Temperature Behavior and Performance of Briquettes in Gasifier using Sawdust as Raw Material

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ABSTRACT
The objective of this research, reported in this paper has been put forward as, the development of different briquettes using briquette press , chemistry of different briquettes ,performance of the gasifier with briquettes. Composition of the syngas or producer gas produced using briquettes and comparison with ordinary fuel and heating value of syngas on various parameters (compressive strength, pyrocracking temperature etc).Quality/Properties of briquettes. Appreciable increase in the calorific value of syngas was achieved by supplying briquette of saw dust and cyclone dust(by -product of syngas) .

Keywords
Biomass, Gasifire, Calorific value Briquettes,.

1. INTRODUCTION
Power generation using oil is ordinary and pullulating approach also there is dependency on oil and fossil fuel. Biomass Gasification had came into existence for the partially replacement of power generation by with biomass based fuel like briquette. In general forestry waste, cattle dung, municipal waste, agriculture leftover are widely used to for the production of heat for steam generation and for fabrication industry also electricity. India is producing enormous amount of biomass which comes under various categories like agricultural crop leftover or residue production, so there has to be many odds in favor of gasification process. There we have a great opportunity to replace fossil fuel coal and petroleum with biomass. In last decades low grade coal (peat) were used as feedstock fuel to produce the producer gas which was more commonly known as town gas used for cooking and street lighting purpose. After some time there were some basic design modification and now, this process is used as commercial power generation and heat generation source. According to [1]sunflower has high potential to produce table briquette in north European condition. Briquettes of municipal waste have different application and density of this briquette depends upon its usage. Cattle slurry cannot be use as fertilizer and sewage sludge briquette could be beneficial for energy crop. Pelleting or briquetting are two commonly use technologies to solve the handling problem of low density biomass [2]. Pellets (1-3cm diameter, 3-5cm length) are usually small in size as compared to briquettes(5-10cm diameter,10-25cm in length). Briquetting is preprocessing technology which improves the handling of large low density lose pore biomass and also appreciable increase in calorific value. The bulk density of loose pore biomass is in between 40-200 kg/m3 and it increase to 600-800 kg/m^3 by compressing it through press [3]. The combustion efficiency of the briquettes depends on moisture content, chemical composition and density [4] .The effects of process variable on the density and durability of the pellets made from high moisture corn stock using 8 mm Pellet die. They have analysis that moisture content influenced all the physical properties. They produced the pallets at different die rotation speed (40-60hz), preheating temperature of (30-110°c)and feedstock moisture contend(28-38%) also they have developed response surface models and their respective plots. There quality attributes of like unit, bulk and tapped density and durability of the pellets measured after drying the partially dry pellets to safe moisture content of <9% were in the range of 813 kg/ m3, 399kg/ m3 and 445kg/ m3.Durability of pellets was increased by reducing the feedstock moisture content to 30-33% and increased in preheating temperature [5]. The briquettes for gasification in a downdraft gasifier were produced with the help of manual press from a blend of wood, grape skins and children litter. The yielded briquettes were stable enough for transport, but unfortunately they disintegrated in the combustion zone of the gasifier. The gasification performance was then stimulated and compared to pine wood, which is commonly used fuel for gasification. Finally they concluded that the briquettes were compared to pine wood in their performance and their stimulation suggested that the briquettes could even perform better than that the pine wood[6].The biomass derived producer gas as a fuel in reciprocating engine .They addressed that the use of producer gas in engine at higher compression ratio. After their experimentation they have finalized that higher compression ratio turned out to more efficient. Maximum break power of 17.5 was optioned at the highest compression ratio. They have done there experimentation at compression ratio from 11.5:1 to 17.5:1. The overall efficiency was decrease by 32.5%[7]. The laminar flame rate of syngas with different range of atmospheric pressure and preheating temperature .Laminar flame speed was very important fundamental parameter of combustion mixture which contains many very basic information of reactivity ,diffusivity and exothermicity .Various parameter like blowers ,flashback etc were affected by flame speed and its combustion characteristics for heating purpose and other operation based on syngas working principal .This paper also have studied the lean mixture of syngas however they studied flame speed and finalized that higher pressure was best fit for engine (gas engine) so as to full fill the desired density and calorific value inside the engine . They have used two model GRI Mech 3.0, which included the reaction relevant to combustion of H_2 and CO. They have used two flame speed approaches 1.)A indirect technique that measure the luminous flame area of conical flame 2.) Direct velocity measure flame speed at

a) H_2: CO = 95:5, ¢ = 0.61 without knife edge

b.) H_2: CO = 95:5, ¢ = 0.61 with knife edge

c.) H_2: CO = 95:5, ¢ =0.61, CO2 = 20% without knife edge d.) H_2: CO = 95:5, ¢ =1 0.61, CO_2 = 20% with knife edge

Finally they have study and provided data for very lean mixture with 20% dilution and finalized that flame speed was very less intense and hence the knife edge was used to make the tip more visible [8].Gasification process was also used to convert heavy petroleum oils and coal in hydrogen synthesis which was used in ammonia and fertilizers production. Since the recent decade gasification process is been used to produce syngas as a combustible fuel for the electricity generation in power industries like co-fired IC engine plants, combined cycle thermal power plants like solar biomass hybrid thermal power plant(SBHTPP) From the preceding data it can be concluded that gasification process using briquettes of saw dust, cyclone ash, other ingredient needs sophisticated work also operating parameters and gasifier design are two important features for reducing ash deposits.

1.1 Densification

Although appreciable amount of biomass is feely available but it has its own limits and fits, where it can be use. Dispersed mass having low density result in low energy feedstock, also increase in the transportation costs, handling cost and inventory carrying. Some time biomass state is not as according to the customer needs. We have a solution to overcome above drawbacks i.e. densification which results in the decrease in the volume of biomass, transportation cost, inventory carrying cost also enhance the energy supply through feedstock. Biomass densification can be done by 1.) Briquette press 2.) Screw press 3.) Pellet press 4.) Agglomerators. These equipments converts loose biomass into high dense solid biomass for the fuel applications.

1.2 Binding behaviors of biomass with different process variables

Process variables like moisture content, density, the binding of raw biomass. Tumulura et al. suggested that thermal pre-

processing and mechanical pre-processing densification technique can have a appreciable influence on the cost, quality and thermal behavior of densified product.

1.2.1 Feed stock moisture content

Moisture content has a great influence on briquettes surface properties. Moisture in the raw material (loose pore biomass) acts as binder due to this property raw biomass become self binder. Moisture act as binder and increase the strength of products through increase in wander wall forces .The impact of moisture in biomass differs depending upon biomass properties low moisture content(i.e.,5-10%) produces stable densified products [9]. The moisture content in between 7-12% (w.b.) of spruce –wood sawdust has more stability, durability and strength [10]. Different biomasses have different moisture content (m.c.) e.g. starch and proteins can have m.c. up to 20% wet basics (w.b.), pelleting cellulosic can have m.c. in between 5-12%.Many researcher have recommended that for best quality strength moisture contents should be in between 5-12% (w.b.).

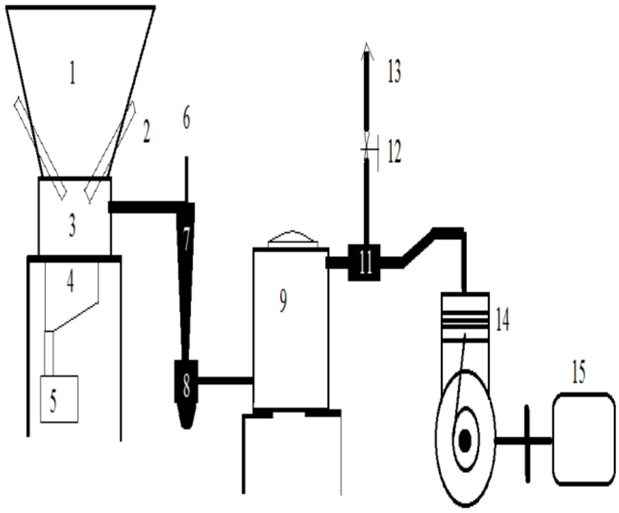
1.2.2 Preheating

Whenever moisture content is more then its desire limit then we has to give some pre-processing treatment and preheating is one of them. Its effects both the chemical as well as physical properties of densified briquettes. Preheating produces more stable, high density and high energy briquettes. Some of nature binder like lignin, starch and proteins become soft on preheating and influence the strength of briquettes and pellets [11].

Our literature search indicated that there is no literature available on pyrocracking temperature of briquette so this area needs further research.

1.3 Response surface methodology (RSM)

RSM is the mathematical technique that is widely use to formulate , design and develop new products [12]. RSM helps in analyzing the impact of independent variable.



A block diagram of biomass gasifier power generating unit

Schematic diagram of the experimental setup 1.)Hopper 2.) Air inlet 3.) Reactor 4.) Residue collector 5.) Ash removal mechanism 6.) Water inlet7.) Scrubber 8.) Drain box 9.) Tar box 10.) Safety valve11.) Bypass valve 12.) Flare control valve 13.) Flare burner for testing gas quality 14.)DFCI engine test setup 15.) Eddy current dynamometer

2. DESCRIPTION OF THE POWER GENERATING UNIT BASED ON BIOMASS.

The experimental set up consist of down draft reactor with multi insulation ,exhaust gas heat recovery unit for supply wet woody biomass, heat exchanger for the hot air supply in the reactor .

Ash removing unit, vibrating unit were also introduced to extract ash from reactor with the time interval. Vibrating unit only extract only ash from the reactor while increase in the charcoal retention time increase the biomass to gas conversion efficiency .a cyclone filter , to remove the coarse dust. After that gas was passed to heat exchanger (shell and tube type) which preheats the air for reactor to 240°C-260ºC by using sensible heat of syngas. Venturi scrubber was next in the line of syngas after heat exchanger which steps down the gas temperature. After that gas was passed to chillier to condense the moisture in it by reducing its temperature up to 18ºC.Finally syngas was passed through the fabric filter and fine filter of 10µm size. After that gas was mixed with air in the mixing chamber finally used to run the 100% producer gas engine which is further connected to alternator to produce electricity. The engine was internal combustion spark ignition

12 cylinder in line V shape (2 rows of cylinder in V shape) engine. Below fig shows the complete arrangement of all the equipment.

The specification of engine is 140c.m. bore diameter, 152c.m. stroke and compression ratio can be vary in between 12:1 to 8.5:1. It can produce maximum power of 293 BHP and its electricity generating unit can supply up to 250 KwH to the grid.

3. OBJECTIVE

Many research have worked on increasing the density of raw material to achieve the desired properties (Liu&li;2000,Tumuluru,Tabil;2010,Erlich,C.Fransson,T.H.;2011,Bhattacharya,S.C.,Sett,S.;1992;,Shankra J.;2014,Bhattacharya, Aqa,s.;2007,Alarn A.;2013,Colomba, D. Blasi;2002, Bhangoria j;2011)All of these researcher have worked on the variable like moisture content, densification , pelleting , pressure and retention time. Our literature review indicated that the study on briquette for the high pyrocracking temperature and calorific value for producing the densified biomass is not available. Other briquette properties like durability, retention time, swelling index etc will affects its quality .The objective our research is to check the calorific value of briquettes of saw dust with cyclone ash in ratio of a.)10:0, b.) 9:1 c.) 8:2 d.) 7:3 e.) 6:4 f.) 5:5 and perform its approximate analysis so as to achieve the desire properties required for the commercial production of briquette for energy generation.

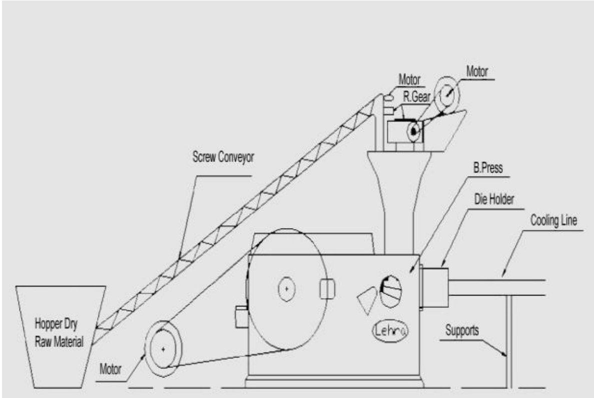
4. MATERIAL AND METHOD

4.1 Feedstock

Saw dust, cyclone dust, tar were used as the basic raw feedstock. One sample rig of 100% saw dust was preheating up to 200℃ and its briquettes were produced at different temperature.

4.2 Briquette press

The flat round die reciprocating piston briquette press of two module (90mm, 40mm diameter die) is used to produced to briquettes. The Raw materials is compressed in between the piston and die. After compressing action biomass passes through die finally its converting into briquettes of desired shape and size depending upon die specifications. Biomass feed through screw conveyer into the hopper of press



A block diagram of briquette press [b294.jpg (lehragroup.com)]

5. RESULTS

Raw materials

Biomass feedstock moisture content of the saw dust was maintained in between 6-14.5 % by weight (w.b.). It varies for biomass to biomass.

Table 1. View of briquettes with different ratio

 Briquette of sawdust and cyclone ash with ratio 8:2	 Briquette of sawdust and cyclone ash with ratio 9:1
 Briquette of sawdust and cyclone ash with ratio 8:2	 Briquette of sawdust and cyclone ash with ratio 9:1

Table 2. Approximate analysis and calorific value of briquette of sawdust and cyclone ash

Sample	Ratio of raw material	Moisture content (%)	Volatile matter (%)	Fixed carbon (%)	Ash content (%)	Calorific Value(Kcal/ Kg)
Sawdust & Cyclone ash	10:0	14.10	70.80	4.18	10.77	4107
Sawdust & Cyclone ash	9:1	11.01	69.73	10.70	8.55	4217
Sawdust & Cyclone ash	8:2	10.42	64.60	11.10	13.85	4456

Sawdust & Cyclone ash	7:3	9.60	58.8	10.60	20.91	4617
Sawdust & Cyclone ash	6:4	10.00	62.00	8.20	19.23	4713
Sawdust & Cyclone ash	5:5	8.77	62.01	8.20	19.24	4800
Sawdust ,charcoal &tar	5.55:3.70:.75	13.60	56.10	16.72	13.57	5000

Table 3. Approximate analysis and calorific value of different biomass available

Sample	**Moisture content (%)**	**Volatile matter (%)**	**Fixed carbon (%)**	**Ash content(%)**	**Calorific Value(Kcal/Kg)**
Poplar wood	42.15	48.74	8.80	.31	3432
Bark wood	43.66	50.61	4.52	1.22	3450
Ply wood	32.50	61.50	5.90	.05	4079

Table 4. Behaviour of briquette made from sawdust, tar and charcoal with respects to the temperature.

 At 150℃	 At 400℃
 At 200℃	 At 450℃

 At 250℃	 At 500℃
 At 300℃	Conclusion: Briquette pyrocracking temperature is below 800ºC. It is not fit for the gasifier as fuel because and it will brust in the pyrolysis zone of the gasifier .

Table 5. Chromatography report of syngas produce by using different sample of fuel

Syngas Produce by poplar wood and 20% briquettes(Saw dust and cyclone ash with different ratio)	**CO_2 (% Volume)**	**H_2 (% Volume)**	**O_2 (% Volume)**	**N_2 (% Volume)**	**CH_4 (% Volume)**	**CO (% Volume)**	**Calorific Value (KCAL/NM^3)**
Sample 1(9:1)	5.21	18.18	0.00	52.03	2.06	21.70	1434.12
Sample 2 (8:2)	4.85	19.04	0.00	51.27	2.00	22.82	1464.32
Sample 3 (7:3)	5.14	17.60	0.00	55.85	1.92	19.46	1310.17
Sample 4 (8:2)	4.79	19.62	0.00	49.15	1.72	24.79	1512.70
Multiplying factor	0	30.23	0	0	94.94	30.66	-------

6. CONCLUSION

Gasifier using briquettes has more syngas conversion efficiency. Briquettes of saw dust with the ratio of 8:2 by weight is best fit for the gasifier as it has maximum calorific value in its category. Briquettes of sawdust and cyclone ash in the ratio 8:2 by mass have maximum compressive strength. Briquette of mixture saw dust , tar and charcoal can sustain up to 400℃ .After 400 ℃ this briquette starts brusting and this type of briquette may not be fit for gasifier, although briquette with woody biomass can be used as fuel for the gasifier for commercial scale power production or for heating purpose. Briquettes having pyrocracking temperature more than 800℃ are best basics fuel for gasifier for the tar free syngas . More research is needed to develop supporting materials to improve the pyrocracking temperature, compressive strength, durability, and economy of briquettes for tar free syngas production.

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