International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 4, pp 259-263, April-2023

https://doi.org/10.47001/IRJIET/2023.704039

Experimental Analysis of Biomass Mixtures in Self Circulating Fluidized Bed Biomass Gasifier

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***Abstract* - The main aim of this project is to design and fabricate a self circulating fluidized bed biomass gasifier in order to carry out cold flow analysis of various biomasses individually and also with different combination like rice husk, groundnut shell, coir pith, sugarcane baggase and saw dust etc… for determining fuel flow rate and air flow rate in the proposed system. Here the fuel feeding system is eliminated and the biomass is brought down by gravity using self circulating arrangement. Proximate analysis of individual biomass and its mixtures were carried out for selecting the combination of mixture before using it for gasification. This system can be used for biomass gasification using self circulating FBG arrangement.**

Keywords: Self circulating FBG; fabrication, biomass Mixtures, Proximate and Ultimate Analysis, Pilot Model Gasifier.

I. INTRODUCTION

The demand for energy in India is growing at an alarming rate with major contribution comes only through conventional energy sources like coal, petroleum and gas, moreover the prices of coal, petroleum and gas are highly volatile which affects our Indian economy on large scale. The exhaustive nature of conventional energy sources making a way for us to go for renewable energy sources like solar, biomass and wind, as the availability for such energy sources in India is abundant.

Gasification process is the thermo chemical conversion of biomass fuel into a product called syngas or producer gas in which atmospheric air is normally used as gasification agent. The producer gas consists of mainly Carbon monoxide, Hydrogen and oxygen which can be used for heating purpose or for generation of motive power either in diesel engine or dual fuel engine with some modification. Various research works on producer gas generation are discussed in this section. Rajiv Varshney reviewed the potential and status of biomass gasification technology used in India for thermal application and power generation with capacity ranges from 5-500 KW gasifiers [1].

J.J.Ramirez designed and fabricated Fluidized bed gasifier for rice husk on a pilot scale and analyzed various parameters like minimum fluidization velocity during gasification, air flow rate, energy balance of gasification process , cold gas efficiency and equivalence ratio for rice husk and the result showed that the performance of gasifiers depends mainly on equivalence ratio range 0.2 to 0.35 on volumetric yield and also compared the result form pilot model with experimental data to validate proposed mathematical model [2].

K.N.Sheeba and S.Jaisankar conducted experiment on gasification of coir pith in a circulating fluidized bed gasifier using air as the gasifying medium and analyzed the effect of various parameters like Equivalence Ratio(ER), Temperature on gas yield, gas composition, carbon conversion, cold gas efficiency and overall thermal efficiency and concluded that highest hydrogen composition is found to be 11.2% at a temperature of 1020 ^{0}c at an ER of 0.18[3]. They also observed that highest heating value of 5.31 MJ/Nm^3 for a temperature of 1020 ^{0}c at an ER of 0.31.

From the literature survey several research works have been carried out in converting biomass like rice husk, coir pith, saw dust, groundnut shell powder and bagasse to syngas generation using different design of biomass gasifiers. Tamilnadu is one among the top ten states in India producing agriculture residues, so there is a large scope of biomass conversion to useful energy. Also Subramanian and Sampathrajan carried out experimentation in selected granular biomaterials like coir pith, rice husk and saw dust in fluidized bed gasification for syngas generation [4]. They also analyzed gas yield, syn gas compositions and percentage of carbon monoxide and carbon dioxide in the equivalence ratio of 0.3 to 0.5.

Even though several research work have been carried out in thermo chemical biomass energy conversion the presence of moisture content in biomass and level of unburnt carbon particles coming out from cyclone separator affects the syn gas generation, gas composition, cold gas efficiency, carbon conversion efficiency and overall thermal efficiency [5, 6]. In the present study an attempt is made to design and

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develop a pilot model gasifier with self circulating setup in order to bring the biomass through gravity for eliminating fuel feeding subsystem and to reduce the level of un-burnt carbon particles coming out from cyclone separator.

II. EXPERIMENTAL SETUP AND PROCEDURE

A) Methodology

From the Literature review a pilot model gasifier was designed and fabricated in order conduct cold flow analysis before gasification process [7, 8]. Proximate and Ultimate analysis were carried out for individual biomass and with different combination like paddy straw and groundnut shell, and Bagasse and in to order to select best combination for energy conversion. This study was carried out in determining air fuel ratio for different air flow rate.

B) Experimentation

The work is carried out at Department of Mechanical Engineering in Parisutham Institute of Technology and Science group of institutions, Thanjavur. Initially Proximate analysis was carried out for individual biomass and with different combination in a muffle furnace which is shown in Figure 1.

Table 1 and Table 2 shows the proximate analysis values for individual and biomass combination. The schematic diagram of experimental setup of a self circulating fluidized bed gasifier is shown in Fig. 2. The photographic view of experimental set up is shown in Fig. 4. Dimension of the gasifier are given in Table 3.

Figure 1: Photograph of Muffle Furnace

Table 1: Proximate Analysis – Individual Biomass

S. No	Proximate Analysis	Rice Husk	Sugarcane Bagasse	Coir Pith	Ground nut Shell	Saw Dust
1	% Moisture content at 110^0C	6	5.5	4	5	13.5
2	% Volatile matter at 925^0 C	64.5	68.5	65	64	71
3	% Ash content at 750^0C	16	9	12.5	17.5	11.5
4	Fixed Carbon	13.5	17	18.5	13.5	4
5	Total	100	100	100	100	100

Table 2: Proximate Analysis – Biomass Mixtures

S. NO.	Proximate analysis	Paddy straw + sugarcane bagasse	Bagasse + Groundnut shell	Ground nut shell + Paddy straw
1	Moisture content at 110^0c	10.5	10.5	6.5
2	Volatile matter at 925^0c	74.5	63	74.5
3	Ash content at 750^0c	9	13.5	9
4	Fixed carbon	6	13	10
5	Total	100	100	100

Table 3: Dimension of Gasifier

Parts	Description	Dimensions
Riser column	Diameter Height	100 mm 550 mm
Outer Chamber	Diameter Height	200 mm 350 mm
Cyclone separator Tangential Inlet and circular Exit	Height Inlet diameter	400 mm 100 mm
Distributor plate	Diameter	150mm

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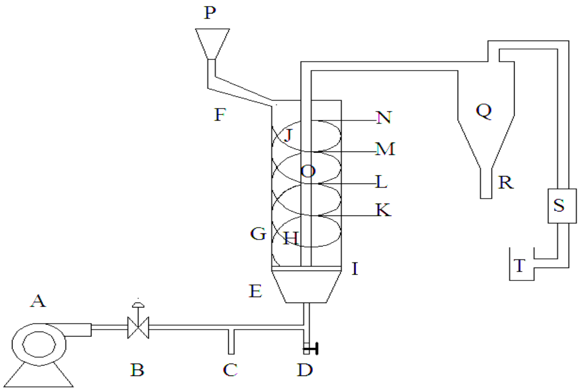

Figure 2: Fluidized bed gasifier- self circulating setup

A – Blower
B – Control Valve
C - Pressure Tapping
D - Drain Valve
E - Pressure Tapping Lower End
F - Pressure Tapping Upper End
G - Reaction Chamber
H - Riser Column
I - Distributor Plate
J - Self Circulating Setup
K, L, M, N - Temperature Indicator
O - Fluidizing Column
P – Hopper
Q - Cyclone Separator
R - Dust Collector
S – Rota Meter
T – Burner

C) Experimental setup- reactor system

The gasifier consists of reaction chamber, riser column distributor plate, hooper and cyclone separator besides pressure and temperature tapping. The entire pilot model is made up of mild steel. A riser column with internal diameter of 10 mm and with a thickness of 3mm for a height of 550 mm is selected. The riser column is kept inside the reaction chamber having an internal diameter of 200 mm for a height of 350 mm. The space between riser column and reaction chamber is fixed with self circulating setup which is also made up of mild steel through which the biomass reaches the bottom surface of reaction chamber by gravity. A blower is attached to the setup through which required air is supplied for conducting cold flow analysis and for gasification. Pressure and temperature tapings are provided at different locations in the experimental setup. An air distributor plate is located at the bottom of the reactor with 200 holes of 2 mm diameter. A suitable cyclone separator is attached at the end of riser column pipe. The cyclone separator has tangential inlet of circular type.

Figure 3: Photograph of experimental setup

D) Operating procedure and Data collection

The proposed system should be tested for conducting cold flow analysis before gasification process. The fuel was charged into the outer reaction chamber through the hopper without any fuel feeding subsystem. Care should be taken while feeding the fuel into the gasifier due to low density of biomass. Air from the blower is allowed to pass through the bottom of the gasifier by using control valve. The air through the tuyer takes the fuel into the riser column and then it is allowed to pass through cyclone separator having a tangential inlet. The weighted quantity of biomasses is fed in to the hopper and the time taken for the biomass to reach the bottom was noted down, thereby the feed rate of biomasses was calculated. Using U Tube Monometer pressure head difference air flow rate was calculated. The above experiment was repeated for various air flow rates with constant biomasses flow rates and the corresponding residence time and fuel ratio was calculated.

The following parameters were considered while conducting cold flow analysis:

(i) Air Flow Rate
(ii) Fuel Flow Rate
(iii) Weight of biomass from cyclone separator for every test
(iv) Pressure at two locations along the gasifier height
(v) Residence Time
(vi) Air Fuel Ratio

III. RESULTS AND DESCUSSIONS

The proposed experimental setup is tested for conducting cold flow analysis without any blockage for air flow and fuel flow into the system. For each biomass like paddy straw, bagasse and ground nut shell and the parameters like residence

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time and air fuel ratios were calculated keeping the biomass flow rate as constant. The same procedure was followed by changing the air flow rate and tabulated in Table 4.

Fig. 4 and 5 shows the relation between air flow rate and air fuel ratio of different biomass fuels. From the above graphs it has been observed that during cold flow analysis the air fuel ratio increases with increase in air flow rate which will be useful for fixing Equivalence Ratio (ER) during gasification process. Moreover the clogging nature of biomass reduces flow rate which can be reduced by self circulating arrangement.

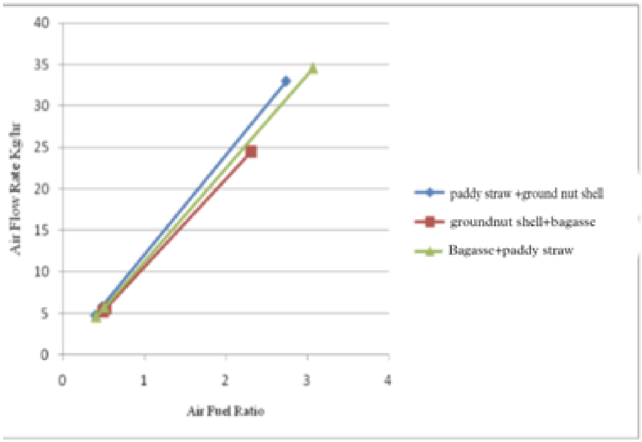

Figure 4: Air Flow Rate vs Air Fuel Ratio

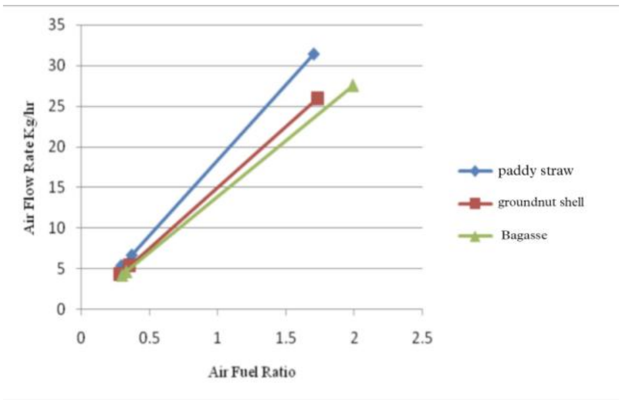

Figure 5: Air Flow Rate vs Air Fuel Ratio

IV. CONCLUSION

Cold flow analysis was successfully carried out in the proposed system for individual biomass and mixtures. The proposed system with self circulating setup can be used to gasify various biomasses like paddy straw, ground nut shell, bagasse. With the introduction of self circulation setup the various biomass can be pre-heated before it reaches the bottom of the gasifier. From the proximate analysis of biomass mixtures the best combination can be selected for gasification process for different Equivalence Ratio(ER) ranges from 0.2 to 0.5. Further in the biomass gasification system a heat exchanger can be added for producer gas cooling which can be connected to an engine for power generation.

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Citation of this Article:

R.Kathiresan, R.Sanjay, M.Santhosh Kumar, Dr. R.Ganesh, "Experimental Analysis of Biomass Mixtures in Self Circulating Fluidized Bed Biomass Gasifier" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 4, pp 259-263, April 2023. Article DOI https://doi.org/10.47001/IRJIET/2023.704039

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