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STUDY ON BRIQUETTING OF COTTON WASTE

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Abstract—In many parts of the world, the primary source of energy for vital activities like cooking and space heating is burning wood and other agricultural products. Increasing populations using dwindling resource of combustible biomass materials will eventually result in shortage of those materials unless and until certain measures are taken to reserve them. One means of making more efficient use of existing resources is through the use of briquetting technique. Briquetting involves collecting combustible materials that are not usable due to lack of density, compressing them into a solid fuel of a convenient shape that can be burnt like wood or charcoal. In this investigation cotton waste was used from Gomti Industry, Bangalore for making briquette and to get efficient energy by burning it. Solid waste from flour mill was used as binder. In this research the composition, compressive strength, calorific value, moisture content, thermal efficiency, proximate analysis of briquettes were analysed.

Index Terms—Briquetting, Binder, Solid Waste from Flour Mill (SWFM), Biomass, Cotton waste.

I. INTRODUCTION

Every year millions of tons of agricultural wastes are generated which are either destroyed or burnt inefficiently in loose form causing air pollution [1]. Many countries are thus turning their attention to the development of new, clean and sustainable energy resources. Among the various potential sources of renewable energy, briquettes are of most interest and expected to play a crucial role in the global energy infrastructure in the future [2]. Briquetting technology is one of the promising solutions to this problem. The technology can be defined as densification process for improving the handling characteristics of raw materials and enhancing calorific value of the biomass. One energy source that could find ready utilization is the fuel briquette. Briquetting of the cotton waste would mitigate those pollution problems while at the same time making use of this important industrial/ domestic energy resource. The briquettes can be used for domestic purpose such as cooking, heating, barbequing and industrial purposes like agro-industries, food processing in both rural and urban areas [3]. There is over exploitation of wood for burning due to the high rise in population. Hence, there is shortage of fuel wood in developing countries today. With successful production of briquettes from cotton waste, fuel wood users especially rural dwellers can have an alternative to fuel wood as source of energy at lower cost [4].

II. MATERIALS AND METHODS

A. Materials/Instruments used

The materials/instruments used for this work were: Mould, Universal Testing Machine (UTM), Hot Air Oven, thermometer (range 0°C to 100°C), Oven, stainless steel vessel, stirrer, crucible and furnace.

B. Sample collection

Cotton waste was obtained from the Gomti Incinco Company, Bangalore.

Fig. 1. Cotton Waste

Fresh cow dung was collected from a local cow yard in Nagenahalli, Bangalore. Saw Dust was collected from SLV furniture shop in Yelahanka, Bangalore. Rice Husk and Rice Bran were collected from a rice mill in Doddaballapura. Solid Waste from Flour Mill (SWFM) was collected from a flour mill in Nagenahalli, Bangalore.

Fig. 2. Mould

C. Briquette Making Process

Cotton waste was made free from unwanted materials such as sand particles, metal pieces. The clean cotton waste was shredded into small pieces of size 150 mm X 100 mm. A known amount of cotton waste was mixed with binder prepared using Solid Waste from Flour Mill (SWFM) along with fillers such as rice husk, rice bran, saw dust and cow dung. Then, the ingredient was transferred to the mould for making briquette and was subjected to an approximate pressure of $25x10^5$ N/m^2. The briquettes were removed from the mould and were subjected to oven drying at a temperature of 50^0C until they were completely dried. After drying, the briquettes were sealed in air tight container.

Fig. 3. Cotton Waste Briquettes

D. Preparation of Binder

100 g of SWFM was mixed with 800 ml of water & was boiled until the mixture became very sticky. On dry basis the binder was weighed and added to make the briquette.

E. Compressive Strength

Compressive strength is measured by applied force against deformation in testing machine. The specimen was placed in the UTM and was made ready for the application of load. Then, the dial gauge was fixed to the bottom platform of the UTM to measure the contraction. The load was applied and the dial gauge was noted down when specimen failed.

F. Moisture Content

Moisture content was obtained by taking the difference of initial weight and final weight of briquette.

G. Thermal Efficiency

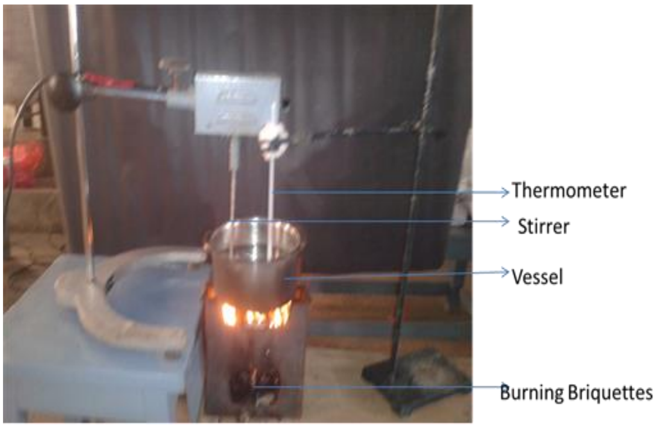

Fig. 4. Experimental setup to determine thermal efficiency

In a stainless steel vessel, one litre of water was filled and a thermometer with a least count of 1^0C was used to monitor the temperature till 70^0C. 70^0C was set as the upper limit, since the higher temperature would lead to nucleate boiling which would give rise to an erratic temperature patterns. In order to prevent the formation of conventional currents in the liquid due to rise in temperature, a stirrer with adjustable speed was used. Thus the experimental setup comprised of an oven along with stainless steel vessel, which acts as a heat sink and a heat load. Fig. 4 gives the experimental setup. The briquette was kept in oven, ignited and time taken for every 5^0C rise in temperature was observed. The findings were tabulated and further calculations and evaluations were performed.

H. Proximate Analysis

Percentage Volatile Matter (PVM):

2 g of briquette sample in a crucible was placed in the oven until a constant weight was obtained. The briquette was now kept in the furnace at a temperature of 550^0C for 10 mins and weighed after cooling and the PVM was determined with the formula:

PVM = [(B-C)/B] ×100

Where B = weight of oven dried sample and C = weight of sample after 10 mins in the furnace at 550^0C.

Percentage Ash Content (PAC):

2 g of briquette sample in a crucible was heated in the furnace at the temperature of 550^0C for 4 hours and weighed after cooling. The PAC was determined by:

PAC = (D/B) ×100

Where D = weight of ash and B = weight of oven dried sample.

Percentage Fixed Carbon (PFC):

The PFC was calculated by subtracting the sum of Percentage Volatile Matter (PVM) and Percentage Ash Content (PAC) from 100.

Heating Value:

Heating Value (H_V) was calculated using the equation:

Hv = 2.326 (147.6C+144V)

Where C = Percentage Fixed Carbon and V = Percentage Volatile Matter (bailey et. al., 1982)

III. Results And Discussion

A. Compositions of Briquette

The compositions of briquette sample are as follows:

Table 1. Compositions of briquette sample 1

Components	Weight (gm)	Weight (%)
Cotton waste	45	45
Binder (SWFM)	87.75	27
Cow dung	32.25	5
Saw dust	8.60	8
Rice husk	5.37	5
Rice bran	10.86	10

Table 2. Compositions of Briquette Sample 2

Components	Weight (gm)	Weight (%)
Cotton waste	40	40
Binder (SWFM)	111.24	30
Cow dung	32.25	5
Saw dust	10.74	10
Rice husk	5.37	5
Rice bran	10.86	10

Table 3. Compositions of Briquette Sample 3

Components	Weight (gm)	Weight (%)
Cotton waste	35	35
Binder (SWFM)	121.66	35
Cow dung	32.25	5
Saw dust	10.74	10
Rice husk	5.37	5
Rice bran	10.86	10

TABLE 4. COMPOSITIONS OF BRIQUETTE SAMPLE 4

Components	Weight (gm)	Weight (%)
Cotton waste	30	30
Binder (SWFM)	139.06	40
Cow dung	32.25	5
Saw dust	10.74	10
Rice husk	5.37	5
Rice bran	10.86	10

TABLE 5. COMPOSITIONS OF BRIQUETTE SAMPLE 5

Components	Weight (gm)	Weight (%)
Cotton waste	25	25
Binder (SWFM)	156.42	45
Cow dung	32.25	5
Saw dust	10.74	10
Rice husk	5.37	5
Rice bran	10.86	10

TABLE 6. COMPOSITIONS OF BRIQUETTE SAMPLE 6

Components	Weight (gm)	Weight (%)
Cotton waste	20	20
Binder (SWFM)	173.8	50
Cow dung	32.25	5
Saw dust	10.74	10
Rice husk	5.37	5
Rice bran	10.86	10

B. The Compressive Strength Test

Highest compressive strength was obtained for 30 % binder for sample 2 and was concluded that briquette made with 30 % binder was mechanically stable and durable. Further increase in % binder resulted in decrease in compressive strength due to less densification of briquette.
The following readings were obtained.

TABLE 7. COMPRESSIVE STRENGTH OBTAINED FROM VARYING QUANTITY OF BINDER

Sl. No	Compositions	Binder (%)	Compressive Strength (kN/m^2)
1	Sample 1	27	1515.1
2	Sample 2	30	2188.5
3	Sample 3	35	1515.1
4	Sample 4	40	1683.5
5	Sample 5	45	1178.4
6	Sample 6	50	1010.1

The compressive strength v/s % binder followed the following pattern as shown in fig. 5. A graph of compressive strength v/s % binder was plotted as shown below.

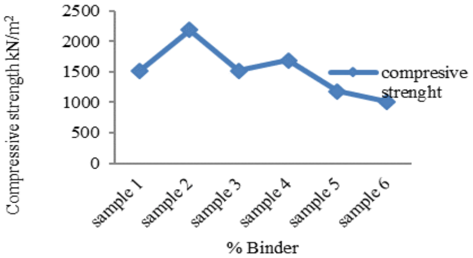

Fig. 5. Plot of Compressive strength v/s % Binder

C. The Calorific Value

With the addition of fillers and binders, calorific value increased significantly. The readings for different samples with % binder are tabulated as follows:

TABLE 8. CALORIFIC VALUE OBTAINED FOR VARYING AMOUNT OF BINDER

Sl. No	Compositions	Binder (%)	Calorific value (cal/g)
1	Sample 2	30	5233
2	Sample 6	50	4916
3	Cotton waste	-	5039

Highest calorific value was obtained for 30 % binder for sample 2 and was concluded that maximum densification was achieved. Later on with further increase in the binder quantity, the calorific value decreased due to less densification of briquette.

D. The Moisture Test

Briquette was dried in a hot air oven until there was no further loss of weight i.e. the moisture was completely removed from the briquette.

TABLE 9. MOISTURE CONTENT OBSERVED FOR VARYING QUANTITY OF BINDER.

Sl. No	Compositions	Binder (%)	Moisture Content (gm)
1	Sample 1	27	32.11
2	Sample 2	30	37.00
3	Sample 3	35	46.56
4	Sample 4	40	46.16
5	Sample 5	45	45.29
6	Sample 6	50	48.06

E. The Thermal Efficiency Test

The thermal efficiency test was carried out as follows:
Assuming law of conservation of energy to hold true,

Heat liberated=Heat absorbed.

Now, Heat absorbed by 1litre of water = m.Cp.ΔT
Where, m = 1kg, Cp = specific heat capacity of water = 4186.8 J/kg^{0}C, ΔT = difference in temperature = (final temp – room temp).

Heat liberation was calculated by experimental data. Thermal efficiency of cotton waste and briquettes were determined by burning the same and time for 5^{0}C rise in temperature till 70^{0}C for 1 litre of water was recorded for each case.

The comparison of thermal efficiency of cotton waste and briquette are as given below:

Cotton waste:
Room temperature of water = 28^{0}C
Volume of water = 1 Litre

TABLE 10. VARIATION OF THERMAL EFFICIENCY WITH TEMPERATURE

Temperature (ºC)	Time (sec)	Thermal efficiency (η) (%)
30	29	8.17
35	66	12.56
40	110	12.92
45	176	11.44
50	228	11.43
55	270	11.84
60	293	12.93
65	324	13.52
70	360	13.08

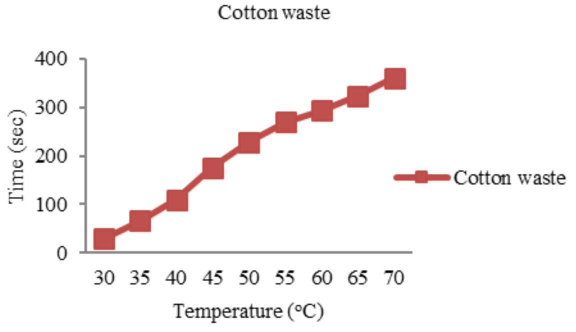

Fig. 6. A Plot of time v/s temperature

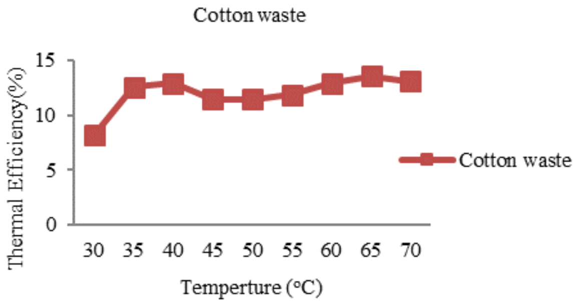

Fig. 7. A Plot of thermal efficiency v/s temperature

A Plot of time v/s temperature for cotton waste was shown in fig 6. It is also called burning rate. This was compared with burning rate of briquette samples made using cotton waste.
A Plot of thermal efficiency v/s temperature for cotton waste was shown in fig 7. This was, later compared with the thermal efficiency of briquette sample made using cotton waste.

Sample – 2: Best case scenario
Briquette (Binder = 30 %)
Room temperature of water = 28^{0}C
Volume of water = 1 Litre

TABLE 11. VARIATION OF THERMAL EFFICIENCY WITH TEMPERATURE

Temperature (ºC)	Time (sec)	Thermal efficiency (η) (%)
30	4	41.12
35	20	28.74
40	43	22.92
45	60	23.20
50	91	19.85
55	116	19.11
60	142	18.50
65	168	18.01
70	193	17.87

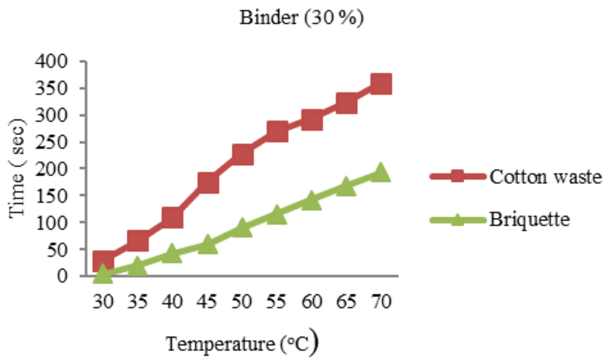

Fig. 8. A Plot of time v/s temperature

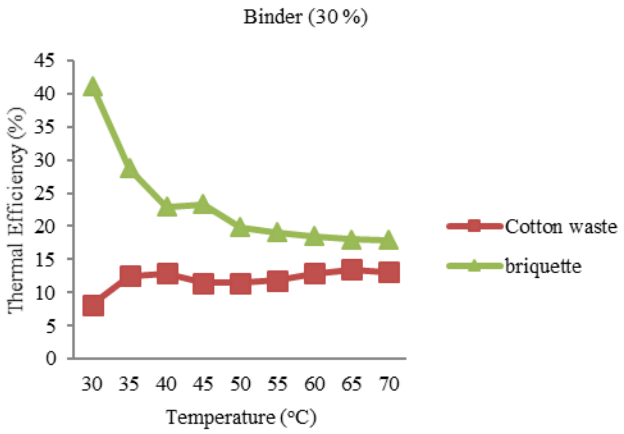

Fig. 9. A Plot of thermal efficiency v/s temperature

It was observed from fig. 9 that the thermal efficiency of briquette which was higher initially, decreased with increase in temperature, while the thermal efficiency of cotton waste which was lower initially, increased with increase in temperature upto 40^{0}C and later on remained more or less constant. This was due to the energy loss in briquetting material.
Sample – 6: Worst case scenario
Briquette (Binder = 50 %)
Room temperature of water = 28^{0}C
Volume of water = 1 Litre

TABLE 12. VARIATION OF THERMAL EFFICIENCY WITH TEMPERATURE

Temperature (ºC)	Time (sec)	Thermal efficiency (η) (%)
30	45	9.72
35	81	10.79
40	117	11.20
45	152	11.50
50	187	11.68
55	228	11.50
60	276	11.08
65	330	10.59
70	407	9.66

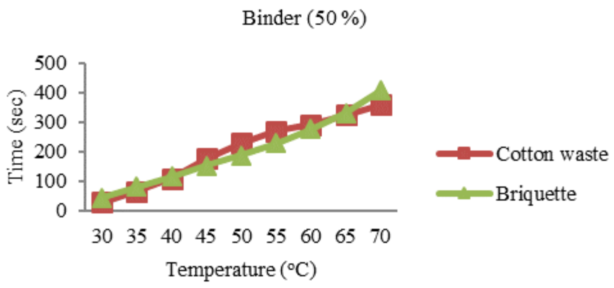

Fig. 10. A Plot of time v/s temperature

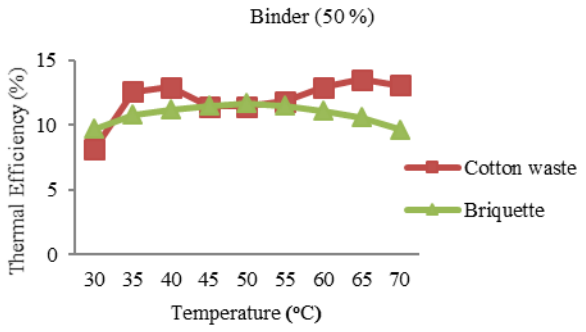

Fig. 11. A Plot of thermal efficiency v/s temperature

It was observed from fig. 11 that the thermal efficiency of cotton waste which was lower initially, increased with increase in temperature upto 40^0C and later on remained more or less constant, while on the contrary thermal efficiency of the briquette which was lower initially, increased with increase in temperature upto 50^0C and thereafter decreased. This was due to the increase in quantity of binder.

F. Proximate Analysis

Volatile matter represents the components of carbon, hydrogen and oxygen present in the briquette that when heated turns into vapours, usually a mixture of short and long chain hydrocarbons. Volatile content has been shown to influence the thermal behaviour of solid fuel but this was also influenced by the structure and bonding within the fuel.

TABLE 13. PROXIMATE ANALYSES OF THE BRIQUETTE SAMPLE 4 (BINDER 30 %)

Trials	PVM (%)	PAC (%)	PFC (%)	Heating value (Kcal/kg)
1	87.26	8.65	4.09	30631.382
2	90.30	6.88	2.82	31213.598

It was observed that PVM, PAC, PFC and H_V were within the range.

IV. CONCLUSIONS

The disposal of cotton waste problem can be overcome by producing briquette from it. The calorific value of the briquette obtained from cotton waste increased with the aid of fillers and binders. The briquette of 30 % binder was optimized because it had 2188.5 kN/m^2 of compressive strength, 5233 cal/g of calorific value, 193 seconds time to attain 70^0C for 1 litre of water and 17.87 % of thermal efficiency. Calorific value of cotton waste briquettes found nearer to coal. The binder SWFM proved to provide good mechanical strength. The briquette produced considerably less smoke. The briquette of 50 % binder had least compressive strength of 1010.1 kN/m^2, 4916 cal/g of calorific value, took 407 seconds time to reach 70^0C for 1 litre of water and 9.66 % of thermal efficiency. Hence, in this work, 30 % binder was optimized. It was also observed that as the percentage of binder increased the compressive strength and calorific value of the briquette decreased.

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