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DOWN DRAFT GASIFIER TO PRODUCE SYNGAS BY BIO WASTE

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ABSTRACT

Biowaste is a valuable resource for sustainable energy production. Through combustion, it generates thermal energy, while gasification a thermo chemical process which transforms solid fuel into gaseous fuel. This process, specifically through a downdraft gasifier, converts biowaste into a combustible gas known as producer gas. Utilizing biowaste as a fuel source plays a crucial role in reducing dependency on fossil fuels, providing a renewable, low-carbon energy alternative. Combining biowaste with other renewable sources like wind and solar power is an effective solution for small-scale, decentralized power generation. This approach not only meets local electricity needs but also supplies heat for rural development. Optimizing operating conditions and methodologies for maximum syngas production in biomass gasification is essential. The gasification system designed here includes a downdraft biomass thermo chemical conversion gasifier, a gas transport line with tar removal, and a fully enclosed combustion chamber – together, forming a robust setup for efficient, clean energy production.

KEY WORD: *Downdraft gasifier, biowaste, gasification, pyrolysis, syngas*

INTRODUCTION

Increasing prices coupled with the instability and uncertainty in the supply of fossil fuels and diminishing reserves has prompted the search for alternate energy sources. In response, the conversion of biomass to energy has gained attention. Biomass is renewable and generally low in Sulphur. Because it is renewable, it can be used without increasing the CO, content of the atmosphere, and the low Sulphur content is an asset for small-scale utilization. The main disadvantages of bio waste compared to fossil fuels are its wide distribution (non- point source) and low energy density.

The low energy density requires larger quantities processed relative to fossil fuels for a given energy need. In this regard, gasification processes (see, e.g. Bain, 1980) are available for improving the properties of biowaste. Biowaste are a prime example of improved biomass. Biowaste is major source of biomass. our total energy needs and could contribute up to 8%within the next decade (Adelekan, B.A. & Bamgboye, A.I., 2009) Over 700 million tons of this material is not used because it is not of the right species, size, length, fiber morphology etc. Thus the potential for the utilization of Biowaste to ensure a continuous supply of fuels and chemicals is significant.

Direct combustion of SSS biowaste is generally inconvenient and usually environmentally unacceptable. Hence various technologies have been investigated to convert biowaste into more attractive fuels. Among these, gasification technology. Utilization of biowaste 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 prototype of downdraft gasifier is designed and developed of 20 KW the capacity for generating producer gas for fulfilling heating requirement of a heat treatment furnace (Adeyosoye, O.I*et al*.,2010)

Biowaste of varying sizes are 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 and LPG is estimated. Performance of gasifier with other feed stocks such as agricultural waste

(Akinbami, J-F.K.,2001)

METHODOLOGY

PRODUCT DESIGN STRUCTURE

The design has 16 parts and divided by 2 sub-assemblies: the gasifier body and body filter guts. The design consists a filter box to filter the fly ash with a circulating water tank and filter chamber. The schematic design with the function of the part the filter body was designed for good cleaning for the tar content, ash content, water absorption in the producer gas, to ensure clean and high-quality gas obtained. Gas cooling is necessary in the present work to reduce thermal stress on the gasifier and piping system. The material used as filter were fine wire mesh integrated with dried corn-cobs which has good permeability to assist producer gas flow and reduce pressure drop which may result blowback during operation. The reactor, grate and other parts were made from stainless and mild steel to ensure strength and ability of the system to ensure structural integrity.

The assembly drawing of the downdraft gasifier Final Design of the downdraft gasifier Thermal analysis Thermal analysis is one of the important analyses in the present study. This is because the gasifier is subjected to thermal load significantly in comparison with other form of loads such as structural loads. The thermals stresses arise from the high temperature ambient inside the gasifier which can be divided into four distinct regions, namely the drying region, pyrolysis region, oxidation (or combustion and finally the reduction zone. Each zone has different temperature range and this will affect the structural integrity during gasification process. The analysis was limited to gasifier body alone hence this is the region the high temperature ambient occurs. All thermal analysis was done via simulation in the Solid Works 2017, and later observed during experimental works.

GASIFICATION

Gasification is the method that can convert carbonaceous biomass material to hydrogen, carbon dioxide, and carbon-monoxide. The method can be achieved by reaction of feed material at over 700 °C temperature, with a limited amount of oxygen and steam. In the gasification method, the feed material is processed without combustion. In this method, the generated mixture of gas is considered synthetic gas or producer gas utilized as fuel.The produced power in the biomass gasification method and combustion of the generating gas. In chemical reactions of gasification method, char type carbonaceous feed material.(C) is reacted with steam (H2O) and generates carbon monoxide (CO) and hydrogen (H2) can be considered as renewable energy source.

$$C+H2O \rightarrow H2+COE \quad .... 1$$

$$C+CO2 \rightarrow 2COE \quad .... 2$$

Therefore, in the gasification method, a small amount of air or oxygen is applied to the gasifier reactor to burn the organic feed material to generate energy and carbon dioxide. The gasification method of biomass renewable energy sources is the potential sources to generate energy, chemical energy, and bio fuels. A gasifier is required to convert biomass renewable energy sources to synthetic gas in the gasification method. The generated synthetic gas is used to operate an internal combustion engine. They can also be used to produce electricity and heat energy by using a cogeneration system.

DRYING

Drying is what removes the moisture in the biomass before it enters Pyrolysis. All the moisture needs to be (or will be) removed from the fuel before any above 100°C processes happen. All of the water in the biomass will get vaporized out of the fuel at some point in the higher temperature processes. (Akinlo, A.E.,2009)

Biomass can contain more than 50% moisture (wet basis) when it is cut; it is generally desirable to dry biomass containing more than 25% moisture (wet basis) before gasification. Drying often can be accomplished using waste heat or solar energy. If the temperature of the drying air is too high, the outer surfaces of the chunk will become dry and begin to pyrolysis before the heat can reach the center. For efficient drying, hot air, which if cooled to 60' -80'C would be moisture saturated, is preferred. The moisture slows feedstock drying (as well as slowing surface pyrolysis). Thus, more air is required, improving the drying process (Thompson 1981). During operation of a gasifier and engine combination. Bio waste can be dried from 50% to 5% moisture content, with drying capacity to spare, using a 20-minute residence time with the hot engine exhaust, tempered with 90% recycle of dryer gases.(Amon, T.,*et al*., 2004)

PYROLYSIS

Pyrolysis is the process where bio waste materials are decomposed in absence of air or oxygen using heat energy. The overall process of pyrolysis method. The pyrolysis oil properties and yield of pyrolysis products depend on the operating conditions and parameters of the pyrolysis process. The pyrolysis process's operating parameters are the heating rate of feed material, the temperature of the reactor, residence time, catalysts, and reactor configurations. Biomass pyrolysis method, feed materials are decomposed to remove the moisture contents and break the bond to form CO, CO2, and residues (Anunputtikul, W. and Rodtong, S., 2004) The remaining compounds are exposed to further conversion using cracking and polymerization In this method, at a lower temperature, such as less than 500 °C temperature, the organic vapour materials are not cracked. However, at higher temperatures, they convert readily with fewer residence times. The optimum temperature to generate the maximum quantity using the bio waste pyrolysis method is over 500 °C.The residence time of vapour materials and heating rate in the pyrolysis process.

COMBUSTION

Combustion is often a complicated sequence of elementary radical reactions. Solid fuels, such as wood and coal, first undergo endothermic pyrolysis to produce gaseous fuels whose combustion then supplies the heat required to produce more of them. Combustion is often hot enough that incandescent light in the form of either glowing or a flame is produced. A simple example can be seen in the combustion of hydrogen and oxygen into water vapor, a reaction which is commonly used to fuel rocket engines (Balat, H.,2007) This reaction releases 242 kJ/mol of heat and reduces the enthalpy accordingly (at constant temperature and pressure) Combustion of an organic fuel in air is always exothermic because the double bond in O2 is weaker than other double bonds or pairs of single bonds involved, and the formation of the stronger bonds in the combustion products CO2 and H2O results in the release of energy (Cuéllar, A.D.& Webber, M.E.,2008) The bond energies in the fuel play only a minor role, since they are similar to those in the combustion products; e.g., the sum of the bond energies of methane, CH4, is nearly the same as that of CO2. The heat of combustion of organic fuels is approximately −419 kJ per mole of O2 used up in the combustion.

REDUCTION

Reduction is the process of stripping oxygen atoms off combustion products of hydrocarbon (HC) molecules, so as to return the molecules to forms that can burn again. Reduction is the direct reverse process of combustion. Combustion is the combination of combustible gases with oxygen to release heat, producing water vapour and carbon dioxide as waste products. Reduction is the removal of oxygen from these waste products at high temperature to produce combustion gases. (Jekayinfa, S.O. & Scholz, V. 2009) Combustion and Reduction are equal and opposite reactions. In fact, in most burning environments, they are both operating simultaneously, in some form of dynamic equilibrium, with repeated movement back and forth between the two processes. Reduction in a gasifier is accomplished by passing carbon dioxide (CO2) or water vapour (H2O) across a bed of Red-hot charcoal (C). The carbon in the hot charcoal is highly reactive with oxygen; it has such a high oxygen affinity that it strips the oxygen off water vapour and carbon dioxide, and redistributes it to as many single bond sites as possible. The oxygen is more attracted to the bond site on the C than to itself, thus no free oxygen can survive in its usual diatomic O2 form. All available oxygen will bond to available C sites as individual O until all the oxygen is gone. When all the available oxygen is redistributed as single atoms, reduction stop through this process; CO2 is reduced by carbon to produce two 15CO molecules, and H2O is reduced by carbon to produce H2 and CO. Both H2 and CO are combustion fuel gases, and those fuel gasses can then be piped off.

RESULT AND DISCUSSION

A downdraft gasifier is the typical configuration used for bio energy production. This well-established technology allows the production of syngas with low tar, due to the syngas passes through the combustion zone at high temperature and the subsequent dimensioning which in turn leads to the thermal cracking of tars.

Heat

Gasifier offer a flexible option for thermal applications, as they can be retrofitted into existing gas fuelled devices such as ovens, furnaces, boilers, etc., where syngas may replace fossil fuels. Heating values of syngas are generally around 4–10 MJ/m3.

Electricity

Currently Industrial-scale gasification is primarily used to produce electricity from fossil fuels such as coal, where the syngas is burned in a gas turbine. Gasification is also used industrially in the production of electricity, ammonia and liquid fuels (oil) using Integrated Gasification Combined Cycles (IGCC), with the possibility of producing methane and hydrogen for fuel cells. IGCC is also a more efficient method of CO2 capture as compared to conventional technologies.

Combined Heat and Power

In small business and building applications, where the wood source is sustainable, 250–1000 KW and new zero carbon biomass gasification plants have been installed in Europe that produce tar free syngas from wood and burn it in reciprocating engines connected to a generator with heat recovery. This type of plant is often referred to as a wood biomass.

Transport Fuel

Diesel engines can be operated on dual fuel mode using producer gas. Diesel substitution of over 80% at high loads and 70–80% under normal load variations can easily be achieved. Spark ignition engines and solid oxide fuel cells can operate on 100% gasification gas. Mechanical energy from the engines may be used for e.g. driving water pumps for irrigation or for coupling with an alternator for electrical power generation. While small scale gasifiers have existed for well over 100 years, there have been few sources to obtain a ready-to-use machine. Small scale devices are typically DIY projects. However, currently in the United States, several companies offer gasifier to operate small engines

Renewable energy and fuels Gasification plant

In principle, gasification can proceed from just about any organic material, including bio waste. The resulting syngas can be combusted. Alternatively, if the syngas is clean enough, it may be used for power production in gas engines, gas turbines or even fuel cells, or converted efficiently to dimethyl ether (DME) by methanol dehydration, methane via the Sabatier reaction, or diesel-like synthetic fuel. In many gasification processes most of the inorganic components of the input material, such as metals and minerals, are retained in the ash. In some gasification processes (slagging gasification) this ash has the form of a glassy solid with low leaching properties, but the net power production in slagging gasification is low (sometimes negative) and costs are higher.

CONCLUSION

The present study entitled "Down Draft Gasifier to Produce Biogas by Bio waste" was conducted at RVS Farms Unit just Opposite to Agri Engineering laboratory Sulur during March to July 2022. The objective of the study was to produce a biogas to study the characteristics of bio char and to assess the effect of biogas crop production. The salient findings of the study are summarized below. Agro residues viz., woody wild growth, coconut petiole and herbal waste which are Surplusly available in Sulur region were analysed for their suitability for biogas production. The materials used for study were woody wild growth, coconut petiole and herbal waste residue. The biowaste downdraft gasifier is mostly used for power

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generation applications. It is basically a reactor into which fuel/feed stock is fed along with a limited supply of air. The heat that is required for gasification is generated through partial combustion of the feed material Producer gas contains carbon monoxide, hydrogen, water vapour, carbon dioxide, tar vapor, and ash particles. Gasification produces a low- or medium-Btu gas, depending on the employed process, which can be used in many combustion systems such as boilers, furnaces, and gas engines Syngas is most commonly burned directly in gas engines, used to produce methanol and hydrogen, or converted via the Fischer process into synthetic fuel. For some materials gasification can be an alternative to land filling and incineration, resulting in lowered emissions of atmospheric pollutants such as methane and particulates. Some gasification processes aim at refining out corrosive ash elements such as chloride and potassium, allowing clean gas production from otherwise problematic feedstock material. Gasification of fossil fuels is currently widely used on industrial scales to generate electricity.

Figure 1: Downdraft gasifier

Figure 2: Biowaste

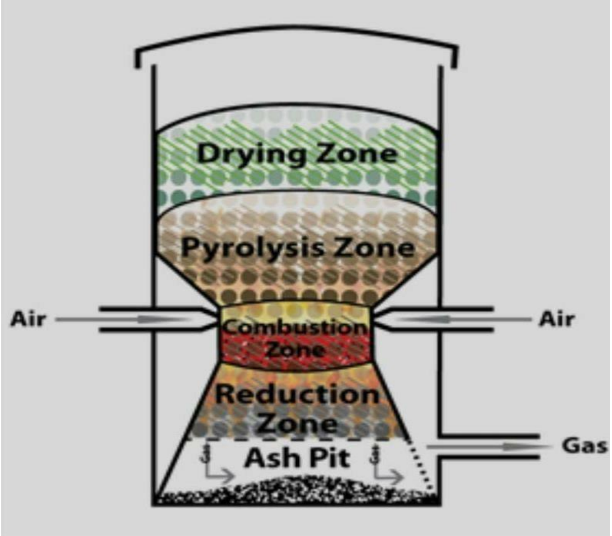

Figure 3: Process

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