Estimate the Potential of Energy Generation from Poultry Waste Litter Using Aspen Plus simulation Tool

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Abstract- **The poultry industry is one of the biggest and quickest developing agro-based businesses on the planet. This can be credited to an expanding interest for poultry meat and egg items. Be that as it may, a noteworthy issue confronting the poultry industry is the vast scale gathering of squanders including compost and litter which may posture transfer and contamination issues except if naturally and monetarily reasonable administration innovations are advanced.**
The general goal of this paper is to play out a near techno-financial examination of the little scale incorporated gasification of poultry litter to offer ascent to both biochar and vitality items. For carried out the study Aspen Plus software is utilized as simulation tool. It is concluded that the energy requirement of the poultry form can be fulfilled by gasification of poultry waste and surplus amount of energy can be generated.

Index Terms- Poultry waste, litter, gasification, Economic Analysis, Energy potential etc.

I. INTRODUCTION

In biochemical conversion, biomass molecules are broken down into smaller molecules by bacteria or enzymes. This process is much slower than thermochemical conversion but does not require much external energy. The three principal routes for biochemical conversion are:

- Digestion (anaerobic and aerobic)
- Fermentation
- Enzymatic or acid hydrolysis

The main products of anaerobic digestion are methane and carbon dioxide in addition to a solid residue Bacteria get to oxygen from the biomass itself rather than from surrounding air. Vigorous assimilation, or fertilizing the soil, is additionally a biochemical breakdown of biomass, with the exception of that it happens within the sight of oxygen. It utilizes diverse kinds of microorganisms that entrance oxygen from the air, delivering carbon dioxide, warm, and a strong digestateIn fermentation, part of the biomass is converted into sugars using acid or enzymes. The sugar is then converted into ethanol or other chemicals with the help of yeasts. The lignin is not converted and is left either for combustion or for thermochemical conversion into chemicals. Unlike in anaerobic digestion, the product of fermentation is liquid.

1.3 Poultry litter

Poultry litter alludes to the material utilized by the poultry for bedding amid the generation cycle. The litter material is commonly sawdust, wood shavings, wheat straw, shelled nut bodies, or rice structures. During broiler production, the accumulating manure is mixed with the litter. To clean out the poultry manure, one must necessarily remove the litter also. Thus, poultry litter commonly denotes the mixture of bedding material and manure. Many management, environmental and physiological factors may influence poultry litter production and composition at a particular time and location.
The only reliable method for litter quality determination is thus by analysing the litter. The best way of utilizing energy from Poultry litter is shown in figure 1.1

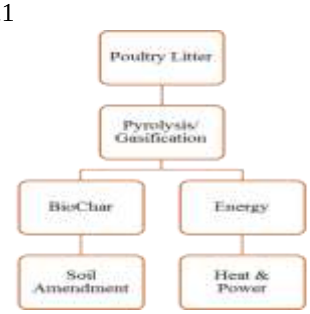

Figure 1.1 Products from Poultry Litter

II-LITERATURE REVIEW

Agrarian and forestry buildups are typically handled as squanders; else, they can be recouped to deliver electrical and warm energy through procedures of thermochemical conversion, such us torrefaction, pyrolysis and gasification. At present, the gasification of remaining biomass for delivering neutral CO2 fuel for energy creation is being developed stage.

Given the high volume generated by broiler poultry and due to shortage of energy sources and the high price of conventional sources, the use of poultry litter as biomass energy is becoming attractive and therefore it may become both technically and economically feasible.

Available literature on the use of poultry litter as biomass energy in industrial production units is still incipient. Recent studies indicate the efficiency of heat and energy production from poultry litter in locations near the waste-generating units.

Deirdre Lynch et al 2013 analyzes poultry litter (PL) as an asset in fuel quality terms and shows how the little scale utilization of fluidised bed technology takes care of both vitality and waste issues, while delivering a supplement rich fiery ash. PL was found to have a higher heating value (HHV) of 18 GJ t^{-1}on a dry basis (db). On an as received basis (ar), it had an ash mass fraction of 9% and the elemental phosphorous content of the ash was 110 g kg^{-1}. The resultant mineral issue can be used as a supplement substitute for mineral manure.

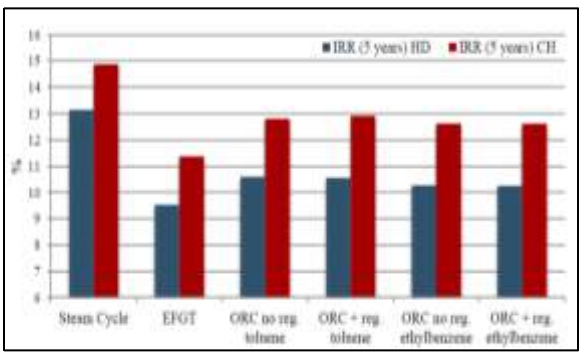

Figure 2.1 5-years Internal Rate of Return results for the selected CHP technologies (reported by Prof.Anna Stoppato2015)

III- RESEARCH METHODOLOGY

3.1 Analysis of Poultry Litter

The model is based on the assumptions that:

- The blocks are implicitly considered zero dimensional and perfectly thermally isolated;
- The squares are described by culminate blending and uniform temperature;
- Residence time is sufficiently long to achieve the thermodynamic harmony in the R-Gibbs square;
- The gases behaviour is considered ideal, due to the high temperature and the low pressure.

Biomass contains countless natural mixes, dampness (M), and a little measure of inorganic contaminations known as ash (ASH). The organic compounds comprise four principal elements: carbon (C), hydrogen (H), oxygen (O), and nitrogen (N). Biomass (e.g., MSW and animal waste) may also have small amounts of chlorine (Cl) and sulfur (S). The latter is rarely present in biomass except for secondary sources like demolition wood, which comes from torn-down buildings and structures. Thermal design of a biomass usage framework, regardless of whether it is a gasifier or a combustor, essentially needs the arrangement of the fuel and also its energy content. The following three primary properties describe its composition and energy content:

(1) ultimate analysis,
(2) proximate analysis, and
(3) heating values.

Experimental determination of these properties is covered by ASTM standard E-870-06.

The results obtained after proximate and ultimate analysis is shown in table 3.1

Table 3.1 Ultimate and Proximate Analysis

Proximate analysis (wt%, dry basis)	
Moisture	27.4
Volatiles	47.3
Fixed carbon	9.8
Ash	15.7
Ultimate analysis (wt%, dry basis)	
C	27.22
H	3.72
N	2.69
S	0.33
O	23.1
Cl	0.71
Ash	15.7

3.2 Gasifier Simulation Model

Commercial plants require optimal operating parameters to achieve maximum interest. The operating parameters are often obtained by conducting experiments on pilot plants. Although accurate data can be obtained through the experiments, it is always expensive and takes a lot of time to get the results. Furthermore, the optimum parameters are often size dependent. The experimental results may not be the optimum in the real plants.

3.2.1 Gasification Reactions Specified in Model

Gasification is a thermochemical procedure in which a carbonaceous fuel is changed over to a burnable gas. This ignitable gas is known as syngas (from engineered or union gas) and comprises of hydrogen (H_2), carbon monoxide (CO), methane (CH_4), carbon dioxide (CO_2), water vapor (H_2O), nitrogen (N_2), higher hydrocarbons and polluting influences, for example, tars, smelling salts (NH_3), hydrogen sulfide (H_2S) and hydrogen chloride (HCl). The procedure happens when a controlled measure of oxidant (unadulterated oxygen, air, steam) is responded at high temperatures with accessible carbon in the fuel inside a gasifier. The combustion responses will happen, however these are overlooked as Aspen Plus can produce them naturally and they rely upon the organization of the fuel. The gasification reactions that has been taken place during the gasification process are as

Heterogeneous Reactions

$C + 2H_2 \leftrightarrow CH_4$ ………….. (3.1)

$C + 2H_2O \leftrightarrow CO + H_2$ ………….. (3.2)

$C + CO_2 \leftrightarrow 2CO$ ………….. (3.3)

Homogeneous Reactions

$CH_4 + H_2O \leftrightarrow CO + 3H_2$ ………….. (3.4)

$CO + H_2O \leftrightarrow CO_2 + H_2$ ………….. (3.5)

NH_3, H_2S and HCl formation Reactions

$0.5N_2 + 1.5H_2 \leftrightarrow NH_3$ ………….. (3.6)

$H_2 + S \leftrightarrow H_2S$ ………….. (3.7)

$Cl_2 + H_2 \leftrightarrow 2HCl$ ………….. (3.8)

3.2.2 Assumptions

- The model is based on the following main assumptions:
- The process is considered as isothermal , steady state and zero-dimensional with no heat loss
- The gasification is carried out at atmospheric pressure i.e. 1 atm
- The characteristics of gases is considered as ideal gases and particle size is neglected.
- No pressure drop
- Char is 100% carbon (C) and no Tar formation
- All elements that compose the biomass yield into char, H_2, O_2, N_2 Cl_2, and S.
- The complete conversion of N_2, S and Cl_2 in NH_3, H_2S and HCl respectively

3.2.3 Model Description

The Peng-Robinson equation of state with Boston-Mathias modifications was designated as the property system for the gasification process. The Process Flow Diagram in Aspen Plus is shown in figure 3.1

- Platform used for the study

Kiran Poultry And Breeding Farm Private Limited was registered at Registrar of Companies Pune on 30 March, 2012 and is categorised as Company limited by Shares and an Non-govt company.

In view of provision of in house resources required for the assurance of quality and quantity we started independent broiler breeder unit of 1 lakhs of laying capacity which can fulfil our monthly requirement of 18 Lakhs of quality Hatching Eggs.

We have well maintained hatchery unit with capacity to produce 5 Lakhs of hygienic chicks.

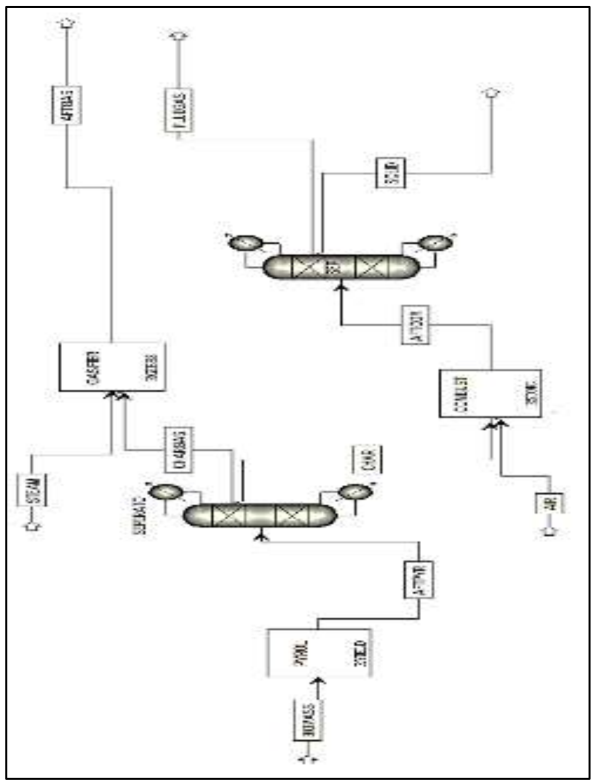

Figure 3.1 Process Flow Diagram of Gasification Process in Aspen Plus Software

Present use of poultry waste in the Poultry Farm

Most of the manure and litter produced by the poultry industry is currently applied to agricultural land. When managed correctly, land application is a viable way to recycle the nutrients such as nitrogen (N), phosphorus (P) and potassium (K) in manure. However, pollution and nuisance problems can occur when manure is applied under environmental conditions that do not favour agronomic utilisation of the manure-borne nutrients.

3.3 Waste Generation by Broiler Poultry

The measured data available in literature in relation to the quantity of poultry litter generated per bird in a 42 day production cycle is quite variable, ranging from 1.5 to 5.7/kg of litter/bird. It is common to use poultry litter in more than one production cycle for chickens. [Felipe Santos Dalólio et al; 2017]

3.4 Suitability as Biomass for Gasification Process

For utilization of alternative biomasses some factors are important, where the main characteristics are: moisture content, energy density, calorific value, the amount of generated volatile material generated during combustion, the volume of ash at the end of the process, the fixed carbon content, the chemical analysis and the elemental content. The moisture content is one of the main indices of non-inherent quality of the evaluated residue, since elevated moisture content may result in more energy consumed for drying the biomass prior to combustion processes. It also influences the initial ignition capability. This decreases the process efficiency and impairs the energy and thermodynamic equilibrium in the final calculation. Furthermore, the high moisture content leads to incomplete combustion and consequent release of carbon monoxide to the environment. In general, for the efficient generation of heat and electricity from poultry litter, it is recommended that the moisture content does not exceed 30%, in Poultry litter it is about 27 % which can be accepted.

IV-RESULT ANALYSIS

4.1 Effect of the Gasification Temperature on the Syngas Composition

To find out the effect of gasification temperature on the yield composition of Syn gas and heating value, the gasification temperature varies from 500 to 1000°C along with other constant parameters like S/B ratio 0.6, air at constant pressure and temperature at 25°C and 1 atm

Figure 4.1 displays the influence of the gasification temperature on the syngas yield (vol. % dry basis). It can be seen that the increment of gasification temperature results in decrement of CH_4 and CO_2 while increment in H_2 and CO.

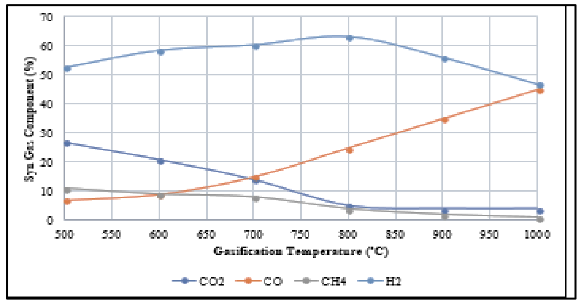

Figure 4.1 Effect of the Gasification temperature on the syngas composition

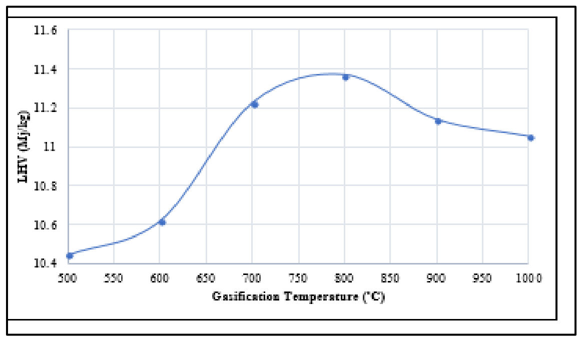

Figure 4.2 Effect of the Gasification temperature on the LHV of the syngas

4.2 Effect of the Steam to Biomass (S/B) Ratio on the Syngas Yields

To find out the effect of Steam to Biomass ratio on the yield composition of Syn gas and the lower heating value, the Steam to Biomass ratio varies from 0.3 to 1 along with other constant parameters like gasification temperature 800°C, air at constant pressure and temperature at 25°C and 1 atm

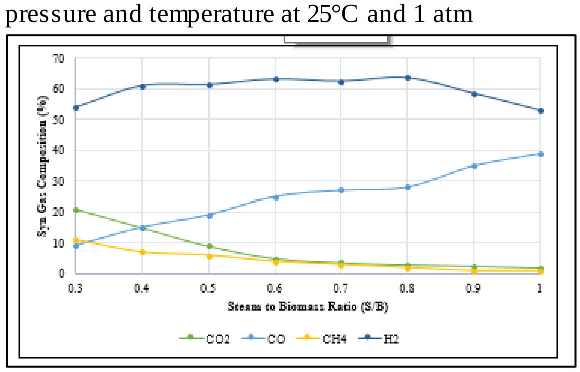

Figure 4.3 Effect of the Steam to Biomass (S/B) ratio on the syngas composition

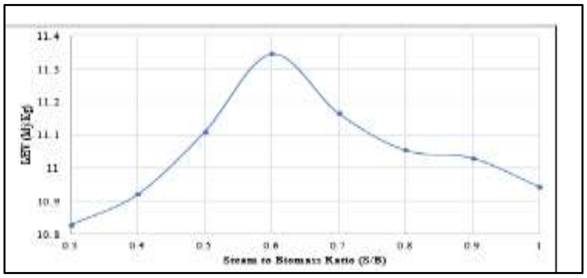

Figure 4.4 Effect of the Steam to Biomass (S/B) ratio on the LHV of the syngas

4.3 Effect of Steam temperature

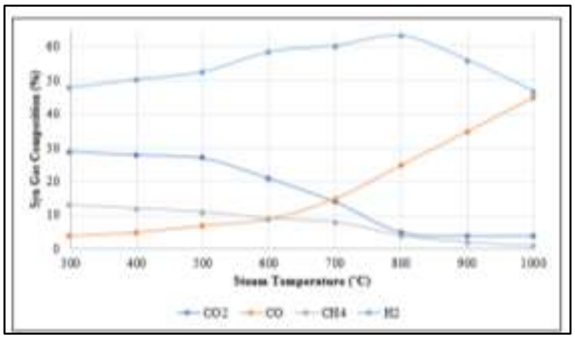

Figure 4.5 Effect of the Steam Temperature on the syngas composition

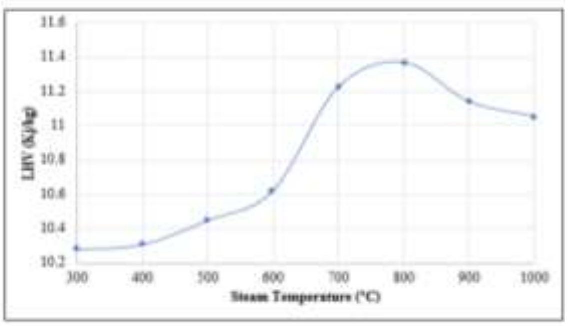

Figure 4.6 Effect of the Steam Temperature on the LHV of the syngas

4.4 Emission from Poultry Litter Syn Gas Combustion

One of the main factors to be evaluated when seeking the use of alternative biomass for energy production is the emission of pollutants to the environment that may occur during thermal processes, or even thermochemical processes.

Table 4.1: The percentage composition of product of Syn Gas Combustion generated after the gasification process

Reactants	Mols per mol of fuel	O_2 required	Products	
			CO_2	H_2O
CO	0.25	0.125	0.25	
H_2	0.634	0.317		0.634
CH_4	0.04	0.08	0.04	0.08
O_2	0			
CO_2	0.05		0.05	
N_2	0.026			
Total	1	0.522	0.34	0.714

Table 4.2: The percentage composition of dry flue gas after Syn Gas combustion generated after the gasification process

Products	Mols per mo. Fuel	% Volume	Molecular Mass (M) kg per mol. Fuel	Kg per mol. Fuel	% by mass
CO_2	0.34	12.22	44	14.96	19.63
H_2O	0.714	25.68	18	12.85	16.86
NO_2	1.729	62.13	28	48.41	63.51
Total	2.78	100		76.224	100.00

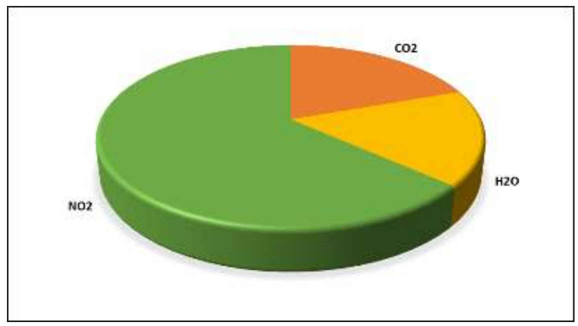

Figure 4.7 Percentage Composition of Dry Flue gas after Syn Gas Combustion generated after the gasification process

Table 4.6 and 4.7 shows the calculation of Syn gas end combustion product. The Product after combustion are NO_2, H_2O and CO_2. About 19.63% (by volume) CO_2 and 63.51% NO_2 is generated which distress the atmosphere.

4.5 Economics

Currently, the management of poultry waste is very arduous and it represents a burden on the financial balance of livestock companies. In addition, the use of poultry waste in the fields as fertilizer may cause several impacts: aerosol production, bad smells, risk of transmission of salmonella and other pathogenic bacteria.

A sustainable solution can be represented by an energy enhancement of poultry waste for thermal energy production. Therefore, the produced energy can be spent for the heating of the breeding, which is usually conducted through terminals as fan coils or aero therms, fed by hot water from methane boilers.

Litter Produce by the chicken

During the typical 47-day growout period, the typical broiler chicken will generate 0.97 kg of litter (manure mixed with wood shavings or similar materials). This translates to about 19gm a day per bird, although that will vary considerably over the life of the bird.

Thus total generation of litter in the poultry farm is about (0.019*100000) kg *i.e. 1900kg per day*.

Methods of Waste Collection

Manually and also with the help of JCB machines

Poultry house energy gets used for housing and feed. More specifically, this breaks down into five main categories:

- Lighting, which is on 24 hours straight at certain points of flock growth
- Ventilation – keeping the air circulated reduces the risk of diseases
- Heating in the winter – cold chickens conserve their energy and don't grow as much
- Cooling in the summer – hot chickens die easier, and also use more energy to breathe
- Feed lines – most of these are automated Energy Use

Energy Consumption (data by field visit)

Electricity

For Water Pumping and For Ventilation

Total No of Fan: 20

Motor Size of Fan: (4*250) + (4*375) + (12*750) = 11500Watt

Heater: No 4 and capacity 73.25KW

Drying Blower: 5.6KW

Lighting:

Bulbes: App. (500*15) + (25*25) = 8125 Watt

Thus total electricity required 98475 Watt or 862641KWh per year

LHV by the gasification process: 11MJ/kg

Thus total generation of litter in the poultry farm is about (0.019*100000) kg *i.e. 1900kg per day*.

Total litter produced in a year: 1900*365= 693500 Kg

Total LHV of the gasification process: (693500*11) MJ = (7628500) MJ or 2121805.556 KWh per year

If consider the average efficiency of Electricity generation is about 45% then the total energy that can be generated after Syn gas combustion in a boiler is 954812 KWh appr energy can be generated by the waste which is higher than the need of the plant.

V-CONCLUSION

Poultry litter refers to the material used by the poultry for bedding during the production cycle. The litter material is typically sawdust, wood shavings, wheat straw, peanut hulls, or rice hulls. During broiler production, the accumulating manure is mixed with the litter. To clean out the poultry manure, one must necessarily remove the litter also. Thus, poultry litter commonly denotes the mixture of bedding material and manure. The aim of the work was to perform a comparative techno-economic analysis of the small-scale integrated pyrolysis and gasification of poultry litter to give rise to both biochar and energy products. An ASPEN plus simulation has been carried out for the Syn gas composition estimation along with economic analysis. The following conclusion can be made:

1. It can be seen that the increment of gasification temperature results in decrement of CH_4 and CO_2 while increment in H_2 and CO. When the gasification temperature increases from 500-800 °C, the LHV of the syngas increases from 10.44 to 11.36 MJ/kg and it is maximum at 800°C but on the further increment it can be seen that LHV decreases rapidly.
2. The H_2 percentage increase till the temperature 800°C about 20.3% from the lower value at 500°C. The extreme yield of the H_2 content is at 800 °C after that the yield of the H_2 decreases. As the gasification temperature increases from 500 to 1000 °C, CO increases rapidly while the other two CO_2 and CH_4 decline.
3. As the steam to biomass ratio increases CO increases, CO_2 and CH_4 decreases.
4. As the steam temperature rises from 300-1000 °C, CO growths from 4% to 45%. Both CH_4 and CO_2 decrease. The value of H2 increases first and then decreases after 800°C. The LHV also increases with increment of Steam Temperature up to 800°C reaches a maximum value of 11.3 MJ/kg and after that it decreases.
5. The Product after combustion are NO_2, H_2O and CO_2. About 19.63% (by volume) CO_2 and

63.51% NO_2 is generated which distress the atmosphere.

6. If consider the average efficiency of Electricity generation is about 45% then the total energy that can be generated after Syn gas combustion in a boiler is 954812 KWh appr energy can be generated by the waste which is higher than the need of the plant.

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