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Performance Analysis of Areca Sheets as a Biomass Briquette Fuel by using different Binders

Deepak K.B[1]
Research Scholar, KVGCE, Sullia ,Asst. Prof.,Department of Mechanical Engineering, Vivekananda College of Engineering & Technology, Puttur.
Dr.Jnanesh N.A [2]
Professor, Department of Mechanical Engineering, Principal, K.V.G. College of Engineering, Kurunjibag, Sullia.

Abstract

In this paper, an experimental study was undertaken to produce biomass briquettes by using Areca sheets with binders, such as coconut coir, paper and sawdust as the binding agent. Ultimate and proximate analysis was done on the Areca sheet briquettes to access their various properties. Briquettes were prepared by using Areca sheets of size 1700µ and mixed with binders in 1:2 ratios. Briquettes were densified in a piston type briquette machine. The results after the analysis were then compared with a commercially available sawdust briquette. Results after analysis showed that briquettes produced using sawdust as a binder has a calorific value of 3541.56 kcal/kg, which was higher than other briquettes, that used paper (3083.13kcal/kg) and coconut coir (2428.63kcal/kg) as a binder. When compared with commercially available sawdust briquette there was reduction in fixed carbon and hydrogen, but a slight increase in sulphur and nitrogen. Areca sheets with sawdust as binder produce the best briquette.

1. Introduction

In the last four decades, researchers have been focusing on alternate fuel resources to meet the ever-increasing energy demand and to avoid dependence on crude oil. Biomass appears to be an attractive feedstock because of its renewability, abundance, and positive environmental impacts resulting in no net release of carbon dioxide and very low sulfur content. Biomass is very difficult to handle, transport, store, and utilize in its original form due to factors that can include high moisture content, irregular shape and sizes, and low bulk density. Densification can produce densified products with uniform shape and sizes that can be more easily handled using existing handling and storage equipment and thereby reduce cost associated with transportation, handling, and storage. [1]

India produces nearly 350 million tonnes of agricultural waste per year (Naidu, 1999). It has been estimated that 110-150 million tonnes crop residues is surplus to its present utilization as a cattle feed, constructional and industrial raw material and as industrial fuel. [2]

As per the Ministry of Agriculture, GOI, the area under arecanut is around 4 lakh hectares with a production of around 4.78 lakh metric tons in 2009-10 in India. Main arecanut growing states are Karnataka and Kerala which together account for 70 per cent of both area and production in the country. Assam, West Bengal, Meghalaya, Tamil Nadu, Tripura, Mizoram are other minor arecanut producing states in India. The Chikmagalur district stands first in both area (19.91%) and production (17.38%), Shimoga stands second followed by Davanagere district. The top 7 districts viz. Chikmagalur, Shimoga, Davangere, Dakshina Kannada, Tumkur, Chitradurga and Uttar Kannada occupy 89 per cent of the area under arecanut and contribute around 91 per cent of areca produced in the state. [3]

The briquettes made from biomass can be used for domestic purposes (cooking, heating, barbequing) and industrial purposes (agro-industries, food processing) in both rural and urban areas. The end use of briquettes is mainly for replacing coal substitution in industrial process heat applications (steam generation, melting metals, space heating, brick kilns, tea curing, etc) and power generation through gasification of biomass briquettes. Being derived from renewable resources, the briquette has superior qualities as well as environmental benefits in comparison with coal. [4]

2. Briquetting Process

Briquetting is a way to convert loose biomass residues, such as sawdust, straw or rice husk, into high density solid blocks that can be used as a fuel.
Briquetting can produce densified products with uniform shape and sizes. Briquetting process starts with collecting of raw materials and drying the same; in the next stage i.e. preparation stage, the raw material is cut into small pieces and crushed. In the mixing stage, the biomass is mixed with a binder, and then molded in a briquette machine. The densified briquettes are taken out and dried in the sun for a few days to completely remove the moisture content. After drying, the biomass briquette is ready for burning, without any further operation.

2.1 Collecting the raw material

Fig. 1 Raw material (areca sheet)

As the required material for the experiment is areca sheets, it's as shown in fig.1. Areca sheet in its natural form contains large amount of moisture content, so they are dried out in the sun for a few days to remove as much moisture as possible.

2.2 Preparation of raw material

After drying, the areca sheets are cut into small pieces, and then fed into a mill. The cutting of areca sheets into small pieces can be done before the areca sheets are dried or after drying. Cutting after drying possess some difficulty as, during drying areca sheets looses much of its moisture and hardens. The areca sheets which have been cut is fed into a mill and powdered. After milling, to determine the areca sheets of size 1700μ, they are sieved in a sieving machine as show in fig.2.

Fig. 2 Sieving machine

The sieving machine has 10 sieves, with sizes starting from 1700μ and above, 850μ, 600μ, 425μ, 350μ, 212μ, 150μ, 106μ, 75μ, and 53μ. The powdered areca sheet was placed in the 1st sieve and machine was started. The sieving machine was run for 5 minutes. As areca sheets were in fine powder form, all the sieves had some amount of powder in them. The powders of different sizes achieved from the sieves are as shown in fig.3. As, in this experiment areca sheet of size 1700μ is used, the sieved raw materials of size of 1700μ were collected and weighed using a weighing machine.

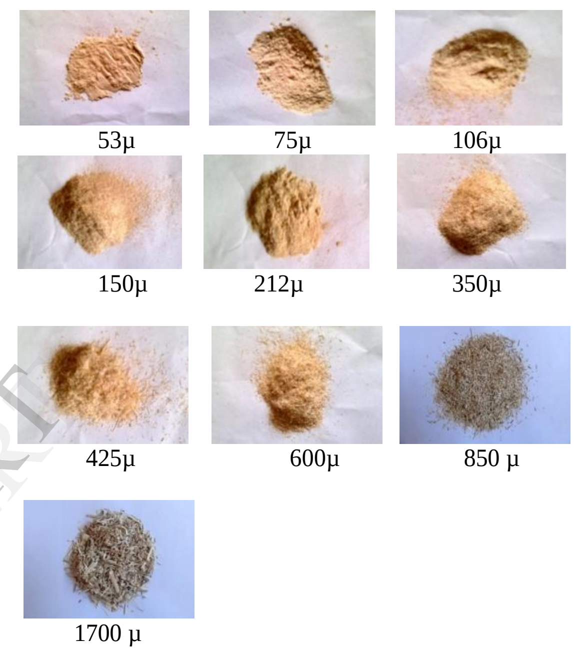

Fig. 3 Powdered areca sheets

2.3 Mixing

Binders like sawdust, paper and coconut coir as shown in fig.4 was used as binders for areca sheet briquettes as, binders help in binding together the powdered particles. Without the use of binders, the areca sheet briquettes would have lost its compactness, and this would have resulted in difficulty in handling. Raw materials along with binders were used in 2:1 ratio i.e. for 100 gms of raw materials 50 gms of binders were added. To soften, this mixture was soaked in water and kept in a container for 3 days.

Coconut coir Paper Sawdust

Fig. 4 Binders

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2.4 Briquetting

Briquetting can be done by using piston type and screw type technology. In this experimental analysis piston type briquetting machine is used, as shown in fig. 5.

Fig.5 Briquette machine

The briquette machine consists of two hydraulic jacks, each placed in the upper and lower side of the machine. In between these jacks, the mould and ram is placed. A set of springs are placed in the frame to lower the jack easily. To make a briquette, the biomass mixture after being soaked in water is filled into the mould. Pressure is applied by lowering the upper jack and raising the lower jack. Due to the pressure applied most of the water gets drained through the holes provided in the mould cavity. After the required pressure has been applied the biomass briquettes formed as shown in fig 6, 7 and 8 are taken out of the mould cavity, and the remaining moisture present in the biomass briquettes are dried out by drying them in the sun for a few days.

Areca Sheets 1700µ

Fig.6 Wet briquettes when paper is used as binder

Areca Sheets 1700µ

Fig.7 Wet briquettes when saw dust is used as binder

Areca Sheets 1700µ

Fig.8 Wet briquettes when coconut coir is used as binder

2.5 Drying

After molding, the briquettes were taken out of the mould cavity and dried in the sun. The briquettes after drying are as show in fig. 9, 10 and 11.

Areca Sheets 1700µ

Fig.9 Dry briquettes when paper is used as binder

Areca Sheets 1700µ

Fig.10 Dry briquettes when saw dust is used as binder

Areca Sheets 1700µ

Fig.11 Dry briquettes when coconut coir is used as binder

The wet weight of the biomass was weighted before drying and the same was done after drying. The wet weight and dry weight of the briquettes are tabulated as shown in the table 1:

Table 1 Wet and dry weights of biomass briquettes with various binders.

Sl.No	Type of briquette	Wet weight (kg)	Dry weight (kg)
	Binder used: Paper		
1	Areca sheets 1700µ	0.245	0.151
	Binder used: Saw dust		
1	Areca sheets 1700µ	0.241	0.153
	Binder used: Coconut coir		
1	Areca sheets 1700µ	0.239	0.154

3. Analysis results

After drying of the biomass briquettes, proximate and ultimate analyses were done and the results of these analyses are as follows:

Table 2 Analysis result for briquettes when paper is used as binder

Sl.No	Parameters	Binders used: Paper
		Areca sheets 1700µ
1	Gross calorific value kcal/kg	3083.13
Proximate analysis		
1	Moisture content, %	23.41
2	Ash content, %	2.82
3	Volatile matter, %	70.61
4	Fixed carbon, %	3.16
Ultimate analysis		
1	Hydrogen, %	5.14
2	Nitrogen, %	0.69
3	Sulphur, %	0.59
4	Oxygen, %	23.34

Table 3 Analysis result for briquettes when saw dust is used as binder

Sl.No	Parameters	Binders used: Sawdust
		Areca sheets 1700µ
1	Gross calorific value kcal/kg	3541.56
Proximate analysis		
1	Moisture content, %	5.37
2	Ash content, %	13.97
3	Volatile matter, %	78.88
4	Fixed carbon, %	2.48
Ultimate analysis		
1	Hydrogen, %	6.67
2	Nitrogen, %	0.52
3	Sulphur, %	0.60
4	Oxygen, %	18.48

Table 4 Analysis result for briquettes when coconut coir is used as binder

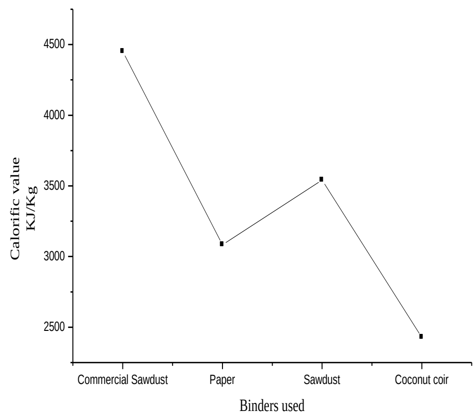
Sl.No	Parameters	Binders used: Coconut coir
		Areca sheets 1700µ
1	Gross calorific value kcal/kg	2428.63
Proximate analysis		
1	Moisture content, %	8.25
2	Ash content, %	3.78
3	Volatile matter, %	81.24
4	Fixed carbon, %	6.73
Ultimate analysis		
1	Hydrogen, %	7.00
2	Nitrogen, %	0.48
3	Sulphur, %	0.59
4	Oxygen, %	20.67

Table 5 Analysis result for Sawdust briquette available in market

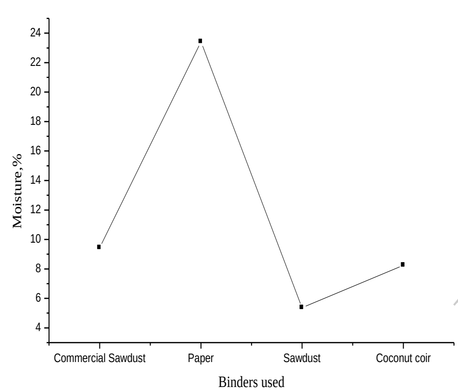
Sl.No	Parameters	Saw dust briquette
1	Gross calorific value kcal/kg	4451.37
Proximate analysis		
1	Moisture content, %	9.44
2	Ash content, %	3.36
3	Volatile matter, %	83.43
4	Fixed carbon, %	3.37
Ultimate analysis		
1	Hydrogen, %	7.03
2	Nitrogen, %	0.43
3	Sulphur, %	0.58
4	Oxygen, %	21.77

4. Comparison Graphs

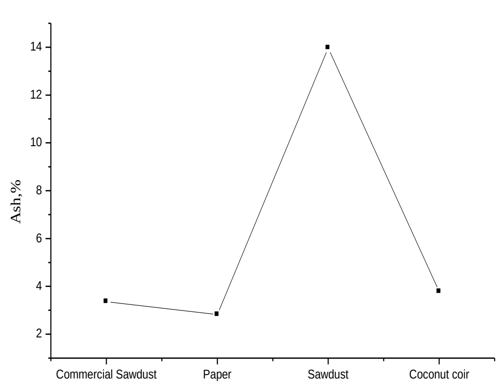
The following graphs were drawn, from the results that were obtained from conducting proximate and ultimate analysis on commercially available saw dust briquette and biomass areca sheet briquettes with various binders.



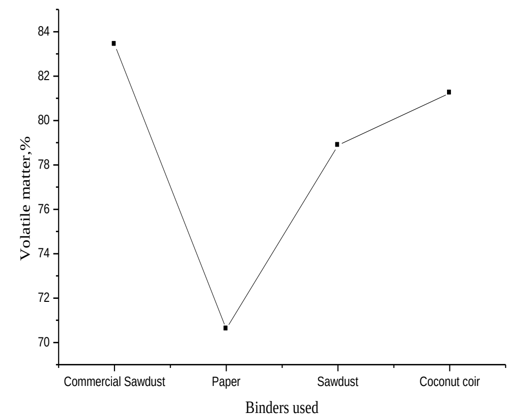
Graph 1 Calorific Values of briquettes, with various binders



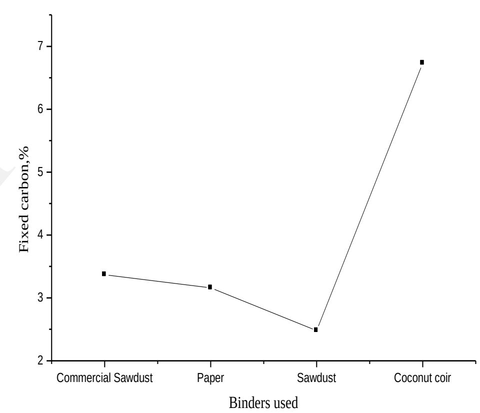
Graph 2 Moisture Content of briquettes, with various binders



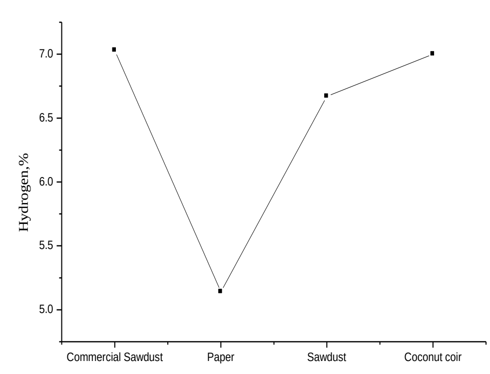
Graph 3 Ash Content of briquettes, with various binders



Graph 4 Volatile Matter of briquettes, with various binders



Graph 5 Fixed Carbon of briquettes, with various binders



Graph 6 Hydrogen Content of briquettes, with various binders

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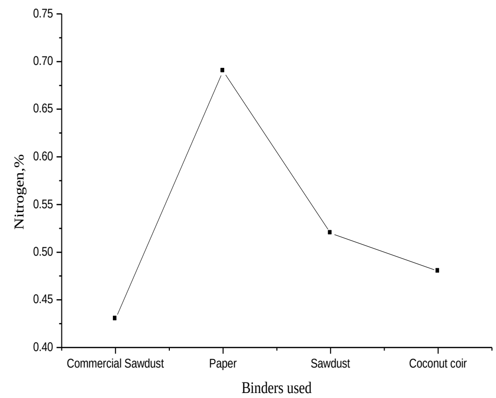
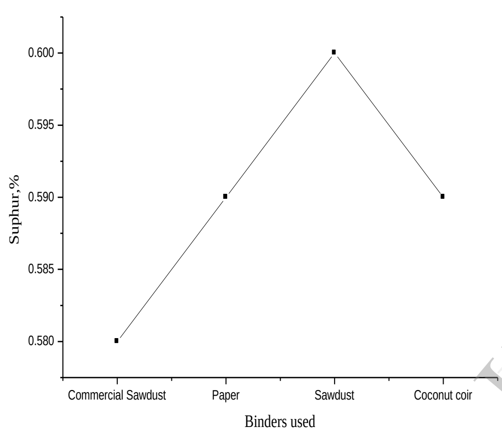
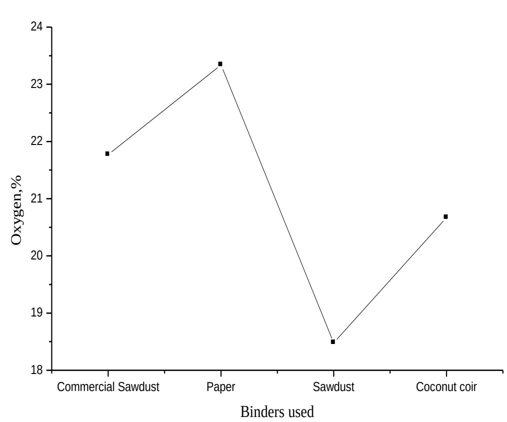


Graph 7 Nitrogen Content of briquettes, with various binders



Graph 8 Sulphur Content of briquettes, with various binders



Graph 9 Oxygen Content of briquettes, with various binders

From the value of analysis tables and graphs drawn, it can be seen that, briquettes made from areca sheets with sawdust as binder gives the best result, as the gross calorific value of briquettes using sawdust as binder is highest among the other two binders used (paper and coconut coir). A slight increase in the sulphur (0.52%) and nitrogen(0.60%) content in briquettes made of sawdust as binder was noticed when compared with the commercially available sawdust briquette(0.43% and 0.50% respectively). But there was a decrease in hydrogen content (5.14%) of briquettes using sawdust as binders, when compared with the commercially available sawdust briquette (7.03%).

5. Conclusion

As can be seen from the analysis, areca sheet briquettes using sawdust as binder gives the best results in terms of gross calorific value, which is of paramount interest with respect to energy. As areca is one of the crash crops in Karnataka, and available aplenty, the areca sheets available from these plants (Rs0.20/sheet) can be utilized for making biomass briquettes, thus producing energy which is environmentally friendly and at a much lower cost, then commercially available. The technique used in building the briquette machine, are very simple and available at any local workshop, thus making it commercially feasible for everyone. Areca sheet briquettes provide an opportunity to make our dependence on conventional energy lesser to a large extent, which is the need of the hour.

6. Reference

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