EXPERIMENTAL ANALYSIS FOR EFFICIENCY OF BIOMASS GASIFIER ON MOISTURE CONTENT

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ABSTRACT

The gasification process is getting attention towards the renewable energy sources. This paper contains the design of gasifier and how the moisture content of solid biomass affects the efficiency of gasifier. It also contains the proximate analysis of solid biomass (wood) and the composition of producer gas. Producer gas contains Carbon dioxide (CO_2), Carbon monoxide (CO), Hydrogen (H_2), Nitrogen (N_2), Methane (CH_4). It is analyze that the efficiency of gasifier increases with increase in moisture content up to some extent and then start decreasing with increase in moisture content. Moisture content also affects the composition of producer gas so study of most efficient syngas composition is also done in this paper.

Keywords: Gasification, Gasifier, Moisture content, Proximate analysis, Renewable energy.

I. INTRODUCTİON

The conversion of solid biomass into combustible gas or producer gas will play a vital role in future energy demand. This technology is eco-efficient and installing cost is not much high. This technology can be used for different purposes in burners (boilers, furnace, water heating etc), can be directly used in internal combustion engines and in the generator to generate electric power. Before using in IC engine or generator we have to decrease its temperature to room temperature and need to clean it using filters to make it tar and dust free.

The gasification process occurs when solid biomass undergo partially combustion i.e. combustion with restricted supply of oxygen, the carbonaceous material of biomass into producer gas thus the chemical properties of biomass also plays a vital role in the design of downdraft gasifier and the producer gas releases contains Carbon dioxide (CO_2), Carbon monoxide (CO), Hydrogen (H_2), Nitrogen (N_2) and some quantity of Methane (CH_4) [1]. This technology is also used to enhance the quality of fuel like wood convert to peat and coal & coal convert to coke. Chemical conversion of the entire particle present in solid biomass take place but the inert material and residue remains in gas which are not combustible and do not play any role in the calorific value of gas. The hydrogen and carbon monoxide are major elements which are responsible for better calorific value. The hydrogen is high calorific value fuel and can be separated out from the producer gas [2].

Temperature and residence time are very important parameter for the quality of combustible gas. The quality of producer gas also depends upon types and design of gasifier. The oxygen blown gasifiers can produce good quality of gas but they are cost efficient only for large scale plants, so form a small capacity plant we generally use air blown to minimize our operating cost. The gasifiers are classified mainly into three category fixed bed gasifiers (Updraft and Down draft), fluidized bed gasifiers (bubble type FBG, circulating type FBG) and entrained bed gasifiers. In updraft gasifiers the oxidant (air/oxygen) in feed from the bottom of gasifier and the solid biomass is feed from the top of gasifier and also the producer gas is collected from the top of gasifier. This paper contains the study of downdraft gasifier in which the oxidant is feed at a height from the base which helps to avoids the disadvantages of tar and producer gas is collected from the bottom. The gasification is done in four stages which are drying zone, pyrolysis zone, combustion zone and reduction zone. In drying zone fresh biomass comes in contact to hot gases the heat of gases gained by fresh biomass which is used to dry the biomass. The pyrolysis zone having more temperature then drying zone, the tar cracking and releasing of volatile matter take place in pyrolysis zone. Actual combustion takes place in combustion/oxidation zone, in which solid particles converted into gas. The main disadvantage of downdraft gasifier is the high carbon content in bottom ash which is explained by the reduction zone, the last zone from the top and first from the grate [3].

The hydrocarbon cracking take place at 950℃ to 1040℃ results in 10 to 100 ppm in producer gas [4]. D'Eglise makes clear in his study that the pyrolysis oil generate at low temperature. The oil removed from the biomass is then convert into gases form and the particle of solid biomass in chamber also play role for producer gas.

II. METHODOLOGY

The different material and methods are use in this work. The fabrication of the apparatus must be done by considering that the material must be sustainable at high temperature (1000℃) and must be fabricate by keeping in mind that less heat should be loss to the surrounding.

A venture is provided in the gasifier near the air inlet for the uniform combustion throughout the area, when we decrease the area near the air inlet the combustion will take place in small area and the flame spread upside uniformly, this concept decreases the numbers of nozzle needed for the gasification. Nozzles are provided for the supply of air with high velocity such that the air supplied from one side can provide the oxygen at other end also.

For the calculation of efficiency we must know about some parameters like biomass feed rate, calorific value of biomass, gas flow rate at outlet and the calorific value of gas, by knowing the values of these parameter we can calculate the efficiency of gasifier by mathematical expression give below:

η=(CV of gas*gas produces)/(CV of wood*wood consume)

- Calorific value of wood can be calculated by using bomb calorimeter.
- Biomass consumption can be calculated by the consumption of biomass when gasifier is in operating condition
- Gas calorific value can be calculated by using gas calorimeter.
- The flow rate of gas can be taken by using anemometer and quantity can be calculated by: (flow rate * area at outlet)

Temperature, Pressure, Moisture content of biomass, Residence time etc are the major parameters on which efficiency of gasifier depends. The study for each parameter can be conduct but this paper contains the effect of moisture content on efficiency of gasifier. As the moisture content of biomass (wood) increases its calorific value decreases and proximate analysis have different results.The moisture content of biomass also affects the content of producer gas i.e. the gas at the outlet which is combustible. When the moisture content is less the content of carbon monoxide (CO) is more and content of hydrogen (H_2) is less. As the moisture content increases H_2 content increase and CO content decreases up to some extent but after some specific percentage of moisture content, the content of H_2 and CO get fixed (contents doesn't change) that is known as most efficient syngas composition. As the hydrogen gas content increase in producer gas the calorific value increases even content of carbon monoxide decreases because the calorific value of H_2 is more the CO.

III. EXPERIMENTAL APPARATUS

In this apparatus the biomass is feed from the top and the air is blown at some height from the bottom, it is feed into gasifier with a nozzle with high speed at the position where a throat is made, it is done so to achieve a uniform combustion in the combustion zone. We provide an initial energy to start burning in gasifier. The biomass starts burning and cracks to oil and gases component. Biomass flows top to bottom and the gases exits from the bottom side, below the grate. At the bottom a ash pit is mounted in which water is filled to make it leak proof.

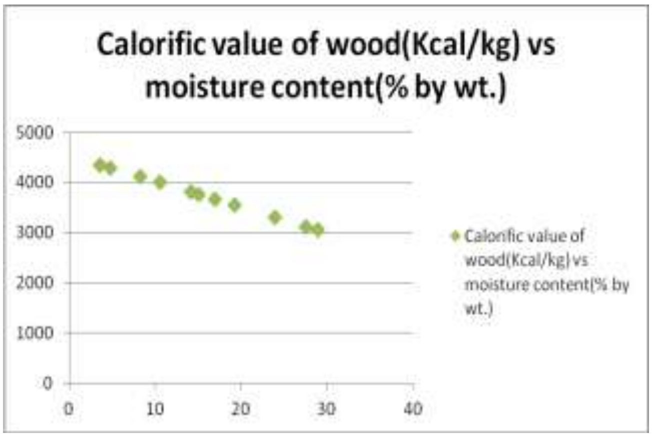
Fig: Construction and Parts of Gasifier

The bottom as well as the top of gasifier is seal by water or we can say it is water sealed. To make leak proof a grove is made at the top and filled with water in which the border of cap or lid is dipped.

The temperature sensor is fitted in the combustion chamber to check inside temperature and it is connected to a control panel to get digital reading of temperature.

IV. RESULTS

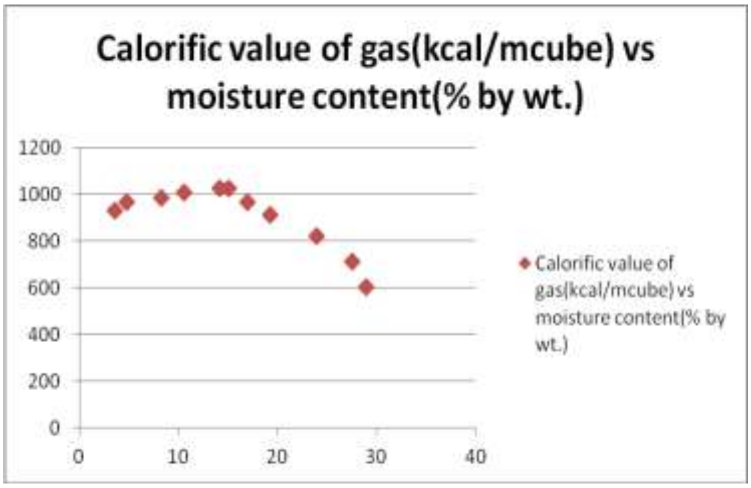
- ❖ Variation of calorific value of wood with respect to moisture content of wood is shown below:



Graph: Calorific Value of Wood vs Moisture Content of Wood

From the graph it can be observed that with increase in moisture content the calorific value of wood continuously decreases.

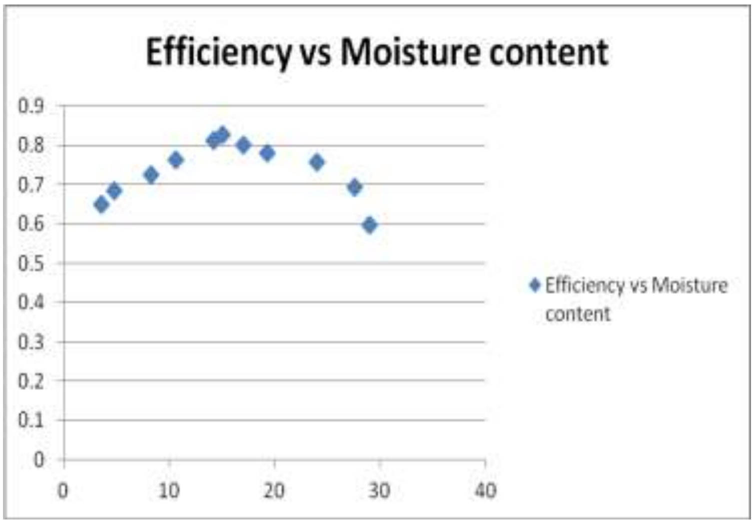
❖ Variation of calorific value of producer gas with respect to moisture content of wood is shown below:



Graph: Calorific Value of Gas vs Moisture Content

From the graph it can be observed that with increase in moisture content of the calorific value of gas increases up to some extent and then start decreasing. Highest calorific value is achieved 15.1% of moisture content.

❖ The analysis of efficiency with varying moisture content of wood and shown in graph below:



Graph: Efficiency vs Moisture Content of Wood

It is clear from the graph that in the range 14% to 17% of moisture content the efficiency of gasifier is more and highest at 15.1% i.e. 82.7%.

❖ The temperature inside the apparatus is observed to be 849°C on which gasification occurs.

V. CONCLUSION

The down draft gasifier gives low tar producer gas and are more appropriate to use in IC engines and generators. The calorific value of wood and gas is 3769.12 Kcal/kg and 1027Kcal/m^3 respectively and the maximum efficiency is observed to be 82.7% at 15.1 % of moisture content and the most efficient syngas composition is present at 15.1% of moisture content where the efficiency is maximum and calorific value of gas is highest.

REFERENCES

[1]. [1] Iyer et.al,2002

[2]. [2] Baratieri M, Baggio P, Fiori L, Grigiante M. Biomass as an energy source: thermodynamic constraints on the performance of the conversion process.Bioresour Technology 2008;99:7063–73.

[3]. [3] Kramreiter R., Url M., Kotik J., HofbauerH. Experimental investigation of a 125 kW twin- fire fixed bed gasification pilot plant and comparison to the results of a 2 MW combined heat and power plant (CHP). Fuel Processing Technology 2008; 89: 90-102

[4]. [4] Storm, 1985

[5]. zainal,AliRifau,G.A.Quadir,K.N.Seetharamu. Experimental investigation of a downdraft biomass gasifier. Biomass and bioenergy 23 (2002) 283-289

[6]. Stassen, H.E.M.; UNDP/World Bank Small Scale Gasifier Monitoring Report, Volume 1 - Findings, Biomass Technology Group, The Netherlands(1993)

[7]. Garcia,X.A. and Huttinger, K.J.; steam gasification of napthalene; catalyst: calcium oxide, Erdol und Kohle, 43,273(1990)

[8]. ED technical evaluation of wood gasification, EPIR-AP-2567, synthetic fuel association Inc., palo alto, CA, august 1982.

[9]. Sadaka, S. S., A. E. Ghaly and M. A. Sabbah. 2002. Two phase biomass air-steam gasification model for fluidized bed reactor: Part I, II, III. Biomass and Bioenergy 22: 439-487

[10]. Gore, W.T. 1981. Priorities in energy research with special assessment of biomass and producer gas. National Timber Research Institute, South Africa.

[11]. Gasifier and Equipment Manufacturing Corporation (GEMCOR), 1982. Gasifier Applications, Manila, Philippines.

[12]. Chopra S. and Jain A. K., 2007.A Review of Fixed Bed Gasification Systems for Biomass, Agricultural Engineering

[13]. Generator Gas: The Swedish Experience from 1939- 1945. SERI/SP-33-140, 1979 (Solar Energy Research Institute, Golden, Colo).

[14]. Solar Energy Research Institute, 1988, Handbook of Biomass Downdraft Gasifier Engine Systems, Colorado.