

Studies on Thermo-Chemical Characterisation of Hybrid Bio-Mass

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ABSTRACT: Biomass is a renewable energy resource derived from carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the wood industry, agricultural crops, raw material from the forest, household wastes etc. Biomass doesn't add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as a fuel. Bio-energy, in the form of biogas, which is derived from the biomass, is expected to become one of the key energy resources for global sustainable development. Biomass offers higher energy efficiency through biogas than from direct burning. In this paper we have made sincere attempt in trying out different combination of bioenergy resources and tested through Muffle furnace & Electric oven and found out the optimum proportion to give the high rate of combustion in order to achieve the compactness in the Gasifier

KEYWORDS: Muffle Furnace, Gasifier, Biomass & Electric oven.

I. INTRODUCTION

Amongst the renewable energies, one of the most important energy sources in near future is biomass. The third among the primary energy sources after coal and oil is the biomass. Because of its wide spread availability, renewable in nature and potential in natural relation to global warming. The potential of biomass to help to meet the world energy demand has been widely recognized. The reduction on the imported forms of energy and conservation of limited supply of fossil fuels depends upon the utilization of all other indigenous fuel energy sources. This has resulted in the use of biomass as an alternate

energy source for developing countries since the economics of these countries are based largely on agricultural and forestry. Bio-chemical and thermo-chemical process is used for the recovery of energy from biomass. Bio-chemical process involves bio mechanization of biomass. Thermo-chemical processes are combustions, Pryolysis and gasification. Combustion burns the biomass to ash with excess air. Bio-methanisation requires powdery and porous biomass with always greater than 60% moisture. In addition to biogas, the fermented biomass is very good manure for agricultural fields.

The hydraulic retention time is always very high resulting in huge volume of digester. Combustion of biomass involves in burning the biomass in air at a flow rate of 4-5 kg of air per kg of biomass. This process on small-scale is always used for thermal applications. For power generation a large-scale combustion plant with steam cycle is essential for power generation. Gasification is economical at all capacities from 5 KWe onwards. Therefore, there is a constant and consistent interest in the production of energy from biomass through gasification. From time to time, several observations are reported to explain the complex nature of gasification. A time has come now to revisit the gasification process to bring out the role of characterization of biomass. The present review aims at analyzing the effect of chemical properties of biomass on gasification.

II. LITERATURE REVIEW

K. Raveendran, Anuradda Ganesh and Kartic C. Khilart [1] Studies on wood and twelve other types of biomass showed that in general, deashing increased the volatile yield, initial decomposition temperature and rate of pyrolysis. However, coir pith, groundnut shell and rice husk showed an increase in char yield on deashing, which is attributed to their high lignin, potassium and zinc contents. These results were supported by

studies on salt-impregnated, acid-soaked and synthetic biomass. A correlation was developed to predict the influence of ash on volatile yield. On de-ashing, liquid yield increased and gas yield decreased for all the biomass studied. The active surface area increased on deashing. The heating value of the liquid increased, whereas the increase in char heating value was only marginal.

J. Werther, M. Saengera, E. -U. Hartgea, T. Ogadab and Z. Siagib [2] investigated various issues related to the combustion of agricultural residues are discussed. Attention has been given to the problems associated with the properties of the residues such as low bulk density, low ash melting points, high volatile matter contents and the presence of nitrogen, sulfur, chlorine and sometimes high moisture contents. Consequently the issues discussed include densification, the combustion mechanisms of agricultural residues, problems of low melting point of ash such as agglomeration and fouling, emissions and co-combustion. Further, design considerations of facilities for the combustion of agricultural residues are discussed.

WILLIAMS P. T. BESLER S. [3] investigated the slow pyrolysis of biomass in the form of pine wood was investigated in a static batch reactor at pyrolysis temperatures from 300 to 720°C and heating rates from 5 to 80 K min⁻¹. The compositions and properties of the derived gases, pyrolytic oils and solid char were determined in relation to pyrolysis temperatures and heating rates. In addition, the wood and the major components of the wood-cellulose, hemi cellulose and lignin- were pyrolysed in a thermo gravimetric analyzer (TGA) under the same experimental conditions as in the static batch reactor. The static batch reactor results showed that as the pyrolysis temperature was increased, the percentage mass of solid char decreased, while gas and oil products increased. There was a small effect of heating rate on product yield. The lower temperature regime of decomposition of wood showed that mainly H₂O, CO₂ and CO were evolved and at the higher temperature regime, the main decomposition products were oil, H₂O, H₂, hydrocarbon gases and lower concentrations of CO and CO_{2s}. Fourier transformation infra-red spectroscopy and elemental analysis of the oils showed they were highly oxygenated. The TGA results for wood showed two main regimes of weight loss, the lower temperature regime could be correlated with the decomposition of hemi cellulose and the initial stages of cellulose decomposition whilst the upper temperature regime correlated mainly with the later

stages of cellulose decomposition. Lignin thermal decomposition occurred throughout the temperature range of pyrolysis.

FRED SHAFIZADEH [4] Cellulosic materials decompose on heating or exposure to an ignition source by two alternative pathways. The first pathway, which dominates at temperatures below 300 °C, involves reduction in the degree of polymerization by bond scission; elimination of water; formation of free radicals, carbonyl, carboxyl, and hydro peroxide groups; evolution of CO and CO₂; and, finally, production of a highly reactive carbonaceous char. The second pathway, which takes over at temperatures above 300 °C, involves cleavage of molecules by transglycosylation, fission, and disproportionate reactions to provide a mixture of tarry anhydro sugars and lower molecular weight volatile products. Oxidation of the reactive char gives smoldering or glowing combustion, and oxidation of the combustible volatiles gives flaming combustion. Flaming combustion could be retarded by inorganic materials that suppress the formation of the combustible volatiles through dehydration and charring of the substrate. The smoldering combustion could be suppressed or enhanced by catalysts that affect the rates of oxidation of the char to CO ($\Delta H = 22.9$ kcal/mol) and CO₂ ($\Delta H = -88.5$ kcal/mol).

The kinetics and mechanisms of the thermal decomposition, the rates of combustion and heat release, the composition of the pyrolysis products, and the formation and reactivity of char have been investigated extensively to provide a chemical description for combustion and fire prevention.

III. CO-COMBUSTION

Co-combustion of biomass is an important technology for CO₂-neutral electricity generation. In many countries biomass co-combustion is one of the most economic ways to save CO₂. In addition it can be motivated by saving of CO₂ taxes. Co-combustion of biomass is practiced in numerous plants, especially in Denmark, Belgium, The Netherlands, Poland, Italy and United Kingdom. Different government subsidy schemes as well as other financial instruments provide various national incentives for biomass co-combustion within the European Union. In Germany biomass co-combustion is excluded from special electricity refunds for renewable energy sources. As co-combustion to a certain extent competes with stand-alone biomass plants for the limited biomass resources, the position towards biomass co-combustion is controversial.

A. Advantages of biomass co-combustion

The major advantages of co-combustion are the common utilization of existing plants, the fuel flexibility, and a wide range of usable fuels and the attainment of higher overall efficiencies for power

generation from biomass. Therefore, co-combustion in large thermal power stations can lead to an overall saving of fuels in comparison to independent fossil and biomass fired plants. Further, use is made of existing flue gas cleaning facilities present in such large-scale facilities. The technical as well as the economic advantages can be described as follows:

B. Technical

The electrical efficiency is higher compared to the use of biomass in small standalone plants. The availability of the substitute is not important because the main fuel remains coal or gas. There exists a wide range of usable biomass fuels. Varying qualities and quantities of fuels can be partially compensated by adjusting the co-firing rate. Higher ratio of sulphur to chlorine reduces risk of corrosion.

C. Economical

The additional investments of the co-combustion equipment are significantly lower (for pulverized coal-fired plants in some examples as low as 300 Euro/kWel; the investments of standalone biomass plants amount from 2,500 to 3,000 Euro/Kw. Due to lower additional investment and higher electric efficiencies with biomass co-combustion the sensitivity on feedstock prices is lower and higher prices than in small stand-alone plants are tolerable for the fuel at the same electricity refund. This might open up new, more expensive biomass potentials for energetic utilization or on the other hand reduce the cost for the utilization of the already available biomass.

The reduction of specific CO₂ emissions is significantly larger for biomass co-combustion because of the higher efficiencies. As a result additional CO₂ certificates can be generated and the CO₂-reduction costs are also lower.

D. Environmental

Reduction of CO₂ emissions by saving of fossil fuels. Lower NO_x, because the content of fuel nitrogen in most types of biomass is lower and large plants are typically equipped with de NO_x installations. NO_x is better controlled in PF-fired than in grate-fired boilers. Lower SO_x, because most types of biomass contain much less than coal

. An improved combustion because of the higher volatile matter content of the biomass, resulting in a better burn out and lower unburned carbon in the ash. In case of (limited) co-combustion the fly ash can be vaporized in cement and concrete. Moreover, due to the abovementioned high temperatures in the combustion chamber, the fly ash particles have an amorphous structure (glass), improving the puzzolanic properties.

IV. EXPERIMENTATION

In the paper, experiments has been done with coir pith, bagasse and rise husk with various proportions. The experiments results are as follows:

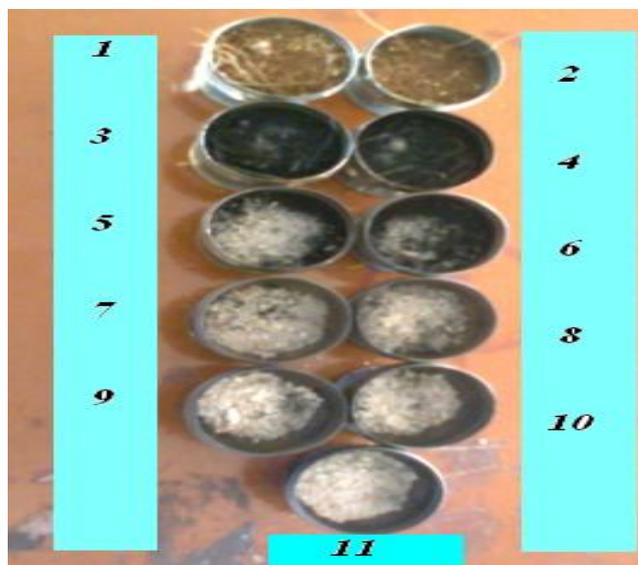


Fig:1 Arrangement of cups inside the Muffle Furance

Cup N.o	Weight of the cup (gms)	Weight of the Bagasse (gms)	Weight of the Rice Husk (gms)	Weight of the cup before heating (gms)	Weight of the cup after heating (gms)	Weight loss (mgs)	Temp (°C)	Time (min)	Weight yet to be converted (%)
1	19.756	5	0	24.756	24.628	128	114	5	97.4
2	17.898	5	0	22.898	22.673	225	137	10	95.5
3	18.916	5	0	23.916	23.407	509	156	15	89.8
4	19.185	5	0	24.185	23.653	532	171	20	89.3
5	18.250	5	0	23.250	19.694	3556	195	25	28.8
6	19.043	5	0	24.043	20.469	3574	241	30	25.0
7	22.074	5	0	27.074	23.499	3575	269	35	28.5
8	22.630	5	0	27.630	23.947	3683	288	40	26.3
9	19.613	5	0	24.613	20.811	3802	309	45	23.9
10	21.267	5	0	26.267	22.241	4023	330	50	19.4
11	19.756	5	0	24.756	20.094	4662	351	55	6.7

Table 1: 100% Bagasse, 0% Rise Husk

Cup N.o	Weight of the cup (gms)	Weight of the Bagasse (gms)	Weight of the Rice Husk (gms)	Weight of the cup before heating (gms)	Weight of the cup after heating (gms)	Weight loss (mgs)	Temp (°C)	Time (min)	Weight yet to be converted (%)
1	6.464	0.9	0.1	7.464	7.462	2	65	5	99.8
2	6.560	0.9	0.1	7.560	7.538	22	104	10	97.8
3	6.478	0.9	0.1	7.478	7.402	76	145	15	92.4
4	6.362	0.9	0.1	7.362	6.923	439	181	20	56.1
5	6.531	0.9	0.1	7.531	6.902	629	218	25	37.1
6	7.174	0.9	0.1	8.174	7.498	676	239	30	32.4
7	5.485	0.9	0.1	6.485	5.773	712	291	35	28.8
8	6.584	0.9	0.1	7.584	6.848	736	331	40	26.4
9	5.833	0.9	0.1	6.833	6.047	786	359	45	21.4
10	6.800	0.9	0.1	7.800	6.920	880	389	50	12.0
11	6.171	0.9	0.1	7.171	6.228	943	412	55	5.7

Table 2: 90% Bagasse, 10% Rise Husk

Similar experiments been done for various combinations of Bagasse and Risk Husk from 100% Bagasse, 0% Risk Husk to 0% Bagasse, 100 % Risk Husk.

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Cup N.o	Weight of the cup (gms)	Weight of the Bagasse (gms)	Weight of the Rice Husk (gms)	Weight of the cup before heating (gms)	Weight of the cup after heating (gms)	Weight loss (mgs)	Temp (°C)	Time (min)	Weight yet to be converted (%)
1	6.464	0	1.0	7.464	7.415	49	112	5	95.1
2	6.560	0	1.0	7.560	7.499	61	155	10	93.9
3	6.478	0	1.0	7.478	7.140	338	203	15	66.2
4	6.362	0	1.0	7.362	6.807	555	251	20	44.5
5	6.531	0	1.0	7.531	6.916	615	294	25	38.5
6	7.174	0	1.0	8.174	7.532	642	340	30	35.8
7	5.485	0	1.0	6.485	5.795	690	283	35	31.0
8	6.584	0	1.0	7.584	6.844	740	423	40	26.0
9	5.833	0	1.0	6.833	6.069	764	461	45	23.6
10	6.800	0	1.0	7.800	7.000	800	494	50	20.0
11	6.171	0	1.0	7.171	6.330	840	524	55	16.0

Table 3: 0% Bagasse, 100 % Risk Husk

Experiments for various combinations of Coir pith and Risk husk also been done from 100 % Coir pith, 0% Risk husk to 0% Coir pith, 100 % Rice husk.

Cup N.o	Weight of the cup (gms)	Weight of the Coir pith (gms)	Weight of the Rice Husk (gms)	Weight of the cup before heating (gms)	Weight of the cup after heating (gms)	Weight loss (mgs)	Temp (°C)	Time (min)	Weight yet to be converted (%)
1	6.464	1.0	0	7.464	7.366	98	147	5	90.2
2	6.560	1.0	0	7.560	7.460	100	191	10	90.0
3	6.478	1.0	0	7.478	6.899	579	240	15	42.1
4	6.362	1.0	0	7.362	6.712	650	282	20	35.0
5	6.531	1.0	0	7.531	6.849	682	325	25	31.8
6	7.174	1.0	0	8.174	7.460	714	367	30	28.6
7	5.485	1.0	0	6.485	5.724	761	402	35	23.9
8	6.584	1.0	0	7.584	6.819	765	434	40	23.5
9	5.833	1.0	0	6.833	6.047	786	451	45	21.4
10	6.800	1.0	0	7.800	6.992	808	476	50	19.2
11	6.171	1.0	0	7.171	6.344	827	502	55	17.3

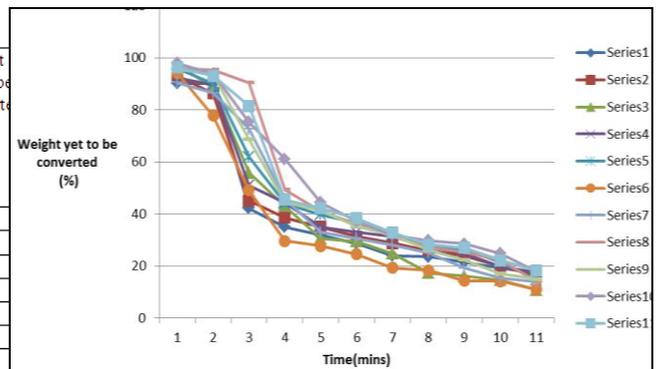
Table 4: 100% Coir pith, 0% risk husk

Cup N.o	Weight of the cup (gms)	Weight of the coir pith (gms)	Weight of the Rice Husk (gms)	Weight of the cup before heating (gms)	Weight of the cup after heating (gms)	Weight loss (mgs)	Temp (°C)	Time (min)	Weight yet to be converted (%)
1	6.464	0.9	0.1	7.464	7.366	68	100	5	93.2
2	6.560	0.9	0.1	7.560	7.423	137	130	10	86.3
3	6.478	0.9	0.1	7.478	6.929	549	141	15	45.1
4	6.362	0.9	0.1	7.362	6.747	615	147	20	38.5
5	6.531	0.9	0.1	7.531	6.881	650	150	25	35.0
6	7.174	0.9	0.1	8.174	7.487	687	151	30	31.3
7	5.485	0.9	0.1	6.485	5.773	712	167	35	28.8
8	6.584	0.9	0.1	7.584	6.842	742	210	40	25.8
9	5.833	0.9	0.1	6.833	6.071	762	265	45	23.8
10	6.800	0.9	0.1	7.800	6.998	802	307	50	19.8
11	6.171	0.9	0.1	7.171	6.336	835	347	55	16.5

Table 5: 90% Coir pith, 10% risk husk

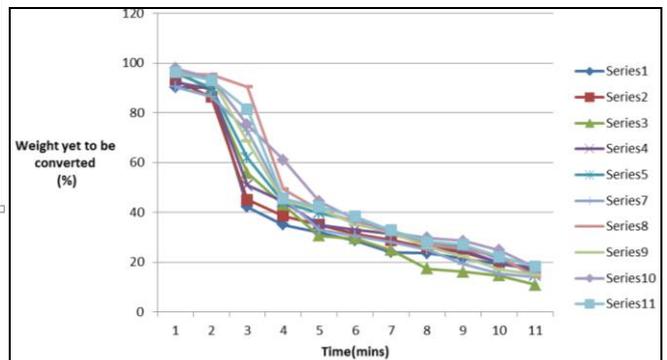
Cup N.o	Weight of the cup (gms)	Weight of the Coir Pith (gms)	Weight of the Rice Husk (gms)	Weight of the cup before heating (gms)	Weight of the cup after heating (gms)	Weight loss (mgs)	Temp (°C)	Time (min)	Weight yet to be converted (%)
1	6.464	0	1.0	7.464	7.427	37	154	5	96.3
2	6.560	0	1.0	7.560	7.490	70	197	10	93.0
3	6.478	0	1.0	7.478	7.293	185	237	15	81.5
4	6.362	0	1.0	7.362	6.817	545	280	20	45.5
5	6.531	0	1.0	7.531	6.952	579	322	25	42.1
6	7.174	0	1.0	8.174	7.557	617	363	30	38.3
7	5.485	0	1.0	6.485	5.812	673	405	35	32.7
8	6.584	0	1.0	7.584	6.866	718	437	40	28.2
9	5.833	0	1.0	6.833	6.103	730	478	45	27.0
10	6.800	0	1.0	7.800	7.022	778	519	50	22.2
11	6.171	0	1.0	7.171	6.352	819	561	55	18.1

Table 6: 100% Bagasse, 0 % Risk Husk



Graph 1: Weight yet to converted Vs time of Bagasse and Rice Husk

Series 1- 100%Bagasse,0% Rice Husk ;Series 2- 90%Bagasse,10% Rice Husk
 Series 3- 80%Bagasse,20% Rice Husk ;Series 4- 70%Bagasse,30% Rice Husk
 Series 5- 60%Bagasse,40% Rice Husk ;Series 6- 50%Bagasse,50% Rice Husk
 Series 7- 40%Bagasse,60% Rice Husk ;Series 8- 30%Bagasse,70% Rice Husk
 Series 9- 20%Bagasse,80% Rice Husk
 Series 10- 10%Bagasse,90% Rice Husk
 Seires 11-0%Bagasse,100% Rice Husk



Graph 2: Weight yet to converted Vs time of Coir pith and Rice Husk

Seires 1- 100%Coir Pith,0% Rice Husk;Seires 2- 90% Coir Pith,10% Rice Husk

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Seires 3- 80% Coir Pith,20% Rice Husk; Seires 4- 70% Coir Pith,30% Rice Husk
 Seires 5- 60% Coir Pith,40% Rice Husk; Seires 6- 50% Coir Pith,50% Rice Husk
 Seires 7- 40% Coir Pith,60% Rice Husk; Seires 8- 30% Coir Pith,70% Rice Husk
 Seires 9- 20% Coir Pith,80% Rice Husk ; Seires 10- 10% Coir Pith,90% Rice Husk
 Seires 11-0% Coir Pith,100% Rice Husk

suitable for combustion in I.C. Engines for production of power.

V. RESULTS AND DISCUSSION

Bagasse	Rice husk	Weight yet to be converted	Rice husk	Coir pith	Weight yet to be converted
100%	0%	6.7	100%	0%	17.3
90%	10%	5.7	90%	10%	16.5
80%	20%	18.2	80%	20%	10.8
70%	30%	9.5	70%	30%	17.6
60%	40%	10.5	60%	40%	14.7
50%	50%	5.2	50%	50%	11.0
40%	60%	15.0	40%	60%	13.8
30%	70%	16.3	30%	70%	14.0
20%	80%	20.5	20%	80%	15.0
10%	90%	25.4	10%	90%	17.7
0%	100%	16.0	0%	100%	18.1

Table 7: Weight to be converted of all the bio-mass with all the proportions.

From the above experiments it has been found out that Rice husk 50% Bagasse 50% & Rice husk 80% Coir pith 20% have given the best results. The constituents in these resources at particular proportions act as catalyst and speed up the combustion process. Hence Gasifier design for these proportions of Bio energy resources, components to other combustions or individual biomass, will be compact for the given output due to high rate of combustion.

VI. CONCLUSION

Biomass Gasifier converts the solid biomass into a combustible gas mixture normally called as producer gas. The conversion efficiency of the gasification process is in the range of 60-70%. The producer gas consists of mainly CO, H₂, N₂ and CH₄ one has a calorific value 1000-1200 Kcal/Nm³. Gasification of biomass and using it in place of conventional direct burning device will result in savings of at least 50% of fuel consumption. The gas has been found

Cogeneration improves its ability and profitability of sugar industries. Indian Sugar mills are rapidly turning to bagasse the leftover of cane after it is crushed and its juice extracted, to generate electricity. This is mainly being done to clean up environment cut down power costs and earn additional revenue. According to the current estimates, about 3500MW power can be generated in the existing 430 sugar mills in the country. Combinations of different biomass resources in optimum proportions will save fuel consumption

VII. FUTURE SCOPE

Lot of work could be done in the future by further trying out different combination of different bio energy resources. Thus TGA (Thermal Gravimetric Analysis) and future analysis and investigation could be done through suitable software to obtain still more an efficient performance.

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