Design and Fabrication of Automatic Fruit Slicing Machine-Testing and Performance

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Abstract— An automatic fruit slicing machine was designed, fabricated and evaluated for performance. The major component of machine includes hopper, mainframe, slicing unit, shaft, pulley, bearing, electric motor and outlet. The machine is powered by a three phase, 1440 rpm and 1KW electric motor. The performance of the machine was evaluated in slicing two selected fruits (banana and apple), grouped into three sizes (small, medium and large) at five speeds of 39 rpm, 41 rpm, 43rpm, 46 rpm and 48 rpm respectively. The parameters that were investigated were slicing efficiency and throughput capacity. The medium and large size samples gave a good result for apple with at a speed 41 rpm with capacities and efficiencies of 72 kg/h, 88 kg/h, 97% and 94% respectively. The small and medium size grade of banana we achieved at speed of 41 rpm gave a capacities and efficiencies of 44 kg/h, 71 kg/h, 91% and 96% respectively. The machine is therefore observed to perform best at the optimum speed of 41rpm for all the fruits. The result of the study shows that the machine can slice different fruits and vegetables satisfactorily with slices ranging from 9-10 mm thickness were obtained.

Key words: Design, Performance Evaluation, Fruits and Vegetables, Slicing Machine, Throughput Capacity, Slicing Efficiency

I. INTRODUCTION

In the late 90', automation was the rage of the engineering world. The best of the minds, railed day and night to bring forth improvements of significant magnitude, something which could make an impact in the day-to-day life. Today, it's a plethora of fields which have embraced with automation, from manufacturing to food processing, biomedical and pharmaceutical industries. In such a scenario, domestic applications have also been developed with the common man in mind. Of late, processes which were manual before are slowly being converted to semi-automated and automated nature. Manual cutting of vegetables is still prevalent, in hostels of educational institutions, marriage catering services and even in restaurants, which can cater to a whole set of varying customer tastes and preferences. The amount of vegetables to be cut for the dishes always remains higher than actually what's consumed. The associated difficulties like time constraint, contamination, etc. make it pretty difficult for any person handling the job. Therein, arose a need to automate the process of vegetable cutting, and here we are with a proposal which can aid in easing the load of the people associated with it.

The slicing technology has already been developed in abroad in 1970s, in the mid-eighties most of the slicer can process large diameter up to 125mm (5 inches), like the horizontal inside diameter slicing machine manufactured by Mayer Bbu Geyer company in Switzerland.

As the structure of the slicer, it can be divided into horizontal type and vertical type which depends on its principle shaft supported by the air bearing or rolling bearing. There are inside diameter slicer, outside diameter slicer, single-blade slicer and multi-blade slicer and the former one is more popular.

The main purpose of the research is to design a small scale industrial slicer to slice the fruits and root vegetables. Its body, material inlet, blade, material outlet, baffle plate, manual adjuster together and the materials are processed by the material inlet and material outlet. It's characterized by small volume, high processing efficiency, good uniformity, stability and safety.

The project was therefore conducted to achieve the following objectives:

1) To design and fabricate a prototype of automatic fruit slicing machine.
2) To evaluate the performance of the machine in slicing apple and bananas by determining its slicing efficiency and throughput capacity at different speeds of operation.

The design and fabrication of a multi-crop slicing machine is expected to lead to the following;

a) Reduction of human hard and boring work associated with the manual method of slicing fruit and vegetables.
b) To reduce the work load and production time.
c) Reduction of slicing losses and infection of fruits and vegetables when compared with the existing slicing machines.
d) Increase in the income of the rural families, hoteliers and those nations engaged in the production or processing of fruits and vegetables.

II. REVIEW ON EXISTING SLICER MACHINE

Several slicing and chipping machines have been designed and tested in various developing countries especially the Caribbean and South East Asian countries as reported by Clarke (1987). Various types of machines are manufactured from small hand-operated batch-types to large automatic continuous operation models. Some are petrol, diesel or electric motor operated. There are cassava chippers, tomato slicer, okra slicers and other root and vegetable choppers. Ukatu and Aboaba (1996) designed, constructed and evaluated a machine for slicing yam and it was reported that the machine's thickness of cut can be varied from 2 mm to 20 mm and the slicing efficiency ranged from 82 to 93% and the rate of work is 45 cuts per minute.

There are also several manually operated kitchen–size chipping and slicing machines in the market. Some of these chipping and slicing machines are either imported or fabricated locally. The imported ones are sophisticated and may not be easily operated and maintained by local users, therefore adaptability of the techniques locally is difficult.

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Furthermore, some of these slicing machines are designed for only a particular type of vegetable and fruit and cannot be used for others because of their peculiar rheological properties.

Problem identification on existing methods of slicing technology:

In the Market and E-survey we have identified different type of problems which are

1) Thickness Variability
2) Moisture Contents
3) Non Robust
4) Accidental Chances
5) Un Portable Due To Large Volume
6) Un- Automated
7) Time Consumption
8) Power Fluctuation

III. OBJECTIVE

The primary objective, upon which the present work is based are providing an alternative to the existing investment factor and to power a domestic product using electrical and mechanical arrangement, thereby eliminating the associated difficulties of manual operating fruit and vegetable cutting.

IV. LITERATURE REVIEW

1) Effect been made to design and fabricate this semi-automated potato chips machine (1).
2) The work provides an alternative to the existing automatic vegetable cutter, in term of automatic vegetable entry into the cutting apparatus eliminates the power fluctuation and lesser initial investment .time consumption is less as compared to manual cutting (2).
3) The idea of pneumatic paper cutting machine has clearly been explained by Ajit Kumar Singh in their research work and design and fabrication of pneumatic the force and dimensions of pneumatic paper cutting machine has been decided by using their process(3).
4) The work provides the automated of the pineapple pilling and slicing process. The time required for pilling and slicing is less compared to Manual operation (4).

V. MATERIAL & METHOD

A. Machine Description:

The assembly and orthogonal drawings of the automatic fruit slicing machine is shown in Figure 1. The machine consists of the following components, namely; hopper, upper housing, feed channel, conveying disc, slicer shaft, outlet, slicing unit, frame, idler shaft and idler frame.

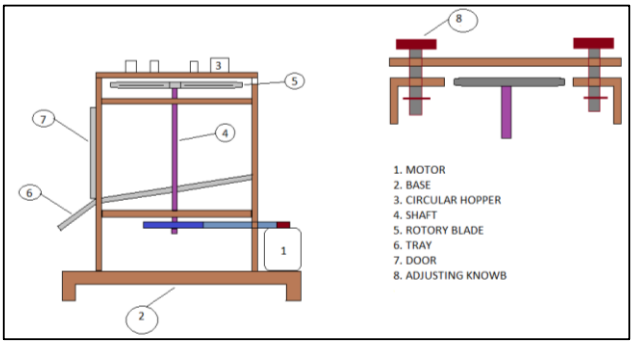

Fig. 1: Assembly of fruit slicing machine

1) The main frame is the unit of the machine on which all other components of the machine are supported. It was fabricated from high strength material so as to withstand vibration.
2) The hopper serves as a container for holding the crop to be sliced. It was bolted to the top of the main upper housing. It was fabricated for made of 1.5 mm thick stainless steel sheet which was adequate to sustain the weight of the crops.
3) The slicing cutter is use to slice the fruits, mounted on the vertical shaft supported with the help of ball bearings.

B. Design consideration:

A number of factors were considered in the design of the slicing machine these include the physical and mechanical properties of the materials for construction. Due to the nature of the selected fruits and vegetables, a device for slicing is expected to be thin and sharp. It must be able to penetrate the fruits and the materials for construction must neither contaminate the fruit nor be corroded when in contact with water. Stainless steel materials were therefore used for fabricating components which are directly in contact with the fruits being sliced.

Other considerations in designing the machine include, cutting resistance of the fruits, moisture content, thickness of slices, speed of cut, maximum power requirement, power source and contamination.

VI. DESIGN & CALCULATION

A. Shaft Design:

d = 25mm   l = 458mm

Power = 20 KW   N = 1440rpm

Torque =?

Torque transmitted by the shaft,

$$T = \frac{P_R*60}{2\pi N} = \frac{(20*10^3)*60}{2\pi*1440} = 132.63 \text{ N-mm}$$

B. Pulley Design

Design power (P_d) = $P_R * K_l$

K_l = Load factor = 1.4 (From table XV-2)

= $(20*10^3)*1.4 = (28*10^3)$ Watt

Belt speed = $\frac{\pi D_1 N_1}{60*1000} = \frac{\pi*254*1440}{60*1000}$ = 3.92m/sec = 235 m/min

Belt tension (F_1-F_2) = P_d/V_p = $28*10^3/3.92$ = 7142.8N

Centre distance (C) = D_1+D_2 = 52+254 = 306mm

Length of belt (L) =

$$L = \frac{\pi}{2}(D_1+D_2) + 2C + \frac{(D_2-D_1)^2}{4C} = \frac{\pi}{2}(52+254) + (2*306) + \frac{(254-52)^2}{4*306}$$

= 728mm

VII. DESIGN & WORKING PRINCIPLE

This machine included the power transmission system of belt and pulley arrangement which is connected to the electric motor. The position of hopper top is place on the rotary cutter housing through which the fruits and vegetables are pouring. At the base of rotary cutter rotates the potato and vegetables strike against the inner blades which removes the slice depending on the type and condition of the products. As the

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slices cuts it falls on the tray below the rotary cutter. We design and fabricated a wide range of slicing machine which requires low maintenance and give high performance. This machine has some following advantages.

1) Compact design thus occupies very little space.
2) Body is from stainless steel with cast iron ring stands for better vibration.
3) Easy to operate, high rinsing and slicing ratio, no damage to worker.
4) Low maintenance and original ingredient cannot destroy.

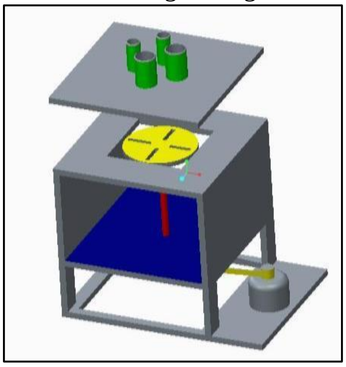

Fig. 2: Fruit Slicer machine

VIII. Experimental Tests

Many factors which could affect the performance of the machine include cutting resistance of the fruits, orientation of the hopper, moisture content, machine speed, size of fruit and variety of fruits.

Kachru, (1996) developed a plantain-slicing machine and evaluated its performance with respect to parameters such as cutting velocity, orientation of hopper, shear angle, number of blades of machine. In the present work, three factors, which were considered critical to the performance of the fruit slicing g machine were investigated including size of the fruit, speed of blade and type of fruit. Tests were conducted at constant rotational speed of the blade in slicing banana and apple grouped into small, medium and large sizes respectively. The experiment was arranged in Randomized Block design and each treatment was replicated two times.

IX. Experimental Procedure:

Preliminary tests were conducted to determine the optimum speed of machine. A tachometer was employed to ensure correctness of operating speed. It was discovered that the machine cannot be operated beyond 50 rpm because it pushed samples instead of slicing, which implies that rotational speed less than 50 rpm is adequate for the operation of machine.

The output materials obtained from the machine outlet was collected and separated into two groups, that is, sliced material and un-sliced material. The mass of each category was determined by an electronic balance. The time taken for each test run was recorded with stopwatch.

X. Performance Parameter

Test parameters that were measured in evaluating the performance of the machine are throughput capacity and slicing efficiency. Throughput capacity was defined as the ratio of the quantity of sliced materials collected from the machine outlet to the time taken.

$$S_c = \frac{W_s}{T}$$

Where;
S_c = Throughput capacity, kg/h
W_s = Weight of sliced material, kg
T = Time taken, sec

The slicing efficiency was defined as the weight of all slices minus weight of damaged slices to the weight of all slices multiplied by 100%

$$\alpha = \frac{W1 - W2}{W1} * 100$$

Where,
α = Slicing efficiency, %
W1 = Weight of all sliced machine, g
W2 = Weight of damaged sliced material, g

XI. Conclusion

A machine is suitable for the cutting of fruits into regular slices for the purpose of making chips. Test results with the machine in slicing samples of banana and apple indicated satisfactory performance. Furthermore, at the constant rotational speed of the cutter obtained, which gave optimum throughput capacity and slicing efficiency of 135.7 kg/h and 96% respectively. Further modification of the machine is necessary to improve the performance of the machine.

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