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Development and Ergonomical Evaluation of Pedal Operated Coconut Dehusker

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Abstracts: Coconuts are cultivated in the world more than 95 countries. Coconuts are made up outer husk, middle shell and inner kernel. The coconuts husks are removed for further use. The process of dehusking are remove outer part of coconuts which is called husk. Dehusking say that in many ways like traditional tools, improved tools and pedal operated and other hydraulic operated and power operated. In traditional, improve tool and their more chances of anccidents. The hydraulic operated dehusking machine is bulky, costly and it cannot be afford by small and marginal farmer. The performance evaluation is done by consider the total time of dehusking and dehusking efficiency, output capacity of dehusker. The dehusk can dehusk random shape and size with different moisture content of the coconut. Average time required for dehusking a coconut was found to be 56.5 seconds per piece. Ergonomical evaluation was different age group subject and measurement overall discomfort rate and moderate, working of dehusking with coconut.

Keyword: Pedal operated dehusker, dehusking efficiency, output capacity, ergonomic.

INTRODUCTION

Cocos nucifera a scientific name of coconut and it is a member of palm tree family *(Arecaceae).* Coconut trees has a habitat of growing well in laterite, alluvial, red sandy loam and coastal sandy soils. Coconut is grown in tropical region of 20^0 N20^0 S latitude with requirement of 2000 mm rainfall per year. Coconut is grown with tree to tree spacing of 7.5m x7.5m. The varieties of coconut - tall varieties are Tiptur tall, Benaulim, Kappadam, Dwarf varieties are Chowghat dwarf orange, Chowghat dwarf yellow and Chowghat dwarf green and the water variety are Bangalore Bondam, Ganga Bondam etc. The harvesting of coconut is done once a month and the life span is about 65years. The average yield is 10,000 to 14,000 nuts/ha. The product of coconut are oils and is used in the manufacture of soaps, hair oil, cosmetics and other industrial products, husk has fibers' and used in coir industries. Virgin coconut oil is rich in

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vitamins, minerals and antioxidants; hence coconut oil is known as "Mother of all oils".

India ranks 3rd place in production of coconut about 11.7 MT. 7.2% of world production of coconut is from India. Kerala ranks 1st in coconut production followed by Karnataka, Tamil Nadu, AP, Odisha etc in the country. Numerous traditional uses of coconuts, from food to cosmetics, attest to their well-known tremendous adaptability. When young, the coconuts are known as tender-nuts or jelly-nuts and can be collected for their consumable coconut water. The coconuts are distinguished from other fruits by their huge quantity of water (also known as "juice"). When fully developed, they can be processed to produce oil from the kernel, charcoal from the hard shell, and coir from the fibrous husk, or they can be utilized as seed nuts. The dehusking of coconuts is a post-harvest procedure that is essential to preparing the coconut for subsequent use. The dehusking of coconuts is a difficult procedure, and research is still in their early stages in all nations that cultivate coconuts. The scientific name for coconuts is Cocos nucifera, and they belong to the Arecaceae family of palm trees. In laterite, alluvial, red sandy loam, and coastal sandy soils, coconut trees can thrive.

In some countries, particularly in India, the coconut also has cultural and religious importance. Farm mechanization promotes the efficient use of machines to increase labour and land production. Additionally, it aids in cutting down on the laboriousness, expense, and duration of farming activities. Three categories of operations are used in agricultural mechanization.

In farm mechanization, the operations are divided into three

i) Pre-harvesting operation
ii) Harvesting operation
iii) Post-harvesting operation.

One of the most important and beneficial perennial plants in the world is the coconut plant (cocosnucifera). The coconut fruit is composed of a hard, protective endocarp or shell underlying a thick, fibrous fruit coat known as the exocarp. In the tropics, the coconut palm is commonly grown. After the Philippines and Indonesia, India is the third-largest producer of coconuts worldwide. Thailand, Malaysia, Papua New Guinea, and the Pacific Islands are additional producers. India produces over 5500 million coconuts every year, with plantations covering more than a million hectares. About 0.35 million tones of copra are produced in the nation, and India is responsible for 50% of global coir trade. In south India, coconut plantations are typically found along the coast and in the delta. The majority of the crop in India is grown by the country's 5 million or more small and marginal farmers. The typical holding is only 0.25 hectares in size. The conversion of more and more plantation area from arca to coconut is occurring as a result of the rising agricultural manpower shortage and the diminishing availability of water. Coconut is easier to grow and pays better than arca. Almost all of a coconut's parts are beneficial. While the meat of a mature coconut fruit can be consumed fresh, the meat of an immature coconut fruit can be turned into ice cream. It is employed in the production of animal feed and coconut flakes.

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While coconut oil is used in cooking and margarine-making, coconut milk is a cooling and wholesome beverage. In addition, coconut oil is crucial for the creation of soap.

The shell is utilised as fuel and a backup supply of heat energy in shell gasifiers. The husk produces fibres that are used to make coir products such coir pith, coir boards, coir asbestos, coir carpets, coir geo-textile, coir composite, and coir safety belts. The mesocarp tissue, or husk, of the coconut fruit is where coir is found. Coir is a versatile natural fiber. After being removed from the coconut husk and cleaned, fiber typically has a golden tint. The tough husk of a coconut is called coir. The coir protects the fruit well enough for it to withstand months of floating on ocean currents before washing up on a sandy shore, where it may sprout and grow into a tree, if it has access to enough fresh water. All the other nutrients it requires have been carried along with the seed. Using the wooden stripes with a knife edge, coconuts are first dehusked. But today, a variety of mechanical tools are used to manually dehusk coconuts. This pedal-operated manual coconut dehusker is one of the most versatile and efficient ones available. The manual coconut dehusker also has two knife edges, one of which is fixed and the other of which is moveable with the aid of the pedal. A manual method of dehusking is done by using machete or spike. This methodinvolves skilled operation to dehusk the coconut and the chances of accidents are high.

In Traditional method of coconut dehusking, the coconut firstly has to be pierced and also it has to be peeled again consuming more forces.

Then, to boost the force and provide resistance to those knife edges, the closed coil helical spring is equipped with the movable knife edge. One of the greatest small manual coconut dehuskers for household tasks is this one. Modern technology is used to mechanize agriculture nowadays. Modern agriculture uses a variety of light to heavy machines for tasks like plough, sow, and harvest. The use of these tools is advantageous to both farmers and labour since it allows farmers to save time while simplifying labour' arduous and complicated tasks. Additionally, it increases agriculture productivity. Three categories can be used to broadly classify the agricultural activities. These activities include pre-harvest, harvest, and post-harvest. These three categories of operations are now all automated by machines. Seed farms, irrigation, and other pre-harvest activities. Harvesting is the process of removing fruits from plants. The procedure known as post-harvesting is necessary for the further processing of the fruits that the plants produce. Dehusking coconuts is one of the various post-harvesting processes that is regarded as being challenging to complete. Because of all of its benefits, coconut is widely farmed in India, and the climate along the coast is ideal for its cultivation..

The coconut provides coconut oil, coconut powder, and rope-making materials from its husk, among other things. Its post-harvesting is crucial as a result. Its post-harvesting has undergone numerous attempts to become mechanized, either manually or electrically. These mechanization efforts have benefits and drawbacks of their own. To choose an appropriate

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mechanism to meet the required need of small-scale tasks, it is necessary to examine such instruments and machines. Coconut de-husking and cutting provide one of the main obstacles in the production of coconut oil. Almost exclusively by hand, Time is wasted in this way, and it can never be recovered. By creating a coconut dehusking and cutting machine that is more effective than current devices, we are attempting to solve this issue.

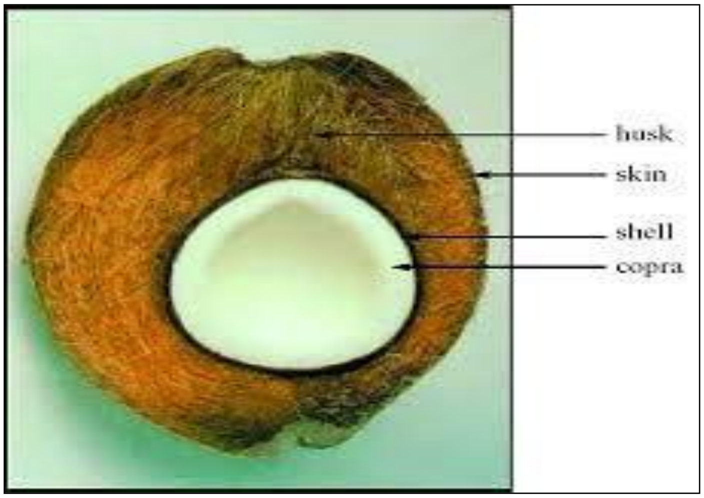

Figure 1.1: Cross section of coconut

Coconut is one of the world's most useful and important perennial plants. A coconut can be divided into three parts:

1. Exocarp-outer covering
2. Thick fibrous fruit coat- husk
3. Endocarp-inner shell

A coconut's length and diameter range from 245mm to 295mm and 145mm to 200mm, respectively. At one end of the nut, there are three recessed 'eyes' made of softer tissue. At maturity, the endocarp contains a thin, white, fleshy layer that is called "coconut meat" and is filled with coconut water. This layer is around 12.25 mm thick. Being from the south of India, and specifically from Kerala, we understand the value of coconut water, which is a natural beverage, and coconut flesh, which is a significant component of our curries. Coconut trees develop faster because of the abundance of cytokines in coconut water. It is a clear liquid that contains bioactive enzymes such acid phosphates, catalase, dehydrogenize, diastase, peroxides, and RNA polymerases as well as carbohydrates, vitamins, minerals, electrolytes, enzymes, amino acids, and enzymes.

What are some of the health hazards

Significant muscular effort is required to maintain an upright posture. Standing significantly lowers the blood flow to the overworked muscles. Pain in the muscles of the legs, back, and neck (which are utilised to maintain an upright position) as well as exhaustion are symptoms of insufficient blood flow. Along with muscle pain, the worker often has additional discomforts. Standing for extended periods of time without moving about causes blood to pool in the legs and feet. Standing for extended periods of time without moving might cause vein inflammation. Over time, this inflammation could develop into painful, long-lasting varicose veins. Additionally, excessive standing can temporarily lock or immobilize the joints in the spine, hips, knees, and foot. Due to degenerative damage to the tendons and ligaments (the structures that connect muscles to bones), this immobility might eventually result in rheumatic disorders.

What are some recommendations for improving workplace design

The worker has the option to select from a number of well-balanced working positions in a well-designed workplace and to switch between these positions often. Adjustable workstations and benches are ideal. It is crucial to have the working height adjustable so that the workstation can accommodate each employee's unique body type and job-specific needs. A worker's capacity to perform tasks in balanced body positions is ensured by adjustability. Platforms to lift the shorter worker or pedestals on top of workstations for the tall worker should be taken into consideration if the workstation cannot be changed. Another crucial factor is how the workspace is organized. There should be sufficient space to move about and adjust one's posture. The worker can shift weight from one leg to the other by having built-in foot rails or portable footrests. For precise labour, elbow supports can assist ease neck and upper arm strain. Controls and tools should be placed where the worker can quickly access them without having to bend or twist. If at all possible, a seat should be offered so that the employee can perform the task while seated or standing. The worker must be seated at a height appropriate for the type of task being done. Only standing is required for work purposes. In any instance, a seat should be offered so the employee can take a break. The range of possible body positions is increased and the worker has more freedom thanks to the seats at the job. More flexibility and a range of body positions have two advantages. Increased muscular involvement in the work equalizes the load distribution among the body's various regions. As a result, the specific muscles and joints required to maintain the upright position are put under less stress. Altering one's posture also increases blood flow to active muscles. Both outcomes assist in lessening general weariness.

How can work practices reduce the effects of working in a standing position

Working in a balanced position without placing undue strain on the body is feasible when a job and environment are both well-designed. Work practices can make a job safer or more dangerous, even though the worker's actual performance of the activity depends on them (including how they stand, move, or lift). A person can work safely if they receive the proper

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knowledge and training. The worker must be made aware of any health risks present at work. In fact, it is a mandate under law.

MATERIALS AND METHODS

The chapter on materials and techniques describes a strategy to designing a straightforward power-operated coconut dehusker, the resources employed in this study, the methodology used for carrying out research, and the facilities that are available to carry out a performance assessment of a power-operated coconut dehusker. Coconut dehuskers had been created by a number of state agricultural universities and several firms. Dehusking was done manually with a billhook, spike, and machete. To dehusk the coconut using this procedure, an experienced operator is needed and the likelihood of injuries are more.

1. Physical Parameter of coconut
2. Design and develop a pedal operated coconut dehusker.
3. Evaluate the performance of a development pedal operated coconut dehusker.
4. Ergonomical analysis of anthropometry of the body (legs, muscle, posture etc.)

In the traditional method of dehusking coconuts, the coconut must first be pierced and then it must be peeled once more, requiring more effort. The pedal-operated coconut dehusker uses the thigh muscles to generate power, making it laborious for the operator to dehusk and inaccessible to farm women. The hydraulic approach uses a big machine that requires more expert staff and more power to operate. The machine is expensive as well. The pedal operated systems currently in use include high initial costs, significant power consumption, and more moving parts, which require highly trained staff.

3.1. Physical Parameter of coconut

Therefore, it is necessary to build a straightforward pedal-operated coconut dehusker that uses less energy and doesn't require specialised manpower to operate. By taking into account all of these factors, this project is undertaken, and the factors for this study are:

3.1.2. Components of Physical Parameter

- Length
- Breadth
- Thickness
- Roundness
- Sphericity
- Weight
- Penetration Resistance
- Dehusking force
- Thickness of husk

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3.1.3. Length

It is a coconut's largest dimension and indicates the distance to the main axis. Vernier callipers are used to measure it, or you can just use a steel ruler or scale. Randomly twenty coconuts are measured for length and documented average19.005cm.

3.1.4. Breadth

It gives the distance of the intermediate axis and is the diameter of a coconut measured from side to side. Vernier callipers are used to measure it, or you can just use a steel ruler or scale. Twenty coconuts' breadths are measured and documented as average 16.02cm.

3.1.5. Thickness

It provides the distance of the minor axis and is the dimension through a coconut. Scale and vernier calliper are used to measure it, or you can just use a steel ruler or scale. Randomly twenty coconuts' thicknesses are measured average 12.505cm.

These three measurements length, breadth, and thickness reflect the coconut's size.

3.1.6. Roundness

It serves as a gauge for coconut pungency. Coconuts were chosen at random and put on a graph paper. The biggest projected area (Ap) of the coconut is traced in its natural resting position. Then, a graph sheet is used to trace the area of the smallest circumscribing circle (Ac). The area of the smallest circumscribing circle was thought to be measured by the diameter, which is given by,

Area of smallest circumscribing circle (Ac) = πr^2

Where,

r = radius of smallest circumscribing circle Roundness was measured by,

Roundness =$\mathit{Largest\ projected\ area\ of\ the\ coconut\ when\ it\ is\ in\ natural\ rest\ position,}$ Ap/$\mathit{Area\ of\ smallest\ circumscribing\ circle,\ Ac}$

Roundness = Ap / Ac

3.1.7. Sphericity

It is the ratio between the diameter of a sphere with the same volume as a coconut and the diameter of the sphere with the lowest circumference, or typically the diameter with which the coconut has the maximum diameter. Coconuts were chosen at random, and sphericity was assessed. The formula, which measures sphericity, is

$$\text{Sphericity} = \frac{(lbt)^{1/3}}{l}$$

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Where l=length of coconut

b= breadth of coconut

t= thickness of coconut

3.1.8. Weight

Ten coconuts were chosen at random and weighed on a digital electronic scale. We watched the measurements and took notes.

3.1.9. Resistance to Penetration

It is the resistance to penetration provided by the coconut husk. Coconut penetration resistance is measured using a penetrometer. It is useful for determining the penetrating force needed to split coconut husk.

3.1.10. Force Dehusking

A load cell mounted to the lever of a pedal operated coconut dehusker was used to quantify the force needed to remove the coconut's husk. Dehusking forces were applied to randomly twenty samples of coconuts throughout the dehusking process. The hand lever was then actuated. The coconut husk is opened and split by the blade. Digital load cells were used to determine the amount of force 8kg and 0.5kg loss of force, Ultimately, using force on a 5-7.5kg coconut necessitates dehusking them.

3.1.11. Thickness of husk

A steel ruler or scale was used to measure the husk's thickness using a vernier calliper. It was measured by either using a calliper after dehusking or by sticking a sharp item into the husk, where the length entered gives the thickness of the coconut husk. The thickness of the husk ultimately determines the power demand as well as the penetration resistance and dehusking force. Twenty coconuts were chosen at random, and their moisture content and husk thickness were measured and recorded.

3.2.1. Design, Development of Pedal operated Coconut Dehusker

- **Material selection**

The machine's construction materials were chosen based on their availability, mechanical qualities, and cost-effectiveness. The supplies came from a nearby open market. Rods and plates made of mild steel are two of the main materials utilized in fabrication.

3.2.2. Closed Coil Spring

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A mechanical tool that is frequently used to store energy and then release it, to absorb shock, or to maintain a force between contacting surfaces is a coil spring, also referred to as a helical spring. The wire's cross-section is often circular, though it can also be square or rectangular. Helical springs are simple to make, dependable, and have a constant spring rate, meaning that the force placed on the spring immediately affects how far it deflects. Compression helical springs and tension helical springs are the two varieties that are available. The compression helical springs are made to withstand compressive loads, and as a result of the tension and the loading, they are compressed. Since helical springs are made to withstand tensile stress, external loads cause them to elongate. These springs' axis is where the load acts. The wire in helical sprigs experiences torsional shear stress. Additionally, there are two types of helical springs: closely-coiled and open-coiled. The wire in open-coiled helical springs is so tightly wound that there is a space between two successive turns, or the helix angle, is high.

3.2.3. Spring Materials

Springs are built of materials that can be formed (rolled or drawn) to a high strength while maintaining a sufficient amount of ductility, or alloys that can be heat treated to a high strength and ductility prior to or after forming. Springs are produced using both hot and cold working techniques. The intended characteristics, spring index, and material size all influence the method choice. The spring's winding creates residual bending tensions, which are relieved by heat treatment.

3.2.4. Terminology of Helical Springs

Solid Length:

Length of the spring when it is compressed so that the coils touch each other.

Solid Length , $L_s = n.d$

where n = numbers of coils and d = wire diameter

Compressed Length:

Length of the spring, when it is subjected to maximum compressive force.

Even under the worst load, minimum clearance is maintained between the two adjacent coils so that they don't clash with each other. It is called clash allowance and is generally taken as 15% of the maximum deflection.

Free Length:

Length of the spring in the free or unloaded condition.

Spring Index:

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Ratio of the mean diameter of the coil to the diameter of the wire .

Spring Rate/Spring Stiffness/Spring Constant:

Force required to produce unit deflection in the spring.

Spring Rate, k = $\frac{W}{\sigma}$

Pitch of the Coil:

Axial distance between adjacent coils of the spring in uncompressed state.

Pitch of the Coil = p = $\frac{Free\ Length}{(n-1)}$

3.2.5. Pedal

The pedal (from the Latin pes, pedis, meaning 'foot') is a lever activated by one's foot, sometimes called a "foot pedal" (but all pedals are used by a foot). A unit of length equal to one third of a yard or 12 inches.

Determination of Forces

$$R = \sqrt{W^2 P^2 - 2WP\cos\theta}$$

Specification:

Size = 60× 8 cm

Force applied: maximum 10-12kg (98.06- 117.67N)

Force applied working condition: 5-7.5kg (49.03-74.53N)

3.2.6. Design of Shafts

Shafts are designed on the basis of strength or rigidity or both. Design based on strength is to ensure that stress at any location of the shaft does not exceed the material yield stress. Design based on rigidity is to ensure that maximum deflection (because of bending) and maximum twist (due to torsion) of the shaft is within the allowable limits. Rigidity consideration is also very important in some cases for example position of a gear mounted on the shaft will change if the shaft gets deflected and if this value is more than some allowable limit, it may lead to high dynamic loads and noise in the gears.

In designing shafts on the basis of strength, the following cases may be considered:

(a) Shafts subjected to torque

(b) Shafts subjected to bending moment

(c) Shafts subjected to combination of torque and bending moment

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(d) Shafts subjected to axial loads in addition to combination of torque and bending moment

Shafts Subjected to Torque

Maximum shear stress developed in a shaft subjected to torque is given by,

$$\tau = \frac{T\,r}{J} \leq [\tau]$$

where

T = Twisting moment (or torque) acting upon the shaft,

J = Polar moment of inertia of the shaft about the axis of rotation

$= \frac{\pi d^4}{32}$ for solid shafts with diameter d

$= \frac{\pi (d_o^4 - d_i^4)}{32}$ for hollow shafts with d_o and d_i as outer and inner diameter.

r = Distance from neutral axis to the outer most fibre = d/2 (or d_o/2)

So dimensions of the shaft subjected to torque can be determined from above relation for a known value of allowable shear stress, [τ].

Shafts Subjected to Bending Moment

Maximum bending stress developed in a shaft is given by,

$$\sigma_b = \frac{M\,y}{I} \leq [\sigma_t]$$

where

M = Bending Moment acting upon the shaft,

I = Moment of inertia of cross-sectional area of the shaft about the axis of rotation

$= \frac{\pi d^4}{64}$ for solid shafts with diameter d

$= \frac{\pi (d_o^4 - d_i^4)}{64}$ for hollow shafts with d_o and d_i as outer and inner diameter.

y = Distance from neutral axis to the outer most fibre = d / 2 (or d_o/2)

So dimensions of the shaft subjected to bending moment can be determined from above relation for a known value of allowable tensile stress.

Shafts Subjected to Combination of Torque and Bending Moment

When the shaft is subjected to combination of torque and bending moment, principal stresses are calculated and then different theories of failure are used. Bending stress and torsional shear stress can be calculated using the above relations.

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$$\tau = \frac{T\,r}{J} = \frac{T\,\frac{d}{2}}{\frac{\pi}{32}d^4} = \frac{16\,T}{\pi d^3}$$

$$\sigma_b = \frac{M\,y}{I} = \frac{M\,\frac{d}{2}}{\frac{\pi}{64}d^4} = \frac{32\,M}{\pi d^3}$$

Maximum Shear Stress Theory

Maximum shear stress is given by,

$$\tau_{max.} = \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + (\tau)^2} = \sqrt{\left(\frac{16\,M}{\pi d^3}\right)^2 + \left(\frac{16\,T}{\pi d^3}\right)^2} = \frac{16}{\pi d^3}\sqrt{M^2 + T^2} \le [\tau]$$

$\sqrt{M^2 + T^2}$ is called equivalent torque, T_e, such that

$$\tau_{max.} = \frac{T_e\,r}{J} \le [\tau]$$

Maximum Principal Stress Theory

Maximum principal stress is given by,

$$\sigma = \frac{\sigma_b}{2} + \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + (\tau)^2} = \frac{16\,M}{\pi d^3} + \sqrt{\left(\frac{16\,M}{\pi d^3}\right)^2 + \left(\frac{16\,T}{\pi d^3}\right)^2} = \frac{16}{\pi d^3}\left[M + \sqrt{M^2 + T^2}\right] \le [\sigma_t]$$

$\left[M + \sqrt{M^2 + T^2}\right]$ is called equivalent bending moment, M_e, such that

$$\sigma = \frac{M_e\,y}{I} \le [\sigma_t]$$

A.S.M.E. Code for Shaft Design

According to A.S.M.E. code, the bending and twisting moment are to be multiplied by factors k_b and k_t respectively, to account for shock and fatigue in operating condition. Therefore, if the shaft is subjected to dynamic loading, equivalent torque and equivalent bending moment will become:

$$T_e = \sqrt{k_b M^2 + k_t T^2} \quad \text{And} \quad M_e = \left[k_b M + \sqrt{k_b M^2 + k_t T^2}\right]$$

Table: Values of k_b and k_t for different types of loading

	k_b	k_t
Gradually applied load	1.5	1.0

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Suddenly applied load (minor shock)	1.5-2.0	1.0-1.5
Suddenly applied load	2.0-3.0	1 .5-3.0

Shafts Subjected to Axial Loads in addition to Combination of Torque and Bending Moment

Tensile Stress due to axial load is given by,

$$\sigma_t = \frac{P}{A}$$

Where

P = axial load acting on the shaft

A = cross-sectional area of the shaft

As nature of the bending stress and this axial stress is same, these can be vectorially added for any location on the shaft, so as to get the resultant tensile/compressive stress, which can then be used to find the principal stresses in the shaft.

Design of Shaft on the basis of Rigidity

Torsional Rigidity

For a shaft subjected twisting moment, the angle of twist is given by,

$$\theta = \frac{TL}{GJ} \leq [\theta]$$

Where,

T = Torqe applied

L = Length of the shaft

J = Polar moment of inertia of the shaft about the axis of rotation

G = Modulus of rigidity of the shaft material

Therefore for the known values of T, L and G and allowable value of angle of twist, diameter of the shaft can be calculated.

Lateral Rigidity

Bending moment acting on any shaft is given by,

$$M = EI\frac{d^2y}{dx^2}$$

Integrating this equation twice with respect to x and applying the boundary conditions, y can be calculated. y should be ≤ allowable value of deflection, [y].

A.S.M.E. Code for Shaft Design

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According to A.S.M.E. code, the bending and twisting moment are to be multiplied by factors k_b and k_t respectively, to account for shock and fatigue in operating condition. Therefore, if the shaft is subjected to dynamic loading, equivalent torque and equivalent bending moment will become:

$$T_e = \sqrt{k_b M^2 + k_t T^2} \quad \text{And} \quad M_e = \left[k_b M + \sqrt{k_b M^2 + k_t T^2}\right]$$

Table : Values of k_b and k_t for different types of loading

	k_b	k_t
Gradually applied load	1.5	1.0
Suddenly applied load (minor shock)	1.5-2.0	1.0-1.5
Suddenly applied load	2.0-3.0	1.5-3.0

3.2.6. Nuts and Bolts

Bolts are externally threaded fasteners that are intended to be inserted through holes in assembled parts and are often designed to be tightened or released by turning a nut.A bolt is an externally threaded fastener that can only be tightened or released by torqueing a nut because it cannot be rotated during assembly. (For instance, track bolts, plough bolts, and round head bolts.) A fastener with a threaded hole of this kind is called a nut. To secure many parts together, nuts are nearly typically used in conjunction with a corresponding bolt. Combining the forces of the bolt's minor stretching, the compression of the pieces to be held together, and the friction between the two partners' threads (with some elastic deformation), the two partners are maintained together.

Performance Evaluation of Development Pedal Operated coconut Dehusker

3.3.2. Time required to dehusking the coconut

It is the overall amount of time needed to pierce the coconut, split the husk, remove the loosening husk, and unload the coconut. Using a stopwatch, the amount of time needed to dehusk the coconut was calculated. All of these activities' required times were observed and noted.

3.3.3. Output Capacity

By measuring the average time needed to dehusk a coconut, the output capacity of the designed pedal-operated coconut dehusker was determined. The output rate was expressed as nuts per hour (Nuts/h), or coconuts.

3.3.4. Dehusking Efficiency

After the coconut was dehusked, the husk was removed and weighed on an electronic scale. After the coconut has been dehusked but the husk is still on the shell, it is then manually

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removed. By combining the weights of the manually and mechanically removed husks, the total weight of the husk can be calculated. The weight of the husk dehusked by the machine divided by the total weight of the husk was determined to determine the dehusking effectiveness of the machine. The following formula was used to determine the dehusking efficiency:

Dehusking Efficiency (%) = $\left(\frac{weight\ of\ husk}{total\ weight}\right)$x100

Instruments used for measurements

The different instruments which are used for calculation of performance evaluation ofdeveloped pedal operated coconut dehusker are listed below

Table 3.14. Instruments used for measurements

Sr.No.	Physical parameters	Instruments
1	Length, Breadth, Thickness of Coconut	Steel ruler or Vernier caliper
2	Penetration resistance	Fruit penetrometer
3	Dehusking force	Load cell
4	Thickness of husk	Steel ruler or Vernier caliper
5	Weight	Electronic weighing scale
6	Speed	Contact type tachometer
7	Time	Stopwatch

3.3.5. Cost of machine

Fixed cost and variable cost are the two categories under which the operating costs of a coconut dehusker are broken down.

The accepted method was used to determine the machine's manufacturing cost approximate 1600/- Rs.

Ergonomical considerations

Physiological parameters of subjects used for evaluation of developed pedal operated coconut dehuske

The experiment examined the relationship between ergonomic body movement size of force and physiological factors as noise, light, and temperature. The second is an evaluation of the performance of the coconut dehusker in this chapter as well as the machine design pedal

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operated. Selection of subject.

The farm workers in the field who were chosen for the ergonomical evaluation of pedal operated coconut dehusker were chosen based on their experience using the machines. Its machine has ten male employees who are between the ages of 25 and 40 and in good health. The anthropometric data identified fifteen various body dimensions (strength measurements were used for the study), with reference to the dimensions of the positions in functional components of coconut dehusker. The selected male were measured in the lab for stature, weight, acromion height, leg push, and muscle strength.

The analyses are anthropometric dimensions (data) of measured using the following equipments.

Weighing balance

Each subject's weight was determined using a platform balance. The digital readout panel displayed each subject's weight in kilo-gram. For a subject to take part in an ergonomic evaluation efficiently, they must be physically and mentally fit. By checking for normal health through a medical examination, the ten people who were ultimately chosen for the study had enough levels of medical fitness.

Energy expenditure rate (EER)

Energy expenditure rate of a worker performing a job is calculated from the oxygen consumption rate data where the calorific value of oxygen depends on the respiratory quotient. It was expressed in kJ/l.

Statistical parameters

Mean

$$m = \frac{x1+x2+x3}{3}$$

Where,

m = Mean value of the variables

x1, x2, x3 = Individual value of the body dimension concerned

Standard deviation

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The standard deviation is computed by using the expression given below:

$$SD = \frac{\sqrt{(x - m)^2}}{n - 1}$$

Where,

SD = Standard deviation of the variables

m =Mean value of the variables
x = Individual value of the body dimension concerned
n = number of subjects in the sample

RESULT AND DISCUSSION

This chapter gives the results of the experiments which are carried out after the measurement of the coconut and testing of developed coconut dehusker. In this chapter different parameters were tested and measured like physical properties of coconut, dehusking force with different moisture content of coconut, torque and pedal (Appendix) and finally the dehusking efficiency, output capacity of the developed coconut dehusker were measured, recorded and studied. After the machine was manufactured, the testing and performance evaluation of the machine was done by considering the followingparameters like:

1. Independent/ Operational parameters:

a) Sphericity

b) Roundness

c) Moisture content (%)

2. Dependent/ Response parameters:

a) Penetration resistance (mm)

a) Dehusking force (kgf)

b) Dehusking time (sec)

c) Output capacity (nuts/h)

d) Dehusking efficiency (%)

Physical parameter of coconut

The physical properties are such as sphericity using length, breadth and thickness of the coconut was determined using 20 different coconut samples.

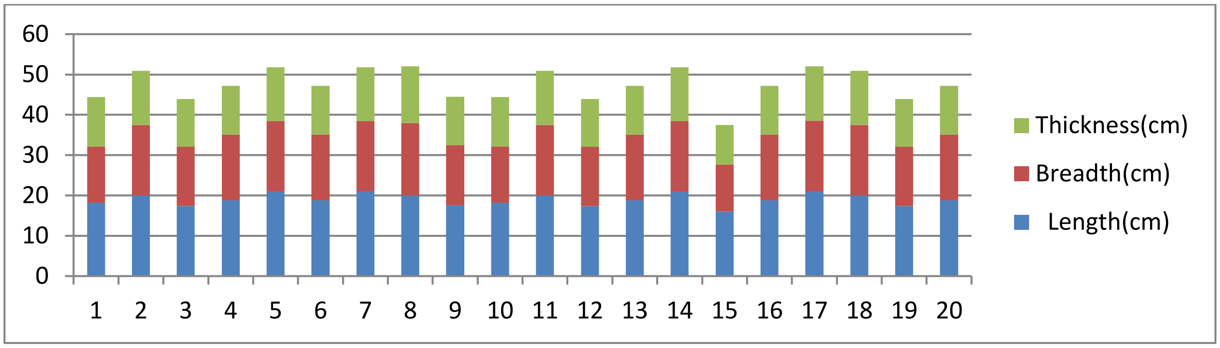

Figure: Physical parameter of coconut

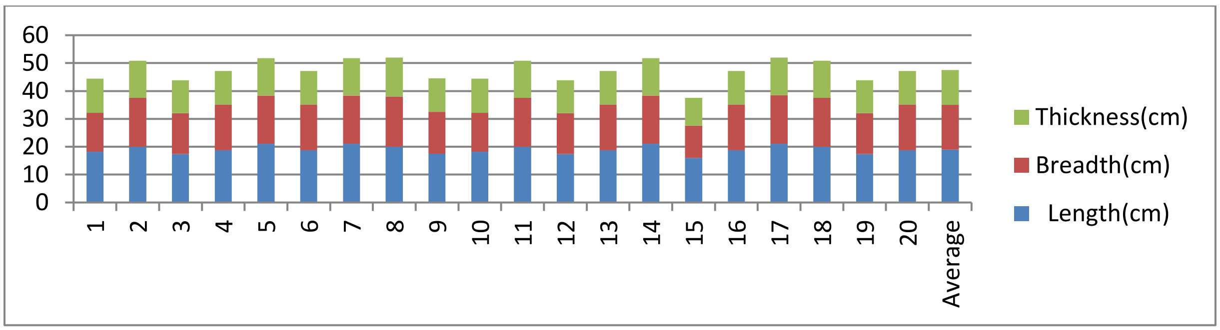

Figure: Average physical parameter of coconut

Table 4.1 provides measured values of the coconut i.e., the length, breadth and thickness of the coconut. The average major axis/length of the coconut is 19.005 cm, intermediate axis/breadth is 16.02cm and minor axis/thickness is 12.504cm.

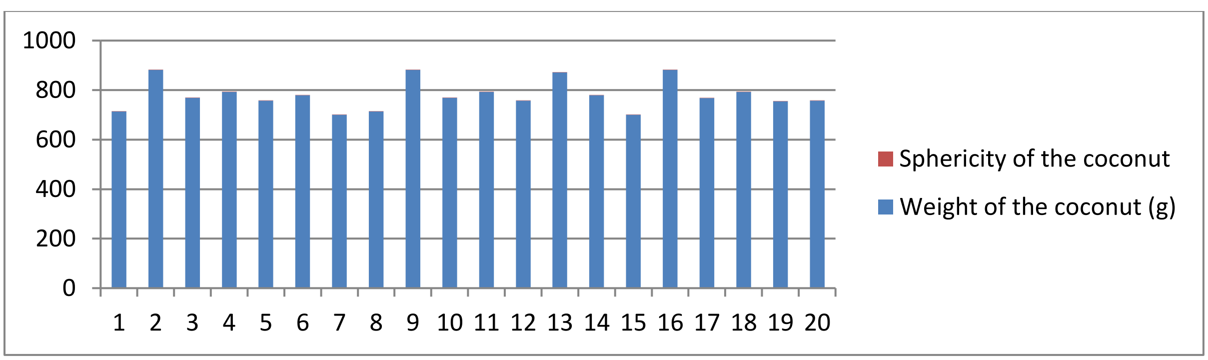

Figure: Weight and Sphericity of the coconut shells

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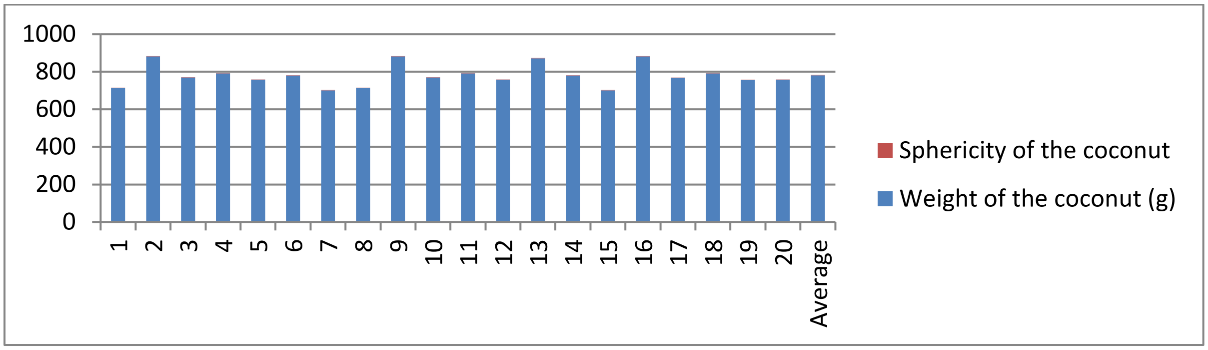

Figure: Average weight and sphericity of the coconut shells

Table 4.2 provides the measurement of weight of the coconut and sphericity values of the coconut calculated from the length, breadth and thickness of the coconut. The weight of the coconut lies in the range of 701gm to 881gm. Similarly, sphericity average values 0.8349. The according to availability in prayagraj of average weight of the coconut measured was 780.55gm.

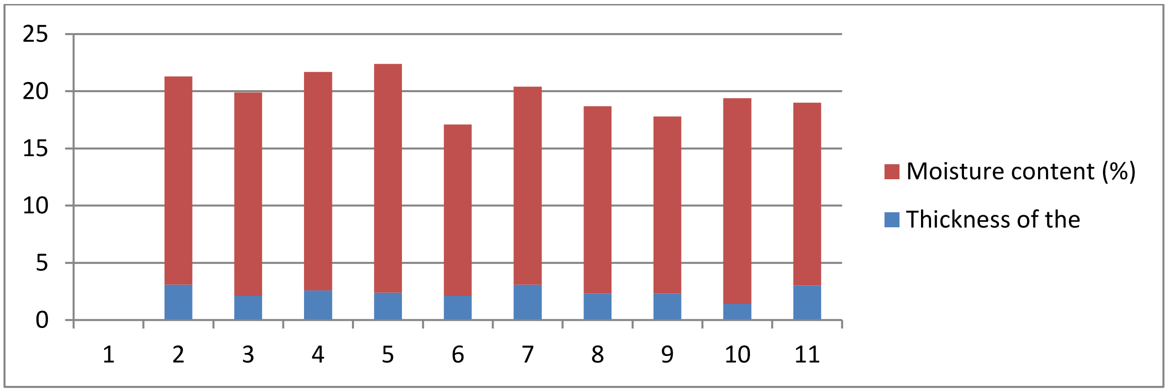

Figure: Thickness of the coconut husk and moisture content

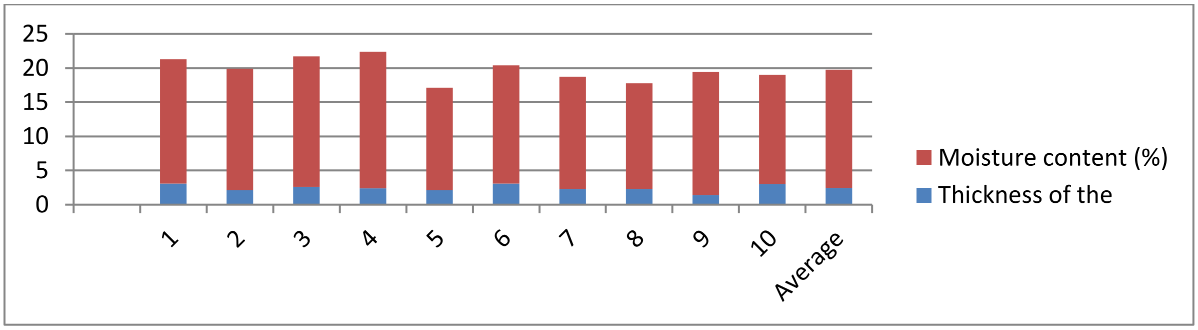

Figure: Average Value thickness of the coconut husk and moisture content

Table 4.3. Provides the thickness of the coconut husk and moisture content of the coconut. The average thickness was 2.44cm and average moisture contentof the coconut measured was 17.33 %. The thickness of husk of the coconut liesin the range of 1.4cm and 3.1cm.

Measurement of dehusking force

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The force needed to remove the coconut's husk is known as the dehusking force. The force for dehusking was observed and recorded for five samples of coconuts, totaling 6-7.5kg observations of dehusking force. It was measured using a digital load cell that is mounted to the lever of a manually operated coconut dehusker. The lower end of the load cell was secured to the base platform or foot rest using thread, and the food lever was then actuated. The higher end of the load cell was attached to the dehusker's lever at a distance of 15cm from the top. The coconut husk is opened and split by the dehusking teeth.

Table 4.4. Dehusking force (kgf) of selected coconuts using pedal operatedcoconut dehusker

	Coconut 1 (18.3% MC)	Coconut 2 (17.8% MC)	Coconut 3 (19.2% MC)	Coconut 4 (20.1% MC)	Coconut 5 (15.3% MC)	Coconut 6 (17.7% MC)	Coconut 7 (16.8% MC)	Coconut 8 (18.1% MC)	Coconut 9 (17.7% MC)	Coconut 10 (20.0% MC)
F1	5.1	6.6	4.1	5.9	7.38	6.02	4.5	6	7.1	6.6
F2	6.3	5.7	5.1	4.7	4.23	5.07	6.9	5.2	6.6	5.6
F3	4.2	6.5	6.9	7.5	4.4	6.8	5.7	5.2	5.4	7.5
F4	6.9	5.9	5.9	4.9	4.26	3.99	5	6.8	5.8	7.1
F5	6.8	5.8	5.7	5.7	6.23	7.07	6.9	4.7	5.7	5.3
F6	4.2	3.5	4.9	3.57	5.4	5.8	6.78	4.2	5.4	6
F7	6.4	5.83	6.2	6.7	5.71	4.9	5.91	5.4	4.7	6.6
F8	4.2	6.5	6.9	7.57	4.4	6.88	5.78	5.2	5.4	7.5
F9	6.8	5.8	5.7	5.7	6.23	7.07	6.9	4.7	5.7	5.6
F10	6.9	5.9	5.9	4.9	4.26	3.99	5	6.8	5.8	7.2
Max DF	**5.78**	**5.803**	**5.73**	**5.714**	**5.25**	**5.759**	**5.937**	**5.42**	**5.76**	**6.5**

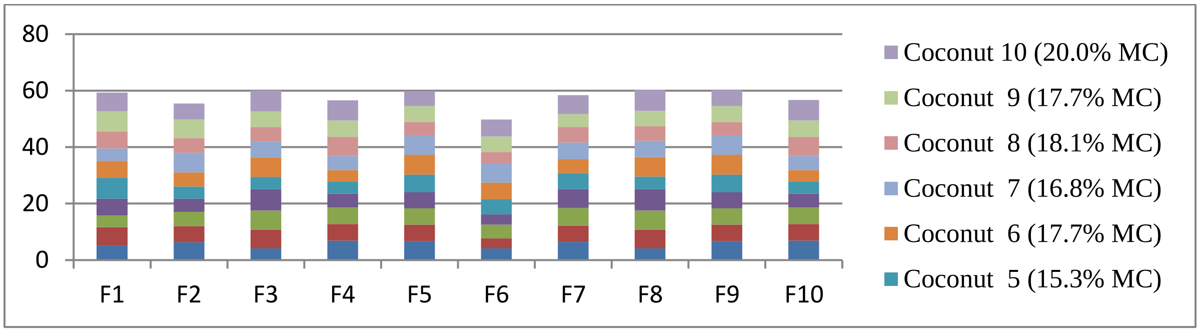
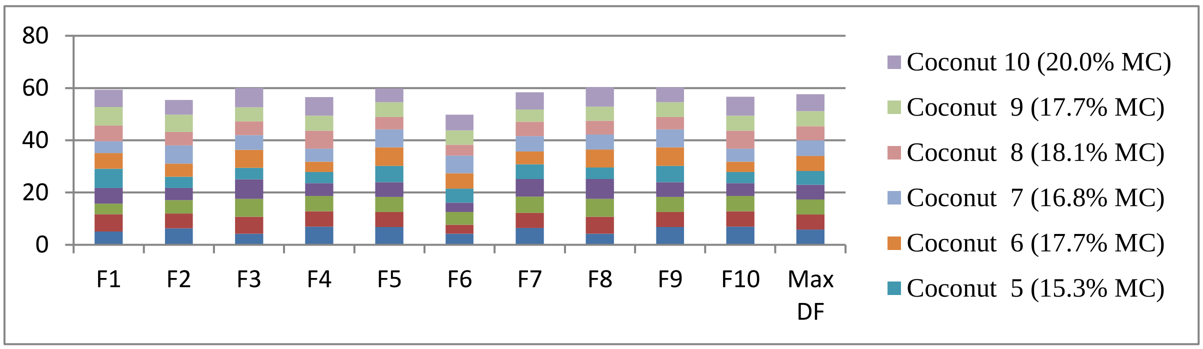


Figure: Dehusking force (kgf) of selected coconuts using pedal operatedcoconut dehusker



Figur: Max Dehusking force (kgf) of selected coconuts

Output Capacity

By measuring the average time needed to dehusk a coconut, the output capacity of the designed pedal-operated coconut dehusker was determined. The output rate was expressed as nuts per hour (Nuts/h), or coconuts.

Output= Nut/ hours

Machine are dehusk 62 coconuts per hour

Time required for dehusking:-

One person is required for operating the dehusker. During the tests, average time required for dehusking a coconut was found to be 56.5 seconds per piece.

Dehusking Efficiency

After the coconut was dehusked, the husk was removed and weighed on an electronic scale. After the coconut has been dehusked but the husk is still on the shell, it is then manually removed. By combining the weights of the manually and mechanically removed husks, the total weight of the husk can be calculated. The weight of the husk dehusked by the machine divided

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by the total weight of the husk was determined to determine the dehusking effectiveness of the machine. The following formula was used to determine the dehusking efficiency:

$$\text{Dehusking Efficiency (\%)} = \left(\frac{weight\ of\ husk}{total\ weight}\right) \text{x100}$$

$$= (453/800) \text{ x } 100$$

$$DE = 56.62$$

CONCLUSIONS

The following conclusions are drawn after performance evaluation of developed pedal operated coconut dehusker:

1. The performance of the developed pedal operated coconut dehusker was found to be satisfactory.
2. No breakage of coconut shell and the inner kernel was observed while dehusking with the developed pedal operated coconut dehusker.
3. The maximum dehusking force was observed to be 7.5 kg (73.58N).
4. The ODR lies in the range of 3 to 4 and 4 to 5 in developed pedal operated coconut dehusker and existing traditional method coconut dehusk respectively.

Dehusking of coconut is considered as light work and moderately heavy work in developed pedal operated coconut dehusker and existing manual operated coconutdehusker respectively.

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