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Development of Dry Fruit Roasting Machine for Continuous Output

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Abstract - *Economies of most countries are predominantly agricultural-based. Global competition and technological advances are forcing engineers to constantly innovate new product manufacturing strategies in product development. We thought to develop a machine for roasting food items such as peanuts, previously there was a machine which works for the same except the output was discontinuous. We have selected a mechanism which we found suitable for satisfying the need for continuous output. This led us to generate the idea of implementing the screw conveyor mechanism along with heating elements below the screw conveyor tunnel. Our goal with this project work was to efficiently and effectively redesign a groundnut roaster that is automated and easy to fabricate. Through literature review, generation of ideas, and keeping given design restrictions in mind, our team developed a detachable roaster. The necessary geometric modeling is done in CAD software CATIA software. The trials are taken to ensure the development as per requirements. Also proper roasting in ensured in a single pass. A single worker is sufficient for this work. In future, the use of variable driving mechanism and more efficient heating methods would result in the more fast collection of desired product and can be made more comfortable to the user.*

Key Words: Automation, Continuous output, Roasting, Screw conveyer, Temperature control, Sprinkler system

1. INTRODUCTION

Groundnuts play an integral role in the livelihoods of the majority of the population in Africa through the provision of dietary nutrients and income. Groundnuts rank top on the list of alternative crops to replace tobacco, Malawi's main foreign exchange earner and are featured in Malawi's National Export Strategy 2013-2018. Malawi is currently the 9th largest exporter of groundnuts in the region (Simtowe et al., 2010), with South Africa as the largest importer of Malawian groundnuts.

Our goal with this project was to efficiently and effectively redesign a groundnut roaster that is automated and easy to fabricate. Through research, generation of ideas, and keeping given design restrictions in mind, our team developed a roaster i.e. a roaster and an auto feeding system together. The roaster is also detachable and easy to fabricate. The objective of our project was to successfully redesign a roasting system, that is cheap and affordable. Generally, our team was to come up with a roaster that is easy to use, detachable, user-friendly and automated. The goal our team accomplished was to design a coffee maker that is automated, a maker bigger than its original design, and still be detachable. Our design process began with the task of analyzing the current market and customer needs. Also, through external research, we generated ideas. Concept generation/selection narrowed our findings down tone superior maker. Objectives for the project work are summarized as under:

i. Proper loading of raw material inside the oven chamber.
ii. Material feeding system in the forward direction.
iii. Sprinkler system to spray as per taste requirement.
iv. Final roasting of raw material in the oven chamber 2.
v. Proper unloading of material at the exit of the system.

The targets that we selected from our project work were capacity of the roaster, the design of the drum, maintenance ease, combination of the feeder and the roaster, ease of use and cost. These targets were complimentary with the customer importance needs we assessed above. The ideal target specification would be the best that our team could hope for. The marginal is the minimal value we can produce with the customer still buying. The features of the capacity of the roaster, the design of the drum, a combination of feeder and roaster, cost, and how much it makes have specific numerical values, not ratings.

2. LITERATURE SURVEY

Under current conditions, crop dependency has made producers vulnerable to losses because of the lower prices paid for the pods and kernels. It is, therefore imperative for them to diversify their production and create added value through processing thereby reducing risks and opening new local and export markets. There is a necessity to investigate new opportunities for the use of groundnut as food and confectionery items. Most of the developing countries have poor drying and storage facilities. Under these conditions, the seed loses its quality and viability in storage rapidly. The purpose of this publication is to discuss the importance of the post-production system in developing countries and to suggest suitable curing, drying, storage and processing technologies. Advised methods are specially meant for the smallholder farmers and the most diversified uses of groundnut in confectionery items [4].

Groundnut, or peanut, is commonly called the poor man's nut. Today it is an important oilseed and food crop. This

plant is native to South America and has never been found uncultivated. The botanical name for groundnut, Arachis hypogaea Linn., is derived from two Greek words, Arachis meaning a legume and hypogaea meaning below ground, referring to the formation of pods in the soil. Groundnut is an upright or prostrate annual plant. It is generally distributed in the tropical, sub-tropical and warm temperate zones. Ethnological studies of the major Indian tribes of South America document the widespread culture of groundnut and provide indirect evidence for its domestication long before the Spanish Conquest. When the Spaniards returned to Europe they took groundnuts with them. Later traders were responsible for spreading the groundnut to Asia and Africa where it is now is grown between the latitudes 40°N and 40°S (Pattee and Young, 1982) [2].

Actual roasting conditions for groundnuts and coding levels of independent variables used in developing experimental for roasted groundnuts [3].

#	Actual		Coded	
	Roasting temperature (°C) T	Exposure time (min) t	Roasting temperature (°C) X_1	Exposure time (min) X_2
1	130	40	−1	1
2	150	20	1	−1
3	150	40	1	1
4	130	20	−1	−1
5	140	30	0	0
6	140	30	0	0
7	160	30	2	0
8	120	30	−2	0
9	140	50	0	2
10	140	10	0	−2

Table 1: Temperature and Roasting Time

Countries like South Africa, India, China and Egypt have good potential to utilize the opportunity to export groundnuts or groundnut products to the developed countries. They can earn valuable foreign exchange to improve their economic conditions. In the international market demand for groundnut products is determined by several factors. The primary factor in Africa has been population growth. In Asia, demand has grown due to a combination of population growth, increase in per capita income and urbanization. Expansion of urban areas signals higher incomes, higher opportunity cost of time and therefore greater demand for convenience foods. Groundnut production and consumption in the period up to 2010 is likely to shift progressively more to developing countries. This boost will be seen in all regions with most rapid growth in Asia. Per capita consumption will grow sharply in Asia, slowly in sub Saharan Africa and will decline in Latin America. Utilization will continue to shift away from groundnut oil towards groundnut meal, especially confectionery products (Freemanetal, 1999) [4].

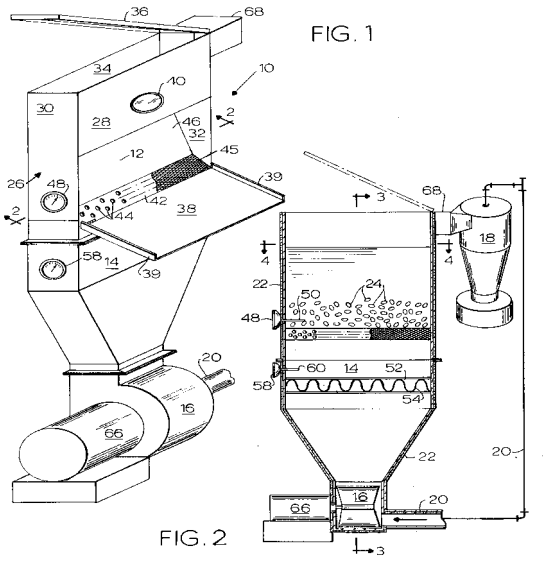

Figure 1 & Figure 2: Coffee bean roasting system

3. CONCEPTUAL DESIGN

This is our conceptual project 2D design as per our group discussion. The figure shows the conceptual model of our project. We have figured this out as per need and the requirement of the client. This includes our screw conveyor mechanism and heating elements.

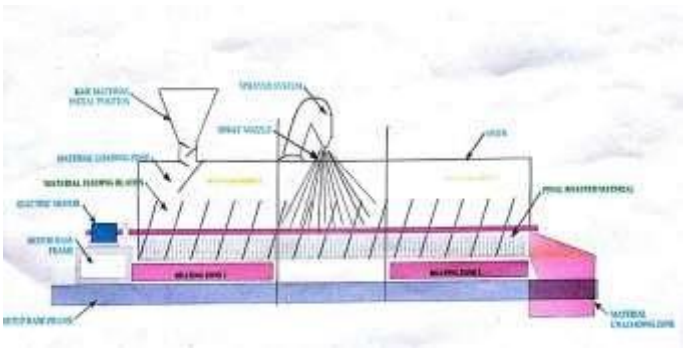

Figure 3: Conceptual Design of Machine

The upper conical shaped show the loading direction of material inside the oven system 1.

I. Further, the material is loaded inside the oven chamber1, now using the screw shaft the loaded, the material will be displaced in the forward direction as per the peed of a motor.

II. Now heating zone 1 get ready for heating.

III. Further material moves toward the additive zone, whereas per the taste requirement additive will be sprinkled on the surface of material of taste addition.

IV. Further, the material moves towards the oven chamber 2, here the final roasting of material takes place.

The material gets finally roasted & further falls inside the tray for material dispatch.

4. DESIGN CALCULATION AND ASSEMBLY USED

4.1 Roasting System Design Calculation

1. Temperature required for roasting

For Ground Nut Roasting temp required is about 187^0c.

2. Heating Chamber Design:

The packaging dimensions of the heating chamber are as under:

Outer Diameter of chamber is about 180mm
Thickness of heating chamber is about 2mm.
Length of heating chamber is 650 mm

3. Lead Screw Design :

Assumption: For one rotation of Lead screw we require forward movement of material by 50mm.
For Length of lead screw 650mm, After 13 Rotation of lead screw our raw material inserted will be converted into to final product.
Now in order to rotate the lead screw in low speed we have to design speed reduction gear box.
Now to reduce the speed we can use worm gear or bevel gear system.

4. Assumptions:

Lead Screw Rotates at 1 rpm. So we require13 minutes to roasting one set of groundnut.

5. For Designing Speed Reduction Gear Box We Have following data to be considered:

i. Output required speed: 1 RPM.
ii. Input Speed: 10 RPM.

We can above combination of gear systems listed below:

I. Worm Gear system
II. Spur gear system
III. Bevel gear system

From above system the system which will be cost effective for our project work we will be using that system.

6. Motor Selection:

Now input speed for gear system is 10 RPM.
So we will be using the DC motor, which will be running at 12 volt DC supply.
Torque Transmitting Capacity of Motor is 10kgcm.

7. Heating System Design:

We will be using Electric Heater.
Two heat arrangements are too be done first for initial heating & second one for Final heating system.

8. Additive Spraying System:

We will be using button operated spryer pump, it will spray the additive at the required pressure.
Its working input is 12 Volt DC Supply

It will be having a reservoir for the additive storage in required Quantity.

Volume of ground nut = (Weight of batch) / (Density)

$=9000gm/0.91gmcm^{-3}$

$=0.0108\ m^3$

Volume of Ground nut in container = 30%
Total volume of Cylinder = $0.0344m^3$

$V= (\pi/4) * d^2 * L$

$d = sqrt [(V*4) / (\pi*L)]$

$= sqrt [(0.0344*4) / (\pi*0.65)]$

$d = 0.205m$

Thickness of cylinder

$t = (p*d) / (2*\rho)$

$= (0.0015*0.20) / (2*0.3)$

$=0.52*10^{-3}$ m

Available sheet thickness = 1.5mm
Torque developed

Let P=0.0015MPa

D=0.20m

ς = 0.3 MPa

$Ts = (\pi*P*0.20^2) / 9.81$

= 1.514 Nm

The authors can acknowledge any person/authorities in this section. This is not mandatory.

4.2 Assembly used

1. Base Frame Assembly:

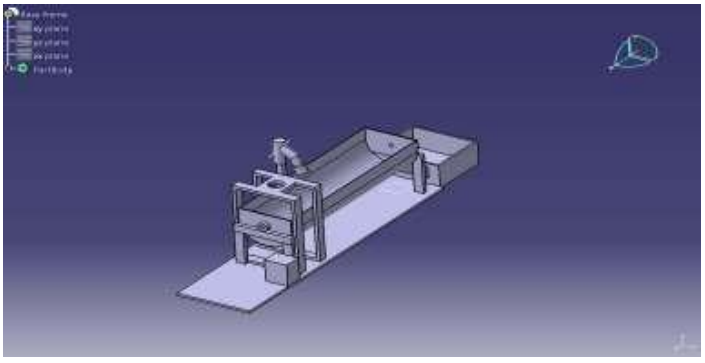

Figure 4: Assembly of Base Frame

2. Screw Conveyor

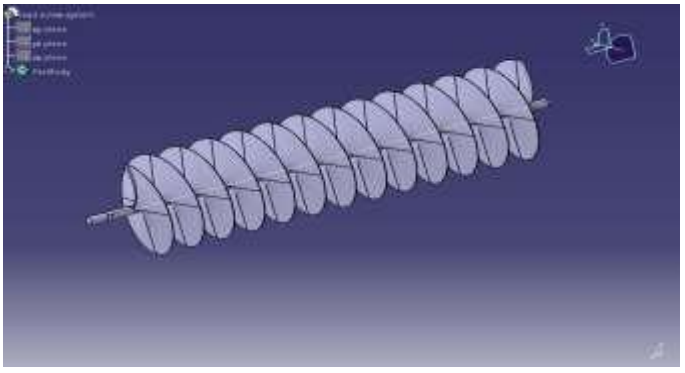

Figure 5: Screw conveyer

5. SYSTEM FINAL DESIGN AND EXPERIMENTAL RESULTS

5.1 System final design:

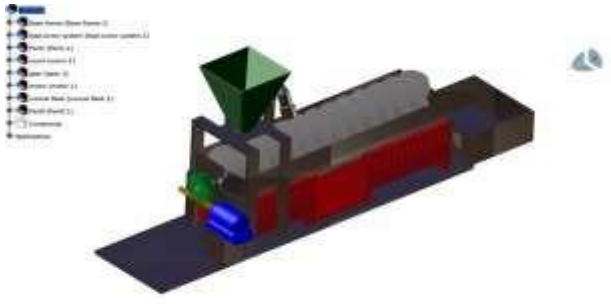

Figure 6: Roasting machine

5.2 Experimental results:

Sr. No	Time Period	Speed	INPUT WEIGHT (gm)	OUTPUT WEIGHT (gm)
1	1	3	600	570
2	1	3	600	580
3	1	3	600	575
4	1	3	600	582
5	1	3	600	568
6	1	3	600	565
7	1	3	600	561
8	1	3	600	569
9	1	3	600	571
10	1	3	600	583

Table 2: Result table

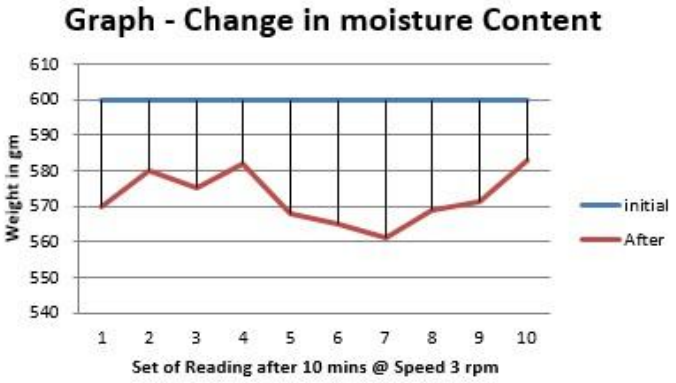

Figure 6: Graphical representation of result

5.3 Analysis of Frame:

i. Static analysis for 100N:

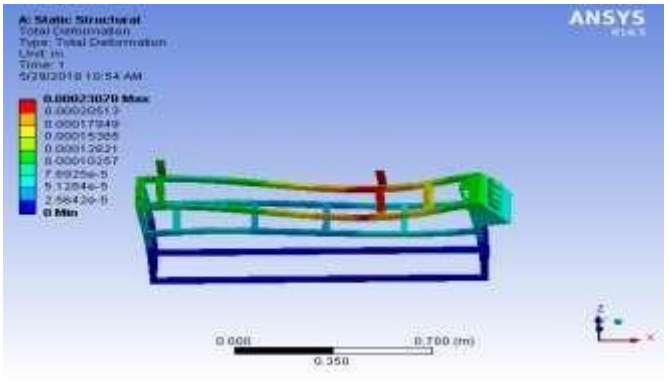

Figure 7: Static analysis

ii. Equivalent stress for 100N:

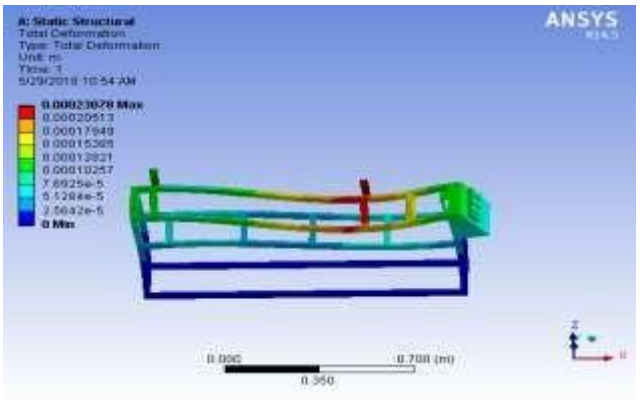

Figure 8: Equivalent Stress

6. CONCLUSION AND FUTURE WORK

The trials are taken to ensure the achievement of objectives of project work. The project confirms results as per objectives. Proper loading of raw material is inside the oven chamber 1. The material is fed in the forward direction. Final roasting of raw material in the oven chamber 2 and then proper unloading of material at the exit of system. In short proper roasting in ensured in single pass. A single worker is sufficient for this work.

Referring to the project work following are scope for future development:

As process as the function of roasting temperature, process timing can be varied by varying driving mechanism. Different materials can be mixed as per requirements, can be processed. By using the sprinkler, proper additive distribution using sprayer system is possible to ensure needed taste requirement.

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