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Generator Powered by Wood gas – An Alternative Approach

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Abstract - *In today's world, pollution is a major growing concern. As the usage of automobiles rises, pollution due to fossil fuels also rises and lead to crisis all over the world. So it is imperative that we device new technologies for substituting with conventional fossil fuels .One way of overcoming this problem is the usage of renewable energy resources instead of fossil fuels . This is difficult to implement because of the huge dependence of fossil fuel powered machines in everyday life , and it's not easy to replace them and find something that does the job just as well .Process of conversion of solid energy(biomass) into vapour form is termed as Wood gasification. This can be used to replace gasoline. This also finds use in providing electricity in remote areas where power lines are absent. Wood fuels will remain the main source of energy for most developing countries for the coming decade. Furthermore, considering the environmental concern raised by CO_2 which emits from the combustion of fossil fuels, forest biomass needs to play a major role in reducing the greenhouse effect and acid rain for developed countries like India.*

Key Words: Fossil fuels, Wood gasification, Biomass, Gasoline, Greenhouse effect.

1. INTRODUCTION

All internal combustion engines run on vapor and not on liquid. The liquid fuels used by petrol engines got vaporize before they enter above the pistons in the combustion chamber. In case of diesel engines, fine droplets of the fuel is sprayed which will burn as they vaporize. The gasifier is used to convert solid fuels into gaseous ones and to make the gas free of hazardous constituents, a gas generator act as an energy converter and a filter. Gasification is done because of the insufficient amounts of oxygen which causes unable to burn completely. Several solid biomass fuels were obtained from wood, paper, lignite, as well as coke derived from coal are suitable for gasification. Above mentioned fuels composed of carbon, hydrogen, oxygen along with impurities like sulphur, ash and moisture. The sole aim of gasification is the transformation of these constituents into gaseous form with the remaining ashes and inert materials.

Gasification is a type of physiochemical process too as chemical transformations also occur. By approximation, wood gas contains almost 20% hydrogen (H), 20% carbon monoxide (CO) and minor methane content along with 50 to 60% nitrogen (N). The nitrogen is not at all combustible however as the wood gas burns, it does occupy volume and dilutes the wood gas as it enters and burns in an engine. The combustion products are generally carbon dioxide (CO_2) as well as water vapor (H_2O).These gases are the filtered and passed through the engine/generator which will power it.

2. BIOMASS

Biomass is an organic matter obtained from living or recently living organisms. This also refers to plants and based materials which are not used as food. Due to this fact, they can be simply used as an energy source. Biomass can be used for direct combustion to produce heat or it can be indirectly done after converting it into various biofuel forms. By adopting different methods like the thermal, chemical as well as biochemical biomass to biofuel conversion can be achieved.

2.1 Biomass Sources

According to history, humans started using biomass derived energy from the historical time itself when they burns wood to make fire. Even in this modern world, biomass is a fuel source that can be used for domestic purposes in many countries. This is a biologically produced matter based on carbon and hydrogen along with oxygen contents. The biomass production is estimated to be almost 104.9 pentagrams per year in the world where half is produced from the ocean and the other half from the land.

Woods are the largest energy source based on biomass nowadays. This energy from woods is derived using lignocellulosic biomass to use as fuel. Harvested wood can be used as a direct fuel or it can be collected from wood waste streams in form of pellet fuel or by other fuel forms. The largest energy source is the pulping liquor, which a waste matter is obtained during pulp processing in paperboard industry. In another sense, biomass consists of plants as well as animal content that can be converted effectively as fibers

or other industrial chemicals including biofuels. Crops like hemp, corn, poplar, willow, sorghum, sugarcane, bamboo along with certain variety of tree species ranges from eucalyptus to oil palms can produce industrial biomass.

Based on the biomass sources, biofuels can be classified into two categories. First-generation biofuels which are derived from sugarcane and corn starch. Sugars which are found in the biomass can be directly fermented to produce bioethanol to be used in a fuel cell to produce electricity or can act as an additive to gasoline. Second-generation biofuels mainly use municipal and agriculture based wastes for biofuel production. These biofuels are not edible and is generally a waste product for industries. Economical production of biofuel cannot be achieved yet because of certain technological issues arise due to the resistance to chemical and inability to change structure rigidity of ligno-cellulosic biomass.

Plant can be energy produced by means of certain crops which can act as fuel that offers high biomass output per hectare with low input energy. The grains can be used instead of liquid fuels while for producing heat or electricity, straws can be used. Through chemical treatments, plant biomass can be degraded from cellulose to glucose that can become a first-generation biofuel.

Conversion of biomass can be done to different energy forms like methane, transportation fuels such as ethanol, biodiesel etc. Rotting garbage, farm and human wastes also releases methane gas or biogas whereas by using corn and sugarcane, transportation fuel ethanol can be produced through fermentation. Biodiesel which is another transportation fuel, can be produced using vegetable oil as well as animal fats. Now research is ongoing regarding the production of cellulosic ethanol and biomass-to-liquids.

2.2 Biomass Conversion – Thermal

In Thermal process, heat is used to convert biomass into another chemical form. Here a liquid phase medium is heated first and then circulated to several users in a closed loop system to provide heat indirectly. The basic combustion alternatives like torrefaction, pyrolysis, and gasification are separated by the means of chemical reactions extent in the process. (Controlled by the oxygen and conversion temperature availability).

Energy developed by burning biomass is suitable mostly in tropical countries, where fuel wood grows much rapidly. There are thermal processes in proprietary manner which are less common and experimental that can offer benefits like hydrothermal upgrading and processing. Some other have been developed been used to convert high moisture content biomass, including aqueous slurries into more convenient forms. Some thermal conversion applications are CHP and co-firing. In a general type biomass plant, overall efficiencies range from 20–27%. Biomass when co-fired with coal helps in attaining efficiencies as that of a coal combustor (30–40%).

2.3 Biomass Conversion – Chemical

Several chemical processes are adopted for fuel production by biomass to other forms conversion which are most convenient, transported, stored, or to exploit some property of the process itself. Major processes are based on coal-based, methanol based, olefins and other chemical or fuel feed stocks. However, the initial step in all these involves gasification, which is the highly expensive and have higher technical risks. The gasification was done frequently at atmospheric pressure for producing a combustible gas formed by mixture of carbon monoxide, hydrogen, and traces of methane because of the difficulty in feeding biomass into a pressure vessel. This producer gas can be provided for wide range of processes such as in internal combustion engines as well as a substitute for furnace oil in direct heat applications. This process is better than ethanol and biomass production because of the gasification property of biomass material. Biomass gasification is an effective process because it can easily convert solid waste into producer gas, which is a very usable fuel.

2. GASIFICATION

The process of conversion of fossil fuel based carbonaceous materials into gases of carbon and hydrogen is called as gasification. By heating the material at temperature range greater than 700 °C, without combustion, gasification is done by usage of a highly controlled oxygen or steam supply. The gas mixture formed is the syngas which can later be used. The power derived from gasification and resultant gas combustion is a renewable energy source as the compounds obtained from biomass were of gaseous form.

The usage of syngas provides more efficiency than combustion of the normal fuel. Because of its combustion nature at higher temperatures, the efficiency obtained were of higher value. Syngas are either burned directly in gas engines or converted to synthetic fuel by means of Fischer–Tropsch process. Gasification always begins with waste material of biodegradable form. The ash elements are refined at high-temperature process which allows production of clean gas from other fuels. The whole process can be divided into four categories - Drying, Pyrolysis, Combustion and Reduction.

2.1 Drying

Drying is a process involves water removal by means of evaporation from a solid, semi-solid or liquid material. i.e., removes moisture before it enters the Pyrolysis stage. This needs to be done before any high temperature process occur. The high moisture content or poor handling of the moisture is the main reason for clean gas production failure.

2.2 Pyrolysis

Pyrolysis is done in the absence of air by applying heat to raw biomass for converting it into charcoal, tar gases as well as liquids. Once the temperature rises above 240°C,

biomass begins to decompose with heat to form charcoal. The released gasses and liquids are commonly called as tars. The goal of this process is to convert different forms of fuel into the fuel gasses composed of both hydrogen and carbon monoxide.

2.3 Combustion

Combustion can be defined as a high temperature exothermic redox chemical reaction process between a fuel and atmospheric oxygen, that produces smoke. This will produces flame and the combustion will remain self-sustained by means of heat produced. Solid fuels, such as wood first undergo endothermic pyrolysis will produce fuels in gas form which supplies required heat for producing more during its combustion. Combining hydrogen and oxygen into water vapor by means of combustion is an example of this process. This reaction releases 242 kJ/mol of heat that will reduce enthalpy at constant temperature and pressure condition.

$$2H_2 + O_2 \rightarrow 2H_2O \quad (1)$$

2.4 Reduction

Reduction is the direct reverse process of combustion. It is the removal of oxygen from these waste products at high temperature to produce combustible gases. Reduction process is done by passage of CO_2 or water vapor (H_2O) through red hot charcoal (C) until whole oxygen is redistributed. Both CO_2 and H_2O are been reduced by means of carbon resulting in formation of two CO molecules along with H_2 and CO.

$$CO_2 + H_2O \rightarrow \text{Red hot charcoal bed} \rightarrow H_2 + CO \quad (2)$$

$$CO_2 + C \rightarrow 2CO \quad (3)$$

$$H_2O + C \rightarrow H_2 + CO \quad (4)$$

3. GASIFIER

The gasification unit consists of the following parts. They are gasifier, cyclone filter, gas cooler, fine filter, blower and valves. Gasification is the process of partial combustion of biomass which takes place at temperatures of 1000 degree Celsius. The reactor used for this is called a gasifier. The product of combustion includes components of nitrogen, CO_2, water vapor along with surplus of oxygen. However due to the presence of surplus, the products obtained are generally gases like Carbon monoxide (CO), Hydrogen (H_2) as well as Methane traces along with tar and dust. The key aim of gasifier design is to reduce biomass into charcoal and to convert this charcoal into CO and H_2. Different types of gasifiers are Counter current (Updraft) gasifier, Co-current (downdraft) gasifier and cross draft gasifier.

Table -1: Advantages and dis-advantages of different types of gasifiers

Sl No.	Gasifier Type	Advantage	Dis-advantage
1	Up draft	Small pressure drop. Good thermal efficiency. Less tendency towards slag formation.	High sensitivity to tar and moisture. Long time required for engine start up. Poor reaction capability with heavy gas load
2	Down draft	Flexible production of gas corresponds to load Low sensitivity to charcoal dust and tar content of fuel	Design tends to be tall
3	Cross draft	Short height Fast response Flexible production	High sensitivity to slag High pressure drop

3.1 Parts of Gasifiers

Main parts of gasifiers are cyclone filter are as cyclone filter, gas cooler, fine filter and blower.

3.1.1 Cyclone Filter

Cyclone filter is the device used to filter solid impurities present in the syngas coming from the gasifier. The method of vortex separation without filters removes particulates from all streams. To remove particulate matter from liquids, a hydro-cyclone is used whereas from gas, gas cyclone is used. For separating solids and fluids of mixtures from gaseous stream, both rotational effects and gravity are used.

3.1.2 Gas Cooler

The gas cooler is used to cool the syngas coming from the cyclone filter. The cooler the gas more efficient the gasifier will be. It is simply a heat exchanger that transfer heat from hot gas to the surroundings.

3.1.3 Fine Filter

Fine filter essentially consist of a bulky layer of sawdust through which the syngas flows. This removes any excess impurities which might have passed through the cyclone filter and also removes moisture content from the gas.

3.1.4 Blower

Blower is a very important part in the proper working of the gasifier unit. It is the blower that will draw air into it by formation of negative pressure in the gasifier. Blower is only necessary for starting purpose, after switching on the generator or starting the engine connected to it, those will create the suction necessary for air to enter the gasifier. A centrifugal fan can act as the blower which can increase the speed and volume of an air by using rotating impellers.

3.2 Wood Gas

Wood gas is a fuel that can replace gasoline, diesel or other fuels in automobiles. During the production process, biomass is gasified within the environment of a wood gas generator in order for producing both hydrogen and carbon monoxide. These gases can be burnt within an oxygen rich environment for producing carbon dioxide, water and heat. This is preceded by pyrolysis in some gasifiers, where the biomass is converted to charcoal by releasing both methane and tar rich in polycyclic aromatic hydrocarbons.

Rise of pressure across units will results in forming high moisture content because of condensing liquid that puts load on both cooling and filtering equipments. For reduction of this moisture, some pretreatment methods needs to be employed.

4 CONSTRUCTIONS

4.1 Construction of Gasifier

Outer chamber dimension
Material: GI
Height: 450mm
Diameter: 203.2mm
Thickness: 3mm

Inner chamber dimension
Material: GI
Height: 450mm
Diameter: 101.6mm
Thickness: 2mm

Fig - 1: Gasifier

4.2 Construction of Cyclone Filter

Material: GI
Height: 450mm
Thickness: 2mm
Diameter: 101.6mm

Fig - 2: Cyclone Filter

4.3 Construction of Cooler

Material: GI
Height: 600mm
Width: 450mm

Fig - 3: Gas Cooler

4.4 Construction of Fine Filter

Material: GI
Height: 450mm
Diameter: 101.6mm
Thickness: 2mm

Fig - 4: Fine Filter

4.5 Construction of Blower

Rated power: 600W
Input supply: 240v

Fig -5: Blower

Fig – 6: Assembled Unit

The whole unit is mounted on a 1m^2 frame made of GI square sections. The gasifier outer chamber is connected to the cyclone filter by using a 2inch diameter GI pipe which creeps in at the side to provide proper circular motion for filtration process. Another 2inch diameter pipe runs along at about three quarters of the length inside the filter. The clean gas rises through this pipe is passed through the gas cooler later and then to the fine filter. The fine filter contains sawdust which absorbs the moisture present in the gas. The gas is then sucked by the blower and sent outside when the blower side valve is open. When starting the generator the blower side valve is closed and generator side valve is opened. Up on cranking the generator it sucks in the flammable wood gas and starts working, it also continues to provide enough suction to make the gasifier run without running the blower. Thus the blower is required only till the starting of the generator.

4.6 Starting of Unit

1. Put a small amount of charcoal and fuel into the grate.
2. Ignite the mixture.
3. Now start the blower, open the valve to the fine filter and close all other valves.
4. When the smoke starts coming out, more fuel should be added into the inner chamber.
5. Wait for about ten minutes for the system to warm up.
6. Now connect the hose to generator and adjust the valves that control air fuel ratios.
7. Close the valve to the blower and pull start the generator.

5. FABRICATION METHODS USED

5.1 Arc Welding

Arc welding can be defined as the process of joining two metal pieces by using an electric arc with an electrode fitted which is moved along the places to be welded. The electrode is a rod that can pass current between the tip and the work or can melt and supply filler metal into the joint. This circuit is either AC or DC powered by means of work cable and hot cable between the work piece and electrode. When the electrode is positioned close to the work piece, an arc is created across the gap between the metal and the hot cable electrode. A gas column of ionized nature will be developed for the completion of the circuit. Types of arc welding - Shielded Metal Arc Welding, Gas Metal Arc Welding and Gas Tungsten Arc Welding.

5.2 Oxy-Acetylene Welding

In this type, oxygen and ethyne gases are combined to produce a flame that burns at over 6000 degrees Fahrenheit. This flame melts the metal faces of the two pieces causing the liquefied metal to flow between and later to be welded. The oxy- acetylene process is versatile one which can be used as both welder as well as a cutting, brazing, and heat metal torch for bending and forming purposes. Oxy- acetylene equipment can be used practically unlike MIG welding because of the shielding gas issue.

5.3 Drilling

Drilling is the process of formation of round holes or enlarging the existing holes by using drills or drill bits. The most common among them is the twist drill. A drilling machine is used for creating holes through metal, wood as well as other materials. The drill tool is held by means of a chuck which is fed at variable speeds to the work piece. A drill press consists of base and a column which supports a table. Work supported by vise can be swiveled and height can be adjusted using a table lift crank placed at vise.

5.4 Cutting

Cutting is a process in which the excess material is removed by using various tools for obtaining a final product which meets design specifications. The result obtained are the waste or excess material and the finished part. In woodwork, the waste would be sawdust whereas in metal cutting, the waste is in chip form.

6 ADVANTAGES AND DIS-ADVANTAGES

Table -2: Advantages and dis-advantages of unit

Advantages	Dis-advantages
➢ It's a renewable form of energy.	➢ Not entirely clean.
➢ It's carbon neutral.	➢ Risk of deforestation.
➢ Widely available.	➢ Requires a large amount of water.
➢ It's cheaper compared to fossil fuels.	➢ Inefficient as compared to fossil fuels.
➢ Minimizes overdependence on electricity.	
➢ Can be used for creating different products.	

7 COST ESTIMATION

Items	Cost in Rs.
GI Pipes	4000
Generator	4000
Valves	4000
Frame	3000
Blower	2000
Miscellaneous	8000
Transportation Charge	2000
Total Cost	27000

The net cost of the whole apparatus found approximately Rs. 27000.

8 FUTURE SCOPE

- The design of this unit may be made more compact by introducing new technologies for replacing the bulky components. This will make it more suitable for mobile applications.
- It is clear that many villages in India still lack electrification. In order to solve this to a great extend the government could introduce gasifiers to these rural areas, which has an abundant supply of wood. This could provide lighting to thousands in need who are still depending on other sources of lighting
- Gasifiers also be used when there is a shortage of gasoline like war, a petroleum crisis etc.

9. CONCLUSIONS

The wood gasifier is used for conversion of solid fuel into gaseous form. The device has been able to successfully create wood gas and can power a 2000W generator. Biomass gasification is the most effective energy source that can be used as an alternative for agricultural purposes. Preferred fuels for gasification process are charcoal and wood. However most appropriate fuels for on-farm systems are found to be biomass residues which is still a great challenge to whole researchers and unit manufacturers. Also limited experience has been gained by all those personnel in biomass residue gasification. This has got potentially large range of application for problem solving including energy crisis.

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