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PERFORMANCE EVALUATION OF PALMYRAH PALM JAGGERY DISINTEGRATING UNIT

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ABSTRACT
This paper introduces the basic structure, methodology, and working principles of a palmyrah palm jaggery disintegrating unit and the performance evaluation in terms of recovery efficiency and final size of the jaggery by using design expert software which shows that the accuracy of the testing result met the designed requirements.

KEYWORDS: jiggery, disintegrating unit, software.

INTRODUCTION

In recent times, different forms of jaggery are available in the market *viz*., solid, liquid and powder or granular forms. Price of palm jaggery is determined by its quality, colour, flavour and texture. The demand of palm jaggery granules is growing rapidly due to ease in use, handling, packaging and storage. Raw jaggery which is large and solid at room temperature gains the moisture after three to four months and reduces the market value of the jaggery. The jaggery granules have same characteristics of taste, sweetness and molecular structure as that of raw jaggery. The overall life and quality of powdered jaggery is much better when compared to the available raw jaggery. Jaggery available in the market is raw and lump sized blocks weighing half kg to one kg each. Nevertheless, these lumps are not feasible for domestic purposes due to the difficulty in handling and storage. So, nowadays the industries are concentrating in producing the palm jaggery granules rather than raw jaggery. Raw Palm jaggery contains a lot of impurities including coconut coir, small stone, sand *etc*. In order to remove these impurities, jaggery is processed further by dissolving in water, filtering, concentrating, drying and grinding to obtain pure jaggery powder. So as to carry out these processes, the lump blocks of palm jaggery should be disintegrated in to small sizes. Currently manual disintegration is being carried out in small scale industries which are crude, unhygienic, labour intensive and time consuming. In addition to this, hammer mill is being used for the size reduction of raw solid jaggery. This decreases the recovery efficiency of the jaggery while performing size reduction. The use of size reduction mills such as ball mill, stone mill, plate mill are limited due to low recovery efficiency. This drudgery can be alleviated by introducing a disintegrating unit for Palmyrah palm jaggery. Based on the above observations the study was carried out.

Basic structure

A lab model disintegrating unit having different components namely, feeding hopper, disintegrating chamber (consisting of two metallic roller fastened with 84 numbers of pegs, in each roller rectangular scrapers having 3 mm thickness made up of 18 gauge mild steel sheet), discharge outlet for collecting disintegrated jaggery, frame to fix all the above said working components and power transmission system with prime mover. The mechanism of disintegration comprises of impact and shearing force. The developed disintegrating unit exploits the principle of impact and shear action, which is generated as a result of contact between the product and the pegs fixed over the cylinder.

1. Feed hopper
2. Disintegrating section
3. Metallic roller
4. Discharge outlet
5. Power transmission system
6. Motor
7. Frame

METHODOLOGY

Power supply was switched on to start the electric motor to run the disintegrating unit. As the disintegrating unit attained the required speed, jaggery was fed in to the feed hopper and operated at desired clearance. The broken jaggery was drawn into the discharge section from the disintegrating section by the impact shearing actions of the rotating rollers. The different sizes of disintegrated jaggery were collected at the outlet.

Principle of operation of the machine

The developed palmyrah palm jaggery disintegrator worked based on the forces of impact and shear actions which was able give different sizes of palmyrah palm jaggery (coarse, medium and fine)

Performance Evaluation of disintegrating unit

Experiments were conducted to identify the process variables and their levels for the disintegrating of jaggery, studies were carried out by changing the various combinations of feed rate, clearance and shaft speed with the help of design expert software (version: 6.0.8). The RSM used in this study was a central composite face-centred design involving three different factors. The results were analysed using Analysis of Variance (ANOVA) (Peng *et al.*, 2012).

Based on the results of preliminary tests, the clearance of pegs on the roller was identified and kept constant. The design layout of the experiments and their levels used in the present study are as follows**.**

Experimental variables of disintegrating unit

Independent variables	Levels
Feed rate, kg/h	100, 250 and 500
Shaft speed, rpm	25, 35 and 45
Clearance, mm	10, 15 and 20

The procedure for determining the recovery efficiency (%) of the newly developed disintegrating unit was calculated by using the following formula. Adekomaya *et al.* (2014)

Recovery efficiency =(weight of the disintegrated product/ weight of the feed) x 100

The size of the disintegrated jaggery was determined by sieve analysis. The disintegrated jaggery from the outlet was taken for a sieve analysis to separate the different size of disintegrated jaggery. The weight of the disintegrated jaggery retained in each sieves was noted. One kg of disintegrated jaggery was taken from the each trails and analysed. Different sizes of jaggery (coarse, medium and fine) were obtained after the disintegration. Average maximum size of the jaggery was determined based on the sieve analysis. During test, the feed rate of jaggery was kept constant.

RESULT AND CONCULSION

Table 1.1 presents the combination of experimental results on speed, feed rate and clearance the corresponding values of three parameters and the response based on experimental runs and predicted values proposed by the CCD design. To validate the adequacy of the model, five sets of experiments were repeated randomly at optimum conditions to obtain a maximum recovery efficiency and minimum size of the jaggery. Based on the above operating parameters recorded, for the best performance of the disintegrating unit recommended Speed of 35 rpm with Clearance 15 mm and Feed rate is 250 kg/hr respectively.

TABLE 1: Experiment results of disintegrated jaggery in the disintegrating unit

Sl No	Combination	Speed (rpm)	Feed rate (kg/hr)	Clearance (mm)	Recovery efficiency (%)	Fineness Modulus
1	S2F2C2	35	250	15	95.2	3.7
2	S1F2C2	25	250	15	85	3.5
3	S2F2C3	35	250	20	94	4.1
4	S1F3C3	25	500	20	80	3.8
5	S2F2C2	35	250	15	94	3.65
6	S2F2C2	35	250	15	95.6	3.72
7	S3F3C3	45	500	20	96	6.3
8	S1F2C1	25	100	10	87	3.53
9	S2F2C1	35	250	10	93	3.52
10	S1F2C1	45	100	10	97.5	5.5
11	S2F2C1	45	100	20	97.2	5.9
12	S1F2C1	45	500	10	95	5
13	S2F2C1	35	250	15	94.1	3.56
14	S1F2C1	25	100	20	86	3.6
15	S2F2C1	35	500	15	90	4.3
16	S3F2C2	45	250	15	95	5.2
17	S1F3C1	25	500	10	80.1	7
18	S2F1C2	35	100	15	96.8	3.45
19	S2F2C2	35	250	15	93	3.75
20	S2F2C2	35	250	15	96.6	3.68

S1, S2 and S3 - Speeds of the roller (rpm) ; C1,C2 and C3 – Clearance (mm);F1,F2 and F3 - Feed rate(kg/hr)

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