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DETERMINATION OF MOISTURE CONTENT OF BAGASSE OF JAGGERY UNIT USING MICROWAVE OVEN

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Abstract

In jaggery making furnaces, sugarcane bagasse is used as fuel. Moisture content of bagasse affects its calorific value. So burning of bagasse at suitable level of moisture is essential from the viewpoint of furnace performance. Moisture content can also be used for indirect calculation of fibre content in sugarcane. Normally gravimetric method is used for moisture content determination, which is time consuming. Therefore, an attempt has been made to use microwave oven for drying of bagasse. It took about 20 to 25 minutes for the determination as compared to 8-10 hours in conventional hot air drying method and the results were comparable to the values obtained from hot air drying method.

Keywords: Sugarcane bagasse, Calorific value, Moisture content.

1. Introduction

Bagasse is the material obtained after extraction of juice from sugarcane stalk. It is used as fuel in co-generation plant of sugar mills but is burnt directly in jaggery/*khandsari* making furnaces. Efficient burning of bagasse depends on its moisture content. Fresh bagasse normally contains 50% moisture and reduction of moisture improves upon its calorific value [1]. It is efficiently dried in sugar industries and in some *khandsari* units in counter-current type driers whereas, in jaggery units, this is normally sun dried. Variation in moisture content of sun-dried bagasse affects performance of jaggery making furnaces. Determination of moisture content to know its suitability for using it as fuel, therefore, becomes important. Calorific value of bagasse dried to half of its initial moisture content is about 10% higher [2]. So a well-dried bagasse will generate more heat per unit weight.

Sugarcane contains juice and fibre and the net calorific value of bagasse is the result of calorific values of its constituents which is as under [1]:

Fibre – 19259 kJ/kg, Sugar – 16559 or 16747 kJ/kg, Water – nil.

Manohar [3] reported that wet mill bagasse has moisture 50%, fibre pith 47%, sugar 2.5% and mineral 0.5%. The composition of bagasse obtained from sugar mill and jaggery plant is given in Table 1.

Table 1. Composition of Bagasse of Sugar Mill and Jaggery/*khandsari* Units.

Composition, %	Mill bagasse	Jaggery/*khandsari* bagasse*
Fibre	43-52 (Avg. 47.7)	40
Moisture	46-52 (Avg. 50.0)	48
Soluble solids	2-6 (Avg. 2.3)	12

**calculated values based on 14% cane fibre and 65% juice extraction with 20 brix*

An estimation of fibre can give the amount of juice present in cane. Fibre also affects juice extraction. There is a method for estimation of fibre in sugarcane. Baboo et al. [4] have given a formula for approximating fibre content of cane wherein moisture content of bagasse is used along with brix of juice and extraction percentage. Furnace performance can also be judged in terms of thermal efficiency for which net calorific value of bagasse is required.

Normally gravimetric method is used for moisture content determination. Bureau of Indian Standards suggested a method for moisture content determination of bagasse [5]. The method is time consuming and normally takes 8 to 10 hours for the estimation.

Many research workers have attempted using microwave technology for moisture determination of agricultural products and this has become popular in recent years. Parrin et al. [6] used this technology for determining moisture content in snap beans and have found its potential in reducing the drying time. Verma and Noomhorn [7] used household microwave oven to judge its accuracy for sorghum beans, wheat, soyabean and rough rice. The found that considerable time was saved and the moisture content was determined accurately. Moisture content of tobacco was determined by Casada and Walton [8] and they found that the accuracy was improved by using shredded samples. Similarly Backer and Walz [9] determined moisture content of high moisture sunflower seeds and observed that it took only 4 to 6 per cent time as compared to hot air method. Sharma [10] suggested that the microwave oven can be used for rapid moisture determination using a two stage exposure. Tsand and Furulani [11] found no statistical difference between microwave drying and forced draft drying for moisture content of macadamia nuts. Bouraoui et al. [12] reviewed the use of microwave drying for food moisture content determination. Successful approaches for a variety of food products were summarized and their findings discussed and the results were compared with conventional techniques. Chen and Tsao [13] reported that the drying period and power out put are main parameters necessary for obtaining accurate measurements. Kowsolofski et al. [14] observed that microwave moisture measurements of ground chickpea were more reliable as compared to whole kernel and took substantially less time than conventional oven

method. Jain et al. [15] conducted a feasibility study on moisture content determination of jaggery using microwave oven. They reported that exposure of the prepared samples of jaggery to low power levels (200-300W) of microwave (2.45 GH) for 2-3 minutes, gave the results at par with conventional method of hot air drying. Jain and Singh [16] concluded that microwave oven method offers a quick and reliable means for jaggery moisture content determination. Fuwape [17] dried samples of pepper by heating in a microwave oven for different duration and at different microwave power. The results were compared with standard measurement. Moisture content measurement accuracy in the microwave oven was affected by drying time and microwave power. Sharma et al. [18] used a laboratory scale microwave dryer to dry garlic cloves applying power in the range of 10-40 W. The biot mass transfer number confirmed that moisture diffusion was the limiting factor in drying of garlic.

The present study aims at using microwave oven for quickly drying jaggery bagasse for its moisture content determination. Assessment of moisture content will enable jaggery manufacturer to use appropriately dried bagasse in the furnace for better utilization.

2. Materials and Methods

Since bagasse is a loose material, almost in shredded form; it is expected that it can be dried easily using microwave oven. A household oven has been used for this purpose. The details of microwave oven are given in Table 2.

Table 2. Details of Microwave Oven Used in the Experiment.

Make – Kelvinator Model – Magicook T-23 Applicable IS – 11676 – 1986 Input Voltage– 230 V, 50 Hz	Input current – 6 Amp A.C. Output – 2450 MHz, 700 Watts Capacity – 20 lit.

Initially 100 g of bagasse sample was taken in a petty dish. Well-shredded samples were collected from the bagasse generated after sugarcane crushing via a 3-roller vertical crusher. To have a preliminary idea of drying in microwave oven, the sample was exposed to microwave radiation for 10 minutes. It resulted in burning of bagasse. The idea of taking large quantity was dropped. Then about 10 g sample was taken in petty dish and was dried for seven minutes. It also did not give the expected results. So lastly the exposure time was segmented into different steps. At first step the bagasse was exposed for four minutes and was kept in a desiccator having silica gel for cooling. After taking the weight on an electronic balance, it was again exposed six times for 30 seconds each. Every time the weight was recorded after keeping and cooling it in desiccator. It was observed that the weight of sample becomes almost constant. So a total exposure time was taken as seven minutes.

The experiment was conducted in two stages. In the first stage, three samples from the same lot having similar moisture content were taken. In the second stage bagasse samples were drawn from different lots having different moisture content. This was done to check the applicability of method for varied moisture content. The results were compared with values obtained from samples (about 100 g), which were kept simultaneously in a hot air oven.

3. Results and Discussion

Results of experiment for moisture content obtained from microwave oven and hot air oven for the bagasse samples collected from homogenous lot have been summarized in Table 3. Bagasse samples were collected from three portions (top, middle and bottom) of the pile and were used for moisture content determination from both the methods.

Table 3. Experimental Results for Bagasse Samples* of the Same Homogenous Lot.

Hot Air Oven			
	Sample A	**Sample B**	**Sample C**
1- Tare wt. of dish, g	226.57	78.00	79.72
2- Dish + wet bagasse, g	319.99	180.46	176.84
3- Wt. of wet bagasse [(2)-(1)], g	93.42	102.46	97.12
4- Wt. of dish + dry bagasse, g	293.51	151.96	149.58
5- Moisture removed [(2)-(4)], g	26.48	28.50	21.26
6- Moisture content, % w.b.	28.35	27.82	28.05

Microwave Oven			
	Sample A	**Sample B**	**Sample C**
1-Tare weight of dish, g	40.20	41.09	40.21
2- Dish + wet bagasse, g	50.06	51.13	50.19
3- Wt. of wet bagasse [(2)-(1)]	9.86	10.04	9.98
4- Wt. of dry bagasse (g) after			
i- 4 min exposure	47.64	48.70	47.84
ii- + 30 s exposure	47.44	48.52	47.65
iii- + 30 s exposure	47.35	48.48	47.58
iv- + 30 s exposure	47.30	48.44	47.53
v- + 30 s exposure	47.27	48.40	47.48
vi- + 30 s exposure	47.26	48.38	47.45
vii- + 30 s exposure	47.25	48.38	47.45
5- Moisture removed [(2)-(4-vii)], g	2.81	2.75	2.74
6- Moisture content, % w.b.	28.5	27.39	27.45

**Sample A from top, sample B from middle and sample C from bottom*

The average values for hot air oven and microwave oven dried bagasse are 28.07 and 27.78 per cent respectively. So it can be seen that microwave oven method gave the values very close to the values of hot air oven method.

Figure 1 shows the effect of exposure time on calculated value of moisture content. This has been shown for five samples of bagasse having 5.97, 19.38, 30.35, 44.01 and 52.32 % moisture content initially determined by hot air oven method. With more exposure time, more moisture is removed from bagasse hence the calculated values of moisture content go on increasing. After 4-minute exposure, two exposures of 30 seconds each are able to remove much of the moisture. Rest of the time (remaining 4 exposures) is sufficient enough to dry the bagasse completely. Drying time segmented into different parts helps in bagasse maintaining its physical characteristics. The graph becomes almost parallel to x-axis after seven minutes of drying, which shows that there is no further moisture

removal. So the last value can be considered as the final moisture content, which is almost equal to the respective values obtained by hot air oven method.

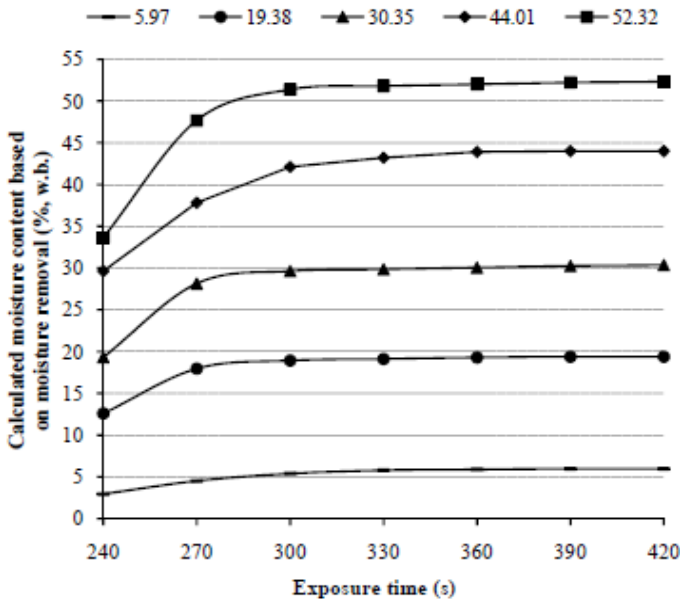

Fig. 1. Effect of Exposure Time on Calculated Moisture Content.
(*Legends show the moisture content value determined by hot air oven method*)

Comparison of final values of moisture content obtained from microwave oven and hot air oven method have been shown in Table 4.

Table 4. Results of Bagasse Samples Having Different Level of Moisture by Hot Air Oven and Microwave Oven Method.

Sample No.	Moisture content (%, w.b.)	
	Hot air oven	Microwave oven
1	5.94	5.97
2	19.38	19.38
3	30.13	30.35
4	43.68	44.01
5	52.07	52.32

It can be seen from the above table that the values of moisture content obtained from microwave oven method is very close to the values obtained from hot air oven method. Time requirement for the estimation is also less as it took only 20 to 25 minutes with microwave oven method. To test the significant difference between average moisture content of bagasse by the two methods, *t*-test was applied. It was

found that calculated t (0.0012) is less than the tabulated t (1.761) at 5% level of significance. Hence it can be concluded that there is no significant difference between the moisture content measured by two different methods.

4. Conclusions

Microwave oven method can effectively be used for determination of moisture content of jaggery bagasse in much lesser time, 20-25 minutes as compared to conventional hot air oven method, which takes about 8 to 10 hours.

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