Design and manufacturing of sugar cane peeling machine

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ABSTRACT: -

This project work is on the design and manufacturing of a sugarcane peeling machine. It is aimed at providing a base for the commercial production of a sugarcane peeling machine, using locally available raw materials at a relatively low cost. The successful fabrication of a sugarcane peeling machine is one of the major, if not the major, challenge in sugarcane processing. This work is intended to help solve some of the problems hindering a successful design and manufacturing of a sugarcane peeling machine.

In recent development, machine designers and engineers intensified efforts toward finding lasting solution to the sugarcane peeling problem. Sugarcanes were graded into small, medium and large sizes. Machine was tested by abrasive tool and efficiency upto 59.66% was achieved.

Key word: Sugar cane, peeling machine, abrasive, efficiency.

INTRODUCTION:

The sugar cane family is made up of over 30 sugar cane varieties. Sugar cane is a perennial grass that thrives in hot, humid locations like Brazil and India. The sugar derived from sugar cane is used in syrups, juices, and molasses, but the rest of the plant can also be used in the production of environmentally friendly paper products. Sugar cane is a subtropical/tropical grass that originated in Papua, New Guinea and spread throughout Southeast Asia, India, the Mediterranean, the Caribbean, Hawaii and the southern United States because of human migration and the slave trade. The migrations have also resulted in hybrid sugar cane plants. The juice from the sugar cane's stalk is highly prized and is the source of 70 percent of the world's sugar. It also has the highest number of calories per unit area of any plant. Fresh sugarcane juice is a popular beverage in many countries particularly in Asian region such as China, India, Malaysia and Thailand due to its taste and cheap price. It is served in many eateries from roadside stalls to five-star hotel dining halls. Additionally, sugarcane juice is used for the medication in some countries. For instance, the Indian systems of medicine have utilized it to cure jaundice and liver-related disorders. Flavonoids that can be found in sugarcane juice have the abilities to protect cells from degenerative processes and to reduce the development of health problems such as cancer and cardiovascular diseases. Although the industrial production of sugarcane juice has a business potential, the selling of sugarcane juice cannot be expanded as expected owing to its rapid quality descent. The juice concentration is deemed as a solution to lengthen the shelf-life, reduce the storage and shipping costs, and elevate the consumer safety while preserving the fresh quality of sugarcane juice.

LITERATURE REVIEW:

Bundit Jarimopas et al (Oct 8, 2008)**:** constructed a prototype automatic young coconut fruit trimming machine. The fruit consists of a husk enclosing shell, flesh and juice. Normally, the fruit is manually trimmed requires considerable physical strength and a very large sharp knife, and thus is a dangerous procedure. Other problems associated with manual trimming are the shortage of skilled labour and the considerable amount of time that the trimming procedure takes. So, they developed a prototype of young coconut fruit trimming machine which appeared to have more potential.

Fara Farhana Binti Abdul Basek : designed and developed orange peeler An orange is a type of citrus fruit which people often eat. Oranges are a very good source of vitamins, especially vitamin C. Orange juice is an important part of many people's breakfast. Peeling orange is not an easy process. There are several problems that need to be encountered during peeling orange process. Common method of peeling orange is using bare hand and a sharp knife. Peeling orange is not very appropriate due to its high risk of causing injury, many of people start to develop a new technique to peel orange. This thesis deals with the design and development of an orange peeler with an ergonomics approach. The objectives of this thesis are to design an orange peeler with an ergonomics approach by using SolidWork and simulate by using ALGOR.

WORKING OF MACHINE:

Principle of working:

"When sugar cane passing through the rotating hollow shaft due to blades and brushes inside the hollow shaft, upper surface of sugar cane is removed and peeled sugar cane is pulled by means of rollers"

Working:

When motor is started, it gives drive to hollow shaft and worm gear. When motor is rotated, due to the worm and worm gear power is transmitted in 90 degree. This is used to rotate the rollers in perpendicular to plane. Inner race of bearing and hollow shaft is rotated by means of direct drive from motor .When sugar cane is passed through the rotating hollow shaft, sugar cane first comes in contact with brushes. These brushes first clean the sugar cane and remove the black carbon present on the sugarcane. Then sugar cane come in contact with spring loaded blade assembly, here actual peeling of sugar cane takes place. Due to the springs, when size of sugar cane varies, diameters between blades also vary. And change in size of sugar cane can be compensated by means of spring loaded blade assembly. After this sugar cane passes through two rollers moving in opposite direction .This rollers is used to pull the peeled sugar cane from the hollow shaft.

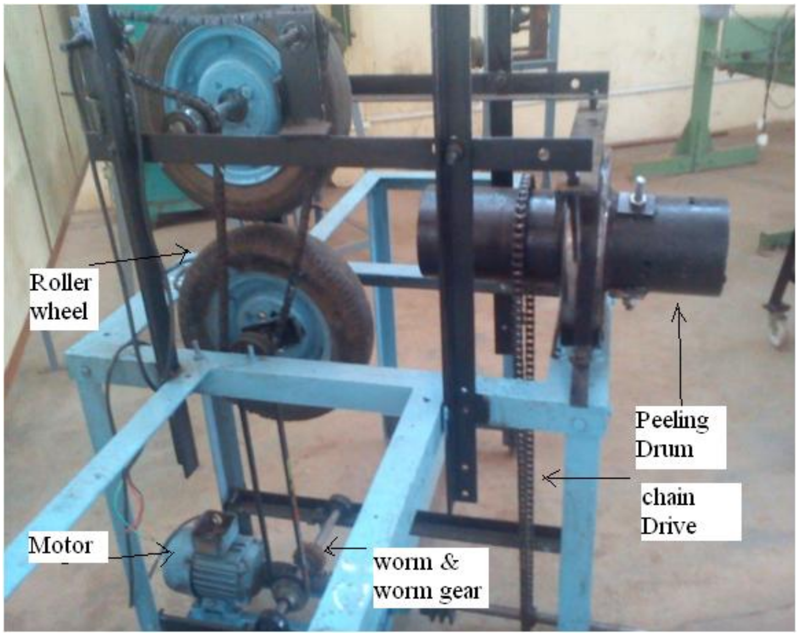

Fig1. Sugar cane peeling machine

DESIGN ANALYSIS

The following were identified as needed to be determined in order to analyze completely the component parts of the machine.

Determination of the weight of the peeling drum

Mass of the drum m is given by,

$m = \rho V$ ………. (1)

Where ρ = the density of the material
V = volume.
L = Length
But,
V = (Length x Area)
$V = L \text{ x } \frac{\pi}{4} \times (D^2 - d^2)$
Hence equation (1) becomes
m = ρ x $V = L \text{ x } \frac{\pi}{4} \times (D^2 - d^2)$
= 2.20 kg……………… (2)
Weight of the drum is given by,
$W = mg$ Substituting equation (2) gives
W = 21.60 N ……………….. (3)

Estimation of Power Required by the Machine

The force F required to peel out the sugarcane by the drum of mass m having a tangential acceleration a is given by:

$F = ma$ …………… (4)

From the equation of motion:

$v = u + at$ Therefore,

$a = v + ut$ …………… (5)

Since the drum is turning at an average constant speed by the time the peeling begins, the initial speed u is zero. Hence equation (5) reduces to:

$a = vt$ ………….. (6)

Substituting equation (6) into (4), gives

$F = mvt$ ……….. (7)

We know that speed, v in terms of angular speed, N is given by:

$v = 2\pi rN/60$ ………. (8)

Where r is the radius of the peeling drum.

Therefore, equation (7) becomes:

$F = m \text{ x } 2\pi rN/60t$ For one seconds, the force becomes:

$F = m\ 2\pi rN/60$ ……… (9)

This is the load per second on the peeling drum as the peeling is in progress. The torque, T due to this load is given by:

$T = Fr$ …………. (10)

Substituting equation (9) from (10)

$T = \frac{2\pi r 2mN}{60}$ ………… (11)

The power P required to drive this torque is given by:

$P = T\omega$ ………. (12)

Where ω is the angular speed, which is given by:

$\omega = 2\pi N60$

Therefore, equation (12) becomes:

$P = T\ 2\pi N/60$ ……………. (13)

Substituting equation (11) into (13), gives

$$P = m\left(\frac{2\pi N}{60}\right)^2$$

$$= 2.2\left(\frac{2 \times 3.14 \times 308.57}{60}\right)^2$$

$= 0.22$ KW

Design Of Bearing: (Pedestal Bearing)

Given Data:

Shaft Diameter= 20 mm, $L_{10}h$ = 30000, Speed=100 rpm, Fr= 5KN

Dynamic Load Capacity= P= Fr= 5000N

$L_{10} = 60 \times N \times L_{10}h/10^6$

$= 60 \times 30000 \times 100 \times 10^6$

= 180 million rev.

$C = P \times (L_{10}h)^{1/3}$

$= 5000 \times (180)^{1/3}$

$=$ **28231.08 N**

From this dynamic load capacity and diameter select bearing **6404**

Difference between the expected and actual dynamic capabilities viz (30700 - 28231.08) = 2468.92 negligible.

Outer diameter of bearing, D=**72mm**

Axial width of bearing, B=**19mm**

Design of main bearing:

Size:

Inner races diameter = sugarcane diameter + blade width + spring height

= 45+60+55

= **160mm**

Outer races diameter =sugarcane diameter + blade width + spring height + pipe diameter + Ball diameter

= 45+60+55+10+40

= **210mm**

Selection of coupling:

Dia. of motor shaft= **14 mm**

We selected flexible coupling with rubber bush.

Selection of pipe :

Inner diameter of shaft = 160 mm

Length of shaft = 300 mm

Material = cast iron

Selection of motor :

Power = 0.37 hp

Speed = 1440 rpm

Design of worm :

Given data:

φ = 20°, P = 0.37 KW, speed = N= 1375 rpm, V. R. = 14, x = 52 mm

$\cot^3\lambda$ = V.R.

$\cot^3\lambda$ = 14

$\cot\lambda$ = 2.41

λ = 22.29°

We know that

$$\frac{x}{l_n} = \frac{1}{2\,\pi}\left(\frac{1}{\sin\,\alpha} + \frac{V.R.}{\cos\,\alpha}\right)$$

$$\frac{52}{l_n} = \frac{1}{2\pi}\left(\frac{1}{\sin\,22.29°} + \frac{14}{\cos\,22.29°}\right)$$

l_n = 35.4 mm

$$l = \frac{l_n}{\cos\,\lambda} = 38.32 \text{ mm}$$

For V.R. of 14 no of starts on the worm

n = 4

Axial pitch of the threads on the worm

p_a = l/4 = 9.58 mm

m = p_a/ π = 3.05 mm

Let us takes standard value of module, m = 4 mm

Axial pitch of the threads on the worms

$p_a = \pi \times m = 12.56mm$

Axial leads of the threads on the worm

$l = Pa \times n = 38.32$ mm

And normal lead of the threads on the worm

$l_N = l \times \cos\alpha = 35.45$ mm

We know that the centre distance,

$$x = \frac{l_N}{2n}\left(\frac{1}{\sin\lambda} + \frac{V.R.}{\cos\lambda}\right)$$

$$= \frac{35.45}{2n}\left(\frac{1}{\sin 22.29} + \frac{14}{\cos 22.29}\right)$$

$= 87.95$ mm

Let D_w = Pitch circle diameter of the worm

We know that, $\tan\lambda = \frac{l}{\pi D_w}$

$$D_w = \frac{l}{\pi \tan\lambda}$$

$$= \frac{38.32}{\pi \tan 22.29}$$

$= 29.75$ mm

Number teeth on worm,

$T_G = 14 \times 1 = 14$

Face length of the worm or the length of threaded portion is,

$L_w = p_c\,(4.5 + 0.02\,T_w)$

$= 9.58\,(4.5 + 0.02 \times 4)$

This length should be increased by 25 to 30 for the feed marks produced by the vibrating grinding wheel as it leaves the root. Therefore let us take

$L_w = 70$ mm

We know that depth of tooth,

h = 0.623 p_c

= 0.623 × 12.56

= **5.96 mm**

And addendum,

a = 0.286 p_c

= 0.286 × 9.58

= **2.73 mm**

Outside diameter of worm,

D_{ow} = D_w + 2a

= 29.75 + (2 × 2.73)

= **35.31 mm**

7.9 Design of worm gear:

We know that pitch circle diameter of the worm gear,

D_G = m × T_G = 4 × 15= **60 mm**

Outside diameter of worm gear,

D_{OG} = D_G + 0.8903 p_c

= 60 + (0.8903 ×9.58)

= **68 mm**

Face width,

b = 2.15 p_c + 5

= (2.15 × 9.58) + 5

= **25.59 mm**

PART DRAWING

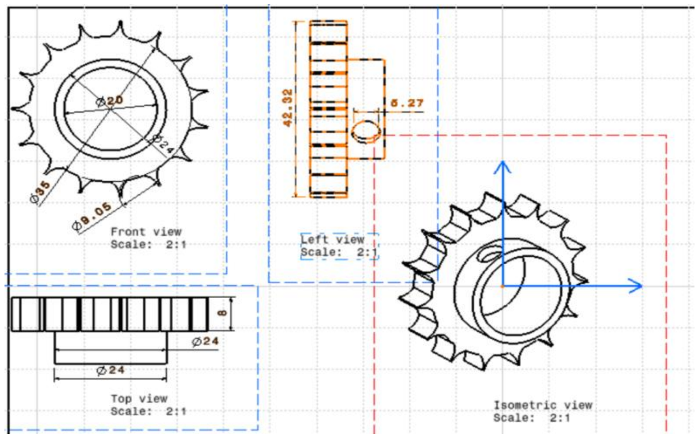

Fig 2 : Sprocket

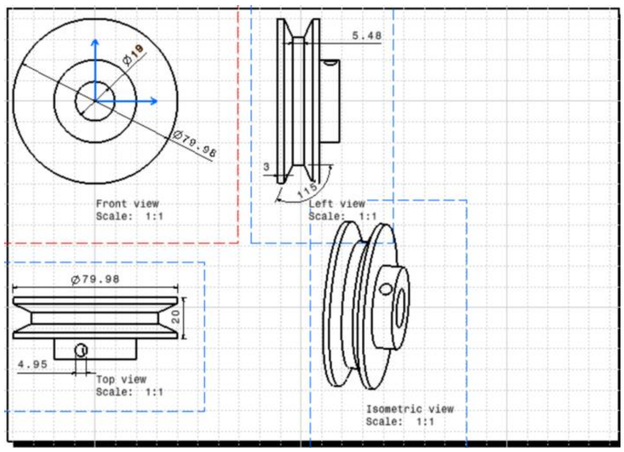

Fig 3: Pulley

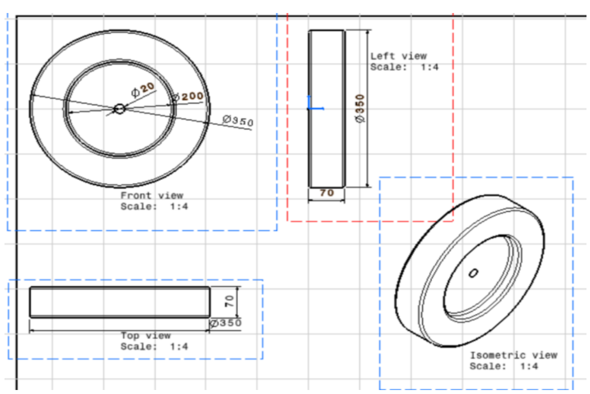

Fig 4: Roller

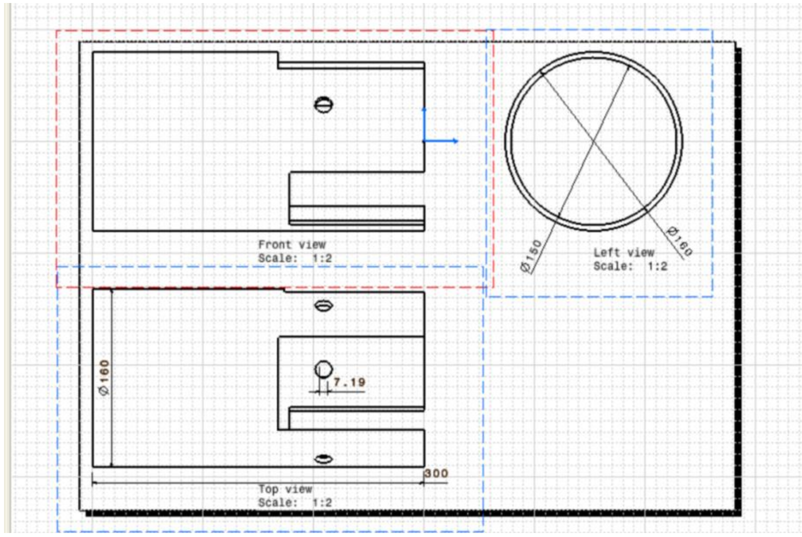

Fig 5: Pipe

13. TESTING

The machine having completed, in terms of the design and fabrication, was tested to verify if the efficiency of peeling is satisfactory. In fact, all the design concepts and calculated results were religiously followed and arrived at with little or no variations. Finally, the peeling machine was tested with approximately linear sugarcane. With continuous rotation of the drum, the portion that comes in contact with the peeling blade was rapidly bruised off.

The Efficiency of peeling of the machine was estimated using the ratio;

Thickness of sugarcane peeled by machine (ta): ideal thickness to be peeled by machine (ti) Thus,

Efficiency = ta/ti x 100

From 3 samples, the efficiency was estimated as follows;

13.1 SAMPLE 1

Diameter of the sugarcane before peeling = 37.11mm

Diameter of the sugarcane after peeling = 36.44mm

Thickness of sugarcane peeled by the machine (ta) = 0.67mm

Ideal thickness to be peeled (ti) = 1.00mm

Efficiency of peeler = ta/ti x 100

$$= \frac{0.67}{1} \text{ x } 100 \quad \mathbf{= 67\%}$$

Fig No.6 Before Peeling

Fig No. 7 After Peeling

13.2 SAMPLE 2

Diameter of tuber before peeling = 28.44mm

Diameter of sugarcane after peeling = 27.93mm

Thickness of sugarcane peeled by the machine (ta) = 0.51mm

Ideal thickness to be peeled (ti) = 1.00mm

Efficiency of peeler = ta/ti x 100

$$= \frac{0.51}{1} \text{ x } 10$$

= 51%

Fig No.8 Before Peeling

Fig No.9 After Peeling

13.3 SAMPLE 3

Diameter of sugarcane before peeling = 32.16mm

Diameter of sugarcane after peeling = 31.55mm

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Thickness of sugarcane peeled by the machine (ta) = 0.61mm

Ideal thickness to be peeled (ti) = 1.00mm

Efficiency of peeler = ta/ti x 100

$$= \frac{0.61}{1} \times 100 = \mathbf{61\%}$$

Fig No.10 Before Peeling

Fig No. 11 After Peeling

Thus, Average Efficiency = (67+57+61)/3

= 59.66%

Hence the Efficiency of peeling of the machine is estimated at 59.66%.

CONCLUSION:

At the end of an intensive literature research, construction and testing, satisfactory sugarcane peeling machine with efficiency of 59.66% was fabricated using the available raw materials and techniques. The approximately linear sugarcane was loaded and conveyed by hand to the peeling drum.

The overall performance of the machine is more efficient compared to already existing ones. The cost of production and maintenance is relatively cheap. Hence, the machine will be welcomed by industries given its performance, affordability and simplicity.

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