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Analysis of crop residue as fuel

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Abstract - Punjab state is known as the food basket of India with main crops such as paddy, wheat, pulses, barley, cotton, maize, arhar, mustard, rapeseed, sesamum, sugarcane and ground nut. Disposal of crop waste is serious problem being faced by the state at present. In order to dispose the crop waste cheaply and at fast rate , it is being openly burned in the fields, which causes national energy loss, environment pollution and decreases the land fertility. The annual production of total crop residue is estimated as 29.46 MT and total unused crop residue as 14.53 MT. Presently standardization of various crop residues as fuel is the biggest problem of their eco-friendly conversion into cleaner energy beside other hurdles. By considering low overall efficiency the practical power potential from unused crop residue is estimated as 1000 MW1. So to make crop residue- based power plants practical feasible, through investigation of various crop residue samples need to be conducted. In this research paper detailed analysis of crop residues has been performed so that it can be compared to fossil fuels presently being utilized and hence their potential replacement for Punjab state.

Keywords – Crop, Fuel, Punjab State, power.

I. INTRODUCTION

In India 64% of the nation's workforce is engaged in agriculture and agriculture contributes 29.4% of the GDP2. The fuel wood, crop residue and animal manure are the dominant biomass fuels which are mostly used in rural areas at very low efficiencies3. Total potential of energy from all these sources was estimated in 1997 equivalent to be 5.14EJ, which amounts to a little more a third of the total fossil fuel used in India. The energy potential in 2010 is estimated to be about 8.26EJ. Today biomass is the world's fourth largest source of energy, contributing 15% of the world's primary energy needs4. It is estimated that total biomass energy consumption in India was about 321 billion kg or 380 kg/capita/ year in the year 1990-91; this amounted to 45% of the total primary energy consumption of the country5. The share of the fuel wood in the traditional energy is about 53%. The household sector is the major end user and consumes 83% of the total biomass energy. The traditional cookstoves are the major end user of the biomass energy and accounted for about 76% of the total consumption. Punjab is an agricultural state with only 1.5 % of the geographical area of India, producing 22.5% wheat, 12% rice and 13% of cotton of the annual productions in 2002-03 in India and producing a large amount of crop residue6. Crop residues in the mechanized farms in Punjab state are burned as this management has the lowest cost and minimum labour requirements7. Burning results in (the) loss of the organic matter and nutrients and increases pollution. The increase in pollution is evident from the fact that one ton of straw burning releases 3kg of particulate matter, 60 kg of CO, 1460 kg of CO2, 199 kg of ash and 2 kg of sulphur8. Agricultural scientists favour plowing the crop residue into the soil to improve soil organic matter content, nutrients and other properties associated with soil productivity, however this increases the cost of seed bed preparation7. Beside the seed bed preparation cost the other bottlenecks are spatial distribution of agricultural biomass across Punjab and the associated cost of collection and transportation in the success of biomass energy conversion facility9. To motivate the disposal of agro waste in an ecofriendly way a state government implemented new energy policy under the new renewable resources of energy (NRSE) policy 2006 and under this policy government of Punjab offered a financial and fiscal incentives to add generation capacity of 1000MW by the year 2020 bringing the share of NRSE to the level of 10% of conventional power10. Punjab state electricity commission has also issued a directives under the section 108 of the electricity act 2003 for the compliance of NRSE policy 200611. Estimation of spatial distribution of economically exploitable crop residue is the backbone of future success of NRSE policy and ultimately instrumental in the designing of agro waste bioenergy power plants across the state with sustainable supply of crop residue. Since reliable data regarding the crop residue as fuel is not available, so in this research paper through investigation of crop residue in the form of proximate and ultimate analysis has been performed to compare the crop residue with other fossil fuels.

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II. MATERIALS AND METHODS

2.1 Sample collection

The nature of crop residue and its yield vary from region to region across the state, hence the sample of corresponding crop residue has been collected from the area at which the crop is dominating crop.

2.2 Sample preparation

Samples were pretreated to decrease the moisture content and then grinded to convert them into powder form so that they become compatible with the testing instruments.

2.3 Proximate analysis of samplers

2.31 Proximate analysis

Proximate analysis provides information on the combustion characteristics of biomass. It is a measure of fixed carbon (FC), volatile matter (VM), Ash (A) and Moisture (M) in the biomass material and expressed in percentage. The term volatile matter and fixed carbon does not have clear definitions. The volatile matter of any substance in a broad sense is the fraction that is driven off by heating the sample to a specific time and temperature. The total amount of volatile matter and its composition is the function of heating rate as well as the final temperature. The volatile matter is an important parameter because it characterizes the expected contamination of the raw gas with condensable vapours in any gasifier or pyrolysis equipment. There are no standard techniques for the proximate analysis of biomass as yet, however, the most commonly adopted procedure for proximate analysis of coal outlined in BS 1016 Part 3&4, 1973 were used for the proximate analysis of crop residue as well12.

2.32 Ultimate analysis of crop residue

The ultimate analysis involves the determination of elemental composition of the fuel. The determination of total carbon, hydrogen and their (C/H) ratio gives an indication of the type of volatiles present in the biomass i.e saturated or unsaturated hydrocarbons, which governs the tar formation. The ultimate analysis does not reveal the suitability of biomass for gasification, combustion or any other process but is the main tool for the determination of stoichiometric formula, stoichiometric air requirement and air fuel ratio, gas composition, temperature limits, gas production rate etc. through a mass and energy balance over the thermochemical conversion processes. It is also used to predict the lower heating value of the biomass12.

Instrument used for C H N S O analysis is CHNSO analyzer as discussed in previous chapter. In this test a known sample of crop residue in powdered form was kept in CHNSO analyzer and noted the values of Carbon, hydrogen, nitrogen, sulphur and oxygen in percentage form. Test was performed for all the crop residues.

III. RESULTS AND DISCUSSIONS

3.1 Proximate analysis

Proximate and thermal analysis of various crop residue samples were evaluated as per the standard procedures and methods. The results of the proximate and thermal analysis for different residue samples presented hereby as per Table 1.

Table 1: Proximate and thermal analysis of crop residue samples

Sr. No.	Biomass Name	Moisture %age	Ash %age	Volatile Matter %age	Gross Calorific Value (kcal/kg)
1.	Rice Straw	5.85	6.12	74.26	3980
2.	Rice Husk	4.69	10.89	69.25	3889
3.	Wheat Straw	4.91	7.20	72.27	3840
4.	Cotton Stalks	5.34	4.67	73.87	3897
5.	Sun Flower Stalks	4.77	9.83	68.81	4085
6.	Mustard Stalks	6.88	6.65	68.93	3933
7.	Pulses	3.18	8.96	71.6	3910
8.	Jheejan	5.67	3.74	75.43	3970
9.	Arhar	5.65	3.38	74.97	4011
10.	Sugarcane Baggasse	4.24	4.22	75.14	4155
11.	Sugarcane Leaves	6.44	8.63	69.71	3825
12.	Maize Cobe	4.09	3.30	75.12	3974
13.	Ground Nut Straw	4.97	8.08	70.21	3850
14.	Wooden Chips	5.29	3.53	75.53	3815

Overall moisture contents varies between 3.18 to 6.88 with minimum for pulses and maximum for mustard stalks. This indicates that all the samples were stored well before being collected. The moisture contents of all the crop residue samples is comparable with coal and well within the permissible limits of biomass gasfier. Higher moisture contents decrease the heating value of the fuel, it also increases the transport, handling and storing cost of the

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fuel. High moisture content in the biomass is disadvantageous in the sense, it makes the fuel unsuitable for combustion and gasification. It affects the thermal stability, which in turn affects gas yield, composition and heating value. A limited amount of moisture on the other hand is beneficial as the steam generation causes steam gasification reaction leading to the better gas quality.

The volatile matter varies between 68.50 to 75.50 with minimum for sun flower stalks and maximum for wooden chips. Volatile contents of all the crop residue samples are much higher than coal. Higher percentage of volatile matter increase the heating value of the fuel and secondary air requirement. It also helps in easy ignition of fuel and increases flame length. The volatile matter, which is normally driven off from the fuel during pyrolysis stage either undergoes further thermal cracking or combines directly with the product gases depending upon the type of operation. Where the volatile matter is allowed to crack, content of tar is considerably reduced. This reduces the operating problems as regards the gas clean up and engine maintenance.

The ash contents varies between 3.30 to 10.89 with minimum for maize cobe and maximum for rice husk. Ash contents of all the crop residue samples are very low as compared with coal. High ash contents of fuel reduces combustion efficiency and increase transport, handling and storage cost of the fuel. Ash is an impurity that will not burn, it reduces burning capacity of the fuel. High ash content in the fuel is quite detrimental. This is because, high ash content affects the thermal balance in the reactor, increases loss of carbon in the residue, creates operating problems due to staging and sintering. Low ash content is always desirable.

Fixed carbon influences the reactor design, as it dictates the extent of oxidation and reduction reactions and residence time in the reactor. The gas composition as well, depends on this value.

The calorific value of crop residue samples varies between 3815 to 4185 kcal/kg with minimum for wooden chips and maximum for sugarcane baggasse. Calorific value of all the crop residue samples are more than common coal grades. Hence coal grades G, H have low calorific value, coal grade E has comparable calorific value and higher coal grades D,C,B have better calorific value than crop residues.

3.2 Ultimate analysis of crop residue

Ultimate analysis of various crop residue samples were performed in the standard laboratories and as per the standard methods and procedures. The results are given in Table 2.

Table 2: Ultimate analysis of crop residue

Sl. No.	Biomass Name	Nitrogen %age	Carbon %age	Sulphur %age	Hydrogen %age	Oxygen %age
1.	Rice Straw	2.301	40.74	0.249	6.529	43.701
2.	Rice Husk	1.263	40.35	0.119	5.853	42.305
3.	Wheat Straw	1.563	41.23	0.227	6.281	43.749
4.	Cotton Stalks	1.442	42.64	0.528	6.308	43.792
5.	Sun Flower Stalks	1.607	39.48	0.425	5.914	43.974
6.	Mustard Stalks	1.314	40.55	0.367	6.124	43.965
7.	Pulses	1.516	40.69	0.203	6.133	43.508
8.	Jheejan	1.125	43.29	0.257	6.411	44.277
9.	Arhar	0.795	43.53	0.145	6.374	45.526
10.	Sugarcane Baggasse	0.932	43.28	0.391	6.293	44.604
11.	Sugarcane Leaves	1.275	40.30	0.190	6.082	43.853
12.	Maize Core	0.715	43.87	1.144	6.228	44.893
13.	Ground Nut Straw	1.193	41.08	0.151	6.008	42.408
14.	Wooden Chips	0.868	44.30	0.128	6147	44.497

The fixed carbon value in crop residue samples varies 39.48 to 44.30 with minimum for sun flower stalks and maximum for wooden chips. The fixed carbon in the solid fuel mainly consist of carbon that contributes for the heating values of fuel. Fixed carbon in all the crop residue samples is comparable with coal.

The sulphur percentage of crop residue samples mainly rice straw, rice husk, wheat straw, mustard sticks, pulses, jheejan, arhar, sugarcane baggasse and sugarcane leaves, maize core, ground nut straw, saw dust and wooden chips is less than as in coal, where as in cotton sticks, sun flower sticks , it is more than as in coal. Sulphur oxides causes corrosion, they make major contribution toward engine wear.

The nitrogen contents of crop residue mainly rice straw, rice husk, wheat straw, cotton sticks, sun flower sticks, mustard stick, pulses and sugarcane leaves is more than coal, whereas nitrogen contents of jheejan, arhar, sugarcane baggasse, maize core, ground nut straw, saw dust and wooden chips is less than coal. More the nitrogen in

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fuel, more it will produces NOx. The NOx is harmful for the environment as it will form photochemical smog in the environment. The higher percentage of nitrogen also lowers the calorific value of the fuel.

The hydrogen percentage of all the crop residue samples is almost triple the value in coal. Hydrogen is beneficial, as higher percentage of hydrogen increases producer gas yield.

The oxygen percentage of all the crop residue samples is much higher than as compared to coal. Hence in all the crop residue samples less external oxygen is required for complete combustion than coal.

IV. CONCLUSIONS

Fixed carbon, sulphur and moisture contents in most of the crop residue samples are same as in coal. Nitrogen contents of crop residue also fluctuate around coal value. Hydrogen, oxygen, volatile matter and calorific values of crop residue are more as compared to coal. Ash content in crop residue is less as compared to coal.

REFERENCES

[1] Bhatnagar AP, Panesar B.S., Gupta P.K. and Jain A.K., " Collection, Storage and Preconditioing of Paddy Straw as fuel for 10 MW power plant in Patiala district" A Report specially prepared for the Punjab State Electricity Board, May, 1986.

[2] Baruah D.C. and Jain A. K. "Distribution of agricultural crop residues in India" Journal of Agricultural Engineering 35(1), July-September [1998] 7-12.

[3] Ravindranath N. H., Somashekar H. I., Nagaraja M. S., Sudha P., Sangeetha G., Bhattacharya S. C., and Salam P. A., " Assessment of sustainable non-plantation biomass resources potential for energy in India" International Journal of Biomass and Bioenergy 29 (2005) 178-190.

[4] Sudha P. and Ravindranath," Land availability and biomass production potential in India" International Journal of Biomass and Bioenergy 16 (1999) 207-221.

[5] Narang H.P., Parashar D.C., Bhattacharya S.C. and Abdul S. P., "A study of biomass as a source of energy in India" RERIC International Energy Journal 21(1), June (1999) 11-24.

[6] http://punjabgovt.nic.in

[7] Aggarwal G.C., "Crop residue management on mechanized farms in India" International Journal of Energy 19 (1994), 957-960.

[8] Jenkins B.M and Bhatnagar A.P., "On the electric power potential from paddy straw in the Punjab and the optimal size of the power generation station" International Journal of Bioresource Technology 37 (1991) 35-41.

[9] Singh Jagtar, Panesar B. S., and Sharma S.K., "A mathematical model for transporting the biomass to biomass based power plant" International Journal of Biomass and Bioenergy 34 (2010) 483-488.

[10] Punjab Government Gaz., December 8, 2006 (AGHN. 17, 1928 SAKA), Part-1 pp-906.

[11] Punjab State Electricity Regulatory Commission Notification no. 10/106/06-STE(1)/5390, dated 24-11-2006.

[12] Jain A.K., "Characteristics of biomass" National Conference on Recent Advances in Bioenergy Research, SSS-NIRE, Kapurthal (2013), 2-20.

 DOI : 10.18231/2454-9150.2018.1080