PELLET OR BRIQUETTE: AN EFFICIENT WAY OF UTILIZING AGRICULTURAL RESIDUE IN POWER GENERATIONS

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ABSTRACT

This paper aims on the utilization of agricultural residue in palletization. Palletization can be performed by adding agricultural waste and cattle dung in appropriate ratio and manufacturing small cylindrical shaped biomass pellets, which are density rich with high heat value and high combustion rate. Cattle dung is added here to act as binding agent. In this paper, different crops which are more commonly grown in Northern Indian region such as rice, wheat and other crops, along with their calorific values are discussed. The physical properties of the biomass pellets such as raw materials, pallet length, pellet diameter, moisture content are further discussed. Germany, Austria and France are the highest pellet producing countries in the world involved in maximum utilization of agro-waste in pelletizing with estimated production of 13.5MT per year while its consumption is 18.8 MT per year as per EPC Survey 2018, FAO. The scope of palletization in agriculture rich country like India is huge. Moreover, their replacement over fossil fuels like coal and wood in power generating units such as NTPC will be a big achievement in energy sector and it will also help in resolving the issues of residue burning by farmers especially in Northern Indian states Punjab, Haryana and western Uttar Pradesh.

Keywords: *Agricultural Residue, Palletization, Cattle Dung, Energy Sector*

INTRODUCTION

The idea for pellet manufacturing came during the oil crisis in 1970's in Europe when alternatives to fossil fuels were sought. With every passing year the need for replacing fossil fuels by some alternative increased. Among many, palletization is the most popular alternative in recent years because wood or agro based pellets are easy to produce, reliable, easy to handle, have high heating values and high calorific values. As per EPC Survey 2018, FAO Europe has been among the leading producer as well as consumer of wood pellets[1]. In Asia and Oceania, the production is 8% with fastest growing percentage in palletization. In India, being rich in agriculture, biomass power plants are based mostly on agricultural waste[2]. Though anaerobic digestion is the most frequently used technique in India, the main problem with anaerobic digestion of agricultural waste is the lignocellulosic content with low nitrogen. In order to treat agricultural waste, pre-treatment methods like size reduction, heat treatment, enzymatic action are necessary. Hence converting agro waste into compact sized pellets is very easy and efficient. Moreover these pellets with high heat and calorific values can replace coal and wood in power sector industries which further reduces our dependence on fossil fuels.

India is the second largest producer of rice and wheat in the world after China with total production of 112.91 thousand metric tonnes and 95 million metric tonne respectively[1]. With this huge production, huge agricultural waste is produced which is discarded after milling. Some farmers made their practice to burn the stubble and remaining straws left in the field which not only destroys the land fertility but also creates challenges for the environment. In addition to this, the discarded waste possesses greenhouse gases. To overcome these challenges, pelletization of the remaining residues such as rice husk, wheat straws, bagasse and other crop residues discarded could be proved to be one of the efficient technologies. Pellets made of rice and wheat straw have high calorific values close to the fossil fuels used in thermal power plants. The heating value of these pellets increases when the moisture content is reduced to some extent.

The scope of pellet manufacturing is very high in India due to the availability of huge amount of agro-waste as well as high demand of fossil fuels in power generation plants. Globally, 140 billion metric tons of biomass is generated every year from agriculture. Pellets are small cylindrical shaped biomass structures with diameter 6-25mm and length ranging 6-25mm respectively. They are compact in size hence easy to handle, transport and storage. The rice and wheat residues are first crushed into fine particles and dried. This fine powder is then mixed with cow dung. Cow dung serves as a binding agent to hold the fine fibers of the crushed residue. This mixed input is then given to the pellet manufacturing machine. The machine produces multiple cylindrical shaped pellets with equal length and diameter. These pellets are then dried to an acceptable moisture content to be packed for storage and commercial use.

NTPC Ltd., India's largest power sector is planning to start biomass co-firing in across all its coal based thermal power stations to reduce greenhouse gas emission. Additionally, this will also reduce air pollution caused due to on-farm burning of surplus agricultural residue by creating an alternate market for its large –scale utilization in power plants.

CROP RESIDUE POTENTIAL IN NORTHERN INDIAN STATES PUNJAB, HARYANA AND UTTAR PRADESH

India is ranked second worldwide in agriculture. It is the second largest producer of rice, wheat, sugarcane, cotton and groundnuts[1]. The major north Indian states which contribute a large percentage of crop production in total production of the country are Punjab, Uttar Pradesh, West Bengal and Haryana. Rice, wheat and sugarcane are the highest sown crops of Rabi and Kharif season in these regions .As per available estimates [Agricultural Statistics (At a Glance)2017],the total production of rice, wheat and sugarcane in these three major agriculture- rich states are given in Table1[3]:

Crop	Punjab (MT)	Uttar Pradesh (MT)	Haryana (MT)	Total production in India(in MT)
Rice	11.03	12.95	4.45	110.15
Wheat	16.44	30.06	11.52	98.38
Sugarcane	7.25	144.78	8.64	306.72

Table1: Crop production in million tonnes (MT),
Source: Agricultural Statistics Report2017,Directorate of Economics and Statistics, MoA&FW, GoI

Other cereals and millets are also sown and grown in these areas at large. This high production of agricultural crops makes the country not only food-rich, increase exports but also generates a huge agro based biomass residue, thus making the region rich in terms of crop residues. The total residue, area, crop production, biomass generation, biomass surplus and power potential for available biomass was calculated by the Biomass Resource Atlas of India latest for the year 2000-04 for different seasons[3]. The same data is taken here for estimating the total residue potential of the north Indian states.

State	**Total Crop Residue**	**Total Area (Kha)**	**Total Crop Production (KT/yr)**	**Total Biomass Generation (KT/yr)**	**Biomass Surplus (KT/yr)**	**Total Power Potential (MWe)**
			Season-Agro-Kharif			
Punjab	Paddy straw, husk, cobs, stalks, Groundnut shell, others	2723.0	9357.1	16187.1	12298.7	1464.3
Haryana	Paddy straw and husk, other stalks, cobs husk(bajra, maize, jowar)	1778.9	3412.6	6438.8	4120.6	494.0
Uttar Pradesh	Paddy Straw, Husk (paddy, bajra, arhar, urad),other stalks and cobs(bajra, jowar, groundnut, millets etc.)	7605.1	13646.4	24895.1	7614.3	914.7
Total		**12107.0**	**26416.1**	**47521.0**	**24033.6**	**2873.0**
			Season-Agro-Rabi			
Punjab	Wheat stalks, pods, other stalks, husk(mustard, barley, gram etc.)	3526.6	15715.1	28304.6	7123.6	948.9
Haryana	Wheat stalks, pods, other stalks (mustard, oilseeds, gram, barley etc.)	3229.0	10762.2	19899.2	4821.5	626.8
Uttar Pradesh	Wheat pod and stalks, other stalks(gram, mustard, masoor, barley, peas &	6454.3	16772.3	30017.3	5054.3	681.5

	beans)					
Total		**13209.9**	**43249.6**	**78221.1**	**16999.4**	**2257.2**

Table2:Residue-wise Biomass-data for Punjab, Haryana and Uttar Pradesh, Year: 2000-04, *Source: Biomass Resource Atlas of India*

The available statistics represents the data for year 2000-04 with total of 125742.1 MT/yr of biomass generation[4]. In recent scenario, the production has gone much high from the last decades and hence the biomass potential has increased much beyond these estimates.

OPPORTUNITIES AND CHALLENGES

Burning of crop residues/ rice straw is common in north-western parts of India causing nutrient losses, and serious air quality problems affecting human health and safety. It causes severe pollution of land and water on local as well as regional and global scales. It is estimated that burning of paddy straw results in annual nutrient losses of 3.85 million ton of organic carbon, 59,000 ton of nitrogen, 20,000 ton of phosphorus and 34,000 ton of potassium at the aggregate - which can be effective resource for the farming sector. However, the other estimate indicates the loss of nutrients is in comparatively lower scale and the details of which is detailed below[5].

S.N.	Crop Residues	N Loss	P Loss	K Loss	Total Loss
1	Rice	0.236	0.009	0.200	0.45
2	Wheat	0.079	0.004	0.061	0.14
3	Sugarcane	0.079	0.001	0.033	0.84
TOTAL		**0.394**	**0.014**	**0.295**	**1.43**

Table: Loss of nutrients (million ton/ year) due to burning of crop residues. Source: NITI Aayog, GoI

AGRO-PELLETS: RAW MATERIALS AND MANUFACTURING PROCESS

***Raw Material*:** For manufacturing of non-torrefied/torrefied biomass pellets, the raw materials to be used could primarily be the surplus agro residue/ crop residue which remain unutilized after harvesting the crop and is otherwise being burnt by the farmers in the field. The type and availability of such surplus agro residue may vary from region to region as per the crop pattern and extent of farm residue being utilized for various purposes. For example, for north western region of the country, the agro residue/ farm residue likely to be available as surplus for making of pellets are paddy stubbles/ straw & husk, cotton stalks & husk, ground nut shell & stalks, maize stalks & cobs, sunflower stalks, gram stalks, castor stalks & shell and cumin seed stalks etc[6].

Agro residue pellets can also be manufactured using single or multiple agro/crop residues together. Lignin, starch, animal dung etc. can be used as natural additive or binder for manufacturing pellets. Any base material/ additive/ binder or modification in proportion, if causes adverse impact on boiler in long run should be excluded[6].

Source	Composition
Rice	Husk, Bran
Wheat	Bran, straw
Maize	Stover, husk, skins
Millet	Stover
Sugarcane	Sugarcane tops, Bagasse, molasses

Table: Crop residues produced by major crops

Manufacturing Process: The two methods which are popularly used for manufacturing pellets/briquettes are:

- **Pelletisation:** In the process of pelletisation firstly the biomass (agro/ crop residue) collected from fields or farmers is cleaned of soil and shredded to get adequate size particle. In case of high moisture content, the shredded material is dried to the extent of acceptable moisture level. The dried biomass is then passed through a screening process to remove bigger size biomass material to be conveyed back to pre-shredding process. The screening system may have magnets also to remove metal particles. The screened dried biomass is collected in the hopper placed above hammer mill through bucket elevator. Hammer mill/ grinder reduces the biomass to adequate particle size say to less than 2 mm. The biomass from the hammer mill/ grinder is pneumatically transferred to a cyclone filter to remove dust particles. The dust free biomass is conveyed to the screw feeder to transfer the feed into pellet mill consisting of perforated die of specified diameter holes. The pellets are cut to the required size by the cutter attached to the pellet mill. The densified hot biomass pellets, having temperature in the range 80-1000°C, is transferred to cooler via drag chain conveyor and is cooled by blower or sucking the cold air from the atmosphere. The cooled pellets is then be transferred to vibrating Screen for removing the fines/ crumbled pellets to be sent back to the hopper above the pellet mill. The proper sized screened pellets are collected into storage hopper/ silo through bucket elevator for subsequent transportation to the power plant(s).

- **Torrefaction:** Torrefaction refers to roasting, slow- and mild-pyrolysis, cooking and high-temperature drying of the biomass in a temperature regime between 200 and 3000°C under an inert atmosphere. It induces depolymerization and devolatilization of hemicellulose. Major products of biomass torrefaction are solid torrefied biomass and volatiles with composition and yield of products depending on torrefaction temperature, holding time, and biomass physical & chemical properties. Torrefied biomass is brittle and hydrophobic with improved physical and chemical properties such as grindability, storage stability, and energy density and has the potential to significantly reduce the cost of transportation, storage, and downstream processing. Torrefaction process involves pre- drying the shredded biomass by heating up to about 1000°C to evaporate physically bound water. Post-drying and intermediate heating shall be carried out between 100 and 2000°C, removing chemically bound water as well as light organic fractions. Further heating will be carried out in the temperature range about 200 to 3000°C with adequate holding time for decomposition & release of various volatile species with high oxygen contents. The remaining solid product called torrefied biomass shall mainly comprise of cellulose and lignin and characterized by increased brittleness, hydrophobicity, microbial degradation resistance, and energy density.

TECHNICAL SPECIFICATIONS AND UTILIZATION OF AGRO-WASTES

As per the Ministry of Power, Government of India, the technical specifications for agro-residue based bio-mass Pellets(non-torrified/terrified) for co-firing in coal based thermal power plants are[6]:

S.N.	Technical Data	Unit	Guaranteed value range
1.	Base Material	-	Agro residue/crop residue
2.	Diameter	mm	Not more than 25mm
3.	Length	mm	Not more than 50mm
4.	Bulk density	kg/m^3	Not less than $600kg/m^3$
5.	Fines%(length<3mm)	Weight %	<=5%
6.	Gross calorific value	kcal/kg	Non-torrified pellets:3500±100 Torrified pellets: 4500±100
7.	Moisture	Weight %	Not more than 9%
8.	Ash	Weight %	Not more than 20%
9.	Hardgrove Gindability Index	-	50 or more
10.	Particle size distribution (After crushing and pulverizing in site lab pulverizer)	Weight %	Passing proportion from 2mm mesh size sieve:≥75% Passing proportion from 3mm mesh size sieve: =100%

Table: Technical Specification of agro residue based bio-mass pallets for co-firing in coal based thermal power plants. *Source: Central Electricity Authority, Ministry of Power, Government of India*

The primary uses of crop residue are bedding material for animals, livestock feed, soil mulching, bio-gas generation, bio-manure/compost, thatching for rural homes, mushroom cultivation, biomass energy production, fuel for domestic and industrial use etc[7]. Crop stubble can be used as fodder for animals, generation of electricity, input in the paper/ pulp industry etc.

In China 37% of crop residues are directly combusted by farmers, 23% used for forage, 2l% discarded or directly burnt in the field, l5% lost during collection, 4% for industry materials and 0.5% for biogas. Thus burning of crop residues in the field is a major problem in China as well[5].

Micro-level evidence in India reveals, Patiala district of Punjab generates 23 and 19 quintal of paddy and wheat residues per acre annually. Out of this in the case of paddy, more than 85% burnt in open field and less than 10% was incorporated, while rest of 5% is used for other purposes. In case of wheat, 77% of the total amount is used as fodder for animals while 9% was incorporated and around 14%o was burnt.

CONCLUSION

Conversion of bio-waste into wealth offers economically viable alternative to prevent burning of crop residues, stubble etc. It creates possibility of giving an added value to the agricultural activity through the availability of an additional source of income for managing the treatment and selling resultant compost. Therefore, it is important to understand the economic use of crop residue to alleviate the problem of in-situ burning of it. Wheat, Rice and Sugarcane which are harvested in abundance in Indo-Gangetic areas produces large amount of agro waste which is mostly burnt by the farmers to prepare their land for the next harvest season. This huge amount of burnt crop residue is virtually a loss of opportunity to its potential use for different purposes such as composite making and bio-energy generation. To reduce crop residue burning, the efforts made so far are: (i) banning of crop residue burning, (ii) detection and prevention of occurrences of crop residue burning on real time basis, (iii) establishment of a marketplace for crop residue burning, (iv) outreach and public awareness campaigns, (v) subsidy on agri-implements and (vi) crop diversification.

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