Design of an Automated Vegetable Cutter and Slicer

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Abstract

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 foodborne diseases. Various methods have been implemented in the process of size reduction of vegetables ranging from manual, electric and automated. The desire to make a design that simplifies, that saves time, that is relatively cheaper and efficienct during the process of size reduction of vegetables was the main scope of the whole project. The contaminant free products will be produced through the use of U.V light and this machine will incorporate U.V light as its integral component. The principle of operation of the machine is attached to the theory of rotating hollow discs. Experiments were conducted at the Department Laboratory and a force of 19.5N was obtained for the hardest vegetable. The machines available in Zimbabwe have posed to be very expensive while they are only availed abroad. The machine must always be used with caution since it has rotating elements. In conclusion, the objectives were met and the most importantly the cost was in the desired range hence acceptable to the market. From the cost analysis, the total price required for the vegetable cutter and slicer is $890.73.

Keywords
Vegetable cutter and slicer, UV-light, Zimbabwe, Low cost

1 Introduction

Vegetables are defined as an herbaceous plant or a part of a plant that is eaten whole or in part (Welbaum, 2015). Over the years, world vegetable production has increased. For example, there was over four times increase in world vegetable production from 1970 until 2009 (FAO, 2011). The increase has largely been as a result of a prolonged technological advancement. On a large scale, vegetables are produced to suit the supermarkets and some food industries for example those which do canning. The major problem arises on reducing the size of the vegetable for it to be easily consumed by the customer. Cutting and slicing have prevailed for over a long period of time and several methods have been used to carry out the special tasks. Traditional methods made use of knives and other machines devised for those purposes. These methods have posed to be tiresome and great time-consuming tasks especially in our busy lives.

Throughout the industrial era revolution, automated machines have gradually become a vital component of human life daily. Compared to their manual counterparts, automated machines have continuously saved most of the people's time to carry out a certain task and this enhancement has greatly led to a more and more competitive and faster way of doing things. In the late 90's, automation was the main focal point of design (Tony, et al., 2014), the engineering field tremendously worked night and day to bring about significant improvements to modern automated products (Talapatra, 2013). Kitchen equipment is being a necessity to commercial kitchen areas these days. Modern kitchen equipment is in a great need in the worldwide market because of their absolute efficiency, durability and they are very reliable (Naveen, 2016).

1.1 Background

The existing vegetable cutters and slicers have been designed based on different criterion. The technology of slicing and cutting of vegetables has dated since long back at around the 1970s (Jiang, 2013) . Traditional methods of cutting and slicing vegetables have been used since long back, people cut and or slice their vegetables using knives. This method is regarded the cheapest one as it does not require sophisticated mechanisms to carry out. Complications arises when evaluating the accidents associated with this method, people tend to accidentally cut themselves whilst trying to make suitable cuts and slices. The structure of the slicer can be split into either horizontal or vertical depending on the shaft and the bearing orientation (Zhou, 2003). Typical cuts such as the brunoise, macedoine etc. require highly skilled personnel to carry and if not, one is most likely to injure himself. Due to these complications this has led to reduction in productivity e.g. within a food industry and more money will be required to train the required labour. The major disadvantage of the method comes due to great time consumption.

1.2 Study objectives

- To design a vegetable cutter and slicer that operates automatically
- To design a machine that eliminates contaminants on the vegetables
- To come up with a machine that is easy to assemble and disassemble

2 Preliminary review

Vegetables include, carrots, rape vegetables, tomatoes, cabbage, potatoes, cauliflower and others, they take part in the contribution of water amount in the body as well as several vitamins and some minerals which assist to maintain body weight and a healthy skin. (FAO, 2013). They can also be referred to as fresh components of plants which, either if raw, cooked, canned or processed in some other way, give adequate human nutrition.

2.1 Cutting

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 (Jiang, et al., 2011). Implying that the sharpness of the blades or the knife can affect the storage life of the vegetables. Blunt knives tend to harm the tissue layers of the vegetable (Allende & Gill, 2012).

2.2 Slicing

Slicing is the cutting of food into thin, relatively broad slices, reducing the size of the vegetable into smaller and thin pieces of the original vegetable, the process is usually 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 difference 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

Table 1. showing some standard cuts and slices.

TYPE	DESCRIPTION
Julienne:	• An average Julienne is (4 x 4) mm x 5cm
Chiffondale:	• is a cut that is mostly used on green and leafy vegetables and herbs, however the definition is not formal because there seem to be no definite size of the cut
Brunoise:	• These are standard cubes measuring (4 x 4 x 4) mm,
Macedoine:	• the dice is bigger from 5mm to 10mm
Jardinière:	• They are in the form of batons measuring 4cm x (10 x 10) mm (1.5 x 2/5 x 2/5 of an inch).
Large dice	• Cubes measuring (¾ x ¾ x ¾) inches
Medium dice	• Cubes measuring (½ x ½ x ½) inches
Small dice	• Cubes of (¼ x ¼ x ¼) inches
Batonnet	• Stick shaped measuring from (2 to 2 ½ x ¼ x ¼) inches
Paysanne	• Square, triangular, round shape of (½ x ½ x 1/8) inches

2.2.1 Existing vegetable cutters and slicers

The most common type of automated vegetable cutters and slicers operate with a motor via a cylindrical shaft (Tony, 2014). Examples of the available machines is the DitoSama combined vegetable cutter and slices which perform both cutting and slicing operations. The vegetables are fed through a hopper either vertically or inclined at an angle and the operational cutting and slicing of the vegetables is obtained by the high-speed rotation of the blade which cuts the vegetables as they pass through it, a hopper is the regulator for the entry or the vegetables and holds them. Most of the vegetable cutters utilise the same principle of operation as the DitoSama.

2.3 Objectives of the study

- To design a vegetable cutter and slicer that operates automatically.
- A machine that eliminates contaminants on the vegetables
- To design a vegetable cutter and slicer that is easy to assemble and dis-assemble.

2.4 Principle of operation

Rotating discs are subject to two fundamental stresses called the hoop and the radial stresses. Both act in different directions on the rotating disc and it is of great necessity to design the disc with the maximum stresses in hand. The blade is secured to the shaft with a gib head key, the rotation of the shaft also rotates the blade at the same speed. The power supplied by the motor depends on the load to be overcome by the blade, the smaller the load then the smaller the power rating of the motor.

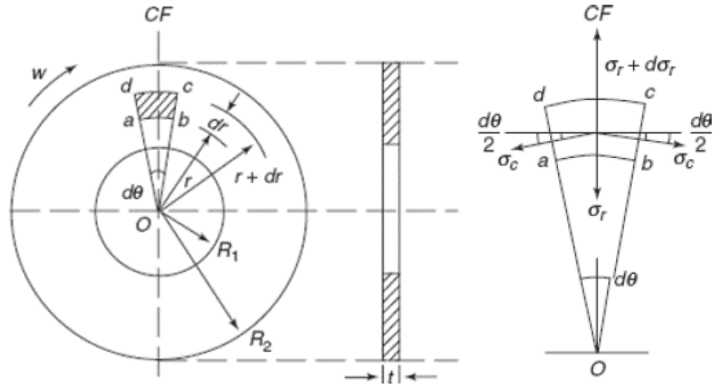

Figure 1. showing the elemental cross-sectional area of a rotating disc.

The fundamental equations for determining the hoop and radial stresses within the disc are 1 and 2.

$$\sigma_r = (3+\upsilon)\frac{\rho\omega^2}{8}[(R_1^{\,2} + R_2^{\,2} - \frac{R_1^{\,2}R_2^{\,2}}{r^2}) - r^2] \qquad (1)$$

$$\sigma_H = (3+\upsilon)\frac{\rho\omega^2}{8}[(R_1^{\,2} + R_2^{\,2} + \frac{R_1^{\,2}R_2^{\,2}}{r^2}) - (1+3\upsilon)r^2] \qquad (2)$$

The principle of operation for the machine lies within the concept of rotating discs, the disc will be attached a blade which will be carrying out the slicing operations, the rotation of the disc will provide the slicing and action and the dicer below the slicer will be producing the required cuts. The feeding system comprises of the conveyor feed, hopper. The conveyor has a variable speed to match the required demand at different times. The feed vegetables are placed on the conveyor belt which leads them to the hopper arrangement, the hopper leads the vegetables to the disc housing were the disc is fixed and the dicer underneath it. If only slicing is required the dicer will be removed and if required both of them are coupled together. The hopper contains some rails sideways which allows it to be easily opened for changing of the dicers and discs. An ejector plate is also part of the disc housing which then forces the cut vegetables out and them not to accumulate inside the housing. The ejector plate leads the products through to the delivery conveyor belt which carries the products out of the system. From the top of the frame is a very important platform for UV light which projects a beam of light directed towards the conveyor containing the cut or sliced vegetables. The final products are obtained at the delivery platform and the products are assumed to be partly clean and safe from pathogens.

2.5 Cutting and slicing of vegetables

The first step is vegetable preparation is the removal of visible dirt and unwanted portion of the plant, then slicing process. Slicing is done by the rotating disc (fixed to the rotating shaft) at high speed with blades attached to it which creates the desired slice thickness. To complete with the cutting process, a stationery dicer is placed underneath the disc whose inlet diameter is slightly greater than the shaft's. The rotating disc allows the slices to be diced into cubes of the desired sizes and once diced, the ejector disc also fixed with the shaft throughs away the finished vegetables. Only the dicer is not married to the shaft as the rotating disc and the ejector disc.

2.5.1 Ultraviolet light

Deterioration of food by pathogenic infections can be combated by various food processing techniques. Most of the diseases associated with food are accompanied with fresh vegetables and fruits since most of them would be consumed as raw. Most of the industries which produce these fresh products use chemicals when disinfecting their products (Srinivasarao, et al., 2012). Even though thermal processes are found to be effective in combating pathogenic infections, they negatively affect food stuff by altering their color, changing its sensory property, flavor and it also eliminates some vitamins (Ruan, et al., 2002). These other methods of pathogenic disinfection can be implemented in ensuring safe and sound food products from a range of both liquid and solid foods (Pereira, et al.,

2009) U.V light projection on food stuff is entirely a non-thermal, does not constitute of chemicals and is cost effective. Moreover, after its operation it does not produce any by-products therefore it's a clean and smart way of securing your products (Tatiana, et al., 2010).

In the electromagnetic spectrum there are three regions of ultraviolet light which are present which are UV-C with a wave length of (200–280) nm, UV-A with a wave length of (315–400) nm and UV-B of wavelength (280–315) nm and. Of the three regions the UV-C contains the properties needed for killing pathogens (Tatiana, et al., 2010). According to study, the disinfection of the substance occurs when the UV-C penetrates the outer membranes of the pathogen's cells thereby causing damage of its DNA. The dimers formed by the later operation therefore prevents the continuously production of more pathogens leading to death of their cells. Generally, the use of UV technology has proved not to cause any alterations on its products using (Krishnamuthy, 2006)

2.5.2 Sources of UV light

UV light can be made from many methods artificially, for example typical ones which exist are the pulsed-UV and excimer lamp technologies, UV low-pressure and the medium pressure mercury lamps, these can be applied to food disinfection (Tatiana, et al., 2010). The UV-excimer lamps have found to produce single directional output that can be altered to produce desired wavelength by using its combination with gases (Warriner, et al., 2004)

3 Materials and Methods

Adequate data was gathered for the development of the machine into the proposed design, enough and relevant formulae were derived from first principles, experiments were conducted in the University laboratory to determine the unknown parameters. The machine drawings, bill of quantities and 2D representations were developed using SOLIDWORKS. The automation process for controlling the cutting and slicing process was developed using Siemens. A number of three possible solutions was generated to meet up with the project's requirements and these were made after the detailed analysis of the preliminary study. The solutions each have different designs and mechanisms in order to cater for the demerits in the previous versions. Each solution was designed to meet the project's objectives.

3.1 Automation

Using Siemens, the automation process will be used to control and select the suitable speed range for cutting the different types of vegetables, control the movement of all moving parts such as the conveyor belts and to connect the sequence linking the components that make up the machine.

3.2 Experimental results

Experiments were conducted in the University Laboratory in determining the force required for slicing the hardest vegetable i.e. the hardest vegetable considered is carrot. A force of 19,5N was recorded. The main emphasis was on the evaluation of the maximum hoop and radial stresses as highlighted by the two graphs below.

Results produced when the disc is rotating at 10000rpm

Table 2. Data representation for plotting the graphs

Hoop Stress (MPa)	Radius(m)	Radial Stress (MPa)	Radius(m)
158.8	0.02	59.8	0.02
87.8	0.05	58,8	0.05
72.2	0.08	53.1	0.08
58.3	0.11	36.8	0.11

42.1	0.14	9.9	0.14
36	0.15	0	0.15

The values obtained for the maximum hoop and radial stresses were precisely as:

Hoop stress (maximum) = 159MPa

Radial stress (maximum) = 59MPa

Graphs below indicate the scattered experimental data for the experiments

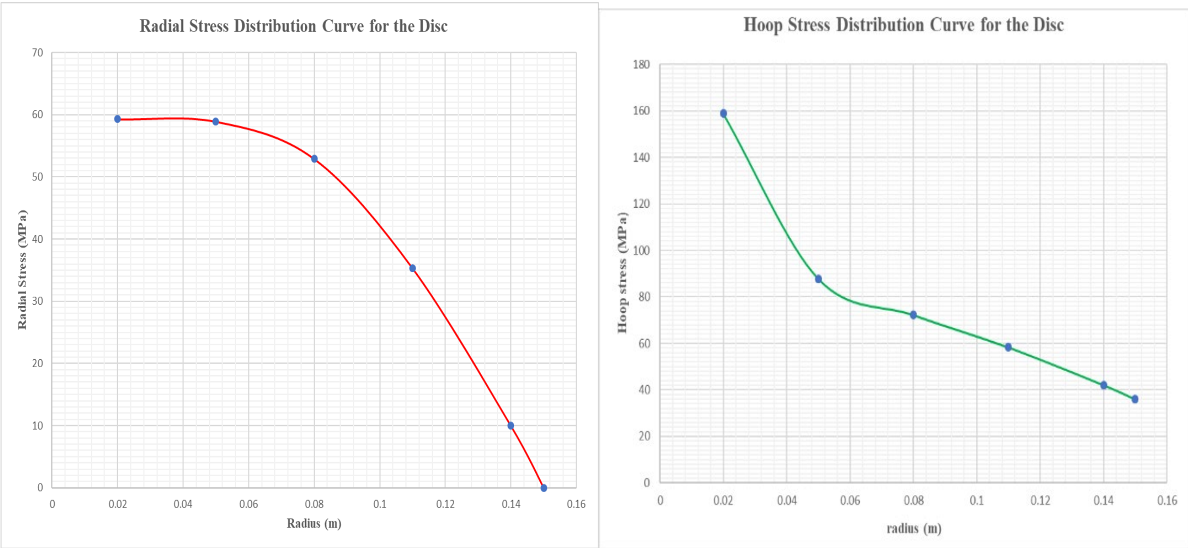

Figure 2. Distribution of experimental data.

Using the values obtained for the maximum hoop and radial stresses, the motor which drives the cutting and slicing assembly was rated at 1.9kW.

3.3 Machine drawings

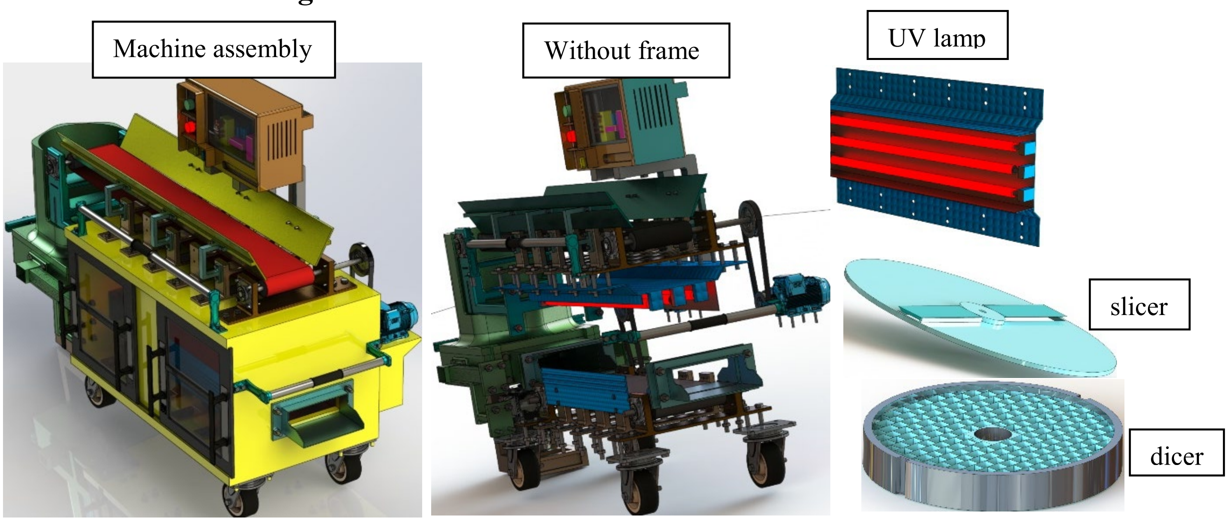

Figure 3. a) the whole machine assembly b) machine assembly without the frame c) UV light arrangement, disc and dicer.

4 Results and Discussion

Designing of the automated vegetable cutter and slicer was successfully implemented within the required budget, the machine can do several cuts and slice sizes depending on the consumer requirement (macedoine, julienne, etc.). Moreover, the Implemented U.V platform ensures safe products for immediate consumption without any harm both to the user and the food. Use was made of locally available materials to construct the design to success thus a great margin was achieved in terms of costs. However, the actual performance of the machine is only visible when it is brought to operation after manufacture and allowed to perform its tasks as according to the design. Force meter reading = 14.5N. Perpendicular distance = 20cm, the results obtained showed that a force of 14.5N was needed to just slice a carrot into two pieces

4.1 Sizing of the Motor

$$\text{electrical power}\,(P) = T \times \omega$$
$$T = \text{The torque required to slice}$$
$$\omega = \text{the speed of rotation of the disc}$$
$$\text{but}\, T = F \times r$$
$$F = \text{force rquired to slice the hardest vegetable}$$
$$\text{r} = \text{the perpendicular distance from the point of slicing to the pivot}$$
$$\text{F=19.5N, r} = 0.25m$$
$$T = 19.5 \times 0.25 = 4.875Nm$$
$$\therefore P = 4.875 \times \left(\frac{3700 \times 2\pi}{60}\right)$$
$$P = 1888.88W = 1.9KW$$
$$\textit{The power rating of the motor } P = 1.9KW$$

Answer Thus, a motor which delivers up to 1.9KW would be adequate

$$\text{Data}: v = 0.55m/s,\ \textit{mass flowrate} = 3000kg/hr$$
$$l = 1{,}9m$$
$$\text{Type of conveyor used : belt conveyor}$$
$$\text{The mass } m = \frac{\textit{massflowrate} \times \textit{lenth of belt}(l)}{\textit{linear velocity of belt}}$$
$$\text{but mass flowrate} = \frac{3000}{3600} = 0.83kg/s$$
$$m = \frac{0.83 \times 1.9}{0.3} = 5.26kg, \textit{adding the mass of the rollers and conveyor belt}$$
$$\textit{mass of rollers and belt} = \leq 10kg$$
$$\textit{assu}\min g\ \textit{that}\ \mu_T = 1$$
$$\textit{mass}(m) = 5.26 + 10 = 15.26kg$$
$$F_\mu = \mu_T \times g \times m$$
$$= 1 \times 9.81 \times 15.26 = 150N$$
$$\textit{Power}(P) = \frac{F_\mu \times v}{\eta}$$
$$\textit{Assu}\min g\ \textit{that}\ \eta = 0.8$$
$$\textit{Power}(P) = \frac{150 \times 0.55}{0.8} = 103.25W$$
$$\textit{The power to drive the conveyor belt is thus } 104W$$
$$\textit{This is the power that must be}\ \text{sup}\ \textit{plied by the motor}$$

FOR THE DELIVERY CONVEYOR BELT

Data : $v = 0.55m/s$, $mass\ flowrate = 3000kg/hr$

$l = 1,41m$

Type of conveyor used : belt conveyor

The mass $m = \dfrac{massflowrate \times lenth\ of\ belt(l)}{linear\ velocity\ of\ belt}$

but mass flowrate $= \dfrac{3000}{3600} = 0.83kg/s$

$m = \dfrac{0.83 \times 1.41}{0.3} = 3.901kg$, *adding the mass of the rollers and conveyor belt*

mass of rollers and belt $= \leq 10kg$

assuming that $\mu_T = 1$

$mass(m) = 5.26 + 10 = 13.901kg$

$F_\mu = \mu_T \times g \times m$

$= 1 \times 9.81 \times 13.901 = 137N$

$Power(P) = \dfrac{F_\mu \times v}{\eta}$

Assuming that $\eta = 0.8$

$Power(P) = \dfrac{137 \times 0.55}{0.8} = 94.19W$

The power to drive the conveyor belt is thus 95*W*

This is the power that must be supplied by the motor

d=200mm, b=22mm, t=14mm, D_1=200mm and also appendix C N_1=13rpm, N_2=28rpm

$$\sin\alpha = \frac{r_2 - r_1}{x} \qquad x = 0.67$$

$$\sin\alpha = \frac{r_2 - r_1}{0.67} \quad = \frac{0.7 - 0.04}{0.67} \quad ,\alpha = \sin^{-1}\left(\frac{0.7 - 0.04}{0.67}\right)$$

$$= 2.57°$$

$$\theta = 180° - 2\alpha \quad ,= 180° - 2(2.53°) \quad = 175°$$

$$= 175\left(\frac{\pi}{180°}\right) \quad = 3.05rads$$

$$D_2 = \frac{N_1 D_1}{N_2}$$

$$= \frac{13(188)}{28} \quad = 90mm$$

$$L = \pi\left(r_1 + r_2\right) + 2x + \frac{\left(r_1 - r_2\right)}{x}$$

$$= \pi\left(0.07 + 0.04\right) + 2(0.67) + \frac{\left(0.07 - 0.04\right)}{0.67}$$

$$= 1.84m$$

$$P_{shaft} = (T_1 - T_2)(v)$$
$$105 = (T_1 - T_2)\left(\frac{13\pi(0.55)}{60}\right)$$
$$105 = (T_1 - T_2)(0.37)$$
$$(T_1 - T_2) = \frac{105}{0.37} \quad ,(T_1 - T_2) = 280N$$

Using standards from Appendix D

$$\frac{T_1 - T_c}{T_2 - T_c} = e^{\mu\theta \operatorname{cosec}\beta} \qquad ,\frac{T_1 - 990}{T_2 - 990} = e^{0.25(3.05)\operatorname{cosec}16}$$
$$T_1 = 15.8T_2 - 16730.94 \quad and (T_1 - T_2 = 290)$$
$$T_2 = 1.01kN, \quad T_1 = 1.35kN$$

4.2 Finite Element Analysis: von Misses Stress analysis for the components.

Analysis using the von Mises is a method that is utilised by design engineers to confirm if their design will withstand a prescribed load condition without failure. For desirable results, the von Mises stress for the material component should be less or equal to the design stress of the that component. For desirable results the bellow relation must be met.

$\sigma_v \leq \sigma_d$ where σ_v *is* the maximum on misses stress recorded by the material
and σ_d *is the design stress of the material.*

$$\sigma_d = \frac{Yield\ stress\ of\ the\ material\ \sigma_s}{factor\ of\ safety(N)}$$

4.3 Disc housing and main frame support

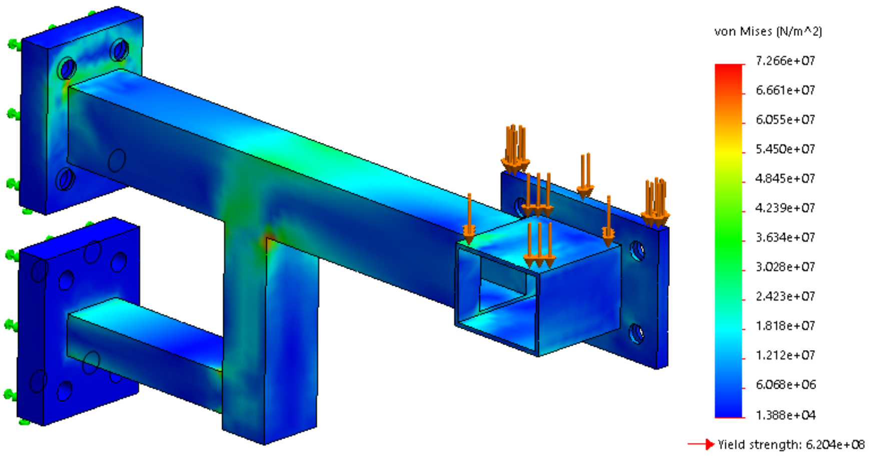

Figure 4. Disc housing

Assuming a factor of safety **1.68,** $\sigma_d = \frac{1.3\times10^8}{1.68} = 3.69 \times 10^8$

$= 7.266 \times 10^7 \leq 3.69 \times 10^8$ therefore, the design is safe (73MPa≤370MPa).

4.3.1 Slicing disc and conveyor shaft and pulley

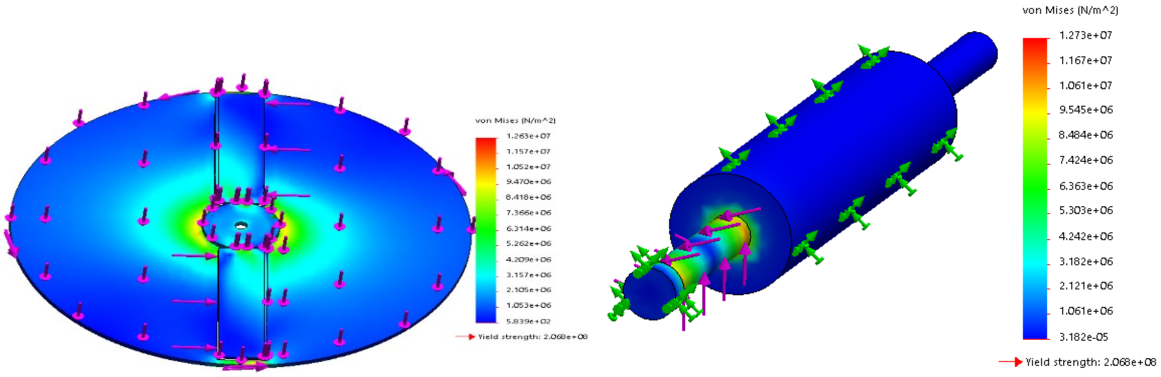

Figure 5 a. slicing disc b. shaft and pulley

Assuming a factor of safety **1.68,** $\sigma_d = \frac{2.088\times10^8}{1.68} = 1.24 \times 10^8 = 1.263 \times 10^7 \leq 1.24 \times 10^8$ therefore, the design is safe (13MPa≤124MPa). In this case assuming a factor of safety of **1.68,** $\sigma_d = \frac{2.088\times10^8}{1.68} = 1.24 \times 10^8$

$1.27 \times 10^7 \leq 1.24 \times 10^8$ Therefore, the design is safe (13MPa≤124MPa).

4.3.2 Ejector plate

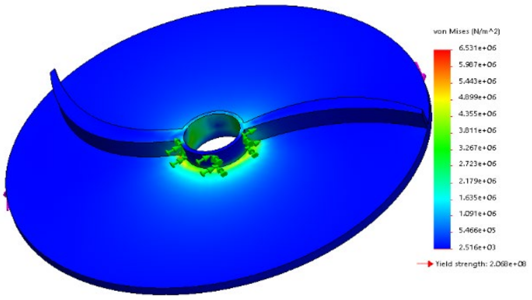

Figure 6. Ejector plate

In this case assuming a factor of safety of **10** $\sigma_d = \frac{2.088\times10^8}{10} = 2.088 \times 10^7 \quad 6.531 \times 10^6 \leq 2.088 \times 10^7$ therefore, the design is safe (6.5MPa≤21MPa).

4.4 Shear Force Diagram (SFD) AND Bending Moment Diagram (BMD)

4.4.1 Shear Force Diagram (SFD) AND Bending Moment Diagram (BMD) for the roller

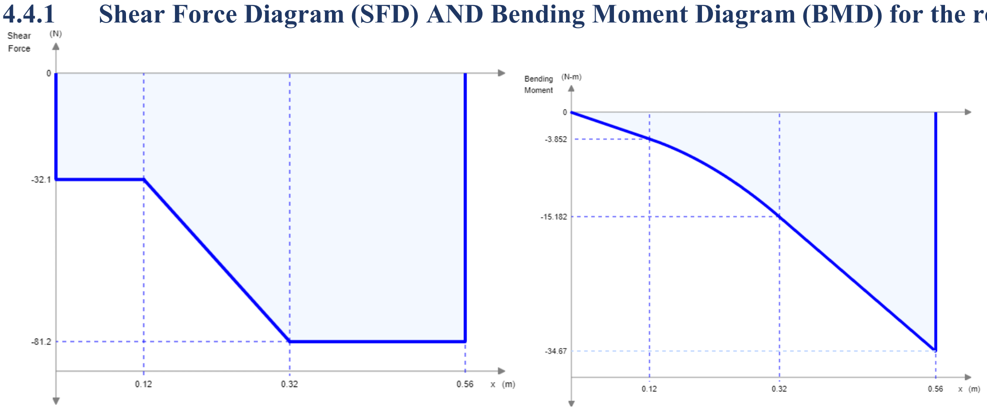

Figure 7. Shear Force Diagram (SFD) AND Bending Moment Diagram (BMD) for the roller

4.4.2 SFD and BMD for motor shaft

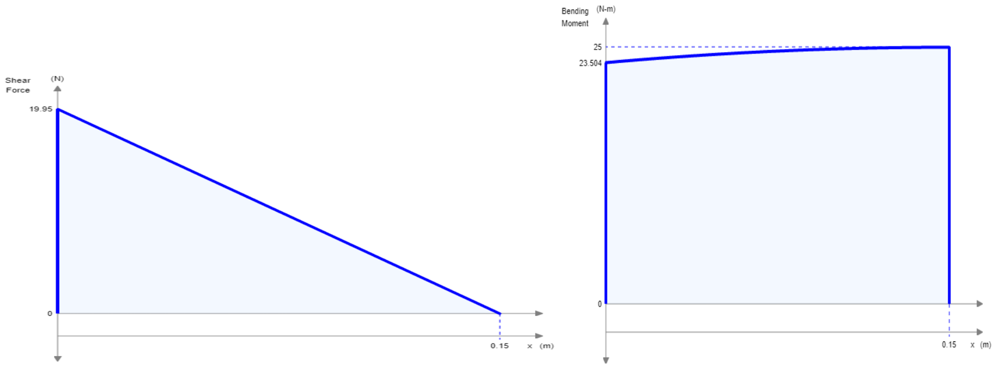

Figure 8. SFD and BMD for motor shaft

4.5 Modal displacements

4.5.1 Modal displacements for the disc housing

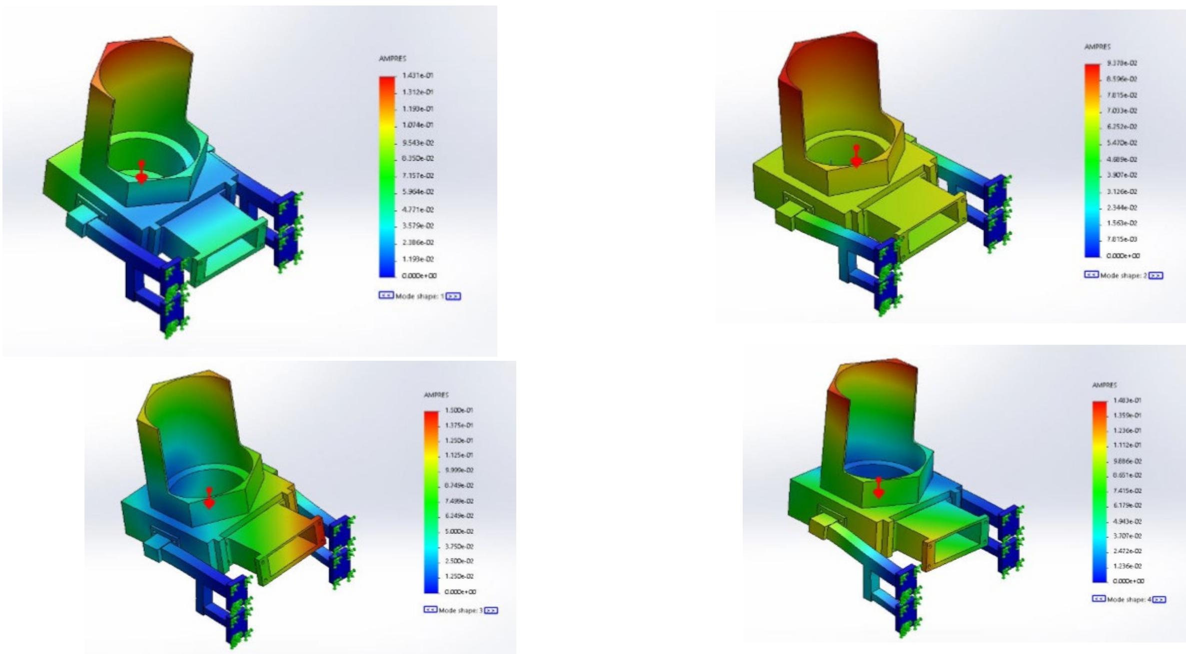

Figure 9. Modal displacements for the disc housing

4.5.2 Modal displacements for the rotating disc

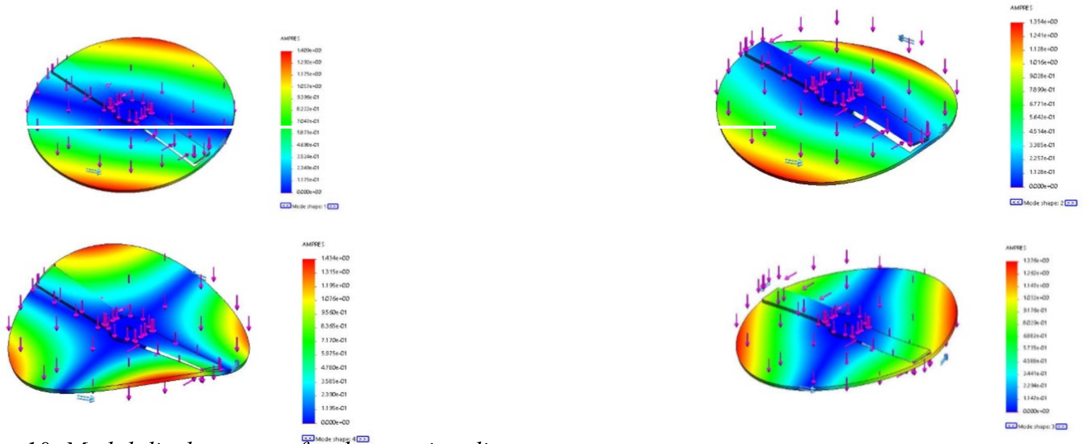

Figure 10. Modal displacements for the rotating disc

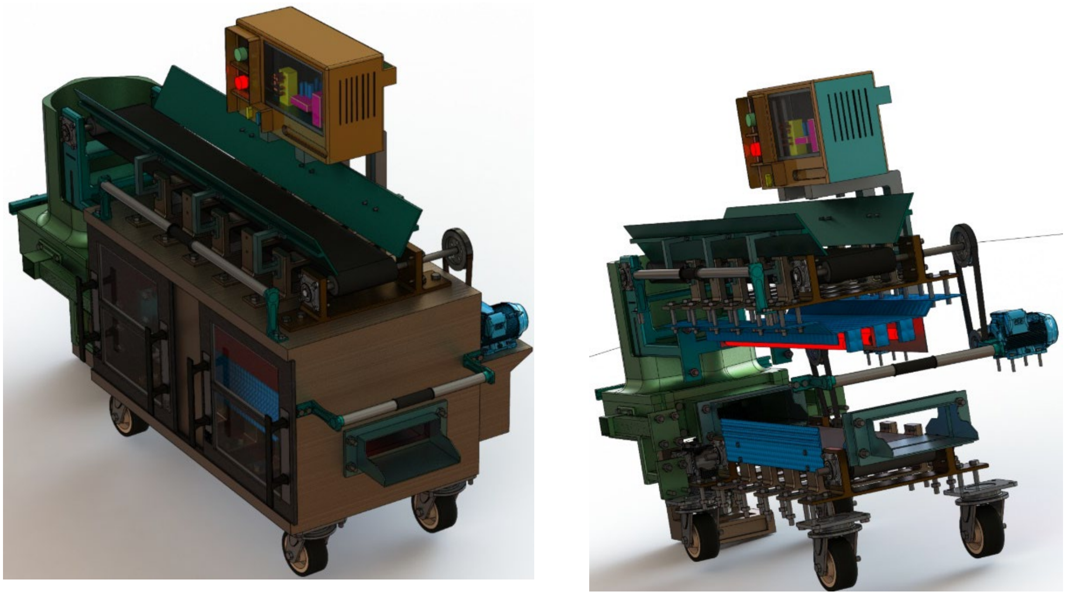

Figure 11. a. Automated vegetable cutter and slicer b. X-ray view

5 Recommendations and conclusion

5.1 Rotating disc

All rotating components should not be exposed in order to ensure safety. The disc, dicers are all interchangeable and since they are always rotating they should be totally enclosed. The following rules should be obeyed to avoid injuries and fatality.

- Never open the disc housing if the disc and ejector plate have not come to a complete halt
- Do not touch the sharp edges of the slicing blade and dicing grid
- The disc housing should be perfectly locked before operation is commenced

5.2 U.V lamps

The UV beam radiation guards should be well in proper position to avoid scattering of the beam. Before any maintenance is carried out, they must be always switched off

5.3 Emergency stop devices

The emergency preparedness devices include the off switch which should be always functional but above all, situations which leads to emergency situations should be always be avoided by ensuring optimum safety precautions throughout the machine operation. The safety devices will be provided for the conveyor belt (both the feed and delivery), the rotating disc such that in the case of any emergency respective action is taken.

5.4 Servicing the machine

The following effective steps should be obeyed while doing any service

- Scheduled services must be carried out using standard task procedures in order to avoid any injuries and fatalities.
- The blade must be handled with engineering gloves,
- the disc replacements must be done only when every part is stationery (lock out system),
- the U.V radiation lamps should be carefully handled and before any process is carried out it must be ensured that they are off.

5.5 Effective use of the machine

- The conveyor belt should not be overloaded, only the rated load should be applied
- The vegetables must be fed only when they have been reduced of their cross-sectional area
- The speed of the disc should match only with the required type of vegetable to be sliced.
- The disc and the dicer should be kept at an enclosed space free from people
- For effective output by the U.V light the machine must operate while the door is closed.

5.6 Conclusion

Designing of the automated vegetable cutter and slicer was successfully implemented within the required budget of USD1000, the machine can do several cuts and slice sizes depending on the consumer requirement (macedoine, julienne, etc). Moreover, the Implemented U.V platform ensures safe products for immediate consumption without any harm both to the user and the food. Use was made of locally available materials to construct the design to success thus a great margin was achieved in terms of costs. However, the actual reveals of the machine are only visible when it is brought to operation after manufacture and allowed to perform its tasks as according to the design.

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Biographies

Mr Guide Simbarashe Ganyani is a male born in Chivhu at Nharira Hospital, conducted his primary education at Daramombe Mission, Lwendulu primary school, Chikomba primary school and completed at Trojan primary school in 2008. He carried out his secondary education at Chipadze High School and completed it at Chipindura High School in 2014. Currently he is enrolled at the University of Zimbabwe studying for a bachelor of science honors degree in Mechanical engineering and was once attached to Bindura Nickel Corporation were, he gained most of the industrial tactics in terms of engineering research and design. His interest lies in Solid Mechanics and machine design were with the help of Dr T Mushiri he has managed to gain more knowledge from the competent Solid Mechanics lecturer. Guide looks forward to be part of a design environment and part of a team which aspire to bring a change to the world through Solid Mechanics.

Dr Tawanda Mushiri received his Bachelor of Science Honors Degree in Mechanical Engineering (2004-2008) and a Masters in Manufacturing Systems and Operations Management (MSc. MSOM) (2011-2012) from the University of Zimbabwe, Harare, and a Ph.D. from the University of Johannesburg, South Africa (2013-2017). He also obtained a Certificate with Siemens in Programmable Logic Controllers in the year 2013 where he worked with SCADA and PLC Programming. His doctorate involved fuzzy logic and automated machinery monitoring and control. Currently, he is a Senior Lecturer and Senior Research Associate at the University of Zimbabwe and University of Johannesburg, respectively. In the past (2012-2013), he has also lectured at the Chinhoyi University of Technology, Zimbabwe, lecturing mechatronics courses. He has also been an assistant lecturer for undergraduate