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Design and Development of Coconut Rancidity testing Machine

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ABSTRACT

Coconut has so varied uses, and since most of the uses are in consumable form, its rancidity needs to be tested before being processed. If a rancid coconut is used, its water, milk and meat subsequently turn rancid; and it may not be palatable or edible for consumption. In any coconut processing industry, a coconut is first broken, water is extracted and coir is used for various purposes. Hence, it becomes very important to detect its rancidity. But this should be done before breaking the coconut for water extraction so that rancid coconuts are not being processed further Water and meat extracted in a coconut processing line may get contaminated due to rancidity of mature coconut. To reduce entire coconut water and meat from being contaminated, it becomes a necessity to separate out rancid coconuts before water and meat extraction. Conventional methods used for rancidity testing are namely sloshing, Visual inspection, Ultra-sound or X-ray but it is found that the techniques though adaptable for full automation may not be reliable or economical hence a new method of rancidity testing needs to be devised where in the process can be reliable , repeatable and also economical. The proposed method involves creation of vibration response of the coconut shell to be tested by striking a brass tong onto the shell at various intensities and study the peak acceleration, displacement and frequency of the holding pad to detect rancidity of the coconut. The project involves design development of the brass tong striking mechanism, mounting pad and vibrometer probe mounting mechanism for non-destructive rancidity detection of a coconut

Keywords- *a* **coconut, coconut rancidity, coconut testing, coconut water extraction, slosh test**

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I. INTRODUCTION

In any coconut processing industry, a coconut is first broken, water is extracted and coir is used for various purposes. [1] [2] Hence, it becomes very important to detect its rancidity. But this should be done before breaking the coconut for water extraction so that rancid coconuts are not being processed further.By doing so, we can eliminate the chances of rancid coconut water contaminating the entire extracted coconut water.

II.OBJECTIVES

The objective is to test the rancidity of a coconut using non-destructive procedures in a reliable & economical way.

III.WHAT IS RANCIDITY

Rancidity is the chemical decomposition of fats, oils and other lipids. When these processes occur in food, undesirable odours and flavours can result.

Rancidity is a very general term and in its most general meaning, it refers to the spoilage of a food in such a way that it becomes undesirable (and usually unsafe) for consumption. When people say that a food has "gone bad," what they're usually talking about is rancidity. Most of the time, but not always, rancidity can change the odours or flavours of a food in such a way that it becomes very unpleasant to smell or taste. While most any food can technically become rancid, this term applies particularly to oils. Oils can be especially susceptible to rancidity because their chemistry can make them exceptionally susceptible to oxygen damage. When food scientists talk about rancidity, they are often talking about a specific type of rancidity involving oxygen damage to foods, and this type of rancidity is called "oxidative rancidity." During the process of oxidative rancidity, oxygen molecules interact with the structure of the oil and damage its natural structure in a way that can change its odours, its taste, and its safety for consumption

IV.NEED OF RANCIDITY DETECTION

The methods conventionally inuse through automation in various industries are destructive testing methods and are also highly expensive.

Hence, the need of a cost effective Coconut Rancidity Testing machine which works on non-destructive testing principles arises.

V.LITERATURE REVIEW

Very less research has been carried out in the field of detection of coconut rancidity. The research has been carried out in this field are destructive methods involving comparison in laminar viscosity of coconut water flowing through pipes. No research or development has been carried out in the field of non-destructive testing of coconut rancidity. Also, after survey in State centre of the Coconut Development Board, it is found that there are no non-destructive techniques developed for use in this field.

A. Methods to Detect Rancidity

i.) Visual Inspection:

Coconut is not just a hard nut to crack, but also one of the most difficult foods to detect rot. Due to the peculiar formation of coconut, it is several times impossible to identify rotten coconut.

- Check the eyes

A fresh coconut has dry eyes with no funny growth around them. However, in case of rotten coconut, the eyes would be seeping.

- Check the Shell

Check the coconut skin (in case of raw green) and shell (in case of ripe brown). If you see any scratches, cracks, and lesions, the coconut is rotten.

ii.) Slosh Test:

Principle: Water contents at 2/3rd full water state specified seems reasonable for a mature coconut and complete with water for a tender coconut. This concept is derived from slosh tests performed for fuel tank under working conditions of aircrafts [4]. the same method can be used for detection of rancidity of coconut; as a rancid coconut does not slosh the way a normal coconut does.

Forced vibration can be imparted to give the coconut a precise hammering. The frequency response obtained for a mature coconut of good quality can be compared with a rancid coconut.For a frequency response out of a certain range as per tested results, the coconut may be termed as rancid and can be separated out using a suitable push-mechanism.

iii.) Ultrasound Scanning Technique:

Ultrasonic testing is a type of non-destructive testing commonly used to find flaws in materials and to measure the thickness of objects. Frequencies of 2 to 10 MHz are common but for special purposes other frequencies are used. Inspection may be manual or automated and is an essential part of modern manufacturing processes. Most metals can be inspected as well as plastics and aerospacecomposites. Lower frequency ultrasound (50–500 kHz) can also be used to inspect less dense materials such as wood, concrete and cement[5].

iv.) X-Ray Technique:

Hard X-rays can traverse relatively thick objects without being much absorbed or scattered. For this reason X-rays are widely used to image the inside of visually opaque objects. The most often seen applications are in medical radiography and airport security scanners, but similar techniques are also important in industry (e.g. industrial radiography and industrial CT scanning) and research (e.g. small animal CT). The penetration

depth varies with several orders of magnitude over the X-ray spectrum. This allows the photon energy to be adjusted for the application so as to give sufficient transmission through the object and at the same time good contrast in the image. This technique can be used for coconut rancidity detection to compare penetration of rancid coconut with normal ones.

TABLE
Comparison of Non-Destructive Tests Identified for this Project

Visual	Sloshing	UT	RT
Very skilled and experience labor is required to be employed for 100% of the time.	Inspection can be fully automatic and reliable.	Inspection can be fully automatic; but initial cost will go on increasing with amount of automation put in.	Inspection can be fully automatic; but initial cost will go on increasing with amount of automation put in.
		2nd most expensive	most expensive
	Extensive programs & standards need to be set before the actual operation can progress.	Extensive programs & standards need to be set before the actual operation can progress.	Extensive programs & standards need to be set before the actual operation can progress.
		Linear defects oriented parallel to the sound beam can go undetected.	Orientation of the radiation beam to non-volumetric defects is critical.
	Access to both sides of the structure is usually required.	Only single sided access is required.	Access to both sides of the structure is usually required.

		Surface must be accessible to probe	Ability to inspect complex shapes and multi-layered structures without disassembly.

All above methods based on application and scope can be used for detection of coconut rancidity in a coconut processing industry. The method to be selected for the same shall depend on the needs and requirement of application.Though, we can say that sloshing, ultrasonic testing and x-ray testing may be more reliable and may give more accurate results.After various surveys & analysis, we consider slosh testing to be implemented for industrial purpose [3].The proposed system is elaborated further in this paper

VI. PROPOSED SYSTEM

i. Working Principle:

The system is designed to detect rancid coconuts using slosh testing& then separate them from the process line post coco-pith removal & prior to coconut water extraction.Slosh testing is based on the principle of frequency response range comparison between a rancid coconut and a normal coconut.

ii. Set-up:

The set-up shall consist mainly of the following components :

- Motor
- Cam
- Brass Tong
- Coconut Platform with Nylon-66 Pad & Base Frame
- Fixed Jaw Clamp
- Moving Jaw Clamp
- Lever
- Spring
- Vibrometer

Standard parts are selected from PSG Design Data/Manufacturer Catalogue [6].

VII.WORKING

Once the cocopith is removed from the coconut, the coconuts are tested for rancidity using the slosh testing method described above. The rancid coconuts may be then separated out using a push mechanism interfaced with the rancidity testing system. In this manner, the quality standards of coconuts required for a given application can be maintained.Now, to increase the fault rejection ratio, the rejected coconuts are broken and testedfor rancidity. If the rejected coconut is found to be acceptable, it can be included in the process by-passing the above system.This will enhance the productivity of the system and at theSame time maintain the quality standards of the coconuts use.

VIII. SLOSH TESTING MECHANISM

The proposed method involves creation of vibration response of the coconut shell to be tested by striking a brass tong on to the shell at various intensities and study of peak acceleration , displacement and frequency of the holding pad to detect rancidity of the coconut. The motor is a 12 V DC motor variable speed , which will rotate the cam plate , which turns the lever about the hinge thereby deflecting the tension spring during rise of the cam, the cam plate is designed such that the lever is released at the end of rise i.e., the dwell of cam plate is zero at a particular instance thereby releasing the entire energy of the tension spring instantaneously making the lever to travel downward and strike the tong onto the coconut shell at a particular intensity governed by the speed of the motor. The striking of the tong on the coconut shell will generate a set of vibrations in the shell which will be transmitted to the nylon-66 pad. These vibrations will be measured for study the peak acceleration, displacement and frequency of the holding pad to detect rancidity of the coconut. The probe is connected directly to the vibrometer set-up to note the readings of above said parameters manually. The same can also be read by logging it to PC by use of RS232 cable.

The schematically the setup of the proposed system can be represented as follows:

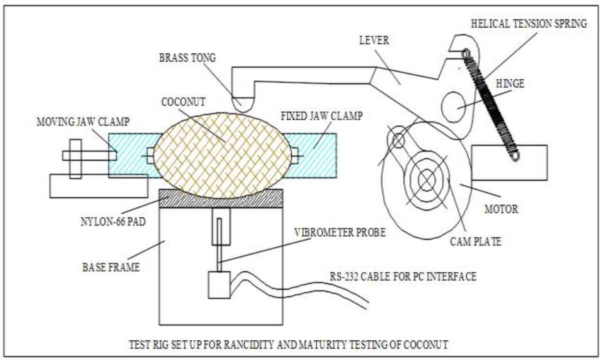

Figure 1: Setup for Rancidity Testing Machine

IX. SLOSH TESTING MECHANISM DESIGN CALCULATIONS

Calculation of motor power and spring dimensions for jumping mechanism:

Input data:

Weight of jumping mechanism: 0.8 kg (assumption)

Maximum height of jumping (h) = 20 mm (assumption)

The potential energy required to overcome the effect of Gravity to propel the mechanism against gravity is given by,

$E_{potential}$ = 0.8 x 9.81 x 20 = 156.96 J

Considering that the mechanism is to have 5 jumps per minute

Power required is given by,

Potential energy required (E-potential) / time = 156.96/ 12 = 13.08 watt
Energy of spring is given by
Where k= spring constant
X = compression / deflection of spring = 20 mm (to achieve a minimum jump of 20 mm)
Thus spring constant can be derived as,
Espring= Epotential
K = 156.96 x 2/ 202
K=0.78
Selection of Motor
Power = 7.2 Watt
Speed = 10 rpm
Torque = 0.29 N-m
Design of Motor Shaft
Material Selection: -Ref:- PSG (1.10 & 1.12) + (1.17)

DESIGNATION	ULTIMATE TEN SILESTRENGTH N/mm^2	YEILD STR ENGTH N/mm^2
EN24	800	600

ASME CODE for design of shaft
Since the loads on most shafts in connected machinery are n ot constant, it is necessary to make proper allowance for the harmful effects of load fluctuations
According to ASME code permissible values of shear stress may be calculated form various relation.
fs_{max}= 0.18 f_{ult}
= 0.18 x 800= 144N/mm^2
OR
fs_{max}= 0.3 f_{yt}
=0.3 x 600=180 N/mm^2
Considering minimum of the above values
 fs_{max}= 144N/mm^2
Shaft is provided with key hole for locking; this will reduce its strength. Hence reducing above value of allowable stress by 25%
 fs_{max}= 108 N/mm^2
This is the allowable valve of shear stress that can be induce d in the shaft material for safe operation.Assuming 100 % ef ficiency of transmission
 T design = 0.29 Nm
Check for torsional shear failure of shaft
Assuming minimum section diameter on input shaft = 6 mm Standard
 d =6mm
 fs_{act}= 6.84 N/mm^2
As fs_{act}<fs_{all}
 Pinion shaft is safe under torsional load.
Maximum radial load due to action of cam = T/r
Where: T= torque =0.29 X10 3 N
R = eccentricity of cam =40
F = 7.25 N

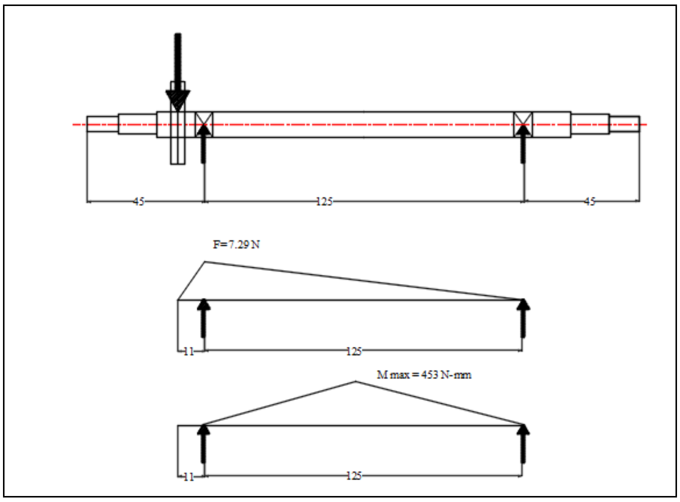

Figure 2: Loading Diagram for Shaft

Design of shaft for combined bending & torsion
$D^3 = (16/ \pi \times 108) \times \text{sq. rt}(k_b M^2 + k_t \times T^2)$
Here $k_b = k_t = 1.5$
D = 5.57 mm
Hence selecting minimum section on shaft to be 6mm
Design of lever
Material Selection: -
Ref:- PSG (1.10 & 1.12) + (1.17)

DESIGNATIO N	ULTIMATE TENS ILE	YEILD STREN GTH
AL	280	180

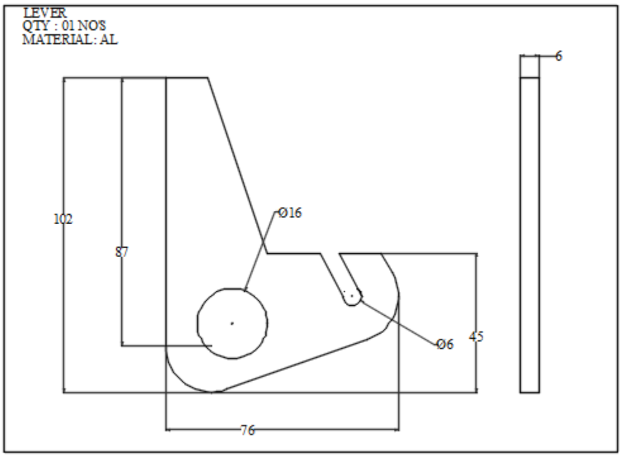

Figure 3: Design of Lever

Cross section of link may be determined by considering leve r in bending ;
The linkage has an section of (32 x 6)mm
Let; t= thickness of link
B= width of link
Bending moment;
Section modulus; Z= 1/6 t b^2
Maximum effort applied by hand(P)= 7.25 N
f_b =0.62 N/mm^2
As fb_{act}<fb_{all}
Thus selecting an (32 x 6) cross-section for the link

Design of Cam:
Design of output shaft:-
Material selection:-
Ref:-PSG Design Data(1.10&12 1.17)

MATERIAL DE SIGNATION	TENSILE STREN GTH	YEILD STREN GTH
EN24	800	600

According to the maximum shear stress theory
f_{sy} =0.5 f_{yt} =300N/mm^2
The permissible shear stress is given by
Fs_{all} = f_{yt}/FOS
=300/2 =150 N/mm^2
Section of the crank pin at xx is subjected to combined bending and torsional
Crank force = T_{design} / eccentricity = 0.29 10^3 /40 = 7.25 N
Considering Direct Shear
Fs_{max} = Force / area
Fs_{max} = 7.25 / ((22x5)-(11x5)) =0.13 N/mm^2
Design of spring
Calculation of force on each Spring (F)
Where 3 is amplification factor desired for jump
F = 10.88 N

STIFFNESS OF SPRING (Ks)

Where K1 = Stiffness of spring per turn K1 (N/mm)
n = Number of turns of spring = 90
Ref. PSG Design Data Handbook
Stiffness and permissible static and dynamic loads for helical compression springs

Wire Diameter (mm)	Outer Diameter (mm)	Stiffness of spring per turn (K1 N/mm)	Permissible load	
			Static Load (N)	Dynamic Load (N)
1	12	7.98	32.4	14.5

Ks = 1.33 N/mm
Compression of Spring to Exert A Force 'F' (□1)
□1 = 8.18 mm
Maximum Deflection of Spring (□max)
□max = 2□1 = 8.18
= 17.64
□max = 18 mm
Free Length of Spring (Lf)
Lf = Solid length + Maximum deflection
Lf = 90 + 18
Lf =108mm

TABLE II
Results

1	Rod diameter of springs	(d')	1 mm
2	Outside diameter of spring	(D')	12 mm
3	Pitch of coil	(p)	2 mm
4	Free length of spring	(Lf)	108 mm

Design of cam pin

We know that
T= force x radius
Force=7.25 N

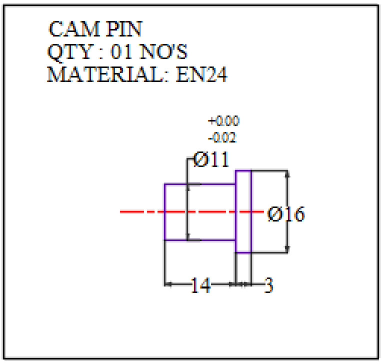

Figure 4: Design of Cam Pin

Check for direct shear of cam pin

Connecting pin minimum section is 8mm for bearing mounting.
shear stress = 0.08 N/mm ^{2}
As fs_{act}<fs_{all}
Hence pin is safe.
With this, the design of major components of Rancidity Testing Machine is complete.

X. Conclusion

From the survey & literature review carried out, we can conclude that the existing methods of Coconut Rancidity Testing are destructive type, expensive & complicated. Hence, a non-destructive testing method which is simple in implementation & cost effective is required.
The method of coconut rancidity detection proposed in this paper is based on slosh testing and is a non-destructive method which is simple in construction, operation and maintenance. Also, this is a cost effective technique. The frequency response on vibrating a coconut can be used as a parameter to detect the rancidity of a coconut. This technique of coconut rancidity detection coupled with further automation can be effectively used for industrial applications in coconut processing industries.

Acknowledgment

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