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Designing of an Automatic Soya Bean Cake Cutting Machine

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ABSTRACT : *There is a growing shift from meat towards plant-based and health-focused products like soya bean cake due to the rise in meat prices. The COVID-19 pandemic has also aided this trend. However, soya bean cake is not widely accepted as a meat substitute due to its texture, cut, and packaging despite its richness in protein which all contribute to the product's quality. Manual cutting is back-straining, energy-intensive, and time-consuming. To overcome these difficulties, it is essential to automate the process. This work presents the design of an automatic soya beans cake cutting machine that cuts soya beans cake into uniform shapes and sizes with minimum wastage. The major components of the paper are a pneumatic cylinder, coagulation mesh plate, and cutting mesh. The machine is modeled and simulated (Finite Element Analysis (FEA)) using Solid Works, Autodesk Inventor (Nastran integrated), and Fusion360. The accessories and fittings that constitute the control system for the automation of the prototype are selected and enhanced using Arduino. The design of the bolts is analyzed using a Bolted Connection Component Generator with calculations indicating design compliance. When the sensor detects the presence of soya bean cake, the pneumatic cylinder is actuated, forcing the coagulation plate and the cutting mesh on the soya beans to press and cut uniformly. The pressing (coagulation) and pressing of the soya beans cake is achieved within 80 seconds producing 16 pieces of cuts and a production capacity of 720 pieces per hour. The machine has an efficiency of 93.67%. The machine design is concluded safe and will help to reduce the consumption of labor input and ensure effective packaging with proper hygiene in place.*

KEYWORDS *soya bean cake, automatic cutting machine production efficiency, machine design, finite element analysis, minimum wastage.*

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I. INTRODUCTION

The development of cutting machines over the years has revealed remarkable progress. Cutting machines have wide usage in the food industry, primarily used for cutting [1] [2]. Cutting can be achieved either manually or automatically, although manual cutting is still widely used because of its wide application and low production costs, it's time and labor-intensive and offers limited productivity [3] [4]. For these reasons, new and more efficient cutting methods have been developed and introduced in the food production process [5]. The modern trend in the food industry is to automate machine operations. As is well appreciated now, automation leads to an increase in productivity, increased consistency of the output, and improved quality and robustness of process [6] [7] [8].

The technological advancement is not only based on giving a practical and useful utilization to the different mechanisms designed in antiquity, with manual movement. It, however, focuses on the creation of a series of mechanisms, equipment, and machines with different motor sources. This leads to advancement in technological innovation, creating new models and automation processes, such as cutting, slicing, and cubing

[9]. Aimed at the food industry, there is a series of manual and automated machines that meet a certain functionality that facilitates and improves the creation of different products marketed daily. Such equipment must comply with safety and hygiene standards using suitable codes and standards as this ensures the quality of the final finished product [10] [11]. The utilization of an automation process in the production of protein-rich bean cakes is a welcome development [12].

Recent economic challenges especially in Nigeria have caused high prices in other well-known sources of protein, such as animal proteins - pork, chicken, beef, and so on [13] [14]. The growing interest in alternatives to animal-derived protein has led to an increased demand for plant-based proteins [15] [16]. The demand for new proteins is not only based on consumer trends but also affected by factors, such as price, availability, suitability, and functional properties [17]. Among the well-known plant-based meat replacers is soya bean, Soya beans cake is an inexpensive and excellent source of protein promoting good health, and t is used by food manufacturers because of its high nutritional value [18] [19].

Soya bean seed is the richest in food value of all plant foods consumed in the world. Food makers use soya beans due to its high nutritional content. It is eaten as soybean cake or as soy milk, moreover, the cake is fed to livestock, and flour is added to corn pudding to make it a healthy meal for infants and children [20]. Soya bean contains all nine essential amino acids. According to the United States Department of Agriculture (USDA), 100 g of cooked soya beans without salt contains; 141 kilocalories, 12.35 g of protein, 6.4 g of fat, 11.05 g of carbohydrate, and 4.2g of fiber [21]. Soya beans are low in saturated fat and high in protein, vitamin C, and folate [22]. Soya bean cake is available in the form of blocks, unseasoned or mild-tasting, with a gel-like high-absorbing structure that can take the flavors of other marinades and dressings while cooking. However, the production of soya bean cake with uniform volume cutting is scarcely available [23].

Thus, this study aims to design an automated cutting machine to obtain uniform volume cutting of soya-beans cake. The development of this research involves an automatic control system, based on the different theories of modern control, the dynamics of the automatic control system, its basic components, and the parameters to be considered. The reason is to avoid errors in the control of the automation of processes. Attention was placed on the hygiene, nutritional value and packaging of the soya beans cake. Parameters include cutting duration, compressive strength and capacity, cutting efficiency, and quality performance efficiency were considered. The appropriate mechanical elements and automated control for this design are defined, and its operation is demonstrated by modeling and simulation using SolidWorks, Autodesk Inventor and Nastran integrated, and Fusion 360.

II. MATERIAL SELECTION CRITERIA

Material selection is of utmost importance to ensure that the components designed to be used have the desired performance requirements. Since different components of the automatic soya bean cake cutting machine would be subjected to varying forms and degrees of stresses, strains, compressive force, the center of gravity, etc., the material with the appropriate engineering property was chosen.

The machine was designed using materials predicted by design analysis. The materials established to be used in fabrication were selected after a careful study of the desired physical, mechanical, chemical, and even aesthetic characteristics of several proposed materials. For this designed Paper, due to economic considerations, food processing hygiene, and availability of raw materials, stainless steel is to be used for the food-contacting parts while reinforced plastic is to be used for the collector. The pneumatic cylinder is to be procured. Some of the materials to be used in the construction of an automatic soya bean cake-cutting machine are listed below in Table 1.

Table 1. Materials to be used in the construction

S/N	Name	Materials
1	Top cover	Stainless Steel
2	Pneumatic cylinder and accessories	Nickel plated, Chromed or Stainless steel
3	Pressing plate	Stainless steel
4	Moisture Collector	Plastic
5	Collector chamber	Plastic (Transparent)
6	Coagulation and cutting chamber	Stainless steel
7	Coagulation mesh plate	Stainless steel
8	Cutting mesh	Stainless steel
9	Bolts and nuts	Mild steel
10	Legs for frame	Hot rolled steel section

III. MACHINE PARTS DESCRIPTION

The pneumatic cylinder fixed with a solid base (pressing plate) with the coagulation mesh plate compresses the collected soya bean extract using pneumatic strength. This brings about the desired coagulation. The moisture content is collected using the moisture collector. However, the compression (coagulation) mesh plate is replaced with the cutting mesh for cutting. Uniform volume cutting will be done through the cutting mesh by the action of pneumatic strength from the pneumatic cylinder with a solid base. The cut soya bean cake is collected using the product collector.

A. Considerations of Pneumatic Cylinder

There are thousands of pneumatic cylinder variations on the market to suit different working environments, so therefore knowing the exact requirements and choosing the right pneumatic cylinder design is extremely important. There is no single industry-recognized criterion to look out for when selecting a pneumatic cylinder. The pneumatic cylinder is simple, economical, durable, and easy to install. It produces a bigger force over a broad range of velocities; cycles at high speeds without overheating; and stalls without internal damage. The pneumatic cylinder also tolerates tough conditions such as high humidity, dusty environments, and repetitive high-pressure washdowns.

The most standard and common pneumatic cylinder design on the market is a rod-style cylinder. Pneumatic cylinders are available in two different varieties to deliver motion in one and both directions (Bharath, Gopal, James, & Lakshmi Sankar, 2020). Considering the design application the single-acting cylinder will be considered. The rod-style pneumatic cylinder suited for the design of the automatic soya bean cake cutting machine is narrowed down to the repairable pneumatic cylinders which are generally used in heavy-duty applications, long strokes, and high moment load requirements, due to the ability to replace seals and internal components – thereby prolonging cylinder lifespan.

1) Pneumatic Cylinder Design

The parameters of choice of the pneumatic cylinder (according to the design chart in Appendix 1) are in Table 2.

Table 2 Parameters of pneumatic cylinder

S/N	Pneumatic cylinder parameter	Dimension
1	Length	380 mm
2	Bore	45 mm
3	Stroke	165 mm
4	Piston rod diameter	45 mm
5	Maximum working pressure	9 bar
6	Weight	4 kg

To calculate the piston rod length;

$$\textbf{Total length of the piston rod} = Approach\ stroke + Length\ of\ threads + Extra\ length\ for\ front\ cover + Extra\ length\ to\ accomodate\ head + Total\ rod$$

$$= 165 + 50 + 13 + 22 = 250\ mm.$$

$$\textbf{Diameter of the piston}\ (\boldsymbol{d}) = 45\ mm$$

$$\textbf{Pressur acting}\ (\boldsymbol{P}) = 7\ kgf/cm^2$$

$$= 7 \text{ x } 0.981 = 6.867\ bar = 0.6867\ N/cm^2\ .$$

$$\textbf{Materials used for rod} = C45$$

$$\textbf{Yield stress}\ (\boldsymbol{\sigma y}) = 37\ kgf/cm^2 = 37 \text{ x } 98.1 = 3629.7\ bar$$

$$= 362.9\ N/mm^2\ .$$

$$\textbf{\textit{Factor of safety}} = 2$$

$$\textbf{Force acting on the rod (F)} = \text{Pressure x Area}$$

$$= \text{p}(\frac{\pi d^2}{4})$$

$$= 0.6867 \text{ x } [(\pi \text{ x } 45^2)/4\ ]$$

$$\text{F} = 1091.59 \text{ N}$$

$$\textbf{\textit{Design stress}}\ (\boldsymbol{\sigma y}) = \sigma y/FOS$$

$$= \frac{362.97}{2} = 181.485\ N/mm$$

$$\textbf{\textit{Minimum diameter of rod required for the load}}\ (\boldsymbol{d})) = \sqrt{4F/\pi[\sigma y]}$$

$$= \sqrt{4 \text{ x } 1091.59/\pi[181.485]}\ = 2.76\ mm.$$

$$\textbf{\textit{Assumed diameter of the rod}} = 20\ mm$$

B. Physical Properties of Designed parts

Major parts of the automatic soya bean cake-cutting machine are procured. However, the physical properties of the parts designed according to design analysis are shown in Table 3.

Table 3 Physical properties of the machine parts

Item	Physical Properties	Description (Coagulation mesh plate)	Description (Cutting mesh)	Description (The machine – Automatic Soya bean cake cutting machine)
1	Material	Stainless Steel, Austenitic	Steel, Mild	-----
2	Density	$8glcm^3$	$7.85glcm^3$	$5.101glcm^3$
3	Mass	2.10787kg	0.151372kg	16.489kg (Relative Error = 0.001294%
4	Area	$123795mm^2$	$24107.5mm^2$	1648087^2 (Relative Error = 0.000120%)
5	Volume	$263484mm^3$	$19283mm^3$	$3232353.528mm^3$ (Relative Error = 0.001294%
6	Center of gravity	x = 108.391mm y = 103.804mm z = 4mm	x = 108mm y = 103.937mm z = 1.75mm	x = 92.488mm y = -113.990mm z = -97.046mm (Relative Error = 0.001294%)

IV. DESIGN RESULTS

The machine's design worked as anticipated, according to the findings of the design study of its components. The conceptual design was modified, modeled, and subjected to simulation giving various design analyses verifying the efficiency of the coagulation and cutting is satisfactory. The automatic soya bean cake-cutting machine is modeled using SolidWorks and fully simulated with Autodesk Inventor with Nastran integrated and Fusion 360. Operational parameters such as the coagulation rate, cutting time, compressive force (pneumatic strength), and cutting efficiency were determined.

The coagulation and cutting are done via the force produced by the pneumatic cylinder. The volume of soya bean extract that would be subjected to coagulation is evaluated. The machine can cut the coagulated soya bean extract into 16 pieces of cakes of uniform volume. The cakes are to be collected through the product collector.

For the soya bean cake per unit;

$$\text{-}Density\ of\ the\ soya\ bean\ cake = 0.753\ g/cm^3$$

$$\text{-}Volume, per\ unit\ size = \frac{1}{16}\ of\ the\ soya\ bean\ extract$$

$$= 44.5 \text{ x } 47.1 \text{ x } 20 = 41919\ mm^3 = 41.919\ cm^3$$

$$\text{-}Mass\ of\ the\ soya\ bean\ cake = Destiny \text{ x Volume} = 0.753 \text{ x } 41.919 = 31.57 \text{ g}$$

$$\text{- } \boldsymbol{For\ the\ 16\ units} = 16 \text{ x } 31.57 = 505 \text{ g}$$

$$\text{- } \boldsymbol{For\ the\ machine\ has\ as\ efficieencyDensity}$$

$$\boldsymbol{Efficiency} = \frac{Output}{Input} \text{ x } 100$$

$$\boldsymbol{Output} = V \text{ x N x } \left(\frac{\text{h}}{\text{t}}\right)$$

$V = Volume\ of\ a\ unit\ soya\ bean\ cake = 41919\ mm,$
$N = Number\ of\ holes\ in\ the\ cutting\ mesh = 16\ units$
$h = Height\ of\ the\ soya\ bean\ cake = 20\ mm$
$t = Thickness\ of\ the\ cutting\ mesh = 4\ mm$

$$:.\ \boldsymbol{Output} = 41919 \text{ x } 16 \text{ x } \left(\frac{20}{4}\right) = 3{,}353{,}520\ mm^3$$

$$\boldsymbol{Input} = Volume\ of\ the\ coagulated\ soya\ bean\ extract\ after\ compression\ in\ the\ coagulation\ cutting\ chamber = 56.5 \text{ x } 264 \text{ x } 240 = 3{,}579{,}840\ mm^3$$

$$\boldsymbol{Efficiency} = \frac{3{,}353{,}520}{3{,}579{,}840} \text{ x } 100 = 93.70\%$$

Also from the stress analysis report, it is deduced that the cutting mesh needs to be optimized. This will be achieved by reducing the cutting-edge areas.

The cutting-edge area can be reduced by sharpening to a knife edge and making the pressure constant. This will require less force (energy) to cut the soya bean cake extract and save the cutting mesh from excess stress. This will enhance cutting and production rate producing a large amount of production in a short time. Coagulation is the most difficult to control as it depends on the complex interrelationship of many variables. The moisture content to be collected after compression is considered to be between the ranges of 15% - 30. Table 4 shows the capacity and production time.

Table 4 Capacity and production time

S/N	Parameters	Value
1	Density of coagulated soya bean	700 g/cm^3 (0.05 – 0.2ph)
2	Overall production time	80 seconds (16 pieces is produced once)
3	Capacity produced per hour	720 pieces

The design of the bolts was analyzed making use of Bolted Connection Component Generator. However, the calculations indicate design compliance. The ability of the machine to perform effectively determines the overall success of the Paper at a high-performance level. The machine is expected to cut 16 pieces of soya bean cake within 60 seconds and 960 pieces within an hour. This was achieved with relative success with an efficiency of 93.70%. The performance of the machine is achieved by simulating some members in the machine (the cutting mesh and the coagulation mesh plate).

A. Performance and Stress Analysis Report

The ability of the machine to perform effectively determines the overall success of the project for a high-performance level. The machine is expected to cut 16 pieces of soya bean cake within 60 seconds and 960 pieces within an hour. This was achieved with relative success with an efficiency of 93.70%. The performance of the machine is achieved by simulating some members in the machine (the cutting mesh and the coagulation mesh plate).

Finite Element Analysis (FEA) was carried out on the parts. Stress analysis was conducted on the coagulation mesh plate and the cutting mesh. Parts like the pneumatic cylinder handles as well as legs are to be procured. The static analysis (Stresses. Displacement, and FDS) for cutting mesh is shown in Fig 1, and for coagulation mesh plate is shown in Fig 2.

The static analysis and result for cutting mesh are in Tables 5 and 6, while that of the coagulation mesh plate is in Tables 7 and 8 respectively.

B. Design Drawing of the Automatic Soya Bean Cake Cutting Machine

The model is developed by using solid works. Solid Works is a solid modeler and utilizes a parametric feature-based approach to create models and assemblies. Building a model in Solid Works usually starts with a 2D sketch [24]. The sketch consists of geometry such as points, lines, arcs, comics, and splines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity. The parametric nature of Solid Works means that the dimensions and relations drive the geometry, not the other way around [25]. The exploded and isometric view of the machine is shown in Appendix 2 and 3.

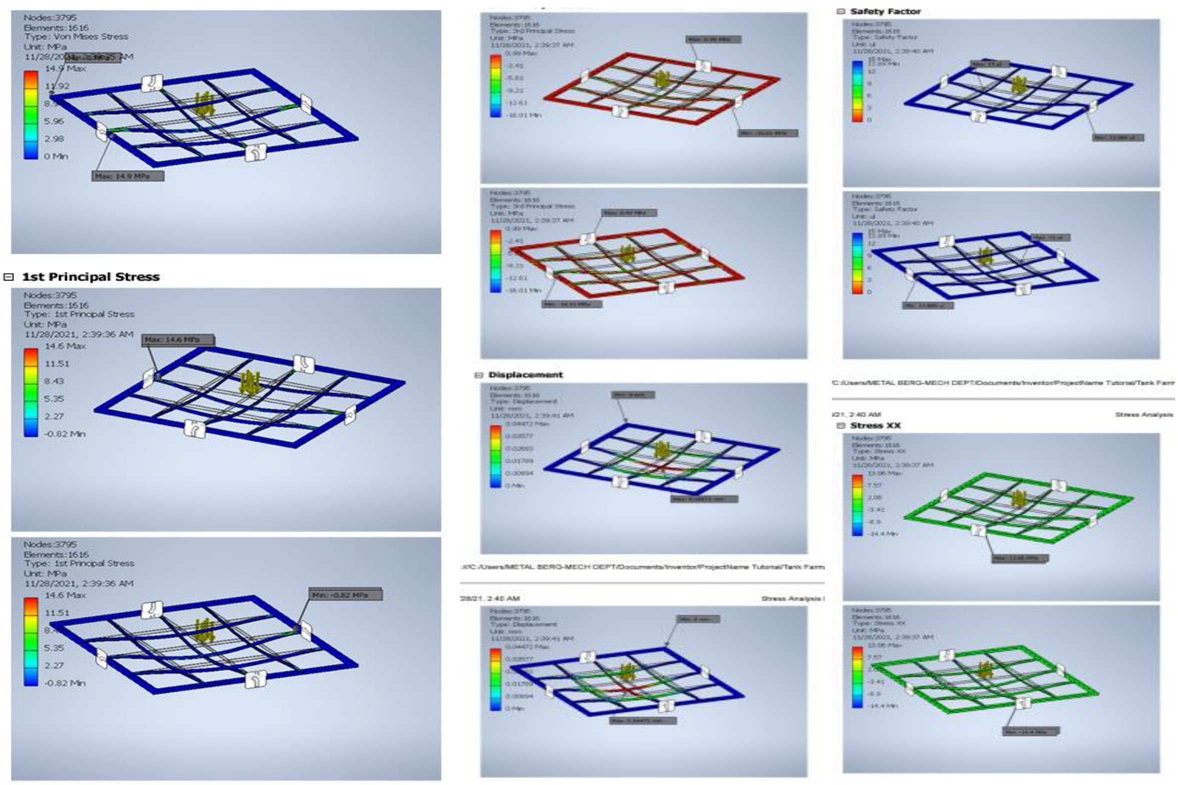

Fig 1. Static analysis (Stresses. Displacement, and FDS) for cutting mesh

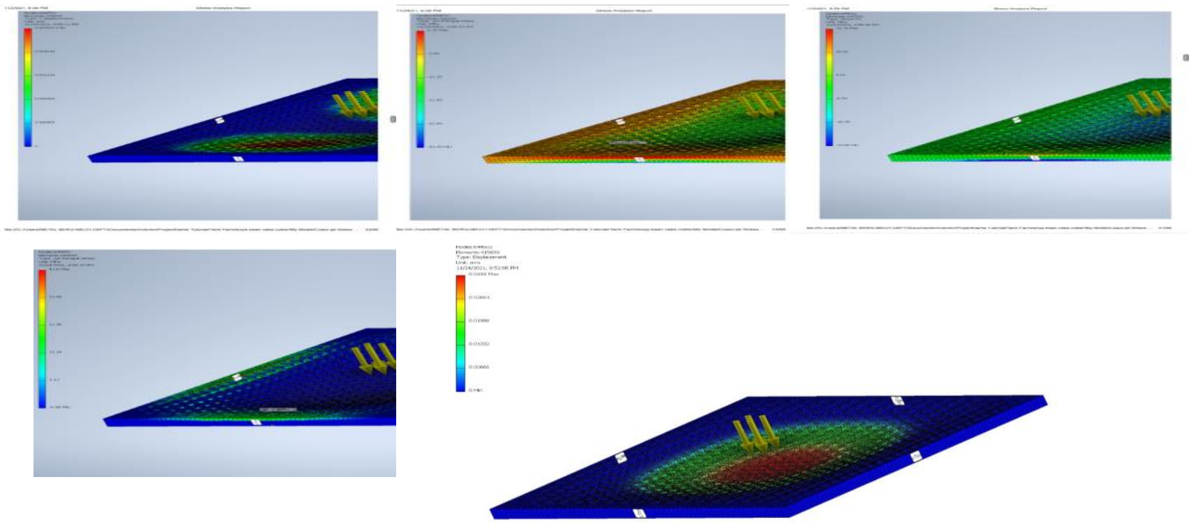

Fig 2. Static analysis (Stresses. Displacement, and FDS) for coagulation mesh plate

Table 5 Static analysis report of the cutting mesh

Static Analysis			
General Objectives and Settings	Design objective	Single point	
	Study type	Static Analysis	
	Detect and eliminate rigid body modes	Yes	
Mesh Settings	Avg. Element size (Fraction of model diameter	0.1	
	Min. Element size (Fraction of Avg, size)	0.2	
	Grading Factor	1.5	
	Max. Turn Angle	60 deg	
	Create Curved Mesh Elements	Yes	
Material(s)	**Name**	Steel, Mild	
	General	Mass Density	7.85 g/cm^3
		Yield Strength	207 MPa
		Ultimate Tensile Strength	345 MPa
	Stress	Young Modulus	220 GPa
		Poisson's Ratio	0.275ul
		Shear Modulus	86.2745 GPa
Operating Condition	Pressure	Load Type	Pressure
		Magnitude	0.009 MPa
	Gravity	Load Type	Gravity
		Magnitude	9810.000 mm/s^2
		Vector X	0.000 mm/s^2
		Vector Y	0.000 mm/s^2
		Vector Z	-9810.000 mm/s^2
	Fixed Constraint	Constraint Type	Fixed Constraint

Table 6 Stress analysis results of the cutting mesh

Results			
Reaction Force and Moment on Constraint	Constant Name	Fixed Constraint	
	Reaction Force	Magnitude	49.4171N
		Component (X,Y,Z)	0N
			0N
			49.4171N
	Reaction Moment	Magnitude	0Nm
		Component (X,Y,Z)	0Nm
			0Nm

			0Nm
Result Summary	Volume	19283mm^3	
	Mass	0.151372 kg	
	Von Mises Stress	0.000804008 MPa	14.9034 MPa
	1st Principal Stress	-0.81589 MPa	14.5958 MPa
	3rd Principal Stress	-16.0133 MPa	0.990418 MPa
	Displacement	0 mm	0.0447163 mm
	Safety Factor	13.8894 ul	15 ul
	Stress XX	-14.3952 MPa	13.0611 MPa
	Stress XY	-2.77099 MPa	1.8887 MPa
	Stress XZ	-1.02941 MPa	1.0193 MPa
	Stress YY	-15.8079 MPa	14.5784 MPa
	Stress YZ	-1.06389 MPa	1.01306 MPa
	Stress ZZ	-1.71986 MPa	1.58526 MPa
	X Displacement	-0.00127682 mm	0.00127743 mm
	Y Displacement	-0.00133469 mm	0.00133587 mm
	Z Displacement	-0.0447163 mm	0 mm
	Equivalent Strain	0.00000000347858 ul	0.0000602305 ul
	1st Principal Strain	-0.00000000321888 ul	0.0000641828 ul
	Z3rd Principal Strain	-0.000069903 ul	0.000000427665 ul
	Strain XX	-0.0000628715 ul	0.0000597954 ul
	Strain XY	-0.0000160592 ul	0.0000109459 ul
	Strain XZ	-0.00000596591 ul	0.00000590731 ul
	Stain YY	-0.0000687126 ul	0.0000641553 ul
	Strain YZ	-0.00000616572 ul	0.00000587112 ul
	Strain ZZ	-0.0000191175 ul	0.0000191205 ul

Table 7 Static analysis report of the coagulation mesh plate

Static Analysis			
General Objectives and Settings	Design objective	Single point	
	Study type	Static Analysis	
	Detect and eliminate rigid body modes	No	
Mesh Settings	Avg. Element size (Fraction of model diameter	0.1	
	Min. Element size (Fraction of Avg, size)	0.2	
	Grading Factor	1.5	
	Max. Turn Angle	60 deg	
	Create Curved Mesh Elements	Yes	
Material(s)	Name	Stainless Steel, Austenitic	
	General	Mass Density	8 g/cm^3
		Yield Strength	228 MPa
		Ultimate Tensile Strength	540 MPa
	Stress	Young Modulus	190.3 GPa
		Poisson's Ratio	0.305 ul
		Shear Modulus	72.9119 GPa
Operating Condition	Pressure	**Load Type**	**Pressure**
		Magnitude	0.118 MPa
	Gravity	Load Type	Gravity
		Magnitude	9810.000 mm/s^2
		Vector X	0.000 mm/s^2
		Vector Y	0.000 mm/s^2
		Vector Z	-9810.000 mm/s^2
	Fixed Constraint	Constraint Type	Fixed Constraint

Table 8 Stress analysis results of the coagulation mesh plate

Results			
	Constant Name	**Fixed Constraint**	
Reaction Force and Moment on Constraint	Reaction Force	Magnitude	3894.48 N
		Component (X,Y,Z)	0N
			0N
			3894.48 N
	Reaction Moment	Magnitude	1.70087 Nm
		Component (X,Y,Z)	-0.765147 Nm
			-1.51905 N m
			0Nm
Result Summary	Volume	263484 mm^3	
	Mass	2.10787 kg	
	Von Mises Stress	0.0135617 MPa	42.9892 MPa
	1st Principal Stress	-8.995 MPa	41.5999 MPa
	3rd Principal Stress	-43.2535 MPa	8.24843 MPa
	Displacement	0 mm	0.0332969 mm
	Safety Factor	12.3941 ul	15 ul
	Stress XX	-34.053 MPa	33.7417 MPa
	Stress XY	-13.0483 MPa	12.9879 MPa
	Stress XZ	-9.38279 MPa	8.53106 MPa
	Stress YY	-41.9382 MPa	40.6299 MPa
	Stress YZ	-8.00299 MPa	8.59002 MPa
	Stress ZZ	-12.4271 MPa	10.5891 MPa
	X Displacement	-0.00202269 mm	0.00202286 mm
	Y Displacement	-0.00210063 mm	0.00210037 mm
	Z Displacement	-0.0332969 mm	0 mm
	Equivalent Strain	0.0000000695717 ul	0.00020104 ul
	1st Principal Strain	-0.000000724288 ul	0.000215058 ul
	3rd Principal Strain	-0.000226405 ul	0.000000936511 ul
	Strain XX	-0.000176092 ul	0.00017326 ul
	Strain XY	-0.00008948 ul	0.0000890658 ul
	Strain XZ	-0.0000643434 ul	0.0000585026 ul
	Stain YY	-0.000221632 ul	0.000212079 ul
	Strain YZ	-0.0000548813 ul	0.0000589068 ul
	Strain ZZ	-0.0000682385 ul	0.0000694236 ul

V. CONCLUSIONS

In this Paper work, an automatic soya bean cake cutting machine was successfully designed which can be used to compress and uniformly cut soya beans cake. The design fulfills all the major design criteria and considerations as identified. Simulation (FEA and Stress analysis) was done to ensure that the machine parts work effectively. It was found that the objective of the Paper was fulfilled with an efficiency of 93.70%. The approach taken toward the Paper will ensure that the design is fully optimized and fully functional. The material to be used was chosen wisely for the cost-effectiveness of the machine. The machine can cut various sizes and shapes of soya bean cake based on the cutting mesh used. The design demonstrates that the machine is viable and capable of meeting the required outcomes and producing the desired output. From the design analysis and performance evaluation, we conclude that the design is safe and will help to reduce the consumption of labor input and ensure effective packaging with proper hygiene in place.

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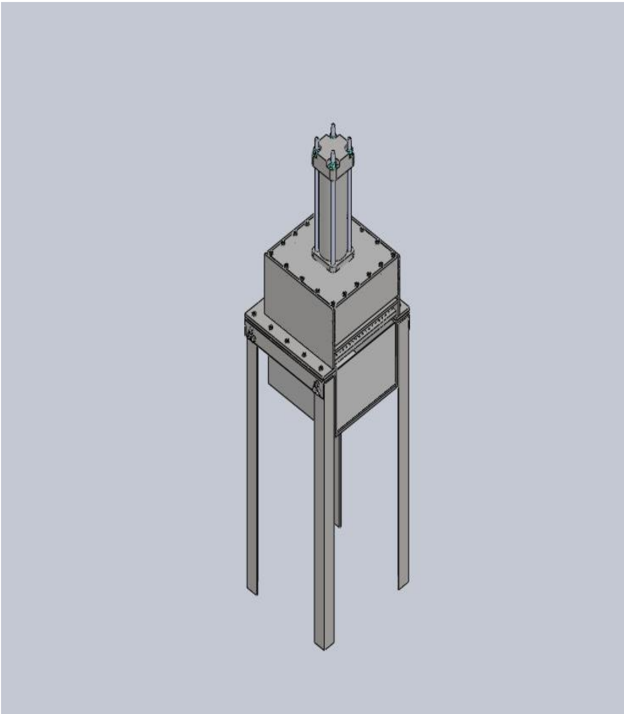
Appendix I: Pneumatic cylinder Chart

Cylinder Bore	Piston Rod È (mm)	Effective Piston area (cm²)		Working Pressure p in bar								
				2	3	4	5	6	7	8	9	10
20	8	3,14	OUT	6.4	9.6	12.8	16.0	19.2	22.4	25.6	28.9	32.0
		2,64	IN	5.4	8.1	10.8	13.4	16.1	19.1	21.5	24.2	26.8
25	10	4,91	OUT	10.0	15.0	20.0	25.0	30.0	35.1	40.1	45.1	50.1
		4,12	IN	8.4	12.5	16.8	21.0	25.2	29.4	33.6	37.8	42.0
32	12	8,04	OUT	16.4	24.6	32.8	41.0	49.1	57.4	65.6	73.8	82.0
		6,91	IN	14.1	21.1	28.1	35.3	49.1	49.3	56.4	63.4	70.5
40	16	12,56	OUT	25.8	28.4	51.6	64.4	77.3	90.1	103.1	115.9	128.9
		10,55	IN	21.6	32.4	43.2	53.8	64.9	75.3	86.6	96.9	107.6
50	20	19,62	OUT	40.0	59.9	80.0	100.0	120.0	140.0	160.1	180.1	200.1
		16,48	IN	33.6	50.4	67.2	84.0	100.8	117.6	134.4	151.2	168.0
63	20	31,15	OUT	63.5	95.3	127.1	158.9	190.6	222.3	254.1	285.9	317.6
		28,01	IN	57.1	85.6	114.8	142.8	172.2	200.0	229.6	257.1	285.5
80	25	50,25	OUT	102.5	153.7	205.0	256.1	307.3	358.6	409.8	461.0	512.3
		45,33	IN	92.5	138.7	184.9	231.2	277.4	323.5	369.7	416.0	462.2
100	30	78,50	OUT	160.1	240.1	320.2	400.2	480.3	560.3	640.4	720.4	800.4
		71,44	IN	145.7	218.5	291.4	364.2	437.0	509.8	582.7	655.7	728.5

Appendix II: Isometric View



Appendix III: Exploded View