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To Study the Effect of Mechanical Comminution on Lignin Percentage and Calorific Value of Dry Sugar Cane Leaves

Rahul A. Patil[a]*, Umesh B. Deshannavar[b]

D. Y. Patil College of Engg and Tech., Kasaba Bawada, Kolhapur 416006, India
KLE Dr. M. S. Sheshgiri College of Engg. and Tech, Belagavi 590008, India

Abstract

India is one of leading consumable of energy in world. It consumes large amount of oil and natural gas to fulfill its demand of energy. The gap between energy supply and demand is increasing day by day. So there is urgent need to reduce this gap, which demands for the other sources to produce energy. The solution for this problem is biomass. India produce large amount of biomass waste like sawdust, woody residues, animal waste, peanuts shell, rice husks, wheat straw, rice straw, energy grass, corn cobs, sugarcane bagasse, sugarcane leaves etc which can generate huge amount of energy. The dry sugar cane leaves as a biomass is studied in present work. This paper high light on effect of mechanical comminution (physical treatment) on lignin percentage and calorific value of dry sugar cane leaves. The ball mill which works on principle of impact is used to study the effect on lignin percentage and calorific value of dry sugar cane leaves.

Selection and/or Peer-review under responsibility of Materials Processing and characterization.

Keywords: Energy; Biomass; Dry sugar cane leaves; Mechanical comminution; Impact

1. Introduction

India is largely depending on oil and natural gas to fulfil the requirement of energy. As the industrialization is increasing the demand for energy is increasing. This increases the demand for oil and natural gas. 70 to 80 % of oil

* Corresponding author. Tel.: +91-231-2601431; fax: +91-231-2601432.
E-mail address: rahulapatil1978@gmail.com

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is imported, which affects the economy of country [1]. Use of oil and natural gas as a source of energy results in gas emission. This creates the environmental pollution. The urgent solution for pollution and economy problem is use of renewable sources instead of oil and natural gas [2]. The example of renewable sources is wind, geothermal, solar, nuclear, biomass. Animal waste, agricultural waste, food processing, forestry and municipal wastes are the biomass used as resources of energy [3]. India produces approximately 320 million tones of agricultural waste. 100 million tones are burned directly in the open field causes environmental pollution. Burning of agriculture waste is loss of energy. Rice husks, wheat straw, rice straw, corn cobs, sugarcane bagasse, and dry sugarcane leaves etc are the main agriculture waste produce [1, 3]. Whole sugar cane crop can be brought in use and it can be also used for generating the energy [4]. Sugar is a main product produce from sugar cane crop, bagasse as waste product along with dry leaves is biomass resource which is used to generate energy [5]. The major content of biomass is cellulose, hemicelluloses and lignin [6]. Energy is librated upon lignin burning [7]. Dry sugar cane leaves is most neglected part of sugar cane crop as biomass than bagasse. In India dry sugar cane leaves are burned directly in open field, creating the pollution [8]. World Sugar cane production is 1877105 thousand metric tons in 2015. Brazil being at top by producing 739267 thousand metric tons of sugar cane and India at second producing 341200 thousand metric tons of sugar cane [9, 10]. The top ten sugarcane producing states in India are listed in Table 1 [9, 10]. The calorific value of some biomass is listed in Table 2 [11, 12].

Table 1. Top ten sugarcane producing states, 2012-13

Rank	State Name	Production (000MT)
1	Uttar Pradesh	132427.6842
2	Maharashtra	69648.0768
3	Karnataka	35732
4	Tamil Nadu	33919.17
5	Andhra Pradesh	15567
6	Bihar	12741.42
7	Gujarat	12690
8	Haryana	7437
9	Uttarakhand	6784.82
10	Punjab	5919

Table 2. Calorific values of some biomass

Sr. No.	Raw Material	Calorific values (KJ/Kg)
1	Sugar Cane	16719.26
2	Corn cob	16988.63
3	Rice Husk	15659.5
4	Bagasse	17318.37
5	Saw dust	19956.63
6	Sun flower Stalk	17991.2
7	Wheat Straw	16988.63
8	Wood	18487.59
9	Cotton stalk	20036.59
10	Cattle Dung	15480.8
11	Groundnut Shell	19355.18

The effect of pretreatment on biomass is studied for long time. Pretreatment of biomass is done to increase the hydrolysis, to avoid loss of carbohydrate, to avoid formation of inhibitors, to remove unwanted materials [13]. There are various pretreatment methods like physical, physico-chemical, chemical and biological. To treat the lignin the physical (mechanical comminution, steam explosion), chemical (CO_2 explosion, acid) pretreatment are preferred

[13, 14]. Lot of study has been made on pretreatment of sugar cane leaves and bagasse pith to convert it into sugars [15]. The mechanical pretreatment is to apply force on the biomass. If force is applied on the biomass the cellulose molecules get rupture. With small pressure, these will be reformed in to a new shape [16]. Mechanical pretreatment reduce the cellulose crystallinity and degree of polymerization of biomass. This pretreatment rupture the complex structure of biomass into simple compound which is used for chemicals and biofuels production. If the purpose of pretreatment is to reduce lignin content it increases the digestibility of biomass and purpose is to increase the lignin content it increase the energy of biomass [17]. Briquetting is to convert loose biomass into high density biomass [18]. Different biomass material like saw dust, mixture of wheat straw, saw dust, dry leaves, mixture of bagasse and leaves, sugar cane waste, municipal solid waste, mixture of rice husk and saw dust, coconut leaves are used for making briquettes [19-25].

2. Materials and methods

2.1 Materials

Dry sugar cane leaves (breed 86032) was used as the material, which was taken from agricultural field of western Maharashtra. The sugar cane of breed 8602 is largely cultivated in Maharashtra and India.

2.2 Experimental set-up

The material was comminuted in the ball mill. The ball mill set-up is shown in Fig. 1.

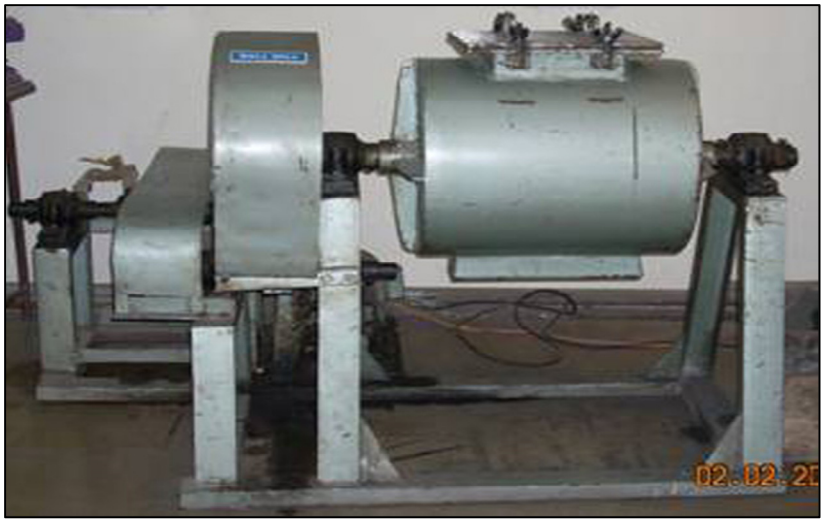

Fig. 1 Ball mill set-up

The principle used in ball mill is impact (single rigid force). Size of the ball mill is 0.2737 m diameter and 0.35 m length. The balls used in the ball mill were 0.02196 m diameter and 1 hp motor (1440 rpm) (Arvind Engineering Company, Hyderabad, Model Number AC-58).

2.3 Experimental procedure

Dried sugar cane leaves was taken from the agriculture field & kept for sun drying for 24 hours. 100 gm sample was weighted by using electronic weighing balance. The weighted sample was cut into small pieces of around 5-10 cm. This sample was then placed in the ball mill along with 21 balls. The mill was rotated with electric motor to make 5 rotations. The above procedure was carried for different rotation, such as 10, 15, 20, 25 and 30 rotations. The crushed sample was removed from the mill and was subjected to analysis.

2.4 Analysis

The acid soluble lignin and acid insoluble lignin method was used for measuring cellulose, hemicelluloses and lignin percentage. Calorific value of dry sugar cane leaves was measured by bomb calorimeter and loss on drying method was used to calculate percentage moisture content of sample.

3. Results and discussion

3.1 Raw material

The content (cellulose, hemicelluloses and lignin) of dry sugarcane leaves is listed in Table 3. If the content of dry sugarcane leaves compared with the other agriculture residue, the dry sugarcane leaves have comparative lignin content which librates energy on burning and also used for making briquettes.

Table 3. Composition of raw material

Sr. No.	Parameter	Unit	(%)
1	Total Ash	%	06.91
2	Cellulose	%	27.64
3	Hemicellulose	%	19.15
4	Lignin	%	11.95
5	Gross Calorific Value	KJ/Kg	17556.06

3.2 Effect of mechanical comminution (Impact) on calorific value of dry sugar cane leaves

Bomb calorimeter (U. P. N. M. Varanasi, S- JB-78-2146) was used to measure the calorific value. The experiments were conducted to see the effect of impact on the calorific value of dry sugar cane leaves. The Fig. 2 shows the gross calorific values at different rotation. There is no much change in the calorific value of the leaves.

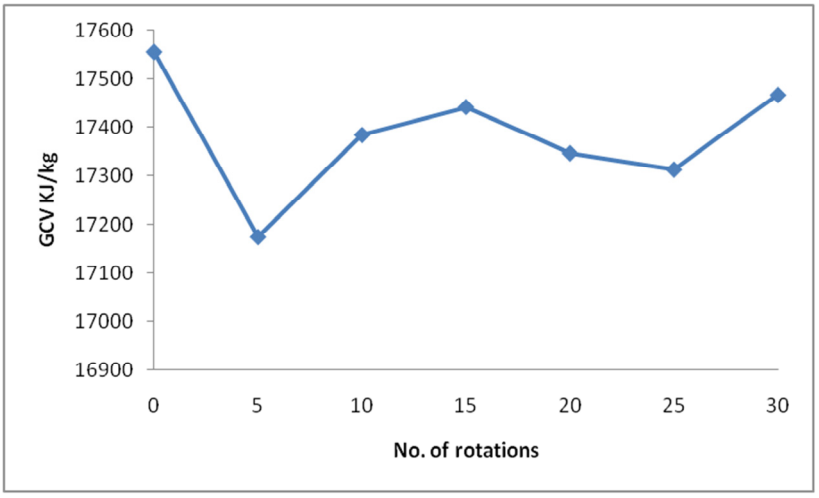

Fig. 2 Effect of no. of rotation on GCV for ball mill diameter 0.2737 m, length 0.35 m and balls diameter 0.02196 m

3.3 Effect of mechanical comminution (Impact) on lignin content of dry sugar cane leaves

The experiments were conducted to see the effect of impact on the lignin percentage of dry sugar cane leaves. If force is applied on the biomass the cellulose molecules get rupture. With small pressure, these will be reformed in to a new shape. Mechanical comminution (Impact) reduces the cellulose crystallinity and degree of polymerization of biomass. This pretreatment rupture the complex structure of biomass into simple compound and shows some alteration in lignin percentage. Fig. 3 shows the lignin percentage at different rotation. There are some changes in the lignin percentage of the leaves.

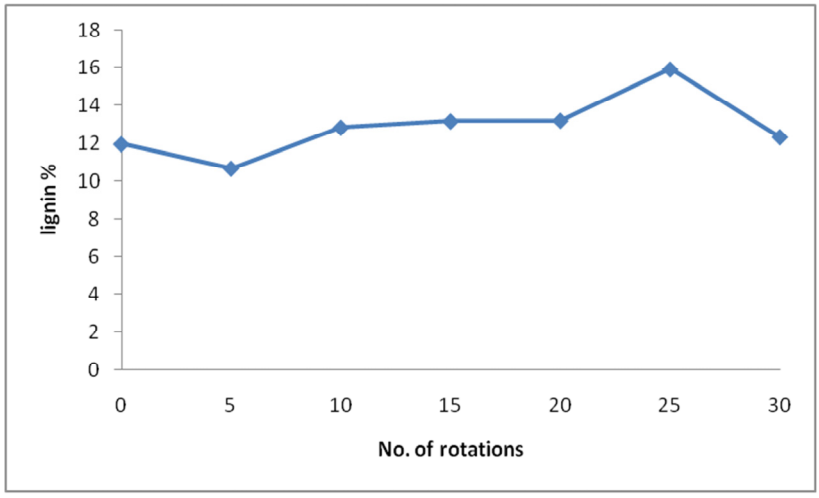

Fig. 3 Effect of no. of rotation on lignin % for ball mill diameter 0.2737 m, length 0.35 m and balls diameter 0.02196 m

3.4 SEM micrographs of the surface of the dry sugar cane leaves

Scanning Electron Microscope (Hitachi, S- 4700 II, 25 KV) was used to study the surface morphology. Fig. 4 shows the structure of raw dry sugar cane leaves. After applying the impact on the leaves the structure of leaves is disturb which is shown in the Fig. 5

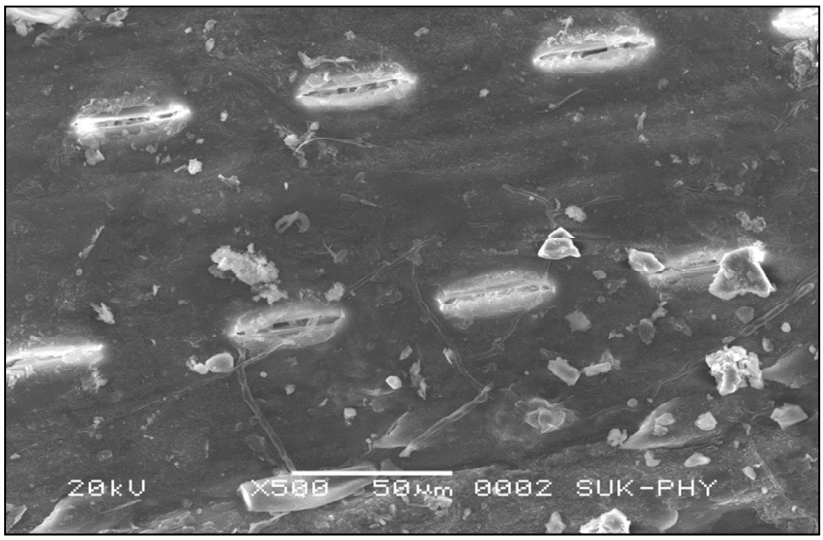

Fig. 4 SEM micrographs (×500) of the surface of raw dry sugar cane leaves

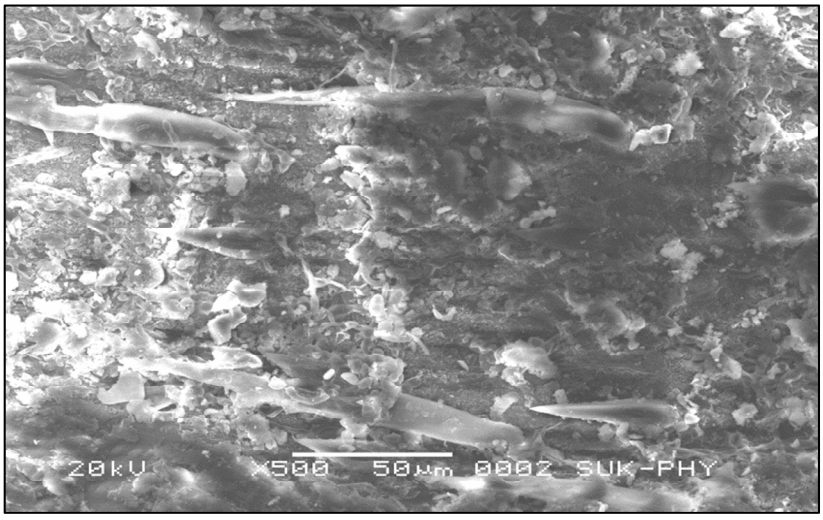

Fig. 5 SEM micrographs (×500) of the surface of dry sugar cane leaves after the treatment of ball mill (impact)

4. Conclusions

The calorific value of sugarcane leaves changes from 17175.3 KJ/Kg to 17556.06 KJ/Kg. From above results it can be concluded that there is no much change in calorific value of Dry sugar cane leaves even after the mechanical comminution (Impact). But mechanical comminution (Impact) shows some alterations in the lignin percentage. The maximum lignin percentage, 15.92 % is achieved at 25 rotations.

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