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FABRICATION OF AUTOMATED VEGETABLE CUTTING MACHINE

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Abstract: In the era of industrialization, automatic machines become an integral part of human life. These machines help to reduce the time needed to do a specific task. Nowadays, human life becomes more competitive and faster than the previous. Automation brought about by technology has saved human effort and time to a large extent. Slicing vegetables are a risky and time-consuming task in our busy life. This project is aimed at solving above stated problems by introducing a special product named Automatic Vegetable Chopper. This chopper is mainly designed to reduce human effort and make the job of chopping vegetables much easier and faster. Its main features are fully automated, easily portable, less power consumption and changeable stainless, sharp blade, etc. This product is designed and established by following a structured product design process and with the help of a board of design engineers. Product planning, customer needs identifying, product specification, concept screening, concept scoring and bill of materials are tools that mainly used to accomplish this task. Finally, this paper also suggests various techniques and opportunities of product planning in manufacturing industries as future recommendations

1. INTRODUCTION

This device the automatic vegetable cutting machine has been developed to later the needs of small and medium home/hotel application, who are normally man powered. In most of the house/hotel the vegetables are cutting by using human hand. This needs more time and high working load.

Knife and plastic grater were the most common devices used for slicing and grating vegetables such as peppers, tomatoes, carrots, onions and lettuce. In the early 1960s, the world's first automatic vegetables cutting machine was developed. The slicing technology has been developed mature abroad in 1970s where most of the slicers can process mono crystal with large diameter up to 125mm. In 1980s, the slicing technology has experienced its peak of development with the commercials of automatic multi-function slicers. It is not easy for those who want to cut a large amount of vegetables into smaller sizes in a short period. It may also causes injuries as a result of carelessness. As the time goes by, the slicing technology has been developed to overcome these problems. Slicing machine was designed to ease the cutting of vegetables, to eliminate the time wasted and to avoid injuries when using the knife.

Vegetable slicing machine can be manual-powered or automated. The design of manual vegetable slicing machine is low operation cost as it eliminates the usage of electricity, safer, consistent and affordable. However, it can be time consuming and low efficiency. An automated slicing machine basically includes a base housing a motor, feeder part, feeder mouth which houses a presser and cutting knife which carried by the cutting plate. It allows the user to cut a large amount of vegetables precisely in a shorter period. However, it is more expensive and difficult when it comes to maintenance operation.

Vegetables which are excellent sources of certain vitamins and minerals and often the main source of dietary fiber consist of a large group of plants consumed as food globally (Gave, 2008). Consumption of vegetables has increased significantly.

The increase in its expenditure can be accounted for by the increased health consciousness of the consumers. Vegetables can be perishable when fresh but able to be preserved using a number of processing method such as blanching, dehydrating, canning, freezing, fermenting and pickling, and irradiating (Gave, 2008). The perishable nature of the fresh produce has confined the international trade in these products in the processed form. The classification of vegetables can be done based on different criteria some of which are; by edible parts into root (e.g., potatoes and carrots), stem (asparagus and celery), leaf(lettuce and spinach), immature flower bud (broccoli and Brussels sprouts), and fruit (tomatoes and cucumbers (Neidhardt, 2008). Differences in the structure, size, shape, and rigidity of the individual cells are dependent on the class of vegetable (Odor and others, 2009). The processing requirements and fresh market life are also different for varying classes.

2. AIM AND OBJECTIVE

The aims of the fabrication of this automated multipurpose vegetable slicing machine is to improves the time constraint problem to cut a large amount of vegetables into smaller size and to design and fabricate a simple automated machine that easy to control with multipurpose function for industrial usage. This project is to design and fabricate a Modified Vegetable Slicing Machine. This aim is achieved through the following objectives

- Reduction of human effort in the process of vegetable slicing.

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- Allowing variation of slicing speed by the user based on the nature of the vegetable to be sliced, as a variable speed motor is utilized.
- Processing of different sizes of vegetable with the aid of the mechanical components of the machine.
- Ensuring that a level of hygiene is maintained and the vegetable is safe for consumption through proper selection of material.
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3. LITERATURE REVIEW

(Owolarafe and others, 2007) developed a manually operated lady's finger (okra) (Abelmoschusesculentus) slicing device suitable for on-farm use. It was designed, fabricated and tested based on the engineering properties of the vegetable. The machine, simulates the traditional method of okra slicing, consists of the feeder, slicer and receiver. It was made simple for ease of operation and maintenance.

(PY Lau–2016) project implementation, technical writing and oral presentation within stipulated time. The title of our final year project is to design and fabricate an automated multipurpose vegetables slicing machine. An automated multipurpose vegetables slicing machine is a device that allows the user to perform multiple functions within a single machine. A survey was conducted to 40 participants in order to study and identify the specifications of the machine through customer preference. According to the data collected from the survey, we had found that functionality of the machine is the most important criterion for an automated multipurpose vegetables slicing machine.

GS Gayani (2019).Manual cutting and slicing of vegetables has proved to be very time consuming and is prone to the risk of contamination of the food leading to high rates of food borne diseases. Various methods have been implemented in the process of size reduction of vegetables ranging from manual.

4. EXISTING SYSTEM

As referred to the context of the project, cutting refers to the removal of something from something larger by using a sharp object such as a knife and blade. The final product is the exact required shape of the vegetable even with the dimensions attained to almost perfection, for example a brunoise cut measures exactly 1/8' x1/8' x1/8'. This clearly implies that a cut is derived from a slice; the thickness of the slice will determine also the thickness of the cut. One of the most relevant factors during the cutting operation is the type of cutting tool used. Imply that the roughness of the blade (or) the cook's knife can have an effect on the storage life of vegetables. Blunt knives tend to harm the tissue layers of the vegetable into less significant and thin pieces of the original vegetable, the process is regularly carried out by the use of knives or blades and the shape of the slice is simple as compared to that of a cut. The main variation between a cut and a slice as referred to the context of this project is that a cut is the required shape of the vegetable while a slice is simply a thin dividend of the original vegetable.

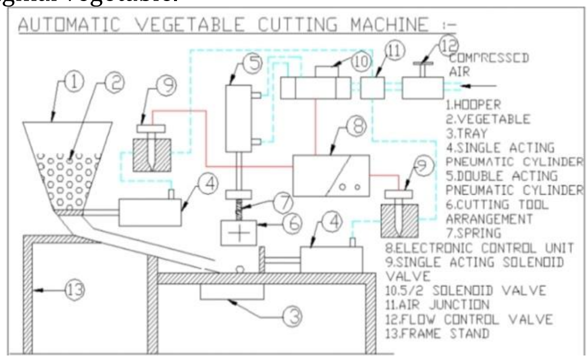

Fig 1: Existing system

5. MATERIAL SELECTION

The selection of a material for a machine part or structural member is one of the most important decisions. The material of the machine is mostly made up of austenitic stainless steel - AISI 304 because hygienic, non-porous surface and the ease of cleaning make it the choice for the application.

- Higher corrosion resistance
- Higher cryogenic toughness
- Higher ductility
- Higher strength and hardness
- Attractive appearance

Machine components	Manufacturing materials
Base and Machine	Grey cast iron
Cutter blade	Austenitic stainless steel
Food Slicing/Processing Chamber	Austenitic stainless steel
Vegetable Feed/Hopper	Austenitic stainless steel
Tray Carriage	Austenitic stainless steel
Tripod stand	Cast iron

6. Component Parts of the Machine

To ease design effort, the system is divided into the following subsystems which include:

a. Frame
b. Rotating Disc Cutter

c. Slide Plate/Tray Carriage
d. Hopper
e. Bearing
f. Motor and Regulator

7. WORKING PRINCIPLE

This work consists of two major parts. One is the mechanical setup involving the base, frame, rotating disc cutter, side plate/tray carriage, and hopper. While another part involves motor and battery. The motor is DC motor and it is connected to the battery. The regulatory system and switch of the motor are connected to the battery. The frame is fixed on the base with the help of bolts and nuts. The rotating disc cutter shaft is connected to the motor shaft with the help of bolt and nut. The blades are arranged at an angle of 90^0 to each other. The blades are fixed at angle of 50^0 at its position.The side plate is used to cover the cutting chamber and it is fixed to the frame with the screws. The hopper is fixed to the side plate at the top of the side.

When the power supply is given, the motor rotates at a speed of 1500 revolutions per minute. The motor is runs the disc cutter through shaft. The vegetables are poured in to the hopper. The hopper is directly connected in to the cutting chamber. The vegetables enter into the cutting chamber through hopper. The rotary cutter cuts the vegetables in the form of slices. The cutting slicing pieces comes out at the bottom of the machine.

The setup of the cutting machine is shown in figure 2 and 3.

Figure 2 Machine setup (top view)

8. CALCULATION

The input parameters are given below

1. Power of the electric motor = 1119 Watts
2. Rotational speed of motor =1500 RPM
3. Density of cutter blade = 7850 kg/m^3
4. Area of cutter blade =0.000233 m^2
5. Length of the shaft = 0.07 m
6. Max allowable shear stress=56x10^6 pa
7. Factor of safety = 4
8. Maximum normal stress = 112× 10^6 pa

Therefore, The torque transferred to the cutting blade due to transmitted power from the electric motor can be estimated using the relationship below;

$$\mathbf{T} = \frac{\mathbf{60 \times P}}{\mathbf{2 \times \pi \times N}}$$

$$= \frac{\mathbf{60 \times 1119}}{\mathbf{2 \times \pi \times 1500}}$$

$$= \mathbf{7.123\ N - M}$$

The shaft is subjected to a load at the end. According to Negan, the density of a material is given as.
The weight of the cutter blade, WC = ρ × V × g
But the volume of the blade is, V = A_c x L_c

$$Wc = \rho\, Ac\, Lc\, g$$

$$= 7850 \times 0.000233 \times 0.13 \times 9.81$$

$$= 2.33\ N$$

Hence, the maximum bending moment of the shaft can be gotten from the expression below;

$$\text{M} = \text{We} \times L$$

$$= 2.33 \times 0.07$$

$$= 0.163\ \text{N}-M$$

For a shaft subjected to twisting moment (or torque) only, then the diameter of the shaft may be obtained by using the torsion equation.

$$\frac{T}{J} = \frac{\tau}{r}$$

$$\frac{7.124}{\frac{\pi}{32}(D^4 - 0.0172^4)} = \frac{56\times10^6}{\frac{D}{2}}$$

D = 0.014 m

From Maximum normal stress theorem, the maximum normal stress in the shaft is,

$$\sigma_{max} = \frac{1}{2}\sigma_b + \frac{1}{2}\sqrt{\sigma_b{}^2 + 4\tau^2}$$

$$= \frac{1}{2} \times 11.2 \times \frac{1}{2}\sqrt{(11.2 \times 10^7)^2 + 4 \times (56 \times 10^6)^2}$$

=118609903.4 N/M

Working Normal Stress $(\sigma) = \frac{\sigma_{max}}{Fos}$

$$= \frac{32}{\pi d^3}\left[\frac{1}{2}\left\{M + \sqrt{M^2 + T^2}\right\}\right]$$

$$= \frac{118609903.4}{4}$$

= 29652475.84 N/M

The equivalent torque (Te) which the shaft is subjected to is given as;

$$T_e = \sqrt{M^2 + T^2}$$

$$= \sqrt{(0.163)^2 + (7.124)^2}$$

= 7.125 N-M

The equivalent bending moment (Me) is also given as;

$$M_e = \frac{1}{2}(M + T)$$

=3.6435 N-M

The force required to produce shearing action can be gotten from the expression;

P = F x V

From the above equation,

$$F = \frac{P}{V}$$
$$= \frac{1119}{10.21}$$
$$= 110 \text{ N}$$

This is the velocity at which the applied shearing force produces a cutting action. it depends on the diameter of the blade and also on the speed of the motor i.e

Cutting velocity $V = \frac{\pi \times D \times N}{60}$

$$= \frac{\pi \times 0.13 \times 1500}{60}$$

$$= 10.210 \text{ m/s}$$

9. RESULT

S.NO	QUANTITY	VALUE
1	Power of electric motor	7.124 Nm
2	Maximum bending moment	0.163 Nm
3	Cutting velocity of Blade	10.210 m/s
4	Cutting force	110 N
5	Weight of cutter blade	2.33 N
6	Shaft diameter	0.014 M
7	Working normal stress	$29 \times 10^6\ pa$
8	Equivalent twisting Torque	7.125 Nm
9	Equivalent bending moment	3.643 Nm

Regulator Position	Weight of Vegetables (g)	Time duration of slicing (sec)	Weight of fully slicing vegetables	Weight of partially slicing vegetables
Very low	25	7.37	22.30	1.70
Low	25	7.15	22.41	2.59
Medium	25	6.93	21.06	3.94
High	25	6.70	21.03	3.97
Very High	25	6.24	21.0	4.0

Table: Effective of slicing speed on time duration and weight

10. CONCLUTION

Over the years, the traditional process of slicing vegetable has always been slow, tedious, boring, time consuming and in some cases unhygienic. The fabricating a machine capable of slicing vegetable which will mechanize the slicing process for both domestic and commercial consumption becomes a necessity. Simple design equations involving Cutting force, Torque, Bending moment and shear forces, etc were related in the course of going through the design process. Almost Every home in Nigeria eats vegetables. Hence, the vegetable slicing machine would serve perfectly in slicing of these vegetables into edible sizes.

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