ISSN 2229-5518

BIOMASS GASIFICATION DEVELOPMENT BY USING DOWNDRAFT GASIFIER

[1]S.Rajesh, [2]K.Santhagiri ,[3]B.Pragathi ,[4]V.Hariprasad.

[1]Assistant Professor, Department of Mechanical Engineering.

Knowledge Institute of Technology, Salem,Tamilnadu.

[2,3,4]Department of Mechanical Engineering.

Knowledge Institute of Technology, Salem, Tamilnadu.

Abstract

Gasification is a thermo-chemical process which converts solid biomass into combustible gases that can be used in various applications. In this paper, a downdraft gasifierBiomass is replacing coals in energy production. With much more concern to the environmental impact, the use of fossil fuels has been greatly limited. Moreover, energy can be recovered from residues and wastes. Biomass, as part of the renewable energy, Wood, coconutshell,arecanut leaf chip and other forms of biomass represent some of the main renewable solid energy sources available and provide the only source of liquid, gaseous and solid fuels.Thermo-chemical conversion was considered the most promising way for a high efficiency conversion of the biomass, transforming the biomass into solid, liquid and gaseous energy products under thermal conditions. According this, a few type of technology have been developed: pyrolysis, combustion, gasification, liquefaction etc.

Key words: Biomass, Gasifier, Producer gas, Performance, Emission.

Introduction

Biomass is the oldest source of energy and currently accounts for approximately 10% of total primary energy consumption. Many of the developing countries has growing their interest in biofuel development and providing greater access to clean liquid fuels while helping to address the issues such as increase in fuel price, energy security and global warming concerns associated with petroleum fuels. Abundant biomass is available throughout the world which can be converted into useful energy. Biomass is considered as a better source of energy because it offers energy security, rural employability and reduced GHG emission. Biomass is traditionally available in the form of solid. Solid biomass include crops residues, forest waste, animal waste, municipal waste, food waste, plant waste and vegetable seeds. This biomass can be converted into heat and power by adopting appropriate method.The utilization of biomass to get various different output.

BIOMASS CONVERSION TECHNOLOGY

BIOMASS GASIFICATION

Biomass gasification was intensively used to operate farmand transportation systems during the World War II. It can be described as process that involves incomplete combustion ofbiomass to theproduce Combustible gases, which include carbon monoxide, hydrogen, methane and tar. This blend is called producer gas, Over the decades, gasification has been improved is being now highly Efficientenergy. If conducted in system specifications, then the technology is capable performing at more than 70% efficiency product of gasification is either a low- or medium – Btu gasDepending on the process employed. This producer gas retains reported that the process of Gasification occurs by heating biomass to high temperature (1200)oxygen deprived environment, therefore limiting combustion. The process takes place in four stages: likewise drying,

Oxidation

In the oxidation zone, the oxygen in the air-stream reacts with the carbon and hydrogen in the fuel to reduce carbon and hydrogen to form carbon dioxide and water. Carbon dioxide is obtained from carbon

$CO + H_2O = CO_2 + H_2$ (+42 MJ/kg mole)

$C + 2H_2 = CH_4$ (+75 MJ/kg mole)

and water is obtained from the

hydrogen in the fuel.

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

$2H_2 + O_2 = 2H2O$ (-242 MJ/kg mole)

Reaction (1) is known as combustion reaction. The oxidation reaction is exothermic and this heat is supplied to the neighbouring zones i.e. reduction zone.

Reduction zone

The partial combustion products CO_2, H_2O obtained from oxidation zone are nowpassed through reduction zone. Here CO_2 and H_2O are reduced to form carbon monoxide (CO) and hydrogen (H_2) by absorbingheat from the oxidation zone,

Reaction (3) is known as Boudouard reaction. Reaction (4) is the water gas reaction and it is very important in gasification as it can the gas manufactured with hydrogen, thus enhancing its calorific value.

Pyrolysis zone

C + O2 = CO2 (+393 MJ/kg)

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

devolatilization, gasification and finally combustion The first phase of the heating and drying , unproductive in terms of energy output, as energy is used to theevaporate remaining moisture from the biomass. In the pyrolysis phase volatile,

In pyrolysis zone, up to the temperature of 200°C only water is driven off and between the temperature 200 to 280°C carbon dioxide, acetic acid and water are given off. The real pyrolysis, starts between 280 produces large quantities ogasescontaining Besides light tars, some methyl alcohol is also formed. Between 500 to 700°C the gas production is small and contains hydrogen. From the reason mentioned above, updraft gasifier produces much more tar than downdraft one because in downdraft gasifier the tars have to go through combustion and reduction zone and are partially broken down.

Distillation zone

In the distillation zone, raw fuel like tar is preheated and carbonized giving of condensable and non-condensable gases.

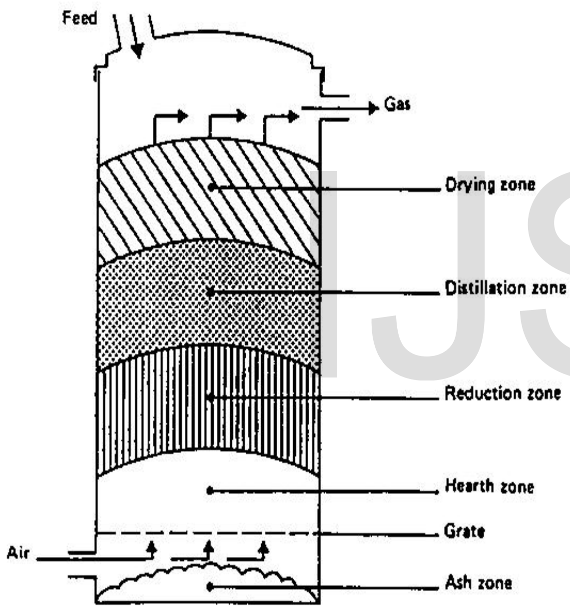
TYPES OF GASIFICATION REACTORS

Gasifiers are available in different types and sizes, and run on various types of feedstock including wood, straw, charcoal, coal, rice husks and agricultural wastes. Updraft (fixed bed) gasification systems are an old technology and were first installed in 1839 and used for coke and coal combustion. Before the Second World War, fluidized-bed wood gas generators were utilized to power combustion engines and automotive applications.downdraft, crossdraft and the fluid-bed gasifier.

Updraft or counter current gasifier

The updraft gasifier is the simplest and oldest type of gasification reactor. It derived its name from the

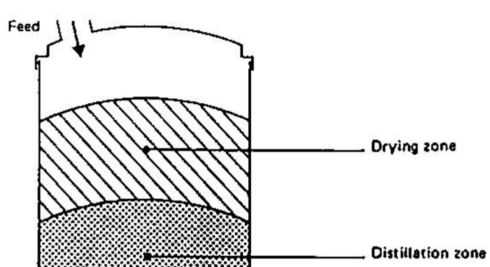
ISSN 2229-5518
fashion in which the oxidant is fed through the reactor. The biomass fuel through the top into the reactor and moves downwards through the different stages of gasification through gravitational forces, The oxidant (usually air, oxygen or a mixture of air and steam) is fed from the bottom of the reactor, from where it moves upwards and gets in biomass. Combustion reactions occur at the bottom near the grate. Pyrolysis of the fuel occurs in the higher parts Inpyrolysis zone light gases, tars and solid char are Which are Gasified in the reduction zone and result in light gases, which are collected from the top of the reactor. The remaining char is transferred to the combustion zone and completely combusted. Ash is then removed from the bottom of the system.



Updraft gasifier

Downdraft or Co-Current gasifiers

In the downdraft gasifier, fuel is also fed from the top and gravitates in the packed bed where it is gasified. Air, oxygen or a mixture of air and steam is fed either from the top or the middle of the reactor and the gasification zones are similar to the updraft reactor. The producer gas is, however, removed from the

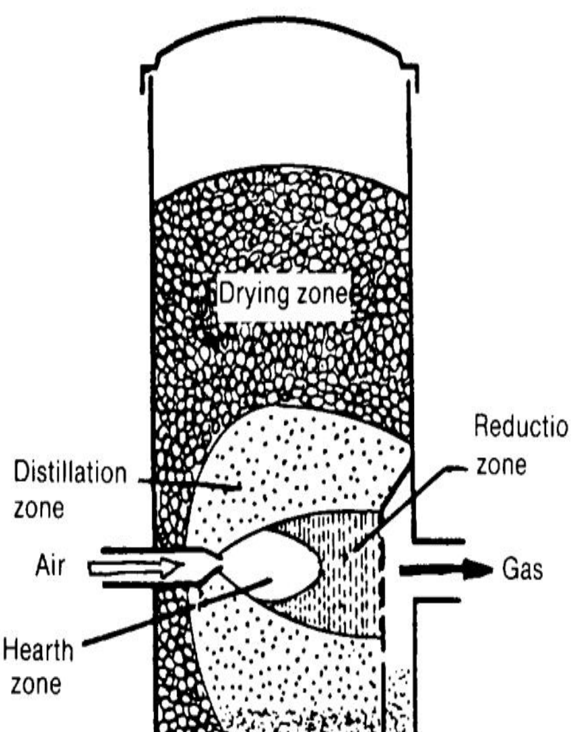


Downdraft gasifier

In which char is transferred and gasified (Brown, 2006) The producer gas obtained from a downdraft reactor contains less tar because the gasses are passed through the hot oxidation zone. The breakdown of tars depends on the temperature of the oxidation zone and the residence time therein.The reactor requires fuel with a uniform size to prevent slagging and blocking. The type of oxidant used has strong effects on the calorific value of the fuel gas produced. Typically, the calorific value of the gas is about 1.80 to 3.33 MJ/kg aerated with air and roughly 6-7.1 MJ/kg when oxygen is used.

CrossdraftGasifier

The crossdraftgasifier is air enters at high velocity through a water cooled nozzle mounted on one side of the firebox, induces substantial circulation and flows across the bed of fuel and char.



ISSN 2229-5518

Crossdraftgasifier

The gas is produced in the horizontal direction in front of the nozzle and passes through a vertical grate into the hot gas port on the opposite side.

COMPONENTS		**Wood chips**	**Ground nut shell**	**Arecanut leaf chips**
Proximate analysis	Moisture	15.00	15.00	15.00
	Volatile matter	80.00	78.00	79.00
	Ash	2.00	5.90	3.50
Ultimate analysis	Carbon	49.48	48.30	48.76
	Hydrogen	5.38	5.70	5.60
	Nitrogen	0.35	0.80	0.70

SOURCES OF FUELS

There is a wide range of original sources of biomass fuels which can be broadly defined in terms of ‘wet’ and ‘dry’ sources. Under these two broad headings, the sources can be grouped into following categories.

Selection of Fuel

From all the above consideration the following fuel choose for the project

Components of gasifier

In the present work, downdraft gasifier is used for producer gas generation, because it produces less tar compared to updraft gasifier. Main components of downdraft gasifier and their design are described below.

Hopper

The purpose of a hopper is to store the biomass for continuous feed to reaction chamber. It is mounted above the reactor of gasifier.

The fuel storage hopper is made up of 2mm thick mild steel. The diameter and height of fuel hopper is chosen to be 250mm and 550mm respectively. Round shaped hopper has been chosen to prevent the problem of biomass being stuck.

Hopper

Gasification Zone

This is the main component of gasifier. The main reaction of gasification like oxidation, reduction and distillation takes place in this zone. It is in the shape of vertical convergent and divergent nozzle (from top to bottom direction) and made by 2mm thick mild steel. Upper diameter of divergent section is 150mm

Lower diameter is of 250mm with 80mm height. A cylinder of 150mm diameter and 100mm height is welded at the top of divergent section. A circular pipe of ¾ inch (approximately 20mm) diameter is Made round with internal diameter 220mm and external diameter 260mm. 8 hole of 6cm diameter is drilled.

Gas outlet

A flat round strip of 250mm internal diameter, 380mm external diameter and 2mm thick with 8 equally spaced hole of 80mm diameter is designed to cover the gap between gasification zone and outer casing of gasification. A hole of 20mm diameter is made in this round flat strip at a radius of 270mm from the same centre. This hole is made to provide outlet to producer gas. Another strip of 380mm external diameter, 330mm internal diameter and 3mm thick with 8 equally spaced hole of 80mm diameter is welded over the other one so as to fix it Bottom cylinder with the help of nut and bolts. Isometric and top view of the gas outlet pipe and cover plate.

Outer Cylinder

A cylinder is made to cover the whole gasification assembly. The height and diameter of cylinder are 600mm and 330mm respectively. 120mm from the top of cylinder, one hole of 20mm is made on the wall of cylinder for inducting air into gasification zone. A flat round strip of 330mm internal diameter, 380mm external diameters and 30mm thickness is welded at the top of the cylinder. 8 hole of 80mm diameter is driller in this strip so as to tight it with gas outlet strip with the help of nut and bolts. A hole of 2mm diameter is made on the wall of cylinder at a height of 250mm from the bottom of cylinder for shaking the grate. A gate 230mm height is made at the bottom of cylinder wall to remove ash. 4 holes of 80mm diameter are made on the four corners of gate to tighten the gate with cylinder wall with the help of nuts and bolts. Fig. 12 shows the design of outer cylinder.

ISSN 2229-5518

Outlet cyclinder

gasification zone as shown in Fig. The complete assembly of gasification zone, casing and gas outlet cover plate.

Gasifier unit

Gasifier unit consists of a downdraft gasifier, air blower, pressure gauge. Char Coal was used to initiate the gasification process, 10 – 12 pieces ,Air was inducted with the help of blower, the flow of air could be regulated as par the requirement. When char coal reaches at its red heat level, a wood chips was poured into the hopper and the hopper cover was tightened by nut and bolts. The blower supplied air in such a way that the biomass burnt partially and generates producer gas. This producer gas thus passed through the gap between gasification zone and casing of gasification zone. Here most of the heavier particles get stuck and tar present in

Equivalence ratio method

Because only H_2, CO and CH_4 in the producer gas have combustion value, the HHV of producer-gas is calculated only based on the concentration of H_2%, CO% and CH4%.

Energy value for
H_2=16.044, CO=20.936,

CH_4=1.059. $HHV_{producer}$ gas
=12.7 H_2%+12.63x CO%+
39.76 x CH_4%

the volume of the producer-gas determine using E.R method

Mass of air =ER*Minimum air required for combustion

Mproducer-gas = Mwoodchip + Mair

$\rho_{producergas}$=ρ(H2)*H2%+ρ(O_2)*O_2%+ρ(N_2)*N_2%+ρ(CH_4)*CH_4%+ρ(CO)*ρ

CO%+ρ(C_2)*CO_2% + ρ (H2O)*H2O%

Vproducer-gas = Mproducer-gas / ρ producer-gas

Thermal conversion efficiency

For wood chips

ERwood chips=0.2

Mass of air =ER*5.73=0.2*5.73=1.15kg

Mproducer-gas = Mwoodchip + Mair = 1 + 1.15 =2.15

kg$\rho_{producergas}$=$\rho(H_2)*H_2\%+\rho(O_2)*O_2\%+\rho(N_2)*N_2\%+\rho(CH_4)*CH_4\%+\rho CO)*\rho\ CO\%+\rho(C_2)*CO_2\%$

=0.0899*20.37 + 1.331 * 0.901 + 1.165 * 42.65 + 0.668 * 1.73 + 1.165 *19.47 + 1.842*7.020.99 kg/m^3

$V_{producer-gas}$ = $M_{producer-gas}$/ ρ producer-gas

= 2.15 / 0.99 = 2.17 m^3 η = 74.74%

Forgroundnut shell

$\rho_{producergas}$=$\rho(H_2)*H_2\%+\rho(O_2)*O_2\%+\rho(N_2)*N_2\%+\rho(CH_4)*CH_4\%+\rho(CO)*\rho\ CO\%+\rho(C_2)*CO_2\%$

0.0899*18.28 + 1.331 * 0.77 + 1.165 * 45.70 + 0.668 * 2.11 + 1.165 *18.16 + 1.842*11.49

=0.99 kg/m^3

$V_{producer-gas}$ = $M_{producer-gas}$/ ρ producer-gas
= 2.145 / 0.951 = 2.19 m^3

η = 68.92%

For arecanut leaf chips

$\rho_{producerg}$=$\rho(H_2)*H_2\%+\rho(O_2)*O_2\%+\rho(N_2)*N_2\%+\rho(CH_4)*CH_4\%+\rho(CO)*\rho\ CO\%+\rho(C_2)*CO_2\%$

=0.0899*18.28 + 1.331 * 0.77 + 1.165 * 45.70 + 0.668 * 2.11 + 1.165 *18.16 + 1.842*11.49

=0.99 kg/m^3

=0.0899*18.28 + 1.331 * 0.77 + 1.165 * 45.70 + 0.668 * 2.11 + 1.165 *18.16 + 1.842*11.49

=0.99 kg/m^3

$V_{producer-gas}$ = $M_{producer-gas}$/ ρ producer-gas = 2.145 / 0.951 = 2.19 m^3

η = 69.9

CONCLUSION

In this project, a downdraft gasifier was designed and developed. The identification of appropriate fuel sources for biomass gasification facilities in a particular region is significant from both energy and economic efficiency perspective. The gasification performance for different biomass fuels may vary because of their different properties. Therefore, to compare the fuel energy value, an evaluation of proximate and ultimate analysis, organic component analysis, as well as calorific value is required.This research investigated gasification and corresponding thermal conversion efficiency of two biomass fuels including woodchips and groundnut shell , Consequently, it was found that the thermal conversion efficiency for woodchips was around 75%, arecanut leaf chips was 69% and groundnut shell was 70% depending upon the calculation It was observed that groundnut shell, due to its light feature, was better for feeding in the gasification system. Much fewer bridging and clogging issues occurred than pure woodchips. Projecting this situation to an industrial scale gasification system, alternate certain amount of groundnut shell could be beneficial for the material handling in a gasification facility.

REFERENCE

[1] NirmalaKaushik&SoumitraBiswas, New Generation Biofuels Technology & Economic Perspectives, Technology Information, Forecasting & Assessment Council (TIFAC) Department of Science & Technology (DST), 2010.

[2] Ministry of New and Renewable Energy, 2011.

[3] Arvind kumar Asthana; Biomass a fuel in small boilers, pp10-52, 2009.

ISSN 2229-5518
[4] G.D. Rai, Non-conventional energy sources, Khanna publishers, ISBN 81-7409-073- 8, p313, 2010.

[5] http://www.renewable.no/sitepageview.aspx?articleID=177

[6] Biomass Conversion Technologies, Renewable Energy World, page no. 46, 2006

[7] H.E.M. Stassen and H.A.M. Knoef, small scale gasification systems.

[8] http://www.britannica.com/EBchecked/topic/278814/hydrogenation

[9] Azam Ali Md.,Ahsanullah Md., Syeda R. Sultana. Construction of a downdraft biomass gasifier, Journal of Mechanical Engineering, 37 (2007), pp 71-73.

[10] Bhattacharya S.C., Hla S.S., Leon M.A., Weeratunga K. An improved gasifier stove for institutional cooking, Asian Institute of Technology, Thailand, (2005)

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

[12] ShethN.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.

[13] LvPengmei, Yuan Zhenhong, Ma Longlong, Wu Chuangzhi, Chen Yong, Zhu Jingxu. Hydrogen-rich gas production from biomass air and oxygen/steam gasification in a downdraft gasifier, Renewable Energy, 32 (2007), pp. 2173-2185