ISSN 2395-1621

Design and development of downdraft biomass gasifier to generate producer gas

#1Nikhil Ashok Ingle, #2Sanjay Shridhar Lakade

[1]nikhilingle26@gmail.com
[2]sslakade65@gmail.com.com

#1Student,Mechanical Department,PCCOE, Pune
#2HOD,Mechanical Department,PCCOE, Pune.

ABSTRACT

Utilisation of waste is the need of hour today. The waste which cannot be degraded by bio-chemical route like agricultural waste, wood waste can be converted into useful fuel through the process called Gasification. Gasification is a thermo-chemical process which converts solid biomass into a mixture of combustible gases that can be used in various applications. In this project, a downdraft gasifier is designed and developed for generating producer gas for fulfilling heating requirement of a heat treatment furnace. Wood pellets are to be used as a feed stock in the gasifier. The performance characteristics of the gasifier are studied at different air flow rates. A reduction in the overall cost for replacing fuel oil is estimated. Performance of gasifier with other feedstoks such as agricultural waste briquettes is checked and their results are compared.

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

Keywords— **Biomass, Gasifier, Producer gas, Performance.**

I. INTRODUCTION

The use of wood to provide heat is as old as mankind, but by directly burning the wood we only utilize about one-third of its energy. Two-thirds is lost into the environment with the smoke. Gasification is the method of collecting the smoke and its combustible components. The laws which govern combustion processes also apply to gasification. The solid biomass fuels suitable for gasification cover a wide range, from wood and paper to peat, lignite and coal. All of these solid fuels are composed primarily of carbon with varying amounts of hydrogen, oxygen and impurities such as sulphur, ash and moisture. Thus, the aim of gasification is the almost complete transformation of these constituents into gaseous form so that only the ashes and inert materials remain.

Gasification is the thermochemical phenomenon in which chemical transformation occurs along with the conversion of energy. In a sense, gasification is a form of incomplete combustion. Heat from the burning solid fuel creates gases which are unable to burn completely, due to insufficient amounts of oxygen from the available supply of air.

In the gasification process, solid biomass are broken down to produce a combustible gas by the use of heat in an oxygen-starved environment. Heat for gasification is generated through partial combustion of the feed material. The resulting chemical breakdown of the fuel and internal reactions result in a combustible gas usually called "producer gas" [1]. The main combustible gases are H_2 and CO, but small amounts of methane, ethane and acetylene are also produced. Overall gasification efficiency is generally dependent on the specific gasifier used, fuel type, fuel moisture content and fuel geometry. Fuel gas from air blown gasifier has low calorific value (around 5MJ/m^3) and fuel gas from oxygen fed gasifier has a medium calorific value (10 – 20 MJ/m^3). This gas can either be used on site to produce heat, electrical or mechanical energy or can be converted into substitute like methane and methanol

The main objective of the present work is to design and develop a down draft gasifier that uses wood as a feed stock to generate producer gas which will help to fulfill heating requirement for heat treatment furnaces. An experimental study [2] was carried out on a 75kW downdraft biomass gasifier system to obtain temperature profile, gas composition, calorific value and trends for pressure drop across the porous gasifier bed, cooling-cleaning train and across the system as a whole in both firing as well as non-firing mode. In the reactor, both gas and biomass feedstock move downward as the reaction proceeds. While biomass flows because of gravity, air was injected with the help of a blower. Experiments were conducted to obtain fluid flow characteristics of the gasifier and also to obtain the temperature profile in the reactive bed, the gas composition and calorific value. For non-firing gasifier, the extinguished bed showed greater pressure drop as compared to a freshly charged gasifier bed.

An experimental study was carried out on producer gas generation [3] from wood waste in a downdraft biomass gasifier. They used sesame wood or rose wood as biomass. They observed that biomass consumption rate decreased with an increase in the moisture content and it increased with an increase in the air flow rate. The performance of the biomass gasifier system was evaluated in terms of producer gas composition, the calorific value of producer gas, gas generation rate, zone temperatures and cold gas efficiency. Thermocouples were placed inside the gasifier at different locations to measure the temperature of various zones of gasifier. They found the producer gas composition using gas chromatograph.

II. EXPERIMENTAL METHOD

A. *Experimental Setup*

The setup was build in company named DECK INDIA Engineering pvt. Ltd. Fig 1 shows the schematic of the downdraft gasifier. It consists of hopper, reactor, grate, ash handling system, air blower. The hopper is made up of MS material with 650 mm OD and 500mm ID. It is used to hold the biomass into it. The biomass is fed through hopper into the reactor. The reactor is a cone shaped cylinder made up of SS 304. material in which the actual reactions take place. The gas is generated in this region and then comes out from the bottom. The feed material is held on grate also made of SS 304. The remaining ash is collected in the ash pond. A air blower of 1 Hp motor with variable air flow rates is used to provide sufficient quantity of air for combustion. Three air nozzles are provided at 120 deg each.

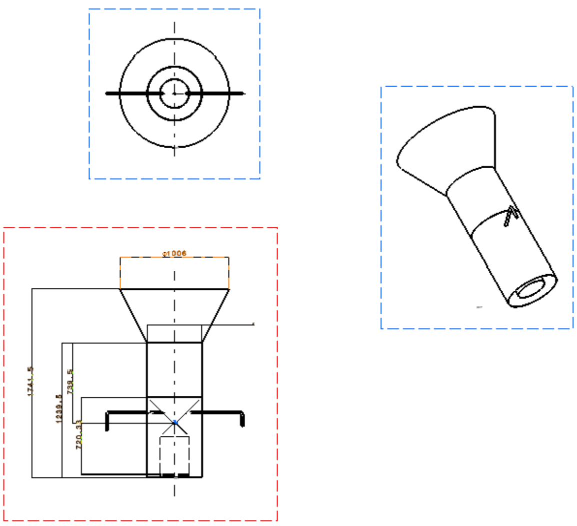

Fig1. Schematic of gasifier

The table 1 below shows the design parameters of various components of gasifier.

Table 1 Specifications of the different components of the gasifier

Gross Diamensions		
Height 1900 mm	Diameter 650 mm	
Hopper	ID 500 mm OD 650 mm	Height 800 mm
Reactor	Throat Diameter 200mm	Height 750 mm
Nozzles	Diameter 12.5 mm	Nos. 3
Grate	Diameter 330 mm	Nos. 1
Ash Pond	Diameter 650 mm	

B. *Experimental Procedure*

In the present work K type thermocouples, hot wire anemometer are used to measure temperature and velocities respectively. Gas analyser is used to measure the constituents of the gas. In this work, first the feedstok used are wood pellets of sizes 100-150 mm, then of size 30-50 mm, and agricultural waste of 70-80 mm.

Fig2. Experimental setup of gasifier

C. *Process Technology*

The Gasification process technology is based on production of a highly combustible gas by controlled reactions of Biomass viz. rice husk, wood, palm nut shell etc. with air and water vapour. A number of chain chemical reactions are believed to take place in the gas generator from the bottom to the top, a proper mixture of air water vapours pass through channel free compact fuel bed ensuring the following reactions to take place.

Oxidation Zone: $C + O_2 = CO_2$ (+393 MJ/kg mole)

$2H2 + O2 = 2H2O$ (-242 MJ/kg mole)

Reduction Zone: $C + CO_2 = 2CO$ (- 164.9 MJ/kg mole)

$C + H_2O = CO + H_2$ (- 122.6 MJ/kg mole)

$C + 2H2O = CO2 + 2H2$ (-88 MJ/kg mole)

$CO + H2O = CO2 + H2$ (+42 MJ/kg mole)

$C + 2H2 = CH4$ (+75 MJ/kg mole)

Composition of Gas : Though for different biomass fuels, there may be little variation in gas composition as well as the heating value, the gas composition and calorific value in general are as follows :-

CO_2 = 8 ~ 10%, O_2 = Less than 1.0%, CO = 24 ~ 26%, CH_4 = 1.5 ~ 2%, N_2 = 54 ~ 56%, H_2 = 10 ~ 12%.

CV. (Gross) = 1200 ~ 1250 kCal/Normal cubic meter

Sp. Gravity = 0.92

Yield of Gas: 2.0 ~ 2.5 Normal cubic meter per kg of biomass.

D. Economic Benefits

Fuel saving: Switching from furnace oil to biomass generates fuel Replacement of 6588 kg per month of furnace oil with 22 tonnes of wood consumption in gasifier monthly.

Electricity saving: The new Biomass Gasifier would save 150 units of electricity per month.

Reduction in other losses: The combustion of producer gas is a more efficient process than burning furnace oil. It reduces the amount of wastage in fuel while performing the process.

Monetary benefits: The monetary benefits of the unit are mainly due to the lower price of wood chips compared to furnace oil. This amounts to monetary savings of Rs. 75000 /month. A detailed estimate of the saving has been provided in the table 2 below:

Table 2 Energy and monetary benefit

Sr. No	Parameter	Value
1	Amount of FO used in furnace (kg/hr)	9.15
2	Amount of FO used in furnace (kg/month)	6588
3	Calorific value of FO(MJ/kg)	42.3
4	Cost of FO (Rs/kg)	35
5	Cost of FO in present system (Rs/month)	2,30,580
6	Amount of wood required by gasifier (kg/hr)	30
7	Amount of wood required by gasifier (kg/month)	22,204
8	Cost of wood (Rs/kg)	7
9	Cost of wood for the gasifier (Rs/month)	1,55,433
10	Monetary saving (Rs/month)	75,147
11	Total investment cost (Rs in Lakhs)	1.75 – 2.25
12	Return on investment (months)	4-6

Reduction in effluent generation: There would be less effluent generation since there would less fuel burned in the furnace.

Producer gas burns more cleanly than furnace oil and produces less ash. The ash produced from wood could be used for fertilizers. Moreover, the generation of dross is reduced due to better temperature regulation.

Reduction in GHG emission: The measure helps in reducing CO2 emission. The sustainable use of biomass as fuel would have zero net emission of CO2 into the environment.

Reduction in other emissions like SO_X: Significant amount of SOX will be reduced due to application of the bio-gasification process. The corresponding SO_X emission would also be reduced.

III.RESULT DISCUSSION

Experiments were carried out to find out the composition of gas for various feed materials. Also the optimum velocity at which the maximum CV of the fuel will be obtained is found out.

A. Gas composition of various feedstocks

Tests were carried out using three kind of feedstocks, wood pellets, biomass briquettes, and wood pieces. The results are depicted in Fig 3. It is observed that the CO and H_2 content are highest in wood pieces of size 30-50 mm. This CO and H_2 content is responsible for the calorific valve of the gas. Agricultural waste briquette has lowest content of CO and H_2.

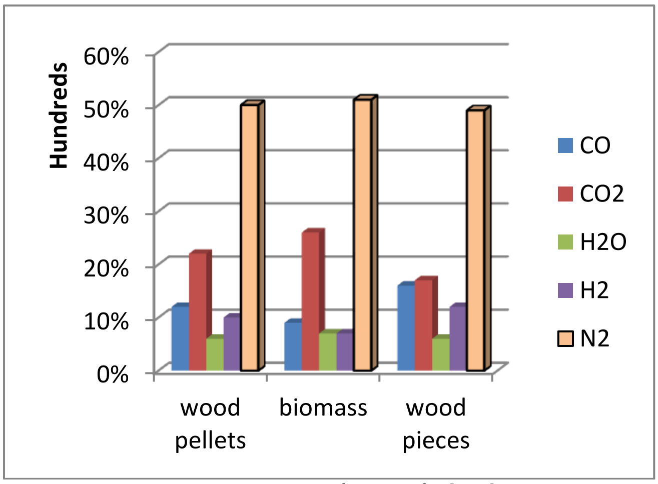

Fig3. Gas composition of various feedstock

B. Effect of air velocity on CO content

Figures 4a and 4b depicts the effect of air velocity on CO content. It is observed that CO content is maximum at air velocity of 8 m/s for wood material. Similarly air velocity of 7 m/s is optimum for biomass material.

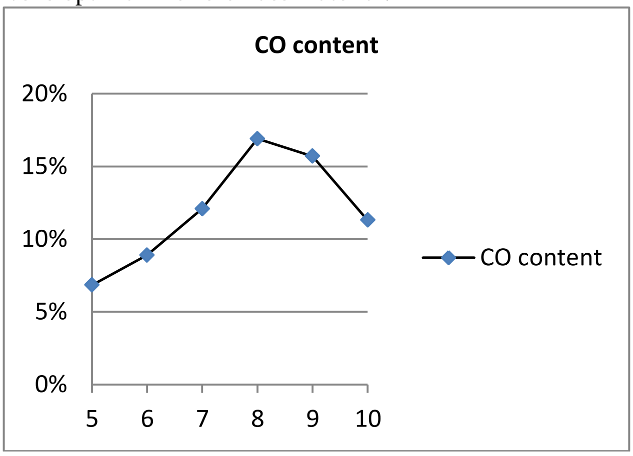

Fig4a. Effect of air velocity on CO content for wood

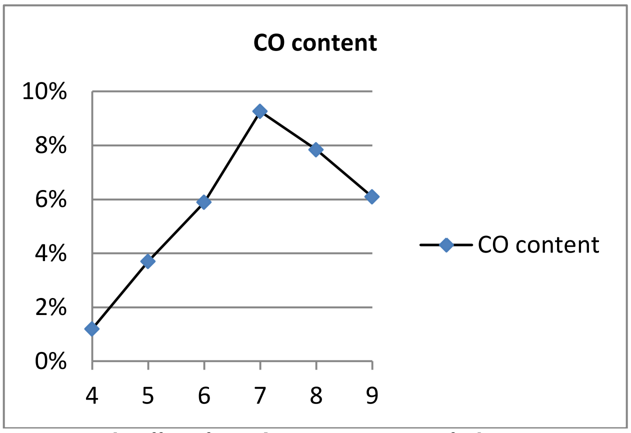

Fig4b. Effect of air velocity on CO content for biomass

IV. CONCLUSION

A downdraft gasifier is designed and experimental study has been carried out to produce the required quality of gas. Following conclusions are made from the experimental study and is detailed below:

- Wood pieces of size 30-50 mm are best suitable as a feedstock than of the size greater than that.
- Wood has more calorific value than agricultural biomass briquettes as it has more CO and H_2 content.
- Air velocity of 8 m/s is optimum for wood and air velocity of 7 m/s is optimum for biomass briquettes.

ACKNOWLEDGMENT

The Authors would like to thank Mr. D. K. Salunkhe, MD of DECK INDIA Engineering pvt ltd. For his valuable support in manufacturing the gasifier.

REFERENCES

[1]T.B. Reed and A. Das, Handbook of biomass downdraft gasifier engine system. Page no. 24.1998.

[2]Sharma K.A. Experimental study on 75 kWth downdraft (biomass) gasifier system, Renewable Energy, 34 (2009), pp. 1726-1733.

[3]Sheth N.Pratik, Babu V.B. Experimental studies on producer gas generation from wood waste in a downdraft biomass gasifier, Bioresource Technology, 100 (2009), pp.3127- 3133.

[4]Parbir Basu, Biomass gasification technology and torrification. 2003.

[5]S. J. Ojolo ,J. I Orisaliye, "Design and development of a laboratory scale biomass gasifier", August 31, 2010.