Development of Downdraft Biomass Gasifier

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Abstract - *Gasification is a thermal conversion process in which both heat and a combustible gases are produced. One method of gasification referred as partial oxidation, It is very similar to combustion, except that it occurs with insufficient oxygen supply. Objective of this research is to come up with a substitution for the use of fossil fuels by producing a gas by burning wood pallets in a oxygen limited environment.*

The produce gas is either a medium-energy content gas referred to as synthetic gas. Synthetic gas consists primarily of carbon monoxide and hydrogen.

The product gas can be burned in conventional boilers, furnaces, engines and turbines, or co-fired with natural gas.

This method can be use in industrial energy applications and to limit the use of Petroleum based fuels which result high emission of sulfur to the atmosphere.

***Keywords*— Gasification, Synthetic gas, Partial oxidation**

I. INTRODUCTION

In Primary gasification air is introduced at or above the oxidation zone and producer gases is removed from bottom of the gasifier

On their way down the acid and tarry distillation products pass through glowing bed of charcoal and converted to permanent gases.

Advantages of such gasifiers are the possibility of producing tar free gas suitable for engine applications, mainly an alternative for domestic cooking purposes, flexible adaptation of gas production to load, less environmental objection, and higher fuel conversion rate.

The downdraft gasifier energy efficiency is maximized by lowering Tar and increasing Char as a byproduct.

An updraft gasifier has clearly defined zones for partial combustion, reduction, and pyrolysis.

Air is introduced at the bottom and act as countercurrent to fuel flow. The gas is drawn at higher location. The updraft gasifier achieves the highest efficiency as the hot gas passes through fuel bed and leaves the gasifier at low temperature. The sensible heat given by gas is used to preheat and dry fuel.

Disadvantages of updraft gas producer is that excessive amount of tar in raw gas, and poor loading capability.

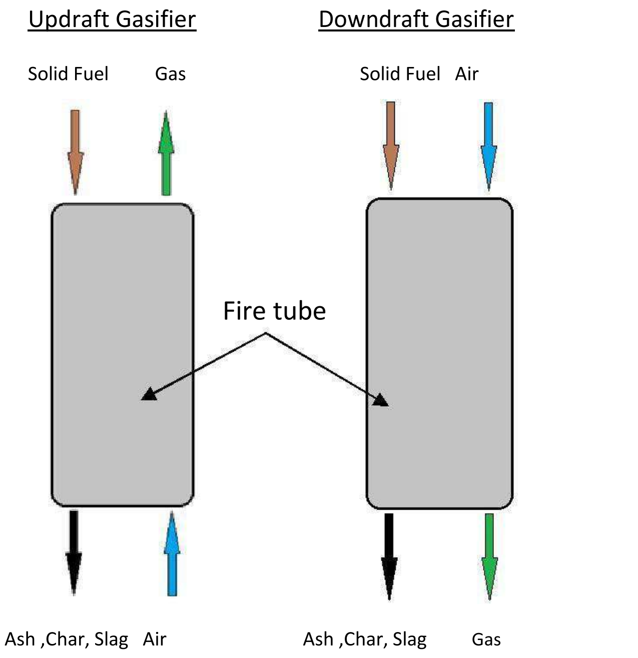

Figure 1:Updraft and Downdraft gasifiers

Gasification VS Combustion

In a financial analysis comparing gasification and combustion options, the lower operating and maintenance costs and longer equipment life cycle possible with gasification. The lower air emissions of gasifiers (and possibly reduced cost of air emissions equipment to achieve environment country standards) should be considered in estimating capital costs.

In comparison, combustion appliances are operated to maximize efficiency by minimizing char. In a financial analysis of a gasification project, the value of producing char as a marketable byproduct versus achieving high efficiency is a grate achievement. If we can Engineer a Gasifier in a such a way that produce no char and their thermal efficiency can be very high. But in practical application it is not possible to achieve this requirement. But by filtering the syngas energy density can be increased.

While gasification has been successfully demonstrated in projects of several megawatts in size over a number of years, it is still an emerging commercial technology. As capital costs drop, operating experience increases, and the economic value of carbon emission reductions increases, cost effectiveness of gasification compared to combustion will improve. It is noted that Bio-mass is a renewable energy source with no Sulphur emission to the environment.

Gasification VS Pyrolysis

Another thermal conversion technology similar to gasification. While gasification occurs with restricted oxygen and pyrolysis occurs in the absence of oxygen or steam.

In pyrolysis, biomass is heated to the point where volatile gases and liquids are driven off and then condensed into a combustible, water soluble liquid fuel called bio-Oil

Bio-oil from fast pyrolysis is a low viscosity, dark-brown fluid with a high tar content and a water content of 15% to 20%. Bio-oil can be burned in a boiler, upgraded for use in engines and turbines, or used as a chemical feedstock. Being a liquid fuel, bio-oil is easier to transport than syngas but its corrosiveness makes long-term storage difficulties.

Both gasification and pyrolysis produce char, which can be used as a soil amendment, precursor to activated carbon, or burned. Slow pyrolysis results in a higher percentage of char (up to 35%), it comes handy if char production is desired co-product. Such uses of the bio char can make gasification and pyrolysis carbon neutral or even carbon negative.

	Combustion	**Gasification**	**Pyrolysis**
Oxidizing Agent	Grater than stoichiometric supply of Oxygen	Less than stoichiometric Oxygen or steam as the oxidizing agent	Absence of oxygen or steam
Typical temperature range	800’ C to 1200’C	800’ C to 1200’C	350’ C to 600’C
Principle Products	Heat	Heat & Combustible Gas	Het , Combustible liquid and Combustible Gas
Principle component of Gas	CO2 and H2O	CO and H2	CO and H2

Table 1 : Combustion ,Gasification ,Pyrolysis

II. Methodology and Approach

Gasification occurs at lower temperatures than combustion. As a result long life cycle in the equipment can be achieve , Low maintains cost comparing with high temperature combustion Engines.

A variety of products can be achieve in gasification process. Syngas can be used as a feedstock to produce other fuels (such as ethanol, methanol, naphtha, hydrogen, gasoline and diesel) and as a feedstock for chemicals (such as acetic acid, dimethyl ether, and ammonia). The char in particular can have a high value as a co-product which can sell in Export market and also the use of Bio-oil as a firing agent oil in furnace.

Figure 2 : Bio Oil as a co-product

Gasification can facilitate combined heat and power. Heat recovery can be achieve through a series of applications with each step using a lower temperature. Heat can be recovered from the gasification process and from electrical generation equipment.

Use of waste heat can be used by.

- Generating steam and hot water for industrial applications.
- Space heating,
- Generating power using an organic Rankin cycle turbine,
- For the use of refrigerating needs with absorption chillers.
- Gasification makes biomass-fired integrated combined cycles possible.

The product gas is first burned in a gas turbine to generate electricity (topping cycle). Second, waste heat from both the turbine and the Gasifier is recovered in a heat recovery boiler and used to generate electricity by a steam turbines, engines and fuel cells increases efficiency of electricity generation.

An important advantage of gasification compared to combustion is, its potential to achieve higher efficiencies and lower emissions. Generating a gaseous fuel makes the use of reciprocating engines, gas turbines and fuel cells possible in the generation of electricity.

Gaseous fuels are easier to transport than solid biomass. A gasifier could be located elsewhere with the product gas piped to the point of use.

	Oil and Tars, Water(Liquid)	Char (Solid)	Product Gas
Fast pyrolysis Medium Temperature T=500'C	60% to 70%	10% to 15%	10% to 25%
Gasification Higher temperature T>800'C	Up to 20%	Up to + 20%	85%

Table2: Gasification vs Pyrolysis.

Updraft gasifier produce 10% to 20% tar while tar content from downdraft gasifier is low. Downdraft gasifier produce 20% or more char, while char content from updraft gasifier is low.

Processes and reaction chemistry for the downdraft gasifier. Biomass is introduced into the downdraft gasifier at the top. Due to the heat transfer from the lower part of the gasifier, drying of biomass takes place in the bunker section case is the fire tube.

Moist feedstock + Hear $\longrightarrow$ Dryfeedstock+H_2O

The water vapor flows downwards and adds to the vapor formed in the oxidation zone. Part of this reduces to hydrogen and the rest ends up as moisture in the gas where certain amount is reduce by using the Cyclone Filter.

Dry feedstock + Hear $\longrightarrow$ Char + Volatiles

An oxidation or burning zone is formed in the section where air/oxygen is supplied which is drawn from the top of the fire tube through the wood pallets.

$C + O_2 = CO_2$ $2H_2 + O_2 = 2H_20$

Instead of generating heat, another important function of the oxidation zone is to convert and oxidize virtually all condensable products coming from the pyrolysis zone.

$$C + CO_2 = 2CO$$
$$C + H_2O = CO + H_2$$
$$CO + H_2O = CO_2 + H_2$$
$$C + 2H_2 = CH_4$$
$$CO + 3H_2 = CH_4 + H_2O$$

III. RESULTS AND DISCUSSION

By heating 1L of water by using , LP Gas , Bio Gas and Bio Mass the following results were observed.

Time	LP Gas	Bio Gas	Bio Mass
0	27	27	27
15	42	42	37
30	52	52	43
45	60	58	49
60	69	65	56
75	74	70	59
90	79	75	63
105	84	79	67
120	87	82	71
135	90	85	74

150	94	89	78
165	95	91	82
180	97	94	85
195	98	96	88
210	100	98	91
225	-	99	93
240	-	100	96
255	-	-	98
270	-	-	99
285	-	-	100

Table 3: Temperature vs Time

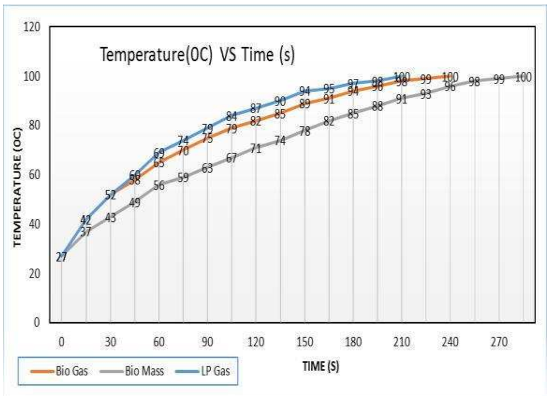

Figure 3 : Temperature vs Time Curve to heat up 1L of Water

This results clearly indicates that this method can be use in Hotel industry which has a very high efficient level in performance.

Also this gas can be use to fire a Petrol Engine with a correct Air to Gas ratio.

The gasifier also will usually requires a ash or bio-char removal equipment. Gas cleanup equipment will generally be required downstream of the gasifier, In oxygen-blown gasifiers, an oxygen plant is required. If wet scrubbers are used for tar removal, water treatment will be required. The project may also include equipment such as boilers, absorption chillers and heat exchangers for heat recovery, depending on the application.

Figure 4 : Syngas emission

Figure 5 : Clean syngas emission

Product Gas Composition

The product gas is primarily composed of carbon monoxide and hydrogen, and if air is used as the oxidizing agent, nitrogen is also there. The product gas will also have smaller quantities of carbon dioxide, methane, water and other contaminants, such as tars, char, and ash. The percentages of each of these components depends on a number of parameters, including the temperature and pressure of gasification.

Significant methane is only produced at high temperatures. More char is produced at lower temperatures, below about 700°C (1300°F), with a corresponding decrease in energy content of the product gas.

Moisture content is critical in combustion, gasification and pillarization. Maximum moisture contents required for gasification depend on the gasifier type. Downdraft fixed bed gasifiers cannot tolerate moisture contents above about 20%. So for selecting Pallets moisture level should be in the tolerance zone.

Updraft fixed bed gasifiers and fluidized bed gasifiers can tolerate higher moisture contents of 50% and 65%, respectively. Pellet mills also generally require moisture contents of less than 15% to produce stable and durable pellets.

Figure 6 : High flammable syngas

IV. Conclusion

Coal and biomass have different properties and each presents different challenges and advantages. There is much more experience gasifying coal than gasifying biomass and conventional designs ,for coal have often been troublesome when used with 100% biomass.

Compared to coal, biomass fuels have varying chemical content, so each type of biomass must be considered separately. But several generalizations can be made. Sulfur and ash is typically lower in biomass, but alkali metal content and silica content, which lead to slagging, is often greater in biomass.

Volatile matter is generally much greater in biomass. At the low end, volatile matter comprises only about 5% of anthracite coal, while wood contains more than 75%. Therefore, wood is more easily converted to gas and produces less char but more tar. Efficient use of char within the gasifier is more important in coal gasification.

Volatile matter content	Greater
Oxygen content	Greater
Sulfur Content	Lower
Ash content	Lower
Alkali metal content	Greater, Especially for agricultural wastes.
Hydrogen to Carbon Ratio	Greater
Heating Value	Lower
Tar reactivity	Greater for woody biomass

Table 4 : Biomass vs Coal

Environmental Benefits of this Research.

- Reduced carbon emissions by improvements in energy efficiency
- Reduced carbon emissions by closing the carbon
- cycle and carbon sequestration
- Reduced NOx emissions

This Project is a tremendous opportunity for domestic industries in Sri Lanka to fulfill their energy needs by using this as a cost effective method.

For the hotel industry this method can be use for

- Cocking purposes ,
- Heating water.
- The co-products can be use for future needs and even sell it in the domestic market.
- Fire up Petrol generators for Electricity.
- Solution for recycling biomass.

Biomass gasification offers one of the most promising renewable energy systems for developing countries like Sri Lanka. A more extensive and attractive system could be a downdraft gasifier capable of generating sufficiently low tar content syngas for engine applications. The biggest challenge in gasification system is reliable and economical cooling and cleaning technology.

The successful Downdraft Gasifier being comparatively easy to build with low cost materials, downdraft gasifiers could be an attractive technology for thermal power applications.

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