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Design and Development of Tomato Sorting Machine

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Abstract: *This paper is intended to discuss the design of tomato sorting machine. Tomato Sorting Machine (TSM) is a machine used to effectively sort the tomatoes on Size based sorting. This machine can be used for the agricultural purpose and it can be also employed in the food industries. TSM will sort the tomatoes in three grades based on their size i.e. Small, Medium and Large. TSM works on belt and pulley arrangement. Tomatoes are fed through feeding tray into the machine. Grading of agricultural produce especially the vegetables has become a perquisite of trading across borders. In India mostly vegetables growers grade the vegetables manually. Manual grading was carried out by trained operators who considered a number of grading factors and vegetables were separated according to their physical quality. Manually grading was costly and grading operation was affected due to shortage of labour in peak seasons. Human operations may be inconsistent, less efficient and time consuming.*

Keywords: Belt and pulley arrangement, Tomatoes, size based sorting, belts and frame

I. Introduction

Tomatoes and tomato products are one of the most familiar vegetables in our diet. Tomato is very widely used and important vegetable in Nigeria. About 25,000 tons of fresh tomatoes are produced annually. It is grown for its fruit and is used in varieties of ways for the production of puree pastes, juices and canned fruits or mixed in chilly sources (Lagos, 1979). Tomato fruit is found to have high amount of vitamin C. the seed contains 22-29% crude fat, 15-28%crude fiber, 5-10% ash content and 23-34% crude protein according to Standarlyin. Moreover, agricultural sector plays an important role in economic development of every developing country like Nigeria. For the provision of food to the increasing population, supply of adequate raw materials to the growing industrial sector, a major source of employment, generation of foreign exchange earnings and provision of market for the product of the industrial sector among others.

As compared with the development in other sectors of the Economy, development in agricultural sectors very slow in Nigeria, due to the rise in crude oil revenue in the early 1970s [4], hence, there is a need to come up with some novel techniques so as to fore front the agricultural sector again. As tomato plays vital role in day-to-day life, sorting of tomatoes is necessary in evaluating agricultural produce, meeting quality standards and increasing market value. It is also helpful in planning and packaging. In Nigeria, human power in agricultural sector is widely used. If the sorting and grading is done through manual techniques, the process will be too slow and sometimes it will be prone terror.

In industry today tomatoes are sorted manually, as are Satsuma, limes, pomegranate, and other fruits. The objective of this research was to develop an efficient automated sorting system for tomatoes based on the image processing techniques that were effectively used with limes, pomegranate, and other products.

II. Problem Definition

Tomato is healthiest vegetable as a diet food. So tomato consumers demand better quality tomatoes. The criteria for evaluating a tomato's external appearance include distribution of color on the surface. Generally it can be identified by human expert but through eyes, it has resulted in a serious problem because miss judgment occurs frequently due to recurring fluctuations in quality identification criteria. This issue motivate intensive research work to implement flexible and effective systems to sort Tomato's.

III. Literature Review

Color is the most important features for accurate classification and sorting of tomato. Because of the ever-growing need to supply high quality food products within a short time, automated grading of agricultural products is getting special priority among many farmer associations. The impetus for these trends can be attributed to increased awareness by consumers about their better health well-being and a response by producers on the need to provide quality guaranteed products with consistency. It is in this context that the field of automatic inspection and machine vision comes into play the important role of quality control for agricultural products [1]–[2].

In [3], Zhang developed a machine vision system to automatically sort cherry tomato according to maturity. Nine features were extracted from each image. Tomatoes were classified into three categories (unripe, half ripe and ripe). Images were captured in the RGB color space. The principle component analysis (PCA) result showed that ripe tomatoes were distinguished from mature and half ripe tomato. The machine was able to correctly classify 93.2% of tomato sample. The use of color sensor would have reduced the processing period.

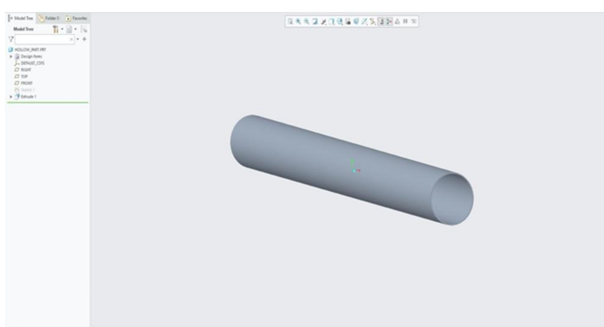
Kalaivani in [4] developed method of identifying good and bad tomatoes by image processing using MATLAB. They used different methods like thresholding, segmentation and k-means clustering after extracting certain features from the input data and used the related database get a specific range for good and bad tomatoes, andtheyachieved80%accuracy. Computerized spoiled tomato detection was developed in [5]. In this paper illustrates the improvement of a low cost machine vision system using webcams and image processing algorithms for defect detection and sorting of tomatoes The sorting decision was based on three features extracted by the different image processing algorithms. This methodology based on the color features, which used for detecting the BER from good tomatoes. Two methods were developed for decision based sorting. The color image threshold method with shape factor was found efficient for differentiating good and defective tomatoes. The overall accuracy of defect detection attained was 94 and 96.5% respectively. This is only applicable when separating Blossom End Rot (BER)from good tomatoes. The system should have used color sensor instead of the webcam

IV. Material and Methodology

Modeling of Tomato sorting machine was done with the help of CATIA software. Then its dynamic working madel is run on solid works to get theoretical calculations. The raw materials used in this work are Hollow rollers, solid rod, bearing, bracket, disc, L-shape plate, covering and dimensions of specimen are as follows:

4.1 Dimension of Roller

- Outer Diameter = 50 mm
- Thickness = 1.2 mm
- Length = 500 mm



4.2 Dimensions for Solid Rod

- Diameter = 15 mm
- Length = 607 mm

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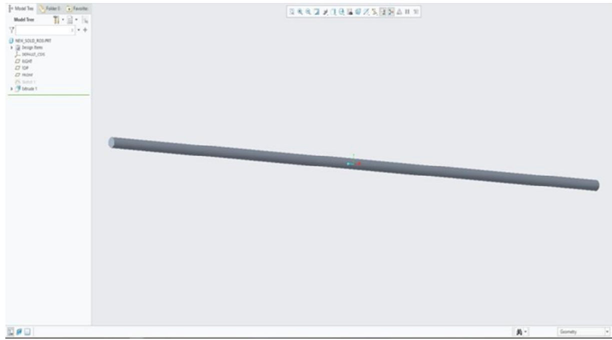
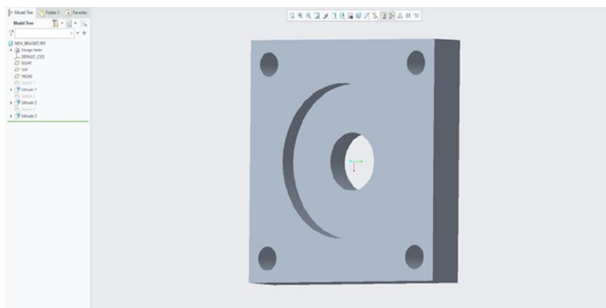


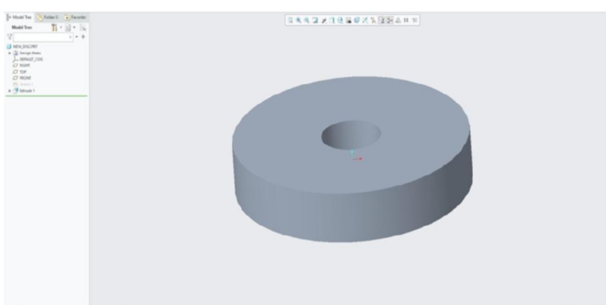
4.3 Dimension of Bracket

- Size = 50x50 mm
- Bearing dia. = 32 mm
- Hole dia. = 12 mm
- Bracket Thickness = 12 mm



4.4 Dimension of Disc

- Outer Dia. = 47.60 mm
- Inner Dia. = 12 mm
- Thickness = 10 mm



4.5 Dimension of L shape Plate

- Length = 1700 mm
- Height = 100 mm
- Width = 60 mm
- Thickness = 3 mm

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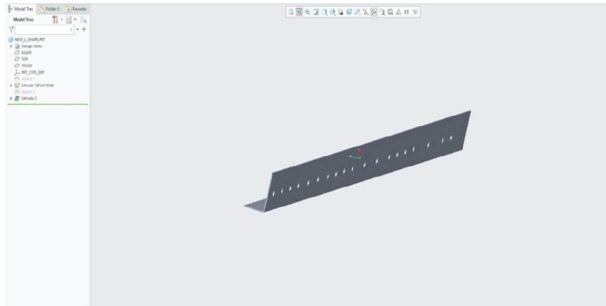
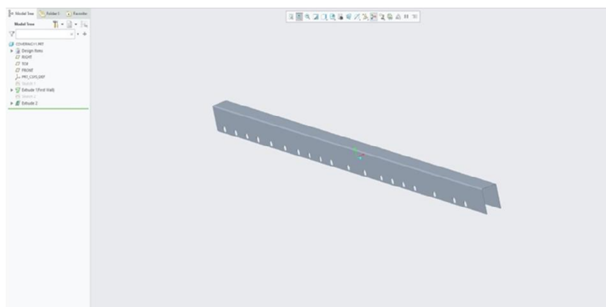


4.6 Dimension of Covering

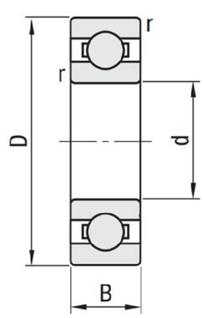
- H1 = 80 mm
- H2 = 22 mm
- Width = 60 mm
- Length = 1700 mm



4.7 Dimension of Bearing

- Deep Groove 6201 Ball Bearings 12mm X 32mm X 10mm

Universal	6201
Type	Ball
Inner/Outer Ring Material	Steel
Precision	Grade 0
Inner Dimension d(Ø)	12
Outer Dimension D(Ø)	32
Width B (or T)(mm)	10
Retainer Type	Punching
Load Direction	Radial
Specifications/Environment	Standard
Number of Raceway Ring Rows	Single Track
Size Standards	Metric Series



4.8 Dimension of Sprocket

- Pitch =3/8
- Thickness = 4.672mm
- OD = 50mm
- ID = 25.1mm

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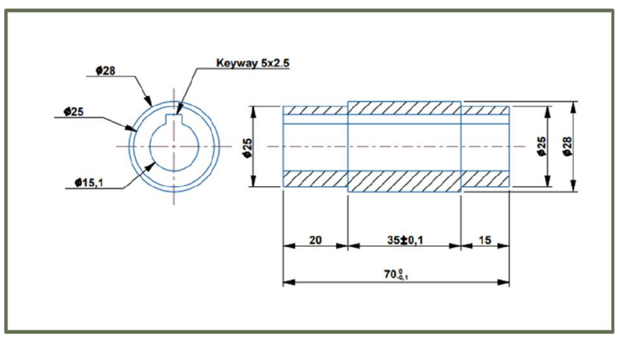
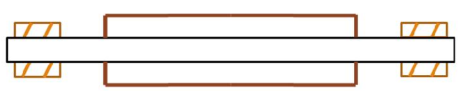
4.9 Dimension of Hub

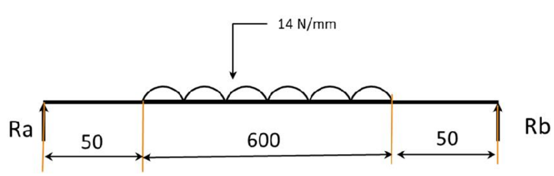
- Length = 70mm
- OD=28mm
- ID= 12mm



V. Calculations

A. Calculation for Solid Rod:





Reaction Forces

$Ra=Rb=4.2KN$.

This force tends to break rod in shear,

$\tau=P/A$

$= (4.2e3/ ((\pi/4)*(12^2))$

$=37.13\ N/mm^2$

Considering FOS =2;

So, $\tau=74.27\ N/mm^2$

$=75\ N/m2 \quad < 230\ N/mm^2$ (Permissible value)

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B. Bending Stress on Shaft:

By flexure formula,

$$\frac{M}{I} = \frac{\sigma b}{y} = \frac{E}{R}$$

For circular shaft and simply supported,

Bending Stress acting is,

$$\sigma b = M.y$$

$$\sigma b = \frac{0.25 \times (14 \times 600) \times 700 \times 6}{\frac{\pi \times (124)}{64}}$$

$$\sigma b = 86.65 \text{ N/mm2}$$

Considering Factor of Safety as 2.

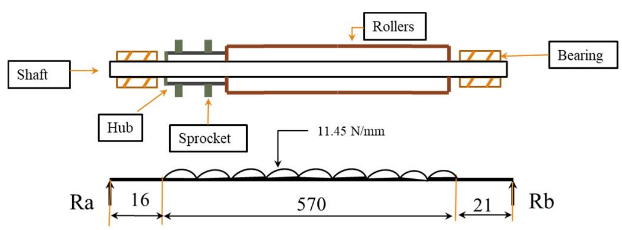
$$\therefore \sigma b = 86.65 \times 2$$

$$= 173.3 \text{ N/mm2}$$

$$\sigma b \cong 173.3 \text{ N/mm2} < 220 \text{ N/mm2}$$

As bending stress and shear stresses on shaft is less than permissible strength of material Therefore design is safe.

C. Calculation for Solid Rod



1. Calculation for Weight of Roller:

Volume of roller = 114275 mm3

Density of Steel = 7.86 x 10-6 Kg/mm3

Weight of roller = Volume X Density

= 114275 x 7.86 x 10-6

= 0.898 Kg.

2. Calculation of forces:

Calculation for Weight of Hub Assembly.

Volume of roller = 34410mm3

Density of Steel = 7.86 x 10-6 Kg/mm3

Weight of roller = Volume x Density

= 34410 x 7.86 x 10 = 0.270 Kg.

3. Total Load Acting on shaft:

Weight of Roller + Weight of Hub assembly = 0.898 + 0.270 = 1.168 kg.

Total Load = 1.168 x 9.81 = 11.45 N.

Therefore, load of 11.45 N is acting uniformly over spam of 570mm.

4. Reaction Forces:

Ra + Rb = 11.45 x 570 = 6526.5 N

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Taking Moment at point A,

ΣMA = 0

6526.5 x 301 - Rb x 607 = 0

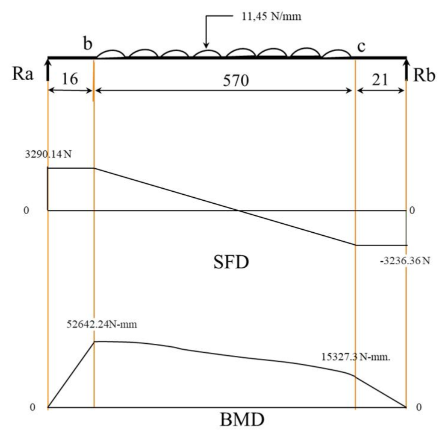
Rb = 1964.47/607 = 3236.36 N.

Therefore,

Ra = 6526.5 - Rb

= 6526.5 - 3236.36

Ra = 3290.14N



5. Shear Force Calculation:

Fal = 0 N

Far = 3290.14 N

Fc = 3290.14 N

Fd = 3290.14 - 6526.5 = -3236.36 N

Fbl = 3290.14 - 6526.5 = -3236.36 N

Fbr = 3290.14 - 6526.5 +3236.36 N

= 0 N

6. Bending Moment Calculations:

Ma = 0 N-mm

Mc = 3290.14 x 16 = 52642.24 N-mm.

Md =3290.14 x 570 - 6526.5 x 285

= 15327.3 N-mm.

Mb=3290.14 x 607 - 6526.5 x 306

= 0 N-mm

7. Principal Stress calculations:-

Shear Stress acting on rod =

Taking maximum force value from SFD

τ = P/A

= 3290.14/ [(π/4)*122]

= 29.09 N/mm²

Torque acing on rod =

T = τπd3/16

T = (29.09 x π x123)/16

T = 9870 N-mm

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Taking Maximum Value of Bending Moment = 52642.24 N.

= (16/πd3) x [M+(M2+T2)-2]

= [16/π(123)] x [52642.24 + (52642.242+98702) -2]

= 156.50 N/mm2 < 230 N/mm² (Permissible value)

As stresses on shaft is less than permissible strength of material,
Therefore design is safe.

VI. Working

6.1 Transmission of Power to the Roller

Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles. We transmit power to rollers by chain drive mechanism. Chain drives are most commonly used to transmit power between two components that are at a greater distance, but they also be used for short distances. Chain drive is a type of mechanical power transmission system that uses chains to transfer power from one place to another. A conventional chain drive consists of two or more sprockets and the chain itself. The holes in the chain links fit over the sprocket teeth. When the prime mover rotates, the chain wrapped on the shaft's sprocket rotates with it. This applies mechanical force onto the driven shaft, transmitting mechanical power in the process.

In our roller conveyor system we use chain drive for reduce friction and improve efficiency.

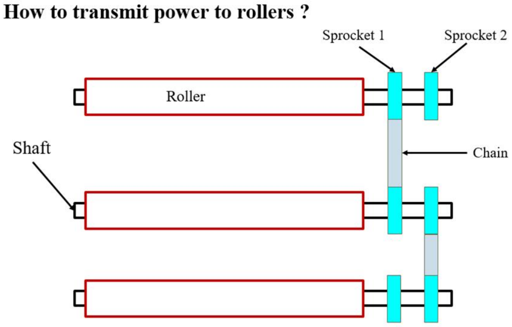

Figure showing how power is being transmitted

VII. Result And Discussion

The experimental setup was carried out to sort the Tomato's according to their sizes. The sizes considered for the experiment are tomatoes of 5 centimeters and 10 centimeters. The roller of the first 3/2 roller-operated DCV is named as A and the roller of the second is named as B. The roller A and B are mounted at a height of 10 centimeters and 5 centimeters respectively. The findings of this experiment are explained and illustrated as follows.

The result shows that modal frequencies are changing as the arrangement of rivets are changing of single lap riveted joint. The result shows that the modal frequencies are depend on mode shapes. The figure 10 shows the modal frequencies behavior for different arrangement of single lap riveted joint. The inspection of modal frequencies shows that most of the modal frequencies are similar for different arrangement of single lap riveted joint.

VIII. Conclusion

The Automatic Sorting Machine works effectively and makes sorting process easy, more precise and reliable and is more advantageous than the conventional methods reducing manual efforts, errors and being much efficient. The proposed prototype allows achieving an economical and a low-cost automation. The sorting action can be made flexible according to the industrial needs. In case of any breakdown, the system can be easily restored and commissioned upon diagnosis.

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Authors Profile

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