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An Experimental Study on Gasification of Chicken Litter

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Abstract

Presently the utilization of energy is mainly dependent on the fossil fuels. The composition and behavior of the atmosphere is changed drastically due to its polluting components. The gap between the energy requirement and energy production is increasing and it can be reduced by utilizing through bio-mass as renewable energy source. Chicken litter is one of the abundantly available and technical feasible fuels, which can fill the gap between the energy productions to energy demand. In this paper a detail discussion on the process of fluidized bed gasification to utilize as an energy source is made and the producer gases obtained from the gasification process is compared with the other author for validation. The gasification is made for the equivalence ratio of 0.12 to 0.26 and it was found that the compositions of Carbon monoxide, carbon dioxide, methane and hydrogen are obtained within the acceptable range in comparison with the other authors.

Keywords: Fluidized bed technology, gasification process, chicken litter.

Introduction

Presently the utilization of energy is largely dependent on fossil fuels. There are drastic changes in the composition and behaviour of our atmosphere due to the rapid release of polluting combustion products from fossil fuels. A significant amount of the carbon-dioxide emissions from the energy sector is related to the use of fossil fuels for electricity generation. As the demand for electricity is growing rapidly, emissions of carbon dioxide and other pollutants from this sector can be expected to increase unless other alternatives are made available.

India boasts a growing economy, and is increasingly a significant consumer of oil and natural gas. With high economic growth rates and over 15 percent of the world's population, India is a significant consumer of energy resources.

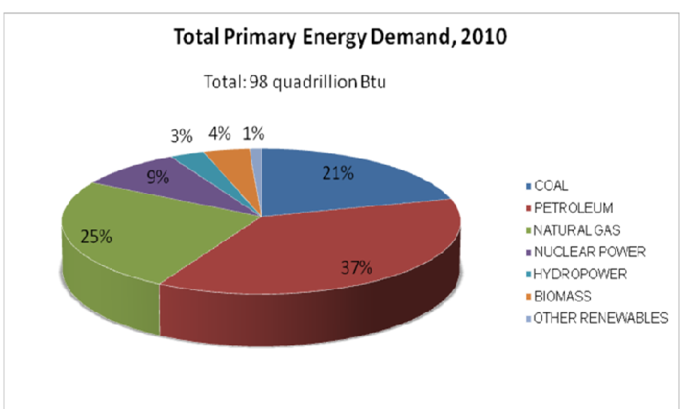

Figure-1
Total Primary Energy Demand 2010[1]

Figure-1 shows that Petroleum account for nearly 37 percent of world's total energy consumption, followed by nearly 25 percent for Natural gases. Coal accounts for nearly 21 percent of total energy consumption, nuclear nearly 9 percent, biomass 4 percent, hydroelectric power almost 3 percent, and other renewable sources less than 1 percent. According to the Indian government, nearly 30 percent of India's total energy needs are met through imports. International Energy Agency (IEA) data for 2008 indicate that electrification rates for India were nearly 65 percent for the country as a whole. In urban areas, 93 percent had access to electricity compared to rural areas where electrification rates were approximately 50 percent. Roughly 400 million people do not have access to electricity in India.

Further, the declining energy supplies and severe environmental constraints compel us to sharply focus our attention on the need for additional amounts of clean energy sources. Among the energy sources that can substitute fossil fuels, biomass fuels appear as the option with the highest general worldwide potential. In both the developed and the developing countries, the interest and activity for obtaining energy from biomass has expanded tremendously and dramatically in the last few years.

There are large quantities of residues, associated with chicken production and processing industries and they can be used for energy production, provided that they satisfy the criteria of plentiful supply and local availability on a renewable and perpetual basis. The Table-1 gives population of chickens in the world major countries. It indicates that out of the total chicken population 15,000 millions, around 45% is from Asia Pacific region. Further, India contributes around 5% towards the total world chicken population, which is quite significant from the energy point of view. In India annual growth rate of poultry production is higher than any other agriculture commodity i.e., about 10% for layers and 15% for boilers. Annual production is reported to be 33,000 million eggs, which ranks fifth in the world. Annual broiler production has reached 530 million and is ranked 22nd in the world. The total poultry population of India is estimated to be 800 million and the states like Andra Pradesh, Maharashtra, Tamilnadu, Haryana, Punjab and Delhi are the major producers of poultry.

Table-1
Chicken Population in various Countries[2]

Country	Unit in Millions
Indonesia	870.00
Malaysia	160.00
Philippines	125.7
Vietnam	163.0
India	823.5
Pakistan	153.0
China	923.6
Iran	270.0
Japan	283.1
Asia and pacific	7433.0
Rest of the world	8420.9
Total	15853.9

The production of poultry litter varies according to the season, type of the feed and type of the bird etc. The production manure from chicken litter varies with the age of the chicks and the type of the chicken and is indicated in table-2.

Table-2
Manure production from Chicken Litter[3]

Birds (10000)	Fresh (avg tons/day)	Fresh (avg tons/year)	Dried (avg tons/year)
Broilers:			
Up to 42 days	0.87	237.2	79.1
Up to 49 Days	1.01	287.0	95.6
Up to 56 Days	1.14	332.8	110.9
Layers:			
White Egg type	1.13	410.6	136.7
Brown Egg type	1.28	465.4	155.1

The quality of the fuel to be used depends mainly on its physical, chemical and Energetic Characteristics which can be determined by the proximate and ultimate analysis and the result of it is tabulated in the table-3.

Table-3 shows the composition of chicken obtained through proximate and ultimate analysis of chicken litter. The volatile matter and ash composition is found to be significantly high compared with fixed carbon. The Carbon and nitrogen elements are present in a middle value; whereas a little traces of sulphur are present. The calorific value present signifies the suitability to utilize it as a fuel. The Ash deformation temperature is found to be high.

Table-3
Various constituents and the heating values of chicken litter

Parameter	Chicken Litter (Dry basis)
Moisture content %	7.3
Fixed Carbon %	4.2
Volatile Matter %	53.7
Ash %	34.8
Carbon %	25.2
Hydrogen %	3.5
Nitrogen %	6.7
Oxygen %	22.25
Sulphur %	0.25
Lower Calorific Value (kJ/kg)	10,256
Higher Calorific Value (kJ/kg)	10,333
Ash Deformation Temperature, ^{o}C	875
Ash Fusion Temperature, ^{o}C	920

The composition of chicken litter is found to have good manure. But, out of the total nitrogen that exists 60 -80% is typically in inorganic form, such as urea and protein. Excessive application of chicken litter in cropping system can result in nitrate contamination of good water. High levels of NO_3 contamination of good water can cause methaemoglobinaemia (blue baby syndrome), cancer and respiratory illness in humans and fetal abortions in live stock. Three options have been considered to utilize the chicken litter as an energy source. Anaerobic digestion, direct combustion and gasification[3,4]. It may not be economical to transport the waste products of chicken industries to long distance to store and to utilize it, because of its high moisture content. The fluidized bed gasification technology is seems to be suitable technology for converting a wide range of chicken litter into energy due to its inherent advantages of fuel flexibility and property of utilizing any quality fuel[4].

In this paper, the procedure of gasification process is discussed and the producer gas obtained from fluidized bed gasification is analyzed and the result obtained is compared with results of the other author.

Research Methodology

Experimental Procedure: Gasification of chicken litter is carried out in an externally heated, atmospheric pressured bubbling fluidized bed Gasifier is shown in figure -1. The design of the same is given[5]. The Gasifier is made up of cylinder of inside diameter of 60 mm, with the fluidized bed height of 30mm and the overall height of the Gasifier is 2m. The Silica sand is used as the bubbling medium. The chicken litter is collected from the poultry farm and is dried for few days and then sieved using the sieve analyzer for the range of 750 to 1000 microns. The operating temperature of the Gasifier is maintained at 800^{0} C. The feed is given to the system through the feed hopper and the liberated gas from the Gasifier comes out of the reaction chamber into the houses, when it is cooled using the cooling jacket and the cooled gas then flows in to the cyclone chamber where the soot is separated from the gas and is collected in the soot collector. Further the gas is passed through the $CaCO_3$ filter, where the process of desulfurization takes place. Then the producer gas is passed through the Vacuum Pump, where the pressure of the producer gas is maintained uniform and the Producer Gas is then passed to the four gases Analyzer to determine the composition of Carbon monoxide, carbon dioxide, Nitrogen and Hydrogen.

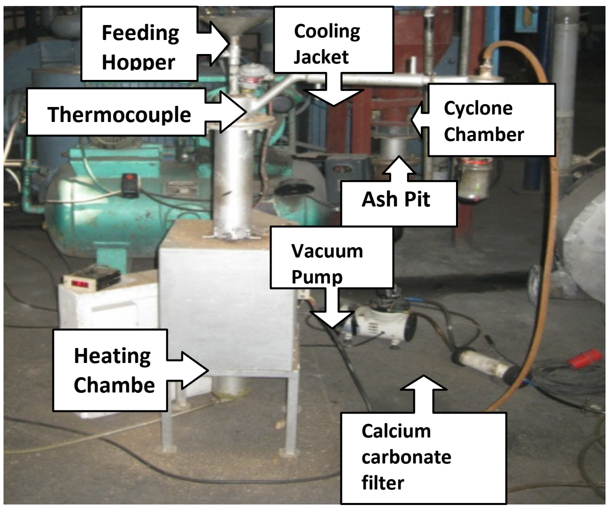

Figure-2
Atmospheric pressured bubbling fluidized bed Gasifier

Table-4
Operating Parameters of the fluidized bed gasifier.

Sl No	Particulars	Condition
1.	Operating temperature	800° C
2.	Mass Flow Rate of Chicken Litter	0.4 kg h^{-1}
3.	Minimum Fluidization velocity	0.07 m.s^{-1}
4.	Air Flow Rate	6 – 8 LPM
5.	Equivalence Ratio	0.12 – 0.3

The table-4 shows the operating condition of the Fluidized bed Gasifier. The operating temperature is considered as 800°C, which is suitable for better gasification and because of its low ash deformation temperature of the chicken litter. The fuel is operated for the equivalence ratio of 0.12 to 0.3, which is finding to be suitable for fluidized bed gasification [6,7]. The calculated[5] minimum fluidization velocity and air flow rate of the chicken litter is tabulated in the table-4.

Results and Discussion

The results obtained by the gasification of chicken litter for different equivalence ratios are tabulated in the table-5. The results obtained shows that with the increase in equivalence ratio the composition of CO_2 increases and the composition of CO, H_2 and CH_4 decreases. These results obtained by gasification process are compared with the results obtained by Arena et. al [8] and Joo et.al[9].

Table-5
Composition of producer gas obtained during gasification

Sl No	E R	CO_2	CO	H_2	CH_4
1	0.12	20.8	22.3	8.5	2.3
2	0.16	22	16.8	2.9	1.1
3	0.21	22.3	13.5	1.8	0.5
4	0.26	22.6	12	1.5	0.4

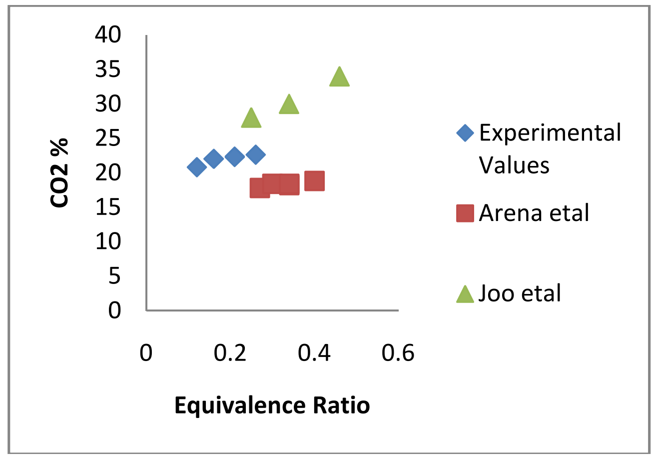

Figure-3
Comparison of CO_2 gas composition obtained during the gasification process with the other Authors

The figure-3 shows the percentage CO_2 components present in the producer gas obtained from the developed fluidized bed Gasifier and is compared with the results of the other authors. Percentage of CO_2 composition is observed to increase with increase in equivalence ratio, similar to the trend established by Arena etal[8] and Joo etal[9]. In reality the trend of CO_2 could be correlated with the trend opposite to that for CO. With decrease of CO_2 indicates the better gasification efficiency [10].

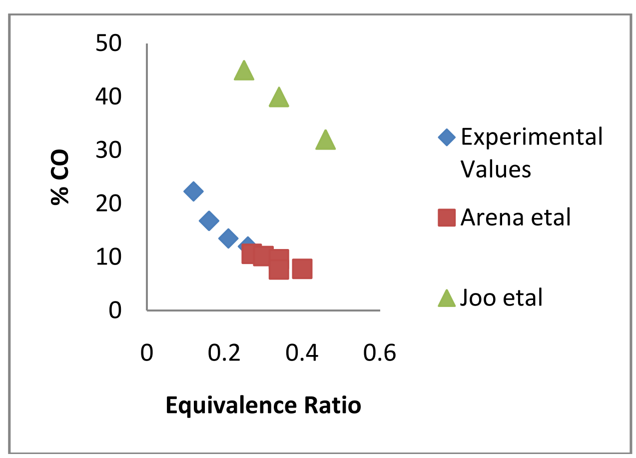

Figure-4
Comparison of CO gas composition obtained during the gasification process with the other Authors

The figure-4 shows the percentage CO composition in the producer gas obtained from the developed fluidized bed Gasifier is compared with the results of the other author. The trend predicts that the with the increase in equivalence ratio the composition of CO in the producer gas decreases, similar trend is observed with the other authors also.

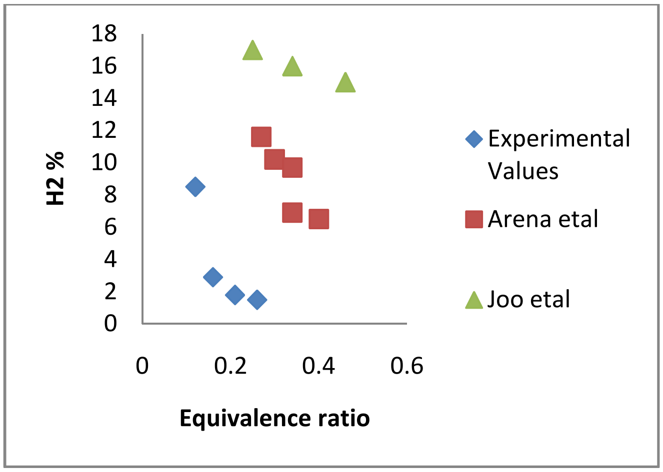

Figure-5
Comparison of H_2 gas composition obtained during the gasification process with the other Authors

The yield of hydrogen from the model is observed to follow a decreasing trend with increasing Equivalence Ratios is shown in the figure -5. A similar trend is reported by other researchers like Arena etal[8] and Joo etal[9]. The trend is quite misleading at first sight. It is a common reality that as the Equivalence Ratio increases; the temperature of the any oxidation reaction is bound to increase. This trend is applicable only where the temperature of the Gasifier is controlled externally[11]. In equilibrium modeling, it is assumed that temperature is maintained constant even at different Equivalence Ratios. However for internal heating systems, When the Equivalence Ratio is increased from low values, the temperature of the system increases, resulting in a marked increase in generation of both gas and its H_2concentration. Considering the range of H_2 yield, as predicted by the experimental values with the other authors in the Equivalence Ratios range of 0.12 to 0.26, the model values compare quite reasonable with the other author values.

The composition of CH_4 gas obtained during the gasification process is compared with the other authors is shown in the figure-6; the trend indicates that with increasing the Equivalence Ratio results in a decrease in concentrations of methane. The model results validate the claim that CH_4 concentration decreases with increasing Equivalence Ratio. The prediction on CH_4 made by the model is lower than the results of the other authors. In an equilibrium model, it is assumed that all reactions achieve a steady-state condition.

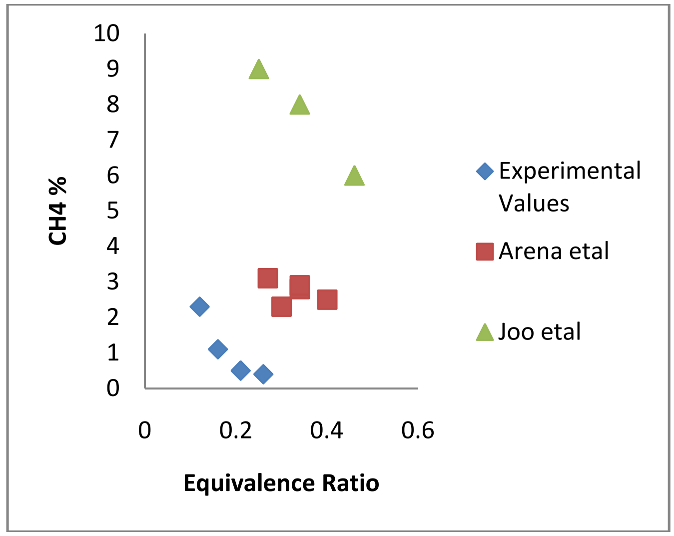

Figure-6
Comparison of CH_4 gas composition obtained during the gasification process with the other Authors

Conclusion

i. Alternative energy resources should be considered to fill the gap between the energy production and energy utilization. ii. The energetic components obtained from proximate and ultimate analysis of Chicken litter indicates that it is one of the bio-mass which can be considered as an alternative fuel. iii. The high moisture content and high ash content chicken litter can be utilized as the energy form by means of fluidized bed gasification process, as it is one of the suitable means through which any quality fuel can be utilized. iv. The gasification of chicken litter shows that the composition of carbon monoxide, methane and hydrogen in producer gas produced decreases with increase in the equivalence ratio and the trend is similar with the other authors also. v. The carbon dioxide composition in the producer gas increases with increase in equivalence ratio, which predicts that the opposite trend would have increased the gasification efficiency.

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