

Performance Evaluation of A Coconut Grating Machine

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ABSTRACT

This study evaluates the performance of a locally fabricated coconut grating machine developed to address the inefficiencies, safety risks, and high labour demand associated with manual coconut grating. The machine operates on the principles of rotation and shearing. It comprises an electric motor, a stainless-steel grating shaft, a collector, and a reinforced support frame. A performance assessment was conducted using replicated trials to determine workability, throughput capacity, grating efficiency, and material loss. The evaluation involved measuring the initial and final weights of coconuts over twenty grating cycles. Results showed that the machine achieved a mean efficiency of 98%, attributed to its optimized shearing mechanism and minimal product loss (0.002 kg over an average grating duration of 59 s). Throughput capacity ranged from 0.16 to 0.77 kg/s, significantly surpassing manual grating operations. Graphical illustrations demonstrated that throughput increased with increasing material weight, while efficiency slightly declined at reduced loading; this could indicate that the machine performed optimally under moderate-to-high feed weights. Comparisons with manual grating revealed similar weight-loss trends but superior speed and safety advantages for the machine. Overall, the developed coconut grating machine offers a safe, efficient, and scalable solution for households and small-scale processors. For future improvements, focus could be on reducing clogging and enhancing adaptability to different coconut varieties.

Keywords: *Coconut, Grating machine, Performance, Efficiency, Throughput*

1.0 INTRODUCTION

The coconut tree (*Cocos nucifera*) is a member of the palm tree family (*Aceraceae*) and the only living species of the genus *Cocos*. The term “coconut” (or the archaic “cocoanut”) can refer to the whole coconut palm, the seed, or the fruit, which botanically is a drupe, not a nut. They are ubiquitous in coastal tropical regions and are a cultural icon of the tropics. Grating coconuts has turned out to be a daunting task for consumers leaving them to depend on packed products that are easily available in the market. In small scale coconut processing, the use of manual tools is very tedious and effort is required [1]. The invention of innovative coconut grater can do the job in just few minutes with improved safety and convenience. The grating machine is one of the machine products resulting from technology that functions as a tool for crushing fruit flesh into small granules [2]. A design of a coconut breaker extractor grater machine was described by [3] comprising mainly of a motor, breaking tool, A review of a multipurpose grating machine was conducted by [4], this machine consists mainly of a cylindrical drum, blade, v-belts, motor, and steel frame. [5] proposed a multi-blade coconut scraping machine with a single drive. A more flexible device for scraping and extracting coconut flesh from a half coconut with minimal human intervention and greater convenience was proposed by [2]. This device incorporates variable-width, variable-movement-control, and variable-opening-entry. [6] stated that the grater machine circulating in the community is a large grater machine with a gasoline motor as the driving force. To meet the need for grating at the household and small business level, tools and grating machines are needed that are light, easy to carry (handy) and suitable for processing food. A compact design for coconut scrapers was proposed by [7] consisting mainly of a clamp (locking mechanism), movers (for lateral and forward feed), a coconut holder, a motor (to rotate the coconut), a plate holder, and blades (for scraping of the coconut halves. After this, grating will be executed. [8] described the proposed machine a coconut breaker

extractor grater which can break a de-husked coconut into two pieces, collect coconut water and grate the coconut pieces into desiccated coconut.

2.0 MATERIALS and METHOD

2.1 Materials used for Fabrication

- 1) Welding machine
- 2) Hammer
- 3) Electrode
- 4) Drilling machine
- 5) Measuring tape
- 6) Iron
- 7) Angle iron
- 8) Bolt and nut
- 9) Grinding and cutting machine
- 10) Paint

2.1.1 Description of Machine Parts

The machine was designed to work on the principle of rotation and shearing; grating occurs when the coconut is placed on the grating blade. It was made up of the following;

i. Electric motor: The drive motor drives the pulley which is connected directly to its shaft; the belt is connected to another pulley which is connected directly to the grate cylinder.



Figure 2.1: Electric motor

ii. Grating shaft: The shaft is a rotating circular cross-section having such transmission elements like pulleys, bearings and the shredding blades. The shredding blades were welded to the shaft and supported on bearings. The bearings and the pulleys were attached by the use of bolts and nuts. Shaft design consists primarily of the determination of the correct shaft diameter to ensure satisfactory strength and rigidity when the shaft is transmitting power under various operating and loading conditions. It is the main component of the grater. The grating shaft was made of stainless steel wrapped around a shaft mounted on two (2) bearings placed on the engine frame and it rotates clock wisely.



Figure 2.2: grating shaft and a bearing

iii. Collector: this was made of stainless-steel plate which was designed to fit into the width of the grating shaft and inclined at an angle of repose of 50°.



Figure 2.2: Collector

iv. Engine Framework: This serves as a skeleton for the grating shaft, the electric motor, and other supporting components. As a basic component and the main seat of the machine, the frame must be strong enough to withstand heavy loads and vibrations from the machine when it is operated.

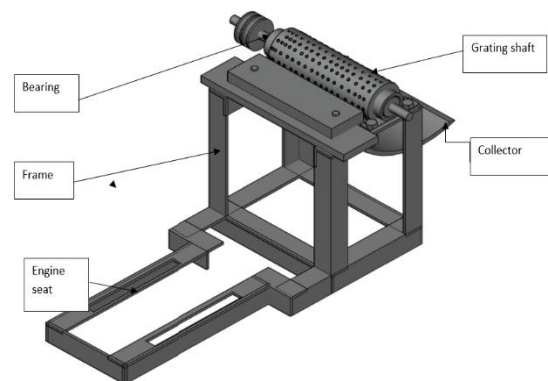


Figure 2.2 Isometric view of the machine

2.2 Methodology

2.2.1 Principle of operation

The grating machine was designed with the ability to grate varieties and different coconut sizes. The machine is driven by an electric source; as soon as it was powered, the coconut was fed through the grating shaft. The materials were grated by the grating mechanism made of shaft with rough surface. The grated coconut was collected through the collector.

2.2.2 Performance test

A performance test was carried out on the farm of Agricultural Technology Department, Federal College of Forestry Ibadan. The machine was tested at idle to ensure it worked perfectly before being subjected to loading and grating operations. The initial and final weight of the coconut varieties were measured. The grating procedure was replicated twenty (20) times. Data collected from the tests was used for evaluations and conclusions were drawn.

2.2.3 Parameters used in evaluating the grating machine

The following parameters were assessed in the evaluation of the grating machine:

i. Workability ... this was the test assessment of the machine to grate coconuts of different sizes successfully. A machine passes the “workability test” if it functions properly before loading and when loaded.

ii. Machine efficiency (%)

The grating efficiency was calculated using the equation below;

$$Eff = W1/W0 \times 100 \quad (1)$$

Where,

Eff = efficiency (%);

W0 = Initial weight of the product (kg); W1 = Weight of after

gratings (kg).

iii. Effective capacity (kg/s)

This test the material used is coconut (kg) divided by the time required for grating (seconds), which is expressed through the equation as follows:

$$EP = m/t \quad (2)$$

Where,

EP = Effective capacity (kg/t), m = Weight of coconut (kg),
t = Grating time (seconds).

iv. Relationship between throughput and efficiency of the machine

v. Effect of weight on the throughput capacity of the machine

vi. Effect of weight on the efficiency of the machine

vii. Influence of grating duration (time) on the efficiency of the machine

viii. Comparison of weight loss between manual and machine grating methods

ix. Comparison of machine efficiency to manual efficiency

3.0 RESULTS AND DISCUSSION

3.1 Result

Table 4.1 Data obtained from machine performance test

Replicates	Initial weight (kg)	Final weight (kg)	Weight loss (kg)	Time (s)	Throughput (kg/s)	Efficiency (%)
1	1.00	0.98	0.02	51	0.39	98
2	0.98	0.95	0.03	50	0.60	97
3	1.00	0.98	0.02	52	0.39	98
4	1.35	1.32	0.03	68	0.44	98
5	.05	1.01	0.04	52	0.77	96
6	1.33	1.30	0.03	67	0.45	98
7	1.25	1.23	0.02	64	0.31	98
8	1.20	1.18	0.02	63	0.32	98
9	1.20	1.18	0.02	63	0.32	98
10	1.10	1.08	0.02	60	0.33	98
11	1.00	0.99	0.01	51	0.20	99
12	1.00	0.98	0.02	50	0.40	98
13	1.35	1.32	0.03	66	0.45	98
14	1.40	1.38	0.02	69	0.29	99
15	1.20	1.18	0.02	63	0.32	98
16	1.30	1.28	0.02	64	0.32	98
17	1.20	1.18	0.02	63	0.32	98
18	1.20	1.18	0.02	62	0.32	98
19	1.15	1.13	0.02	59	0.34	98
20	1.20	1.19	0.01	62	0.16	99
Mean	1.17	1.15	0.02	59.95	0.37	98

3.2 Discussions

Workability ... The machine worked satisfactorily at idle operation without component failure. Subsequently, it also worked comfortably well when loaded; i.e. it was able to grate matured coconuts completely at permissible noise level.

Effective capacity (kg/s)

Figure 3.1 is a graphical illustration of the effective capacity of the fabricated machine; it shows that the throughput for the considered conditions of operations in this project, varied between 0.16 and 0.77 kg/s. This could be due to varying conditions of operations, human error or inconsistency of the machine.

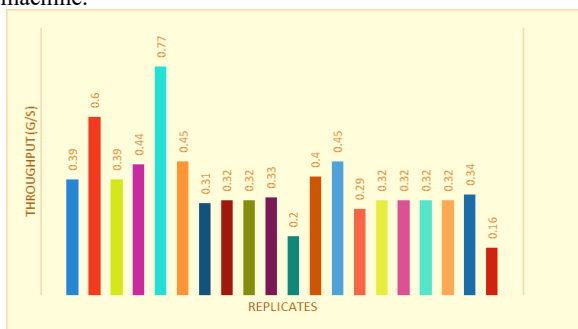


Figure 3.1: Effective capacity (kg/s) of the machine

Efficiency (%)

Figure 3.2 is an illustration of the efficiency of the fabricated machine; in all the replicates, it was observed that the efficiency was very high. It had efficiency values as high as 98% and lowest efficiency value of 96%. The variations in the efficiencies were random and did not follow any order. One of the reasons for very high efficiency results could be because very minimal grated materials were lost during grating operations and the output at the collection tray was approximately close to the input.

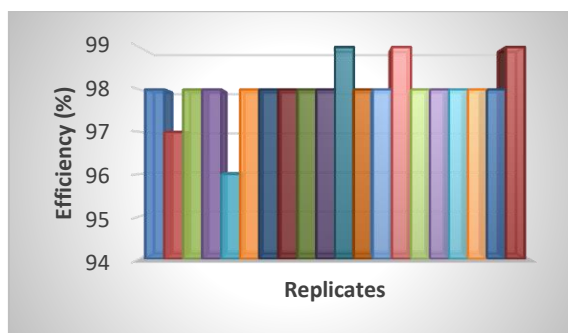


Figure 3.2: Machine efficiency (%)

Throughput against efficiency

Figure 3.3 shows a graphical representation of the relationship between the effective throughput capacities of the machine its efficiency. It was observed that at increased, efficiency values, there were decrease in throughput values. This could imply that the machine worked at a much secured speed, thereby minimizing wear and tear, also leading to fewer breakdowns. It could also suggest that materials were optimally allocated to reduce waste. It is also believed that slower throughput or

production rate at the expense of efficiency often allows for thorough quality checks.

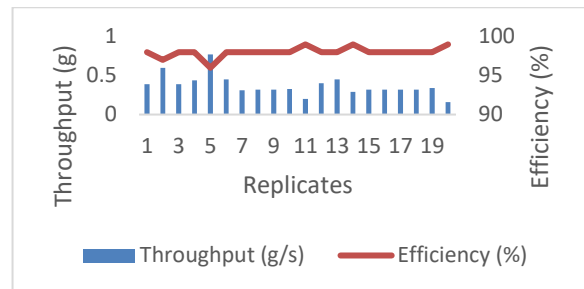


Figure 3.3 Relationship between the throughput and efficiency of the machine

Weight against throughput capacity of the machine

Figure 3.4 is an illustration that describes the effect of the weight of materials to be grated on the throughput capacity of the grating machine. It was observed that the graphical curve follows the same pattern and trajectory for both parameters. There was a corresponding increase on the throughput capacity of the machine for every increase in the weight of material, and vice versa. This could suggest that the machine was calibrated to optimal level, therefore it could handle higher weights to give high outputs. It could also imply that the machine had the ability to operate efficiently at higher loads, balancing out speed and capacity.

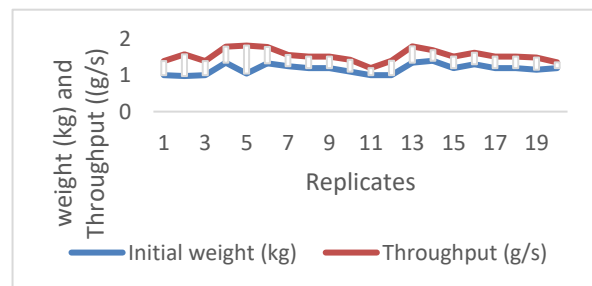


Figure 3.4: Effect of weight on the throughput capacity of the machine

Effect of weight on the efficiency

Figure 3.5 gives a graph that reflects the effect of weight of the materials to the efficiency of the machine; it shows a similar pattern in their trajectory, suggesting that both parameters were proportional to each other. This could also imply that the machine performs more efficiently when it is optimally loaded ensuring full utilization. Similarly, there was a drop in efficiency each time the weight reduces. It therefore means that optimal loading of the machine ensures energy utilization, reduced downtime, improved stability and proper material handling.

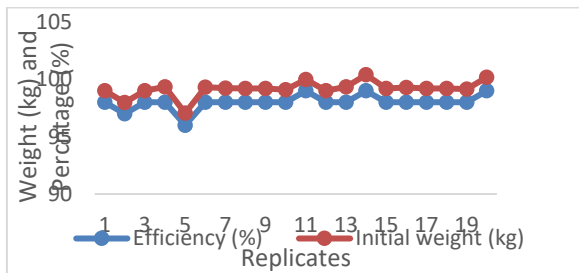


Figure 3.5: Effect of weight on the efficiency of the machine

Influence of time on efficiency

Figure 3.6 shows the influence of time on the machine efficiency during grating operations; it was observed that despite the variations in time of grating, the efficiencies across all the replicates were approximately constant. This suggests that time may not have affected the efficiency of the machine for this project. This could be that the machine got to steady-state operation where efficiency remains constant even at varying time. It could also infer that the machine has the ability to maintain high and steady efficiency beyond the recorded times in this project.

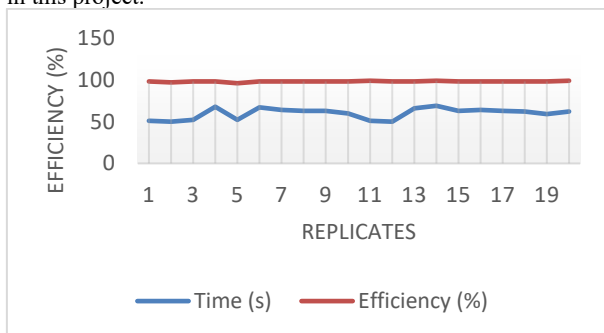


Figure 3.6: Influence of grating duration (time) on the efficiency of the machine

Comparison of manual against machine grating methods

Figure 3.7 presents a graph that compares weight loss in manual methods to machine usage; it was observed that in all the replicates, there were similar weight losses for both. This suggests that the machine performed very well and was very competitive with manual method when it had to do with complete grating and keeping back residuals. However, the manual method had a non-significant performance advantage in terms of weight-loss. This could be because machine might not be able to adjust to complex details as humans, machines are automated and could easily lose, waste or destroy materials during operations.

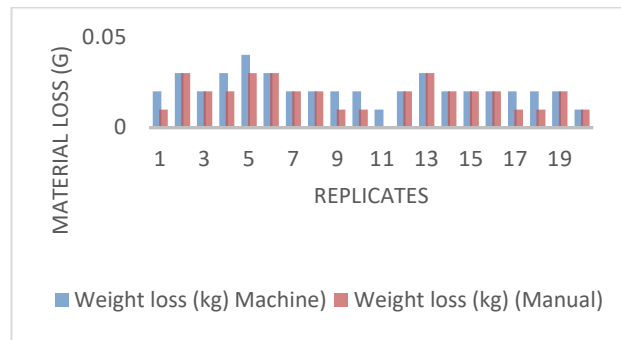


Figure 4.7: Comparison of weight loss between manual and machine grating methods

Comparison of efficiencies

Figure 4.8 presents a graphical representation of the comparison of the efficiency of the constructed grating machine to manual grating method. It shows that both performed closely in terms of efficiency for some replicates. Overall, manual method had better performance efficient wise than the machine. This could be because the manual method allows flexibility to adapt to complex and variable tasks; manual method could also identify and rectify spontaneous error thereby enhancing efficiency. It is also believed that manual methods are most suitable for small batch production as efficiency is usually optimized.

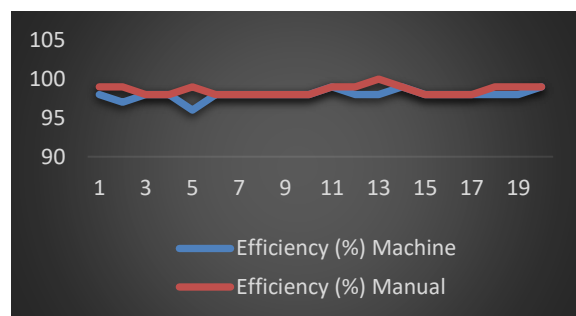


Figure 3.8: Comparison of machine efficiency to manual efficiency

4.0 CONCLUSION

The performance evaluation confirmed that the fabricated coconut grating machine exhibited a high operational efficiency, structural reliability, and functional stability under varying load conditions. It achieved an average mechanical grating efficiency of 98%, which demonstrate an excellent material-handling capability with negligible product losses. It had a throughput values of 0.16–0.77 kg/s which indicated that it had superior processing capacity relative to manual methods. The machine maintained consistent performance due to its optimized shaft geometry, effective blade–material interaction, and rigid support frame that minimized vibration during operation. Performance trends further showed that the machine operates most efficiently under optimal loading, ensuring full utilization of torque and steady-state rotational speed. Although manual grating recorded slightly lower material losses in some replicates, the automated system offers greater productivity, operator safety, and process uniformity.

This research suggests that the machine represents a robust, ergonomically safer, and energy-efficient solution for decentralized coconut processing. Future design enhancements should incorporate anti-clogging features, improved blade geometry, and adaptive feeding mechanisms to accommodate coconut varieties of different moisture content and hardness. These improvements will further enhance reliability, reduce downtime, and expand applicability for small-to-medium-scale agro-processing enterprises.

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