

Experimental Analysis of Red Gram Stalk Pellet Non-Conventional Energy Potential from Agricultural Residue Biomass as an Alternate Fuel for Internal Combustion Engines

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Abstract – As one of the many renewable energy sources, producer gas presents a great prospect for long-term energy and transportation sector sustainability. In locations where petroleum and diesel costs are high or supply are inconsistent, producer gas can provide an economically feasible option. The Red Gram stalk pellet producer gas composition is detailed in this study. The calorific value of Red Gram stalk biomass is also discussed in this paper. The study was undertaken to investigate the properties of Red Gram stalk fuel from the agricultural residues. The ultimate analysis of the Red Gram stalk on air dried basis in terms moisture content 5.9 %, ash content 1.85 %, fixed carbon 42.57 %, hydrogen 5.71 %, nitrogen 0.41 %, sulphur 0.35 %, oxygen 43.21 % and calorific value of Red Gram stalk biomass is 14820 KJ/Kg respectively.

Key Words: Producer Gas, Biomass, Calorific Value, Ultimate Analysis.

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I. INTRODUCTION

Biomass is a renewable energy source that has the potential to meet the world's energy needs. A renewable supply of energy services, as well as heat, electricity, and transportation fuels, will be provided by the use of biomass, which will lessen the impacts of carbon dioxide and sulphur dioxide emissions into the environment. It will also provide energy security and boost the rural economy by replacing coal, crude oil, and gas with renewable resources. Around 14% of global energy needs are met by biomass, which is ranked fourth among all energy sources. Developing countries rely heavily on biomass as a source of energy, accounting for 35% of their overall output.

A country's ability to grow economically and socially relies heavily on its supply of energy. There has been an increase in interest in alternative fuels like producer gas as fossil fuel costs have skyrocketed. Compression ignition and spark ignition engines can utilise producer gas, which has a low calorific value. Producing producer gas is possible from a wide range of carbonaceous and biogenic sources. Instead of diesel, producers gas is typically utilised in CI engines, resulting in a reduction of 15-30% in engine output. Producer gas and diesel have

different air/fuel ratio needs, which is the primary reason for the discrepancy.

Keywords - Biomass, Internal combustion engine, Engine power, Producer gas.

Gasification of solid waste (also known as gasification) is a viable alternative fuel to fulfil energy demand in many countries, which may be used for fueling a compression ignition (CI) engine in dual-fuel mode or a spark ignition (SI) engine in the gas-alone mode for a variety of vehicles. For internal combustion engines, this technology is both ecologically friendly and promising.

The use of alternate gaseous fuels in place of fossil diesel is one of the most effective ways to reduce emissions from diesel engines. Sox and NO_x, the primary acid rain components, are virtually nonexistent in the combustion of gaseous fuel, but CO₂ is a major contributor to greenhouse gas emissions in the burning of most oil products and coal [1]. Alternative gaseous fuels for compression ignition (CI) engines that can replace diesel include natural gas, liquefied petroleum gas, hydrogen (H₂), biogas, landfill gas, sewage gas, digester gas, syngas, and so on. All of these can be utilised in CI engines. Carbon monoxide

CO and hydrogen dioxide H₂ are the building blocks of the whole area of fuel research and technology since they are the two diatomic molecules in syngas. In the past, syngas has been known by a number of names, including producer gas, town gas, blue water gas, synthesis gas, and syngas. Any hydrocarbon source may potentially be used to produce syngas. They include natural gas, naphtha and residual oil, petroleum coke, coal as well as biomass and lignocellulose.

For the production of syngas, solid fuel feed stocks such as coal or biomasses are converted into gas. Combustible gases may be produced as a result of a biomass's incomplete combustion. Carbon monoxide (CO), hydrogen (H₂), and methane (CH₄) make up roughly 40% of the mixture, with the remaining being nitrogen (N₂) and carbon dioxide (CO₂). CO₂, H₂O, H₂, and CH₄ may be present in varying quantities.

As a result of its high flammability limitations and fast flame propagation speed, H₂ is the primary component in syngas. Compared to natural gas, the laminar combustion speed of H₂ is around eight times higher. Internal combustion (IC) engines run more efficiently because the combustion time is shortened when a gaseous fuel contains more H₂. A gaseous fuel's lean operating limit can be extended without approaching the lean misfire area if H₂ is added to it. Combustion of a lean mixture has the potential to improve thermal efficiency and reduce NO_x emissions while increasing hydrocarbon emissions just somewhat.

Fuel, particle size, flow rate, chemical reactor topologies, operating parameters of the gasification process, gasifying agent and catalyst and residence time all affect the gas composition of syngas. This gas can be used to generate electricity on its own or in conjunction with another fuel source. Syngas has a lower heating value (LHV) of 4-6 MJ/m³, which is significantly lower than natural gas. The LHV of syngas may be increased to 9-13 MJ/Nm³ [5] by gasifying with pure oxygen. Using diesel as a pilot fuel, this study explores syngas as a single fuel in SI engines and a dual fuel in CI engines. Significant potential exists for SI ignition engines using syngas, which can be as inexpensive or cheaper than natural gas. The anti-knock properties of H₂ and CO mixtures might make them suitable for use as a spark ignition (SI) fuel. Under stoichiometric SI combustion, however, the addition of H₂ to CO tends to raise combustion temperature, which raises emissions of nitric oxide (NO). As a result, in a CI diesel engine, where combustion temperatures are tempered by a surplus of air, H₂ and CO combinations are a better fit for lean burn circumstances. In addition to being able to run on a variety of fuels, the dual fuel engine has the ability to run as a traditional diesel engine [6]. Air and high octane index gasoline are mixed in a carbureted manner, and the mixture is sucked and compressed in the same way as a traditional diesel engine does.

The low ignition quality of the gaseous fuel prevents the compressed air and fuel-gas mixture from self-igniting. A little liquid fuel injection, known as the pilot, spontaneously ignites at the conclusion of compression. Review of syngas as an alternative fuel for internal combustion engines was the focus of this communication.

Resurgent attention to biomass energy has led to a rise in the use of biomass-based technologies as both rural and industrial power plants. Using a wide variety of bio-residues as a feedstock, gasification produces clean gas that may subsequently be used to generate power. As a general rule, they are used in diesel engines that run on two fuels as well as gasoline engines.

Researchers have been working on manufacturing gas engines since World War II. The number of automobiles adapted to produce their own gas is estimated to have been over seven million throughout Europe, Australia, South Africa, and the Pacific Islands by the end of World War II. Charcoal or biomass-derived gas was used in these spark-ignited engines, which often had low compression ratios. The National Swedish Testing Institute of Agriculture Machinery in Sweden (ANON-FAO Report, 1986) has carried out extensive fieldwork by placing gas generators and engine sets on trucks and tractors as sited by Martin et al (1981)

Biomass gasification reawakened in the latter end of the twentieth century, igniting a fresh wave of interest in engines powered by producer gas. As a result of anticipated restrictions of knock at higher Compression Ratio (CR) engines prior to the 21st century, this research was confined to engines with lower CRs (less than 12.0). Another important obstacle is the lack of readily available traditional and well-established gasification systems that might provide engine applications with gas of consistently high quality on a continual basis. Earlier studies on producing gas engines are briefly summarised in the next section to provide background information.

II. LITERATURE REVIEW

Using biomass-derived gaseous fuel in IC engines and fuel cells has been studied by Paul and others. Commercial-scale operation of the IC engine path is well-established.

G. Sridhar et. al., [G. Sridhar, 2006] can be utilised as a decentralised power generating system in order to improve the quality of life, which includes providing high-quality energy for lights, water supplies and irrigation.

An investigation of the development research on producer gas engines carried out by [G Sridhar] and his colleagues has revealed that smooth

operation is attainable from CR 17 on up, with different de-rating observed at lower CR. In order to run a commercially available gas engine (such as one intended for natural gas) on low-energy density producing gas, the carburetor must be specifically developed.

According to Friedrich Lettner et al. [Friedrich Lettner, 2007], the highest expectations are placed on the exploitation of biomass gasification plant producer gas in order to assure electrical and thermal energy supply while meeting standards for stability, efficiency, and emissions. Secondary exhaust gas treatment costs are reduced and emissions are reduced as a result of the principle.

It was discovered by Abrar Inayat et. al. [Abrar Inayat, 2009] that the product gas composition can be predicted using a reaction kinetics model in a steam gasification system that also includes adsorption. As a result, each step in the biomass gasification process has been accurately modelled. Hydrogen production is increased by raising the steam/biomass ratio, which is an essential consideration in the steam gasification process.

III. METHODOLOGY

3.1 Analysis of Coal

Extreme research and proximal examination are the two methods. A definitive study determines all coal part components, whether solid or vaporous, whereas a preliminary analysis disqualifies mines based solely on fixed carbon, unpredictable problem, dampness, and powder rates. A definitive investigation is completed in a well prepared lab by a skilled scientific specialist, whereas a proximate investigation is completed using a simple mechanical assembly. It's worth noting that "proximate" has nothing to do with "inexact."

3.2 Ultimate Analysis:

Carbon, Hydrogen, Oxygen, Sulphur, and other elemental chemical ingredients are identified in the final analysis. It may be used to figure out how much air is needed for combustion, as well as the volume and composition of the combustion gases. The work's major goal is to use ultimate analysis to determine the calorific values of biomass samples.

3.3 Proximate Analysis

Moisture content, volatile matter, ash content, and fixed carbon were all determined using proximate analysis. The fuel's volatility and burning qualities are determined by a proximate analysis. For these analyses, the ASTM standard (ASTM, 1983) was employed, which is recommended for coal, sparky fuels, and other materials and generally fits the need for biomass material.

3.4 Moisture Content

The dampness content of a substantial amount of biomass is determined by the kind of fuel, its source, and treatment prior to gasification. The dampness material plays an important role in the igniting process. For trouble-free and careful gasifier operation, a moisture content of less than 15% by weight is ideal. The fuel dampness content (FMC) of cotton stalk was determined by drying the known load of test in a tourist oven at 1050C for 24 hours while keeping the ground test in petridish till consistent weight.

3.5 Volatile Matter

In the pyrolysis zone, unstable issue and intrinsically bonded water in the fuel were relinquished, forming a vapour composed of water, tar, oils, and gases. More tar is produced by fuels with a high level of uncertain problem material. Unstable considerations in the fuel dictate the design of the gasifier for tar extraction. The material emits unstable matter of cotton stalk biomass as a gas or vapour when strong biomass is heated out of contact with air under regulated circumstances that may alter as stated by the material's notion.

3.6 Ash Content

Ash is the mineral component of fuel that remains in an oxidised state after burning. Ash does, in fact, contain some unburned gasoline. The smooth operation of the gasifier is influenced by the powder material and the generation of flaming remnants. Slagging and clinker formation are caused by the liquefaction of cinders in the reactor. Slagging or clinker arrangement causes unnecessary tar growth or full reactor obstruction if no precautions are taken.

3.7 Fixed Carbon

The fixed carbon refers to the combustible portion of the fuel that isn't unpredictable. The amount of fixed carbon contained in the sample offers an unfavourable indication of the charcoal output. Furthermore, a material with greater fixed carbon content is usually better suited to gasification than one with a lower fixed carbon content. After deciding on the fuel dampness content (d.b.), the unpredictability issue (d.b.), and the fuel powder content (d.b.), (d.b.).

3.8 Calorific value of biomass

Calorific value refers to the quantity of heat produced per unit mass of fuel when it is completely burned. It might be explained in two ways: HHV (higher warming value) and LHV (lower warming value) (lower warming worth).

Calorific assessment of biomass feed stalk is determined in order to determine its suitability for gasification and gasifier efficiency. The calorific estimate of cotton stalk biomass was determined using a bomb calorimeter. In the cauldron, one gramme of air dried ground test was collected. The circuit wire was attached to the bomb's cathodes.

IV. TESTING OF BIOMASS SAMPLES

At ICT, a sample of red Gram stalk biomass was obtained to examine the elements makeup (Indian Institute of Chemical Technology). Before being tested in a gasifier, these samples were evaluated using various procedures to determine their characteristics.

4.1 Biomass sample:

Red Gram stalk

4.2 Testing Procedure:

4.2.1 Determination of Moisture:

This is a description of the solid fuel sample proximate analysis method. In an air oxygen – ventilated drying oven, a constant and uniform temperature of 108(+/-) 2 degrees may be maintained.

4.2.2 Determination of Ash:

Temperature range of 500 to 815 degrees Fahrenheit may be achieved in 30 minutes, rising to 815 degrees Fahrenheit in another 30 to 60 minutes, and holding this temperature until the end of the run-up period. The furnace should be able to be raised to a temperature of 50(+/-) 10 degrees if necessary. The ventilation must be set up in such a way that enough air is provided.

4.2.3 Determination of Carbon & Hydrogen:

Heating the combustion apparatus requires two furnaces, each with a length of 80 cm, as shown below. To build them, nichrome wire is wrapped around an aluminium frame with an inch thick wall. 35 cm in length, furnace No-1 is designed for heating a boat and its contents to a temperature of 800 to 900 degrees Celsius. Copper gauge, lead chromate, red lead and silver gauge are heated in furnace No. 2: 2-23 cm in length, with the temperature gradient from 555 deg C to 250 deg C along the remaining 14 cm.

4.2.4 Determination of Nitrogen

To digest the sample material, a 50 ml conical flask of 500 ml for distillation is required. Deliver tub, condenser and 250 ml conical flask receiver are the apparatus for conducting the experiment..

4.2.5 Determination of Sulphur by Bomb method:

At least one of the three piece Bertha bombs would be ideal for this purpose. Austenitic chromium-nickel molybdenum steel or aluminium bronze bars with 0.5 percent proof stress of not less than 2.0 kg/cm² are used for the cup and cap, respectively. An oxygen supply is required for this to work, so that the bomb can burn exactly one gramme of strong or fluid fuel with the aid of an oxygen supply. B) Withstanding, yet with an adequate wellness element that will not be made of austenitic steel as that utilised for the cup and the top. String seizing may be dangerous, thus this is required to keep everyone safe. Low molybdenum (free cutting) austenitic steel can be replaced by aluminium bronze, which can be coated to improve the finish.

V. RESULTS

Ultimate Analysis of Red Gram stalks Biomass Sample on air dried basis.

Table:

SL. NO.	ELEMENT	% BY WEIGHT
1.	moisture content	5.9
2.	ash content	1.85
3.	fixed carbon	42.57
4.	Hydrogen	5.71
5.	Nitrogen	0.41
6.	Sulphur	0.35
7.	Oxygen	43.21
8.	calorific value	14820 kJ/kg

The ultimate analysis of the Red Gram stalk on air dried basis in terms moisture content, hydrogen, carbon, nitrogen, sulphur, oxygen have been experimentally found.

VI. CONCLUSIONS

The findings of this study indicate that the physical and chemical features of Red Gram stalk agricultural leftovers to be utilised as feedstock for an open core downdraft gasifier may be accurately characterised. Red Gram stalk biomass has a calorific value of 14820 KJ/Kg and a moisture content of 5.9%, an ash content of 1.85%, a fixed carbon content of 42.57 percent, a hydrogen content of 5.71 percent, a nitrogen content of 0.41 percent, a sulphur content of 0.35 percent, and an oxygen content of 43.21 percent on an air dried basis.

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