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An Experimental Study to Evaluate the Calorific Values of Bagasse after Solar Cabinet Drying

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Abstract- In this research work experiments are performed to calculate the calorific value of bagasse fuel after drying in a solar cabinet dryer. Experiments are performed on a fixed mass (1312 grams) of freshly crushed bagasse taken from a traditional jaggery making plant. The high calorific value (HCV) and low calorific value (LCV) of bagasse are calculated by using mathematical formulae based on the percentage of major contents like moisture, ash and brix. It was observed that both HCV and LCV of bagasse are much influenced by the content of moisture in it. After solar cabinet drying of bagasse it was found that the average values of moisture content decrease from 53.28 % to 19.76% as result of which average values of HCV and LCV are increases from 8446.68 kJ/kg to 15017.31 kJ/kg and 6530.45 kJ/kg to 13489.195 kJ/kg respectively.

Keywords: Sugarcane, Bagasse, Jaggery plant, Moisture content, Calorific value of bagasse.

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I. INTRODUCTION

The fibrous part of sugarcane left after crushing is known as bagasse. In all traditional jaggery making plants bagasse is directly used as a fuel. Among different crops sugarcane is one of the best natural converters of solar energy into biomass and sugar [1]. Depending upon the variety of sugarcane used the percentage of bagasse varies from 23% to 37% [2]. The main constituents of bagasse are fibers and sugar having high calorific values 19259 kJ/kg and 16747 kJ/kg respectively [3]. The calorific value of bagasse is much influenced by the percentage of moisture contents. The fresh bagasse coming from crusher contains moisture 50%, fibers 47%, sugar 2.5% and minerals 0.5% [4]. Traditionally to remove moisture from fresh bagasse open sun drying is used [5]. The cost of bagasse used as a fuel is 1/3rd of the other available fuels [6]. In rural areas of India where jaggery manufacturing is the main employment it is an important cash crop [7]. Because of low crushing efficiency of crushers used in traditional jaggery making plants, drying of bagasse is very important issue [8]. The calorific value of bagasse is much influenced by the contents of moisture in it. Bagasse is also used to manufacture Kraft papers, printing papers, particle board and to generate bio-electricity etc. [9]. Bagasse is a renewable source of energy and can be used to generate electricity at lowest cost [10]. In this research paper, experiments were performed to calculate the calorific values of bagasse after solar cabinet drying in a traditional Jaggery making plant.

II. STUDY APPROACH

The study is approached towards the calculation of calorific value of dried bagasse in a cabinet dryer. Generally, there are two types of calorific values: Gross Calorific Value (GCV) or High Calorific Value (HCV) and Net Calorific Value (NCV) or Low Calorific Value (LCV). The GCV is the total heat energy released per unit mass at atmospheric pressure and at 20^{o}C with complete combustion. It can be accurately measured by using bomb calorimeter. The NCV is the GCV of fuel without the latent heat of water formed by the combustion process [11]. However, both of these values can also be calculated by using experiment based formulas listed in ISO1928 [12].

III. MATHEMATICAL MODELING

According to Southern African Sugar Technologists Association Laboratory Manual the HCV and LCV of bagasse can be calculated by using following formulae:

HCV = [19605 - 196.05 (moisture % sample) - 196.05 (ash % sample) - 31.14 (brix % sample)] kJ.kg^{-1}
LCV = [18260 - 207.63 (moisture % sample) - 182.6 (ash % sample) - 31.14 (brix % sample)] kJ.kg^{-1}

IV. MATERIALS AND METHODS

In this research work experiments were performed on a sample of freshly crushed bagasse taken from a traditional jaggery making plant in Haryana. The size ($50 \times 50 \times 6\ cm^3$) and mass (1312 grams) of the sample remains constant in all experiments. The samples are tested in a laboratory to calculate the percentage of moisture, ash and brix in it.

Determination of moisture content:

The moisture contents in a bagasse sample were determined by using Microwave oven (KENSTAR, Model No. OM 20 DGQ), where a sample of bagasse (50 grams) was kept for a period of 20 to 25 minutes. Then the percentage of moisture content was calculated by using the equation as given below:

$$Moisture\ content\ (\%) = \frac{(W_i - W_f)}{W_i} \times 100$$

Where:

W_i = Initial mass of bagasse sample.

W_f = Final mass of bagasse sample.

Determination of Ash content:

The ash content in a bagasse sample was determined by using Muffle Furnace (SKU LA.LA.Co.FU.1424562Model No. RSW 126) where the sample of (5 gram) bagasse at a temperature of 550° C kept until the complete bagasse sample was converted into ash. The crucible was then cooled and weighted again. The ash content of the bagasse sample was calculated by using the equation:

$$Ash\ content\ (\%) = \frac{(W_2 - W_c)}{(W_1 - W_c)} \times 100$$

Where:

W_c = Weight of Crucible.

W_1 = Initial weight (Crucible + Bagasse sample).

W_2 = Final weight (Crucible + Bagasse sample).

Determination of Brix:

The brix of sugarcane juice was calculated by using a Hand-Held Refractometer (ATAGO). In this experimental work a constant value of brix 1.5% is used.

V. RESULTS SAND DISCUSSIONS

Numbers of experiments were performed on constant mass of bagasse (1213 grams). The effect of moisture content on calorific value of bagasse is shown in the graphs given below. It can be clearly seen from the graph that both HCV and LCV increase with the decrease in percentage of moisture contents.

Fig.1. Effect of moisture content on calorific value of bagasse.

[Source: results are based on experimental data]

Fig.1. Shows that under direct sun drying of bagasse when the moisture content decreases from 54.497 % to 21.676 % then the both HCV and LCV values increases from 8207.593 kJ/kg to 14642.081 kJ/kg and 6277.248 to 13091.799 kJ/kg respectively.

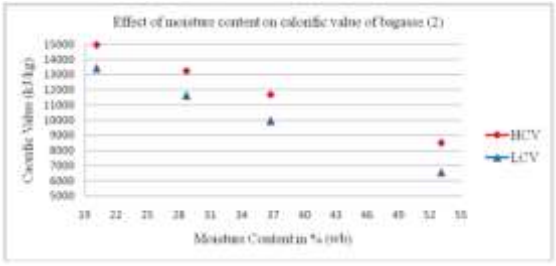

Fig.2. Effect of moisture content on calorific value of bagasse.

[Source: results are based on experimental data]

Fig.2. Shows that under direct sun drying of bagasse when the moisture content decreases from 53.049 % to 20.103 % then the both HCV and LCV values increases from 8491.507 kJ/kg to 14950.378 kJ/kg and 6577.932 to 13418.306 kJ/kg respectively.

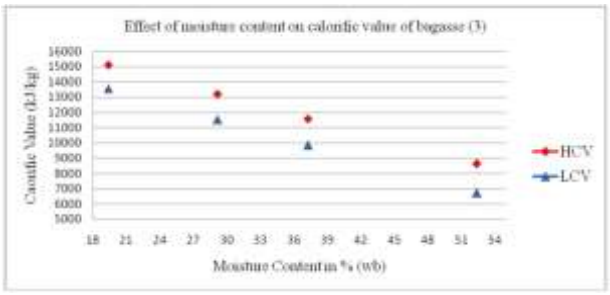

Fig.3. Effect of moisture content on calorific value of bagasse.

[Source: results are based on experimental data]

Fig.3. Shows that under direct sun drying of bagasse when the moisture content decreases from 52.368 % to 19.355 % then the both HCV and LCV values increases from 8625.992 kJ/kg to 15097.204 kJ/kg and 6720.361 to 13573.805 kJ/kg respectively.

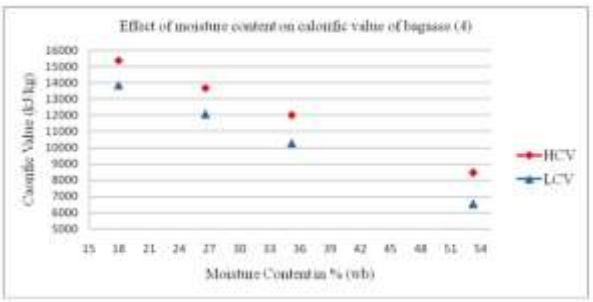

Fig.4. Effect of moisture content on calorific value of bagasse.

[Source: results are based on experimental data]

Fig.4. Shows that under direct sun drying of bagasse when the moisture content decreases from 53.201% to 17.914% then the both HCV and LCV values increases from 8461.62 kJ/kg to 15379.594 kJ/kg and 6546.28 to 13872.87 kJ/kg respectively.

VI. LIMITATIONS

The present research work was performed under climatic conditions of Hisar (Haryana) in the months of February and March 2016.

VII. CONCLUSIONS

From the analysis of present research work it is concluded that:

1. The average value of moisture contents was observed to decrease from 53.28 % to 19.76%.
2. The average values of HCV and LCV are found to increase from 8446.68kJ/kg to 15017.31 kJ/kg and 6530.45kJ/kg to 13489.195kJ/kg respectively.

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