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Design Development and Automation of Roasting System

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Abstract - *Many industrial processes need to control the transportation of food solids. Screw conveyers are one of the most useful conveyer devices and they are widely used in feeding device and lifting and grain process and for transporting and elevating particulates at control and steady rate. They are also used for metering from storage bins and adding small controlled amounts of trace materials. 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 with design a ground nut roaster 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.*

Key Words: Roasting Machine, Industrial Automation, Continuous output, zero pollution roasting, Dry fruit Roasting, Temperature.

1. INTRODUCTION

The problem given for our team to resolve was to redesign the system that is available at the market. We then needed to redesign this system to meet the needs of the everyday of the users in industry. However, our team was asked to keep several constraints in mind. These constraints included: to have the feeding be as automated as possible, able to perform two processes in one machine. 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 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. Our redesign altered the appearance of the former roaster. We did this externally, by incorporating an adjustable rotating blade with two of its ends, hence creating space for higher capacity rather than the fixed drum on the original roaster which had a small capacity for the beans. In the measurement and instrumentation aspect for temperature regulation, we decided to include a resistance temperature which is used as a temperature measuring device by passing a low current through it and measuring the voltage drop. The more the temperature rises the more the resistances build up and are hence translated to degrees. First, we completed product research. Next, customer needs were analysed and target specifications were determined. After, a concept generation morphological chart was used to develop ideas, and then limit them to the several best options for redesign. Lastly, one concept was selected via the use of a concept selection matrix. This specified design process is one which our team followed to a tee to bring forth the best possible option for redesign. It further proves that this is the best redesign selection through calculations and obtained evidence.

2. LITERATURE SURVEY

Olanrewaju T.O. et al. designed a material handling equipment, precisely a belt conveyor that was 3-roller idlers for crushing limestone. Their design preference were the size, length, capacity and speed, roller diameter, power and tension, idler spacing, drive type, angle and axis of rotation, and pulley arrangements. Their study was able to generate design data for industrial uses in the development of an automated belt conveyor system which was found to be fast, safe and efficient. Undisputedly, manual loading of grains into trailer and silo has its associated disadvantages, a mounted or trailer type of auger could be introduced for loading grains. Considering the economics of a trailer or mounted. type of auger, which are expensive in terms of fuel, man labor and maintenance, not also available in small/medium scale; this study designed and fabricated a simple and medium size auger aimed at conveying grains upward into a silo. The design and construction are expected to enhance handling of agricultural products during postharvest operations. Screw conveyors are one of the most useful conveyor devices, and they are widely used in feeding devices and lifting apparatuses, such as those used in pharmacies, mineral processing, and grain processing. Screw conveyors have good metering characteristics, use relatively simple components, are easy to control, and transport material at a steady rate. This conveyor device consists of an outer cylinder and an inner screw (Orifice & Khinast, 2017). Despite their simple mechanical structure, the flow behavior of solids in screw conveyors is complex. As a result, the relationships between the flow rate, material properties, and operation and design parameters are not clear.

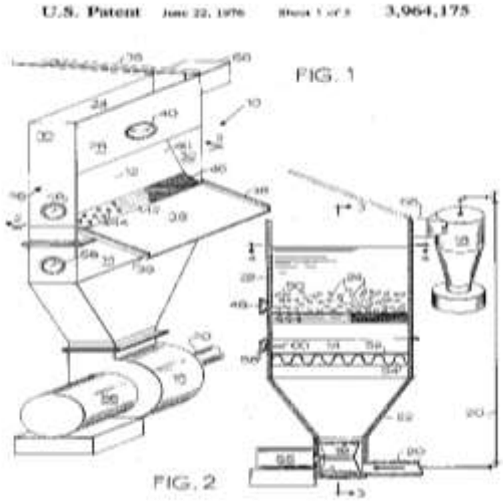

Figure 1: Coffee bean roasting system.

3. CONCEPT OF DESIGN

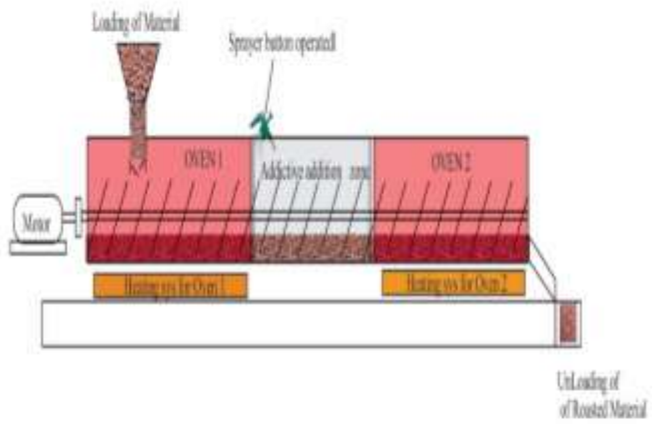

Figure 2: Concept of roasting system

The above points show the complete process flow of setup. The upper conical shaped show the loading direction of material inside the oven system 1. Further the material is loaded inside the oven chamber1, now using the screw shaft the loaded material will be displaced in forward direction as per the peed of motor. Now heating zone 1 get ready for heating. Further material moves toward the addictive zone, where as per the taste requirement addictive will be sprinkled on the surface of material of taste addition. 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 CALCULATIONS

According to speed for roasting, the conveyor speed is 5 to 7 rpm as per our observation. Therefore, on the basis of gear reduction we have selected motor of 10 rpm for getting required speed.

Motor Description: -

Speed: -10 rpm Voltage: - 12 volt Current: - 5 Amp

Power = V * I

= 12* 5

Power = 60 watts

$P = 2\pi NT/60000$

T = 0.057 N/mm

Mass of plates

Material used for shaft: Mild Steel

Density of Mild Steel(ϱ): 7850 kg/m^3

$\varrho = m/v$

$V = \pi/4(D^2 - d^2) * t$

$= \pi/4(0.170^2 - 0.025^2) * 1$

= 0.0000111 m^3

Therefore

$m = \varrho * v$

m = 0.08 kg

Mass of 11 plates

= 0.08*11

m all = 0.958 kg

Uniformly distributed load for shaft

= 10 N/m

W1=5 W2=5

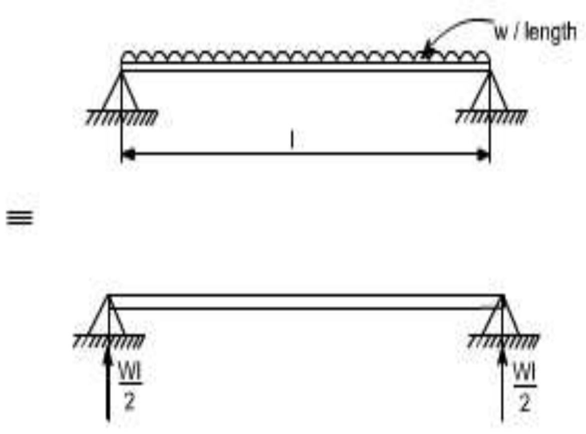

Figure 3: Bending Moment diagram.

Moment At point 1

M1= 0.3075*5 – 0.615*5

M1=3 Nm

M1= 0.3 *10^3 Nmm

Power transmitting = 60 Watt

P = Mtω

Mt = 47.77 Nm

Mt = 0.0477 * 10^3 Nmm

Equivalent BM from

$$M_e = \frac{1}{2}[M + \sqrt{M^2 + M_t^2}]$$

Me = 0.02543*10^3 Nmm

115 = 16*0.02543*10^3/πd^3

D = 24.40mm

≈ 25 mm

Type of gear: spur gear

Material used for gear: Cast iron

We have 10 rpm speed for gear 1

Teeth of gear 1 = 29

Teeth of gear 2 = 50

Z1/Z2 = N2 / N1

29/50 = N2/10

N2 = 5.8 rpm

≈ 6 rpm

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 require 13 minutes to roasting one set of ground nut.

5. Speed reduction of gear box:

For designing speed reduction gear box, we have following data to be considered:
i. Output required speed: 1 RPM. ii. Input Speed: 10 RPM.

6. Combination of gear systems

We can above combination of gear systems listed below:

1. Worm Gear system.
2. Spur gear system.
3. Bevel gear system.

From above system the system which will be cost effective for our project work we will be using that system. 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 = $0.0344m^3$

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

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

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

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.

5. DESIGN OF SETUP

Design of frame

The design of frame is major part while considering the overall setup mounting on the product. For Material bending material failure and structural analysis, we have chosen the Ansys software. All major components of system are analyzed under this software.

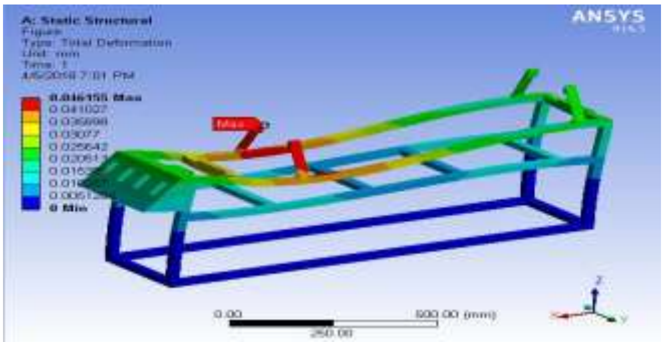

Figure 4: Static structural analysis of frame.

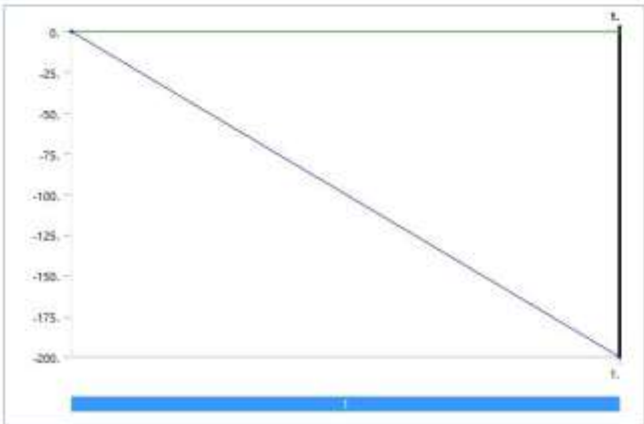

Figure 5: static structural force

Structural Steel > Strain-Life Parameters

Strength Coefficient MPa	920
Strength Exponent	-0.106
Ductility Coefficient	0.213
Ductility Exponent	-0.47
Cyclic Strength Coefficient MPa	1000
Cyclic strain hardening exponent	0.2

Structural Steel > Isotropic Elasticity

Temperature C	920
Young's Modulus MPa	2.e+005
Poisson's Ratio	0.3
Bulk Modulus MPa	1.6667e+005
Shear Modulus MPa	76923
Relative Permeability	10000

Structural Steel > Constants

Density	7.85e-006 kg mm^-3
Coefficient. of expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e - 004-ohm mm

Structural Steel > Isotropic Relative Permeability

Relative Permeability	10000

Design of Screw Conveyor

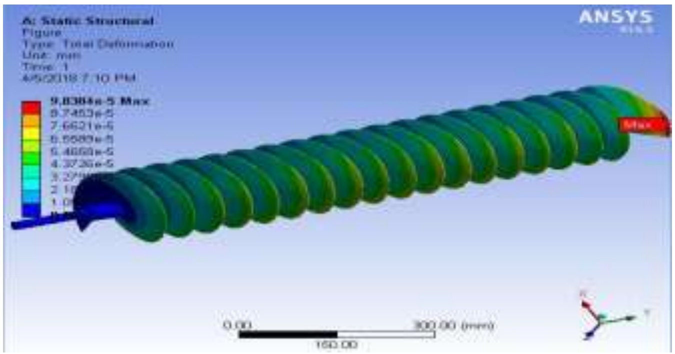

Figure 6: Static Structural analysis.

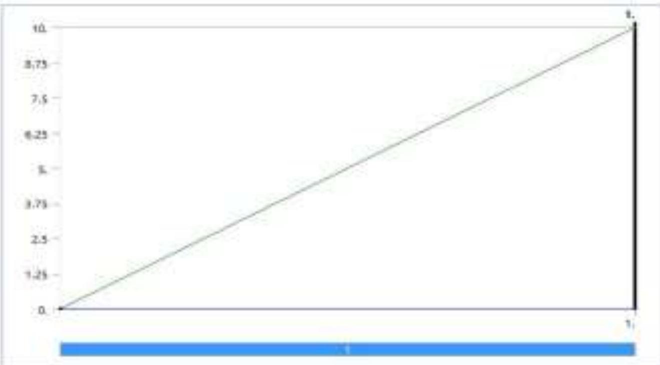

Figure 7: Static Structural force

Tensile Yield Strength MPa	250
Tensile Ultimate Strength MPa	460
Reference Temperature C	22
Compressive Yield Strength MPa	250
Compressive Ultimate Strength MPa	0
Bulk Modulus MPa	1.6667e+005

6. CONCLUSIONS

One of the most major drawback of conventional roasting system was heat loss occurring due to material. As the system is now fully electrical, zero pollution occurs from this setup with high rate of energy utilization. Continuous output of given input is possible in this setup. There are many manual temperature adjustments from which we can control and set the different temperature for different roasting products. Also, system is equipped with pre-heating and post heating due to which the lifespan of that products increases. By going through the food quality grade taste, it is found that due to even separation of heat we got uniform heating throughout all the products. Also due to temperature controls there are no any risk of over roasting. Pre-heating and post heating temperatures get maintained throughout the system.

Conventional system was greater in size and also skilled manpower requirement was there. Also, there was time lag in between two successive roasting operations due to which the continuous output for conveyor system was not possible. All above drawbacks are recovered in updated roasting setup. This setup gives continuous output. The system will work 24 hours because no manpower is required for this setup.

In future this machine will replace existing roasting system for fast output and zero pollution. This setup is manufactured under industrial purpose. By reducing dimensions we can manufacture same setup for running household applications.

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