made very oversize, a fortuitous decision as it turned out. The hole is offset to the side of the drum opposite the small bung. The large bung was sacrificed, since I wasn't planning on using it. Next I cut a flange from a piece of 1/8 in steel for mounting the flame tube into the drum. I installed clip nuts on the corners of the hole in the top of the drum, and drilled mating holes in the above flange. This would allow me to bolt the flange down to the top of the drum. Next, I made some angle brackets out of aluminum and bolted the flame tube to the flange. I left 6.5 inches of the flame tube sticking up above the flange. The rest protrudes down into the drum. Here the unit is being test fit on top of the drum. The holes in the ends of the angle brackets are over the clip nuts in the top of the drum. The high temperature silicone gasket material (figure 2.5) is used to seal every crack, crevasse, joint and bolt hole in the gasifier.

Figure 2.3 Cutting of the air tank

Figure 2.4-Cutting flange for tank

Figure 2.5- Silicon gasket

Figure 2.6- Six numbers of j type copper tubes

Here I have installed the six j-tubes (figure 2.6). They are made of 1cm inside diameter, 0.5 mm thickness, and 1 foot length copper tubing. They are called j-tubes because they are shaped like the letter J. I used a large hose clamp cinched down tight to hold the tubes in place. The opening in the top of the drum needed to have a few notches cut in it to accommodate a couple of the j-tubes that stuck out too far.

The constrictor plate (figure 2.7) installed in the bottom of the flame tube. To make the plate I cut a circle out of a 11 inch sheet steel that would fit in the bottom of the flame tube. Then I cut a 1.6 inch diameter hole in the center of the circle. To mount the constrictor in the flame tube, I welded three 1/4-20 nuts to the plate, and drilled passage holes in the flame tube for three 1/4-20 bolts. The manifold I made to cover the inlets of all six j-tubes. It was cut from a 6 in to 4 in steel AC duct reduction fitting. It slips down over the flame tube and covered all six j-tubes. A single air inlet fitting will be installed on the side of the manifold.

Figure 2.7-Constrictor plate

Figure 2.8- Updraft gasifier

After this, the gasifier is ready to use. But before starting the gasifier, it has been equipped with all the measuring instruments to take the readings.

3. Experimental Set-Up and Procedure -

In this setup (figure 3.1) the updraft biomass gasifier installed with the blower of different speeds, Anemometer, k type thermocouple and digital temperature reader. First of all the pulverized coal is heated with direct burning and this coal is used for the initial combustion of biomass fuel. This burn coal placed to the grate. And firstly I used wood chips as a biomass fuel and filled the flame tube and closed the upper portion of the flame tube with the special type cap which having two outlet valves for the producer gas one is going to the burner and another to the nozzle.

Figure 3.1 Experimental setup of updraft biomass gasifier

Figure 3.2: Experimental setup and burning flame in the burner.

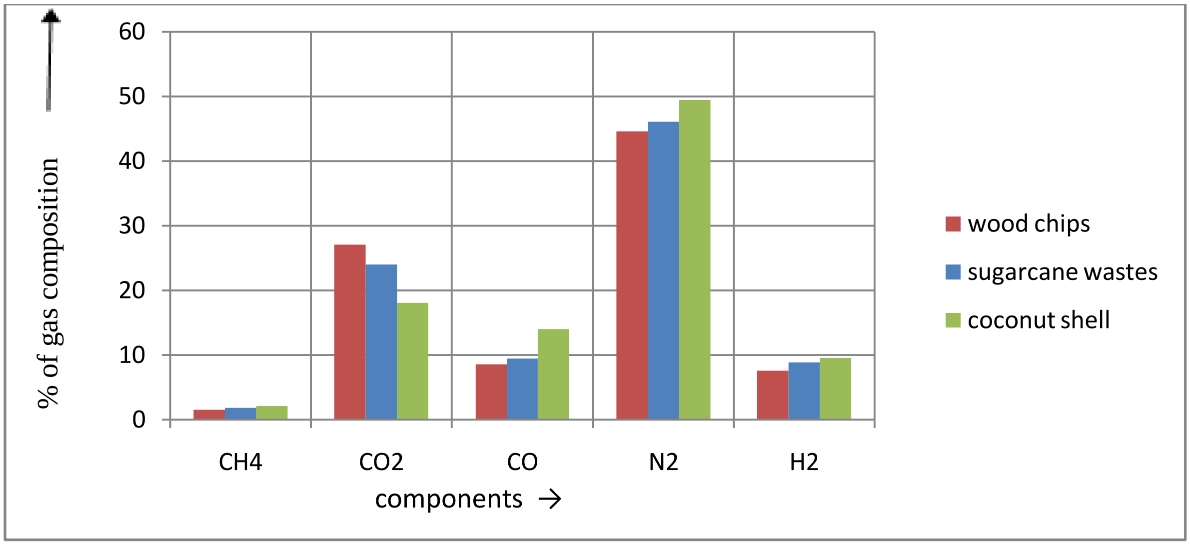
After this I will starting the blower with minimum speed the process of the gasifier is started and when the speed of the blower increases the combustion presses of the gasifier gets faster at a time the temperature of the three different zones of the gasifier increase greatly. And the readings of different air velocity taken from the Anemometer and temperatures of three different zones taken from the Digital Temperature reader. And this process Continues with the other two fuels sugarcane wastes and coconut shell.

4. Results & Discussion

Table 4.1 shows the composition of the producer gas for three different biomass fuels were found by the gas analyzer. Air flow rate is constant for all three fuels.

Table: 4.1 Composition of gases for three biomass fuels.

Gases	Composition (mol %)			
	Typical	Experimental		
		Wood chips	Sugarcane wastes	Coconut shell
CH4	2-5	1.5	1.8	2.1
CO2	8-12	27	24	18
CO	20-22	8.5	9.4	14
N2	50-54	44.6	46	49.4
H2	10-15	7.5	8.8	9.5



Graph-1: The % of gas composition and gas components for these three fuels.

From the Table and graph, it is found that the obtained gas composition for wood chips, sugarcane wastes, and coconut shell particularly the hydrogen content is close to but less than the desired composition. The composition data for these fuels also show that the produced gas contained a large amount of CO_2. But excessive tar formation occurred during the gasifier operation. All of these results referred to poor partial oxidation. This was due to poor control of airflow rate and lack of strong suction at gas outlet as well inadequate drying of feedstock. Lower moisture content of the feedstock is necessary for efficient operation of the gasifier. The further treatment such as filtration of the producer gas is needed before the gas can be used as engine fuel.

5. Conclusion

An updraft biomass gasifier was successfully constructed and operated using wood, sugarcane wastes, and coconut shell as feedstock. The results of the composition of the producer gas of these three biomass fuels were not up to the desired level, but it is expected that a few minor modifications with this gasifier will provides better results.

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