# EXPERIMENTAL ANALYSIS OF GROUNDNUT SHELL GASFICATION IN A FLUIDIZED BED GASIFIER

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## ABSTRACT

Gasification process analyses the potential of groundnut shell to produce combustible gas in a fluidized bed gasifier. Gasification is one of the primary thermo chemical conversion methods to convert biomass into valuable energy rich fuel gas. Biomass is widely considered to be a potential fuel and renewable resource for the future. Gasification of biomass has been denied a possible system for producing renewable hydrogen, which is to exploit biomass resources to develop a highly efficient clean way for large-scale hydrogen production and has less dependence on insecure fossil energy sources. In the present study the biomass gasification to be carried out in a fluidized bed with the samples of groundnut shell (GS) with air and steam as fluidization and gasification agents respectively. During the experiment the producer gas composition under varying performance is to be predicted by influencing parameters viz., temperature and steam with biomass ratio.

Keywords: *Gasification, Gasifier, Fluidized bed .*

## I. INTRODUCTION

### A. BIOMASS

India being a developing nation, sustainable development is more important. Energy is an important factor for any developing country. The utilization of renewable energy sources is an effective approach towards alleviating these constraints. In this context, biomass stands out as a promising source of energy..

Biomass is an important in energy conversion processes due to their favorable status with respect to greenhouse gas emissions. However, conversion of biomass into producer gas by thermal gasification broadens the scope of biomass applications. Biomass research is recently receiving increasing attention because of the probable waste-to-energy application. Fluidized bed gasification (FBG) is an emerging energy conversion technology for solid and liquid fuels, well suited to low-grade fuels and waste materials. Biomass is potentially an attractive feedstock for producing transportation fuels as its use contributes little or no net carbon dioxide to the atmosphere. Thermo chemical gasification of biomass is a well-known technology that can be classified depending on the gasifying agent: air, steam, etc.

### B. GASIFICATION

There are several techniques available for biomass-to-energy conversion. They are broadly classified as (i) thermo-chemical conversion methods and (ii) bio-chemical conversion methods. Under the first category, (i) combustion, (ii) gasification, and (iii) pyrolysis are the methods. In this project, the aim is to utilize bio residues to produce thermal energy or mechanical energy by gasification. In this method, solid biomass is converted to a gaseous fuel which is then burnt to produce thermal energy or mechanical energy.

Groundnut shell is a non-woody shell portion covering the groundnut. Groundnut is also calledas peanut in some countries. The botanical name of groundnut plant is Arachishypogaea .Ground nut shell results as a by-product during de-shelling of groundnut.

### C. GENERAL

Even though the heating value of GNS is nearly equal to that ofwood, factors like low density and poor material flow characteristics lead to difficulties in its processing, handling and feeding into gasifiers. These shortcomings can be overcome if loose GNS is dried, sized, screened, and briquetted. It may be economical for large scale gasification plants to use briquettes but certainly not for small scale gasifiers of 10-100 kw ratings.

## II. ENERGY SCENARIO IN INDIA

A serious energy shortage and growing pressure on imports have been seen in the Indian energy sector. In the middle of 2015, India's power shortage led to massive rolling power cuts across the nation. Industries and businesses shut down and public protests followed, demanding better power supply. That the current power crisis is not a temporary hiccup in the power system, but worrying.

The average electricity consumption in India is still among the lowest in the world at just 630 kw h per person per year, but this is expected to grow to 1000 kwh with incoming years. The Ministry of Power has set an agenda of providing power to all by 2020. India is ranked the third most attractive country to invest in renewable energy, after USA and Germany.

All because of lack of electricity andwater. Biomass exists in these villages and needs to be tapped intelligently toprovide not only electricity but also water to irrigate and cultivate fields tofurther increase production of biomass .Studies reveal that the low grade of land suitable only forscrub vegetation can be turned to advantage and form an excellent source of biomass – fast growing trees and shrubs.

| Agricultural residue | Proximate analysis (weight %) VM(daf)* | Ash(db)* | Ultimate analysis (weight %, dry) C | H | N | O | HHV $MJkg^{-1}$ | Density $kgm^{-3}$ |
|---|---|---|---|---|---|---|---|---|
| Bagasse | 84.2 | 2.9 | 43.8 | 5.8 | 0.4 | 47.1 | 16.29 | 111 |
| Coconut coir | 82.8 | 0.9 | 47.6 | 5.7 | 0.2 | 45.6 | 14.67 | 151 |
| Coconut shell | 80.2 | 0.7 | 50.2 | 5.7 | 0.0 | 43.4 | 20.50 | 661 |
| Coir pith | 73.3 | 7.1 | 44.0 | 4.7 | 0.7 | 43.4 | 18.07 | 94 |
| Corn cob | 85.4 | 2.8 | 47.6 | 5.0 | 0.0 | 44.6 | 15.65 | 188 |
| Corn stalks | 80.1 | 6.8 | 41.9 | 5.3 | 0.0 | 46.0 | 16.54 | 129 |
| Cotton gin waste | 88.0 | 5.4 | 42.7 | 6.0 | 0.1 | 49.5 | 17.48 | 109 |
| Groundnut shell | 83.0 | 5.9 | 48.3 | 5.7 | 0.8 | 39.4 | 18.65 | 299 |

## III. THERMO CHEMICAL CONVERSION PROCESS

Biomass energy can also be used by thermo-chemical conversion process. Thermo chemical conversion can happen in three ways:

i) Pyrolysis
ii) Gasification

### A. PYROLYSIS PROCESS

Pyrolysis is a chemical process of decomposition of biomass materials by heating without the involvement of oxygen. Pyrolysis of biomass starts at 350ºC – 550 ºC and goes up to 700 ºC. This leads to the production of useful liquid oil, gases and solid products. Pyrolysis is heavily used in the chemical industry, for example, to produce charcoal, activated carbon, methanol and other chemicals from wood.

### B. GASIFICATION PROCESS

Gasification uses air, oxygen, or steam as a reaction medium to convert the organic portion of a dry or wet feedstock into the minor by-product like char and primarily non condensable permanent gases CO, $CO_2$, $H_2$.Gasification uses preheated oxidizers (800 1300°C) at atmospheric pressure to convert the dry biomass in to chars and low-calorific value gas.

**I) OXYGEN GASIFICATION**:

It yields a better quality gas of heating value of 10–15 MJ/Nm$^3$. In this process, the temperatures between 1000 and 1400 °C are achieved. $O_2$ supply may bring a simultaneous problem of cost and safety.

**II)AIR GASIFICATION**:

It is most widely used technology as being cheap, single product is formed at high efficiency and without requiring oxygen. A low heating value gas is produced containing up to 60 % of $N_2$ having a typical heating value of 4– 6 MJ/Nm3 with by-products such as water, $CO_2$, hydrocarbons, tar, and nitrogen gas. The reactor temperatures between 900 and 1100°C have been achieved.

**III) STEAM GASIFICATION**:

Biomass steam gasification converts carbonaceous material to permanent gases ($H_2$, CO, $CO_2$, $CH_4$and light hydrocarbons), char and tar. Fluidized bed steam gasification processes (with or without $O_2$ added) are capableof producing a Medium Heating Value (MHV) in the range of10 – 16 MJ/Nm$^3$ gas with a 30 – 60 vol. % $H_2$ content.

## IV. FLUIDIZED BED GASIFIER TEST SETUP

A laboratory scale bubbling fluidized bed gasifier system was designed, fabricated for an experimental investigation. The schematic diagram of an experimental set up is shown in Figure 6.1A photographic view of the experimental setup is shown in Figure6.2. The main elements of the installation are : The fluidized bed gasifier, a steam generator, cleaning and sampling system, temperature control system, and the measurement equipment consists of a Siemens make gas chromatograph for gas quality measurement as well as thermocouples and manometer for temperature and pressure control inside the reactor.

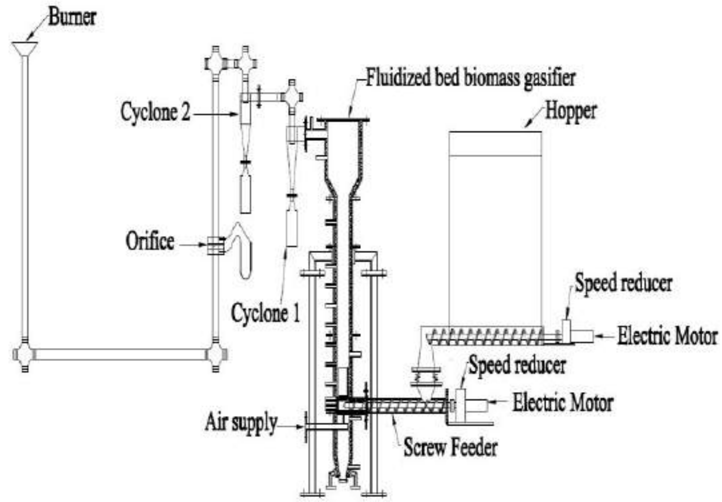
A fluidized bed system with screw feeder, microprocessor based automatic control unit was fabricated in this work for analyzing the fuel gas behavior and distribution of product yields of different agricultural residues (coconut shell, groundnut shell, rice husk) and sawdust samples. The system consisted of an external electric heater inside the reactor, cyclone, blower, water scrubber, burners and dry filter, Chromel-Alumel thermocouples, and microprocessor based automatic control unit with temperature indicators, PID (Proportional–Integral–Derivative)controller, heating rate and temperature setting unit. The gasifier unit detail describe in Table6. 1. The product gas from the gasifier was made dust – free and cleaned by passing it through a gas cleaning and cooling system before it was being put into gas analyzer. The hot fuel gas from the fluidized bed gasifier was made to pass through a cyclone to remove the larger particles. After passing through the cyclone, the gas still contained dust particle sand tar and hence, it is further cooled and cleaned by passing it through a water scrubber and dry filter. The dry and clean product gas was then analyzed in a gas analyzer to measure the composition of CO, $CO_2$, $CH_4$, $N_2$and $H_2$presence in the fuel gas.

## V. BIOMASS SAMPLE PREPARATION

The moisture content in all the samples was initially removed by exposing to natural sun light for a period of 2 weeks. Then all the sample swere crushed in the mills, followed by separating into different particle size ranges. The standard sieve (IS designation 460-1962) separator was used to separate the crushed samples into different particle size ranges.334 µm is found to be suitable for better fuel particle mixing characteristics.

### A. EXPERIMENTAL FLUIDIZED BED GASIFICATION SYSTEM

The details of various components, fabrication details, preparation of samples with different particle sizes and its properties, experimental procedures, TG and DTG analysis for samples are discussed in this chapter. The heating coils were wired at the centre of the furnace and it was insulated with ceramic fiber blankets to prevent the heat loss from the heating coil to atmosphere. The ceramic fiber layer was covered with mild steel sheets as an outer cover. 310 grade stainless steel pipes were used as reactor for heating the samples.





GAS ANALAYSER

PHOTOGRAPHIC VIEW OF THE EXPERIMENTAL SETUP

VI. STAGES IN GASIFICATION

DRYING

Biomass consists of moisture ranging from 5 to 35%. At temperatures above 100°C, water is evaporated. While drying, biomass do not experience any kind of decomposition.

### A. DE VOLATILIZATION

Devolatilization involves the release of three kinds of products: solid, liquid and gases. The ratio of products is influenced by the chemical composition of biomass and the operating conditions. The gas contains high molecular weight condensable hydrocarbons. In an open top downdraft gasifier, because of the downward passage of air through the bed,

| | |
|---|---|
| Type of gasifier | fluidized bed |
| Geometrical parameters | ID: 108 mm; total height :1400 mm |
| Heating Type | External electric heating |
| Cooling medium | Water |
| Feedstock capacity | 5-20 kg / h (depending on the type of fuel) |
| Feeding equipment | Screw feeder |
| Gasifying agents | Air, Steam |
| Operating temperature | 650-950 ºC |
| Heating rate | 1-60°C/min |
| Feed stock | Coconut shell, groundnut shell, rice husk, and saw dust |
| Main process variables | Reactor temperature, steam to Biomass ratio |
| Fuel gas treatments | Cyclone, Water scrubber, Dry filter |

these hydrocarbon gases react with air stream

thus undergoing combustion.

### B. OXIDATION

Oxygen present in air is partially consumed in the combustion of hydrocarbon gases While the rest is consumed in the heterogeneous reaction with char produced after. Oxidation takes place at a high temperature of 700°C-1400°C.

$C + O_2 \leftrightarrow CO_2 + 393.8$MJ/kgmol.

Hydrogen in fuel reacts with oxygen in the air, producing steam.

$H_2 + O_2 \leftrightarrow H_2O + 239$ MJ/kgmol.

### C. REDUCTION

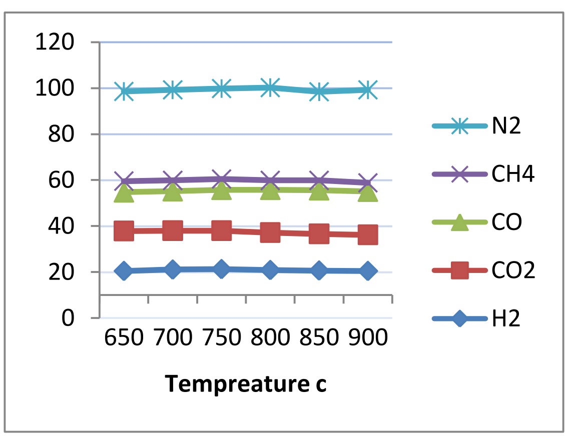
In the reduction zone, a number of high temperature chemical reactions take place inthe absence of oxygen. The principal

reactions that take place in reduction zone are mentioned below:
Carbon oxy reaction: $CO_2 + C \leftrightarrow 2CO - 172.6$ MJ/kgmol
Water- gas reaction: $C + H_2O \leftrightarrow CO + H_2 - 131.4$ MJ/kgmol
Water shift reaction: $CO + H_2O \leftrightarrow CO_2 + H_2 + 41.2$ MJ/kgmol
Methane production reaction: $C + 2H_2 \leftrightarrow CH_4 + 75$ MJ/kgmol
Hence, the temperature of gas goes down during this stage. If complete gasification takes place, no carbon is left over; only ash is formed.

### EXPERIMENTAL RESULTS OF DIFFERENT TEMPERATURES

| Temp | 650 | 700 | 750 | 800 | 850 | 900 |
|---|---|---|---|---|---|---|
| $H_2$% | 20.4 | 21 | 21.2 | 20.8 | 20.6 | 20.4 |
| $CO_2$% | 17.5 | 17 | 16.8 | 16.4 | 16 | 15.8 |
| CO% | 16.8 | 17.2 | 17.8 | 18.6 | 19 | 18.8 |
| $CH_4$% | 4.8 | 4.6 | 4.2 | 4 | 4.2 | 3.8 |
| $N_2$% | 39 | 39.4 | 40.6 | 40.4 | 38.6 | 40.4 |

(Biomass feed rate: 10 kg / h; E.R: 0.18; S/B: 0.30)

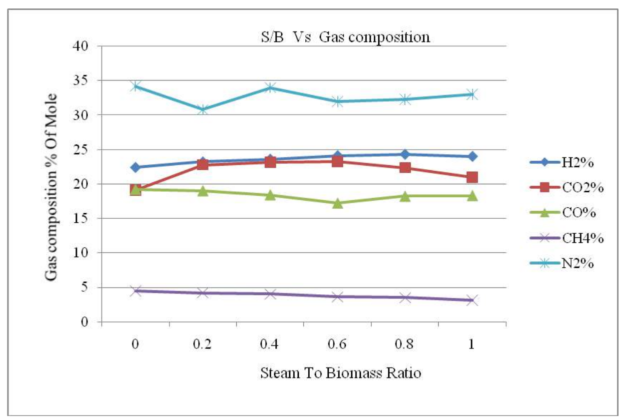



**TEMPERATURE VS GAS COMPOSITION**

### EXPERIMENTAL RESULTS OF DIFFERENT S / B RATIOS AT BED TEMPERATURE OF 750 ºC

| S/B | 0 | 0.20 | 0.40 | 0.60 | 0.80 | 1.0 |
|---|---|---|---|---|---|---|
| $H_2$% | 22.4 | 23.2 | 23.6 | 24.1 | 24.3 | 24 |
| $CO_2$% | 19.1 | 22.8 | 23.2 | 23.3 | 22.4 | 21 |
| CO% | 19.2 | 19 | 18.4 | 17.2 | 18.2 | 18.3 |
| $CH_4$% | 4.5 | 4.2 | 4.02 | 3.6 | 3.5 | 3.1 |
| $N_2$% | 34.2 | 30.8 | 34 | 32 | 32.3 | 33 |

(Biomass feed rate: 10 kg / h; E.R: 0.18; T: 750)




**S/B VS GASCOMPOSITION**

## VII. CONCLUSION

This project present the result of a fluidized bed gasifier made of stainless steel tube with inside diameter of 108 mm and a height of 1400 mm, extending into a 300 mm inside diameter and 450 mm high expanded freeboard section was fabricated with cleaning and cooling system of cyclone, water scrubber and dry filter. A drilled holed distributor plate of 115 mm ID and 200mm

OD was used for air distribution. The present lab scale model can gasify groundnut shell with the range of 4 to 18 kg/h with the optimum value of 10 kg/h. From the analysis of the two critical parameters(temperature, steam-to-biomass ratio). The temperature plays a significant role in the process. A higher temperature will be more favorable for gas and hydrogen yield. A too-high S/B will lower reaction temperature, and then will cause hydrogen yield to decrease. The highest hydrogen yield per kg of biomass is achieved at the condition of temperature 750°C, S/B of 0.80 and equivalence ratio of 0.18. It is shown that under proper operating parameters biomass air - steam gasification in fluidized bed is one effective way for the generation of hydrogen-rich gas.

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