Utilisation of wastes for power– "An attempt to make NTPC plant a zero wastes discharge station"

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ABSTRACT:

A study has been carried out of availability and suitability of waste biomass at one of the NTPC station. Quantity of biomass (wood/stem, grass and leaves) has been found 1033 MT/yr, woods/stem (332MT), leaves (146MT) and grass (555MT) respectively. Proximate analysis of wastes, GCV (woody part) 4351 kcal/kg, grass 4173kcal/kg and leaves 4310 kcal/kg, Moisture content, woody biomass 14.63 %, grass 20.63%, leaves 15.87%, Bulk density (woody biomass) 191 kg/m^3, grass 42 kg/m^3 and leaves 60 kg/m^3 in the range. Woody part shows high flow ability, positive ignition test and ash fusion temperature >1200^0 C. This can be easily gasified. On the basis of available quantity & suitability of woody biomass, 2X50 kw biomass gasifier power is being developed at NTPC Singrauli. Rest of the biomass i.e. grasses and leaves have potential but not been utilized so far due to low ash fusion temperature, poor flow ability, poor bulk density etc. To utilize this, NETRA has installed a 250 kg/hr briquetting plants for carrying out experiment on briquettes of un-utilized grass and leaves. Analysis of two sets of briquettes of grass and leaves (1-pure form & 2- mixture) have been carried out. Results of pure 1- form- moisture %(12.87, ash %- 27.49, Volatile% 54, fixed carbon% 17.65 and GCV (kcal/kg) 3755.In the 2nd set of experiments, several types of briquettes were made of grass and leaves having wheat straw (5%) and mill rejects (1-2%).Proximate analysis of briquettes were carried out and their results are, moisture % (4.35-5.11), ash % (35-40.1), VM % (51-53), fixed carbon% (18-22), GCV (kcal/kg) 3260-3510 respectively. In both the results, bulk density has increased. This has made the biomass handling easy. Initial experiments have shown that these briquettes have good flow ability and positive ignition test. Briquettes do not disintegrate in 5 min when put into water. Briquettes were not deformed at 1200 deg.c. It means that silica contents in these briquettes are in decreasing trends. It also indicates that briquettes may be good fuel to be used in gasifier. But these briquettes are yet to be studied for gasification and power generation.

Biomass briquettes burning profile (Residence time vs temp) has also been carried out. Its burning profile is similar with coal. This results give us confidence to mix it with coal up to 5% with existing coal fired mills. Further different types of briquettes (paddy straw, wheat straw) are also being made and will be mixing it with coal at one of existing power plant. This may also create an opportunity to utilize such types of briquettes for power generation either thru gasification or mixing with coal. In this way, we may utilize wastes generated at NTPC sites and make NTPC a zero wastes discharge station. Suitability of such type of bio-fuel may create a revolution in the area of power generation in the field of biomass, as these are available in-plenty in rural area. This will also help to accelerate the clean energy move by Govt of India. Power generation thru this is also clean and green as biomass is considered carbon neutral.

Key words: Briquettes, Paddy-straw, Coal blending, Biomass power, Gasification ,Leaves & grass

INTRODUCTION:

International Renewable Energy Agency developed a global renewable energy road map called Re Map 2030, which maintains that biomass would become the single most important renewable source if all additional renewable technology options in the 26 RE map countries were to be implemented worldwide by 2030 (1). Biomass use worldwide could grow by 3.7% every year from 2010 to 2030. Renewables have also been increasing their share in global electricity generation capacity. In 2013 they accounted for an estimate 22.1% of global electricity production, which is approximately 340 GW out of the total global capacity of 1,560 GW (REN 21, Global Status Report, 2014 Renewable energy shares of Global Electricity production). Renewable energy is future. As on 30^{th} Jun,16, installed capacity of renewable energy based power generation was 45,586 MW, out of this, bio-power is approx. 5900 MW (grid & off grid). Govt of India, Ministry of New and Renewable Energy (MNRE) has formulated an energy roadmap aimed at adding 175 GW of renewable energy capacity by 2022. India is rich in biomass and has a potential of 33,292 MW (agro-residues, plantations, forest &waste lands). Only 5900 MW has been exploited so far. Thus, around 80% of potential lies untapped (2) India's conditions offer an ideal environment for biomass production. Owing to its virtues, biomass gasification in India could play a key role in the electrification of rural and remote communities if we gave a solution of continuous supply chain, suitable technology to utilize abundantly available Biomass. Government has set a target of 10000 units of solar, wind, biomass based capacity (average 50 kw) under micro and mini grids. Aim is to promote the deployment these grids power in un-served and undeserved part of country. Biomass is renewable in nature, carbon neutral and has the potential to provide large productive employment in rural areas. It is considered as one of the promising sources for generation of power / energy using commercially available thermal and biological conversion technologies. Considering the importance of biomass power, Government of India and various states with high biomass power potential are trying to promote biomass power through various policies, programmes and financial assistance. Despite huge efforts, biomass sector is still not able to tap the potential available optimally. The sector faces immense barriers and challenges in enhancing this vast scattered renewable energy resource (3).

Co-firing with biomass at Edenderry power station:

This case study is provided as an example of the use of biomass resource along with conventional fuels in combustion based power plants in order to significantly reduce the carbon emissions by replacing significant quantities of fossil fuels with net carbon neutral renewable biomass fuel tonnes of peat, and preventing the emission of some 16,800 tonnes of CO_2 (4). The biomass materials consumed were sawdust, arising as a co-product at sawmills, and wood chips, supplied either as a co-product or direct from the forest. Other materials trialed included SRC (willow) chips, birch chips from cutaway peat lands, wood pellets, recovered wood chips, miscanthus and imported materials such as olive pellets and palm kernel shells

Biomass combined gasification heat and power plant at Australia:

In Austria, the biomass has a primary role in accomplishing the energy demand in the country with contribution of 70% in the total renewable energy consumption. Güssing is a small town located in eastern Austria and well known for its 8 MW biomass gasification plant. Due to lack of connectivity, the energy costs in the town were extremely high. Therefore, the government of Güssing decided to make the town self-sufficient in energy. Since, the biomass is abundant in the town with 40% of the region covered with wood which could provide sufficient raw material for energy generation; a biomass gasification plant was implemented in 2002. The plant has not only resulted in providing energy security but also being a carbon neutral source does not contribute in increasing CO_2 emissions unlike fossil fuels. As a result, Güssing became the first community in the European

Union to cut carbon emissions by more than 90 to 2005, optimization for nitrogen consumption was done so as to reduce the usage by 50%.

De-centralised application for thermal energy demand:

In India, there is increasing concern of depleting fossil reserves and impacts of Climate change due to GHG emissions on utilizing fossil fuels for energy needs (6). Indian industries are one of the major sectors where total energy demand has grown more rapidly since 2000, almost doubled over the 2000-2013 period. Figure below shows that in industries, coal and oil products are used in significant quantity and therefore, it is important to look out for alternative renewable energy resources for fulfilling the energy demand of the sector.

"Biomass" is a natural substance having combustible organic matter, generally refers to renewable organic matter generated by Plants through the process of 'Photosynthesis', in which, Plant uses 'Solar Energy', 'Carbon Dioxide' and *Moisture'* to form Carbohydrates and Oxygen. 'Biomass' contains C, H and O, which are oxygenated hydrocarbons. 'Biomass generally has high volatile matter constituents, high moisture and low bulk density, low calorific value. Few examples of 'Biomass' are branches of tree, Twigs, Coconut shell, Ground nut shell, Corn Cob, Bagasse, Stalk of plants, Rice Husk, Saw Dust etc are tableted in table-1.

"Producer Gas" is a Low Calorific Value gas, which mainly consists of Carbon Monoxide (CO), Hydrogen (H2), Methane (CH4), Carbon Dioxide (CO2), Water (H2O) and Nitrogen (N2). Small contaminants like Char particles, Ash and Tar are also present. Cleaning makes the Gas suitable for Heating and Power generation applications (7).

Biomass Gasification is a process of conversion of biomass (solid fuels like wood / wood waste, agricultural residues etc. into a' combustible gas mixture, normally called as" producer gas". The Biomass is put in a reactor, subjected to various thermo chemical changes to give out producer gas. 'Producer Gas' can be used to run 'Gas Engine-Generator' to generate mechanical power and/or electricity, can be used to replace Diesel up to 75% in 'Diesel Generators' in dual fuel mode and 100 % in pure gas engine generators, and to replace Diesel / LPG / LDO completely for heating applications (8).

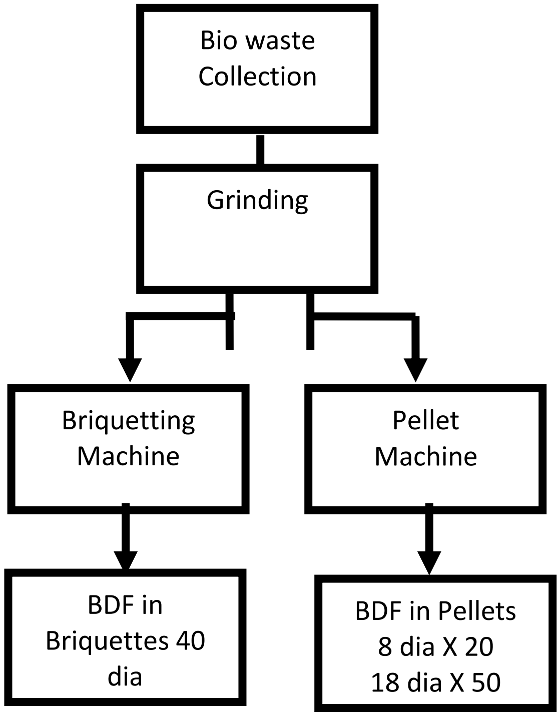
In this paper, efforts have been put to utilize the unutilized biomass like grass and leaves which are in large quantity by blending with biomass (such as wheat husk), mill rejects etc and also briquettes of paddy straw. These briquettes have been studied for GCV, FC, moisture contents etc. Briquettes have also been studied for burning residence time vs temperature. Experimental studies have been carried out and data are given in experimental section. Initial studies show that these briquettes have potential to be utilized as gasifier fuel.

NETRA is dedicated in harnessing green power thru various bio-fuel research projects including Biomass. In this direction, A pilot set up is being developed at NETRA for briquetting and gasification of blended briquettes of grass, leaves, twigs, husk, mill rejects, paddy straw etc. for suitability for gasification and power generation. In this continuation, a briquetting plant having capacity 250 kg/hr and diameter size 40 mm was commissioned on 16.03.2016. This plant is being used for making briquettes of leaves, grass with mill rejects and also paddy straw at NETRA for its suitability studies to utilize as Bio-fuel.

Briquettes machines:

Briquetting plant is required for preparation of binder less briquettes from all types of bio-mass, wastes residues such as paddy straw, leaves, grass and other organic wastes. This plant is consist of briquetting press, Hammer mill grinder and screw conveyor, able to give briquettes output @ 250 kg/hr having diameter size of briquettes are (40+2 mm)

Process flow Diagram



2. EXPERIMENTATIONS:

2.1 Briquetting ,blending analysis:

Various types of biomass like leaves and grasses have collected from the NTPC Singrauli, stations and data are given in table-2. Images of these wastes were given in fig1-4. Capacity of gasification unit can be developed if we can use all the biomass as given in table 4. Mill rejects were collected from station BTPS and its proximate analysis is given at table-3. Different types of briquettes of grass & leaves were made by varying 3-5 % of wheat straw and 1-2 % mill rejects. The size of the briquettes were 40 mm. Briquettes images are given at fig 5-6.

(a) Proximate analysis of briquettes:

Proximate analysis of wastes are given at table 5. Proximate analysis of briquettes are given in table-6-8. Briquettes were tested for burning residence time Vs temperature. Their data are put in to table-9 and burning profile are depicted in fig 7.

Table-1: Heating value of various fuels

Types	Calorific value of flue gas	Approx heating value Kcal/Kg	
		Natural State	Dry state
A	**Biomass**		
1	Wood	1500	3500
2	Bagasse	2200	4400
3	Wheat and rice straw	2400	2500
4	Cane trash, rice husk, leaves and vegetable wastes	3000	3000
5	Coconut husks, dry grass and crop residues	3500	3500
B	**FOSSIL FUELS**		
1	Coal		4000-7000
2	Petrol		10800
3	Coal gas		4000
4	Bio gas(Kcal/cu mtr) (12 kg of dung produces 1 cu. Mtr gas)		4700-6000

Table-2: Types of Biomass

Details of wastes available at Different thermal stations				
Types of Biomass		SSTPS[1]	VSTPS[2]	RhSTPS[3]
Inside plant area	Wood/stems	150	225	250
	Leaves	100	5	45
	Grass	500	20	300
Outside plant area	Wood/stems	182	400	350
	Leaves	46	115	0
	Grass	55	1800	250
Total(MT/Yr)		1,033	2,565	1,195

Table 4: Possible capacity

Biomass	SSTPS[1]	VSTPS[2]	RhSTPS[3]
Considering Total (MT/Yr)	1,033	2,565	1,195
For 6 hrs operation in a day	472	1171	546
Power generated with available Biomass for 6/ hrs	250 KWe/hr	1000 KWe/hr	400 KWe/hr

Table 5: Proximate analysis of wastes

Parameters	Woody Biomass	Leaves	Grass	Plant wastes
Moisture content on wet basis,(%)	14.63	15.87	20.63	45.20
Ash,(%) on dry basis	3.18	15.46	7.23	9.55
Volatile,(%)on dry basis	76.65	62.21	74.35	70.82
Ash fusion,(in ^{0}C)	No ash fusion at 1200	Slight Deformation at 1200	Fusion at 1200, No ash fusion at 1100	Fusion at 1200, No ash fusion at 1100

Bulk density,(kg/m^3)	191	42	60	62
Shape & Size (mm)	20 to 30	10 to 35	15 to 30	20 to 35
Ignition test	Burns easily	Burns easily	Burns easily	Burns easily
Flow ability test	Flow easily	Does not flow easily	Does not flow easily	Flow easily
Caloric value,(Kcal/kg) dry matter	4351	4173	4310	4277

Table-6: Proximate analysis of Briquettes

Parameters	Grass Briquette	Leaves Briquette
Moisture content on wet basis,(%)	7.90	9.40
Ash, (% on dry basis)	29.38	16.63
Volatile,(% on dry basis)	53.79	62.11
Fixed carbon, (% on dry basis)	16.83	21.26
Ash fusion (in ºC)	Ash Fusion at 1200, No Ash Fusion at 1100	Ash Fusion at 1200, No Ash Fusion at 1100
True density,(kg/m^3)	1081	1033
Shape & Size(mm)	H:65mm; Dia:43mm	H:76mm; Dia:43mm:
Disintegration in Water	180 Seconds	200 Seconds
Ignition test	Burns easily	Burns easily
Flow ability test	Flows easily	Flows easily

Table-7: Proximate analysis of Briquettes

Types of Bio-mass	Moisture (%)	Ash (%)	Volatile Matter (%)	Fixed Carbon	True Density (kg/m^3)
Grass	12.87	27.49	54.86	17.65	1144
Leaves	8.63	18.95	61.50	19.55	1109

Table-8 : Briquettes (grass,leaves,straw,rejects)

Parameters	Values
Moisture (%)	4.35-5.11
Ash (%)	35.00-40.1
V.M (%)	51.2—53.02
FC (%)	18.00-22.04
GCV (Kcal/kg)	3260-3510

Table 9: Briquettes residence time Vs temp

Time (mints)	Temp (^{0}C)
0	102
10	254
15	705
20	707
25	705
30	652
35	431
40	263
45	242

Table-3 Proximate analysis of mill rejects

Parameters	Values
Moisture (%)	0.42
Ash (%)	77.48
V. M (%)	13.64
FC (%)	8.46
GCV (kcal/kg)	901
HGI	73

Biomass Samples

Figure 1: Woody Biomass

Figure 2: *Leaf*

Figure 3: Grass (After sizing)

Figure 4: Plant Waste

Figure 5: Grass Briquette

Figure 6: Leaves Briquette

RESULTS & DISCUSSIONS:

Biomass survey has been carried out at NTPC Singraul i, Vindhyachal & Rihand stations. Biomass are found l1033, 2565 and 1195 MT/yr respectively and reported in table-2. If all the Biomass available were used for power generation, Power generation with available biomass for 6 hrs will be 250 kwe/hr, 1000kwe/hr and 600 kwe/hr respectively at these stations. Keeping this in mind, these samples were tested for proximate and other parameters as given in table 5. Grasses and leaves have ash fusion temperature at 1200 deg C. They cannot be gasified as such. However, twigs and wood can be gasified. On the basis of this, 2*50 kw gasifier unit is being developed at NTPC Singrauli. Grass and leaves were briquetted. Proximate analysis of these samples have been carried out from outside lab. Data are reported in table-6. The inference drawn from these data are like this. Both grasses and leaves briquettes have very high ash contents with low ash fusion temperature. Heavy clinkering will be an issue. High ash may be due to presence of soil which could have entered while handling and collecting the leaves and grasses. Elimination of soil during collection and handling would lower the overall ash in the briquettes. Soil free and low ash briquettes could be used in gasifier. This promted us to do the further study. These briquettes were again made at NETRA briquetting plant. Proximate analysis are reported in table 7. Data has revealed that silica content has reduced significantly. In the 2nd set of experiments, several types of briquettes were made of grass and leaves having wheat straw up to (5%) and mill rejects up to (1-2%). Proximate Analysis of mill rejects were carried out and data are tabulated in table 3. It is found that mill rejects contain FC in the tune of 9 % which is a very very small percentage but it contains VM around 14% and GCV(kcal/kg) 900. This is a good sign that mill rejects can be utilized as a fuel. Proximate analysis of these briquettes were carried out and their results are as given in table 8. Moisture% (4.35-5.11), ash% (35-40.1), VM% (51-53), fixed carbon% (18-22), GCV (kcal/kg) 3260-3510 respectively. In both the results, bulk density has increased. It is found that these briquettes contain FC in the tune of 18-22%, VM around 51-53% having GCV(kcal/kg) around 3510. These may be utilized as fuel as co-firing with coal or fuel for gasifier.

Briquettes (approx wt , 23.05 gram) was put in to fire to see whether it was burning or not. It was showing red hot flame when put in the oven. After burning, briquettes ash was tested for percentage of un-burnt carbon. It was found to be 1.21 % un-burnt carbon. It means, it is burning completely. After complete burning, ash wt. was measured. It was found 10-15 % of the total wt. It means, briquettes have around 85 % of combustible components.

Again briquettes were put into fire. Through IR gun, temperature of burning briquettes were measured at different time interval. Burning residence time Vs temperature were plotted as shown in figure 5. From the graph, it is evident that briquettes are burning up to 45 minutes. This shows that these briquettes can be used as co-firing with coal / fuel for gasifier. Further, NETRA is working to make around 5 ton briquettes so that it may be fired with coal in existing plant to know the other data like mill behavior, estabilisation of flame, heat etc.

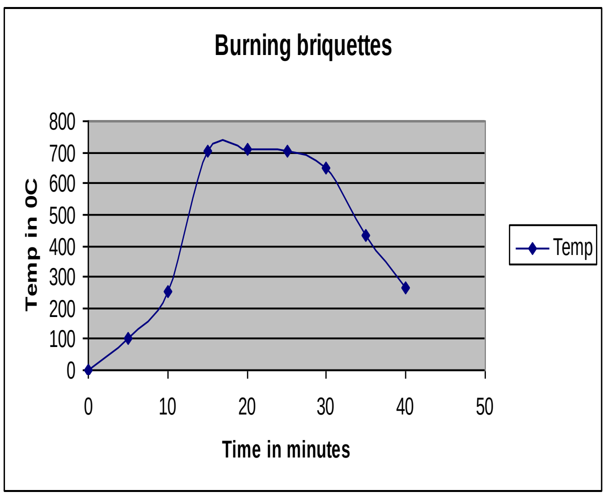


Figure 7: burning residence time Vs temperature

Figure 8: Briquetting plant

ADVANTAGE OF BIOMASS USE:

Biomass gasification/commixing with coal provides sustainable & affordable alternative to fossil fuel based power plants (9). Gasification technology can assure 'Continuous power supply' even at 'peak load conditions'. Efficiency of the system is very high when compared to other Renewable energy systems such as wind and solar. Entire project is eco-friendly as it is "CO2 Neutral", generates very little SO2 & nitrogen oxides compared to conventional fossil fuel based power plants. We can have benefit of 'Green Power'. Improves country's energy self reliance and reduces crippling oil import bill. It is a cost effective solution as it combines 'Low Unit Capital Cost' with 'Low Unit Cost of Production'. This process produces 'Very Low Emissions' of un-burnt primary fuel and no fly ash, because, solid fuel is subjected to 'pyrolysis' and the gas is passed through cleaning and cooling process to remove particulates. Biomass production & conversion activities stimulate local economics by providing employment opportunities to local people and also product & market opportunities for agribusiness. Economic, Social and Environmental benefits associated with biomass make it as an attractive energy option.

CONCLUSION:

Looking at the way biomass energy is consumed currently in all sectors of the global economy, whether in the industry or for grid power or for captive power, the demand will definitely increase. This increasing demand can be managed through effective strategies, new policies that take into account the uncertainties in demand and supply, cost related problems, availability of land and water resources, as well as the environmental impacts of biomass. Further, the policies should be tailored to different applications and technologies. If the biomass sector is to succeed in any country, it is important that policies target a number of options, depending on the structure of a country's power sector.
These briquettes may be good fuel to be used with coal in existing coal fired plants or fuel for gasifier. NETRA is further making briquettes of paddy straw, other wastes to study the real time data along with coal in an existing plant to come out conclusion to know the decrease in mitigation gases, saving coal and to make NTPC plant as zero discharge station. This also creates an opportunity to carry out further research to find out suitability of such types of briquettes for power generation. Proof and suitability of such biofuel may create a revolution in the area of power generation, as these are available in-plenty in rural area. This will also help to accelerate the clean energy move by Govt of India. Power generation thru this is also clean and green as biomass is considered carbon neutral.

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23 years of experience in the field of development of different types of catalyst development, working on convertion SVO into Biodiesel, o engaged in developing different bio-fuels like bio-diesel, bio-ethanol, waste biomass (shells, twigs, leaves and grass) in to pellets as energy fuels, development of briquettes with mill rejects , different bio mass (%) to utilize as fuel for power generation ,develop and set up a self powered Biodiesel unit at NTPC site & also developing a bio-fuel centre at NETRA. Presently working as DGM (NETRA).